PHYSICS HOMEWORK #1 KINEMATICS
DISPLACEMENT & VELOCITY

$$v_{average} = \frac{\Delta d}{\Delta t} \qquad v_{ins} = \frac{\Delta d}{\Delta t_{verysmall}} \qquad +/-error = \frac{\Delta d \uparrow}{\Delta t \downarrow} - \frac{\Delta d}{\Delta t} \qquad a_{ave} = \frac{\Delta v}{\Delta t}$$

1. You walk exactly 250 steps North, turn around, and then walk exactly 400 steps South. How far are you from your starting point?

2. An automobile travels 25 miles West, then goes 45 miles East and finally goes 15 miles West. How far will this car be from its starting point?

3. A car goes North a distance of 120 miles during a time period of 3.0 hours. What is the average speed of the car during this time interval?

4. The distance between Denver Colorado and Vail Colorado is 132 miles. With what average speed should you drive your car in order to travel this distance in exactly 2½ hours?

5. A small cart is rolling along a horizontal surface and you measure that the cart moves a distance of 3.25 meters over a time period of 1.35 seconds. What is the average speed of the cart?

6. A block of wood, which is 12.0 cm long, is dropped through an infrared sensor designed to measure the time that the sensor is blocked. Assuming that this block of wood blocks the sensor for a time interval of 0.27 seconds, what is the speed of this block as it passes through the sensor? Is this speed "average" or "instantaneous"?

7. Suppose that in problem #6 above the length of the block is known to an accuracy of +/- 0.3 cm, while the timer is limited to an accuracy of +/- 0.05 seconds.
   a. What is the maximum speed you would calculate for this block, based on these error limits?
   b. How much does this maximum differ from the speed calculated in #6 above?
   c. What is the minimum speed you would calculate for this block based on these error limits?
   d. How much does this minimum speed differ from the calculated speed in #6 above?
   e. How do the maximum (b) error and the minimum (d) errors compare?

8. An infrared sensor system is set up so that two sensors start timing when the infrared beam of the first sensor is blocked and then the timer stops when the beam of the second sensor is blocked. Suppose that a cart is moving toward the right when it blocks the first sensor and then later the cart blocks the second sensor. The distance between the sensors is measured to be 88.0 cm with a possible error of 2.0 cm and the time interval recorded by the sensors is recorded to be 0.35 seconds with a possible error of 0.03 seconds.
   a. What is the average speed of this cart?
   b. What will be the maximum possible error in the speed of this cart?

9. A car travels West at 35 mph for a time period of 2.5 hours and then travels West at 55 mph for an additional time of 4.0 hours. How far will this car be from its starting point at the end of the journey?

10. A car is to travel a distance of 225 miles in 4.0 hours. During the first two hours the car travels with an average speed of 52 mph. What must the average speed of the car be during the second two hours in order to arrive at its destination on time?

ANSWERS TO THE OPPOSITE SIDE: 11. 2.0 m/s/s 12. -20.0 mph 13. 0.250 m/s^2 14. -7.00 m/s^2 15. 63 m/s 16. 6.0 mph/s 17a. 0.42 m/s, 1.28 m/s, 2.04 m/s, 2.94 m/s, 3.86 m/s 17b. 8.6 m/s^2, 7.7 m/s^2, 9.0 m/s^2, 9.2 m/s^2 17c. 8.6 m/s^2 17e. +/- 0.06 m/s, +/- 1.2 m/s^2

PHYSICS HOMEWORK #2 KINEMATICS
DISPLACEMENT & VELOCITY

11. The speed of an automobile increases from 18.0 m/s to a speed of 30.0 m/s over a time period of 6.0 seconds. What is the average rate at which the speed of this car is changing during this time period?

12. A car is moving with a speed of 65.0 mph when a squirrel runs into the road in front of your car. The driver then hits the brakes and reduces the speed of the car to 25.0 mph over a time period of 2.00 seconds. What is the average rate at which the speed of the car decreases during this time period?

13. The speed of a cart increases from rest to a speed of 5.25 m/s over a period of 21.0 seconds. What is the average rate of acceleration if this cart?

14. A speedboat is moving through the water at a speed of 28.0 m/s when the engine stalls. As a result the boat comes to a halt in 4.00 seconds. What is the average rate of acceleration for the boat?

15. A race car, moving initially with a speed of 15.0 m/s, is capable of accelerating at a rate of 6.0 m/s^2. What will be the speed of this car after accelerating for a time period of 8.00 seconds?

16. You are driving down the highway at a speed of 25.0 mph when your car accelerates at 55 mph in order to pass another car. What is the average acceleration of this car if this increase in speed occurs over a time period of 5.00 seconds?

17. A tickertape timer is to be used to measure the speed and acceleration of a block of wood dropped out of a second story window. While attached to a piece of tickertape threaded through a timer the following TIME and POSITION data are collected:

TIME (sec)	POSITION (+/- 0.3 cm)	SPEED	ACCELERATION
0.00 sec	0.0 cm		
0.10 sec	4.2 cm	________	________
0.20 sec	17.0 cm	________	________
0.30 sec	37.4 cm	________	________
0.40 sec	66.8 cm	________	________
0.50 sec	105.4 cm	________	

According to the above data;

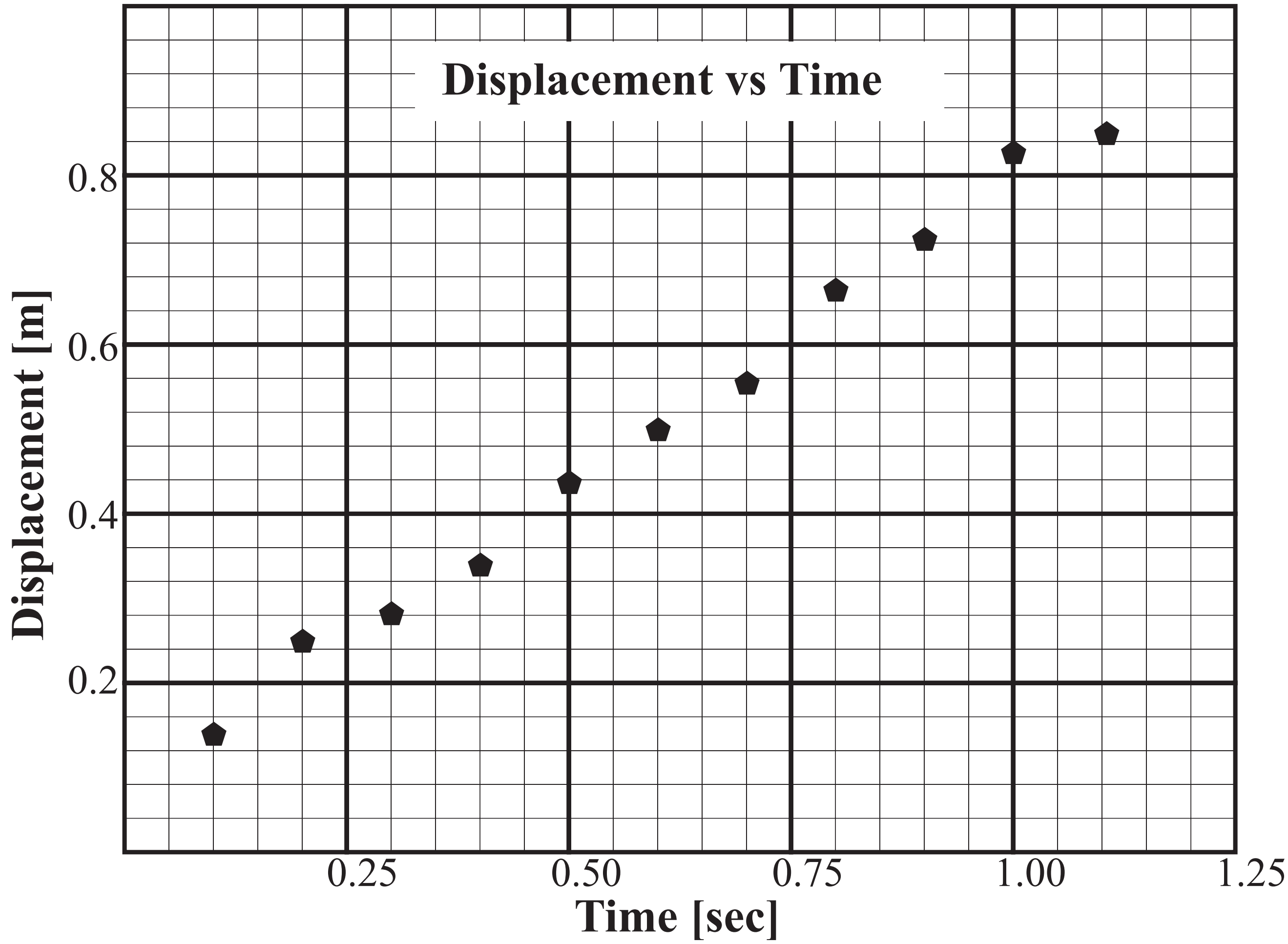
a. Determine the average speed during each of the time intervals above.
b. Determine the average acceleration during each time interval.
c. Determine the average acceleration during the entire 0.5 second time interval.
d. Why are there only 5 answer spaces in the SPEED column of the table above and only 4 spaces in the ACCELERATION column?
e. Based on the error estimates for the measured positions given in the table, what would be reasonable error estimates for the speeds and accelerations?

ANSWERS TO THE OPPOSITE SIDE: 1. 150 steps South 2. 5.0 miles East 3. 40.0 mph
4. 52.8 mph 5. 2.41 m/s 6. 0.44 m/s 7a. 0.56 m/s b. 0.12 m/s c. 0.37 m/s d. 0.07 m/s
7e. maximum error > minimum error 8. 2.5 m/s, +/- 0.30 m/s 9. 308 miles 10. 60.5 mph

PHYSICS HOMEWORK #3 **KINEMATICS**

GRAPHICAL ANALYSIS

The following graph describes the position of an object as a function of time.



Show all work on the paper in detail! Don't leave anything out!

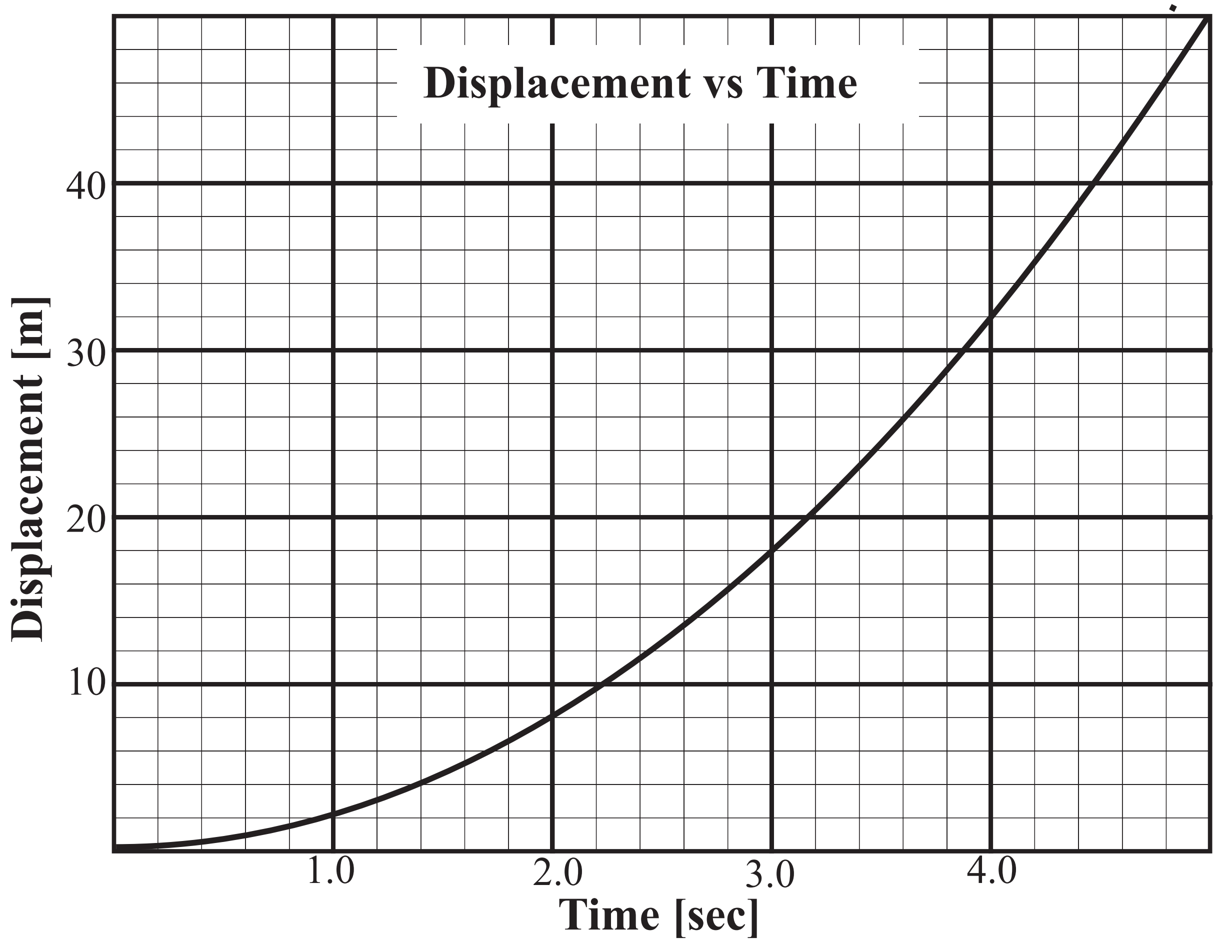
1. On the graph above use a straight edge to draw a BEST FIT line.
2. What is the slope of the line that best fits this set of points?
3. What are the units of the slope of this line?
4. What would be a reasonable estimated error on the slope of this line?
5. What physical quantity does the slope of this line represent?
6. Determine the equation of this line using y = mx + b as your starting point.
7. Test your equation by using it to predict the displacement of the object at 0.4 seconds.
8. Make a bar graph comparing the prediction of your equation with the plotted displacement at 0.4 seconds.
9. Write a one sentence conclusion regarding the ability of your equation to predict the displacement of this object.
10. From your graph determine the average velocity of this object as a function of time.
11. From your graph determine the average acceleration of this object as a function of time.

Answers to the opposite side: 2. ~ 12.5 3. m/sec 4. ~ +/- 0.2 5. speed or velocity

PHYSICS HOMEWORK #4 **KINEMATICS**

GRAPHICAL ANALYSIS

The following graph describes the position of a moving object as a function of time.



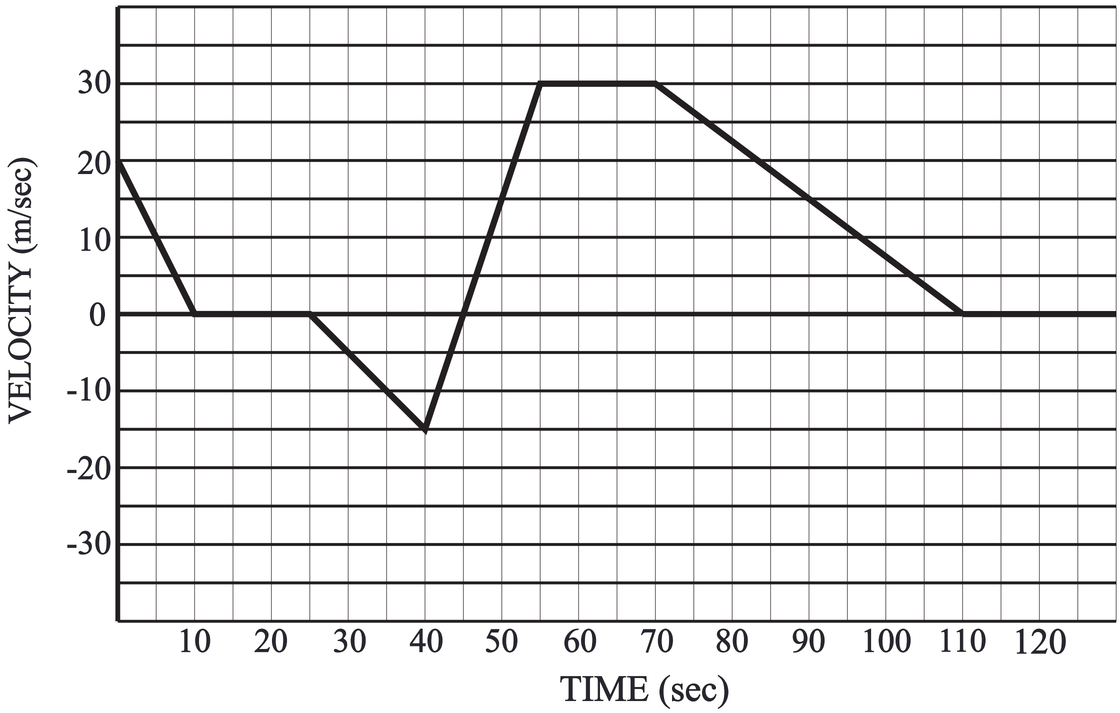
Please show ALL work on the graph above.

1. On the graph above use a straight edge to draw in a straight line tangent to the above curve at 3.0 seconds.
2. What is the slope of the tangent line you have drawn? [Draw in the rise and run where appropriate, indicate the magnitudes of the rise and run and how each was calculated.]
3. What are the units of this tangent line? [Show how you arrived at your answer!]
4. What would be a reasonable estimated error on the slope of this tangent line? [Again show ALL of your work!]
5. What physical quantity is represented by this tangent line? How did you reach this conclusion?

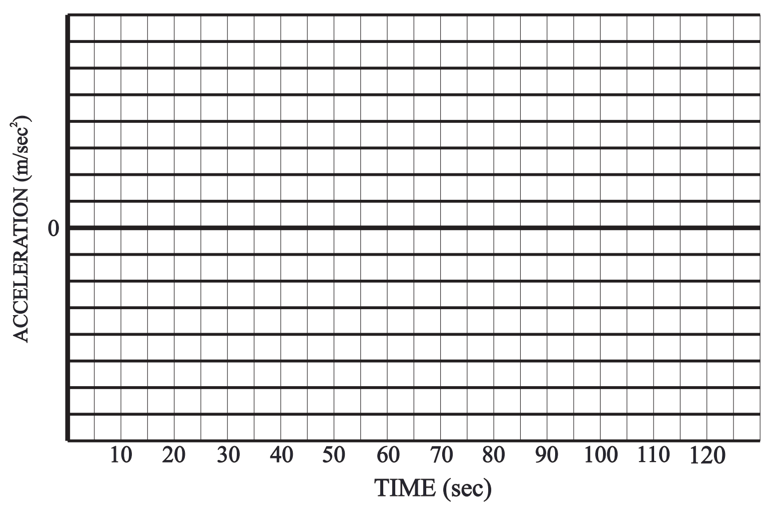
Answers to the opposite side: 2. ~ 0.73 3. m/sec 4. ~ +/- 0.03 5. speed or velocity 6. D = (~ 0.73 +/- 0.03 m/sec)t + 0.07 10. ~ 0.73 m/sec 11. 0.0 m/sec^2 [slope is constant]

PHYSICS HOMEWORK #5 KINEMATICS
GRAPHICAL ANALYSIS

The following graph describes the velocity of an automobile as a function of time.



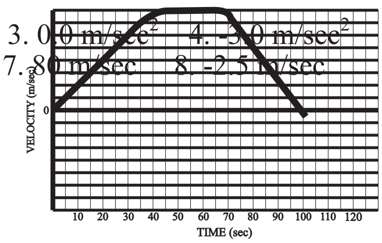
1. What was the velocity of this car when t = 35 seconds?
2. What was the rate of acceleration of this car when t = 20 seconds?
3. What was the rate of acceleration of this car when t = 5 seconds?
4. What was the rate of acceleration of this car when t = 40 seconds?
5. What was the displacement of this car between t = 0 and t = 10 seconds?
6. What was the displacement of this car between t = 10 and t = 25 seconds?
7. What was the displacement of this car between t = 25 and t = 35 seconds?
8. What was the total displacement of this car between t = 0 and t = 110 seconds?
9. What was the total distance traveled by this car between t = 0 and t = 110 seconds?
10. During which time interval/intervals was the car at rest?
11. During which interval/intervals was the car moving in reverse?
12. On the graph at the right sketch the acceleration of this car as a function of time.

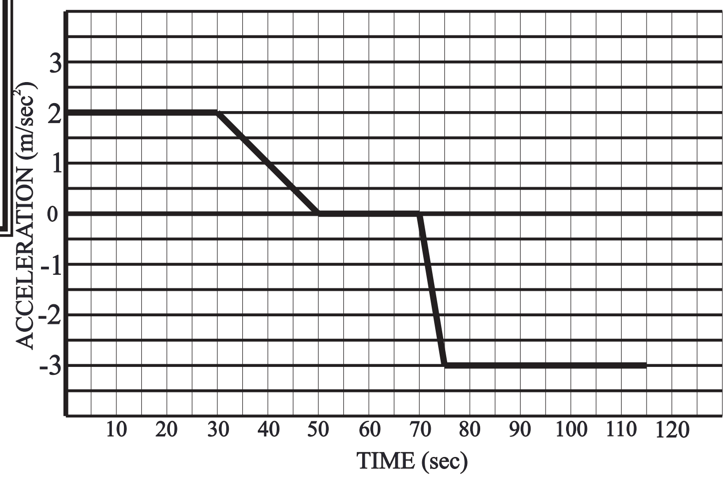


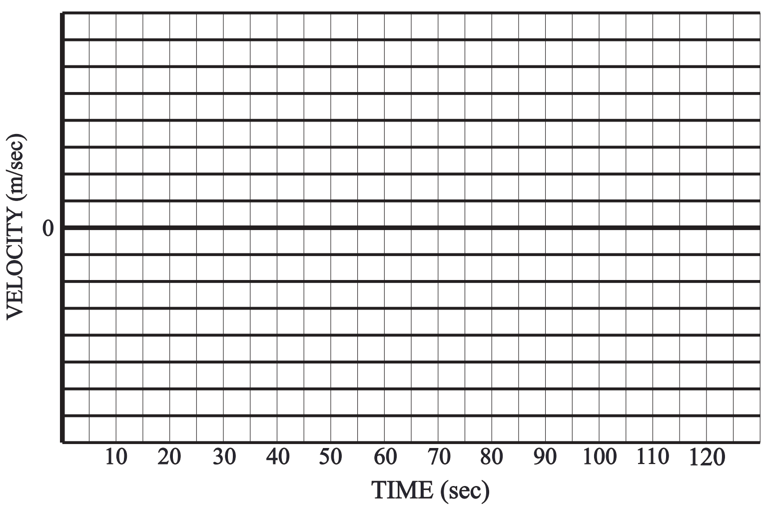
PHYSICS HOMEWORK #6 KINEMATICS
GRAPHICAL ANALYSIS

13. At what times t [other than at t= 0] was the displacement of the car again exactly zero?

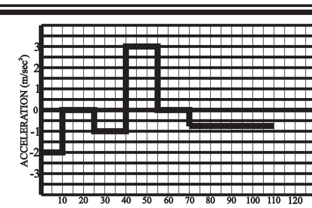
Answers to opposite side:
1. 2.0 m/sec^2 2. 1.0 m/sec^2 3. 0.0 m/sec^2 4. -3.0 m/sec^2
5. 20 m/sec 6. 60 m/sec 7. 80 m/sec 8. -2.5 m/sec
10. 900 m 9. Graph at right







Answers to opposite side: 1. -10.0 m/sec 2. zero 3. -2.0 m/sec^2
4.cannot be determined because this point lies on two different lines with two different slopes! 5. 100 m 6. zero 7. -50 m 8. 1150 m 9. 1450 m
10. between t = 10 s and t = 25 s, at 45 s and at 110 s 11. between t = 25 s and t = 45 s 13. t = ~39 sec & t = ~ 51 sec 12. sketch a vs t to the right



PHYSICS HOMEWORK #7 — KINEMATICS

ACCELERATION

$$D_f = \tfrac{1}{2}at^2 + v_o t + D_o \qquad v_f = at + v_o \qquad D = \bar{v}\,t \qquad \bar{v} = \frac{(v_f + v_o)}{2}$$

The following graph describes the acceleration of an automobile as a function of time. For each of the following questions assume that this car is at rest at t = 0 seconds.

Set up a data table for ALL problems!

D_o = ____
D_f = ____
v_o = ____
v_f = ____
a = ____
t = ____

1. What was the rate of acceleration of this car when t = 10 seconds?
2. What was the rate of acceleration of this car when t = 40 seconds?
3. What was the rate of acceleration of this car when t = 50 seconds?
4. What was the rate of acceleration of this car when t = 85 seconds?
5. What was the velocity of this car when t = 10 seconds?
6. What was the velocity of this car when t = 30 seconds?
7. What was the velocity of this car when t = 50 seconds?
8. What was the velocity of this car when t = 100 seconds?
9. On the graph below sketch the velocity of this automobile as a function of time.
10. What was the total distance traveled by this car between t = 0 and t = 30 seconds?

PHYSICS HOMEWORK #8 KINEMATICS
ACCELERATION

1. A car is at rest on a horizontal surface. The accelerator is applied and the car accelerates at 3.00 m/s^2;
   a. What will be the speed of this car after 6.50 seconds?
   b. What will be the average speed of this car during these 6.50 seconds?
   c. How far will this car move during these 6.50 seconds?

2. Suppose that another car is moving with a speed of 18.5 m/s when the brakes are applied so as to slow the car down at a rate of -2.85 m/s^2;
   a. What will be the speed of this car 3.55 seconds after the brakes are applied?
   b. How far will this car move during this 3.55 second period?
   c. How long will it take for this car to stop?
   d. How far will this car move from the time that the brakes are applied until the car comes to a stop?

3. Suppose that the space shuttle Columbia accelerates at 14.0 m/s^2 for 8.50 minutes after takeoff;
   a. What will be the speed of the shuttle at the end of 8.50 minutes?
   b. How far will the shuttle have traveled during this time?

4. A ball is dropped from the top of a building to the ground below. Assuming that the acceleration of gravity is -9.80 m/s^2 and that it takes 2.87 seconds for this ball to reach the ground;
   a. What will be the speed of this ball as it reaches the ground?
   b. What is the average speed of the ball as it falls to the ground?
   c. How tall is the building?

5. A ball is thrown straight upward with an initial speed of 52.0 m/s;
   a. What will be the speed of this ball when it reaches the highest point? (Think!)
   b. What will be the speed of this ball just as it returns to the ground?
   c. How long will it take for this ball to reach the highest point?
   d. How high will the ball be when it reaches the highest point?
   e. What will be the speed of this ball after 3.85 seconds?
   f. What will be the average speed of this ball during this same 3.85 second period?

6. You are standing on the top of a building 135 meters tall. You throw a ball upward with a velocity of 22.0 m/s. At the exact same moment a friend throws a second ball upward from the ground with a velocity of 46.0 m/s. these two balls then collide at some later time.
   a. How long after these two balls are released will they collide?
   b. Where will these two balls be when they collide?
   c. What will be the velocity of each ball just as they collide?
   d. What will be the relative velocity between these two balls at the moment they collide?

Answers to opposite side: 7a. 11.9 s b. 3.88 s c. 7.03 s, 0.73 s d. -78.6 m/s e. zero
7 f. 314 m g. -20.3 m/s h. 4.12 s i. -78.4 m/s 8. 51.3 m 9a. 1.85 s b. 68.3 m 10. 33.1 m
11. -61.9 m/s 12. -7.4 m/s 13. same speed, -59 m/s 14a. -6.1 m/s^2 b. 82 m
15a. 4.82 s & 23.5 s b. 6.97 m & 166 m c. 4.80 m/sec

PHYSICS HOMEWORK #9 KINEMATICS
VECTOR ADDITION

7. A ball is thrown upward with a speed of 38.0 m/s from the top of a building 240. meters tall;
   a. How long will it take for this ball to reach the ground?
   b. How long will it take for this ball to reach the highest point?
   c. How long after the ball is thrown will the ball be found 265 meters above the ground?
   d. What will be the velocity of this ball as it reaches the ground?
   e. What will be the velocity of this ball at the highest point?
   f. How high above the ground will the ball be when it reaches the highest point?
   g. What will be the average speed of the ball from the time it is thrown until the time it strikes the ground?
   Suppose that instead of throwing this ball upward it is thrown downward with a speed of 38.0 m/s;
   h. How long will it take for the ball to reach the ground?
   i. What will be the speed of the ball as it reaches the ground?

8. A ball is thrown upward from the ground with a speed of 35.5 m/s. 5.25 seconds after the ball is thrown it lands on the roof of a building. What is the height of the building?

9. From the top of a building 85.0 meters tall a ball is dropped. At the same time another ball is thrown upward from the ground with a speed of 46.0 m/s.
   a. How long after the balls are released will they hit?
   b. How high above the ground will these two balls hit?

10. A ball is thrown upward so that it just barely reaches the top of a telephone pole and then falls back to the ground. The time from the release of the ball until its return to the ground is measured to be 5.20 seconds. What is the height of the telephone pole?

11. A ball is thrown downward from the top of a building 122 meters tall with an initial speed of 38.0 m/s. What will be the speed of this ball as it reaches the ground?

12. You are on the top of a building 44.2 meters tall. The adjacent building is 98.1 meters tall. You throw the ball upward so that the ball lands on the roof of the adjacent building 4.15 seconds after the ball is thrown. What will be the speed of this ball when it lands on the roof?

13. You are standing on the top of a building which is 115 meters tall. You throw one ball upward at 35.0 m/s and it lands on the ground some time later. You throw a second ball downward from the same building with a velocity of 35.0 m/s and it also hits the ground at a later time. Which ball will be moving faster when each hits the ground? Support your answer with calculations!

14. You are driving your car down the highway with a speed of 31.5 m/s. You hit the brakes and skid to a halt in 5.2 seconds.
    a. What will be the rate of acceleration of your car?
    b. How far will your car move from the time you apply the brakes until the car stops?

15. You are rushing to the train station to catch your morning commute. The train leaves the train station from rest with an acceleration of 0.600 m/sec^2. You arrive at the station exactly 4.00 seconds after the train leaves and you immediately start running after the train with a constant velocity of 8.50 m/sec.
    a. How long after the train leaves the station do you catch up with the train?
    b. How far from the train station do you catch up with the train?
    c. With what minimum speed would you have to run in order to catch up with the train?

Answers to opposite side: 1a. 19.5 m/s b. 9.75 m/s c. 63.4 m/s 2a. 8.38 m/s
2b. 47.7 m c. 6.49 s d. 60.0 m 3a. 7140 m/s b. 1820 km 4a. -28.1 m/s b. -14.1 m/s
4c. 40.4 m 5a. zero b. -52.0 m/s c. 5.31 s d. 138 m e. 14.3 m/s f. 33.1 m/s
6a. 5.63 sec b. 104 meters c. v_1 = -33.1 m/sec, v_2 = -9.1 m/sec d. 24 m/s

PHYSICS HOMEWORK #10 KINEMATICS

VECTOR ADDITION

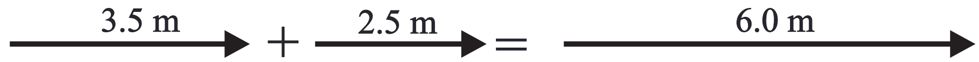
If two vectors are parallel, the sum of two vectors can easily be determined by just adding or subtracting the magnitudes of the two vectors. [Note! A vector, which is a directed line segment, can be used to represent any physical quantity which requires both direction and magnitude for a complete description.]

Examples:

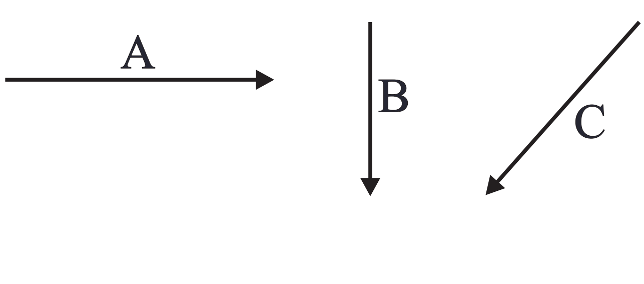
a. 3.0 miles North + 2.0 miles North = 5.0 miles North

b. 8.0 miles East + 5.0 miles West = 3.0 miles East

c.

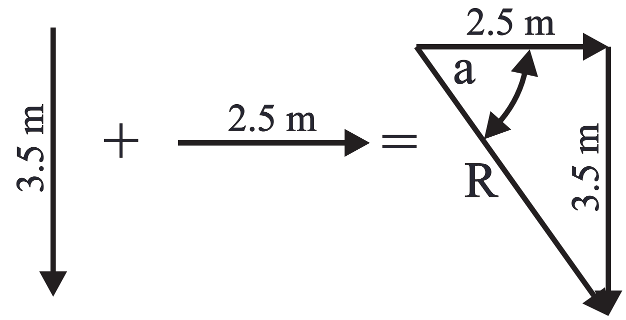


d.



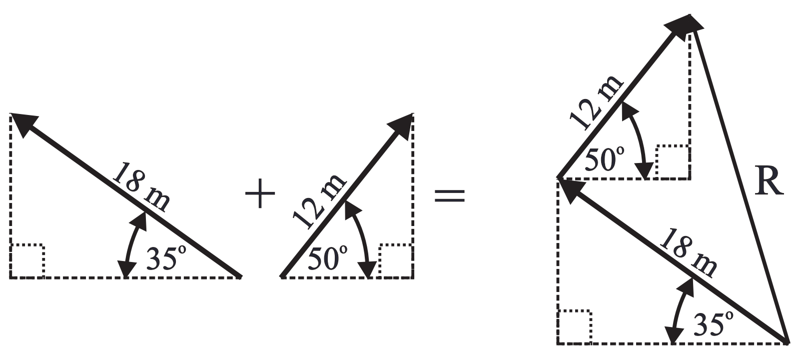
PHYSICS HOMEWORK #11 — KINEMATICS DISPLACEMENT & VELOCITY

If two vectors are perpendicular then they can be added together by using the Pythagorean Theorem in combination with the inverse tangent [$\tan^{-1}$] function



$$R = \sqrt{2.5^2 + 3.5^2} = 4.3m$$
$$\tan\alpha = 3.5 / 2.5 = 1.4$$
$$\tan^{-1}(1.4) = 54.5^o$$
$$R = 4.3m \text{ at } 54.5^o \text{ SE}$$
$$(\text{or } 35.5^o \text{ ES or } 305.5^o)$$

If the two vectors to be added are neither parallel nor perpendicular then each vector must first be broken up into vector components that are either parallel or perpendicular. For example;

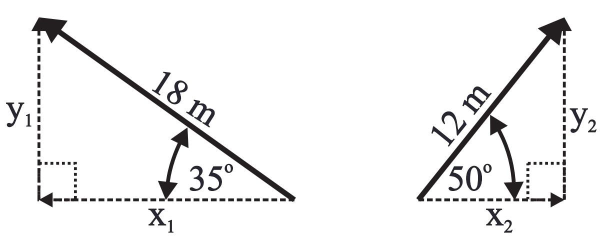


The resultant R goes from the tail of the first vector to the tip of the last vector, as shown.

Note how these two vectors have been connected together "TIP TO TAIL"!

The first quantitative step in adding these two vectors together is to break each vector into components that are either parallel or perpendicular to the x and y axes.The resultant R goes from the tail of the first vector to the tip of the last vector as shown.

Be

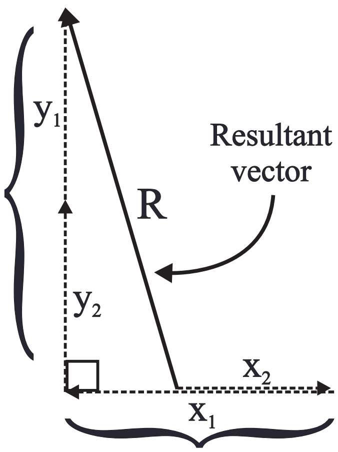


x_1 = 18 cos 35° = -14.7 i **x_2 = 12 cos 50° = 7.71 i**
y_1 = 18 sin 35° = 10.3 j **y_2 = 12 sin 50° = 9.19 j**

After these two vectors have been broken into components then these components must be added together. Since all i vectors are in the same direction [parallel to the x axis] they can be added together just like scalars as shown in parts a-d. Likewise, all j vectors are in the same direction [parallel to the y axis], and can therefore be added together arithmetically.

y_1 = 18 sin 35° = 10.3 j	**x_2 = 12 cos 50° = -14.7 i**
+ y_2 = 12 sin 50° = 9.19 j	**+ x_2 = 12 cos 50° = 7.71 i**
19.5 j	**-7.0 i**

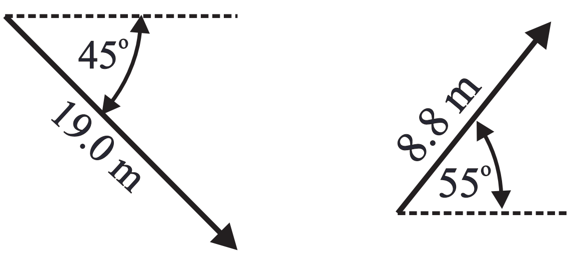
These two components can then be added together using the pythagorean theorem to find the resultant!



$$R = \sqrt{19.5^2 + 7.0^2} = 20.7\ m$$
$$\tan\beta = 19.5 / 7.0 = 2.79$$
$$\tan^{-1}(2.79) = 70.3^0$$
and therefore the final answer is
$$R = 21\ m\ at\ 70^o\ NW$$
$$(or\ 20^o\ WN\ or\ 110^o)$$

Note that since the resultant is a vector the final answer has both a magnitude [how long is the vector] and a direction [what is the angle]! **BOTH** are required for full credit in any vector problem!

Determine the resultant of the following two vectors! Organize and show your work **carefully and completely**!



Answer: 19.5 m at 18.5° SE

Sketch the resultant of the following three vectors! Be sure to indicate the direction of each vector with an arrow head and label the resultant vector **R**!

PHYSICS HOMEWORK #11 KINEMATICS
TWO DIMENSIONAL KINEMATICS

[Remember that ALL vectors must be described by BOTH <u>magnitude</u> and <u>direction</u>!]

1. You walk 250. steps North and then 400. steps East. What is your displacement? (**Distance and direction** from the starting point!)

2. An automobile goes 45.0 miles West, then 45.0 miles North, and finally 15.0 miles East. What is the final displacement of the car?

3. Your car is heading North on Route 9 with a velocity of 45.0 mph. A second car is also heading North but with a velocity of 60.0 mph. What is the velocity of the second car relative to your car?

4. One car is heading West on I_80 with a velocity of 75 km/hr while another car is heading East at 92 km/hr. What is the velocity of the second car relative to the first car?

5. You are on a railroad passenger train and you are walking toward the front of the train with a velocity of 6.00 mph relative to the passenger car in which you are riding. At the same time the train itself is moving down the tracks at 37.0 mph. What is your velocity as measured by observer at rest along the railroad tracks?

6. A boat, which has a speed of 12.0 mph while traveling in still water, heads directly down a river, which has a current of 7.00 mph. What will be the speed of this boat relative to an observer standing along the banks of the river?

7. The same boat in #6 turns around and heads back upstream. What will the speed of this boat now be as measured by an observer standing along the banks of the river?

8. Suppose that this boat is now aimed directly across the river. What will be the velocity of this boat (speed **and** direction!) as measured by an observer standing along the banks of the river?

9. An airplane, which has an airspeed of 235 mph, heads directly West. The wind, in turn, is blowing due South with a velocity of 45.0 mph. What will be the velocity of this airplane as measured by an observer on the ground?

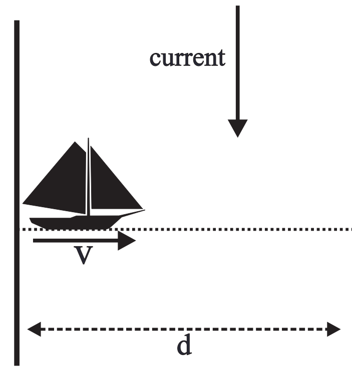
10. An airplane, which has an airspeed of 575 km/hr, heads directly East. The wind is blowing with a velocity of 82.0 km/hr on a heading of 35.0^o West of South. What will be the resulting velocity of this airplane as measured from the ground?

11. A boat, which has a speed of 13.0 m/s in still water, heads down a river which has a current of 4.00 m/s;
    a. How long will it take for the boat to reach a point 220. meters downstream?
    This boat then reverses direction and returns to the point of origin.
    b. How long will it take to return to the starting point?

Answers to opposite side: 12a. 13.9 m/s at 30.3^o downstream b.40.0 s c. 280. m
12d. 556 m at 30.3^o downstream 13a. 22.9^o upstream b. 66.3 s 14. 347 mph at 19.7^o SW
15. 479 mph at 7.79^o NW 16. 935 km/hr at 26.2^o EN 17. 711 m at 24.0^o downstream
18. 421 km/hr at 41.5^o SW 19. 519 mph at 43.9^o NE

PHYSICS HOMEWORK #12 KINEMATICS
TWO DIMENSIONAL KINEMATICS

12. A boat, which has a speed of $v = 12.0$ m/s in still water, heads directly across a river which has a current of 7.00 m/s and is $d = 480.$ meters wide;
   a. What will be the velocity of this boat as measured by an observer standing along the shore?
   b. How long will it take for this boat to reach the opposite shore?
   c. How far downstream will this boat reach the opposite shore?
   d. What will be the final displacement of the boat when it reaches the opposite shore?



13. A boat, which has a speed of 9.00 m/s in still water, would like to reach a point on the shore directly across a river. The river has a current of 3.50 m/s and the river is 550. meters wide;
   a. In what direction should the boat be aimed in order for the boat to head directly across the river?
   b. How long will it take the boat to reach the opposite shore?

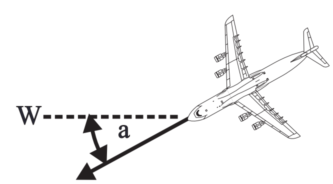
14. An airplane has an airspeed of 435 mph and has a heading of 25.0° SW. The wind is blowing with a speed of 95.0 mph on a heading of 45.0° NE. What will be the velocity of this airplane as measured from the ground?

15. In order for an airliner to arrive at its destination on time it must travel due West with a velocity of 475 mph. However, the wind is blowing due South with a velocity of 65.0 mph. What should the airspeed and heading of this airplane be in order for this airplane to arrive at its destination on time?

16. In order for an airplane to arrive at its destination on time it must fly with a velocity of 985 km/hr and a heading of 35.0° East of North. However, the wind is blowing with a velocity of 155 km/hr on a heading of 12.0° South of East. With what velocity should the airplane fly in order to arrive at its destination on time?

17. A boat heads directly across a stream, which has a current of 4.00 m/s and which is 650. meters wide. The boat has a speed of 9.00 m/s when it travels in still water. What will be the displacement of this boat when it reaches the opposite shore?

18. An airplane heads $\alpha = 35.0^{\circ}$ SW, as shown to the right, with an airspeed of 370.0 km/hr while the wind is blowing 68.0 km/hr at 80.0° SW. What will be the velocity of this airplane as measured from the ground?



19. In order for a jetliner to arrive at its destination on time it must fly with a velocity of 555 mph on a heading of 38.0° NE. The wind, however, is blowing with a velocity of 65.2 mph on a heading of 15.8° SE. What should the velocity of this jet be in order for it to arrive at its destination on time?

Answers to opposite side: 1. 472 steps at 32.0° NE 2. 54.1 miles at 56.3° NW 3. 15 mph
4. -167 km/hr 5. 43.0 mph 6. 19 mph downstream 7. 5 mph upstream
8. 13.9 mph at 30.3° downstream 9. 239 mph at 10.8° SW 10. 532 km/hr at 7.25° SE
11a. 12.9 sec b. 24.4 sec

PHYSICS HOMEWORK #13 KINEMATICS
TWO DIMENSIONAL PROJECTILES

[Remember that ALL vectors must be described by BOTH magnitude and direction!]

1. A ball, which has a mass of 3.35 kg., is thrown straight up from the ground with an initial velocity of 55.0 m/s;
   a. How long will it take for this ball to reach the highest point?
   b. How high above the ground will this ball be when it reaches the highest point?
   c. What will be the velocity of this ball when it reaches the ground again?

2. A marble, which has a mass of 24 grams, is dropped from a height of 94 cm. How long will it take for this marble to reach the floor?

3. A marble is rolling along a horizontal tabletop, which is 94.0 cm above the floor, when the marble reaches the edge of the table and then falls to the floor. How long will it take for the marble to strike the floor?

4. A rifle bullet, which has a mass of 57.0 grams, is fired horizontally from a rifle which is held 94.0 cm above the floor, with a velocity of 385 m/s. How long will it take for the bullet to strike the floor?

5. A marble is fired horizontally from a launching device attached to the edge of a tabletop which is 94.0 cm above the floor. The marble then strikes the floor 2.35 meters from the edge of the table.
   a. How long will it take for the marble to reach the floor?
   b. What is the initial velocity of the marble as it leaves the launching device?
   c. What will be the horizontal velocity of the marble as it reaches the floor?
   d. What will be the vertical velocity of the marble as it reaches the floor?
   e. What will be the direction and magnitude of the velocity of the marble as it reaches the floor?

6. A projectile is fired from the ground with a velocity of 96.0 m/s at an angle of 35.0^{O} above the horizontal;
   a. What will be the vertical and horizontal components of the initial velocity of this projectile?
   b. How long will it take for this projectile to reach the highest point of its trajectory?
   c. How long will this projectile be in the air?
   d. What will be the velocity of this projectile at the highest point?
   e. What will be the velocity of this projectile as it again reaches the ground?
   f. How high will this projectile be at the highest point of its trajectory?
   g. What will be the range [the horizontal displacement] of this projectile?

Remember to set up TWO data tables, one for the vertical and

7. A projectile, which has a mass of 5.5 kg., is fired from the ground with a an initial velocity of 169 m/s at an angle of 23.0^{O} above the horizontal;
   a. What will be the velocity of this projectile at the highest point of its trajectory?
   b. What will be the total flight time of this projectile?
   c. What will be the height of this projectile at the highest point of its trajectory?
   d. What will be the range of this projectile?
   e. What will be the vertical velocity of this projectile 3.50 seconds after it has been fired?
   f. What will be the horizontal velocity of this projectile 3.50 seconds after it has been fired?
   g. What will be the direction and magnitude of the projectile's velocity 3.50 seconds after it has been fired?
   h. What will be the height of this projectile 3.50 seconds after it has been fired?
   i. How far downrange will the projectile be 3.50 seconds after it has been fired?
   j. What will be the final displacement of the projectile 3.50 seconds after the projectile has been fired?

Answers to opposite side: 8. 40.0 s b. 1960 m c. 8280 m d. 221 m/s at 21.0^{o} down
8e. 6030 m at 16^{o} upward f. 29.7 s & 10.3 s g. 207 m/s 9a. 20.3 s b. 8440 m
9c. 430 m/s at 14.8^{o} downward 10. 9090 m 11a. 2.1 s b. 75 m c. 8.3 m 12a. 0.43 s
12b. 3.8 ft c. 3.0 ft 13a. 60.6 ft 13b. 2.04 s

PHYSICS HOMEWORK #14 KINEMATICS
TWO DIMENSIONAL PROJECTILES

8. A projectile is fired from the ground with an initial velocity of 285 m/sat an angle of 43.5^{O} above the horizontal;
   a. How long will this projectile be in the air?
   b. How high will this projectile be at the highest point of its trajectory?
   c. What will be the range of this projectile?
   d. What will be the velocity of this projectile 28.0 seconds after it has been fired?
   e. What will be the displacement of the projectile 28.0 seconds after it has been fired?
   f. When will this projectile be 1500 meters above the ground?
   g. What will be the velocity of this projectile at the highest point of its trajectory?

Remember to set up TWO data tables, one for the vertical and

9. A rifle is fired from the top of a building 220 meters high with an initial velocity of 425 m/s at an angle of 12.0^{O} above the horizontal;
   a. How long will it take for the bullet to reach the ground?
   b. How far from the base of the building will the bullet strike the ground?
   c. What will be the velocity of the bullet just as it reaches the ground?

10. A Spanish Galleon enters a harbor defended by cannon placed on top of a castle wall which is 135 meters above the water level. The cannon have a known muzzle velocity of 323 m/s and are aimed 28.0^{O} above the horizontal. How far from the base of the castle wall will the Galleon be within the range of the cannon?

11. A motor cycle is moving with a velocity of 36.0 m/s when it encounters a ramp which is 22.0 meters long and meets the horizontal at an angle of 13.0^{O}. The motorcycle goes up the incline without losing speed and flies off the end of the incline;
   a. How long after the motorcycle leaves the end of the ramp will the motorcycle land on the ground?
   b. How far from the end of the ramp will the motorcycle land on the ground?
   c. How high above the ground will the motorcycle be at its highest point?

12. Suppose that a baseball is thrown horizontally from a pitcher's mound, which is 1.50 feet above the ground level, to home plate located 60.0 feet away. The ball is released from the pitchers hand with a velocity of 139 feet/second when the pitcher's hand is 5.30 feet above the mound. Ignoring the effects of air friction and given that the acceleration of gravity is g = -32.2 feet/second^2;
   a. How long will it take for the ball to reach home plate?
   b. What will be the height of the ball above the ground when it reaches home plate?
   c. How far did the ball drop on its way to home plate?

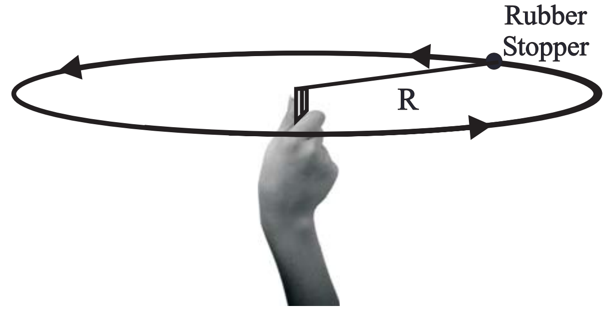
13. Suppose that a shotputter throws a 16 pound shot with a velocity of 43 ft/s at an angle of 45^{O}. At the time the shot is released the shotputter's hand is 6.5 feet above the ground.
   a. What will be the final horizontal displacement of this shot? [World men's record 74 ft 4¼ in 1989, women's record 73 ft 10 in 1977]
   b. How long will it take for this shotput to strike the ground?

Answers to opposite side: 1. 5.61 s b. 154 m c. -55.0 m/s 2. 0.44 s 3. 0.44 s 4. 0.44 s 5a. 0.44 s b 5.3 m/s c. 5.3 m/s d. -4.3 m/s e. 6.8 m/s at 39^{O} downward 6a. 55 m/s, 79 m/s 6b. 5.60 s c. 11.2 s d. 79 m/s e. 96 m/s at 35^{O} downward f. 154 m g. 887 m 7a. 156 m/s 7b. 13.5 s c. 222 m d. 2100 m e. 31.7 m/s f. 156 m/s g. 159 m/s at 11.5^{O} up h. 171 m 7i. 545 m j. 571 m at 17.4^{O} upward

PHYSICS HOMEWORK #15

KINEMATICS
CENTRIPETAL ACCELERATION

1. You are spinning a rubber stopper over your head as shown in the diagram at the right. The rubber stopper has a mass m and is moving in a circle which has a radius R.



   a. In what direction must you apply force to the string in order to keep the stopper moving in a circular path?

   b. What will happen to the stopper if you let go of the string? Describe precisely!

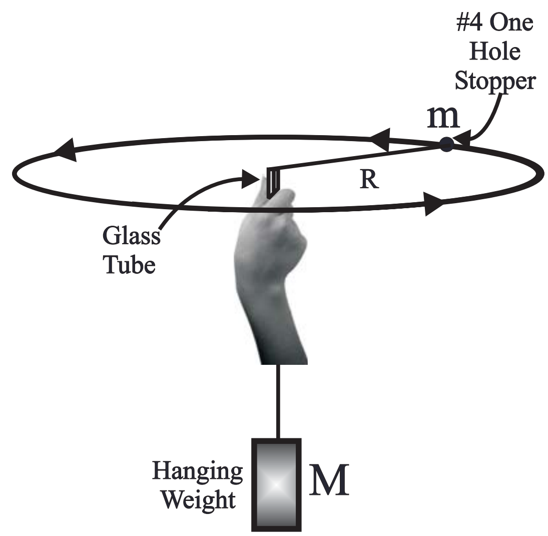
   c. What is the direction of the force acting on the stopper to keep the stopper moving in a circular path?

   d. How would the force being applied to the string by your hand be different if you were to spin the stopper faster?

   e. How would the force being applied to the string by your hand be different if you were to spin the stopper at the same speed, but if you significantly increased the mass of the stopper?

   f. How would the force being applied to the string by your hand be different if you were to spin the stopper in a larger radius circle?

2. You are spinning a rubber stopper over your head as shown in the diagram at the right. The rubber stopper has a mass of 18.5 grams and is moving in a circle which has a radius of R = 110 cm. You measure that the rubber stopper moves 10 times around your head every 9.0 seconds.



   a. What is the distance once around this circular path?

   b. What is the distance 10 times around this circular path?

   c. What is the average speed of this rubber stopper as it circles above your head?

   d. What is the direction of the centripetal acceleration of the stopper as it circles above your head? Show the direction on the diagram with a clearly labeled vector.

   e. What is the magnitude of the centripetal acceleration of the stopper as it circles over your head?

   f. What is the direction of the velocity of this stopper when in the position shown in the diagram? Show the direction on the diagram with a clearly labeled vector.

   g. How much force would be required to keep this stopper moving in the given circular path?

   h. How much mass M must be hung on the lower end of the string to keep the stopper moving in the given circular path?

Answers to opposite side: 3. 15.0 m/s^2 4. 4.98 m/s^2 5a. 7.23 m/s b. 12.4 m/s^2 6a. 13.6 m/s^2 b. towards center, left 6c. 1.84 N d. towards center, left e. in a straight line towards top of the page 7a. q = k b. $V \propto q$ c. $F \propto 1/r$ d. $T \propto$ ‡L

3. A ball, whose mass is 0.650 kg, is moving in a circular path. The radius is 1.35 meters and the linear speed is 4.50 m/sec. What is the magnitude of the centripetal acceleration of this ball?

4. A car, whose mass is 1200 kg is moving with a speed of 18.0 m/sec as it passes through a curve in the road whose radius of curvature is 65.0 meters. What is the magnitude of the centripetal acceleration of the car?

5. There is an amusement park ride called the "ROTOR" where you enter a cylindrical room. room begins to spin very fast until at some point the floor beneath you "falls out". Suppose that this room has a radius of 4.20 meters and the room rotates such the you make one complete revolution in 3.65 seconds.
   a. What will be your linear speed as the room spins?

   b. What is the magnitude of your centripetal acceleration?

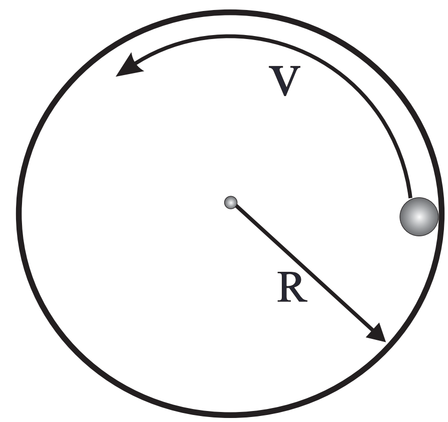
6. Consider a roulette wheel as shown to the right. The radius of the wheel is R = 0.850 meters. A ball whose mass is m = 135 grams is thrown into the roulette wheel after which it rotates counter-clockwise with a speed of v = 3.40 m/sec.
   a. What will be the magnitude of the centripetal acceleration of this ball?

   b. What will be the direction of the centripetal acceleration of this ball while in the position shown?

   c. What will be the magnitude of the centripetal force acting on this ball?

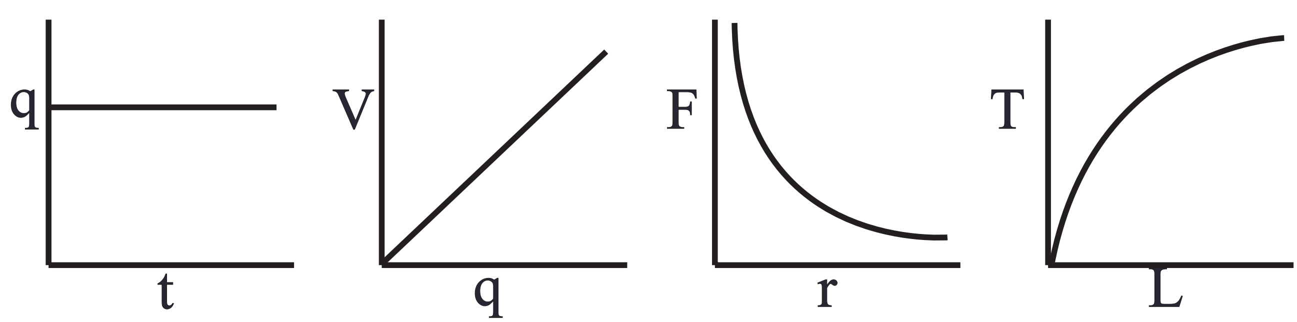
   d. What will be the direction of the centripetal force acting on this ball?

   e. Suppose that this ball escaped from the roulette wheel while in the position shown, what will be the direction of the motion of the ball as it exits the wheel?



7. For each of the following graphs indicate the most likely relationship between the plotted variables.

a. b. c. d.



Answers to opposite side: 1a. toward your hand b. it moves off in a straight line c. toward your hand d. you would need more force 1e. you would need more force f. you would need less force 2a. 6.9 m b. 69.1 m 2c. 7.68 m/sec d. toward your hand e. 53.6 m/sec^2 f. straight ahead [up and to the left] g. 0.992 N h. 101 gm

PHYSICS HOMEWORK #21 NEWTON'S LAWS

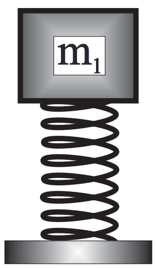
FIRST LAW OF MOTION

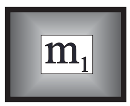
Newton's First Law of Motion

In the absence of an unbalanced, external force the velocity of an object remains constant!

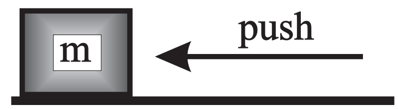
1. For each of the following, complete the free body diagram showing all of the forces acting on the mass M. Be sure to show the direction of each force as an arrow and label each force clearly! [For example; T, F_N, F_f, F_g, F_a, F_s etc.]

a.

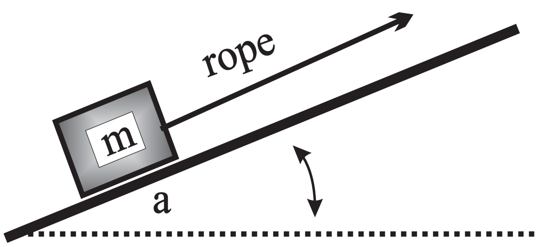


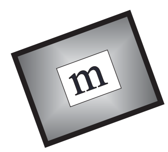


b.

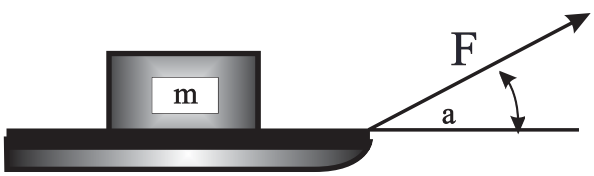


c.



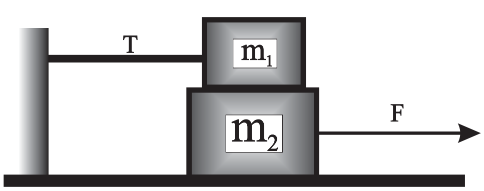


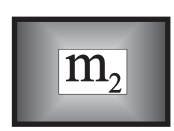
d.



e.

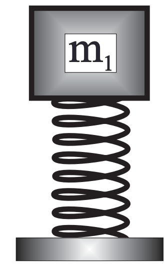
f.

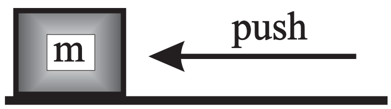


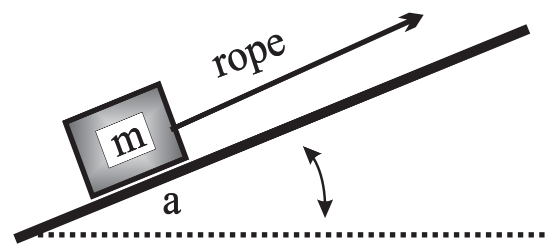


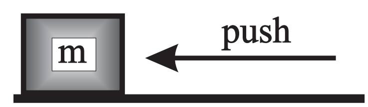
Answers to opposite side #2: 2a. 39.2 N 2b. 39.2 N 3. 539 N 4b. 539 N 4c. 539 N 4d. 85.0 N 5b. 361 N 5c. 253 N 6a. 49.0 N 6b. 49 N 6c. 8.0 N 7a. 16.4 N 7b. 7.32 N 8b. 277 N 8c. 147 N

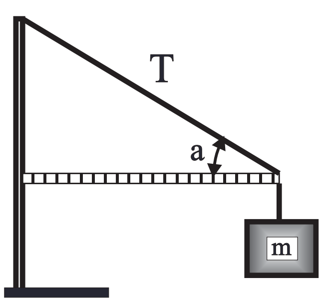
FIRST LAW OF MOTION

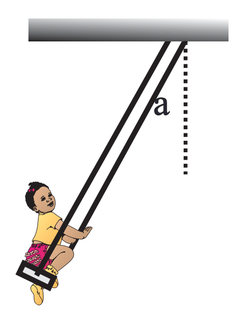






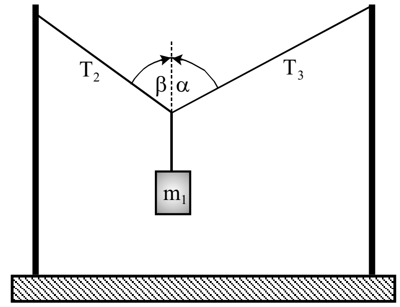


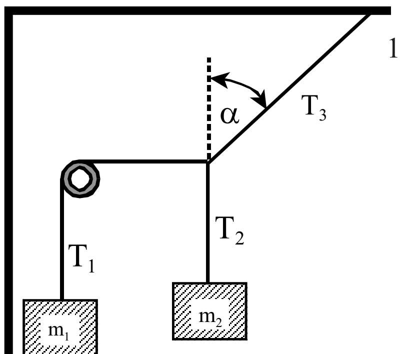




FIRST LAW OF MOTION

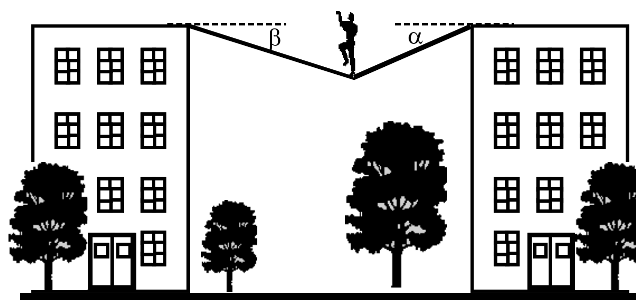
9. A string is tied between two support points as shown to the right. A mass of $m_1 = 3.80$ kg is hung from the string as shown. As a result the string makes an angle of $\alpha = 52.0^o$ and $\beta = 41.0^o$. What will be the tensions, T_2 and T_3, in the string?

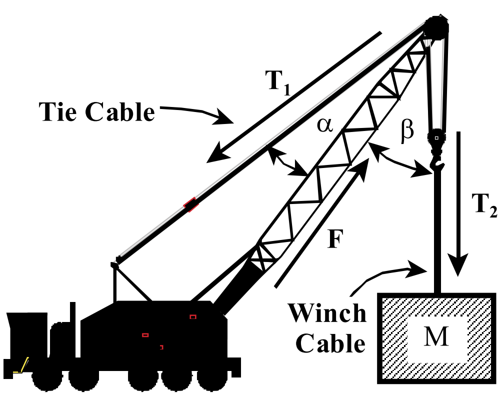




10. A string is tied to a hook in the ceiling. A mass of $m_2 = 6.00$ kg is hung from the end of this string such that the mass hangs from the ceiling. A second string is tied to the first string at a point. This second string is then threaded through a pulley as shown to the left and a second mass of $m_1 = 2.50$ kg is suspended from it.
    a. What will be the tensions in each of the three segments of string?
    b. What is the angle α shown in the diagram?

11. A tightrope walker, who has a mass of m = 65.0 kg., is walking along a tightrope stretched between two buildings. The walker is standing part way across the rope as shown. The angle between the rope and the roof of the left building is $\beta = 19.0^o$ while the angle between the rope and the roof of the right building is $\alpha = 28.0^o$. What will be the tensions T_1 and T_2 in each half of the rope?





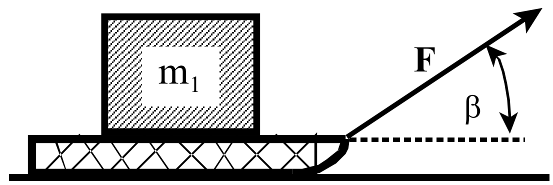
12. Consider a large crane which is being used to lift a heavy load of M = 18,000 kg. To the top of cabin of the crane there is attached a steel cable T_1 which is connected to the end of the boom. The angle between cable T_1 and the boom is $\alpha = 25.0^o$. A second cable T_2 has one end attached to the load while the other end of the cable is attached to a winch at the base of the cabin after passing over a large pulley at the upper end of the boom. The angle between cable T_2 and the boom is $\beta = 56.0^o$. The mass M is being lifted upward at a constant speed.
    a. What will be the tension T_2 in the cable lifting the load?
    b. What will be the tension T_1 in the tie cable?
    c. What will be the magnitude of the thrust force **F** being exerted by the boom?

Answers to opposite side: 13b. 275 N 13c. 226 N 13d. 115 N 14a. 49 N 14b. 23 N 14c. 0.59 14d. 0.47 15. 0.24 16. 223 N 17a. 221 N 17b. 194 N 17c. 171 N 18. 8830 N 19a. 63.2 N 19b. 408 N 19c. 71.6 N

PHYSICS HOMEWORK #24 NEWTON'S LAWS

FORCE OF FRICTION

13. A rope is being used to pull a sled along a horizontal surface at a constant speed with an applied force of F = 125 N as shown to the right. The sled, including the load, has a mass of m_1 = 28.0 kg. The angle between the rope and the horizontal is $\beta = 23.0^o$ as shown.



   a. Complete the free body diagram showing all the forces acting on the sled as it is pulled along this horizontal surface at a constant speed.
   b. What is the magnitude of the gravitational force acting on this sled as it is pulled to the right at a constant speed?
   c. What will be the magnitude of the normal force acting on this sled as it is pulled to the right at a constant speed?
   d. What will be the magnitude of the frictional force acting on the sled as it is pulled to the right at a constant speed?

14. A block of wood, which has a mass of m = 5.00 kg., is at rest on a horizontal surface. A spring scale is attached to a hook on the end of the block. The spring scale is slowly pulled until the block just begins to move. At this point the reading on the scale is 29.0 N. After the block starts sliding the reading on the scale drops back to 23.0 N.
   a. What is the magnitude of the normal force acting on this block?
   b. What is the magnitude of the frictional force on this block as it slides along the surface at a constant speed?
   c. What is the coefficient of static friction μ_s between the block of wood and the horizontal surface?
   d. What is the coefficient of kinetic friction μ_k between the block of wood and the horizontal surface?

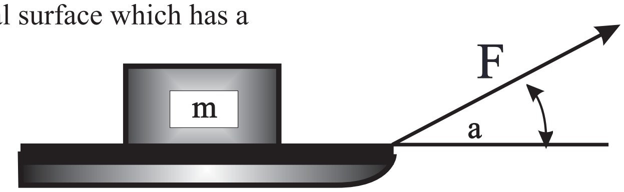
15. A 4.00 kg mass is sitting at rest on a horizontal surface. A horizontal force of 9.30 Newtons is needed to start this mass sliding across the surface. What is the coefficient of static friction μ_s between the mass and the surface of the table?

16. A 35.0 kg crate is sitting on a horizontal surface where the coefficient of sliding friction is μ_k =0.650. How much force must be applied to this crate in order to slide the crate across the surface at a constant speed?

17. A sled, which has a mass of m = 22.5 kg., is sitting on a concrete driveway. The coefficient of static friction between the sled and the driveway is μ_s =0.880 while the coefficient of kinetic friction is μ_k = 0.775.
   a. What will be the normal force acting on his sled?
   b. How much horizontal force must be applied to this sled in order to start it sliding across the driveway?
   c. How much horizontal force must be applied to keep this sled in motion along the driveway at a constant speed?

18. A car, which has a mass of 1250 kg., is moving along an icy highway at a speed of 35.0 mph. The coefficient of kinetic friction between the tires of the car and the road is μ_k = 0.720. The driver applies the brakes so as to lock the wheels. How much frictional force is available to bring the car to a halt?

19. A sled, which has a mass of m = 45.0 kg., is sitting on an icy horizontal surface which has a coefficient of kinetic friction of μ_1 = 0.155. A rope is attached to the front end of the sled such that the angle between the rope and the horizontal is $\alpha = 28.0^o$ and a force F is applied to the rope so as to pull the sled along the horizontal surface at a constant speed.

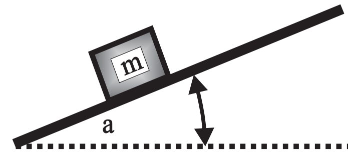


   a. What is the magnitude of the frictional force F_f acting on this sled?
   b. What is the magnitude of the normal force F_N acting on the sled?
   c. What is the magnitude of the force F applied to the rope of the sled?

Answers to opposite side: 9. 29.4 N, 24.5 N 10a. 24.5 N, 58.8 N, 63.7 N 10b. 22^o
11. 824 N, 769 N 12a. 176,000 N 12b. 346,000 N 12c. 412,000 N

PHYSICS HOMEWORK #25 NEWTON'S LAWS
FIRST LAW & FRICTION

20. A crate, which has a mass of 65.0 kg., is sitting at rest on an inclined plane as shown to the right. The angle between the incline and the horizontal is $\alpha = 13.0^o$.



a. Complete the free body diagram showing all the forces acting on the crate.
b. What is the magnitude of the normal force acting on this crate?
c. What is the magnitude of the frictional force acting on this crate?

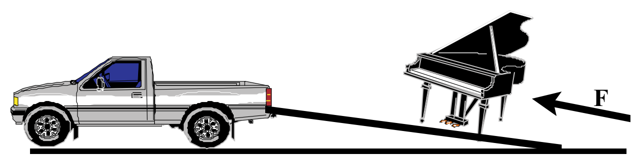
The end of the incline is slowly lifted until the crate begins to slide down the incline at a constant speed. At this point the angle between the incline and the horizontal is $\alpha = 34.0^o$.

d. What is the coefficient of static friction between the crate and the surface of the incline?

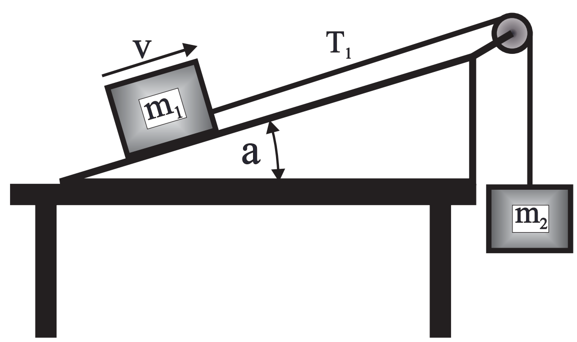
21. A sled, which has a mass of m = 125 kg., is sitting on an icy horizontal surface. A rope is attached to the front end of the sled such that the angle between the rope and the horizontal is $\alpha = 33.0^o$ and a force of 95.0 N is applied to the rope. As a result the sled moves along the horizontal surface with a constant speed.

a. Complete the free body diagram showing all the forces acting on the sled.
b. What is the magnitude of the frictional force acting on this sled?
c. What is the magnitude of the normal force acting on the sled?
d. What is the coefficient of sliding friction between the sled and the icy horizontal surface?

22. You would like to push a piano, which has a weight of 550 lbs, onto the bed of a truck which has a height of 3.5 ft above the road surface. You have available a long inclined plane which is 15.0 ft long and which has a coefficient of rolling friction of $\mu_r = 0.220$. How much force F would you have to apply to roll the piano up the incline and onto the truck bed?



23. A mass of $m_1 = 6.00$ kg is sitting on an inclined plane, which meets the horizontal at an angle of $\alpha = 22.0^o$, as shown to the right. A string is attached to mass m_1, which is strung over a pulley, and is then attached to a second mass $m_2 = 4.00$ kg. A slight push is given to m1 and as a result m_1 slides up the incline at a constant speed v.

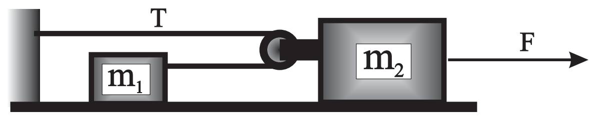


a. What is the magnitude of the tension T_1 in the string connecting the two masses?
b. What will be the coefficient of sliding friction m_k between mass m_1 and the surface of the incline?

Answers to opposite side #26:	24a. 143 N	24b. 40.8 N	25a. 0.683	25b. 46.9 N	
26a. 14.9 N	26b. 64.9 N	27. 14.1 N	28. 809 N	29a. 1180 N	29b. 50,400 N

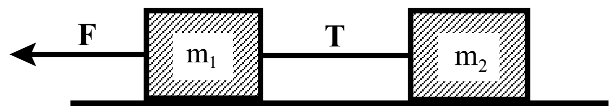
FIRST LAW & FRICTION

24. Two masses are sitting on a horizontal surface as shown to the right. The coefficient of sliding friction between these two masses and the horizontal surface is $\mu_k = 0.520$. A string is attached to the end of mass $m_1 = 8.00$ kg. This string is then looped around a pulley and is finally attached to the left vertical surface. The pulley is attached to mass m_2 = 12.0 kg as shown and then a force F is applied to m_2 such that m_2 moves toward the right at a constant velocity of 5.0 m/sec.



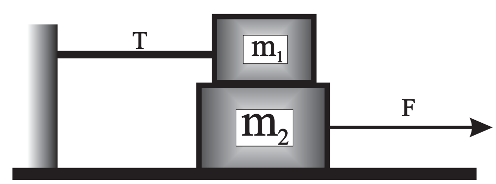
a. What will be the magnitude of the force F needed to pull mass m_2 to the right at a constant speed?
b. What will be the tension T in the string?

25. Two masses, $m_1 = 3.0$ kg and $m_2 = 7.0$ kg. are sitting on a horizontal surface as shown to the right. The two masses are attached together by a string in which the tension is T. A force F = 67.0 N is applied to the system so as to pull the two masses to the left at a constant speed.



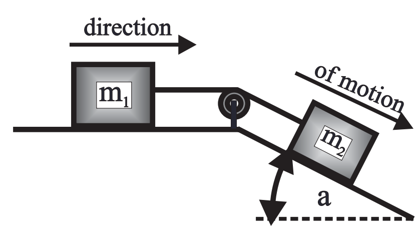
a. What will be the coefficient of sliding friction μ_k for this surface?
b. What will be the tension T in the string connecting the two masses together?

26. Two masses are arranged as shown. Mass m_1 has a mass of 4.00 kg and is attached to the vertical surface on the left with a string in which the tension is T. Mass $m_2 = 6.00$ kg, is sitting on the horizontal surface and is being pulled to the right by a force F so that m_2 is moving to the right at a constant speed. The coefficient of sliding friction between m_1 and m_2 is $\mu_1 = 0.380$ while the coefficient of sliding friction between m_2 and the horizontal surface is $\mu_2 = 0.510$.



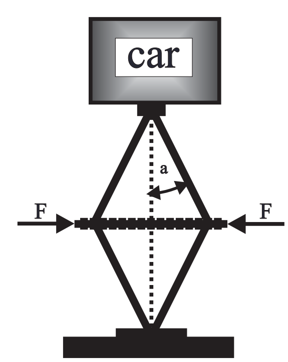
a. What will be the tension T in the string?
b. What will be the magnitude of the force F required to pull m_2 to the right at a constant speed?

27. In the diagram at the right $m_2 = 8.00$ kg. is sliding down the incline at a constant speed. m_1 is being pulled by a string attached between these two masses. The coefficient of kinetic friction between m_1 and the horizontal surface is $\mu_1 = 0.220$ while the coefficient of kinetic friction between m_1 and the incline is $\mu_2 = 0.380$. The angle between the incline and the horizontal is $\alpha = 42.0^o$. What is the mass of m_1 ?



28. The coefficient of kinetic friction between the tires of a car, which has a mass of 1650 kg., and the road is $\mu_k = 0.630$ while the coefficient of static friction is $\mu_s = 0.680$. How much more frictional force is available to the driver of this car when the car is NOT in a skid?

29. A scissors jack is a common configuration for a simple jack used to lift a car to replace a flat tire. The diagram at the left shows the basic configuration of such a jack. The force F is generally supplied by a screw which is turned by a lug wrench. Assume that the angle in the diagram is $\alpha = 15.0^o$.



a. What will be the magnitude of the force F required to lift a mass of M = 450 kg?
b. What will be the magnitude of the force F if the angle is $\alpha = 85.0^o$?

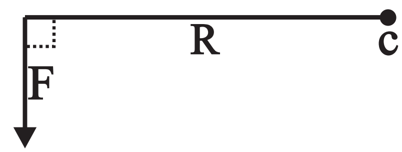
Answers to opposite side:	20b. 621 N	20c. 143 N	20d. 0.675	
21b. 79.7 N	21c. 1170 N	21d.0.0679	22. 243 lb	23a. 39.2 N
23b. 0.315				

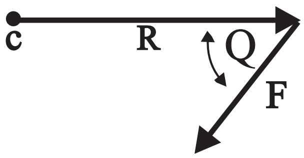
PHYSICS HOMEWORK #27 NEWTON'S LAWS

TORQUES AT EQUILIBRIUM

1. A force of 45.0 Newtons is applied at a right angle to a lever which is 1.50 meters long. What will be the magnitude of the applied torque?

2. A force of F = 54.0 Newtons is applied to a lever which is R = 42.0 cm long as shown in the diagram to the right. What is the magnitude of the applied torque?



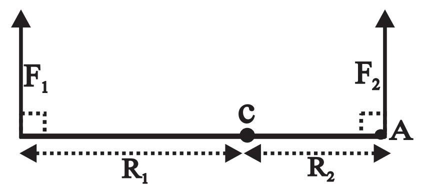


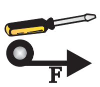
3. What will the magnitude of the applied torque in the diagram to the left where a force of F = 54.0 N is applied to a lever R = 1.25 meters long at an angle of $\alpha = 35.0^{o}$?

$$\textbf{\textit{Torque}} = \mathrm{T} = \boldsymbol{r} \times \boldsymbol{F} = |\boldsymbol{r}| \cdot |\boldsymbol{F}| \cdot \mathbf{sin}(\Theta)$$

4. How much force F would have to be applied perpendicularly to a lever arm of r = 88.0 cm. in order to generate a torque of 72.0 N m?

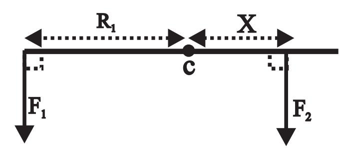
5. A force of F_1 = 22.0 N is applied at a distance of R_1 = 32.0 cm from the center of rotation as shown to the right. How much force must be applied at point A, which is R_2 = 16.0 cm from the center of rotation, in order to produce rotational equilibrium?



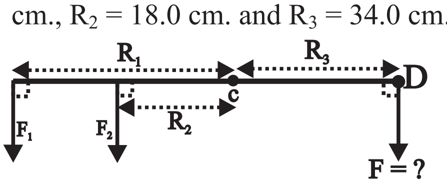


6. A screw driver has a handle which has a diameter of 3.50 cm. How much force F must be applied tangentially to the handle of the screwdriver to generate a torque of 7.00 Nm?

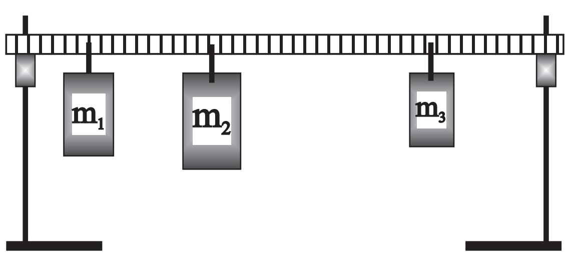
7. Where X in the diagram to the right should the F_2 = 84.0 N force be applied in order to balance the F_1 = 24.0 N force which is applied R_1 = 75.0 cm. from the center of rotation as shown?



8. How much force F should be applied at point D in the diagram below in order to produce rotational equilibrium in the diagram to the left where F_1 = 14.0 N, F_2 = 24.0 N, R_1 = 40.0 cm., R_2 = 18.0 cm. and R_3 = 34.0 cm.?



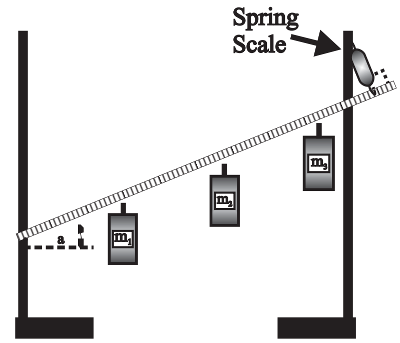
9. The diagram below shows a meter stick resting on two ring stands. Different masses are hung from the meterstick, which has a mass of 135 grams. A mass of m_1 = 250 gm is suspended from the meter stick at the 20.0 cm mark, a mass of m_2 = 500 grams is suspended from the 40.0 cm mark of the meterstick and m_3 = 150 grams is suspended from the 70.0 cm mark of the meterstick as shown.What will be the **magnitude** and **point of application** of the single **upward force** that can lift this meterstick? [Complete the diagram to the right & select a center of rotation!]



ANSWERS TO OPPOSITE SIDE : 10a. - 0.54 N m b. - 8.57 N m c. 8.57 N m d. 9.20 N 11. 175 gm
12. 96.3 lb 13. 5.50 N 14a. 9.02 N b. 0.673 m 15. left = 294 lb, right = 96.1 lb

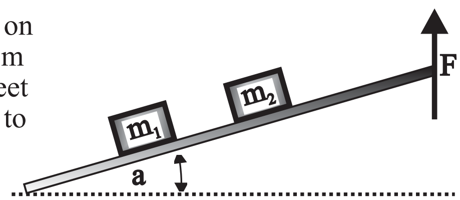
PHYSICS HOMEWORK #28 NEWTON'S LAWS
TORQUES AT EQUILIBRIUM

10. A meterstick is pivoted at one end by a nail inserted through the 2.0 cm mark. The angle between the meterstick and the horizontal is $\alpha = 24.0^o$. A spring scale is attached perpendicularly to the meterstick through a hole located at the 95.0 cm mark as shown. The mass of the meter stick is 125 grams, mass m_1 = 200 grams is hung from the 38.0 cm. mark, m_2 = 700 grams is hung from the 62.0 cm. mark and m_3 = 500 grams is hung from the 83.0 cm mark.
    a. What will be the magnitude of the torque exerted on the system by the weight of the meterstick?
    b. What will be the total clockwise torque acting on this system?
    c. What will be the total counter-clockwise torque acting on this system?
    d. What will be the reading on the spring scale?



11. A meter stick is suspended on a nail sticking through a hole drilled through the 50.0 centimeter mark. A mass of 250 grams is suspended from the 22.0 cm mark, a mass of 550 gm is suspended from the 65.0 cm mark and 150 gm is suspended from the 100 gm mark. How much mass should be suspended from the 0.0 cm mark in order to generate equilibrium? [Draw diagram!]

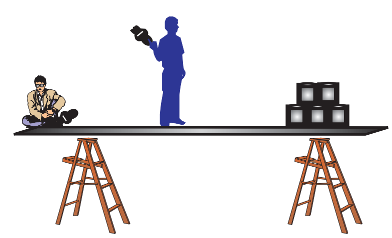
12. A board, which is 7.0 feet long and weighs 24 pounds, is sitting on the floor. Sitting on this board are two crates. The first crate weighs 115 pounds and is sitting 2.5 feet from the left end of the board while the second crate weighs 55 pounds and is sitting 1.5 feet from the right end of the board. How much upward force F would you have to apply to the right end of the board in order to lift that end of the board off of the floor?



13. A meterstick, which has a mass of 138 grams, has a nail through a hole drilled at the 100 cm mark. A mass of 150 grams is hung from the 82.0 cm mark, a mass of 550 gm is suspended from the 45.0 cm mark and a mass of 250 gm is suspended from the 35.0 cm mark. How much upward force must be applied at the 0.0 cm mark in order to achieve equilibrium? [Draw diagram!]

14. A mass of 220 gm is hung from the 25.0 cm mark of a meterstick, a mass of 475 gm is hung from the 95.0 cm mark and the weight of the meter stick is 2.20 N. [Draw diagram!]
    a. How much upward force would be required to keep this system at translational equilibrium?
    b. Where along the meterstick could you apply this force in order to generate rotational equilibrium?

15. A board , which is 14.0 feet long, is placed on the top of two stepladders as shown to the right. The weight of the board is 42 lb. One painter, who weighs 128 lb., is sitting on the left end of the board, while another painter, who weighs 155 lb., is standing 6.0 feet from the left end of the board. A stack of paint cans, which weigh 65 lb., sits 3.0 feet from the right end of the board. The ladders are each located 3.0 feet from the ends of the board. How much weight will each ladder have to support?



ANSWERS TO OPPOSITE SIDE: 1. 67.5 Nm 2. 22.7 Nm 3. -55.3 Nm 4. 81.8 N 5. 44.0 N 6. 400 N 7. 0.214 m 8. 29.2 N 9. 10.2 N up, 0.409 from left end

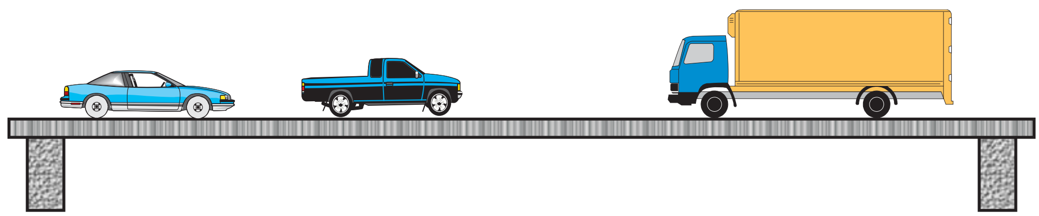
PHYSICS HOMEWORK #29 NEWTON'S LAWS TORQUES AT EQUILIBRIUM

16. A metal bar, which is 4.50 meters long and has a weight of 450 N is suspended from a metal cable. A mass weighing 1250 N is suspended from the right end of the bar while a mass weighing 425 N is suspended from the left end of the bar. Assuming that this bar is at equilibrium, where must the cable be attached to the bar?

17. Consider a bridge which is 38 meters long, weighs 34 tons and is supported at each end by a concrete pier. The following vehicles can be found sitting on the bridge starting from the left; 4.0 meters a car weighing 2.2 tons, 12.0 meters a truck weighing 4.6 tons, and 27.0 meters a truck weighing 19.6 tons.

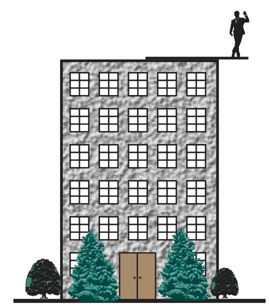
a. How much upward force must be supplied by each pier to in order to support the weight of the bridge and the three vehicles?

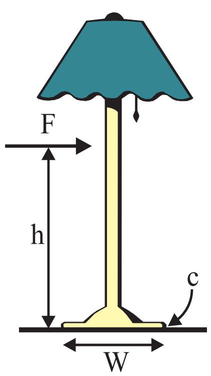
b. Where along the length of the bridge could a single upward force be applied so as to lift the bridge without tilting?



c. What is the magnitude of the single upward force that could support the weight of this bridge?

18. Suppose that you were on top of a building where there was a board which weighed 375 lb and was 18.0 feet long. The end of the board sticks out a distance of 7.00 feet beyond the edge of the building and the board is oriented perpendicularly to the edge of the roof. Assuming that you weigh 155 lb and you are going to "walk the plank", how far beyond the edge of the building will you be when you fall to your death on the pavement 325 feet below?





19. Consider the lamp to the left which has a mass of 3.80 kg and a base which has a width of W = 28.0 cm. The coefficient of friction between the base of the lamp and the floor is $\mu = 0.38$. A force F is applied to the lamp at a height of h = 33.0 cm. above the floor so as to slide the lamp across the floor at a constant speed.

a. What is the magnitude of the frictional force acting on this lamp as it slides across the floor?

b. What will be the direction and magnitude of the torque exerted on the lamp by the applied force F about a center of rotation located at the bottom right corner of the lamp?

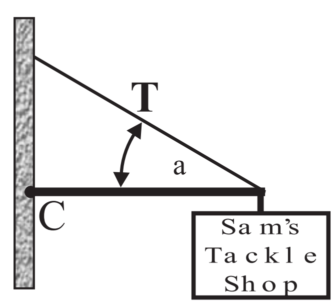
c. What will be the direction and magnitude of the torque exerted on the lamp by the weight of the lamp about the indicated center?

d. What is the maximum height h above the base that you can exert the force F without the lamp tilting?

20. A sign hangs in front of a store as shown to the right. The sign consists of a bracket, which has a mass of 6.20 kg. and a length of 1.40 m., attached to the building and supported by a cable attached to the end of the bracket at an angle of $\alpha = 28.0^{o}$ The sign, which has a mass of 14.2 kg., is hanging from the end of the bracket as shown.

a. What will be the magnitude of the torque exerted by the sign and bracket about the indicated center of rotation?

b. What is the tension T in the cable?

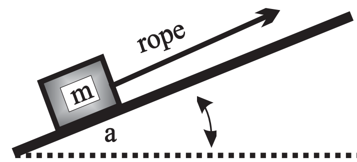


Answers to this side: 16. 3.12 m from left end 17a. right = 27.8 tons, left = 32.6 tons b. 20.5 m 17c. 60.4 tons 18. 4.84 ft beyond edge of building 19a. 14.2 N b. 4.67 Nm c. 5.22 Nm d. 0.368 m left 20a. -238 Nm b. 361 N

PHYSICS HOMEWORK #31 NEWTON'S LAWS
SECOND LAW $\Sigma F=ma$

Newton's Second Law of Motion
The acceleration of an object is directly proportional to the force applied, inversely proportional to the mass of the object and in the same direction as the accelerating force!

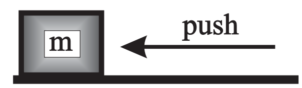
1. A crate, which has a mass of m = 45.0 kg., is being accelerated at 3.20 m/sec^2 up a frictionless inclined plane, which meets the horizontal at an angle of α = 35.0^o relative to the horizontal, by a rope as shown to the right.
   a. Complete the free body diagram showing all the forces acting on the crate as it moves up the incline at a constant speed.
   b. What will be the magnitude of the normal force acting on the crate?
   c. What will be the magnitude of the tension T in the rope?



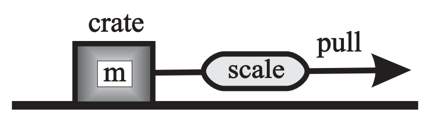
Make a freebody diagram for EVERY problem!

2. A crate, which has a mass of 55.0 kg. is being accelerated straight up by a rope at a rate of 3.80 m/sec^2. What will be the tension in the rope?

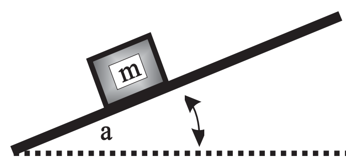
3. A crate, which has a mass of 55.0 kg., is being pushed along a horizontal surface by a force of F = 125.0 Newtons so that the crate is accelerating to the left at a constant rate of a = 1.10 m/sec^2.
   a. Complete the free body diagram showing all the forces acting on the crate.
   b. What will be the magnitude of the frictional force acting on this crate?
   c. What is the coefficient of sliding friction between the crate and the horizontal surface?



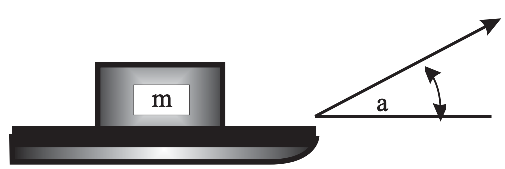
4. A block of wood, which has a mass of m = 5.00 kg., is at rest on a horizontal surface which has a coefficient of sliding friction of μ = 0.43. A spring scale is attached to a hook on the end of the block and is pulled until the reading on the scale is 47.0 N. As a result the block accelerates to the right.
   a. What is the magnitude of the normal force acting on this block?
   b. What is the magnitude of the frictional force on this block as it slides to the right?
   c. What is the rate of acceleration of this block?



5. A crate, which has a mass of 65.0 kg., is sitting at rest on an inclined plane, which has a coefficient of sliding friction of μ = 0.430, as shown to the right. The end of the incline is lifted until the angle of the incline reaches α = 27.0^o, at which point the crate accelerates down the incline at a constant rate.
   a. Complete the free body diagram showing all the forces acting on the crate.
   b. What is the magnitude of the normal force acting on this crate?
   c. What is the magnitude of the frictional force acting on this crate?
   d. What is the rate of acceleration of this crate as it slides to the bottom of the inclined plane?



6. A sled, which has a mass of m = 125 kg., is sitting on an icy horizontal surface. A rope is attached to the front end of the sled such that the angle between the rope and the horizontal is α = 28.0^o and a force of 585 N is applied to the rope. As a result the sled accelerates to the right at a rate of 3.30 m/sec^2.
   a. Complete the free body diagram showing all the forces acting on the sled.
   b. What is the magnitude of the frictional force acting on this sled?
   c. What is the magnitude of the normal force acting on the sled?
   d. What is the coefficient of sliding friction between the sled and the icy horizontal surface?
   e. What will be the displacement of this sled at the end of 5.0 seconds?

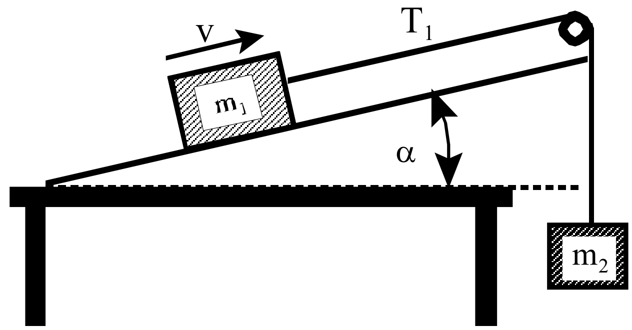


Answers to opposite side: 7a. 52.0 N b. 2.37 m/sec^2 c. 0.741 sec d. 1.76 m/sec 8a. 2.40 m/sec^2 8b. 60.0 N c. 195 N 9a. 8.03 m/sec^2 b. 66.5 N 10a. 22.3 N b. 22.3 N c.75.0 N d. 126 N

PHYSICS HOMEWORK #32 NEWTON'S LAWS

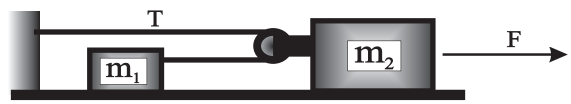
SECOND LAW $\Sigma F = ma$

7. A mass of $m_1 = 6.00$ kg is sitting on an inclined plane, which meets the horizontal at an angle of $\alpha = 22.0^o$, which has a coefficient of sliding friction of $\mu = 0.290$, and which is L = 3.50 meters long, as shown to the right. A string is attached to mass m_1, it is strung over a pulley, and is then attached to a second mass $m_2 = 7.0$ kg. which is initially a distance of h = 65.0 cm above the floor. As a result m_1 accelerates up the incline at a constant rate.



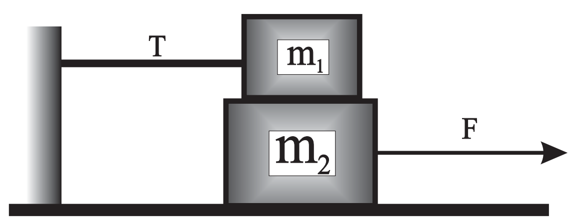
a. What is the magnitude of the tension T in the string connecting the two masses?
b. What will be the rate of acceleration of this system?
c. How long will it take for mass m_2 to reach the floor ?
d. What will be the speed of m_2 just as it reaches the floor ?

8. Two masses are sitting on a horizontal surface as shown to the right. The coefficient of sliding friction between these two masses and the horizontal surface is $\mu_k = 0.520$. A string is attached to the end of mass $m_1 = 8.00$ kg. This string is then looped around a pulley and is finally attached to the left vertical surface. The pulley is attached to mass $m_2 = 12.0$ kg as shown and then a force F is applied to m_2 such that m_2 accelerates toward the right at a constant rate of $a_2 = 1.20$ m/sec^2.
a. What will be the corresponding acceleration a_1 of mass m_1 ?
b. What will be the tension T in the string that is accelerating mass m_1 ?
c. What will be the magnitude of the force F required to accelerate this system at the given acceleration ?



9. Two masses, $m_1 = 3.00$ kg and $m_2 = 7.00$ kg. are sitting on a horizontal surface, which has a coefficient of kinetic friction of $\mu_k = 0.150$, as shown to the right. The two masses are attached together by a string in which the tension is T. A force F = 95.0 N is applied to the system as shown so as to accelerate the two masses to the left at a constant rate a.
a. What will be the rate of acceleration of this system ?
b. What will be the tension T in the string connecting the two masses together?

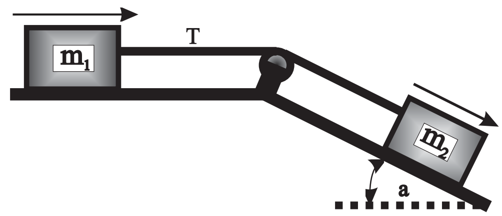
10. Two masses are arranged as shown. m_1 has a mass of 6.00 kg and is attached to the vertical surface on the left with a string in which the tension is T. m_2 has a mass of 9.00 kg, is sitting on the horizontal surface and is being pulled to the right by a force F so that m_2 is accelerating to the right at a constant rate of a = 3.20 m/sec^2. The coefficient of sliding friction between m_1 and m_2 is $\mu_1 = 0.380$ while the coefficient of sliding friction between m_2 and the horizontal surface is $\mu_2 = 0.510$.
a. What will be the tension T in the string?
b. What is the magnitude of the frictional force between m_1 and m_2?
c. What will be the magnitude of the frictional force between m_2 and the horizontal surface?
d. What will be the magnitude of the force F required to accelerate m_2 to the right at 3.20 m/sec^2 ?



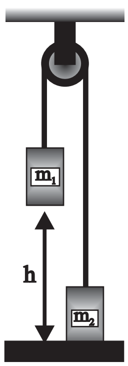
Answers to opposite side: 1b. 361 N c. 397 N 2. 748 N 3b. 64.5 N c. 0.12 4a. 49 N b. 1.1 N 4c. 5.2 m/sec^2 5b. 568N c. 244 N d. 0.692 m/sec^2 6b. 104 N c. 950 N d. 0.109 e. 41.3 m

PHYSICS HOMEWORK #33 NEWTON'S LAWS

SECOND LAW $\Sigma F=ma$

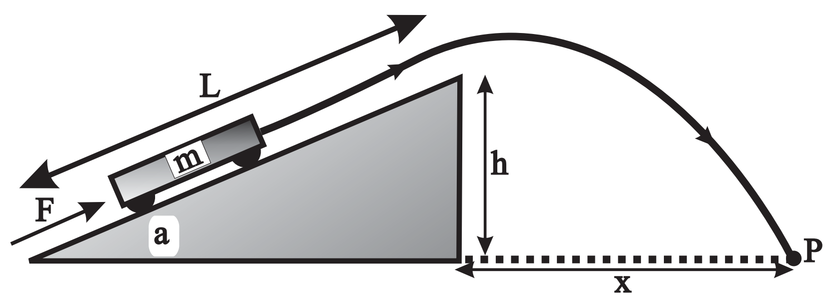


11. In the diagram at the right $m_2 = 8.50$ kg. is accelerating down the incline at a constant rate. m_1 is being pulled by a string attached between these two masses. The coefficient of friction between m_1 and the horizontal surface is $\mu_1 = 0.220$ while the coefficient of friction between μ_2 and the incline is $\mu_2 = 0.380$. The angle between the incline and the horizontal is $\alpha = 42.0^o$. As a result the system accelerates down the incline at 1.65 m/sec^2.
    a. What is the mass of m_1 ?
    b. What is the tension in the string connecting the two masses together ?
    c. What will be the acceleration of this system if $m_1 = 10.0$ kg and $m_2 = 2.00$ kg.?



12. Two masses are connected together by a string which is then hung over a pulley which is mounted on the ceiling as shown in the diagram to the left. Mass $m_1 = 7.50$ kg and mass $m_2 = 6.50$ kg. Initially mass m_1 is suspended h = 135 cm above the floor while mass m_2 is sitting on the floor.
    a. What will be the net [unbalanced] force on this system?
    b. What will be the resulting acceleration of this system ?
    c. What will be the tension in the string as m_1 accelerates to the floor ?
    d. How long will it take for m_1 to reach the floor?
    e. What will be the velocity of m_1 just as it reaches the floor ?

13. A cart, which has a mass of m = 4.50 kg., is sitting at the bottom of an inclined plane which is L = 4.20 meters long and h = 1.30 meters high. The coefficient of rolling friction between the cart and the surface of the incline is $\mu = 0.0950$. A force of F = 40.0 N is applied as shown so as accelerate the cart all the way up the incline until the car leaves the end of the incline and flies through the air until it lands at point P which is X meters from the base of the incline as shown.
    a. What will be the rate of acceleration of the cart as it moves up the incline?
    b. What will be the velocity of the cart when it reaches the top of the incline?
    c. How long after the cart leaves the top of the incline will the cart land on the floor?
    d. How far from the base of the incline X will the cart land on the floor?

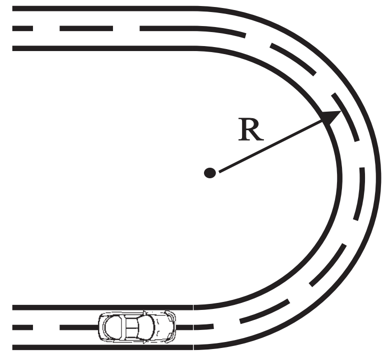


Answers to opposite side: 14. 9.75 N 15. 5980 N [up to the left] 16a. 7.23 m/sec b. 12.4 m/sec^2, 1.27 g's
16c. F_f up, F_N left, F_g down d. 622 N e. 622 N f. 490 N g. 0.788 17a. 28.0 m/sec b. 6.29 m/sec^2
17c. 0.64 g's d. down and to the right [toward the center]

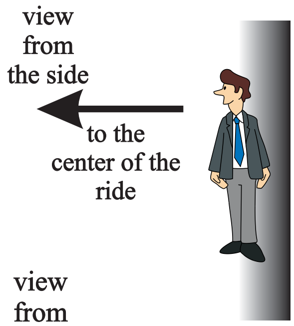
PHYSICS HOMEWORK #34 NEWTON'S SECOND LAW

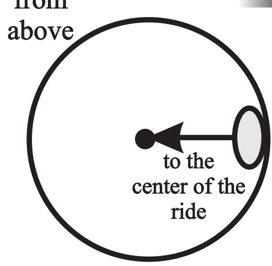
CENTRIPETAL FORCE $F_c = \dfrac{m \cdot v^2}{r}$

14. A ball, which has a mass of 0.65 kg., is moving in a circular path, which has a radius of 1.35 meters, with a linear speed of 4.50 m/sec. What is the magnitude of the centripetal force acting on this ball?



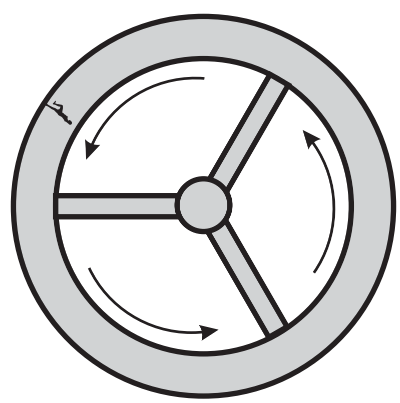
15. A car, which has a mass of 1200 kg is moving with a speed of 18.0 m/sec as it passes through a curve in the road which has a radius of curvature of R = 65.0 meters as shown to the right. What are the magnitude and direction of the centripetal force acting on this car when at the location shown?





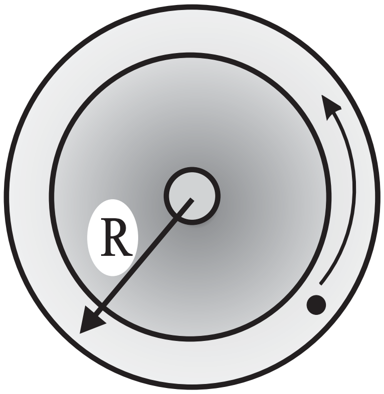
16. There is an amusement ride called the "ROTOR" where you enter a cylindrical room. The room begins to spin very fast until at some point the floor beneath you "falls out". Suppose that this room has a radius of 4.20 meters and that the room rotates such that you make one complete revolution in 3.65 seconds. The diagram to the left shows an occupant of this ride standing suspended next to the exterior wall of this ride.
   a. What will be your linear speed as the room spins at this speed?
   b. What is the magnitude of your centripetal acceleration? How many "g's" is this?
   c. On the diagram to the left label all of the forces acting on the rider.
   d. What will be the magnitude of the centripetal force acting on a 50.0 kg person on this ride?
   e. What will be the magnitude of the normal force acting on this person?
   f. What will be the minimum frictional force acting on this person?
   g. What is the minimum coefficient of friction between the rider and the wall?

17. One of the classic stories of science fiction is the concept of a spoked wheel space station [as in 2001 A Space Odyssey]. The point of this concept is to use the rotation of the wheel to generate an artificial gravity. Suppose that a space station was built as shown to the right with a radius of R = 125 meters and a period of rotation of 28.0 seconds.
   a. What would be the linear speed of a person standing on the outer rim of the space station as shown to the right ?
   b. What would be the magnitude of the centripetal acceleration of this person?
   c. How many "g's" is this acceleration?
   d. What would be the direction of the centripetal acceleration of this person while in the location shown?

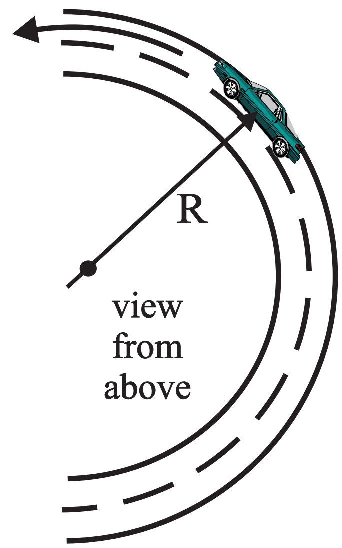


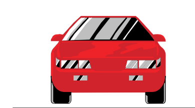
Answers to opposite side: 11a. 4.78 kg b. 18.2 N c. 0 m/sec^2 12a. 9.8 N b. 0.70 m/sec^2 c. 68.3 N 12d. 1.96 secretary e. 1.37 m/sec 13a.4.97 m/sec^2 b. 6.46 m/sec c. 0.76 sec d. 4.66 m

PHYSICS HOMEWORK #35 NEWTON'S SECOND LAW
CENTRIPETAL FORCE



18. Consider a roulette wheel, as shown to the left, where the radius of the wheel is $R = 0.850$ meters. A ball, which has a mass of 135 grams, is thrown into the roulette wheel after which it rotates counter-clockwise with a speed of $v = 3.40$ m/sec.
   a. What will be the magnitude of the centripetal acceleration of this ball?
   b. What will be the direction of the centripetal acceleration of this ball while in the position shown?
   c. What will be the magnitude of the centripetal force acting on this ball?
   d. What will be the direction of the centripetal force acting on this ball?
   e. Suppose that the ball escaped from the roulette wheel while in the position shown, what will be the direction of motion of the ball as it exits the wheel?





19. An automobile, which has a mass of 1140 kg, is moving with a velocity of 22.0 m/s around a curve in the highway which has a radius of $R = 85.0$ meters and which has a coefficient of static friction of $\mu = 0.720$.
   a. Draw a freebody diagram showing each of the forces acting on this car.
   b. What will be the magnitude of the normal force acting on this car?
   c. What will be the maximum frictional force available to this car as it passes through the curve?
   d. What will be the direction and magnitude of the centripetal acceleration of this car?
   e. What will be the direction and magnitude of the centripetal force acting on this car?
   f. Is this car going too fast to make it safely through the curve? Explain!

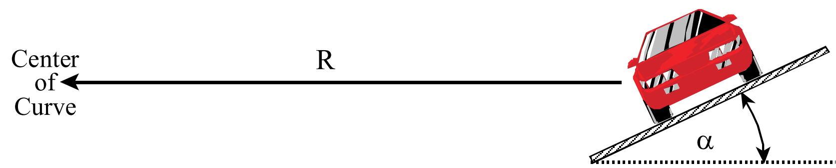
20. An automobile, which has a mass of 2200 kg, is moving around a flat curve in the highway which has a radius of $R = 92.0$ meters and which has a coefficient of static friction of $\mu = 0.670$.
   a. Draw a freebody diagram showing each of the forces acting on this car.
   b. What will be the magnitude of the normal force acting on this car ?
   c. What is the maximum speed with which this car can pass through the curve without losing control?
   d. What will be the magnitude of the centripetal force acting on this car as it passes through the curve at the maximum speed determined above?

21. You are standing a distance of 17.0 meters from the center of a merry-go-round. The merry-go-round takes 9.50 seconds to go completely around once and you have a mass of 55.0 kg.
   a. What will be your speed as you move around the center of the merry-go-round?
   b. What will be your centripetal acceleration as you move around the center of the merry-go-round?
   c. What will be the magnitude of the centripetal force necessary to keep your body moving around the center of this merry-go-round at the calculated speed?
   d. How much frictional force will be applied to you by the surface of the merry-go-round?
   e. what is the minimum coefficient of friction between your shoes and the surface of the merry-go-round?

Answers to opposite side: 22a. F_f - down incline, F_N - perpendicular to incline, F_g - straight down
22b. 35.3 m/sec c1. 24,900 N c2. 8220 N 23a. T - up and to the left, F_g - straight down
23b. 0.437 N c. 5.99 m/sec d. 0.460 N e. 45 gm 24a. F_g - down, F_N - down b. 15.3 m/sec

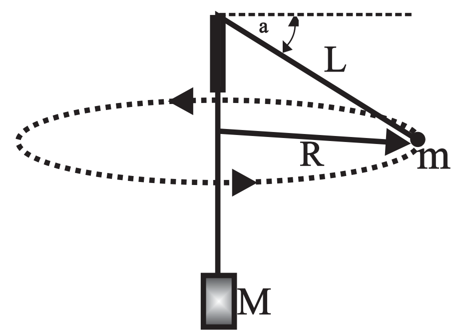
PHYSICS HOMEWORK #36 NEWTON'S SECOND LAW
CENTRIPETAL FORCE

22. An automobile, which has a mass of 1850 kg., is moving through a banked curve, which has a radius of curvature of R = 122 meters, as shown to the right. The angle between the roadbed and the horizontal is $\alpha = 28.0^{o}$ while the coefficient of static friction between the tires of the car and the roadbed is $\mu = 0.330$.



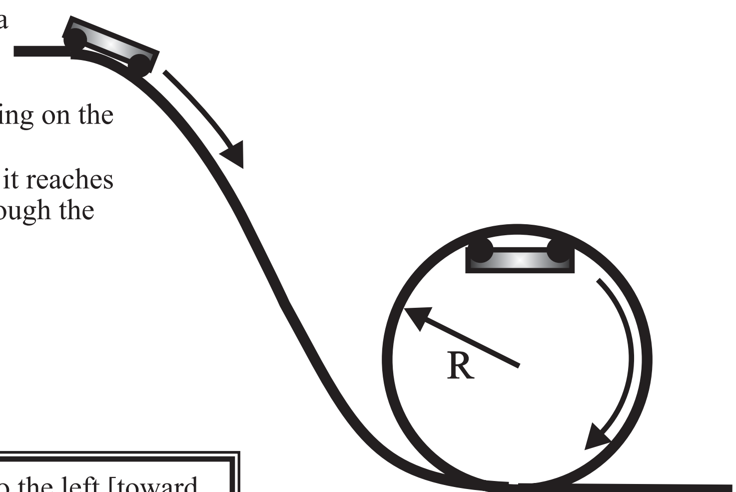
a. Draw the freebody diagram showing each of the forces acting on the car as it passes through the curve.
b. What will be the maximum speed with which the car can negotiate the curve without losing control?
c. While moving at this maximum speed, what will be the direction and magnitude of:
 1. the normal force acting on the car.
 2. the frictional force acting on the car.
 3. the centripetal force acting on this car.
d. What will be the minimum speed with which the car can negotiate the curve without losing control?
e. With what speed should the car proceed through the curve if there was no friction at all?

23. A rubber stopper, which has a mass of m = 14.5 grams, is tied to the end of a string which is threaded through a glass tube. You then spin the rubber stopper about your head in a horizontal circle as shown to the right. The stopper sags $\beta = 18.0^{o}$ below the horizontal as shown and the distance from the top of the tube to the stopper is L = 1.25 m.



a. Draw the freebody diagram showing each of the forces acting on the rubber stopper.
b. What will be the magnitude of the centripetal force acting on the stopper?
c. What is the speed of the stopper?
d. What is the tension in the string?
e. How much Mass M is hanging on the end of the string?
f. How long will it take for the stopper to move around the circular path 10 times?

24. A roller coaster rolls down a hill and then passes through a loop-the-loop which has a radius of R = 24.0 meters as shown.
a. Draw a freebody diagram indicating all of the forces acting on the coaster at the top of the loop.
b. What will be the minimum velocity of the coaster when it reaches the top of the loop if the coaster is to make it safely through the loop?



Answers to opposite side: 18a. 13.6 m/sec^2 b. up and to the left [toward the center] c. 1.84.N d. up and to the left [toward the center]
18e. up and to the right [tangent to the curve]
19a. F_N - up, F_f - down and left [toward the center], F_g - straight down
19b. 11,200 N c. 8040 N d. 5.69 m/sec^2 e. 6490 N f. all is well!
20a. same as 19a b. 21,600 N c. 24.6 m/sec d. 14,500 N
21a. 11.2 m/sec b. 7.44 m/sec^2 c. 409 N d. 409 N e. 0.759

PHYSICS HOMEWORK #37

NEWTON'S SECOND LAW
UNIVERSAL GRAVITATION

PLANET	RADIUS	MASS	ALTITUDE	PERIOD
Sun	6.96×10^{8} m	1.99×10^{30} kg	N/A	N/A
Earth	6.38×10^{6} m	5.97×10^{24} kg	1.50×10^{11} m	365.25 days
Moon	1.74×10^{6} m	7.35×10^{22} kg	3.80×10^{8} m	27.3 days
Mars	3.39×10^{6} m	6.42×10^{23} kg	2.28×10^{11} m	687 days
Jupiter	7.14×10^{7} m	1.90×10^{27} kg	7.79×10^{11} m	4333 days
Io	1.82×10^{6} m	7.87×10^{22} kg	3.48×10^{8} m	1.53×10^{5} sec
Saturn	6.00×10^{7} m	5.68×10^{26} kg	1.13×10^{12} m	10,759 days
Titan	2.58×10^{6} m	1.19×10^{23} kg	1.22×10^{6} m	1.42×10^{6} sec
Neptune	2.43×10^{7} m	1.03×10^{26} kg	4.50×10^{12} m	60,188 days
Triton	1.90×10^{6} m	1.34×10^{23} kg	3.54×10^{5} m	5.08×10^{5} sec
Pluto	1.50×10^{6} m	1.50×10^{22} kg	5.91×10^{12} m	90,885 days

Universal gravitational constant $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

$$F_g = \frac{G \cdot m_1 \cdot m_2}{r^2}$$

1. What will be the gravitational force between two masses, $m_1 = 15$ kg. and $m_2 = 35$ kg., if the distance between the two masses is measured to be 18.5 cm., center to center?

2. What will be the gravitational force between a 12.0 kg. mass and the Earth when the mass is sitting on the Earth's surface?

3. What will be the gravitational force between a 12.0 kg. mass and the planet Mars when the mass is sitting on the surface of Mars?

4. What will be the gravitational force constant "g_{Mars}" on the surface of Mars?

5. What would be the gravitational force constant "$g_{Jupiter}$" on the surface of Jupiter, if Jupiter had a surface?

6. What is the gravitational attraction between the Earth and the Moon?

7. A satellite, which has a mass of 550 kg. and a radius of 2.20 meters, is orbiting the Earth at an altitude of 375 kilometers.
   a. What will be the magnitude of the gravitational force between this satellite and the Earth ?
   b. What must the velocity of this satellite be in order for the satellite to remain in a stable orbit ?
   c. What will be the magnitude of the centripetal acceleration of this satellite ?
   d. How long will it take for this satellite to orbit the Earth once ?

8. A space ship is orbiting the planet Mars at an altitude of 1200 km. above the surface of Mars.
   a. What is the required velocity for this space ship to remain in a stable orbit ?
   b. What will be the period of this orbit ?

Answers to opposite side: 9a. 6.53×10^{3} m/sec 9b. 2.97×10^{6} m 10a. 3.07×10^{3} m/sec b. 3.58×10^{7} m 11a. 1.13×10^{4} m/sec b. 1.89×10^{27} kg 12a. 2.42×10^{4} m/sec b. 1.99×10^{30} kg 13a. 4.34×10^{20} N 13b. 2.03×10^{20} N c. 2.14 14a. 6.70×10^{3} m/sec b. 8.33×10^{3} sec c. decrease 15. 9.13 m/sec^2 16a. 8.55 m/sec^2 b. toward the center of the Earth c. 2780 N

PHYSICS HOMEWORK #38

NEWTON'S SECOND LAW UNIVERSAL GRAVITATION

9. A satellite is to orbit the Earth so that its period is 2.50 hours.
   a. What velocity is required to maintain this orbit ?
   b. What will be the altitude of this orbit ?

10. A satellite is designed so that it will orbit the Earth once every 24.0 hours. [Called geosynchronous orbit because the satellite will remain above the same point on the Earth's surface !]
    a. What velocity will be required to maintain this orbit ?
    b. What will be the altitude of this orbit ?

11. The moon Io orbits the planet Jupiter at an altitude of 3.48×10^8 m with an orbital period of 1.529×10^5 seconds.
    a. What is the orbital velocity of Io about Jupiter ?
    b. According to this information what is the mass of the planet Jupiter ?

12. The planet Mars orbits the sun at a distance of 2.28×10^{11} m with an orbital period of 687 days.
    a. What is the orbital velocity of Mars about the Sun ?
    b. According to this information, what is the mass of the sun ?

13a. What is the magnitude of the gravitational force of the Sun on the Earth's moon ?
   b. What is the magnitude of the gravitational force of the Earth on the moon ?
   c. How does the gravitational force of the Sun on the moon compare to the force of the Earth on the moon ?

14. A satellite is orbiting the Earth at an altitude of 2500 km. above the Earth's surface.
    a. What velocity is required for this satellite to maintain a stable orbit ?
    b. What will be the orbital period of this satellite ?
    Suppose that you are on the space shuttle Endeavor and are orbiting the Earth at the same altitude as the satellite, but you are trailing the satellite by 28 km. and would like to catch up with and capture the satellite for repair and maintenance.
    c. Should you increase or decrease your orbital velocity in order to catch up with the satellite ? [Support your answer with quantitative evidence!]

15. What will be the gravitational acceleration in the space shuttle when it is orbiting the Earth at an altitude of 225 km. above the Earth's surface ?

16. A satellite, which has a mass of 325 kg., is orbiting the Earth at an altitude of 450 km. above the Earth's surface with a linear velocity of 7640 m/sec.
    a. What will be the magnitude of the centripetal acceleration of this satellite?
    b. What will be the direction of the centripetal acceleration of this satellite?
    c. What will be the magnitude of the centripetal force acting on this satellite?

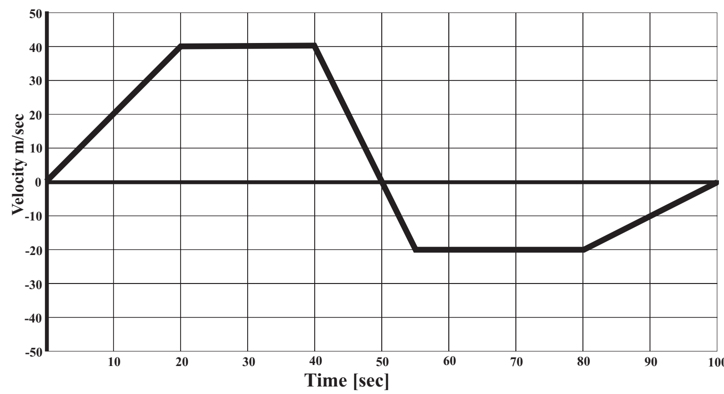
Answers to opposite side : 1. 1.02×10^{-6} N 2. 117 N 3. 44.7 N 4. 3.73 m/sec^2
5. 24.9 m/sec^2 6. 1.94×10^{20} N 7a. 4.80×10^3 N b. 7.68×10^3 m/sec c. 8.73 m/sec^2
7d. 5.53×10^3 sec 8a. 3.05×10^3 m/sec b. 9.44×10^3 sec

PHYSICS HOMEWORK #39 MECHANICS REVIEW

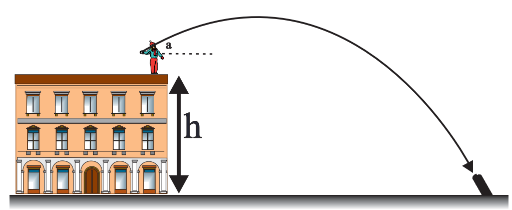
1. A car is moving down a highway with an initial velocity of 35.0 m/sec when the brakes are applied and the car begins to slow down at the rate of -5.0 m/sec^2.
   a. What will be the velocity of this car 4.0 seconds after the brakes are applied?
   b. How far will the car move during the first 4.0 seconds that the brakes are applied?
   c. What will be the average velocity of the car during these 4.0 seconds?
   d. How long will it take for this car to come to a halt?

2. A ball, which has a mass of 1.25 kg., is thrown straight up from the top of a building 86.0 meters tall with an initial velocity of 42.0 m/sec.
   a. What will be the velocity of this ball at the highest point?
   b. What will be the acceleration of this ball at the highest point?
   c. How long will it take for this ball to reach the highest point?
   d. What will be the height of this ball above the ground when it reaches the highest point?
   e. How long will it take for this ball to reach the ground?
   f. What will be the velocity of this ball when it reaches the ground?
   g. When will this ball be 144 meters above the ground?

3. A graph is made, as shown to the right, plotting the velocity of a car as a function of time.
   a. What is the velocity of this car when t = 30 seconds?
   b. How far did this car travel during the first 20 seconds?
   c. What is the acceleration of this car when t = 10 seconds?
   d. What is the displacement of this car between t = 50 seconds and t = 100 seconds?
   e. What is the acceleration of this car when t = 50 seconds?
   f. During which time interval/intervals does this car have zero acceleration?
   g. What are the units of the slope of this graph?
   h. Write the equation describing the velocity of this car between t = 40 seconds and t = 55 seconds.



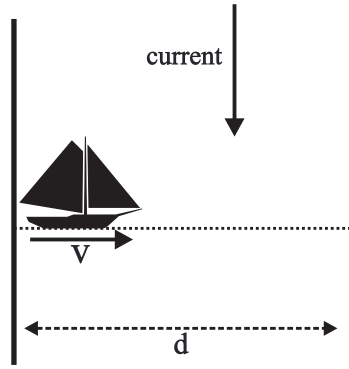
4. A baseball is thrown, with an initial velocity of 37.0 m/sec at an angle of 26.0^o above the horizontal, from the top of a building which is 72.0 meters high.
   a. What will be the horizontal and vertical components of this baseball's velocity?
   b. What will be the vertical velocity of this baseball at the highest point of its trajectory?
   c. What will be the horizontal velocity of this baseball at the highest point of its trajectory?
   d. What is the "trajectory"?
   e. How long will it take for this baseball to reach the highest point?
   f. What will be the highest point reached by this baseball?
   g. How long will it take for this baseball to reach the ground?
   h. How far from the base of the building will the baseball strike the ground?
   i. What will be the baseball's velocity just as it reaches the ground?



Answers to opposite side: 5a. 200 s b. 1000 m c. 2600 m at 22.6^o downstream d. 13 m/sec at 22.6^o downstream
5e. 24.6^o upstream f. 343 s 6. Fn - perpendicular to incline, Ff - parallel to and down the incline, Fa - up the incline
6a(cont). Fg - straight down b. 427 N c. 235 N d. 345 N e. 1380 J f. 441 J g. AMA = 1.28 h. IMA = 4
6i. 32% j. 940 J 7a. -1.08 Nm b. -2.57 Nm c. 2.57 Nm d. 1.75 kg e. 22.3 N 8a. 608 N b. 580 N & 665

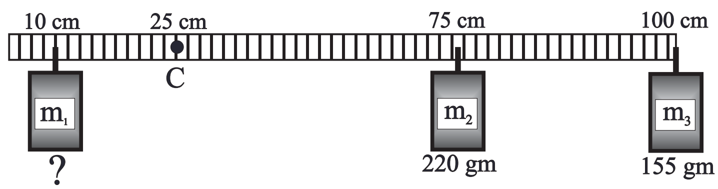
PHYSICS HOMEWORK #40 MECHANICS REVIEW

5. A boat, which has a speed of 12.0 m/sec in still water, heads directly across a river which has a current of 5.0 m/sec and which is 2400 meters wide.
   a. How long will it take for this boat to reach the opposite shore of the river?
   b. How far downstream will this boat reach the opposite shore of the river?
   c. What will be the final displacement of this boat when it reaches the opposite shore of the river?
   d. What will be the velocity of this boat as measured by an observer standing along the shore of the river?
   e. In direction should this boat be aimed if it is to go directly across the river?
   Suppose that this boat was aimed directly up stream.
   f. How long will it take for this boat to go 2400 meters upstream?

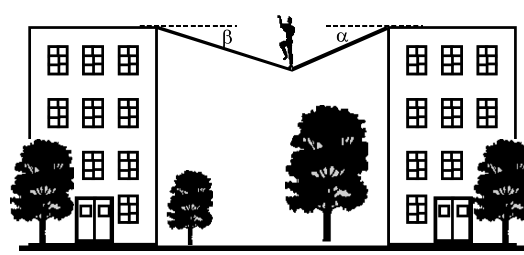


6. A 45.0 kg crate is sitting at the bottom of an inclined plane which is 4.0 meters long and 1.0 meters high. This crate is then pushed up the incline at a constant force. The coefficient of friction between the crate and the incline is $\mu = 0.55$.
   a. Complete the freebody diagram showing all of the forces acting on this crate.
   b. What will be the magnitude of the normal force acting on this crate as it slides up the incline at a constant speed?
   c. What will be the frictional force acting on this crate as it slides up the incline at a constant speed?
   d. What is the magnitude of the force required to push this crate up the incline at a constant speed?
   e. How much work will be done by the applied force on the crate as it is pushed to the top of the incline?
   f. How much gravitational potential energy will this crate have when it reaches the top of the incline?
   g. What is the AMA of this inclined plane?
   h. What is the IMA of this inclined plane?
   i. What is the efficiency of this inclined plane?
   j. How much energy was wasted by the frictional force in pushing the crate to the top of the incline?

7. Three weights are hung from a meterstick, which has a mass of 145 grams, as shown in the diagram to the right. The system is at equilibrium.
   a. What is the torque supplied by the 220 gram mass about the 25.0 cm mark on the meterstick?
   b. What is the total clockwise torque about the 25.0 cm mark of the meterstick?
   c. What is the total counterclockwise torque about the 25.0 cm mark of the meterstick?
   d. What is the mass m_1 required to produce equilibrium about the 25.0 cm mark of the meterstick?
   e. How much upward force must be applied to this meterstick at the 25.0 cm mark in order to generate equilibrium?



8. A tightrope walker, who has a mass of 62.0 kg., is standing on a cable stretched between two buildings as shown to the right where the angles formed by the cable and a horizontal line between the two buildings are $\beta = 22.0^o$ and $\alpha = 36.0^o$.
   a. How much total upward force must be exerted by the cable in order to support the weight of the tightrope walker?
   b. What will be the tensions, T_β and T_α, in the sections of the cable to the left and right of the tightrope walker?



Answers to opposite side: 1a. 15 m/sec b. 100 m c. 25 m/sec d. 7.0 s 2a. 0.0 m/sec b. -9.8 m/sec^2 2c. 4.28 s 2d. 220 m e. 10.3 s f. -58.7 m/sec g. 6.84 s & 1.73 s 3a. 40 m/sec b. 400 m c. 2.0 m/sec^2 3d. -750 m 3e. -4.0 m/sec^2 f. 20 s < t < 40 s & 55 s < t <80 s g. m/sec^2 h. v = -4t + 200 4a. 16.2 m/sec 4b. 0.0 m/sec 4c. 33.3 m/sec d. path followed by projectile e. 1.65 s f. 85.4 m g. 5.83 s h. 194 m i. 53 m/sec at -51^o

PHYSICS HOMEWORK #41 ENERGY CONSERVATION

WORK & ENERGY

Work $W = Fd\cos\alpha$

1. A force of 25.0 Newtons is applied so as to move a 5.0 kg mass a distance of 20.0 meters. How much work was done?

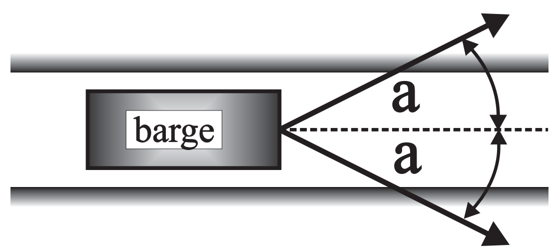
2. A force of 120 N is applied to the front of a sled at an angle of 28.0^o above the horizontal so as to pull the sled a distance of 165 meters. How much work was done by the applied force?

3. A sled, which has a mass of 45.0 kg., is sitting on a horizontal surface. A force of 120 N is applied to a rope attached to the front of the sled such that the angle between the front of the sled and the horizontal is 35.0º. As a result of the application of this force the sled is pulled a distance of 500 meters at a relatively constant speed. How much work was done to this sled by the applied force?

4. A rubber stopper, which has a mass of 38.0 grams, is being swung in a horizontal circle which has a radius of R = 1.35 meters. The rubber stopper is measured to complete 10 revolutions in 8.25 seconds.
   a. What is the speed of the rubber stopper?
   b. How much force must be applied to the string in order to keep this stopper moving in this circular path at a constant speed?
   c. How far will the stopper move during a period of 25.0 seconds?
   d. How much work is done on the stopper by the force applied by the string during 25.0 seconds?

5. How much work would be required to lift a 12.0 kg mass up onto a table 1.15 meters high?

6. A barge is being pulled along a canal by two cables being pulled as shown to the right. The tension in each cable is T =14,000 N and each cable is being pulled at an angle $\alpha = 18.0^o$ relative to the direction of motion as shown. How much work will be done in pulling this barge a distance of 3.0 kilometers?



Kinetic Energy $KE = \frac{1}{2} mv^2$

7. A car, which has a mass of 1250 kg is moving with a velocity of 26.0 m/sec. What is the kinetic energy of this car?

8. What will be the kinetic energy of a bullet, which has a mass of 22.0 grams, moving with a velocity of 650 m/sec.?

9. How fast must a 4.40 kg bowling ball move in order to have a kinetic energy of 185 Joules?

10. A ball, which has a mass of 2.40 kg., is dropped from the top of a building 96.0 meters tall.
    a. How long will it take for this ball to reach the ground?
    b. What will be the velocity of the ball just as it reaches the ground?
    c. What will be the kinetic energy of the ball just as it reaches the ground?
    d. How much work would be needed to lift this ball back up to the top of the building at a constant speed?

11. A cart, which has a mass of m = 2.50 kg., is sitting at the top of an inclined plane which is 3.30 meters long and which meets the horizontal at an angle of $\beta = 18.5^o$.
    a. How long will it take for this cart to reach the bottom of the inclined plane?
    b. What will be the velocity of the cart when it reaches the bottom of the incline?
    c. What will be the kinetic energy of the cart when it reaches the bottom of the incline?

Answers to opposite side: 12a. 56.4 J b. 56.4 J c. zero 13a. 246 N b. 701 J c. 1.49 m d. 701 J
14a. 7290 J b. 7290 J 15a. 292 N/m b. 2.10 J 16a. 18.0 N b. 1.35 J 17a. 29.4 N b 56.6 N/m c. 7.65 J
18a. 123 J b. 123 J c. 2720 N/m

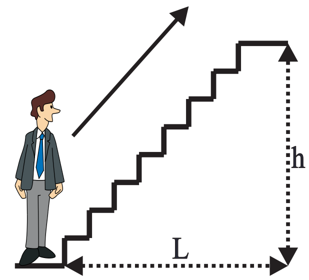
PHYSICS HOMEWORK #42 ENERGY CONSERVATION
WORK & ENERGY

Gravitational Potential Energy GPE = mgΔh

12. A 5.0 kg mass is initially sitting on the floor when it is lifted onto a table 1.15 meters high at a constant speed.
    a. How much work will be done in lifting this mass onto the table?
    b. What will be the gravitational potential energy of this mass, relative to the floor, once it is placed on the table?
    c. What was the initial gravitational potential energy, relative to the floor, of this mass while sitting on the floor?

13. A crate, which has a mass of 48.0 kg., is sitting at rest at the bottom of a frictionless inclined plane which is L = 2.85 meters long and which meets the horizontal at an angle of $\alpha = 31.5^o$. A force F is applied so as to push the crate up this incline at a constant speed.
    a. What is the magnitude of the force F required to push the crate to the top of the incline at a constant speed?
    b. How much work will be done in pushing the crate to the top of the incline?
    c. What is the height of this incline?
    d. What will be the GPE of this crate when it reaches the top of the incline?

14. Suppose that you have a mass of 62.0 kg and that you walk to the top of a stairway which is h = 12.0 meters high and L= 15.0 meters deep.
    a. How much work will you have to do in walking to the top of the stairway?
    b. What will be your GPE when you reach the top of the stairway?

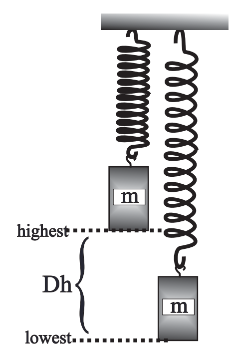


Elastic Potential Energy EPE = ½ k(Δx)^2 and [F = kΔx]

15. A force of F = 35.0 N is applied to a spring and as a result the spring stretches a distance of Δx = 12.0 cm.
    a. What is the spring constant for this spring?
    b. How much energy will be stored in this spring?

16. A spring, which has a spring constant of k = 120 N/m, is being stretched a distance of Δx = 15.0 cm by a force F.
    a. How much force F is being applied to this spring?
    b. How much energy will be stored in this spring?

17. A spring, which has a spring constant k, is hung from the ceiling as shown to the right. A mass m = 3.00 kg is added to the end of the spring and is then slowly lowered until equilibrium is reached. At this point the bottom of the mass has been lowered a distance of Δh = 52.0 cm.
    a. What is the magnitude of the force being exerted by the spring when the system reaches equilibrium?
    b. What is the spring constant of this spring?
    c. How much energy is stored in the spring when equilibrium is reached?



18. A mass of 5.00 kg is dropped from a height of 2.20 meters above a vertical spring sitting on a horizontal surface. Upon colliding with the spring the mass compresses the spring Δx = 30.0 cm before it momentarily comes to halt. [Assume h = 0 at the lowest point!]
    a. How much gravitational potential energy was contained in the 5.0 kg mass before it was dropped?
    b. How much energy will be stored in the spring when the mass comes briefly to a halt?
    c. What is the spring constant of this spring?

Answers to opposite side: 1. 500 J 2. 1.74×10^4 J 3. 4.91×10^4 J 4a. 10.3 m/sec b. 2.98 N c. 257 m 4d. zero 5. 135 J 6. 7.99×10^7 J 7. 4.23×10^5 J 8. 4.65×10^3 J 9. 9.17 m/sec 10a. 4.42 sec b. -43.4 m/sec c. 2260 J d. 2260 J 11a. 1.46 sec b. 4.53 m/sec c. 25.7 J

PHYSICS HOMEWORK #43 ENERGY CONSERVATION

WORK & ENERGY

1. A cart, which has a mass of 2.30 kg is sitting at the top of an inclined plane, which is 4.50 meters long and meets the horizontal at an angle of 14.0º. The car is then allowed to roll to the bottom of the incline;
   a. What was the gravitational energy of the cart before it rolls down the incline?
   b. What will be the magnitude of the force that tends to cause the cart to accelerate down the incline?
   c. What will be the acceleration of the cart as it moves down the incline?
   d. How much time to it take for the cart to reach the bottom of the incline?
   e. What will be the velocity of the cart as it reaches the bottom of the incline?
   f. What will be the kinetic energy of the cart as it reaches the bottom of the incline?
   g. How much work was done by the gravitational force on the cart as it rolls to the bottom of the incline?

2. A car is sitting at the top of an inclined plane, which is 5.2 meters long and meets the horizontal at an angle of 12.0º. The cart is then allowed to roll to the bottom of the incline. What will be the velocity of the cart as it reaches the bottom of the incline?

3. A sled, which has a mass of 45.0 kg., is sitting on a horizontal surface. A force of 120 N is applied to a rope attached to the front of the sled such that the angle between the front of the sled and the horizontal is 35.0º. As a result of the application of this force the sled is pulled a distance of 500 meters at a relatively constant speed. How much work was done to this sled by the applied force?

4. A 25.0 kg crate is sitting at the bottom of an inclined plane. The inclined plane is 12.0 meters long, meets the horizontal at an angle of 15.0º and has a coefficient of sliding friction of $\mu = 0.55$. A force is applied to the crate so as to slide the crate up the incline at a constant speed.
   a. What will be the magnitude of the frictional force between the crate and the incline?
   b. What will be the magnitude of the gravitational force component opposing the motion of the sled up the incline?
   c. How much work will be done against the gravitational force in moving the crate to the top of the incline?
   d. What is the magnitude of the force F required to push the sled up the incline at a constant speed?
   e. How much work will be done by the applied force in pushing the mass to the top of the incline?
   f. What will be the gravitational potential energy of the crate when it reaches the top of the incline?
   g. How much work was done against the frictional force as the crate is pushed to the top of the incline?
   h. How are the work done by the external force, the work done against friction and the work done against gravity related?

5. A box, which has a mass of 14.0 kg , is sliding along a horizontal surface with a velocity of 18.0 m/sec when it encounters a frictionless inclined plane which meets the horizontal at an angle of 28.0^{o}. The box slides up the incline until it comes to a halt.
   a. What will be the kinetic energy of the crate before it reaches the bottom of the incline?
   b. What will be the gravitational potential energy of the crate when it finally stops on the incline?
   c. How far up the incline will the box slide before it stops?

Answers to opposite side: 6a. 427 N/m b. 143.5 J c. 143.5 J d. 143.5 J e. 5.81 m/sec
6f. 54.2 N g. 143.5 J h. 2.65 m i. 34.25 Cal 7a. 282 J b. 282 J c. 13.05 m d. 15.5 m/s
8a. 7.44 m/sec^2 b. 9.05 m/sec c. 1840 J d. 4470 J e. 1340 J f. 1290 J g. 1840 J

WORK & ENERGY

6. A spring is mounted horizontally as shown to the right. A crate, which has a mass of 8.5 kg is pressed against the spring with a force of 350 N. As a result the spring is compressed a distance of 82.0 cm. The mass is then released and is allowed to slide along the horizontal, frictionless surface.
   a. What is the spring constant of this spring?
   b. How much elastic potential energy will be stored in the spring?
   c. How much work will be done in compressing this spring?
   d. What will be the kinetic energy of this crate after it has left the spring?
   e. What will be the velocity of the crate after it has left the spring?

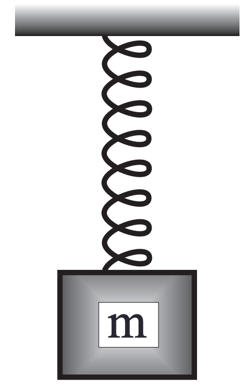
   Suppose now that there is friction between the crate and the horizontal surface and that the coefficient of sliding friction between the crate and the surface is $\mu = 0.65$ As a result the crate slows down until it stops.
   f. What will be the magnitude of the frictional force acting on the crate as it slides across the surface?
   g. How much work will be done on the crate by the frictional force from the time the crate is released until the mass stops?
   h. How far will the mass slide before it comes to a halt?
   i. How much heat will be generated as a result of the crate sliding across the surface? [Cal = 4.18 J]

7. A mass of 2.20 kg is placed on a stiff vertical spring, which has a spring constant of 950 N/m. The object is then pressed against the spring until it has been compressed a distance of 77.0 cm. The mass is then released and is allowed to be thrown up into the air.
   a. What will be the elastic potential energy stored in the spring just before the mass is released?
   b. What will be the gravitational energy of this mass when it reaches the highest point?
   c. How high in the air will the mass be thrown?
   d. What will be the velocity of the mass just as it leaves the end of the spring?

8. A mass of 45.0 kg is sitting at the bottom of an incline plane which is 5.5 meters long, has a coefficient of sliding friction of $\mu = 0.65$, and which meets the horizontal at an angle of 32.0°. A force of 812 N is applied to the mass so as to accelerate the mass up the inclined plane.
   a. What will be the rate of acceleration of this object up the inclined plane?
   b. What will be the velocity of this object when it reaches the top of the incline?
   c. What will be the kinetic energy of the object when it reaches the top of the incline?
   d. How much work is being done on the object by the applied force as it moves to the top of the incline?
   e. How much work will be done by the frictional force as the object is pushed to the top of the incline?
   f. What will be the gravitational potential energy of the mass when it reaches the top of the incline?
   g. What will be the NET work done to the object as it is pushed to the top of the incline?

Answers to opposite side: 1a. 24.6 J b. 5.46 N c. 2.37 m/sec^2 d. 1.95 sec e. 4.62 m/sec
1f. 24.6 J g. 24.6 J 2. 4.61 m/sec 3. 49,100 J 4a. 130 N b. 63.5 N c. 761 J d. 194 N
4e. 2320 J f. 761 J g. 1560 J h. 2320 J 5a. 2270 J b. 2270 J c. 35.2 m

WORK & ENERGY

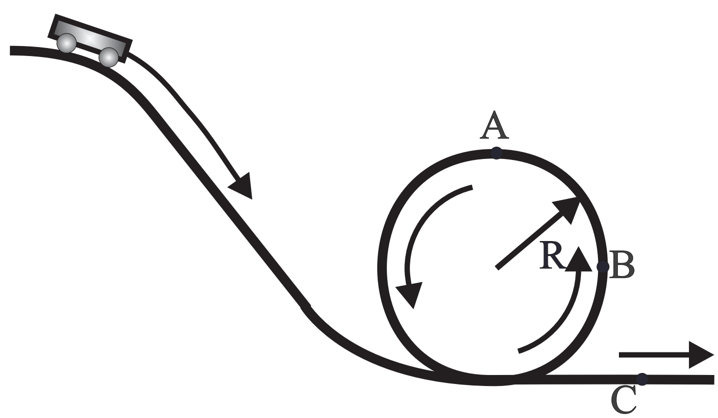


9. A vertical spring is hung from one end as shown to the right. A mass of m = 5.0 kg is hung from the end of the spring. As a result of the addition of this mass the spring is stretched a distance of 125 cm.
   a. What is the spring constant for this spring?
   b. How much would this spring be stretched if the mass was m = 15 kg instead?

   The 5.0 kg mass is then lifted up until the spring is unstretched. The mass is then released and is allowed to fall until at some lower point it stops. Assume that at this point h = 0 m.

   c. How far will the mass have fallen when it stops at the lowest point?
   d. What will be the gravitational potential energy stored in this system when the mass is at the lowest point?
   e. What will be the kinetic energy of this system when the mass reaches the lowest point?
   f. What will be the elastic potential energy stored in the spring when the mass is at the lowest point?
   g. What will be the elastic potential energy stored in the system when the mass is at the highest point?
   h. What will be the kinetic energy of this system when the mass is at the highest point?
   i. What will be the gravitational potential energy of this system when the mass is at the highest point?
   j. What will be the total energy of this system at the highest point?
   k. What will be the total energy of this system at the lowest point?
   l. What will be the total energy of this system when the mass is 65.0 cm below the highest point?
   m. What will be the gravitational energy of this system when the mass is 65.0 cm below the highest point?
   n. What will be the elastic potential energy of this system when the mass is 65.0 cm below the highest point?
   o. What will be the kinetic energy of this system when the mass is 65.0 cm below the highest point?
   p. What will be the velocity of the mass when it is 65.0 cm below the highest point?

10. A roller coaster sits at the top of a hill and is preparing to enter a loop-the-loop as shown to the right. The hill has a height of 86.0 meters, the loop has a radius of 22.0 meters and the roller coaster has a mass of 525 kg. Assume h=0 at the bottom of the hill.
   a. What is the gravitational potential energy of the roller coaster while at the top of the hill?
   b. What will be the velocity of the roller coaster when it reaches point C?
   c. What will be the velocity of the roller coaster when it reaches point A?
   d. What will be the velocity of the roller coaster when it reaches point B?
   e. Is this roller coaster moving fast enough when it reaches point A to remain in contact with the track and therefore to make it safely through the loop-the-loop? Support your answer with evidence!

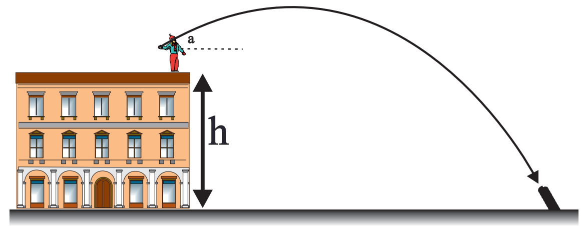


Answers to opposite side: 11a. 2041 J b. 2041 J c. 47.6 m/sec d. 2041 J e. 0.697 m 12a. 212 J 12b. 212 J c. 4.30 m/sec d. 307 N 13a. 4.03 J b. 67.2 N c. 1.35 m/sec d. 4.03 J e. 9.34 cm f. 15.4 ^{o}

PHYSICS HOMEWORK #46 ENERGY CONSERVATION

WORK & ENERGY

11. You are standing on top a building h = 42.0 meters high when you throw a ball, which has a mass of m = 1.8 kg., from the roof with a velocity of 38.0 m/sec at an angle of α above the horizontal as shown to the right. The ball flies through the air and lands on a spring which has a spring constant of 8,400 N/m. [Assume that air friction is negligible and the length of the spring is much shorter than the height of the building.]



a. What will be the total energy of this ball as it is thrown from the top of the building?

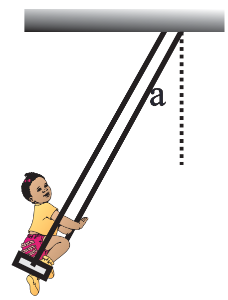
b. What will be the total energy of the ball just as it reaches the spring?

c. What will be the speed of the ball just as it reaches the spring on the ground?

d. How much energy will be stored in the spring when the mass briefly comes to rest against the spring?

e. How much will the spring be compressed just as the ball comes to rest against the spring?

12. A child, which has a mass of 23.0 kg., is sitting on a swing. The ropes of the swing are L =5.2 meters long and the child is pulled back until the angle between the ropes of the swing and the vertical is $\alpha = 35.0^o$ as shown to the right. The child is released and is allowed to swing back and forth.

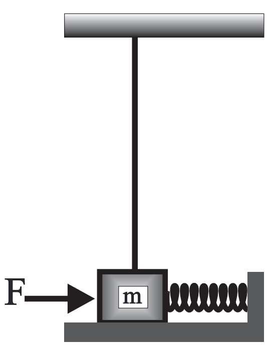


a. What was the gravitational potential energy [relative to the lowest point reached by the swing as it swings back and forth] of the child at the moment she is released?

b. What will be the total kinetic energy of the child at the lowest point of her swing?

c. What will be the child's velocity at the bottom of her swing?

d. What will be the tension in the ropes of the swing when the child swings through the lowest point?



Before

13. A mass at the end of a string, which is 2.60 meters long, is pressed against a horizontal spring as shown to the left. The other end of the string is attached to the ceiling. The mass is m = 4.40 kg, the spring has a spring constant of k = 560 N/m and the spring is compressed Δx = 12.0 cm by the applied force. The mass is then released and is allowed to swing outward until at some point it stops.

a. What will be the total energy of this system just before the mass is released?

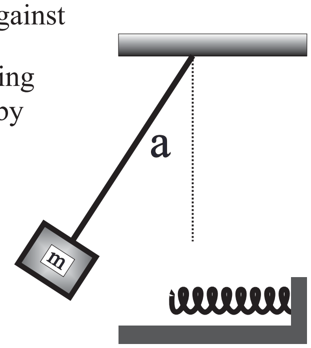
b. How much force F is needed to press this mass against the spring as shown?

c. What will be the velocity of the mass just as it leaves the spring?

d. What will be the total energy of the mass when it reaches the highest point?

e. How high will the mass be when it stops at the highest point?

f. What will be the angle α between the string and the vertical line as shown in the diagram to the right when the mass reaches the highest point?



After

Answers to opposite side: 9a. 39.23 N/m b. 3.75 m c. 2.50 m d. 0.0 J e. 0.0J f. 122.6 J 9g. 0.0 J h. 0.0 J i. 122.6 J j. 122.6 j k. 122.6 J l. 122.6 J m. 90.7 J n. 8.29 N 9o. 23.6 J p. 3.07 m/sec 10a. 443,000 J b. 41.1 m/sec c. 28.7 m/sec d. 35.4 m/sec 10e. Yes! 28.7 m/sec>14.7 m/sec

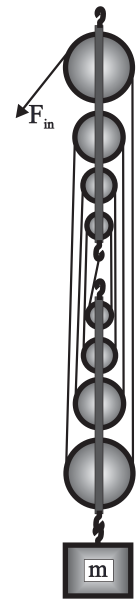
PHYSICS HOMEWORK #47 ENERGY CONSERVATION
MECHANICAL ADVANTAGE

1. What will be the mechanical advantage of a simple machine which produces an output force of 350 N for every 70 N of force put into the machine ?

2. A simple machine is known to have an actual mechanical advantage [AMA] of 4.4x. What will be the resulting output force of this machine if 120 N of force is put into this machine ?

3. A simple machine, which has a know AMA of 3.0x, produced an output force of 380 N. How much force must put into this machine ?

4. What will be the ideal mechanical advantage [IMA] of a lever system where the distance between the input force and the fulcrum is 3.5 m while the distance between the output force and the fulcrum is 45 cm. ?



5. What will be the IMA of a simple machine which consists of a system of eight pulleys used as shown to the right? How much force F_{in} must be applied in order to lift a LOAD of m = 8000 kg. ?

6. What will be the IMA of an inclined plane which meets the ground at an angle of 37.0^o ?

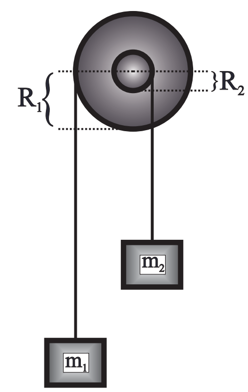
7. A force of 62 N is needed to push a 22 kg mass up an inclined plane. What is the AMA of this machine?

8. A system of pulleys is used to lift the engine [LOAD] out of the engine compartment of a car. The weight of the engine is 630 lbs. A force of 105 lbs [F_{in}] is applied to the input of the pulley system in order to lift the engine. Assuming negligible friction, how many pulleys are there in this pulley system ?

9. You would like to use an inclined plane to push a piano, which weighs 1255 lbs., into a truck. The bed of the truck is 1.22 meters above the ground. Assuming negligible friction and that the maximum force that you are capable of exerting is 160 lbs., how long should the incline be?

10. A simple machine, which has an AMA of 2.3x, is used to apply a force to a second simple machine, which has an AMA of 5.0x. What will be the total AMA of this compound [a machine made up of two or more simple machines!] machine ?

11. A wheel and axle, as shown to the right, is used to lift a load m_2 = 15.0 kg. with an input mass of m_1. The radius of the wheel is R_1 = 12.0 cm and the radius of the axle is R_2 = 4.0 cm.
   a. What is the ideal mechanical advantage of this simple machine ?
   b. What minimum mass m_1 is required to lift the load question ?
   c. Suppose that the input mass falls a distance of 24.0 cm, how high will the load then be lifted ?



12. A series of simple machines is set up so that the output of each machine is the input of the next machine in series. The AMA of the individual machines is 4.5x, 12x, 5.6x, and 9.2x. What will be the total AMA of this compound machine ?

13. What will be the output force of the machine in #12 if a force of 866 lbs is applied to the input ?

14. A simple machine, which has an IMA of 6.2x and an efficiency of 100%, is used to lift a load of 650 kg to a height of 25 cm with an input force of 1028 N. Through what distance must the input force be applied?

15. A simple machine is designed so that an input force of 670 N produces an output force of 32 N. What is the AMA ? Why would such a machine be designed since the output force is clearly less that the force input ?

Answers to opposite side: 16a. 12.7 J b. 9.9 J c. 78% d. 4.7x e. 6.0x 17. 66% 18. 57% 19. 83%
20a. 2.7x b. 76.8 N c. 1.5x d. 57% 21. 73% 22a. 24% b. in the environment around the engine
22c. raise the temperature at which the fuel is being burned 23. 32% 24. 362^o C 25. work is being done by the gas

PHYSICS HOMEWORK #48 ENERGY CONSERVATION
MECHANICAL & THERMAL EFFICIENCY

$$EFF = W_{out}/W_{in} = AMA/IMA$$

16. A force of 23 N is applied through a distance of 55 cm to the input of a simple machine. As a result of this, the output force lifts a load of 11 kg to a height of 9.2 cm.
 a. How much work will be put into this machine ?
 b. What will be the work output of this machine ?
 c. What is the efficiency of this machine ?
 d. What is the AMA of this machine ?
 e. What is the IMA of this machine ?
 f. Why are the two answers to d and e different ?

17. A system of eight pulleys generates an AMA of 5.3x. What is the efficiency of this machine?

18. A given machine has an AMA of 4.5x and an IMA of 7.9x. What is the efficiency of this machine?

19. A force of 44 N is applied to the input of a simple machine which has an IMA of 6.0x. The resulting output force is 220 N. What is the efficiency of this machine ?

20. A 12 kg mass is sitting at the bottom of an inclined plane which meets the ground at an angle of 22.0^o. The coefficient of sliding friction between the incline and the mass is $\mu = 0.30$.
 a. What is the IMA of this inclined plane ?
 b. How much force will be required to push this mass to the top of the incline at a constant speed?
 c. What is the AMA of this machine ?
 d. What is the efficiency of this machine ?

THERMAL EFFICIENCY

21. A furnace has an output of 80,000 BTU with an input of 110,000 BTU. What is the thermal efficiency of this furnace? Where did the missing energy go ?

22. An automobile engine operates such that the air_fuel mixture burns at a temperature of 620^o C while the exhaust leaves the engine with a temperature of 410^o C.
 a. What is the thermal efficiency of this engine ?
 b. Where in the missing heat energy ?
 c. What could be done to improve the thermal efficiency of this engine ?

23. Suppose that the steam coming out of a steam generator in a nuclear power plant is at a temperature of 730^oC when it is allowed to expand against the blade of a turbine electrical generator and in doing so cools to a temperature of 412^o C. What is the thermal efficiency of this power plant?

24. A heat engine is desired to have a minimum thermal efficiency of 52%. Given that the heat sink that is economically available has a temperature of 32.0^o C, at what temperature should the fuel be burned ?

25. When hot steam expands against the blade of a turbine the temperature of the steam drops. Why ?

Answers to opposite side: 1. 5.0x 2. 530 N 3. 127 N 4. 7.8x 5. 8.0x, 9800 N 6. 1.7x
7. 3.5x 8. 6 pulleys 9. 9.6 m 10. 11.5x 11a.3X b. 5.0 kg c. 8.0 cm 12. 2780x
13. 2,410,000 lb !! 14. 1.55 m 15. 0.048x [increased distance]

PHYSICS HOMEWORK #49 ENERGY CONSERVATION
UNIVERSAL GRAVITATION

PLANET	RADIUS	MASS	ORBITAL ALTITUDE
Sun	6.96×10^{8} m	1.99×10^{30} kg	N/A
Mercury	2.44×10^{6} m	3.30×10^{23} kg	5.79×10^{10} m
Venus	6.05×10^{6} m	4.87×10^{24} kg	1.08×10^{11} m
Earth	6.38×10^{6} m	5.97×10^{24} kg	1.50×10^{11} m
Moon	1.74×10^{6} m	7.35×10^{22} kg	3.80×10^{8} m
Mars	3.39×10^{6} m	6.42×10^{23} kg	2.28×10^{11} m
Jupiter	7.14×10^{7} m	1.90×10^{27} kg	7.79×10^{11} m
Io	1.82×10^{6} m	7.87×10^{22} kg	7.18×10^{7} m
Europa	1.57×10^{6} m	4.78×10^{22} kg	7.21×10^{7} m
Ganymede	2.63×10^{6} m	1.54×10^{23} kg	7.25×10^{7} m
Callisto	2.40×10^{6} m	7.35×10^{22} kg	7.33×10^{7} m
Saturn	6.00×10^{7} m	5.68×10^{26} kg	1.13×10^{12} m
Titan	2.58×10^{6} m	1.19×10^{23} kg	6.12×10^{7} m
Uranus	2.54×10^{7} m	8.66×10^{25} kg	2.87×10^{12} m
Neptune	2.43×10^{7} m	1.03×10^{26} kg	4.50×10^{12} m
Triton	1.90×10^{6} m	1.34×10^{23} kg	2.47×10^{7} m

Gravitational Force

$$F_g = \frac{G \cdot m_1 \cdot m_2}{r^2}$$

Gravitational Potential Energy

$$F_g = \frac{-G \cdot m_1 \cdot m_2}{r}$$

Universal Constant

$G = 6.67 \times 10^{-11}$ Nm²/kg²

Speed of Light

$c = 3.0 \times 10^{8}$ **m/sec**

For each of the following questions assume that zero gravitational energy occurs at infinity. [Very far away!]

1. What will be the **gravitational force** acting on a 32,000 kg rocket ship orbiting Mars at an altitude of 450 km?
2. What will be the **gravitational force** acting on a 650 kg. satellite orbiting Uranus at an altitude of 12,500 km.?
3. What will be the **gravitational potential energy** of a 32,000 Kg rocket sitting on the surface of Mars?
4. What will be the **gravitational potential energy** of a 32,000 Kg rocket orbiting Mars at an altitude of 450 km?
5. What will be the **gravitational potential energy** of a 52,000 kg rocket orbiting Saturn at an altitude of 10,000 km?
6. What would the **velocity** of a 52,000 kg rocket have to be in order to orbit the planet Saturn at an altitude of 10,000 km?
7. Each of the following questions refers to a rocket which has a mass of 64,000 kg. and Jupiter's moon Callisto.
   a. What would the **velocity** of this rocket have to be in order for it to orbit Callisto at an altitude of 4,600 km?
   b. What would be the **gravitational force** between this rocket and Callisto while orbiting at this altitude?
   c. What would be the **kinetic energy** of this rocket while orbiting Callisto at this altitude?
   d. What would be the **gravitational potential energy** of this rocket while orbiting Callisto at this altitude?
   e. What would be the **total energy** of this rocket while orbiting Callisto at an altitude of 4,600 km?
   f. What would be the **total energy** of this rocket while sitting at rest on the surface of Callisto?
   g. How much **kinetic energy** would you have to give to this rocket while sitting on the surface of Callisto in order to put the rocket into orbit around Callisto at an altitude of 4,600 km.?
   h. With what **velocity** would this rocket have to be launched from the surface of Callisto in order to go into orbit around Callisto at an altitude of 4,600 km.?
   i. With what **velocity** would this rocket have to be launched from the surface of Callisto in order for the rocket to escape the gravitational effects of Callisto?

Answers to opposite side: 8a. -2.04×10^{12} J b. 7020 m/sec c. -9.35×10^{11} J d. 7630 m/sec e. 10,400 m/sec 8f. 9410 m/sec 9a. 14,200 m/sec b. -6.41×10^{12} J c. 1.28×10^{13} J d. 20,000 m/sec e. 0.15 m 10a. 37,200 m/sec b. -2.22×10^{13} J c. 2.22×10^{13} J d. 24,800 m/sec e. 2.82 m 11a. 8.85 mm b. 16.22 km 11c. 3.22 km d. 59.0 km e. 50.1 km 12a. BD b. BH c. BD d. NS e. BD f. NS g. BH h. BD 13a. 1.41×10^{12} J b. -5.00×10^{12} J c. 6.41×10^{12} J

PHYSICS HOMEWORK #50 ENERGY CONSERVATION
UNIVERSAL GRAVITATION

8. A rocket, which has a mass of 38,000 kg is initially sitting at rest on the surface of the planet Venus.
   a. What is the **total energy content** of this rocket while sitting at rest on the surface of Venus?
   b. What **velocity** would be required for this rocket to orbit Venus at an altitude of 550 km.?
   c. What **total energy** is required if this rocket is to orbit Venus at an altitude of 550 km.?
   d. With what **velocity** should this rocket be launched from the surface of Venus in order to go into orbit around Venus at an altitude of 550 km.?
   e. With what **minimum velocity** should this rocket be launched from the surface of Venus in order to escape the gravitational effects of Venus?
   f. What will be the **velocity** of this rocket when it is very far from Venus if the rocket is launched from the surface of Venus with a velocity of 1.40×10^4 m/s?

9. A rocket, which has a mass of 64,000 kg, is sitting on the surface of Neptune [impossible since Neptune does not, as far as we know, have a solid surface, but let's pretend!]. This rocket is to be launched from Neptune's surface with the intention of going into orbit around the planet Neptune at an altitude of 10,000 km.
   a. With what **minimum velocity** should this rocket be launched from Neptune's surface in order to go into orbit around Neptune at the given altitude?
   b. What will be the **total energy** content of this rocket while orbiting Neptune at the given altitude?
   c. How much **kinetic energy** must be added to this orbiting rocket if it is to escape the gravitational effects of Neptune?
   d. What **velocity** must this orbiting rocket attain in order for it to escape the gravitational effects of Neptune?
   Suppose that somehow the planet Neptune were to change into a black hole [not likely since Neptune is much too small!]
   e. What would the **maximum radius** of Neptune have to be in order for it to become a black hole?

10. A 32,000 kg rocket is orbiting the planet Jupiter at an altitude of 20,000 km.
   a. What is the **velocity** of this rocket while orbiting Jupiter at this altitude?
   b. What is the **total energ**y content of this rocket while orbiting at this altitude?
   c. How much **additional energy** must this rocket acquire in order to leave orbit and escape the gravity of Jupiter?
   d. Suppose that this orbiting rocket is given an additional 3.2×10^{13} J of energy, what will be the resulting **velocity** of this rocket when it is very far from Jupiter?
   e. What would the maximum **radius** of Jupiter have to be if it was to become a black hole?

11. Determine the **event horizon** of each of the following if each was to become a black hole:
   a. Earth b. Cygnus X-1 [5.5 solar masses - known black hole - http://www.owlnet.rice.edu/~spac250/steve/index.html]
   c. Alpha Centauri [1.09 solar masses] d. Betelgeuse [20 solar masses] e. Rigel [17 solar masses]

12. Which of the following stars is likely to become a: 1. Brown Dwarf? 2. Neutron Star? 3. Black Hole?
   a. Canis Minoris [1.8 solar masses] b. Rigel [17 solar masses] c. Epsilon Eridani [0.80 solar masses]
   d. Algol [2.8 solar masses] e. Alpha Libra [1.33 solar masses] f. Altair [2.0 solar masses]
   g. Spica [10.9 solar masses] h. Barnard's Star [0.16 solar masses]

13. A rocket, which has a mass of 18,000 kg is moving through space with a velocity of 12,500 m/sec when it begins its approach to Saturn. This rocket would like to go into orbit around Saturn at an altitude of 8,200 km.
   a. What is the **initial total energ**y of this rocket before it approaches Saturn?
   b. What **total energy** is required in order for the rocket to go into orbit around Saturn at the given altitude?
   c. How much **energy** must be **dumped** in order for this rocket to go into orbit around Saturn at the given altitude?

Answers to opposite side: 1. 9.29×10^4 N 2. 2.61×10^3 N 3. -4.04×10^{11} J 4. -3.57×10^{11} J
5. -2.81×10^{13} J 6. 2.33×10^4 m/sec 7a. 837 m/sec b. 6400 N c. 2.24×10^{10} J d. -4.48×10^{10} J
7e. -2.24×10^{10} J f. -1.31×10^{11} J g. 1.08×10^{11} J h. 1.84×10^3 m/sec i. 2.02×10^3 m/sec

PHYSICS HOMEWORK #51 MOMENTUM CONSERVATION
ONE DIMENSIONAL MOMENTUM

[Each problem should be accompanied by a clearly labeled diagram showing the masses and velocities both objects before and after the collision!]

1. What will be the momentum of a 1250 kg automobile moving with a velocity of 23.0 m/s?

2. What will be the momentum of a 0.675 kg baseball moving with a velocity of 39.5 m/s?

3. How fast must a 3.50 kg bowling ball move in order to have a momentum of 44.5 kg m/s?

4. What will be the momentum of a proton [$m_p = 1.67 \times 10^{-27}$ kg] moving with a velocity of 2.50×10^7 m/s?

5. A ball, which has a mass of 1.25 kg, is thrown straight up from the top of a building 225 meters tall with a velocity of 52.0 m/s. What will be the momentum of this ball just as it reaches the ground?

6. A 2.38 kg projectile is fired with a velocity of 187 m/s at an angle of 22.7^o above the horizontal. What will be the momentum of this projectile at the highest point of its trajectory?

7. Consider a rifle, which has a mass of 2.44 kg and a bullet which has a mass of 150 grams and is loaded in the firing chamber. When the rifle is fired the bullet leaves the rifle with a muzzle velocity of 440 m/s;
   a. What will be the momentum of the rifle immediately before the bullet is fired?
   b. What will be the momentum of the rifle-bullet combination before the bullet is fired?
   c. What will be the momentum of the bullet immediately after the rifle has been fired?
   d. What will be the momentum of the rifle immediately after it has been fired?
   e. What will be the momentum of the rifle-bullet combination immediately after the bullet had been fired?
   f. What will be the velocity of the rifle immediately after the rifle has been fired?
   g. After the rifle has been fired it comes into contact with the marksman's shoulder and then comes to a halt during a time period of 0.38 seconds. What is the average force applied to the rifle by the shoulder?

   After the bullet leaves the rifle is strikes a block of wood which has a mass of 5.10 kg. and is sitting on a horizontal surface which has a coefficient of sliding friction of $\mu = 0.83$.

   h. What will be the velocity of the bullet-block combination immediately after the bullet strikes the block of wood?
   i. How far will the block slide along the horizontal surface before it comes to a halt?
   j. How much energy was lost as the bullet was lodged in the block of wood?

8. An object, which has a mass of 6.0 kg, is moving to the right with a velocity of 8.0 m/s when it collides with a second mass of 12.0 kg which is initially at rest. After the collision the 12.0 kg mass moves off to the right with a new velocity of 5.33 m/s.
   a. What will be the final velocity of the 6.0 kg mass?
   b. Is this collision elastic? How do you know? Support your answer with evidence!

9. A railroad car, which has a mass of 18,000 kg., is moving with a velocity of 2.80 m/s when it collides with a second railroad car, which has a mass of 13,000 kg. and is at rest.
   a. The first car couples with the second car upon collision. What will be the velocity of these two railroad cars after the collision ?
   b. How much energy is lost in the collision between these two railroad cars?

Answers to opposite side: 10. 41,400 kg m/s 11a. =4.69 m/s b. -10.0 m/s c. 10.0 m/s d. *e* = 1
12a. -23.8 m/s [53 MPH] b.- 3.7 m/s c. 3.14 m/s d. *e* = 0.85 e. 1.93×10^3 J 13. 3.90 m/s
14. 146,000 m/s 15a. 1.71 m/s b. 0.542 c. 222 J 16. -10,800 N s 17a. -65.1 N s b. ~ 0.000526 s
17c. ~ 49,500 N

PHYSICS HOMEWORK #52 MOMENTUM CONSERVATION
ONE DIMENSIONAL MOMENTUM

10. A car, which has a mass of 1800 kg and is moving with a velocity of 23.0 m/s, suddenly explodes into many pieces. What will be the momentum of this car immediately after the explosion?

11. A mass of 8.0 kg is moving toward the right with a velocity of 3.0 m/s when it collides head on with a mass of 5.0 kg moving to the left with a velocity of 7.0 m/s. After the collision the 5.0 kg mass rebounds toward the right with a velocity of 5.3 m/s.
    a. What will be the final velocity of the 8.0 kg mass after the collision?
    b. What is the relative velocity between these two masses immediately before they collide?
    c. What will be the relative velocity between these two masses immediately after they collide?
    d. What will be the coefficient of elasticity in this collision?

12. A car, which has a mass of 1750 kg, is moving South on route 9 with a speed of 24.6 m/s [55 MPH] when it rear ends a second car, which has a mass of 2325 kg, and which is also moving South on Route 9 but with a velocity of 20.9 m/s [47 MPH]. After the collision the first car's velocity is reduced to 20.7 m/s [44.5 MPH].
    a. What will be the final velocity of the second car immediately after the collision?
    b. What is the relative velocity between these two cars immediately before they collide?
    c. What will be the relative velocity between these two cars immediately after they collide?
    d. What is the coefficient of elasticity in this collision?
    e. How much energy will be lost in this collision?

13. An elephant, which has a mass of 2200 kg., is moving with a velocity of 11.0 m/s across a frozen lake in Africa when it begins to slide across the ice. The sliding elephant then collides with a massive 4000.0 kg ball of putty which was left behind when a local pottery business went kaput. After the collision the elephant sticks to the putty and both slide across the ice together. What will be the velocity of the elephant-putty combination?

14. A rocket, which has a rest mass of 235,000 kg, including 186,000 kg of fuel, is sitting "at rest" in space. When this fuel is burned it is exhausted from the rocket with a velocity of 38,500 m/s. [For simplicity assume that all the fuel is emitted at once!] What will be the final velocity of the rocket?

15. A 5.0 kg mass is moving toward the right with a velocity of 8.0 m/s when it collides with a second mass of 9.0 kg which is moving toward the left with a velocity of 6.0 m/s. After the collision the 5.0 kg mass rebounds to the left with a final velocity of 5.88 m/s.
    a. What will be the final velocity of the second mass after the collision?
    b. What is the coefficient of restitution in this collision?
    c. How much energy was lost in this collision?

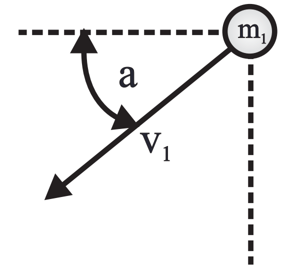
16. An automobile is moving with a velocity of 22.0 m/s and has a mass of 1350 kg. After braking for a short time the velocity of the car is reduced to 14.0 m/s. How much impulse was delivered to the car?

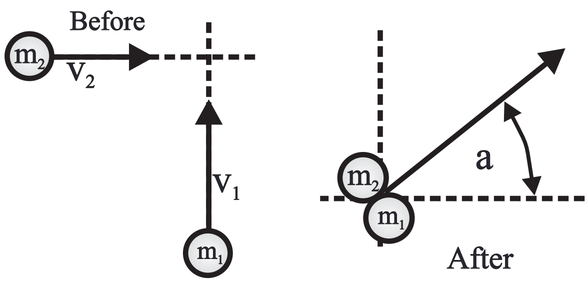
17. A baseball, which has a mass of 0.685 kg., is moving with a velocity of 38.0 m/s when it contacts the baseball bat during which time the velocity of the ball becomes 57.0 m/s in the opposite direction.
    a. How much impulse has been delivered to the ball by the bat?
    While in contact with the bat the ball undergoes a maximum compression of approximately 1.0 cm.
    b. Approximately how long did it take for the ball to be stopped by the bat?
    c. What will be the average force applied to the ball by the bat while stopping the ball?

Answers to opposite side: 1. 28,800 kg m/s 2. 26.7 kg m/s 3. 12.7 m/s 4. 4.2×10^{-20} kg m/s
5. 106 kg m/s 6. 411 kg m/s 7a. zero b. zero c. 66 kg m/s d. -66 kg m/s e. zero f. -27.0 m/s
7g. 174 N h. 12.6 m/s i. 9.7 m j. 1.41×10^{4} J 8a.- 2.66 m/s b. yes elastic; 192 J = 192 J
9a. 1.63 m/s b. 29,600 J

PHYSICS HOMEWORK #53 MOMENTUM CONSERVATION
TWO DIMENSIONAL MOMENTUM

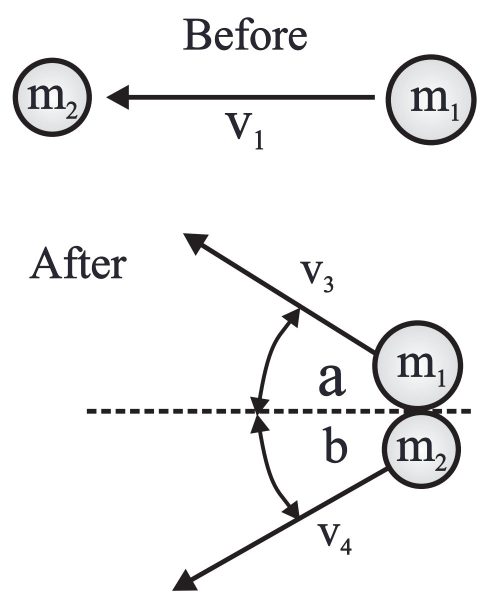
18. A ball, which has a mass of $m_1 = 2.50$ kg., is moving with a velocity of 8.00 m/s at an angle of $\alpha = 25.0^{o}$ South of West as shown to the right.
   a. What is the magnitude of the momentum of this ball?
   b. What will be the magnitude of the ball's momentum parallel to the x axis?
   c. What will be the magnitude of the ball's momentum parallel to the y axis?





19. A mass $m_1 = 6.20$ kg is moving North with a velocity of $v_1 = 13.5$ m/sec when it collides perpendicularly with another mass $m_2 = 4.40$ kg. moving East with a velocity of $v_2 = 8.80$ m/sec. as shown to the left. Mass m_1 runs into mass m_2 in an inelastic collision and both masses stick together and move off after the collision at an angle α as shown.
   a. What will be the direction and magnitude of the momentum of m_1 before the collision?
   b. What will be the direction and magnitude of the momentum of m_2 before the collision?
   c. What will be the direction α and magnitude of the total momentum of these two masses before the collision?
   d. What will be the direction and magnitude of the total momentum of these two masses after the collision?
   e. What will be the velocity of these two masses after the collision?
   f. How much kinetic energy was lost in this inelastic collision?

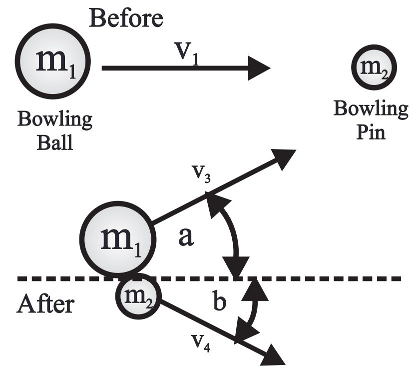
20. A mass $m_1 = 6.40$ kg is moving toward the left with a velocity of $v_1 = 11.2$ m/sec when it collides with a second mass $m_2 = 4.60$ kg which is initially at rest. After the collision the first mass bounces off to the right of the initial path of motion with a velocity of $v_3 = 9.50$ m/sec at an angle $\alpha = 20.4^{o}$ while the second mass m_2 bounces off to the left of the original path of motion with a velocity v_4 at an angle β as shown to the right.
   a. What is the initial total momentum in this system ?
   b. What is the initial momentum of this system in the x direction ?
   c. What is the initial momentum of this system in the y direction ?
   d. Write the expression relating the momentum of this system in the x direction before and after the collision.
   e. Write the expression relating the momentum of this system in the y direction before and after the collision.
   f. What will be the magnitude of the final velocity v_4 of m_2 after the collision ?
   g. What will be the direction of motion β of m_2 after the collision ?
   h. What will be the total kinetic energy of this system before the collision ?
   i. What will be the total kinetic energy of this system after the collision ?
   j. Was the collision between these two masses elastic or inelastic ?

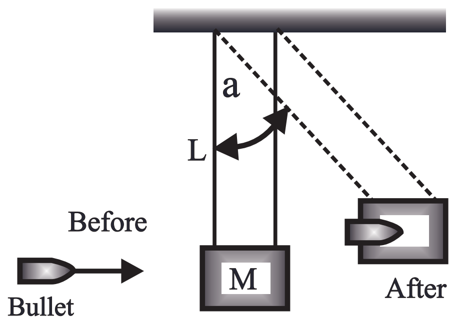


Answers to opposite side : 21a. 8.40 m/sec b. 8.37° c. elastic; $KE_{before} = KE_{after} = 260$ J
22a. 13.2 J b. 2.30 m/sec c. 179 m/sec d. 1030 J e. 2.11 m/sec f. 1050 J
23a. 3.80 m/sec b. $\alpha = 82.2^{o}$ c. 5.29 J [lost] d. inelastic, because KE was lost

PHYSICS HOMEWORK #54 MOMENTUM CONSERVATION
TWO DIMENSIONAL MOMENTUM

21. A bowling ball, which has a mass of $m_1 = 5.75$ kg., is moving toward the right with a velocity of $V_1 = 9.50$ m/sec when it collides with a bowling pin which has a mass of $m_2 = 850$ grams. After the collision the bowling pin is deflected with a velocity of $V_4 = 11.54$ m/sec at an angle of $\beta = 45.8^o$.
   a. What will be the final speed of the bowling ball after this collision ?
   b. To what angle a will the bowling ball be deflected by its collision with the bowling pin ?
   c. Is this collision elastic or inelastic? Explain and justify numerically!

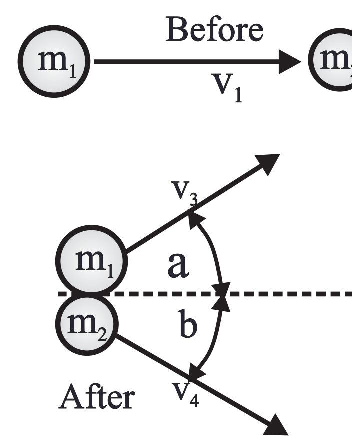




Ballistics Pendulum

22. A rifle, which has a mass of 5.50 kg., is used to fire a bullet, which has a mass of m = 65.0 grams., at a “ballistics pendulum”. The ballistics pendulum consists of a block of wood, which has a mass of M = 5.00 kg., attached to two strings which are L = 125 cm long. When the block is struck by the bullet the block swings backward until the angle between the ballistics pendulum and the vertical reaches a maximum angle of $\alpha = 38.0^o$.
   a. What will be the maximum gravitational energy contained in the ballistics pendulum when it reaches the maximum angle?
   b. What was the velocity of the block of wood immediately after being struck by the bullet?
   c. What was the velocity of the bullet immediately before it strikes the block of wood?
   d. How much work was done by the bullet as it lodged in the block of wood?
   e. What will be the recoil velocity of the rifle?
   f. How much energy was released when the bullet was fired?

23. A mass of $m_1 = 3.50$ kg is moving toward the right with a velocity of $V_1 = 7.70$ m/sec when it collides with a second mass of $m_2 = 5.50$ kg. After the collision the second mass bounces off to the right of the original path of motion of the first ball at an angle of $\triangle\beta = 27.65^o$ with a speed of $V_4 = 5.16$ m/sec.
   a. What will be the magnitude of the final velocity v_3 of the first mass after the collision?
   b. What will be the direction of motion $\triangle\alpha$ of the first ball after the collision?
   c. How much energy was lost or gained in this collision?
   d. Was this collision elastic or inelastic? Explain!



Answers to the opposite side: 8a. 20.0 kg m/sec b. -18.1 kg m/sec i c. -8.45 kg m/sec j
19a. 83.7 kg m/sec j b. 38.7 kg m/sec i c. 92.2 kg m/sec at 65.2^o NE d. same as c e. 8.70 m/sec
19f. 334 J lost 20a. -71.7 kg m/sec i b. -71.7 kg m/sec i c. 0.0 kg m/sec
20d. $71.7 = 57.0 + 4.6\, V_4 \cos(\beta)$ e. $0 = 21.2 - 4.6\, V_4 \sin(\beta)$ f. 5.61 m/sec g. 55.3^o h. 401 J
20i. 361 J 20j. Inelastic

PHYSICS HOMEWORK #61 ROTATIONAL KINEMATICS
ANGULAR VELOCITY

1. A wheel rotates three times. Through what angular displacement [in radians] did this wheel rotate?

2. Through what angular displacement does the earth turn in 24 hours?

3. According to the tachometer in a car the engine is rotating at 3500 RPM [revolutions per minute]. Through what angle will this engine rotate each minute?

4. The Milky Way Galaxy rotates once each 200,000,000 years. Through what angle will this galaxy rotate over a period of 2,000 years?

5. A spinning wheel rotates 47 times in 12 seconds. What is the angular velocity of the wheel?

6. What is the angular velocity of the Earth's orbit around the sun?

7. Jupiter rotates once on its axis every 10 hours. What is Jupiter's angular velocity?

8. An ice skater going into a spin rotates with an angular velocity of 27 Rad/sec. How many revolutions will the skater make each second?

9. A motor is rotating with an angular velocity of 285 Rad/sec. What is the angular velocity of this motor in RPM's?

10. A wheel, which has a radius of 14 cm., is rotating with an angular velocity of 25 Rad/sec. What will be the linear velocity of a point on the outer edge of the wheel?

11. An automobile is moving with a velocity of 22 m/s. The tires on the car have a diameter of 78 cm. What will be the angular velocity of the wheels on this car?

12. What is the angular velocity of the Earth's rotation?

13. What will be the linear velocity of someone standing at the equator of the Earth, assuming that the diameter of the Earth is 7926 miles?

14. Suppose that a wheel, which is rotating with an angular velocity of 14 Rad/sec., is accelerated to an angular velocity of 22 Rad/sec. over a period of 5.0 seconds. What is the rate of acceleration of this wheel?

15. Suppose that the angular velocity of a spinning ball fell from 27 Rad/sec to 6.0 Rad/sec over a period of 2.3 seconds. What is the angular acceleration of this ball?

16. A disc is accelerated from rest at a rate of 4.3 Rad/sec2 for a period of 12 seconds. What will be the final angular velocity of this disc?

17. A wheel rotates with a constant angular velocity of 34 Rad/sec for a period of 12 seconds. What will be the final angular displacement of this wheel?

Answers to opposite side: 18. 4.0×10^{-8} Rad/s^2 19. 0.52 kg m^2 20. 0.0036 kg m^2 21. 0.46 kg m^2 22. 9.7×10^{37} kg m^2 23. 24 Nm 24. 0.25 Rad/s^2 25. 10.7 Rad/s^2 26a. 18.5 Nm b. 1.12 kg m^2 26c. 16.5 Rad/s^2 d. 82.5 Rad/s e. 30.5 m/s f. 41.3 Rad/s g. 206 Rad h. 3810 J i. 3810 J 26j. 92.4 kg m/s k. 1526 Watts l. 94.4 Rad/s m. 266 Rad n. 4920 J

PHYSICS HOMEWORK #62 ROTATIONAL KINEMATICS
MOMENT OF INERTIA

18. What angular acceleration would be required in order to stop the Earth from rotating over a period of 30.0 minutes?

19. What is the moment of inertia of a wheel shaped like a ring, which has a radius of 34 cm and a mass of 4.5 kg.?

20. What is the moment of inertia of a 2.5 kg. sphere which has a radius of 6.0 cm.?

21. What is the moment of inertia of a disc which has a mass of 4.4 kg and a radius of 45 cm.?

22. The Earth has a mass of 5.98×10^{24} kg and an average radius of 6.37×10^{6} meters. Assuming that the Earth is a uniform sphere [which it is not!] what is the moment of inertia of the Earth?

23. A force of 80.0 Newtons is tangentially applied to the outer edge of a wheel which has a radius of 30.0 cm. How much torque is being applied?

24. A torque of 100. Nm is applied to a sphere which has a moment of inertia of 400 kg m^2. What will be the resulting angular acceleration of the sphere?

25. A torque of 30.0 Nm is applied to a ring which has a moment of inertia of 2.81 kgm^2. What will be the resulting angular acceleration of this ring?

26. Consider a wheel, which is shaped like a ring, has a mass of 8.2 kg and a diameter of 74 cm. A tangential force of 50.0 N is applied to the outer edge of the wheel for 5.0 seconds. The wheel is initially at rest.
   a. What is the magnitude of the torque being applied to the wheel?
   b. What is the moment of inertia of this wheel?
   c. What will be the resulting angular acceleration?
   d. What will be the angular velocity of the wheel after 5.0 seconds?
   e. What will be the linear velocity of a point on the outer edge of the wheel after 5.0 seconds?
   f. What will be the average angular velocity of this wheel during this 5.0 second interval?
   g. What will be the total angular displacement of this wheel during the 5.0 second interval?
   h. What is the total work done on the wheel during the 5.0 second interval?
   i. What will be the final kinetic energy of this wheel at the end of the 5.0 second interval?
   j. What will be the angular momentum of this wheel at the end of the 5.0 second interval?
   k. What is the power being applied to the wheel when t = 5.0 seconds?

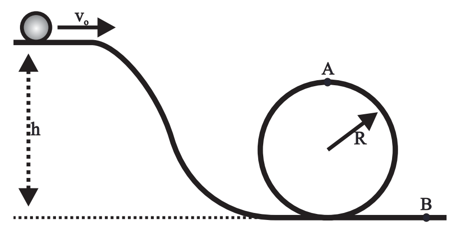
   Suppose that the wheel has an initial angular velocity of 12.0 Rad/s before the external torque has been applied.
   l. What will be the angular velocity of the wheel at the end of 5.0 seconds?
   m. What will be the total angular displacement of this wheel during the 5.0 second period?
   n. How much work will be done on this wheel during the 5.0 second period?

Answers to opposite side: 1. 18.8 Rad 2. 6.28 Rad 3. 22,000 Rad 4. 6.28×10^{-5} Rad
5. 25 Rad/s 6. 2.0×10^{-7} Rad/s 7. 1.74×10^{-4} Rad/s 8. 4.3 Rev 9. 2720 RPM 10. 3.5 m/s
11. 56.4 Rad/s 12. 7.27×10^{-5} Rad/s 13. 0.288 miles/s 14. 1.6 Rad/s^2 15. -9.1 Rad/s^2
16. 51.6 Rad/s 17. 408 Rad

PHYSICS HOMEWORK #63 ROTATIONAL KINEMATICS
ANGULAR ACCELERATION

27. A uniform disc, which has a mass of 3.50 kg and a radius of 28.0 cm, is accelerated from rest by a tangential force of 28.0 N applied to the outer edge of the disc.
 a. What is the moment of inertia of this disc?
 b. What is the magnitude of the torque being applied to this disc?
 c. What will be the angular acceleration of this disc?
 d. What will be the angular velocity of this disc after 8.00 seconds?
 e. What will be the linear velocity of a point on the outer edge of the disc at the end of 8.00 seconds?
 f. What will be the angular displacement of this disc during the 8.00 seconds period?
 g. What will be the linear displacement of a point on the outer edge of this disc during the 8.00 second period?
 h. How much work was done on this disc during the 8.0 seconds time period?
 i. What will be the final angular momentum of this disc?
 j. What is the final angular kinetic energy of this disc?

28. Consider a ball [shaped like a solid sphere], which has a mass of 4.80 kg and a radius of 18.0 cm, and which is rolling along a horizontal surface with a velocity of 7.20 m/s when it encounters a hill, rolls to the bottom of the hill and through a loop-the-loop as shown to the right. The hill has a height of h = 5.60 m and the loop has a radius of 2.20 m.



 a. What is the total energy of this ball as it rolls along the top of the hill?
 b. What will be the total energy of this ball when it reaches point B?
 c. What will be the velocity of this ball when it reaches point B?
 d. What will be the total energy of this ball when it reaches point A?
 e. What will be the kinetic energy of the ball when it reaches point A?
 f. What will be the velocity of this ball when it reaches point A?
 g. Is this ball going fast enough to make it through the loop?

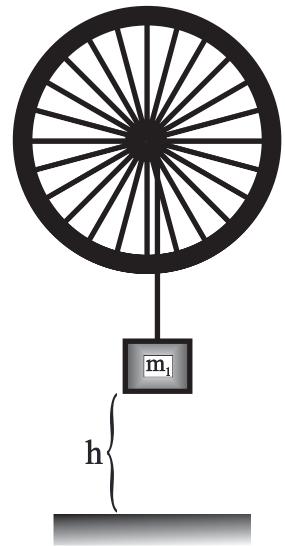
29. A disc, which has a mass of 12.0 kg and a radius of 65.0 cm., sits at the top of an inclined plane, which is 8.40 meters long and 1.50 meters high. At t = 0 the disc is released and is allowed to roll to the bottom of the incline without slipping.
 a. What is the GPE of this disc as it sits at the top of the incline?
 b. What will be the total kinetic energy of this disc as it reaches the bottom of the incline?
 c. What will be the linear velocity of this disc when it reaches the bottom of the inclined plane?
 d. What would the linear velocity be if the disc is replaced by a sphere?
 e. What would the velocity be if the object was a ring?

30. Consider a uniform sphere, which has a mass of 4.80 kg and a radius of 22.0 cm. A tangential force of 11.2 N is applied to the outer edge of this sphere:
 a. What is the moment of inertia of this sphere?
 b. What is the magnitude of the applied torque?
 c. What will be the resulting angular acceleration?
 d. That will be the angular velocity of this sphere after 3.50 seconds?
 e. What will be the total angular displacement of this sphere after 3.50 seconds?
 f. What will be the total work done on the sphere by the tangential force?
 g. What will be the angular kinetic energy of this sphere after 3.50 seconds?
 h. What will be the magnitude of the angular momentum of this sphere after 3.50 seconds?

Answers to opposite side: 31a. 34.9 Rad/s b. 156 J c. 62.7 J d. 219 J e. 28.4 m f. 4.66 sec
31g. -2.62 m/s^2 h. -7.47 Rad/s^2 i. 0.103 kg m^2 j. -0.77 N m k. 219 J 32a. 1.04 Rad/s^2 b. 5.08 sec
32c. 13.3 Rad d. 13.1 J e. 13.1 J 33a. 52.4 kg m^2/s b. counter-clockwise c. 105 kg m^2/s
33d. 101 Rad/s e. 5290 J

PHYSICS HOMEWORK #64 ROTATIONAL KINEMATICS
ANGULAR MOMENTUM CONSERVATION

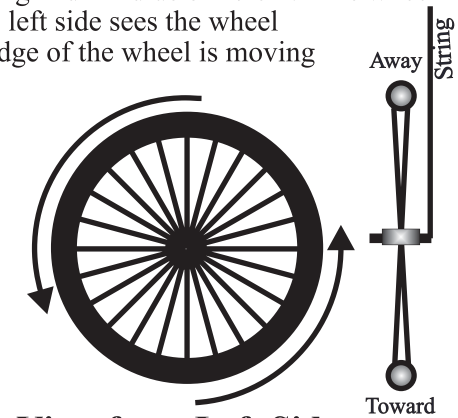
31. A sphere, which has a mass of 2.10 kg and a radius of 35.0 cm., is rolling along a horizontal surface with a velocity of 12.2 m/s when the sphere encounters an inclined plane which meets the horizontal at an angle of 22.0^o.
   a. What is the angular velocity of this sphere?
   b. What is the linear kinetic energy of this sphere?
   c. What is the angular kinetic energy of this sphere?
   d. What is the total kinetic energy of this sphere?
   e. How far up this incline will the sphere roll before it comes to a halt?
   f. How long will it take for this sphere to come to a halt?
   g. What will be the linear acceleration of this sphere as it rolls up the incline?
   h. What will be the angular acceleration of this sphere as it rolls up the incline?
   i. What is the moment of inertia of this sphere?
   j. What will be the net torque acting on this sphere as it rolls up the incline?
   k. What will be the gravitational potential energy of this sphere just as it comes to a halt on the incline?



32. A bicycle wheel is mounted as in the lab and as shown to the right. This wheel has a mass of 6.55 kg, a radius of R = 38.0 cm and is in the shape of a ring. A mass M = 1.85 kg is attached to the end of a string which is wrapped around an inner hub which has a radius r = 5.40 cm. Initially, the mass M is a distance h = 72.0 cm above the floor. [Assume friction is negligible!]
   a. What will be the resulting angular acceleration of this wheel?
   b. How long will it take for the mass M to reach the floor?
   c. What will be the total angular displacement of the wheel during the time in which the mass M is falling to the floor?
   d. How much work was done on the wheel by the external torque as the mass M falls to the floor?
   e. What will be the angular kinetic energy of this wheel just as the mass M reaches the floor?

33. Consider a gyroscope which consists of a large wheel [ring] which has a mass of 8.8 kg and a radius of 27 cm. This wheel does 13 complete rotations each second and is rotating such that an observer from the left side sees the wheel rotating counterclockwise as shown to the right. When viewed from in front the top edge of the wheel is moving away from you.
   a. What will be the direction and magnitude of the angular momentum of this wheel?
   b. Suppose that a single upward force F is applied to the right end of the axle as shown. What will be the resulting direction of precession?

Suppose that you are holding this same wheel in your hands while you are sitting on a chair capable of rotating freely. Your body has a mass of 72 kg and a radius of gyration [average radius enabling you to treat an irregular body as a ring!] of 12 cm. When observed from above the wheel is rotating clockwise. [All of the above data still apply!] You suddenly turn the wheel over during a time interval of 0.35 seconds.
   c. What will be the change in angular momentum of the wheel as you turn it over?
   d. What will be your final angular velocity after inverting the wheel?
   e. How much work did you do in inverting the wheel?



View from Left Side

Answers to opposite side: 27a. 0.137 kg m^2 b. 7.84 N m c. 57.2 Rad/sec^2 d. 458 Rad/sec
27e. 128 m/s f. 1830 Rad g. 513 m h. 14,300 J i. 62.7 kg m^2/s j. 14,300 J 28a. 438 J
28b. 438 J c. 11.4 m/sec d. 438 J e. 248 J f. 8.59 m/sec g. yes, 8.59 m/s > 4.64 m/s
29a. 176 J b. 176 J c. 4.42 m/s d. 4.58 m/s e. 3.83 m/s 30a. 0.093 kg m^2 b. 2.46 N m
30c. 26.5 Rad/s2 d. 92.7 Rad/s e. 162 Rad f. 400 J g. 400 J h. 8.62 kg m^2/s

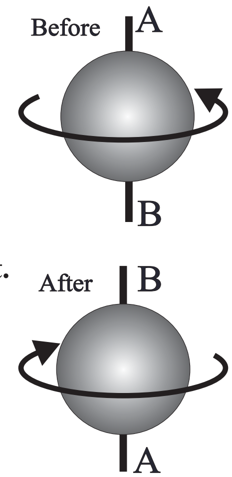
PHYSICS HOMEWORK #65 ROTATIONAL KINEMATICS
ANGULAR MOMENTUM CONSERVATION

34. A star, which has a mass of 4.60×10^{30} kg and a radius of 9.30×10^{8} m, rotates on its axis once every 16.0 days.
 a. What is the moment of inertia of this star?
 b. What is the angular velocity of this star?
 c. What will be the linear velocity of a sunspot that is located on the equator of this star?
 d. What is the angular momentum of this star?

As this star finally consumes most of its Hydrogen fuel it starts to contract and heat up until it gets hot enough to start burning Helium as a fuel. The burning of the Helium fuel is very intense and the star quickly becomes a "red giant" as it expands to a new radius of 4.65×10^{9} m.
 e. What will be the angular momentum of this star after it has expanded into a red giant?
 f. What will be the angular velocity of the star after it has expanded into a red giant?
 g. What will be the new rotational period of this star after it has become a red giant?

After a few million years the Helium fuel is all used up and the star again begins to contract, becomes extremely hot and then undergoes a massive supernova explosion. After the explosion the remaining neutron star has a radius of only 1200 km. [Assume that the mass of the star remains unchanged.]
 h. What will be the angular momentum of this star after it has collapsed into a neutron star?
 i. What will be the moment of inertia of this star after it has collapsed into a neutron star?
 j. What will be the angular velocity of this star after it has collapsed?
 k. What will be the rotational period of this star after it has collapsed?

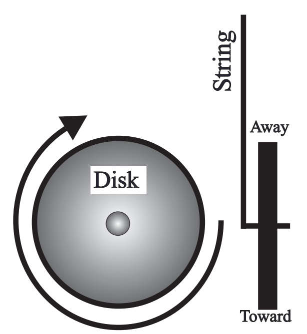
35. You are holding a sphere, which has a mass of 3.55 kg and a radius of 0.38 m, by an axle inserted vertical through its center as shown to the right. Initially, the sphere is rotating about its vertical axis 12 times every 5.0 seconds as shown.



 a. What is the moment of inertia of this sphere?
 b. What is the magnitude of the angular velocity of this sphere?
 c. What is the magnitude of the angular momentum of this sphere?
 d. What is the direction of this sphere's angular momentum?

Assuming that you are sitting on a freely rotating chair, that your mass is 65.5 kg, and that your radius of gyration is 14.0 cm. Suddenly, you invert the sphere as shown in the diagram to the right.
e. What will be the sphere's final angular momentum?
f. What will be the direction of the sphere's final angular momentum?
g. What will be the magnitude of **your** final angular momentum?
h. What is the magnitude and direction of the impulse delivered to the sphere?
i. How much work was done in inverting the sphere?

36. A uniform disk, which has a mass of 8.50 kg and a radius of 35.0 cm, is rotating on its axis such that it makes 8.0 complete rotations each second.



a. What is the moment of inertia of this disk?
b. What is the angular velocity of this disk?
c. What is the angular momentum of this disk?
d. What is the angular kinetic energy of this disk?

A string is attached to the end of the axle as shown to the right.
e. What is the direction of the angular velocity vector in the diagrams to the right?
f. What will be the direction of the torque exerted on the disk by the gravitational force? Be specific!
g. What will be the direction of the wheel's precession?

Answers to this side: 34a. 1.59×10^{48} kgm^2 b. 4.55×10^{-6} rad/sec c. 4.23×10^{3} m/sec d. 7.23×10^{42} kgm^2/sec e. same as d 34f. 1.82×10^{-7} rad/sec g. 400 days h. same as e i. 2.65×10^{42} kgm^2 j. 2.73 rad/sec k. 2.30 sec 35a. 0.205 kgm^2 35b. 15.1 rad/sec c. 3.09 kgm^2/sec d. up e. - 3.09 kgm^2/sec f. down g. 6.18 kgm^2/sec h. - 6.18 kgm^2/sec i. 14.9 J 36a. 0.521 kgm^2 b. 50.3 rad/sec c. 26.2 kgm^2/sec d. 658 J e. into page, left f. into page g. downward

PHYSICS HOMEWORK #67 ROTATIONAL KINEMATICS
MOMENT OF INERTIA - INTEGRATION

Moment of Inertia through Integration

1. Consider a disk which has a radius of R = 12.0 cm and which has a mass density σ which varies with the radius of the disk according to the function $\sigma = (18.0 + 36\ r^2)\ kg/m^2$.
   a. What is the total mass of this disk?
   b. What will be the moment of inertia of this disk through an axis through the center of mass and perpendicular to the plane of the disk?

2. Consider a rod which has a length of L = 56 cm and which has a mass density which varies with length according to the formula $\lambda = (28 + 44r^2)$ kg.
   a. What is the total mass of this rod?
   b. Where is the center of mass of this rod?
   c. What is the moment of inertia of this rod about an axis perpendicular to the rod and through the lighter end of the rod?

3. Consider a rectangular plate x = 35.0 cm long and y = 15.0 cm wide, as shown to the right, where the surface mass density of the plate varies with the x coordinate according to $\sigma = (120 - 2800\ x^3)\ kg/m^2$.
   a. What is the total mass of this plate?
   b. Where is the center of mass of this rectangular plate?
   c. What will be the moment of inertia of this plate about an axis along the left edge of the plate?
   d. What will be the moment of inertia of this plate about the bottom edge of the rectangular plate?

4. Consider a thick ring with an inner radius of r_1 = 6.0 cm and an outer radius of r_2 = 16 cm where the mass per unit area varies according to $\sigma = (85.0 + 25\ r^2)\ kg/m^2$.
   a. what is the total mass of this ring?
   b. What will be the moment of inertia of this disk through an axis perpendicular to the plane of the ring and through the center of mass?

Moment of Inertia - Parallel axis Theorem/Plane Figure Theorem

5. Consider a uniform disk which has a radius of R = 35.0 cm and a total mass of M = 8.20 kg.
   a. What is the moment of inertia of this disk about an axis perpendicular to the plane of the disk and through the center of mass?
   b. What will be the moment of inertia of this disk about an axis perpendicular to the plane of the disk and through the outer edge of the disk?
   c. What will be the moment of inertia of this disk about an axis in the plane of the disk and through the center of mass of the disk?
   d. What will be the moment of inertia of this disk about an axis in the plane of the disk and tangent to the edge of the disk?
   e. What will be the moment of inertia of this disk about an axis perpendicular to the plane of the disk and through a point 155 cm from the center of mass?

6. Consider a rectangular plate which has a length of L = 35.0 cm., a width of w = 20.0 cm. and a uniformly distributed mass of m = 6.60 kg.
   a. What is the moment of inertia of this plate about an axis in the plane of the plate and tangent to the width of the plate?
   b. What will be the moment of inertia of this plate about an axis in the plane of the plate and tangent to the length of the plate?

Answers to opposite side: 6c. 0.358 kgm^2 d. 0.0894 kgm^2 e. 0.0674 kgm^2 f. 0.0220 kgm^2 g. 0.0894 kgm^2 7a. 0.847 kgm^2 b. 2.96 kgm^2 c. 27.8 kgm^2 8a. 173 kg b. 0.583, 0.110 m c. 64.8 kgm^2 d. 2.78 kgm^2 8e. 67.6 kgm^2 f. 6.84 kgm^2 g. 0.696 kgm^2 h. 6.15 kgm^2 9a. 3.11 kg b. 0.0594 kgm^2 c. 0.0297 kgm^2 9d. 0.131 kgm^2 e. 0.160 kgm^2

PHYSICS HOMEWORK #68 ROTATIONAL KINEMATICS
MOMENT OF INERTIA - PLANE FIGURE/PARALLEL AXIS THEOREMS

6c. What will be the moment of inertia of this plate about an axis perpendicular to the plane of the plate and through one of the corners of the plate?
   d. What will be the moment of inertia of this plate about an axis perpendicular to the plate and through the center of mass of the plate?
   e. What will be the moment of inertia of this plate about an axis in the plane of the plate and through the center of mass parallel to the width of the plate?
   f. What will be the moment of inertia of this plate about an axis parallel to the plane of the plate, through the center of mass and parallel to the length L of the plate?
   g. What will be the moment of inertia about an axis perpendicular to the plane of the plate and through the center of mass of the plate? [Use your answers to e & f above to determine this moment of inertia!]

7. Consider a uniform sphere which has a radius of R = 42.0 cm and a total mass of M = 12.0 kg.
   a. What is the moment of inertia of this sphere about an axis through the center of mass?
   b. What will be the moment of inertia of this sphere about an axis tangent to the surface of the sphere?
   c. What will be the moment of inertia of this sphere about an axis tangent to the surface of the sphere but at a distance of 150 cm from the center of the sphere?

8. Consider a rectangular plate x = 82.0 cm long and y = 22.0 cm wide, as shown to the right, where the surface mass density of the plate varies with the x coordinate according to $\sigma = (150 + 3600\ x^2)\ \mathrm{kg/m^2}$.

   a. What is the total mass of this plate?
   b. What are the x and y coordinates of the center of mass of this rectangular plate?
   c. What will be the moment of inertia of this plate about an axis along the left edge of the plate?
   d. What will be the moment of inertia of this plate about the bottom edge of the rectangular plate?
   e. What will be the moment of inertia about an axis perpendicular to the plane of the plate and through the bottom left corner of the plate as shown in the diagram?
   f. What will be the moment of inertia of this plate about an axis perpendicular to the plane of the plate and through the center of mass?
   g. What will be the moment of inertia about an axis in the plane of the plate, through the center of mass and parallel to the x axis?
   h. What will be the moment of inertia about an axis in the plane of the plate, through the center of mass and parallel to the y axis? [Confirm that you can get this answer through both the parallel axis theorem and the plane figure theorem!]

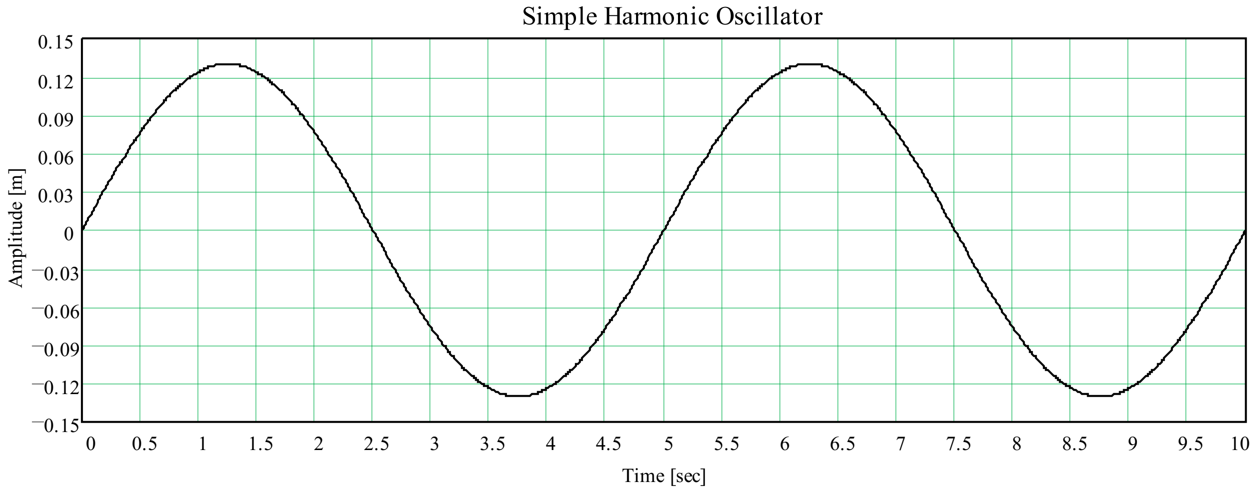
9. Consider a disk which has a radius of R = 18.0 cm and which has a mass density σ which varies with the radius of the disk according to the function $\sigma = (18.0 + 5400\ r^3)\ \mathrm{kg/m^2}$.
   a. What is the total mass of this disk?
   b. What will be the moment of inertia of this disk about an axis through the center of mass and perpendicular to the plane of the disk?
   c. What will be the moment of inertia of this disk about an axis parallel to the plane of the disk and through the center of mass?
   d. What will be the moment of inertia of this disk about an axis parallel to the plane of the disk and tangent to the edge of the disk?
   e. What will be the moment of inertia of this disk about an axis perpendicular to the plane of the disk and through the edge of the disk?

Answers to opposite side: 1a. 0.826 kg b. 0.00598 $\mathrm{kgm^2}$ 2a. 18.3 kg b. 0.300 m c. 2.12 $\mathrm{kgm^2}$
3a. 4.72 kg b. 0.140, 0.075 m c. 0.129 $\mathrm{kgm^2}$ d. 0.0354 $\mathrm{kgm^2}$ 4a. 5.90 kg b. 0.0862 $\mathrm{kgm^2}$
5a. 0.502 $\mathrm{kgm^2}$ b. 1.507 $\mathrm{kgm^2}$ c. 0.251 $\mathrm{kgm^2}$ d. 1.26 $\mathrm{kgm^2}$ e. 20.2 $\mathrm{kgm^2}$
6a. 0.270 $\mathrm{kgm^2}$ b. 0.0880 $\mathrm{kgm^2}$

PHYSICS HOMEWORK #71 SIMPLE HARMONIC MOTION

SHM GRAPHS

Each of the following questions refers to the graph below which plots the position of a pendulum as a function of time.



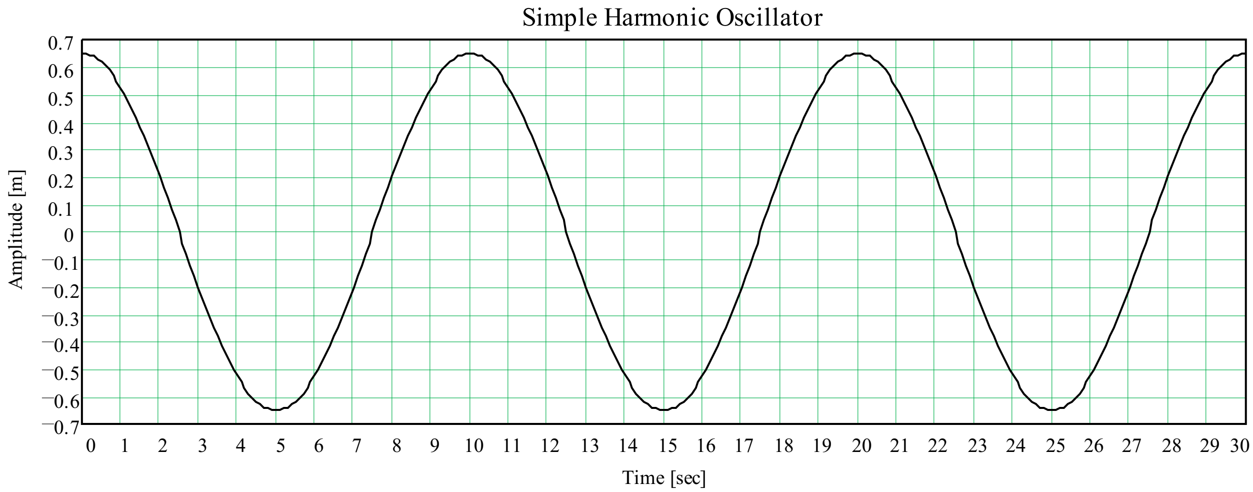
1. What is the period of this pendulum?
2. What is the maximum displacement of this pendulum from the equilibrium position?
3. What is the angular velocity of this pendulum?
4. Write the equation which describes the position of this pendulum as a function of time.
5. What will be the position of this pendulum 4.5 seconds after it is released?
6. What will be the position of this pendulum 11.5 seconds after it is released?
7. What will be the maximum speed of this pendulum?
8. Write the equation predicting the velocity of this pendulum as a function of time.
9. What will be the velocity of this pendulum 4.5 seconds after it has been released?
10. What will be the velocity of this pendulum 3.75 seconds after it is released?
11. What will be the maximum acceleration of this pendulum?
12. What will be the acceleration of this pendulum 4.5 seconds after it was released?
13. What is the length of this pendulum?
14. Based on the graph above, at what times is the velocity of this pendulum zero?
15. Based on the graph above, at what times is the acceleration of this pendulum zero?

ANSWERS TO OPPOSITE SIDE: 1. 10.0 sec 2. 0.650 m 3. 0.628 rad/sec 4. $A=A_o \cos(0.628\ t)$ 5. 0.382 m 6. -0.618 m 7. 0.408 m/sec 8. $v=0.408\sin(0.628\ t)$ 9. 0.33 m/sec 10. 0.0 m/sec 11. 0.257 m/sec^2 12. -0.151 m/sec^2 13. 0.257 m/sec^2 14. 0 sec, 5 sec, 10 sec, 15 sec etc. 15. 2.5 sec, 7.5 sec, 12.5 sec etc.

PHYSICS HOMEWORK #72 SIMPLE HARMONIC MOTION

SHM GRAPHS

Each of the following questions refers to the graph below which plots the position of a pendulum as a function of time.



1. What is the period of this pendulum?

2. What is the maximum displacement of this pendulum from the equilibrium position?

3. What is the angular velocity of this pendulum?

4. Write the equation which describes the position of this pendulum as a function of time.

5. What will be the position of this pendulum 18.5 seconds after it is released?

6. What will be the position of this pendulum 44.5 seconds after it is released?

7. What will be the maximum speed of this pendulum?

8. Write the equation predicting the velocity of this pendulum as a function of time.

9. What will be the velocity of this pendulum 18.5 seconds after it has been released?

10. What will be the velocity of this pendulum 25.0 seconds after it is released?

11. What will be the maximum acceleration of this pendulum?

12. What will be the acceleration of this pendulum 18.5 seconds after it was released?

13. What will be the acceleration of this pendulum 25.0 seconds after it has been released?

14. Based on the graph above, at what times is the velocity of this pendulum zero?

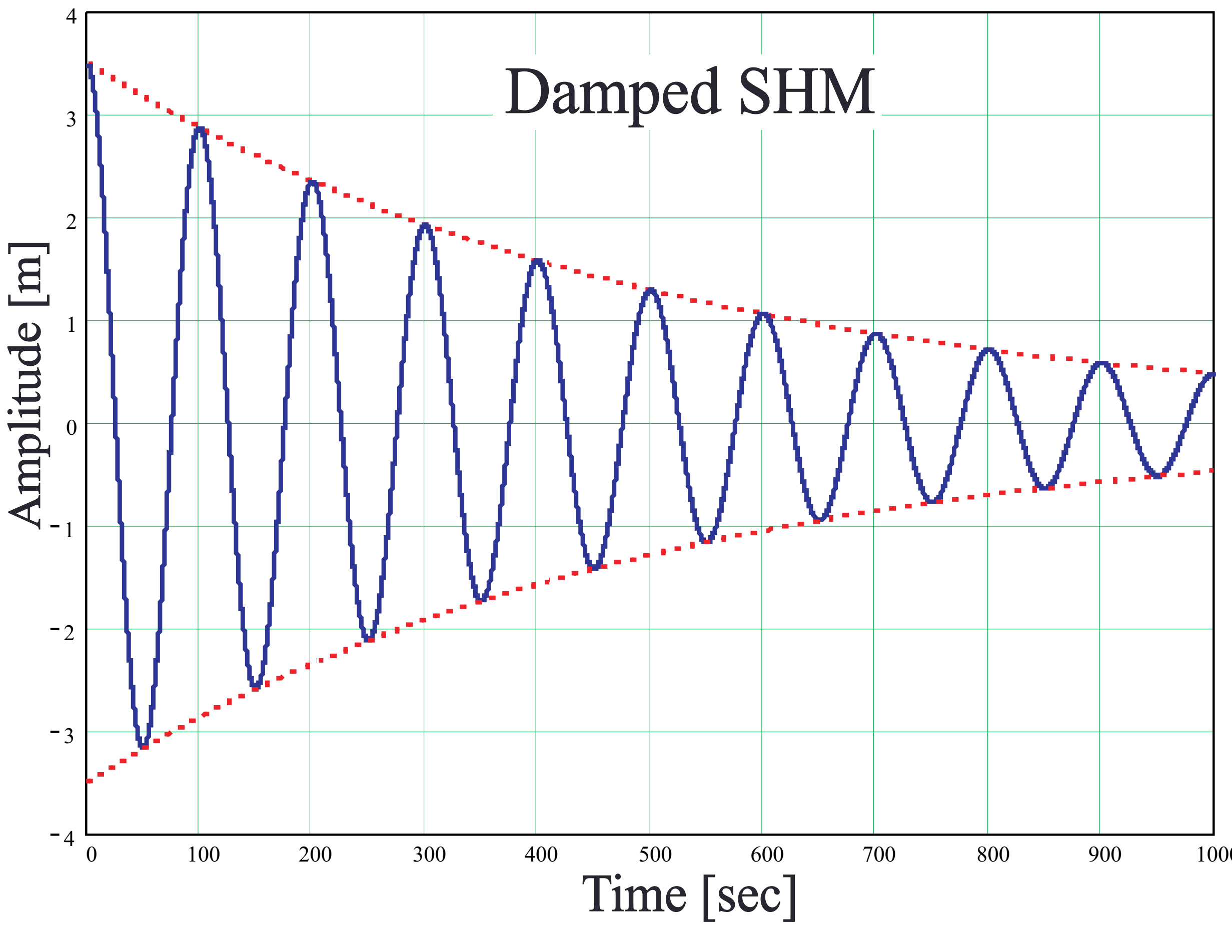
15. Based on the graph above, at what times is the acceleration of this pendulum zero?

ANSWERS TO OPPOSITE SIDE: 1. 5.00 sec 2. 0.130 m 3. 1.257 rad/sec 4. A = 0.13 sin (1.257 t) 5. -0.0764 m 6. 0.124 m 7. 0.163 m/sec 8. v = 0.163 cos (1.257 t) 9. 0.132 m/sec 10. 0.0 m/sec 11. 0.205 m/sec^2 12. 0.121 m/sec^2 13. 6.21 m 14. 1.25 sec, 3.75 sec, 6.25 sec etc. 15. 0.0 sec, 2.5 sec, 5.0 sec etc.

PHYSICS HOMEWORK #73 SIMPLE HARMONIC MOTION

DAMPED SHM

The graph below describes the maximum amplitude of a simple harmonic oscillator as a function of time.



1. What is the period of this simple harmonic oscillator?
2. What is the initial amplitude of this simple harmonic oscillator?
3. What will be the time constant of this oscillator?
4. Write the equation that will predict the maximum amplitude of this oscillator as a function of time.
5. Using the equation you developed above predict the maximum amplitude of this oscillator at the end of 200 sec.
6. What will be the maximum amplitude of this oscillator at the end of 1200 seconds.
7. How long will it take for the maximum amplitude of this oscillator to be reduced to 50 cm.?
8. How long will it take for the maximum amplitude of this oscillator to be reduced to 20 cm.?

Suppose that the initial energy content of this oscillator was 10.0 Joules.

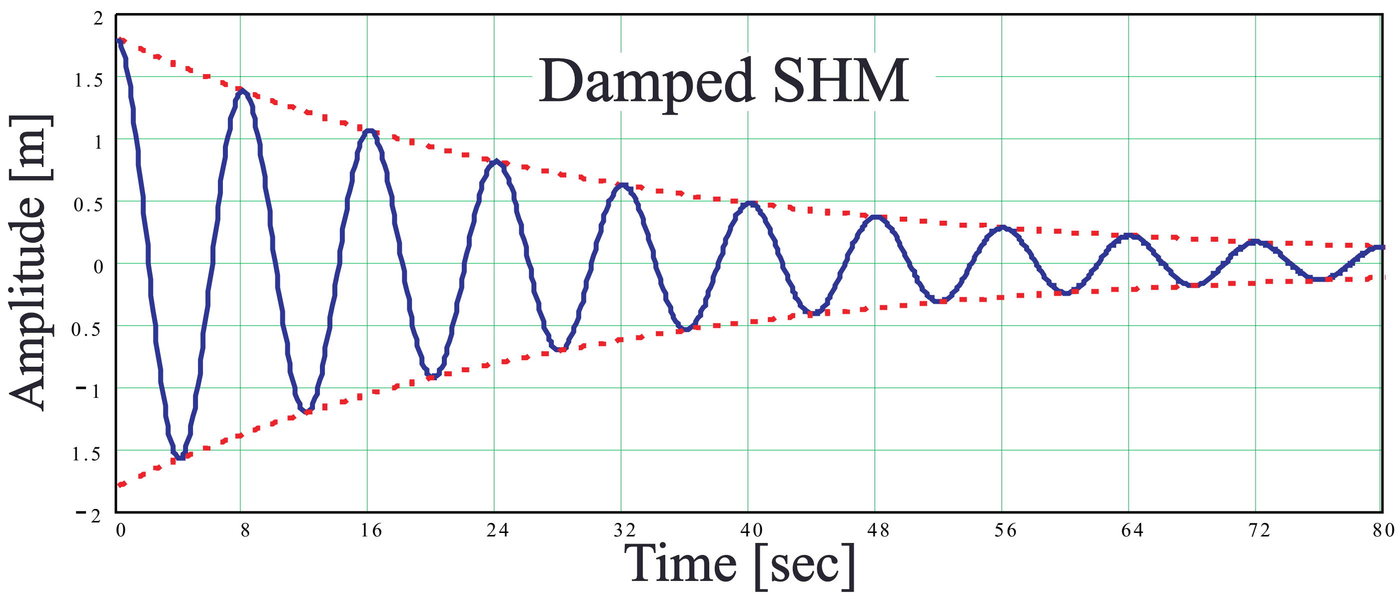
9. How much energy will remain after 120 second?
10. How much energy will remain after 700 seconds?
11. How long will it take for the energy content of this oscillator to reach 10% of its initial value?

ANSWERS TO OPPOSITE SIDE: 1. 8.0 sec 2. 1.80 m 3. 15.6 sec 4. A = (1.80 m)$e^{-(t/31.2sec)}$
5. 0.0732 m 6. 0.00 m 7. 68.6 sec 8. 112 sec 9. 0.00184 Joule 10. 0.00 J 11. 46.8 sec

PHYSICS HOMEWORK #74 SIMPLE HARMONIC MOTION

DAMPED SHM

The graph below describes the maximum amplitude of a simple harmonic oscillator as a function of time.



1. What is the period of this simple harmonic oscillator?
2. What is the initial amplitude of this simple harmonic oscillator?
3. What will be the time constant of this oscillator?
4. Write the equation that will predict the maximum amplitude of this oscillator as a function of time.
5. Using the equation you developed above predict the maximum amplitude of this oscillator at the end of 100 sec.
6. What will be the maximum amplitude of this oscillator at the end of 500 seconds.
7. How long will it take for the maximum amplitude of this oscillator to be reduced to 20 cm.?
8. How long will it take for the maximum amplitude of this oscillator to be reduced to 5.0 cm.?

Suppose that the initial energy content of this oscillator was 4.0 Joules.

9. How much energy will remain after 120 second?
10. How much energy will remain after 700 seconds?
11. How long will it take for the energy content of this oscillator to reach 5.0% of its initial value?

ANSWERS TO OPPOSITE SIDE: 1. 100 sec 2. 3.50 m 3. 250 sec 4. $A=(3.50\text{ m})e^{-(t/500\text{sec})}$
5. 2.35 m 6. 0.318 m 7. 973 sec 8. 1430 sec 9. 6.19 J 10. 0.608 J 11. 576 sec

PHYSICS HOMEWORK #75 SIMPLE HARMONIC MOTION

SIMPLE PENDULUMS

1. A simple pendulum consists of a 2.0 kg mass hanging at the end of a string 3.0 meters long. This pendulum is displaced a distance of 35.0 cm from the equilibrium point and is then released. After 100 swings the maximum displacement of the pendulum has been reduced to 15.0 cm.
   a. What is the period of this pendulum?
   b. What will be the angular velocity of this pendulum?
   c. What will happen to the period of this pendulum if the mass of the end of the string is doubled to 4.0 kg.?
   d. What will happen to the period of this pendulum if the pendulum is pulled back 70.0 cm instead of 35.0 cm.?
   e. What will happen to the period of this pendulum if it is shortened to 2.0 meters instead of 3.0 meters?
   f. What is the equation that predicts the position of this pendulum as a function of time?
   g. What will be the position of this pendulum 1.45 seconds after it is released?
   h. What is the maximum velocity of this pendulum?
   i. What is the equation that predicts the velocity of this pendulum as a function of time?
   j. What will be the velocity of the pendulum 1.45 seconds after it is released?
   k. What is the maximum acceleration of this pendulum?
   l. What is the equation that predicts the acceleration of this pendulum as a function of time?
   m. What will be the acceleration of this pendulum after 1.45 seconds?
   n. What is the time constant for this pendulum?
   o. What is the equation that predicts the maximum displacement of this pendulum as a function of time?
   p. What will be the maximum displacement of this pendulum after 200 swings?
   q. After how many swings will the maximum displacement be reduced to only 1.0 cm.?

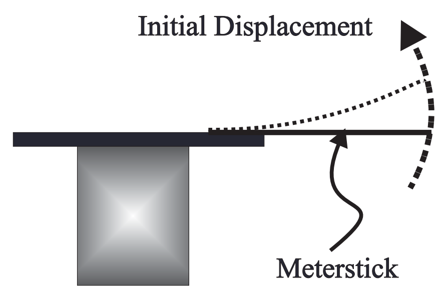
2. A simple pendulum consists of a 5.0 kg mass hanging at the end of a string 2.0 meters long. This pendulum is displaced a distance of 50.0 cm from the equilibrium point and is then released. After 150 swings the maximum displacement of the pendulum has been reduced to 20.0 cm.
   a. What is the period of this pendulum?
   b. What will be the angular velocity of this pendulum?
   c. What will happen to the period of this pendulum if the mass of the end of the string is tripled to 15.0 kg.?
   d. What will happen to the period of this pendulum if the pendulum is pulled back 25.0 cm instead of 50.0 cm.?
   e. What will happen to the period of this pendulum if it is lengthened to 4.0 meters instead of 2.0 meters?
   f. What is the equation that predicts the position of this pendulum as a function of time?
   g. What will be the position of this pendulum 5.5 seconds after it is released?
   h. What is the maximum velocity of this pendulum?
   i. What is the equation that predicts the velocity of this pendulum as a function of time?
   j. What will be the velocity of the pendulum 5.5 seconds after it is released?
   k. What is the maximum acceleration of this pendulum?
   l. What is the equation that predicts the acceleration of this pendulum as a function of time?
   m. What will be the acceleration of this pendulum after 5.5 seconds?
   n. What is the time constant for this pendulum?
   o. What is the equation that predicts the maximum displacement of this pendulum as a function of time?
   p. What will be the maximum displacement of this pendulum after 300 swings?
   q. After how many swings will the maximum displacement be reduced to only 2.0 cm.?

Answers to opposite side: 3a. 0.907 b. 6.93 Rad/sec c. 1.81 sec d. 1.81 sec e. no effect
3f. $A = 0.12\cos(6.93t)$ g. -0.098 m h. 0.831 m/sec i. $v = -0.831\sin(6.93t)$ j. 0.484 m/sec k. 5.76 m/sec^2
3l. $a = 5.76\cos(6.93t)$ m. 4.684 m/sec^2 n. 51.8 sec o. $A = 0.12\,e^{(-t/104)}$ p. 0.0208 m q. 284
4a. 0.55 sec b. 11.4 Rad/sec c. -0.211 m d. 0.708 m/sec e. 27.5 m/sec^2 f. 6.08 sec g. 0.00240 m

PHYSICS HOMEWORK #76 SIMPLE HARMONIC MOTION
MASS ON SPRING

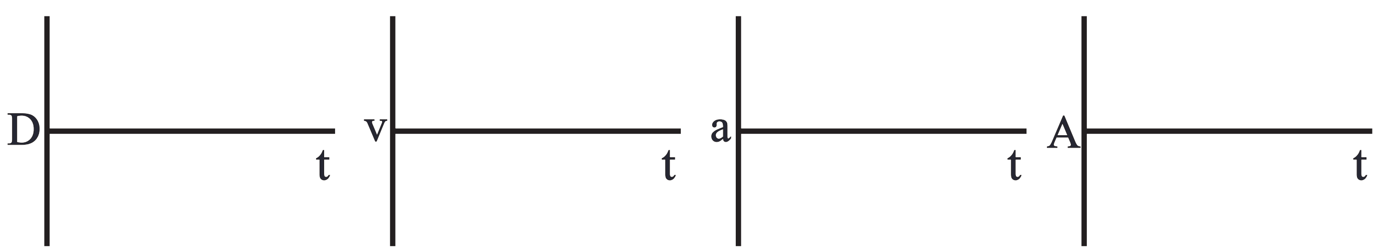
3. A simple harmonic oscillator consists of a 2.5 kg mass suspended from the end of a spring which has a spring constant of k = 120 N/m. The 2.5 kg mass is lifted a distance of 12.0 cm above the equilibrium point and is then released. After 100 cycles the maximum displacement of the mass has been reduced to 5.0 cm.
   a. What is the vibrational period of this system?
   b. What will be the angular velocity of this system?
   c. What will happen to the period of this system if the mass of the end of the spring is increased to 10.0 kg.?
   d. What will happen to the period of this system if the spring constant is decreased to 30 N/m?
   e. What will happen to the period of this system if the maximum displacement is reduced to 8.0 cm?
   f. What is the equation that predicts the position of this system as a function of time?
   g. What will be the position of this system 1.45 seconds after it is released?
   h. What is the maximum velocity of this system?
   i. What is the equation that predicts the velocity of this system as a function of time?
   j. What will be the velocity of the system 1.45 seconds after it is released?
   k. What is the maximum acceleration of this system?
   l. What is the equation that predicts the acceleration of this system as a function of time?
   m. What will be the acceleration of this system after 1.45 seconds?
   n. What is the time constant for this system?
   o. What is the equation that predicts the maximum displacement of this system as a function of time?
   p. What will be the maximum displacement of this system after 200 swings?
   q. After how many swings will the maximum displacement be reduced to only 1.0 cm.?

4. A meter stick is clamped to the end of a lab table with a C-clamp. A mass of 2.5 kg is attached to the end of the meterstick. The end of the meterstick. is displaced upward a distance of 22.0 cm and is then released. The end of the meterstick. is measured to oscillate through 10 complete cycles during a time period of 5.5 seconds. After 10 oscillations the maximum displacement of the meter stick has been reduced to 14.0 cm.



   a. What is the period of this oscillator?
   b. What is the angular velocity of this oscillator?
   c. What will be the position of the end of this meterstick. 4.7 seconds after it has been released?
   d. What will be the velocity of the end of this meterstick. after 4.7 seconds?
   e. What will be the acceleration of the end of this meterstick. after 4.7 seconds?
   f. What is the time constant for this system?
   g. What will be the maximum displacement of the end of this meterstick. after 100 cycles?
   h. On the graphs below sketch the following graphs;

1. displacement vs time **2. velocity vs. time** **3. acceleration vs. time** **4. maximum displacement vs time**



Answers to opposite side: 1a. 3.48 sec b. 1.81 rad/sec c. no effect d. no effect e. 2.84 sec f. A= 0.35 cos (1.81t) 1g. -0.304 m 1h. 0.633 m/sec i. v = -0.633 sin(1.81t) j. -0.314 m/sec k. 1.144 m/sec^2 l. a= -1.144 cos (1.81t) 1m. 0.993 m/sec^2 n. 205 sec o. A=0.35 e$^{(-t/410)}$ p. 0.064 m q. 420 2a. 2.84 sec b. 2.21 rad/sec c. no effect 2d. no effect e. 4.01 sec f. A=0.50 cos (2.21t) g. 0.463 m 2h. 1.11 m/sec i. v = -1.11 sin(2.21t) 2j. 0.418 m/sec k. 2.45 m/sec^2 l. a=-2.45 sin(2.21t) m. -2.27 m/sec^2 n. 232 sec o. A=0.50 e$^{(-t/464)}$ p. 0.080 m 2q. 527

PHYSICS HOMEWORK #81 WAVE MOTION

MECHANICAL WAVES

1. A wave has a period of 2.20 seconds. What is the frequency of this wave?

2. A wave has a frequency of 14.0 Hz. What is the period of this wave?

3. You are at the beach sitting on a pier in the water and you notice that the water level where you are sitting rises and falls once every 4.10 seconds. What is the frequency of these waves?

4. A wave has a frequency of 5.50 Hz and a wavelength of 2.50 meters. What is the velocity of this wave?

5. What will be the wavelength of a wave which has a wave speed of 0.56 m/s and a frequency of 4.40 Hz?

6. The speed of sound waves at 25^{o}C is 346 m/s. What will be the wavelength of a sound wave which has a frequency of 512 Hz under these conditions?

7. The speed of light waves is 3.0 x 10^{8} m/s in a vacuum. What will be the wavelength of the radio signal generated by WCBS FM, given that the frequency assigned to it by the FCC is 101 MHz?

8. A wave, which has a wavelength of 1.40 meters and a wave speed of 4.80 m/s, enters a second medium where the wavelength is reduced to 0.90 meters. What will be the wave speed in the second medium?

9. A wave, moving with a velocity of 0.45 m/s, enters a second medium where the wave speed increases. How does the impedance of the second medium compare to the impedance of the first medium?

10. A wave pulse moves down a large spring such that the displacement of the medium is on the right side of the spring as observed by the initiator of the wave. This wave then reflects from the opposite end of the spring which is being held firmly by a student. On which side of the spring will the reflected pulse be found?

11. One student sends a wave train down a large spring such that the amplitude of the wave train is 0.44 meters, its frequency is 12.0 Hz. and the energy content of the wave train is 3.5 Joules. A second student sends another wave down the same spring but with an amplitude of 0.88 meters.
    a. What is the energy content of this second wave?
    b. What would the energy content of the wave be if the amplitude of the second wave was 0.22 meters?
    c. What would the energy content of this wave be if the frequency of the wave was tripled?

12. A wave travels through an interface from one medium into another. Which of the wave characteristics below does NOT change as the wave changes mediums?

13. Which of the wave characteristics below can be changed so as to affect on the energy content of a wave?

14. Define each of the following terms:

reflection	period	impedance	refraction	impedance matching	polarization	wave
diffraction	damping	attenuate	pulse	law of reflection	superposition	crest
interference	harmonic	amplitude	phase	rectilinear propagation	interface	pulse
fundamental	wavelength	wave speed	node	destructive interference	incident	trough
frequency	transverse	longitudinal	antinode	constructive interference	standing	loop
resonance	normal	rarefaction	compression	elastic medium	law of refraction	

ANSWERS TO THE OPPOSITE SIDE: 15a. 32.0^{o} b. 2.84 cm c. 8.44 Hz d. 8.44 Hz e. m_2
16a. 1.03 m/s b. 6.80 cm c. 18.4 Hz 17a. 8.2 Hz b. +/- 0.60 Hz c. 29 cm/s d. +/_ 7.0 cm/s
18a. 29o b. 73^{o} c. no such angle 19b. 13.8 cm 20. n = 3 21a. 0.60 m b. 55 Hz c. 275 Hz

PHYSICS HOMEWORK #82 WAVE MOTION

MECHANICAL WAVES

15. A wave moving with a velocity of 38.0 cm/s and having a wavelength of 4.50 cm, strikes an interface at an angle of 57.0^o relative to the normal. In the second medium the velocity of the wave is reduced to 24.0 cm/s:
    a. What will be the angle of the wave in the second medium?
    b. What will be the wavelength in the second medium?
    c. What will be the frequency of this wave in the first medium?
    d. What will be the frequency of this wave in the second medium?
    e. Which medium has the higher impedance? Justify!

16. A wave moving with a velocity of 1.25 m/s strikes an interface at an incident angle of 82.0^o. After passing through the interface the angle shifts to 55.0^o and the wavelength becomes 5.60 cm:
    a. What will be the velocity of this wave in the second medium?
    b. What will be the wavelength in the first medium?
    c. What will be the frequency in the second medium?

17. While looking at waves in a ripple tank you note that with the strobe disc adjusted so that the wave appear to “stand still” the wavelength is measured to be 3.50 cm +/- 0.50 cm and the strobe, which contains 6 slits, rotates 10 complete times over a period of 7.3 sec +/- 0.5 seconds:
    a. What is the frequency of these waves?
    b. What is the estimated error on this frequency?
    c. What will be the measured speed of the wave?
    d. What is the estimated error on this speed?

18. Two point sources are placed 8.80 cm apart and are generating waves that are in phase and which have a wavelength of 4.20 cm:
    a. At what angle will the first order antinode occur?
    b. At what angle will the second order antinode occur?
    c. At what angle will the third order antinode occur?

19. Two point sources are placed an unknown distance apart and are producing waves which are in phase and which have a wavelength of 4.25 cm. It is noted that at an angle of 38.0^o from the central antinode occurs the second order antinode:
    a. What is true about all points on the second order antinode?
    b. What is the distance between these two point sources?

20. Two point sources are placed 14.0 cm apart and are used to generate waves which are in phase and which have a wavelength of 3.70 cm. What is the maximum order of the antinodes produced by these two sources?

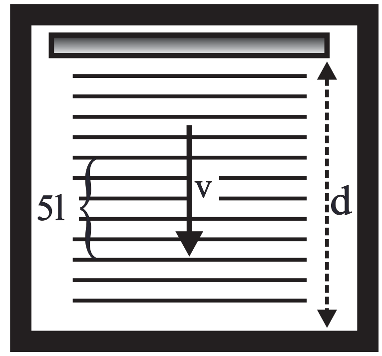
21. A string is stretched between two rigid supports which are 1.20 meters apart. The string is plucked and it is noted that a standing wave is formed on the string which consists of 5 nodes [including endpoints] and 4 antinodes.
    a. What is the wavelength of this standing wave?
    b. If the frequency of this vibration is 220 Hz, what is the frequency of the fundamental frequency that will vibrate in this string?
    c. What will be the frequency of the 5th harmonic that will vibrate in this string?

ANSWERS TO THE OPPOSITE SIDE: 1. 0.45 Hz 2. 0.071 seconds 3. 0.24 Hz 4. 13.8 m/s 5. 12.7 cm 6. 0.68 m 7. 2.97 meters 8. 3.09 m/s 9. $I_2 < I_1$ 10. left 11a. 14.0 J b. 0.88 J 11. 31.5 J 12. frequency, period, phase 13. amplitude, frequency, wavelength, period

PHYSICS HOMEWORK #83 WAVE MOTION

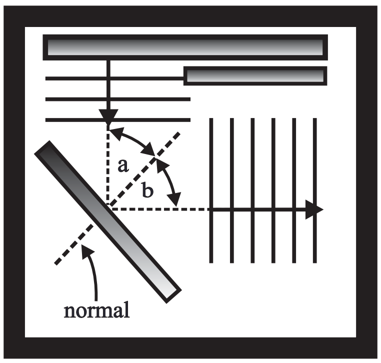
RIPPLE TANK WAVES

Consider a ripple tank where waves are being produced by a plastic bar. An over head strobe light is shined through the resulting waves and images of these waves are projected onto a screen below. [Sound familiar?] The strobe indicates a frequency of 12.8 +/- 0.3 Hz. A ruler is used to measure the wavelengths of 5 full waves to be 5λ = 17.5 +/- 0.5 cm as shown to the right.



1. What is the speed of these water waves [including error!]?

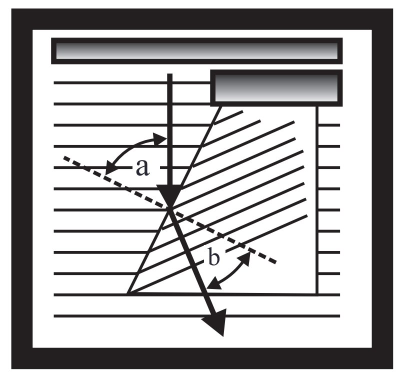
2. How long will it take for these water waves to move a distance d = 65.0 cm.?



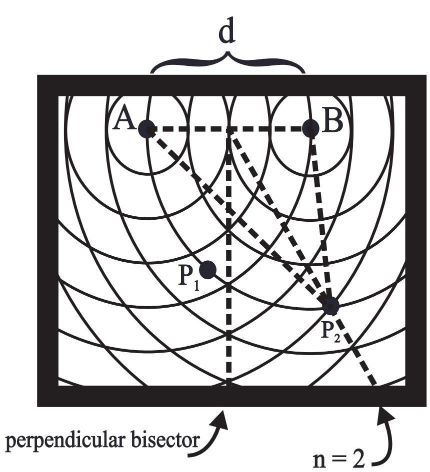
A barrier is added to the tank as shown in the diagram to the left so as to reflect the waves as shown. The angle between the incoming wave and the normal to the barrier is $\alpha = 38.0^o$.

3. What is the angle β between the reflected wave and the normal?

A glass plate is added to the water so as to produce an area in the wave tank where the water is shallow. The wave front intercepts the interface at an angle of $\alpha = 42.0^o$ and then refracts to $\beta = 28.0^o$ as shown to the right. The wave is measure to have a wavelength of 3.80 cm in the deep water and the wave in the deep water "stands still" when illuminated by a strobe which has a frequency of 12.0 Hz.



4. What will be the speed of this water wave in the deep water?
5. What will be the speed of the wave in the shallow water?
6. What will be the frequency of the water waves in the shallow water?
7. What will be the wavelength of the water waves in the shallow water?



Suppose that the plane wave generator is now replaced by two point sources so as to generate circular waves. The two point sources are separated by a distance d and the waves generate an interference pattern as shown in the diagram to the left.

8. How does the distance between point source A and point P_1 compare with the distance between point source B and point P_2?

9. What will be true about ALL points on the dotted line indicated as n = 2 in the diagram?

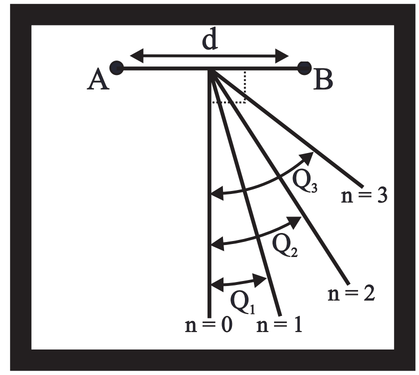
10. Is point P_1 in the diagram a node or an antinode? Explain!

Answers to opposite side: 11. 4.13 cm 12. 74.4 cm 13. 33.4^o 14. 55.7^o 15. $n_{max} = 3$ 16. diffraction 17. the waves will become less curved 18. slow down 19. 1.0 m 20. 28 m/sec 21. 7.84 N 22. 4.0 Hz 23. 7.0 m 24. 4, 8, 12 etc. Hz

PHYSICS HOMEWORK #84 WAVE MOTION

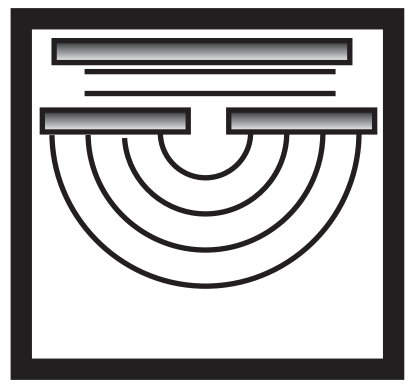
RIPPLE TANK WAVES

Two point sources are used to generate circular waves in a ripple tank as shown to the right. The distance between the two sources is measured to be d = 15.0 cm. and the sources are vibrating up and down with a frequency of f = 18.0 Hz. A line, n = 0, is drawn as a perpendicular bisector of $\overline{AB}$ and the antinodal lines n = 1, n = 2, and n = 3, are drawn as shown. The angle between the antinode n = 1 and the perpendicular bisector is measured to be $\Theta_1 = 16.0^o$.



11. What is the wavelength of the waves being generated?
12. What was the speed of these water waves?
13. At what angle Θ_2 will the second order antinode be drawn?
14. At what angle Θ_3 will the third order antinode be drawn?
15. What is the maximum order of antinodes **n** that can be produced by these two point sources?

A plane wave generator is used to produce linear waves in a ripple tank. Blocks of wood are placed in the tank and as a result waves are allowed to pass between the blocks and produce waves as shown.

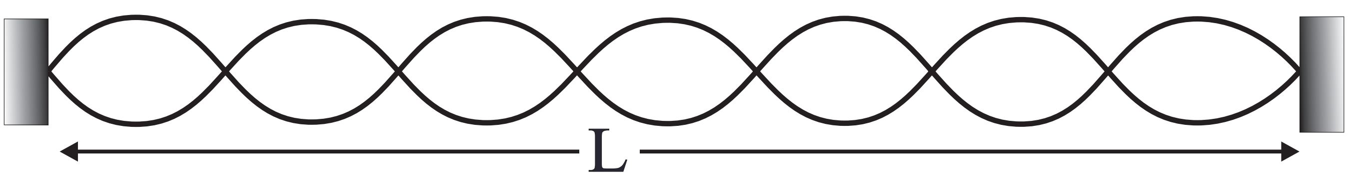


16. What wave property is responsible for the observed waves following the blocks?
17. What will happen in the area after blocks as the two blocks are moved farther apart?

- -

18. Water waves are moving through a wave tank when they enter an area of the tank where the water is more shallow. What will be the resulting effect on speed of the waves? Explain!

Transverse waves are being generated in a string between two fixed points which are L = 3.5 meters apart as shown below by a wave oscillator which is generating a frequency of f = 28 Hz. The string has a mass of 35.0 grams.



19. What is the wavelength of the wave in this string?
20. What is the speed of the wave in the string?
21. What tension is required to generate this wave speed?
22. What is the lowest frequency that could be used to generate a standing wave in this string?
23. What would be the wavelength of the lowest frequency wave that could form a standing wave in this string?
24. What other frequencies could form standing waves in this string?

Answers to opposite side: 1. 44.8 +/- 2.4 cm/sec 2. 1.45 sec 3. 38.0^o 4. 45.6 cm/sec 5. 32.0 cm/sec 6. 12.0 Hz 7. 2.67 cm 8. $\Delta d = 2\lambda$ 9. $\Delta d = 2\lambda$ 10. node, $\Delta d = \lambda/2$

PHYSICS HOMEWORK #85 WAVE MOTION

SOUND WAVES

[Unless stated otherwise assume room temperature 25°C!]

<u>**Speed of Sound**</u> **[S_o = 346 m/sec $^+/_-$ 0.6 m/sec/^{o}C at 25 ^{o}C]**

1. What is the speed of sound at 30°C?

2. What is the speed of sound at -12°C?

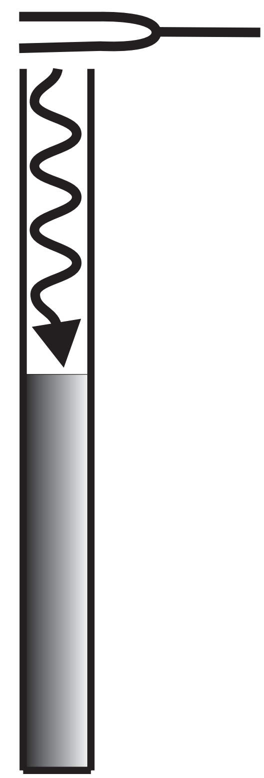
3. While standing is front of the "Obsidian cliffs" you shout loudly and note that the echo of your voice returns after 2.7 seconds. Given that the temperature is 20.0 °C, how far from the base of the cliff are you standing?

4. The frequency of high C on the piano is 512 Hz. What is the wavelength of this sound when the temperature is 15.0 °C?

5. Sonar is used to determine how deep water is below the hull of a ship by sending out a short burst of sound and listening for the return of the echo. Given that the speed of sound in typical water is 1498 m/s and that the the depth of the water is 1760 m, how long after the production of the burst of sound should the echo return?

<u>**Resonance of Sound**</u> **[λ = 4 (l+ 0.4d)]**

A tube, as shown to the right, has an inner diameter of 3.50 cm, and is filled to the top with water. A tuning fork, which has an unknown frequency f_o, is held over the mouth of the tube. The water level in the tube is gradually lowered until the sound of the tuning fork suddenly gets very loud when the water level in the tube has fallen to a point L = 26.0 cm below the top.



6. What is the wavelength λ of the sound produced by this tuning fork?

7. What is the frequency of this tuning fork?

The water level in the tube is lowered further until the sound again gets loud.

8. What is the distance L between the top of the tube and this second resonance point?

A tuning fork, which has a frequency of f = 512 Hz. is held over the mouth of a tube which has an inner diameter of 3.0 cm and is filled with water to the top. The water is slowly lowered until resonance is achieved.

9. What is the distance **L** between the top of the tube and the water level when this first resonance occurs?

The water level in the tube is lowered further until resonance again occurs.

10. What is the distance L between the top of the tube and water level when this second resonance occurs?

The water level in the tube is lowered even further until resonance occurs for the third time.

11. What is the distance L between the top of the tube and water level when this third resonance occurs?

Answers to opposite side: 12. 0.286 m 13. 131 Hz 14. 420 Hz 15. 840 Hz 16. 218 Hz 17. 655 Hz 18. 0.028 Watt/m^2 19. 0.0071 Watt/m^2 20. 40.2 m 21. 40 dB 22. 1.0 x 10^{-7} Watt/m^2 23. 36.7 dB 24. 0.032 Watt/m^2

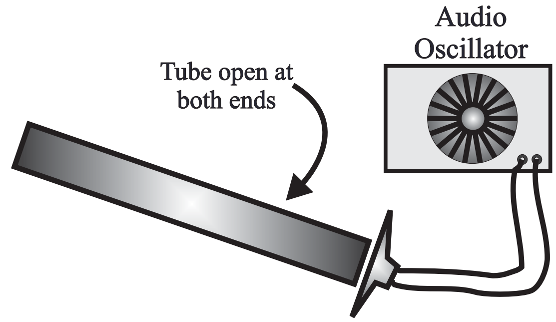
PHYSICS HOMEWORK #86 WAVE MOTION

SOUND WAVES

12. A tuning fork, which has a frequency of 288 Hz., is resonating over the mouth of a tube closed at one end and which has an inner diameter of 3.50 cm. What is the length of the tube?

13. What is the lowest frequency tuning fork which will resonate over a closed tube which has an inner diameter of 3.00 cm and is 65.0 cm long?

An open tube [a tube open at both ends!], which has an inner diameter of 4.0 cm and is 38.0 cm long, is placed in front of a speaker which is attached to an audio oscillator. The audio oscillator begins at the lowest possible frequency setting and is slowly turned up to higher frequencies.
[$\lambda = 2\ (l + 0.8d)$]



14. What is the lowest frequency that will cause this open tube to resonate?

15. What is the next higher frequency which will cause this open tube to resonate?

This open tube is replaced by a closed tube [a tube closed at one end and open at the other!] which has the same length and inner diameter as the open tube.

16. What is the lowest frequency that will cause this closed tube to resonate?

17. What is the next higher frequency which will cause this closed tube to resonate?

<u>Sound Intensity</u> **[$dB = 10 \log (I/I_o)$ assume $I_o = 10^{-12}$ Watt/m^2]**

18. A point source is emitting sound energy at the rate of 2.2 Watts. What will be the sound intensity [Watts/ m^2] a distance of 2.50 meters from this source?

19. The sound intensity is measured to be 4.60 x 10^{-5} Watts/m^2 a distance of 3.5 meters from a point source. At what rate is sound energy being emitted from the sound source.

20. A stereo amplifier is supplying 35.0 Watts of power to a point source speaker with an efficiency of 5.80 %. At what distance from this source will the intensity be 1.00 x 10^{-4} Watts/m^2?

21. The sound intensity in a room is measured to be 1.00 x 10^{-8} Watts/m^2. What is this sound intensity in decibels?

22. The sound intensity in a room is measured to be 50.0 decibels. What will be the intensity of sound in this room in Watts/m^2?

23. What will be the sound level in decibels if the intensity is measured to be 4.7 x 10^{-9} Watts/m^2?

24. The sound intensity is a football stadium is measured to be 105 decibels. What is the corresponding intensity in Watts/m^2?

Answers to opposite side: 1. 349 m/sec 2. 324 m/sec 3. 463 m 4. 0.664 m 5. 2.35 sec 6. 1.096 m 7. 316 Hz 8. 0.808 m 9. 0.157 m 10. 0.495 m 11. 0.833 m

PHYSICS HOMEWORK #87 WAVE MOTION

SOUND WAVES

25. When two automobiles are compared in a typical consumer testing magazine it is found that the sound level in one car moving down the highway at 50 mph is 68.0 dB while the sound level in a second car under the same conditions is measured to be 75.0 dB. How does the intensity level in the second car compare to the sound level in the first car?

26. The sound level in a quiet living room may be 44.0 dB while the sound level in a noisy subway station may be 108 dB. How does the sound intensity in the subway station compared to the sound intensity in the living room?

27. The signal to noise ratio of a typical audio cassette deck is on the order of 40.0 dB. [The signal to noise ratio is a comparison of the strength of the desired signal compared to the unwanted background noise.] How strong is the signal compared to the background noise for a cassette deck?

28. The audio discs [CDs] have a dynamic range [Dynamic range compares the loudest passage of a musical piece to the quietest passage of the same piece.] of 90.0 dB. How will the intensity of the loudest sound produced by a CD compare to the intensity of the quietest sound?

<u>Doppler Effect</u> [$f = f_o (S\ {}^{+}/_{-}\ S_o)/(S\ {}^{-}/_{+}\ S_s)$]

29. Suppose that the horn of a car generates a frequency of 256 Hz while at rest. What will be the apparent frequency of this horn if the car is moving toward you at 35.0 m/s? [Assume room temperature 25°C]

30. What will be the apparent frequency of the horn above if the car is moving away from you at 35.0 m/s?

31. A train is moving toward you with a velocity of 43.0 m/s when the horn, which has a frequency of 420 Hz while at rest, is sounded continuously as the train passes through the intersection directly in front of you. Assuming that the ambient temperature is 10.0 °C, what will be the **change** in frequency of the horn as the train passes you?

32. The temperature is 15.0 °C and a car, which has a horn with a rest frequency of 355 Hz., is moving toward you so that the apparent frequency that you hear is 372 Hz. What is the velocity of this car?

33. Suppose that a car is sitting at an intersection ahead of you with the horn blaring. The frequency of the horn while at rest is 440 Hz. What frequency will you hear if you are approaching the intersection at 26.0 m/sec?

34. What frequency will you hear above if you are moving away from the intersection at 26.0 m/sec?

35. You are driving North on Route 9 with a speed of 22.0 m/sec when you encounter a car moving South at 28.0 m/sec. The car moving South has a horn which has a frequency of 440 Hz. when measured at rest. What frequency will you hear as you approach this southbound car with its horn blaring?

Answers to opposite side: 36. 4.0 Hz 37. 517 Hz & 507 Hz 38. 128 Hz 39. 362 Hz 40. 85.3 Hz 41. 1024 Hz 42. 0.50 m 43. 90.0 m/sec 44. 30 Hz 45. 90 Hz 46. 270 Hz 47. 10.0 Hz 48. 60.0 Hz 49. 85 Hz

PHYSICS HOMEWORK #88 WAVE MOTION
SOUND/MECHANICAL WAVES

Beats

36. Two different sounds, with frequencies of 550 Hz and 554 Hz, are sounded simultaneously. What will be the frequency of the resulting beats?

37. A tuning fork, which has a frequency of 512 Hz., is struck while simultaneously a string on a guitar is plucked. You note that the sound volume generated by these two sources together beats 5 times each second. What is the frequency of the guitar string?

Laws of Strings

A string, which is 35.0 cm long and which is connected between two fixed points, is measured to have a resonant frequency of 256 Hz.

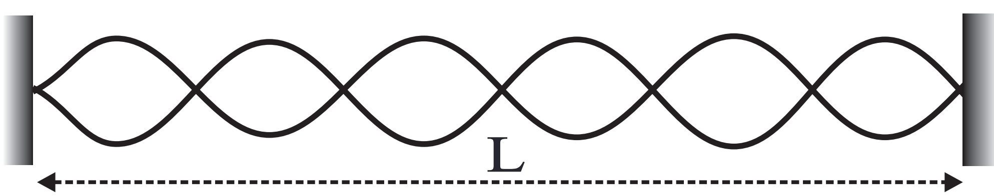
38. What will happen to the resonant frequency of this string if the length of the string is increased to 70. cm?

39. What will be the new resonant frequency of this string if the tension in the string is doubled?

40. What will be the new resonant frequency of this string if the diameter of the string is tripled?

41. What will be the new resonant frequency of this string if the Tension is quadrupled while the diameter of the string is halved?

Consider the string vibrating below and forming a standing wave with a frequency of 180 Hz. The length of this string is L = 1.50 m.



42. What is the wavelength of this wave?

43. What is the speed of this wave?

44. What is the fundamental frequency that will resonate in this string?

45. What will be the frequency of the 3rd harmonic that will resonate in this string?

46. What will be the frequency of the 9th harmonic that will resonate in this string?

47. What will be the new fundamental resonant frequency if the diameter of this string is tripled?

48. What will be the new fundamental resonant frequency if the tension in this string is quadrupled?

49. What will be the new resonant frequency if the tension is tripled while the diameter of the string is halved?

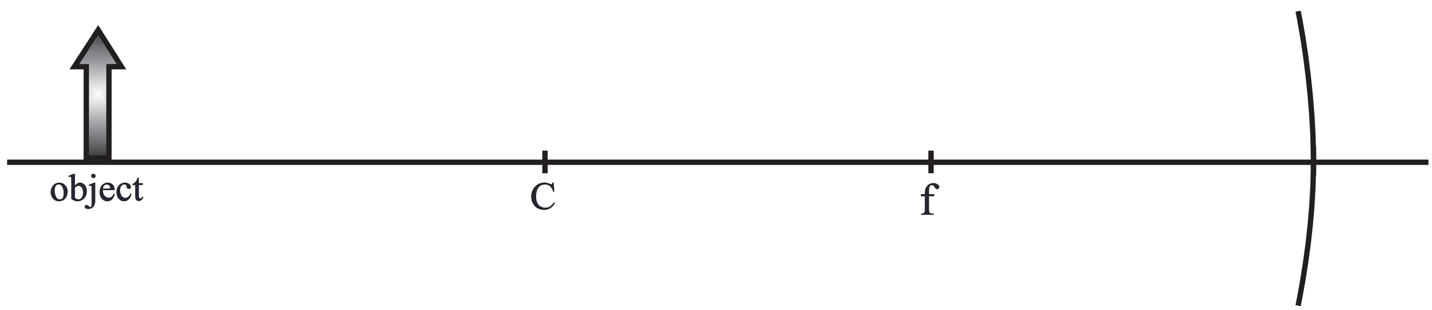
Answers to opposite side: 25. 5.01x 26. 2.51×10^6 x 27. 1.0×10^4 x 28. 1.0×10^9x
29. 285 Hz 30. 233 Hz 31. 109 Hz 32. 15.5 m/sec 33. 473 Hz 34. 407 Hz 35. 509 Hz

PHYSICS HOMEWORK #91 WAVE PROPERTIES OF LIGHT

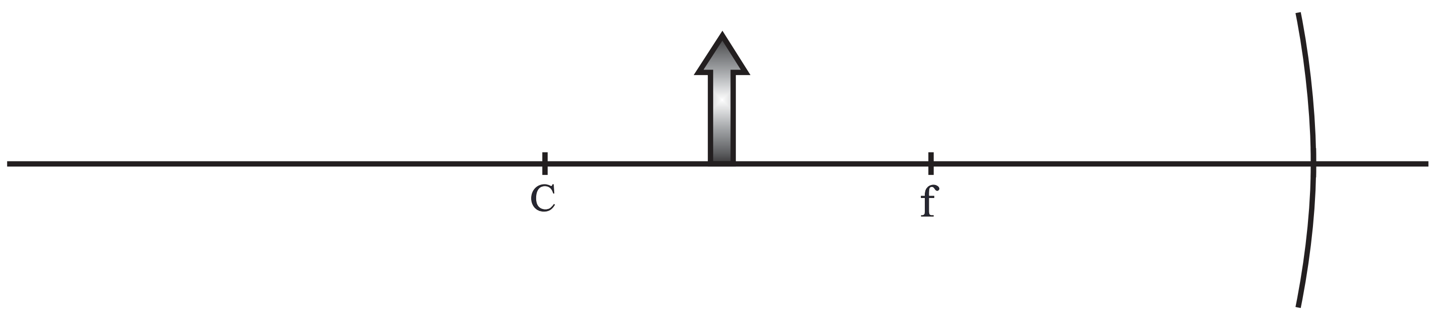
REFLECTION - MIRROR DIAGRAMS

For each case determine the position of the image using at least two light rays [drawn with a straight edge!], draw in the image and indicate whether the resulting image is real or virtual.

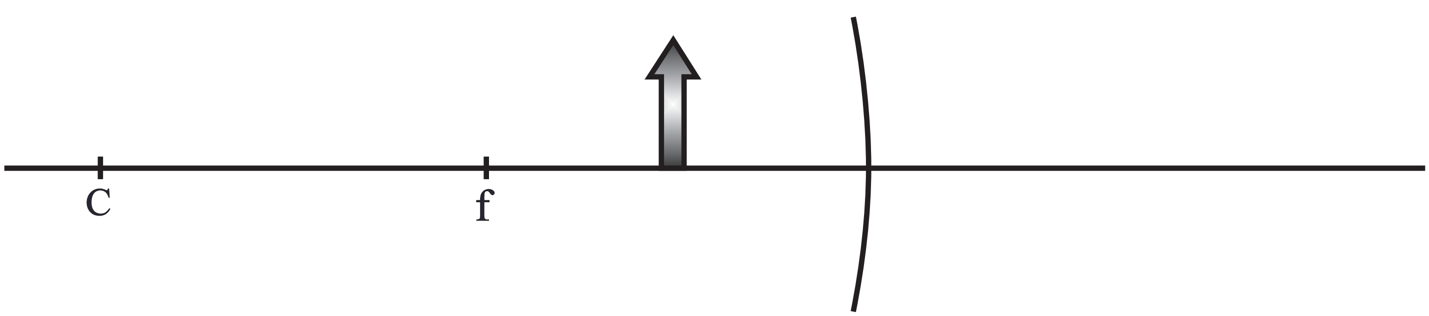
1. Real or Virtual?



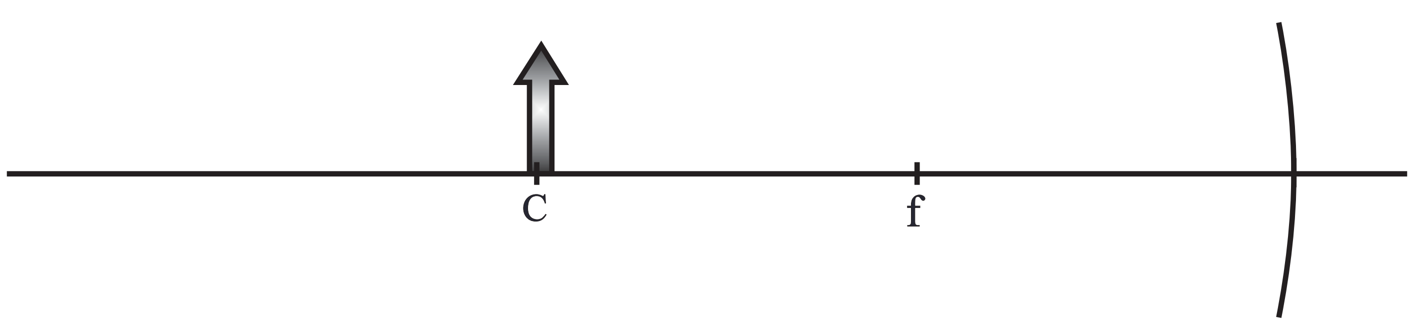
2. Real or Virtual?



3. Real or Virtual?



4. Real or Virtual?

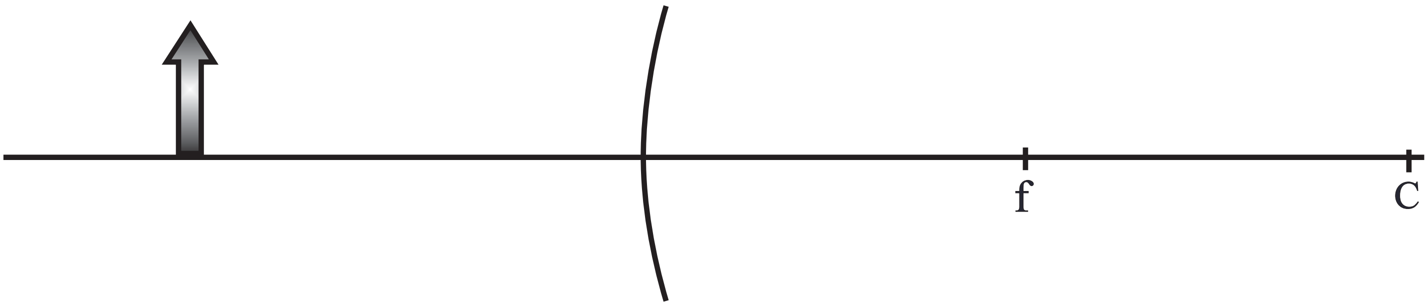


PHYSICS HOMEWORK #92 WAVE PROPERTIES OF LIGHT

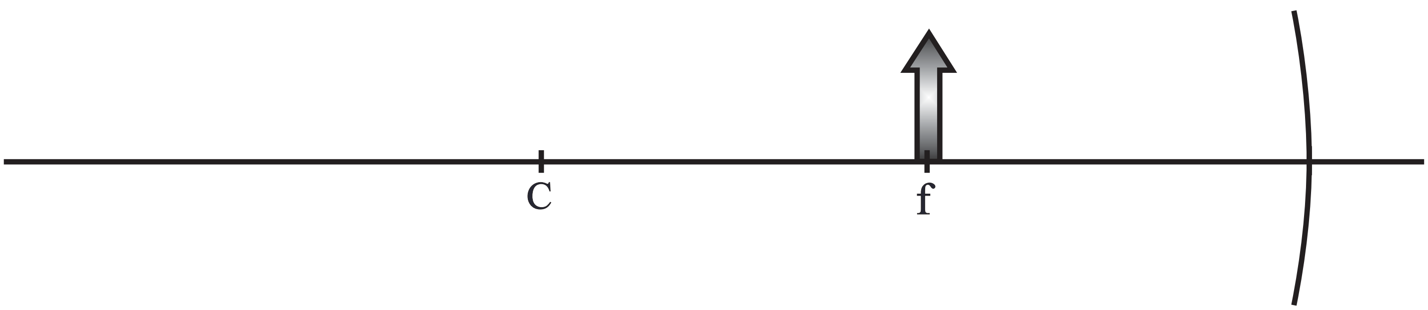
REFLECTION - MIRROR DIAGRAMS

For each case determine the position of the image using at least two light rays [drawn with a straight edge!], draw in the image and indicate whether the resulting image is real or virtual.

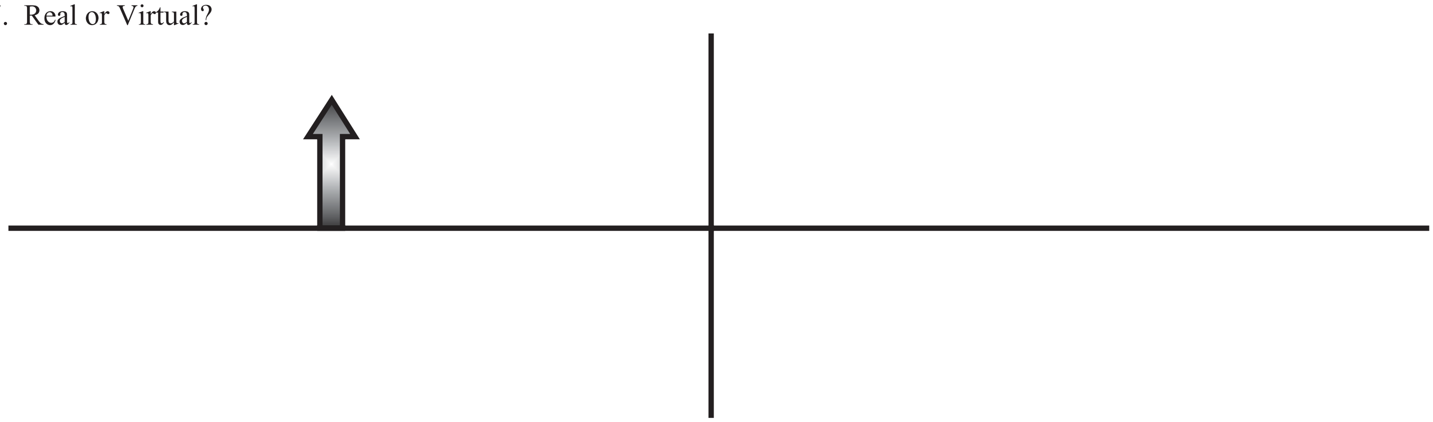
5. Real or Virtual?



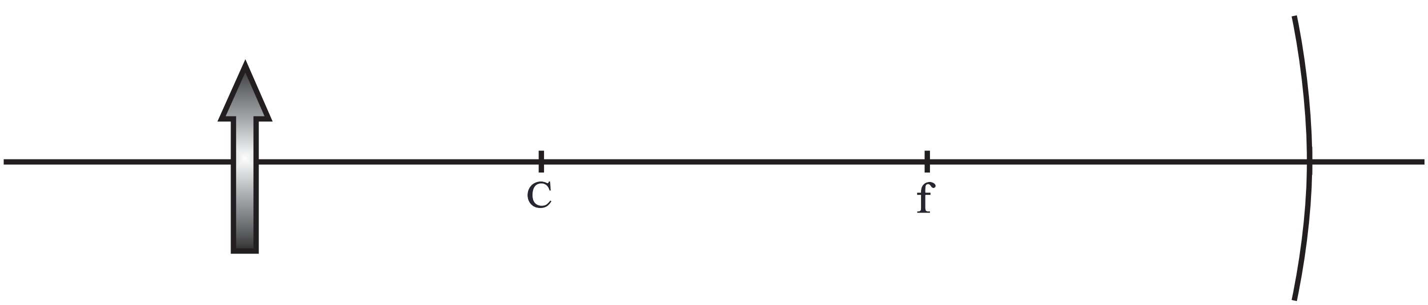
6. Real or Virtual?



7. Real or Virtual?



8. Real or Virtual?



PHYSICS HOMEWORK #93 WAVE PROPERTIES OF LIGHT

REFLECTION OF LIGHT

1. An object, which has a height of 5.50 cm, is placed 22.0 cm in front of a plane mirror:
   a. What will be the position of the resulting image?
   b. What will be the height of the resulting image?
   c. What will be the magnification of the resulting image?
   d. What is the focal length of this mirror?
   e. Is the resulting image real of virtual?

2. An object, which has a height of 12.5 cm, is placed 45.0 cm in front of a concave, spherical mirror, which has a focal length of 15.0 cm:
   a. What is the radius of curvature of this mirror?
   b. What will be the position of the resulting image?
   c. What will be the magnification of the resulting image?
   d. What will be the height of the image?
   e. Is the resulting image real or virtual? Explain!

3. An object, which has a height of 14.0 cm, is placed 25.0 cm in front of a convex mirror, which has a focal length of - 45.0 cm:
   a. What is the radius of curvature of this mirror?
   b. What will be the position of the resulting image?
   c. What will be the magnification of the resulting image?
   d. What will be the height of the resulting image?
   e. Is the resulting image real or virtual? Explain!
   f. What is the maximum magnification that this mirror is capable of producing?

4. An object, which is 11.0 cm tall, is placed 15.0 cm from a concave mirror, which has a focal length of 25.0 cm:
   a. What will be the position of the resulting image?
   b. Is the resulting image real or virtual? Explain!
   c. What is the magnification of the resulting image?
   d. What will be the height of the resulting image?

5. An object, which has a height of 27.0 cm, is placed 18.0 cm from a concave mirror, which has a radius of curvature of 22.0 cm and a diameter of 3.70 cm:
   a. What is the focal length of this mirror?
   b. What will be the position of the resulting image?
   c. What will be the height of the resulting image?
   d. What is the aperture of this mirror?

6. An object, which has a height of 3.50 cm, is to be placed in front of a concave mirror, which has a focal length of 15.0 cm, so as to produce a real image 49.0 cm high. How far from the mirror should the object be placed?

7. Whenever an object 12.0 cm tall is placed in front of a certain mirror, an image 30.0 cm tall is projected on a screen placed 63.0 cm away from the mirror. What is the focal length of the mirror?

8. A reflecting telescope is made with a concave mirror which has a diameter of 6.0" and an aperture of f/9.0. This telescope is to be used to observe the moon, which has a diameter of 1090 miles and is located an average of 220,000 miles from the Earth:
   a. What is the focal length of the primary mirror in this telescope?
   b. How far from the primary mirror should the viewing screen be placed in order to produce a sharp image?

c. What will be the diameter of the image that is projected on the viewing screen?

Answers to opposite side: 9. 0.026" 10. 9.00 cm 11. 17.0 cm 12a. 12.5 cm b. 12.8 cm 13a. 36.0 cm 13b. -18.0 cm 14a.2.00 m b. 4.00 mm c. 9.46×10^{15} m d. 2.84×10^{16} m e. 1.41×10^{-19}x f. real 14g. 0.0667 m h. 1.33 mm i. 0.0667 m j. real

PHYSICS HOMEWORK #95 WAVE PROPERTIES OF LIGHT
REFRACTION OF LIGHT

9. A reflecting telescope, which has a primary mirror with a diameter of 10" and an aperture of f/11, is used to view a galaxy in the Virgo Cluster which has a diameter of 12,000 c yrs [light year - the distance traveled by light in one year] and is nearly 50,000,000 c yrs from the Earth. What will be the diameter of the resulting image of this galaxy projected on the viewing screen?

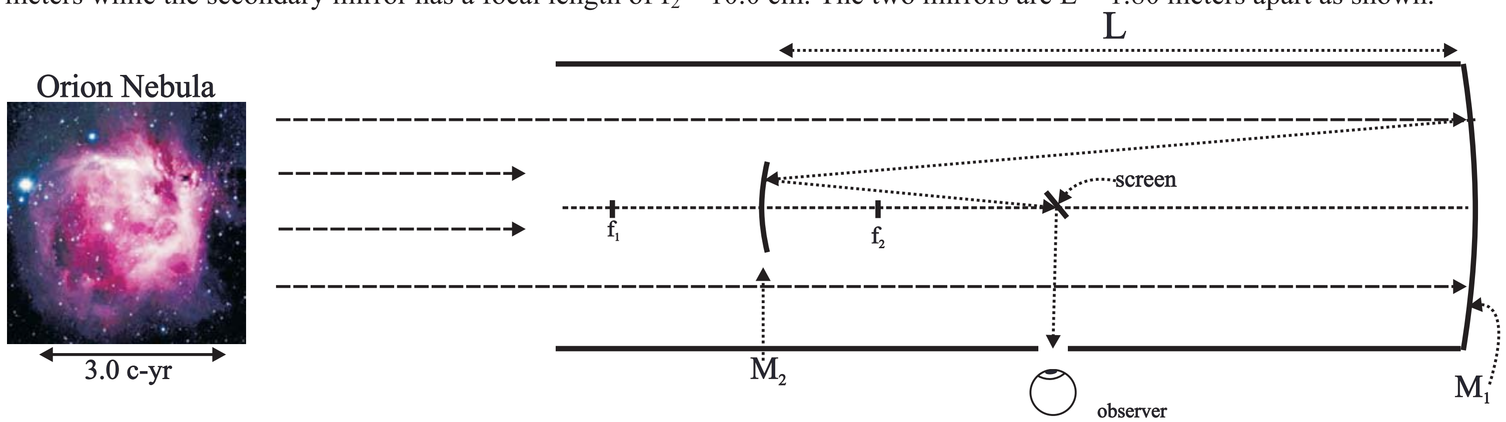
10. A shaving/beauty mirror [concave] has a focal length of 18.0 cm. How far from the mirror should your face be in order for your image to be twice its normal size?

11. An object, which has a height of 13.0 cm, is placed 6.00 cm from a concave mirror, which has an aperture of f/8.0 and a diameter of 3.00 cm. What will be the height of the resulting image?

12. You are going to use a concave mirror to project a 35.0 millimeter slide [width of the slide] onto a screen, which is 1.50 meters wide and which is located 5.50 meters away from the mirror. Assuming that this image is to fill the screen fully:
   a. What should the focal length of the mirror be?
   b. How far from the mirror should the slide be placed?

13. An object, which has a height of 6.90 cm, is placed in front of a convex mirror so as to produce a virtual image, which has a height of 2.30 cm, a distance of 12.0 cm from the mirror:
   a. How far from this mirror must the object be placed?
   b. What is the focal length of the mirror?

14. An optical reflecting telescope is used to observe the Orion nebula, which is located 1500 light years from the Earth and which has an average diameter of 3.0 light years. The primary mirror M_1 of the telescope has a focal length of $f_1 = 2.00$ meters while the secondary mirror has a focal length of $f_2 = 10.0$ cm. The two mirrors are L = 1.80 meters apart as shown.



   a. How far from the primary mirror will the first image be found?
   b. What will be the height of the first image?
   The speed of light is 3.0 x 10^8 m/sec.
   c. How far does light travel in one year?
   d. What is the diameter of the Orion Nebula in meters?
   e. What is the magnification of the first image of the Orion Nebula?
   f. Is the first image real or virtual? How do you know?
   g. How far from the secondary mirror will the image be found?
   h What will be the height of the secondary image?
   i. How far from the secondary mirror should the screen be placed?
   j. Is the secondary image real or virtual? How do you know?

Answers to opposite side: 1a. -22.0 cm b. 5.50 cm c. 1.0x 2a. 30.0 cm b. 22.5 cm c. 0.50x d. 6.25 cm 3a. 90.0 cm b. -16.1 cm c. 0.644x d. 9.02 cm f. 1.0x 4a. -37.5 cm c. 2.50x d. 27.5 cm 5a. 11.0 cm 5b. 28.3 cm c. 42.5 cm d. f/2.97 6. 16.1 cm 7. 18.0 cm 8a. 54" b. 54" c. 0.27"

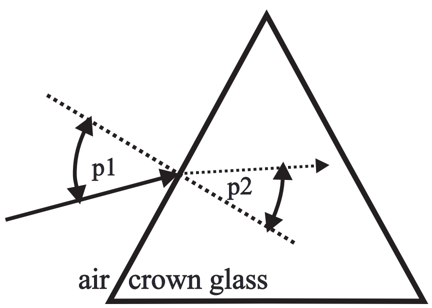
PHYSICS HOMEWORK #96 WAVE PROPERTIES OF LIGHT
REFRACTION OF LIGHT

INDEX OF REFRACTION	
AIR	1.00
ALCOHOL	1.36
BENZENE	1.50
CALCITE	1.658
	1.486
DIAMOND	2.42
GLASS, CROWN	1.52
GLASS, FLINT	1.63
GLYCEROL	1.48
ICE	1.31
LUCITE	1.50
QUARTZ	1.54
	1.55
SAPPHIRE	1.769
	1.76
WATER	1.33

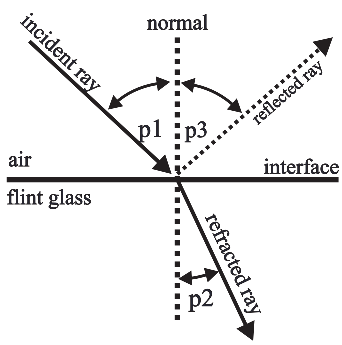
1. The speed of light in a vacuum is $c = 3.0 \times 10^8$ m/s while the speed of light in diamond is measured to be 1.24×10^8 m/s. What is the index of refraction of diamond?

2. The index of refraction of light in water is $n_{water} = 1.33$. What is the speed of light in water?

3. Light, which has a wavelength of $\lambda = 450$ nm, is moving through Carbon Tetrachloride with a speed of 2.056×10^8 m/s.
   a. What is the index of refraction of this liquid?
   b. What is the frequency of this light wave?
   c. What will be the corresponding wavelength of this light wave in air?



4. Light, which has a wavelength of 625 nm in air, enters flint glass.
   a. What is the speed of light in flint glass?
   b. What will be the wavelength of this light within the glass?
   c. What is the frequency of this light within the glass?
   d. What is the frequency of this light in air?



5. As shown in the diagram to the left a light ray, which has a wavelength of 580 nm, strikes a horizontal interface going from air into flint glass. Given that the angle between the incident light ray and the normal to the interface is $\angle 1 = 47.0^o$,
   a. What will be the corresponding angle $\angle 2$ in the flint glass?
   b. What will be the wavelength of this light within the flint glass?
   c. What will be the frequency of this light within the flint glass?
   Some of the light reflects at the interface as shown
   d. What will be the angle $\angle 3$ between the reflected light ray and the normal to the interface?

6. A beam of light is moving through lucite when it encounters an interface leading into water at an angle of 46.0^o relative to the normal. What will be the corresponding angle in the water?

7. A light beam traveling through glycerol encounters an interface at an angle of 67.0^o relative to the normal to the surface. The corresponding angle in the second medium is measured to be 50.5^o. What is the second medium?

8. A light wave moving through an unknown medium encounters an interface at an angle of 52.0^o and then refracts to an angle of 45.2^o into lucite. What is the first medium?

9. A light beam is moving from flint glass into water.
   a. What will be the corresponding angle in the water if the angle in the glass is $\angle = 30.0^o$?
   b. What will be the corresponding angle in the water if the angle in the glass is $\angle = 50.0^o$?
   c. What will be the corresponding angle in the water if the angle in the glass is $\angle = 55.0^o$?
   d. What is the critical angle between these two mediums?

10. What is the critical angle between diamond and water?

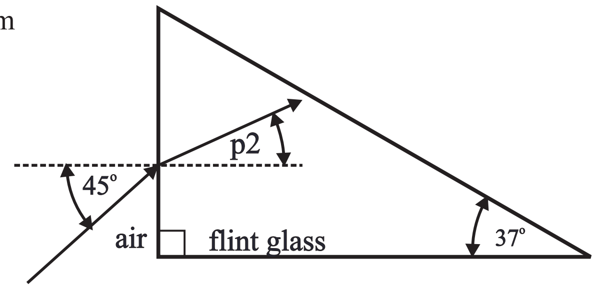
11. What is the critical angle between alcohol and lucite?

PHYSICS HOMEWORK #97 WAVE PROPERTIES OF LIGHT
REFRACTION OF LIGHT - LENS DIAGRAMS

12. What is the critical angle between hot air [n_{hot} = 1.02] and room temperature air [n_{room} = 1.00]?

Answers to opposite side: 13a. 25.7° b. 27.3° c. 48.4° 14a. 32.6° b. 27.3° c. 44.4° 15a. 14.3° b. 45.7° c. 22.0° 16a. 1.66 b. 2.21

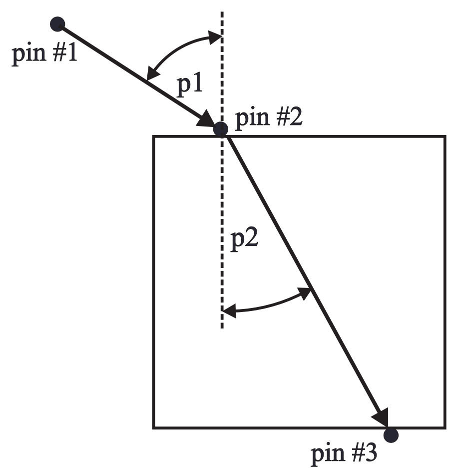
13. A light ray encounters a **right** prism, made of flint glass, as shown in the diagram to the right. The angle between the incoming light beam and the normal is ∠1 = 45.0°.
   a. What will be the corresponding angle ∠2 of refraction within the glass?
   b. What will be the angle between the light beam and the normal to the opposite interface ∠3?
   c. What will be the angle at which the beam of light emerges from the prism ∠4?



14. A light ray encounters an **equilateral** prism made of crown glass at an angle of incidence of ∠1 = 55.0° as shown in the diagram to the left.
   a. What will be the corresponding angle of refraction ∠2 in the crown glass?
   b. What will be the angle between the light ray and the normal to the opposite interface ∠3?
   c. What will be the angle at which the beam of light emerges from the prism ∠4?
   d. Complete the ray diagram.

15. A light ray encounters an **equilateral** prism made of crown glass at an angle of incidence of ∠1 = 22.0°
   a. What will be the corresponding angle of refraction ∠2 in the crown glass?
   b. What will be the angle between the light ray and the normal to the opposite interface ∠3?
   c. What will be the angle at which the beam of light emerges from the prism?
   d. Complete the ray diagram showing the path of the light ray through the equilateral prism.

16. A square plate of glass is sitting upon a piece of white paper which is in turn sitting on a piece of cardboard. You outline the glass plate with a pencil. A pin is inserted into the cardboard at location #1 as shown. You look through the front edge of the glass plate and then insert a second pin in location #2 along the back edge of the glass plate and finally you insert a third pin into location #3 along the front edge of the glass plate. As you look through the front edge of the glass plate all three pins appear to be in a straight line. The glass plate is then removed and a straight edge is used to connect the three pins together and the normal is added as shown. Finally, the angles, ∠1 & ∠2, formed between the normal to the interface and the light rays are measured to be ∠1 = 62.0° and ∠2 = 32.1°.
   a. What is the index of refraction of this glass plate?
   Suppose that these same measurements were made while the plate was submerged in water rather than in air as in the lab.
   b. What would the index of refraction of this plate?



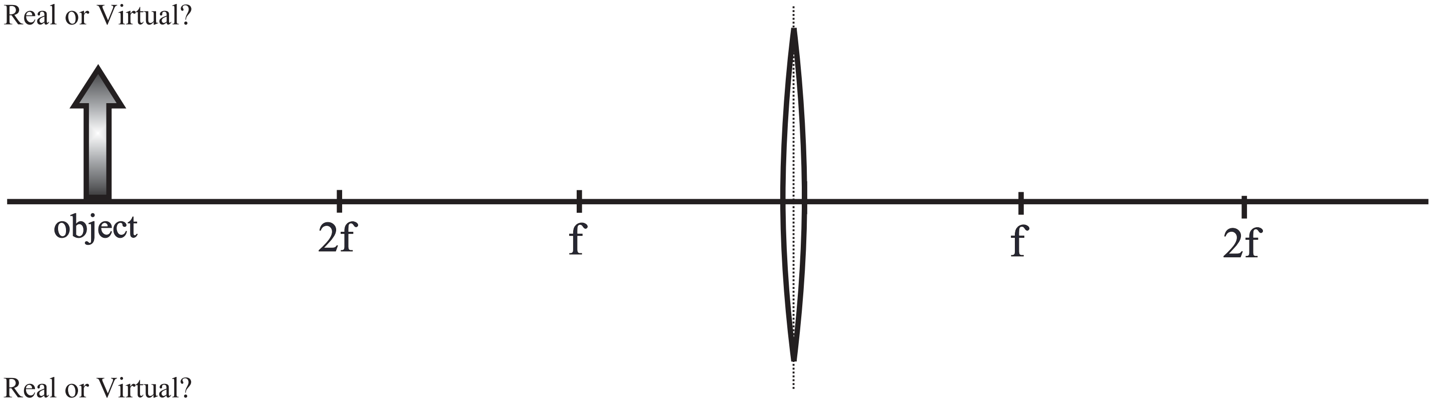
Answers to opposite side: 1. 2.42 2. 2.26 x 10^8 m/s 3a. 1.46 3b. 4.57 x 10^{14} Hz 3c. 657 nm 4a.1.84 x 10^8 m/s 4b. 383 nm 4c & d. 4.80 x 10^{14} Hz 5a. 26.7° b. 356 nm 5c. 5.17 x 10^{14} Hz

5d. 47.0° 6. 54.2° 7. 1.77 [sapphire] 8. 1.35 [alcohol] 9a. 37.8° b. 69.9°

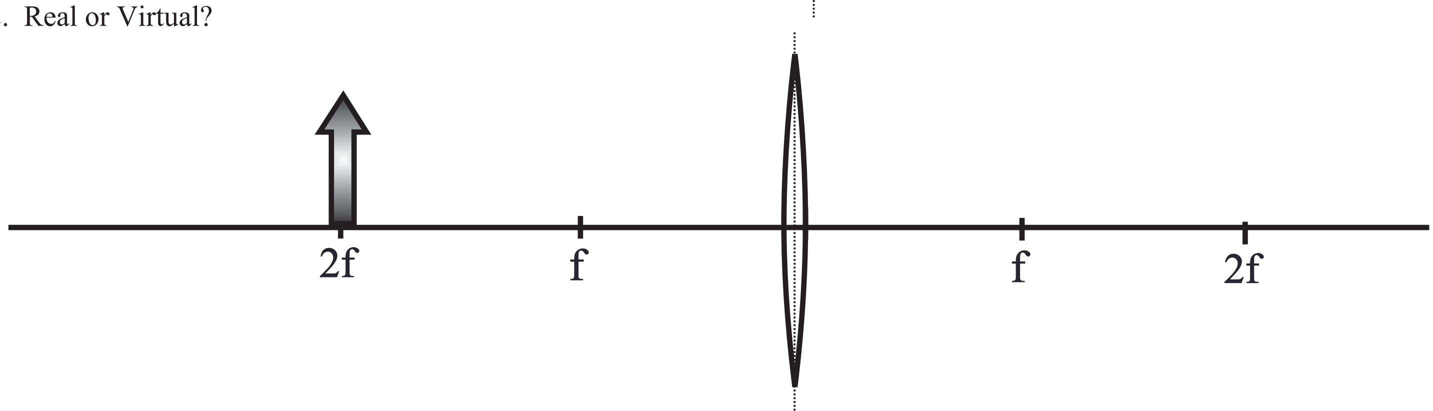
PHYSICS HOMEWORK #98 WAVE PROPERTIES OF LIGHT
REFRACTION OF LIGHT - LENS DIAGRAMS

For each case determine the position of the image using at least two light rays [drawn with a straight edge!], draw in the image and indicate whether the resulting image is real or virtual.

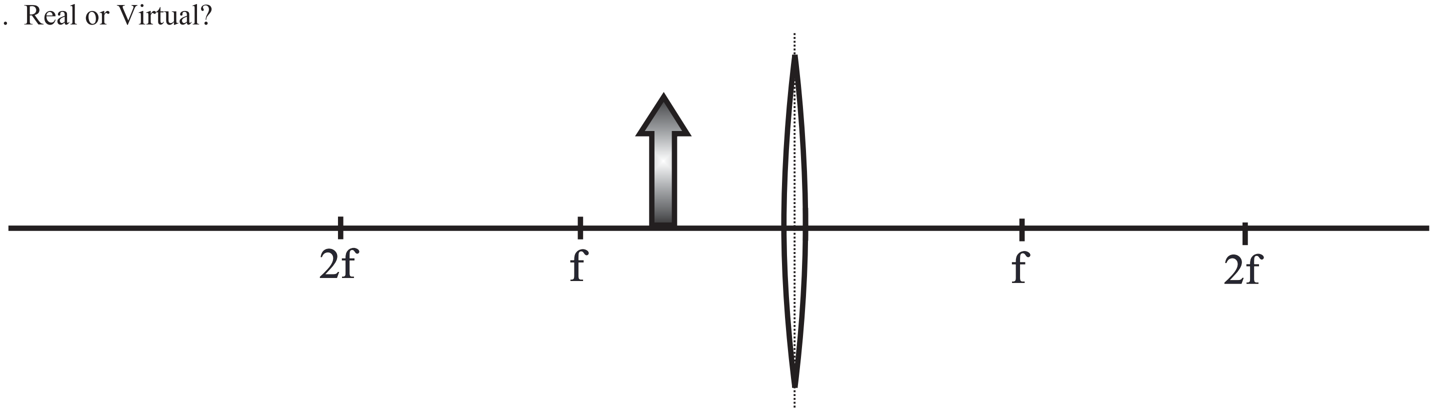
1. Real or Virtual?



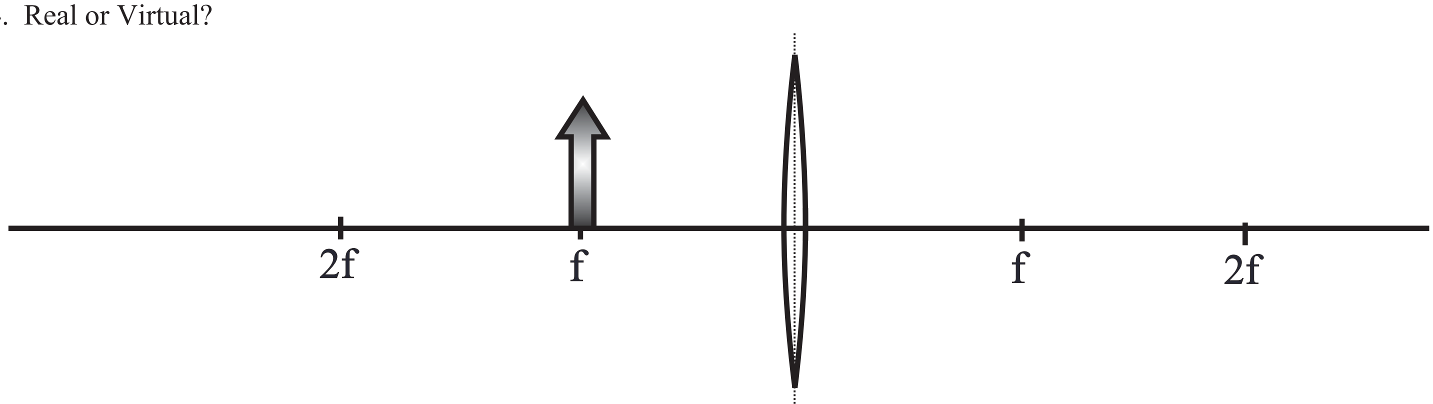
2. Real or Virtual?



3. Real or Virtual?



4. Real or Virtual?

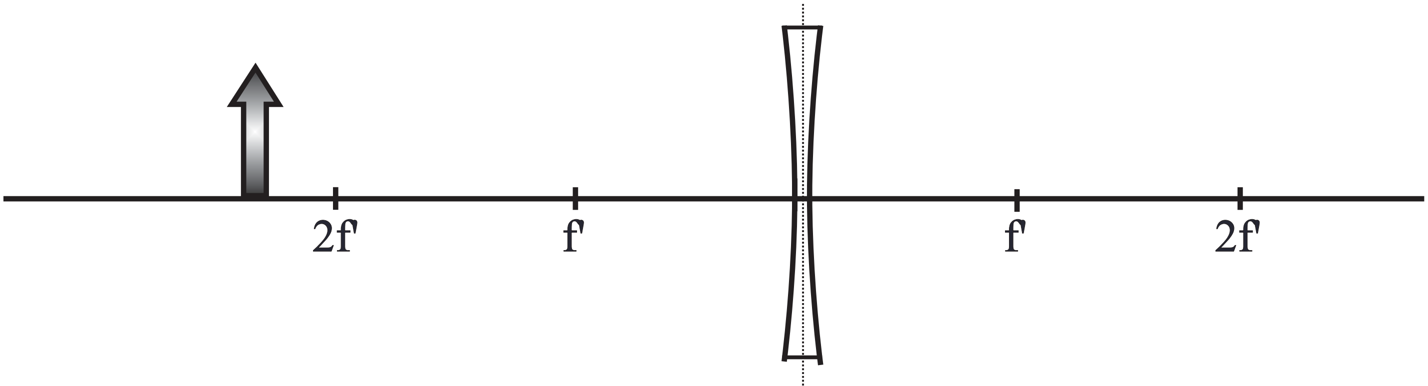


PHYSICS HOMEWORK #99 WAVE PROPERTIES OF LIGHT

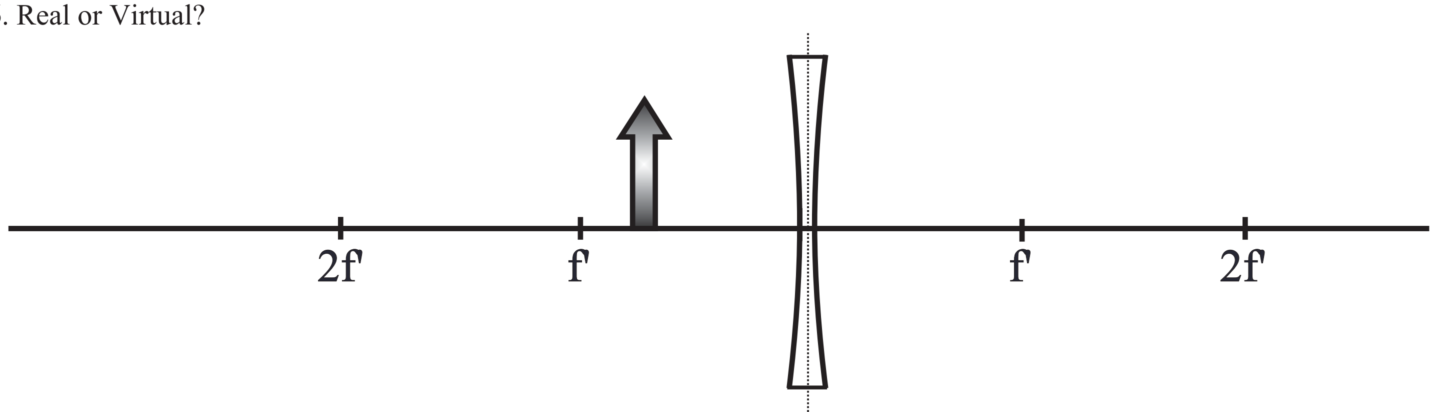
REFRACTION OF LIGHT

For each case determine the position of the image using at least two light rays [drawn with a straight edge!], draw in the image and indicate whether the resulting image is real or virtual.

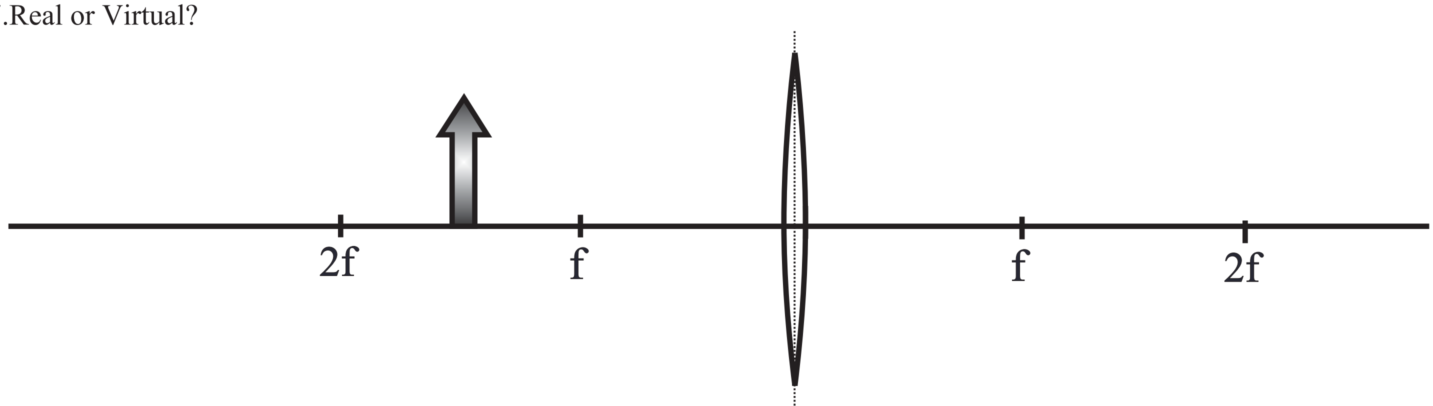
5. Real or Virtual?



6. Real or Virtual?

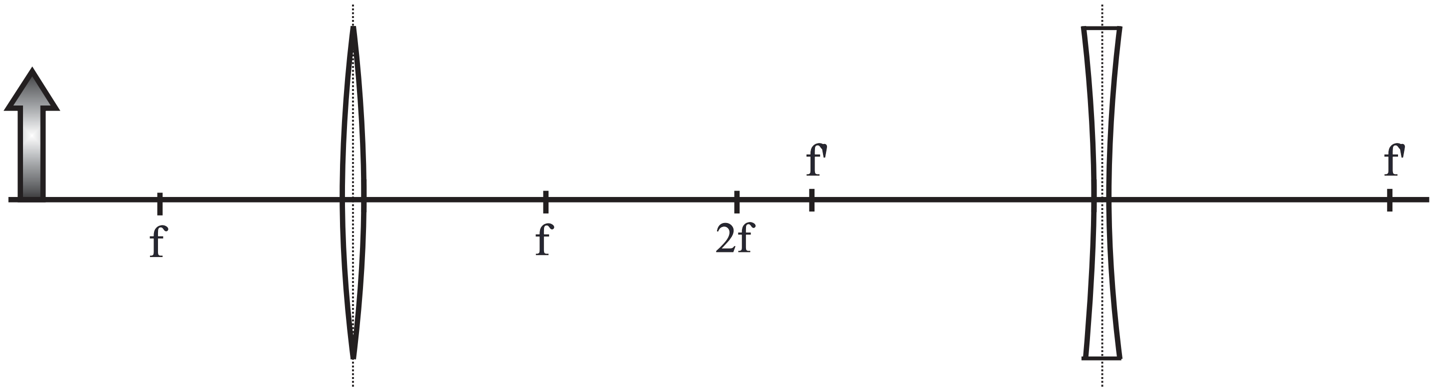


7.Real or Virtual?



REFRACTION OF LIGHT

8. Real or Virtual?



1. A thin lens is made out of flint glass, which has an index or refraction of $n_{glass} = 1.58$. The lens is a double convex which has a radius of curvature of 8.8 cm on one side and 12.5 cm on the other.
   a. What is the focal length of this lens in air [$n_{air} = 1.0$] ?
   b. What will be the focal length of this lens if is is immersed in a liquid which has an index of refraction of n = 1.44 ?

2. Determine the focal length of each of the following lenses in air:
   a. n = 1.55, R_1 = 7.5 cm, R_2 = 7.5 cm, double convex
   b. n = 1.58, R_1 = 11.2 cm, R_2 = 7.7 cm, convex, concave
   c. n = 1.61, R_1 = 7.5 cm, R_2 = 9.8 cm, double concave

3. An object, which has a height of 2.3 cm, is placed 44.0 cm from a double convex lens, which has a focal length of 12.0 cm and a diameter of 3.5 cm.
   a. What is the aperture of this lens?
   b. Where will the image be located?
   c. What will be the magnification of the image?
   d. What will be the height of the resulting image?
   e. Will this image be real or virtual? How do you know?

4. An object, which has a height of 7.2 cm, is placed 18.0 cm from a double concave lens, which has a focal length of -11.0 cm.
   a. Where will the image be formed?
   b. What will be the magnification of the resulting image?
   c. What will be the height of the image?
   d. Will this image be real or virtual? How do you know?

5. An object, which has a height of 4.5 cm., is placed 7.0 cm from a double convex lens, which has a focal length of 11.0 cm.
   a. Where will the image be found?
   b. What will be the magnification of the resulting image?
   c. What will be the height of the resulting image?

6. An object is placed 34.0 cm from a double convex lens which has a focal length of 8.50 cm. A real image, which is 5.2 cm high, is formed on the other side of the lens. What is the height of the object?

7. You would like to project a real image, which is to have a height of 2.50 meters, on a screen placed 5.50 meters away from the lens. The object itself is 25.0 cm tall. What focal length lens do you need?

8. While looking through a concave lens, which has a focal length of - 35.0 cm, you measure the diameter of a pencil to be 2.5 millimeters. The measured diameter of the pencil is known to be 7.0 millimeters. How far from the lens is the pencil placed?

9. A lens, which has a focal length of 22.0 cm, is placed into contact with a second lens, which has a focal length of 12.0 cm. What will be the combined focal length of these two lenses?

10. A lens, which has a focal length of - 15.0 cm, is placed into contact with a second lens which has a focal length of 22.0 cm. What will be the combined focal length of these two lenses?

Answers to opposite side #63: 11. 18.97 cm 12. -16.2 cm 13. 9.9 cm 14a. 13.0 cm to the left of lens #2 14b. 1.13x 15a. 14.0 cm to the left of lens #2 b. 0.036x

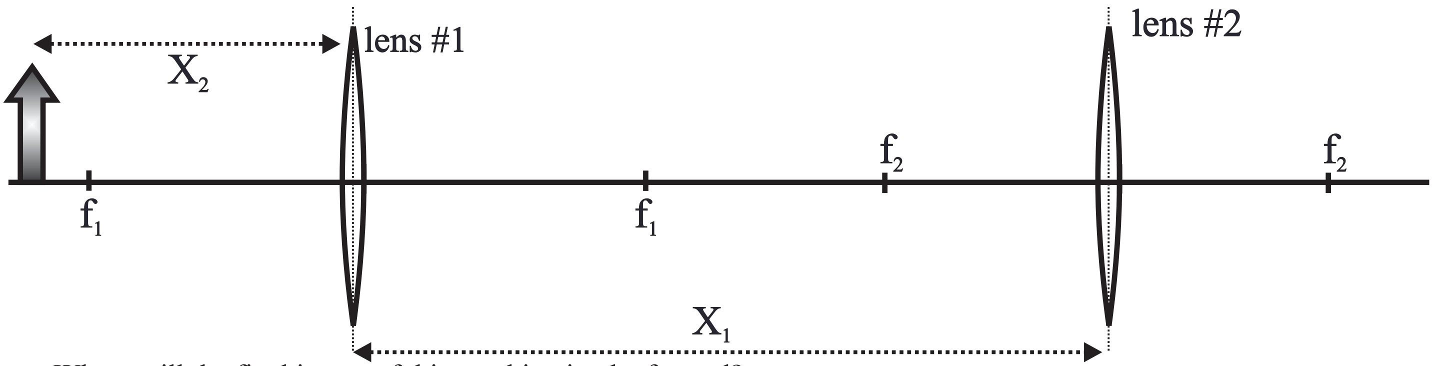
PHYSICS HOMEWORK #102 WAVE PROPERTIES OF LIGHT
REFLECTION OF LIGHT

11. You are looking at a street sign 12.0 meters away from you with your left eye. The distance between the lens of your left eye and the retina [the eye's projection screen!] is 19.0 millimeters. What should the focal length of your eye's lens be if the image is to be sharply projected on the retina?

12. The distance between the lens and retina of an eye is 19.0 mm while the focal length of this eye is 17.0 mm. What focal length corrective lens should be used to project a sharp image on the retina?

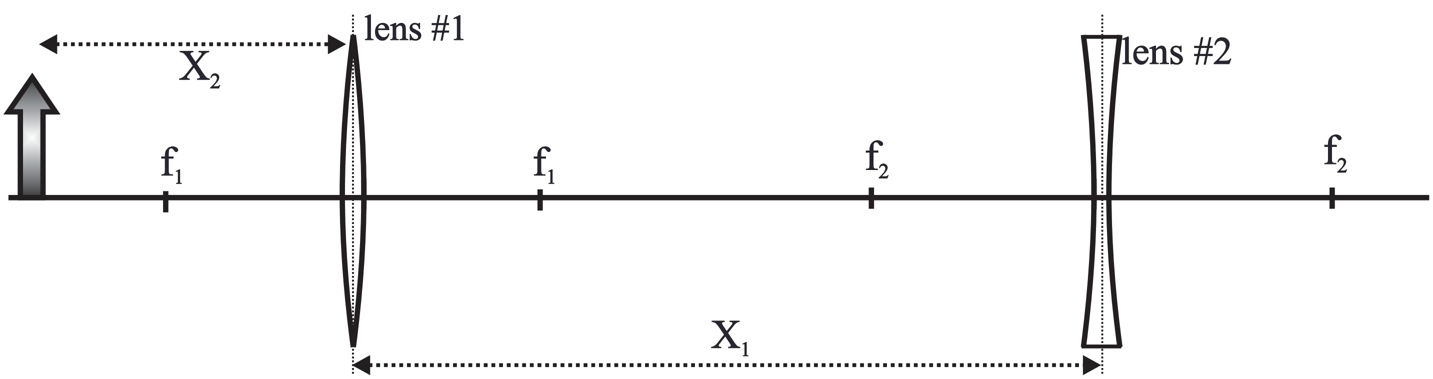
13. The distance between the retina and lens of an eye is 18.0 mm while the focal length of the lens of this eye is 22.0 mm. What focal length correcting lens is required to produce a sharp image on the retina?

14. Two lenses, which are separated by a distance of $X_1 = 42.0$ cm, are arranged as shown below. Lens #1 has a focal length of $f_1 = 22.0$ cm, while lens #2 has a focal length of $f_2 = 15.0$ cm. An object, which has a height of 4.40 cm, is placed $X_2 = 58$ cm to the left of lens #1 as shown. [Diagram **NOT** to scale!]



a. Where will the final image of this combination be formed?
b. What will be the magnification of the final image?
c. Is the final image real or virtual? How do you know?

15. Suppose that in the diagram below the focal length of the first lens is $f_1 = 12.0$ cm, the focal length of the second lens is $f_2 = -18.0$ cm, the distance between the two lenses is $X_1 = 78.0$ cm and the object is placed $X_2 = 86.0$ cm to the left of the first lens. [Diagram **NOT** to scale!]



a. Where will the final image be formed?
b. What will be the magnification of the final image?
c. Is the final image real or virtual? How do you know?

Answers to opposite side: 1. 8.9 cm 2a. 6.8 cm b. +/- 42 cm c. -7.0 cm 3a. f/3.4 b. 16.5 cm 3c. 0.375 x d. 0.86 cm 4a. - 6.8 cm b. 0.38x c. 2.73 cm 5a. -19.3 cm b. 2.73x c. 12.4 cm 6. 15.6 cm 7. 50.0 cm 8. 63.0 cm 9. 7.8 cm 10. - 47.0 cm

PHYSICS HOMEWORK #103 PARTICLE PROPERTIES OF LIGHT INTERFEROMETER

POLARIZATION - BREWSTER'S ANGLE

1. Light is incident on a pane of glass [$n_{glass} = 1.53$] at an angle such that the reflected light beam is totally polarized. What is the angle of incidence?

2. Light reflects off of an unknown surface at an angle of 60.4° such that the reflected beam is totally polarized. What is the medium?

3. At what angle should light be shined on a diamond in order for the reflected beam to be totally polarized?

INDEX OF REFRACTION	
AIR	1.00
ALCOHOL	1.36
BENZENE	1.50
CALCITE	1.658
	1.486
DIAMOND	2.42
GLASS, CROWN	1.52
GLASS, FLINT	1.63
GLYCEROL	1.48
ICE	1.31
LUCITE	1.50
QUARTZ	1.54
	1.55
SAPPHIRE	1.769
	1.76
WATER	1.33

DIFFRACTION

4. While observing a gas discharge tube through a diffraction grating, which has 600 slits/mm, you note that the first bright yellow emission line is visible at an angle of 20.6° from the center antinode. What is the wavelength of this yellow light?

5. The same diffraction grating as above is used to observe a gas discharge tube containing Mercury gas and the first bright violet light is visible at an angle of 15.1° from the central antinode.
   a. What is the wavelength of this light?
   b. At what angle will the second order antinode appear?

6. While looking through a diffraction grating at a Nitrogen discharge tube you note that light with a known wavelength of 5679Å is visible at an angle of 37 from the central antinode. How many slits are there in this diffraction grating for each millimeter of width?

7. You are looking through a diffraction grating, which contains 520 slits for each millimeter of width, at a light source emitting light with a wavelength of 5890Å. At what angles will the first and second order antinodes be visible?

INTERFERENCE

8. Light, which has a wavelength of 5890Å, is incident on a thin film of soapy water [$n_{water} = 1.35$] sitting in air.
   a. What will be the wavelength of this light within the thin film of soapy water?
   b. What is the minimum thickness of this film [other than zero] which will generate complete constructive interference?
   c. What is the minimum thickness of this film [other than zero] which will generate complete destructive interference?

9. What wavelength of light will be constructively reflected from a thin film of galena [$n_{galena} = 3.91$] which is 465Å thick and which is coated on a glass surface [$n_{glass} = 1.56$]?

10. After a rain storm you note that a puddle on the road shows bright red [about 740 nm] light reflecting. What is the approximate, minimum thickness of the oil film [$n_{oil} = 1.23$] laying on top of the water [$n_{water} = 1.33$]?

11. Two glass plates, each of which is 12.0 cm long, are placed one on top of the other and are separated at one end by a thin sheet of paper. These two plates are then illuminated by a monochromatic light source [$\lambda = 4900$Å] placed directly above the plates. You then count 325 interference fringes from end to end. What is the thickness of the thin sheet of paper?

Answers to opposite side: 12. 1.58×10^{-5} m 13. 1.82×10^{-5} m 14a. 3.75×10^{-4} m b. 4.4 mm 14c. 2.75 mm 15. 4.16×10^{-3} m 16a. 900 ft cd b. 302 ft cd 17a. parallel b. 410 ft cd 17c. perpendicular 17d. 60.2 ft cd

PHYSICS HOMEWORK #104 PARTICLE PROPERTIES OF LIGHT WAVE PROPERTIES OF MATTER

INTERFERENCE [CONTINUED]

12. Two glass plates, each 15 cm long, are laid one on top of the other with one end touching and the other end separated by a thin piece of plastic. The entire set up is illuminated from above by a Sodium vapor light which emits monochromatic light at a wavelength of λ = 5890Å. You observe the glass plates from above and note that 9 interference fringes are visible over a linear distance of 2.5 cm. What is the thickness of the piece of plastic?

13. What would be the thickness of the plastic film in #12 above if the illuminating light had a wavelength of λ = 7200Å and if there were 34 interference fringes over a distance of 5.0 cm?

SINGLE AND DOUBLE SLITS

14. A monochromatic light source [λ = 5500Å] is shined through a single slit onto a screen placed 75 cm from the slit. The distance between the center of the central antinode and the first node is measured to be 1.1 mm.
    a. What is the width of the single slit?
    b. How far from the center of the central antinode will the fourth order node be found?
    c. How far from the center of the central antinode will the second order antinode be found?

15. You are looking at a Sodium discharge tube [λ = 5890Å] through a double slit which has a distance of 0.17 millimeters between the centers of the two slits. The light source is placed 1.20 meters from the double slit. What will be the distance between the interference fringes visible on the screen?

POLARIZATION - SELECTIVE ABSORPTION

16. Two polarizers are placed in the path of a beam of light. The second polarizer [called the analyzer] is rotated until the maximum intensity of the transmitted light is measured to be 450 foot candles. The analyzer is then rotated until the angle between the transmission axes of these two polarizers is 35.0^o. Assuming that these two polarizing filters are perfect [i.e. each polarizer absorbs exactly 50% of the incident light];
    a. What should the intensity of the light beam be in the absence of the two filters?
    b. What will be the intensity of the light transmitted by these two filters when the angle between their transmission axes is 35^o?

17. A light beam is shined on a light meter which shows an intensity of 820 ft cd. Two polarizing filters are inserted between the light source and the light meter. The analyzer is rotated until the light intensity detected by the light meter reaches a maximum. [Assume that these polarizers are all perfect.]
    a. What is the relative orientation of the transmission axes of these two polarizers when maximum intensity is transmitted?
    b. What will be the intensity detected by the light meter under these conditions?

    The transmission axis of the analyzer is then rotated until the light intensity reaches a minimum.

    c. What is the relative orientation of the transmission axes of these two polarizers when the light intensity reaches a minimum?

    A third polarizer is inserted between the first two polarizers and the angle of this third polarizer is rotated until the angle between it and the first polarizer is 25^o .

    d. What will be the intensity of the light now being transmitted by all three polarizing filters?

Answers to opposite side: 1. 56.8^o 2. 1.76 [sapphire] 3. 67.5^o 4. 5860Å 5a. 4340Å 5b. 31.4^o 6. 1060/mm 7. 17.8^o, 37.8^o 8a. 4360Å b. 1090Å c. 2180Å 9. 7270Å 10. 301 nm 11. 7.94 x 10^{-5} m

PHYSICS HOMEWORK #105 — WAVE PROPERTIES OF LIGHT REFLECTION OF LIGHT

MICHELSON MORLEY INTERFEROMETER

1. Consider a stream which has a current of 4.5 m/s and which is 725 meters wide. A boat, which has a speed of 13.5 m/s in still water is to head directly across the stream, turn around and return to the near shore. A second boat is to head downstream a distance of 725 meters, turn around, and then return upstream the same distance.
   a. How long will it take for the first boat to reach the opposite shore and return?
   b. How long will it take the second boat to go downstream and back?
   c. If both began their trips at the same time, what will be the difference between their return times?

2. What results were Michelson and Morley expecting from their interferometer experiment?

3. What conclusions could logically be derived from the results of the Interferometer experiment?

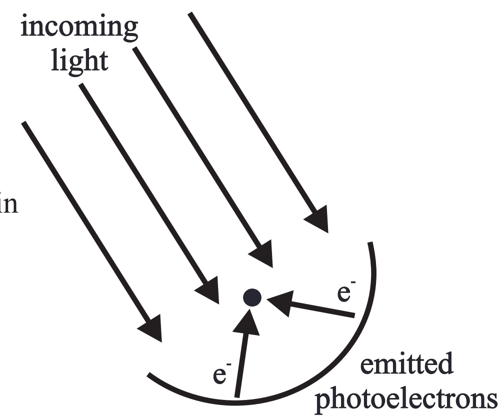
4. Was the Interferometer experiment a success? Explain!

PHOTOELECTRIC EFFECT [KE = hf - ϕ]

5. What is the energy content [in Joules] of a light wave which has a wavelength of 4400Å?

6. What will be the energy content [in Joules] of a light wave which has a frequency of 5.25×10^{14} Hz?

7. A light wave has an energy content of 2.93×10^{-19} Joules, what will be the wavelength and frequency of this light wave?



8. A photoelectric experiment is performed and data are collected as shown in the table to the right.
   a. Determine the kinetic energies of the emitted photoelectrons.
   b. Determine the frequencies of the incoming light waves.
   c. Plot a graph comparing the energies of the emitted photoelectrons to the frequencies of the incoming photons.
   d. From your graph calculate an experimental value for Planck's constant.
   e. From your graph determine the cut off frequency for this surface and the resulting work function for this surface.
   f. Determine the equation describing the kinetic energies of the emitted photoelectrons as a function of the incoming light photons and the work function ϕ of the surface. [the "Photoelectric equation"]

WAVELENGTH	STOPPING POTENTIAL
4425Å	1.45 Volts
4975Å	1.13 Volts
6200Å	0.81 Volts
7075Å	0.56 Volts

9. Light, which has a wavelength of 890Å is incident on a photoelectric surface which has a work function [ionization potential] of -13.6 eV.
   a. What is the energy content [in Joules] of this incoming light wave?
   b. How much energy [in Joules] would be required to free the least strongly bound electron from this surface?
   c. What will be the kinetic energy of the emitted photoelectrons?
   d. What will be the velocity of the emitted photoelectrons?

10. What should have happened in the Photoelectric Effect according to classical wave theory? Include details!

11. How did Einstein explain the experimental results of the Photoelectric Effect? Include details!

Answers to opposite side: 12a. 2.32 x 10-18 J b. 1.08×10^{-18} J c. 1.54×10^{6} m/s 13. 3180Å
14a. 2.00×10^{-19} J [1.25 eV] b. 5.38×10^{-19} J [3.36 eV] c. 3.38×10^{-19} J [2.11 eV] 15. 1.87×10^{-19} J
16. 1.38×10^{-27} kg m/s 17. 16.2Å 18. 1.01Å 19. 2.24×10^{-35} m 20a. 1.44×10^{-27} kg m/s
20b. 2.88×10^{-27} kg m/s 21a. 1.21×10^{-27} kg m/s b. 231 N sec c. 1.48 m/sec^2 d. 235 days

PHYSICS HOMEWORK #106 — WAVE PROPERTIES OF LIGHT / REFLECTION OF LIGHT

PHOTOELECTRIC EFFECT [cont]

12. Light, which has a wavelength of 855Å, is shining on a photoelectric surface which has a work function of -7.724 eV for the least strongly bound electron [Copper].
    a. What is the energy of the incoming photon?
    b. What will be the kinetic energy of the emitted photoelectrons?
    c. What will be the velocity of the emitted photoelectrons?

13. The work function for Cesium is -3.90 eV. What is the wavelength of the least energetic light wave which can free a photoelectron from a Cesium surface?

14. Light, which has a wavelength of 3700Å, is used to illuminate a photoelectric surface. As a result of this illumination photoelectrons are emitted from the surface. A stopping potential of 1.25 Volts is required to reduce the photocurrent to zero.
    a. What is the maximum kinetic energy of the emitted photoelectrons?
    b. What is the energy content of the incoming photons?
    c. What is the work function of this surface in eV?

15. An atom absorbs a photon with a wavelength of 375 nanometers and then immediately emits a second photon having a wavelength of 580 nanometers. How much energy was absorbed by the atom in this process?

WAVE PARTICLE DUALITY [$h/\lambda = p$]

16. What is the momentum of a light photon which has a wavelength of 4800Å?

17. What will be the wavelength of an electron [$m_{electron} = 9.11 \times 10^{-31}$ kg] moving with a velocity of 4.5×10^{5} m/s?

18. What will be the wavelengths of the Hydrogen molecules [$m_{Hydrogen}$ atoms = 1.67×10^{-27} kg each] in a gas which is at a temperature of 35.0 °C? [Hint ! $KE_{ave} = 3/2\ kT$ where $k = 1.38 \times 10^{-23}$ J/°K and remember that Hydrogen is diatomic!]

19. What will be the wavelength of a baseball [$m_{baseball} = 0.78$ kg] moving toward home plate with a velocity of 38.0 m/s?

20. A light wave, that has a wavelength of 4600Å, strikes a mirror with an angle of incidence of 0.0° and reflects off.
    a. What is the momentum of this photon?
    b. What is the magnitude of the impulse delivered by the mirror to the light wave?

21. At the distance of the Earth from the Sun approximately 3.83×10^{21} photons, with an average wavelength of 550 nanometers, strike each square meter every second [called the solar flux]. Suppose that a huge "solar sail" made of metallized mylar [which behaves like a mirror] and which is 5.0 kilometers square is deployed by a spacecraft with a payload bound for the planet Mars. The mass of the payload and the solar sail is 156 kg. [1 nanometer = 10^{-9} m]
    a. What will be the momentum of a single photon of this light?
    b. What will be the magnitude of the impulse delivered to the solar sail each second?
    c. What will be the resulting rate of acceleration for this payload?
    d. How long will it take to increase the velocity of this space craft to 10% light speed?

Answers to opposite side: 1a. 107 s b. 121 s c. 14 s 5. 4.5×10^{-19} J 6. 3.48×10^{-19} J
7. 6780Å, 4.4×10^{14} Hz 8a. 2.32×10^{-19} J, 1.81×10^{-19} J, 1.30×10^{-19} J b. 6.77×10^{14} Hz., 6.03×10^{14} Hz.,
8b. 4.84×10^{14} Hz., 4.24×10^{14} Hz. d. 5.4×10^{-34} J s e. 2.5×10^{14} Hz. f. $KE = 5.4 \times 10^{-34} f + 1.7 \times 10^{-19}$ J
9a. 2.23×10^{-18} J b. 2.18×10^{-18} J c. 5.2×10^{-20} J d. 3.37×10^{5} m/s

PHYSICS HOMEWORK #111 SPECIAL RELATIVITY
LENGTH CONTRACTION

$$\boxed{L = L_o\sqrt{1-(v^2/c^2)}}$$

WHERE L_o = Length measured by an observer at rest relative to the length being measured
AND L = Length measured by an observer moving with a velocity V relative to the length being measured
AND WHERE c = 3.0 x 10^8 m/s [the speed of light in a vacuum]

1. A rocket at rest on Earth is measured to have a length of 45.0 meters and a diameter of 5.60 meters. The rocket is then launched toward Alpha Centauri, which is 4.3 light years from the Earth, at 2.2 x 10^8 m/s.
   a. What will be the length of this rocket as measured by an observer on the Earth?
   b. What will be the length of the rocket as measured by an astronaut on board the rocket?
   c. What will be the diameter of the rocket as measured by an observer on the Earth?
   d. What will be the distance to Alpha Centauri as measured by the astronaut on board the rocket?

2. The distance to the star Epsilon Indi, as measured from the Earth frame of reference, is 1.07 x 10^{17} meters.
   a. What is this distance in light years?
   b. What will be the distance to Epsilon Indi as measured by an observer on a rocket heading toward this star at 85% of the speed of light?
   c. How long will it take for this rocket to reach Epsilon Indi according to an observer on the Earth?

3. A rocket is moving toward the star Sirius ["The Dog star"] with a velocity of 2.955 x 10^8 m/s. The distance to Sirius as measured from the rest frame on the Earth is measured to be 8.14 x 10^{16} meters.
   a. What will be the velocity of this rocket as a decimal fraction of the speed of light?
   b. What is the distance to Sirius in light years?
   c. What will be the distance to Sirius as measured by an astronaut on board the rocket?

4. As measured from the Earth the distance to Tau Ceti is determined to be 11.8 c yrs. How fast must a rocket be moving toward Tau Ceti so that the distance to Tau Ceti is reduced to 1.18 c yrs?

5. How fast must a rocket be moving in order for its length to be reduced to 1.0% of its rest length?

6. A rocket is launched toward Barnard's star, which has a rest distance of 6.00 c yrs from the Earth, with an acceleration of 1.20 g's [where 1 g = 9.81 m/s^2].
   a. How long after launch will it take for the speed of the rocket to reach 98% of the speed of light?
   b. Assuming that this rocket travels at a constant speed of 0.980c and then decelerates at -1.2 g's until the rocket reaches Barnard's star. How long will it take for the rocket to arrive at its destination according to an observer at rest on the Earth? [Hint! Try making a graph of velocity vs time!]
   c. What will be the distance to Barnard's star as measured by an astronaut on board the rocket during the constant velocity [0.98c] phase of the trip?

7. The rest diameter of the Milky Way galaxy is measured to be 200,000,000 c yrs as measured by an observer at rest on the Earth. What will be the measured diameter of the Milky Way galaxy as measured by an astronaut on a rocket heading across the across the galaxy at .99999999c?

Answers to opposite side: 8. 1.29 years 9a. 6.12 years b. 1.21 years c. 1.19 c yrs 9d. 1994 AD e. 22.2 years f. 65/minute g. 13/ minute 10. 56 hours 11a. 2014 AD b. 1.93 years 11c. 23.9 years d. 24.1 years 12. 6.23 minutes

PHYSICS HOMEWORK #112 SPECIAL RELATIVITY
TIME DILATION

$$T = T_o\sqrt{1 - V^2 / c^2}$$

WHERE T = time interval measured in the moving system
AND T_o = time interval measured in the rest system

8. According to an observer on the Earth the time it should take to reach a certain star is determined to be 7.50 years. How long will it take to reach this star according to an observer on board a rocket moving toward this star with a velocity of 0.985c?

9. The distance to Barnard's star is measured to be 6.00 c yrs by an observer at rest on the Earth;
   a. Assuming that a rocket is moving toward this star at 0.98c, how long will it take for this rocket to reach Barnard's star according to an observer on the Earth?
   b. How long will it take to reach this star according to an observer on board the rocket?
   c. What will be the distance to Barnard's star according to an observer on board the rocket?
   d. Assuming that the astronaut was 21 years old when she left the Earth is 1988, in what year will the astronaut arrive at Barnard's star?
   e. How old will the astronaut be when she arrives at Barnard's star?
   f. Suppose that the astronaut has a normal heart rate of 65 beats per minute when measured while at rest on the Earth. What will be the astronaut's heart rate as monitored by an observer on board the rocket with the astronaut?
   g. What will the astronaut's heart rate be while on the rocket moving toward Barnard's star, as monitored by an observer on the Earth?

10. Two astronauts play a game of chess on a rocket moving with a velocity of 0.999c away from the Earth. According to the astronauts the game takes 2.5 hours. How long does the game take according to an observer at rest on the Earth?

11. A rocket is moving toward Epsilon Eridani, which is 11.3 c yrs away as measured by an observer at rest on the Earth, at 0.998c. When the astronaut leaves the Earth in 1991 he has just had his 22nd birthday and his young daughter has just turned 1.0 years old. The rocket travels to the star, remains 6.0 months and then returns to the Earth at the same speed;
   a. In what year will the rocket return to the Earth?
   b. How many years will the journey take according to the astronaut on board the rocket?
   c. How old will the astronaut be when he returns to the Earth?
   d. How old will his daughter be when he returns to the Earth?

12. A neutron outside the confines of the nucleus of an atom is unstable and has a life expectancy [half-life] of 6.0minutes. Suppose that a fast moving alpha particle collides with a block of Beryllium and knocks a neutron out of the nucleus with a speed of 8.15×10^7 m/s. What will be the expected lifetime of this neutron as measured by an observer in the rest frame?

Answers to opposite side: 1a. 30.6 meters b. 45.0 meters c. 5.6 meters d. 2.9 c yrs
2a. 11.3 c yrs b. 5.95 c yrs c. 13.3 yrs 3a. 0.985 c b. 8.6 c yrs c. 1.48 c yrs 4. 0.995 c
5. 0.99995 c 6a. 0.79 yrs b. 6.91 yrs c. 1.19 c yrs 7. 28,300 c yrs

PHYSICS HOMEWORK #113 SPECIAL RELATIVITY
VELOCITY TRANSFORMATION

$$v = (v' + V) / (1 + v'V / c^2)$$

WHERE v = velocity measured from rest frame
v' = velocity measure from moving frame
V = velocity of the moving frame

1. A rocket is moving away from the Earth with a velocity of 0.95c. This rocket then launches a missile forward with a velocity of 0.65c relative to the rocket ship. What will be the velocity of this missile as measured from the Earth?

2. A rocket ship is returning from Alpha Centauri with a velocity of 0.97c as measured by an observer on the Earth. At the same time a second rocket ship is moving toward Alpha Centauri with a velocity of 0.93c as measured from the Earth.
   a. What will be the velocity of the first rocket as measured by an observer on board the second rocket?
   b. What will be the velocity of the second rocket as measured by an observer on the first rocket?
   c. What will be the velocity of the first rocket relative to the second rocket as measured by an observer on the Earth?

3. Two rockets are moving toward Tau Ceti in a race. The velocity of rocket A as measured from the Earth is 0.99c while the velocity of rocket B as measured from the Earth is 0.995c.
   a. What will be the velocity of rocket A relative to rocket B as measured by an observer on rocket B?
   b. What will be the velocity of rocket B relative to rocket A as measured by an observer on rocket A?
   c. Assuming that the distance to Tau Ceti is 10.8 c yrs as measured by an observer at rest on the Earth, what will be the distance to Tau Ceti According to an observer on board rocket A?
   d. What will be the distance to Tau Ceti according to the pilot on rocket B?e. How long will it take for rocket A to reach Tau Ceti according to the pilot on rocket A?
   f. How long will it take rocket B to reach Tau Ceti according to the pilot on rocket B?
   g. According to the observer on the Earth, how much sooner does rocket B reach Tau Ceti compared to rocket A?

11. A proton is moving in a circular path inside a strong magnetic field generated by a cyclotron with a velocity of 0.98c. What will be the magnitude of the centripetal force required to keep this proton moving in a circular path which has a radius of 5.0 meters?

12. A neutron [mass = 1 AMU] moving with a velocity of 0.99c compared to the rest frame collides with a Uranium 239 [mass = 239 AMU] atom which is at rest. After the collision the two particles stick together. What will be the final velocity of this combination? [Use momentum conservation but note that it is NOT necessary to treat the mass of the final combination relativistically! Why not?]

13. What velocity would be required to increase the mass of an object by a factor of 100x?

14. How fast must an electron mass move in order to have the same mass as a proton at rest?

15. A proton is moving with a velocity of 2.9×10^8 m/s when it enters a uniform magnetic field. Upon entering the magnetic field the proton begins to move in a circular path which has a radius of 2.80 meters. What must the strength of the magnetic field be in order to keep this proton moving in this circular path?

16. Consider a rocket ship which has a rest mass of 18,600 kg. and is accelerating through space at 9.8 m/s^2.
   a. How much force would be required to accelerate this rocket if the velocity of the rocket is 0.10c?
   b. How much force would be required to accelerate this rocket if the velocity of the rocket is 0.95c?
   c. How much force would be required to accelerate this rocket if the velocity of the rocket is 0.99999999c?

Answers to opposite side: 1. 0.989c 2a. 0.999c b. 0.999c c. 1.90c 3a. -0.334c 3b. 0.334c 3c. 1.52 cyrs d. 1.08 cyrs e. 1.54 yrs f. 1.09 yrs g. 0.055 yrs 4a. 0.998c 4b. 1.86 yrs c. 0.98 yrs 4d. 1.38 yrs 5. c

PHYSICS HOMEWORK #114 SPECIAL RELATIVITY
MASS EXPANSION

$$m = m_o \,/\, \sqrt{1 - V^2 / c^2}$$

WHERE m_o = mass measured while at rest relative to object and m = mass measured while in motion relative to object

6. A rocket is measured to have a mass of 4.5 x 10^8 kg while at rest on the Earth. What will be the mass of this rocket while moving through space with a velocity of 0.98c as measured by an observer on the Earth?

7. A proton has a rest mass of 1.67 x 10^{-27} kg. What will be the mass of a proton while moving with a velocity of 2.4 x 10^8 m/s?

8. How fast must a proton [m_p = 1.67 x 10^{-27} kg] move in order to have the same mass as a 50 gram bullet at rest?

9. A rocket has a rest mass of 2500 kg. What will be the momentum of this rocket when it is moving with a velocity of 0.95c relative to the observer?

10. A rocket at rest in space ignites its engines. Over a time period of 10 seconds the rocket emits 2200 kg of hot gases out the engine exhaust with a velocity of 0.92c compared to the rest frame. The rest mass of the rocket, including fuel, is 12,000 kg before ignition. Using momentum conservation determine the final velocity of the rocket.

11. A proton is moving in a circular path inside a strong magnetic field generated by a cyclotron with a velocity of 0.98c. What will be the magnitude of the centripetal force required to keep this proton moving in a circular path which has a radius of 5.0 meters?

12. A neutron [mass = 1 AMU] moving with a velocity of 0.99c compared to the rest frame collides with a Uranium 239 [mass = 239 AMU] atom which is at rest. After the collision the two particles stick together. What will be the final velocity of this combination? [Use momentum conservation but note that it is NOT necessary to treat the mass of the final combination relativistically! Why not?]

13. What velocity would be required to increase the mass of an object by a factor of 100x?

14. How fast must an electron mass move in order to have the same mass as a proton at rest?

15. A proton is moving with a velocity of 2.9 x 10^8 m/s when it enters a uniform magnetic field. Upon entering the magnetic field the proton begins to move in a circular path which has a radius of 2.80 meters. What must the strength of the magnetic field be in order to keep this proton moving in this circular path?

16. Consider a rocket ship which has a rest mass of 18,600 kg. and is accelerating through space at 9.8 m/s^2.
    a. How much force would be required to accelerate this rocket if the velocity of the rocket is 0.10c?
    b. How much force would be required to accelerate this rocket if the velocity of the rocket is 0.95c?
    c. How much force would be required to accelerate this rocket if the velocity of the rocket is 0.99999999c?

Answers to opposite side: 1. 0.989c 2a. 0.999c b. 0.999c c. 1.90c 3a. -0.334c 3b. 0.334c 3c. 1.52 cyrs d. 1.08 cyrs e. 1.54 yrs f. 1.09 yrs g. 0.055 yrs 4a. 0.998c 4b. 1.86 yrs c. 0.98 yrs 4d. 1.38 yrs 5. c

PHYSICS HOMEWORK #115 SPECIAL RELATIVITY
ENERGY RELATIONSHIPS

$$RE = m_oc^2 \qquad TE = mc^2 \qquad KE = TE - RE = mc^2 - m_oc^2 = m_oc^2\,(\beta\text{-}1)$$

1. What will be the rest energy of a 2.50 kg mass at rest?

2. What is the rest energy of a proton?

3. Suppose that an electron moving with a non_relativistic speed encounters a positron moving at an identical but opposite non relativistic speed. These two particles meet and then each particle disappears and in their place remains only energy.
   a. How much energy will be released by this interaction?
   b. Assuming that the energy which is released escapes in the form of two identical light photons, what will be the wavelength of each photon?
   c. Why must the released energy take the form of TWO photons?

4. What will be the total energy of a 2.5 kg mass moving with a velocity of 0.98c?

5. What will be the total energy of a proton moving with a velocity of 0.99c?

6. What will be the kinetic energy of a proton moving with a velocity of 0.99c?

7. A rocket is moving toward Alpha Centauri with a velocity of 0.995c:
   a. What will be the rest energy of this rocket if its rest mass is 76,000 kg.?
   b. What will be the total energy of this rocket?
   c. What will be the kinetic energy of this rocket?
   d. By what percentage would the value for the kinetic energy have been wrong had you used the classical equation for the calculation of the kinetic energy instead of the relativistic equation?

8. An electron moving with a velocity of 0.995c collides with a heavy atom. As a result of this collision the speed of the electron is reduced to 0.45c. What will be the energy lost by the electron in this collision?

9. The atomic mass of a single mole of Carbon 12 is defined to be exactly 12.000 grams.
   a. What is the mass of a single atom of Carbon 12?
   b. A single atom of Carbon 12 consists of 6 protons, 6 neutrons and 6 electrons. What will be the total mass of a Carbon atom based on the sum of its parts [carry out your calculations to at least 5 significant digits!]
   c. What is the nuclear mass defect of a single atom of Carbon 12?
   d. How much energy will be released from the "construction" of 1.0 mole of Carbon 12?
   e. If mass is supposed to be conserved, where did the missing mass go?
   f. Assuming that all of the released energy remains with the resulting Carbon atom, determine the velocity of the resulting atom.

REST MASSES
Proton = 1.6726×10^{-27} kg = 1.00728 AMU
Neutron = 1.6750×10^{-27} = 1.008665 AMU
Electron = 9.11×10^{-31} kg = 0.000549 AMU
1 AMU = 1.6606×10^{-27} kg = mass of C_{12}

Answers to opposite side: 1. 30.0 meters 2. 135 meters 3. 420,000 kg 4. 1,890,000 kg 5. 0.955 c yrs 6. 4.41 years 7. 0.979 years 8. 1.7×10^{23} Joules 9. 3.8×10^{22} Joules 10. 1.3×10^{23} J 11. 28 years 12. 2003 AD 13. 0.99997c 14. 0.9996c 15. 5.5×10^{14} kg m/s 16a. c b. 0.99998c 16c. depends on the observer!

PHYSICS HOMEWORK #116 SPECIAL RELATIVITY
ALL TOGETHER

A rocket, which has a rest mass of 420,000 kg and a rest length of 135 meters, is moving toward Alpha Centauri with a velocity of 0.975c. The distance to Alpha Centauri, as measured from an observer at rest on the Earth, is 4.3 c yrs.

1. What will be the length of this rocket as measured by an observer at rest on the Earth?

2. What will be the length of the rocket as measured by an observer on board the rocket?

3. What will be the mass of the rocket as measured by an observer on board the rocket?

4. What will be the mass of the rocket as measured by an observer at rest on the Earth?

5. What will be the distance to Alpha Centauri as measured by an observer on board the rocket?

6. How long will it take for the rocket to reach Alpha Centauri according to an observer at rest on the Earth?

7. How long will it take for the rocket to reach Alpha Centauri according to an observer on board the rocket?

8. What will be the total energy of this rocket as it moves toward Alpha Centauri as measured by an observer at rest on the Earth?

9. What is the rest energy of this rocket?

10. What will be the kinetic energy of this rocket as measured by an observer at rest on the Earth?

11. If the astronaut on board the rocket was 24.0 years old when she left the Earth, spent exactly 2.0 years on a planet orbiting Alpha Centauri, and then returned to Earth at the same speed. How old will the astronaut be when she returns to the Earth?

12. Assuming that this astronaut left the Earth in 1992, in what year will she return to the Earth?

13. Assuming that this rocket on the return trip encounters a second rocket on its way to Alpha Centauri with a velocity of 0.998c, as measured form the Earth. What will be the velocity of the second rocket as measured by an observer on board the first rocket?

14. What should the velocity of a rocket be if it is to traverse the distance to Alpha Centauri in only 32 days rocket time?

15. What is the momentum of the first rocket as measured by an observer at rest on the Earth?

16. Suppose that the rocket returning from Alpha Centauri suddenly discovers that the second rocket on its way to Alpha Centauri is a space pirate. The space pirate fires a LASER blast [light] at the first rocket and the first rocket responds by firing a photon torpedo at the pirate with a velocity of 0.87c relative to the first rocket.
   a. What will be the velocity of the LASER blast as measured by the first rocket?
   b. What will be the velocity of the photon torpedo as measured by the pirate rocket?
   c. Assuming that these two rockets were 0.10 c yrs apart, as measured by an observer at rest on the Earth, when the two weapons were fired, how long does each have to live in [in their own reference frames!]?

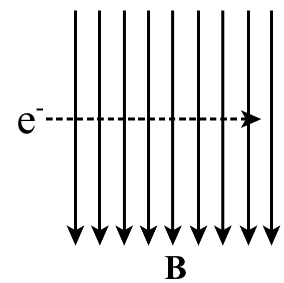
Answers to opposite side: 1. 2.3 x 10^{17} Joules 2. 1.5 x 10^{-10} Joules 3a. 1.6 x 10^{-13} Joules 3b. 0.024 Angstroms 4. 1.13 x 10^{18} Joules 5. 1.1 x 10^{-9} Joules 6. 9.2 x 10^{-10} Joules 7a. 6.8 x 10^{21} Joules 7b. 6.9 x 10^{22} Joules
7c. 6.2 x 10^{22} Joules d. -94% 8. 7.3 x 10^{-13} Joules 9a. 1.9924 x 10^{-26} kg 9b. 2.0091 x 10^{-26} kg

MAGNETIC FORCE ON MOVING CHARGES

$$\boxed{F_m = q \cdot \vec{v} \times \vec{B} = I \cdot \vec{l} \times \vec{B}}$$

1. A proton [mass of 1.67×10^{-27} kg and a charge of 1.6×10^{-19} C] is moving with a velocity of v = 820 m/s through a magnetic field which has a field intensity of B = 1.20 Tesla. Assuming that this proton is moving at right angles to the field.
   a. What will be the magnitude of the resultant magnetic force?
   b. What will be the force on the proton if the direction of motion of the proton is parallel to the direction of the magnetic field lines?

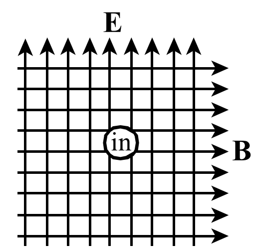
2. A magnetic field, which has an intensity of T = 0.950 Tesla, is directed vertically downward. An electron ($m_e = 9.11 \times 10^{-31}$ kg, $q_e = 1.6 \times 10^{-19}$ C) is moving horizontally through the field from left to right at v = 12,000 m/s:
   a. What will be the direction of the magnetic force acting on this electron?
   b. Describe the path of motion of this electron as it moves through the magnetic field.
   c. What will be the magnitude of the magnetic force acting on this electron?
   d. What will be the radius of the circle in which this electron will move?



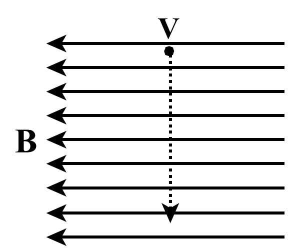
3. A proton is moving with a velocity of v = 21,000 m/s through a uniform magnetic field such that the proton moves in a circular path which has a radius of r = 4.50 cm. What is the strength of the magnetic field B?

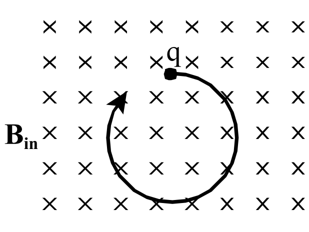
4. An alpha particle ($\alpha_{mass} = 6.64 \times 10^{-27}$ kg, $q_\alpha = 3.2 \times 10^{-19}$ C) is moving with a velocity of v = 20,000 m/s through a uniform magnetic field, which has a field strength of B = 2.20 Tesla, at right angles to the field. What will be the magnitude of the resulting magnetic force?

5. A charged particle moves through an area of space where both an electric field, which has an intensity of E = 12,000 N/C, and a magnetic field, which has an intensity of B = 2.40 Tesla, are present. The two fields are mutually perpendicular as shown to the right and the velocity of the charged particle is moving perpendicularly into the paper as shown such that the charged particle passes through the fields undeflected. What is the velocity of the charged particle?



6. A magnetic field is directed as shown in the diagram to the right. The magnetic field has a strength of B = 0.78 Tesla. A positively charged particle of 1.20 μC enters the field from the top of the paper as shown with a velocity of V = 550 m/s.
   a. What will be the direction of the resultant magnetic force?
   b. What will be the magnitude of the magnetic force acting on this positive particle?
   c. What will be the direction of the force if the particle is negative?
   d. What will be the direction of the force if the negative particle is moving from left to right?



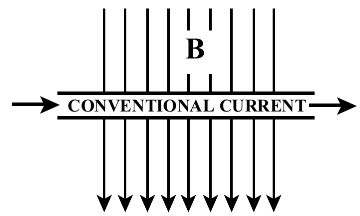


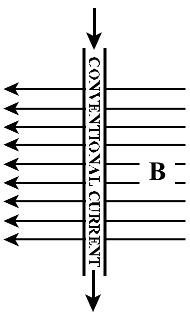
7. A doubly ionized [$q = -3.2 \times 10^{-19}$ C] Gold atom [$m_{gold} = 3.29 \times 10^{-25}$ kg] is moving in a circular path in a uniform magnetic field as shown below. The radius of the path is r = 12.8 cm and the gold atom is moving with a velocity of $v = 6.50 \times 10^5$ m/sec. What is the strength of the required magnetic field B?

ANSWERS TO OPPOSITE SIDE: 8a. 0.209 N b. into paper 9a. 1.27 N b. into paper c. parallel to B 10a. 0.132 N 10b. out of paper 11a. 853 Gauss b. into paper c. out of the paper 12a. 16.5 N/m b. toward the bottom of the page 13a. 0.47 Amperes b. clockwise

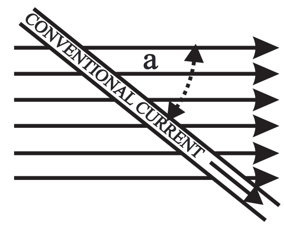
PHYSICS HOMEWORK #122 MAGNETISM
MAGNETIC FORCE ON CURRENT CARRYING WIRES

8. A piece of wire L = 15.0 cm long has a current of I = 3.10 Amperes flowing through it and is sitting in a uniform magnetic field which has an intensity of B = 0.450 Tesla. The wire is oriented perpendicularly to the magnetic field as shown to the right.
   a. What will be the magnitude of the resulting magnetic force?
   b. What will be the direction of the resulting magnetic force?



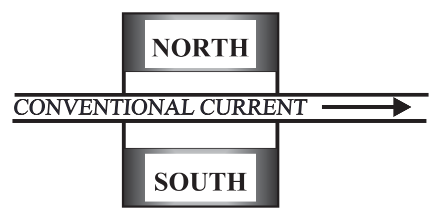


9. A conventional current of I = 5.30 Amperes is flowing through a wire oriented perpendicularly to a magnetic field as shown to the left. The strength of the magnetic field is B = 0.600 Tesla and the length of the wire sitting in the magnetic field is L = 40.0 cm.
   a. What will be the magnitude of the resulting magnetic force?
   b. What will be the direction of the resulting magnetic force?
   c. How could this wire be oriented so that it will feel NO magnetic force?

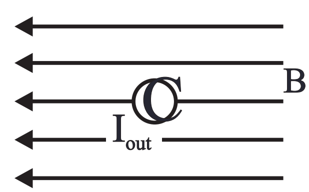


10. A wire L = 30.0 cm long is sitting in a uniform magnetic field and is oriented as shown in the diagram at the right. The strength of the magnetic field is B = 0.220 Tesla, a current of I = 3.25 Amperes is flowing through the wire and the wire is oriented at an angle of $\alpha = 38.0^{o}$ relative to the magnetic field.
   a. What will be the magnitude of the resulting magnetic force?
   b. What will be the direction of the resulting magnetic force?

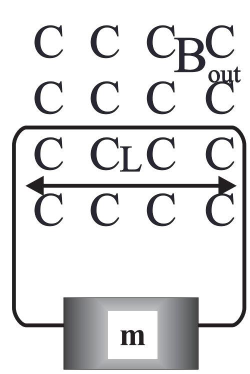
11. A wire loop [As in the lab!] is sitting in a uniform magnetic field between the poles of a permanent magnet as shown to the left. The magnet is L = 3.00 cm wide. When a conventional current of I = 6.25 Amperes flows through this wire it feels a magnetic force of $F_m = 0.0160$ N.
   a. What is the strength of the magnetic field generated by the permanent magnet?
   b. What will be the direction of the magnetic force acting on the wire?
   c. What will be the direction of the magnetic force if the direction of the current is reversed?



12. A conventional current of I = 7.50 Amperes is flowing out of the paper as shown to the right where the magnetic field has a strength of B = 2.20 Tesla and is directed toward the left as shown.
   a. What is the magnitude of the resulting magnetic force for each meter of length of this wire?
   b. What is the direction of the resulting magnetic force?



13. A loop of wire is attached to a mass of m = 50.0 grams. One end of the loop is sitting in a magnetic field directed out of the paper as shown and which has a magnitude of 3.00 Tesla. The length of the wire sitting in the magnetic field is L = 35.0 cm.
   a. What is the magnitude of the conventional current in the wire if the loop is to support the weight of the hanging mass?
   b. What will be the direction of the required conventional current to support the hanging mass?



ANSWERS TO OPPOSITE SIDE: 1a. 1.57×10^{-16} N b. zero 2a. out of paper b. circle 2c. 1.82×10^{-15} N d. 7.19×10^{-8} m 3. 4.87×10^{-3} Tesla 4. 1.41×10^{-14} N 5. 5000 m/s

PHYSICS HOMEWORK #123 MAGNETISM
MAGNETIC FORCE BETWEEN CURRENT CARRYING WIRES

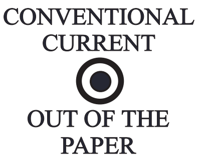
$$\boxed{B = \frac{\mu_o \cdot I}{2 \cdot \pi \cdot r}}$$

1. What will be the magnetic field strength r = 4.00 cm from a straight wire carrying a current of I = 2.50 Amperes?

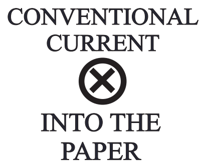
2. What will be the current flowing through a straight wire if the magnetic field strength is B = 5.50 Gauss a distance of r = 2.20 cm from the wire?

3. Describe **EXACTLY** the magnetic field for each of the following.

a.



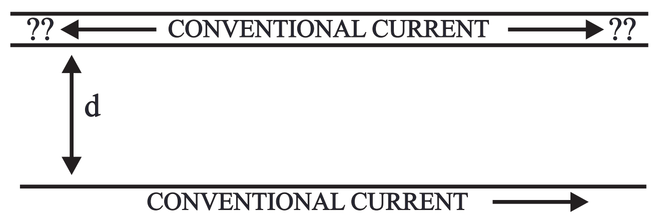
b.



c.

4. Two parallel, current carrying wires are spaced d = 2.00 cm apart. The currents in the two wires are I_1 = 3.50 Amperes and I_2 = 5.50 Amperes respectively.
   a. What will be the magnitude of the magnetic force per unit length between these two wires?
   b. What will be the direction of this force if the two currents are in the same direction?
   c. What will be the direction of this force if the currents are in opposite directions?

5. Consider two parallel wires oriented such that one wire is immediately above the other as shown at the right. The current in the lower wire is I_2 = 38.0 Amperes to the right and the distance between the wires is d = 2.20 cm. A second current flows in the upper wire so that the upper wire "floats" above the lower wire due to the magnetic repulsion between the two wires. The upper wire is made of copper [density of copper = 8.90 gm/cm^3] and has a diameter of D = 1.10 millimeters.



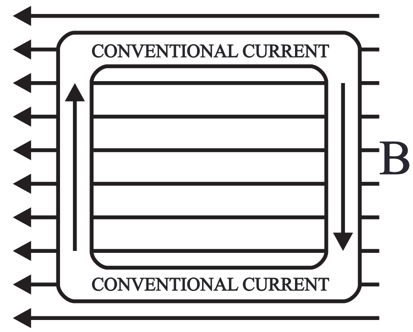
   a. What will be the direction of the magnetic field at the location of the upper wire as caused by the lower wire?
   b. In what direction should the current flow in the upper wire so that the force between these two wires is repulsive?
   c. What will be the magnitude of the required current in the upper wire?

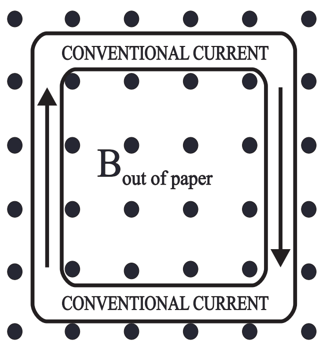
ANSWERS TO OPPOSITE SIDE: 6a. upper wire - no force, right wire - 0.351 N into paper, 6a. lower wire - no force, left wire - 0.351 N out of the paper 6b. 0.063 Nm 6c. 1.26 Nm 7a. upper wire - 0.144 N downward, right wire - 0.144 N left, lower wire - 0.144 N upward 7a. left wire 0.144 N right 7b. tends to compress the loop 7c. tends to expand the loop 8a. 4.33 Nm 8b. 3.75 Nm 8c. zero 8d. 4.33 sinΘ 8e. 1.33 Nm/T

PHYSICS HOMEWORK #124 MAGNETISM
MAGNETIC TORQUE ON A LOOP/COIL & MAGNETIC MOMENT

$$\mathrm{T} = N \cdot I \cdot A \cdot \hat{n} \cdot \vec{B} = \vec{m} \times \vec{B} \qquad \vec{m} = N \cdot I \cdot A \cdot \hat{n}$$

6. A conducting loop is sitting in a uniform magnetic field directed to the left as shown in the diagram to the right. The current in the loop is I = 1.30 Amperes clockwise and the magnetic field has an intensity of B = 2.25 Tesla. The loop is 12.0 cm high and 18.0 cm wide as shown.
   a. Determine the direction and magnitude of the resulting magnetic force on each section of the loop.
   b. What will be the direction and magnitude of the resulting magnetic torque exerted on the loop?
   c. What will be the magnitude of the resulting torque if the loop consists of 20 turns of wire instead of a single loop?





7. A conducting loop, which is 15 cm by 15 cm, is sitting in a uniform magnetic field directed out of the paper as shown in the diagram to the left. The current is flowing clockwise as shown and has a magnitude of I = 1.75 Amperes. The magnetic field strength is B = 0.550 Tesla.
   a. Determine the direction and magnitude of the magnetic force exerted on each segment of the loop.
   b. What will be the resulting magnetic effect on the loop? Explain!
   c. What will be the effect on this loop if the direction of the current is reversed? Explain!

8. A coil of wire, which is shaped into a square where each side is L = 5.50 cm., consists of N = 110 turns and through which a current of I = 4.00 Amperes flows, is placed in a uniform magnetic field which has a magnitude of B = 3.25 Tesla.
   a. What will be the maximum torque felt by this loop?
   b. What will be the torque applied to this loop when the normal to the plane of the loop is tilted at an angle of $\Theta = 60.0^{o}$ relative to the direction of the magnetic field?
   c. What will be the torque on the loop when the normal to the plane of the loop is parallel to the direction of the magnetic field lines?
   d. Write an equation which would describe the torque acting on this loop as a function of the angle Θ between the normal to the loop and the direction of the magnetic field?
   e. What is the magnetic moment of this coil of wire?

ANSWERS TO OPPOSITE SIDE: 1. 1.25×10^{-5} Tesla 2. 60.5 Amperes 3a. counterclockwise 3b. clockwise 3c. out of paper above, down in front, into paper below 4a. 1.93×10^{-4} N/m b. attractive c. repulsive 5a. out of paper b. to the left c. 240 Amperes

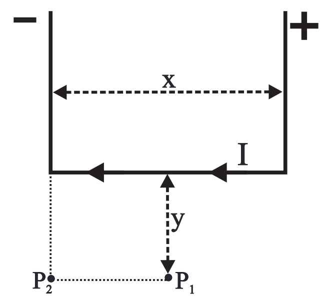
PHYSICS HOMEWORK #125 — MAGNETISM

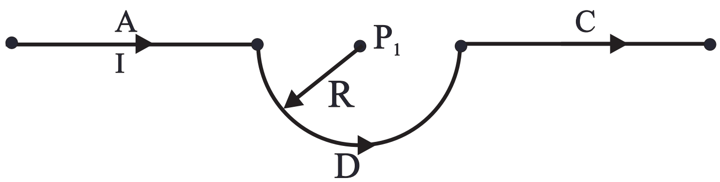
MAGNETIC FIELD AND THE BIOT-SAVART LAW

Use the Biot-Savart Law to solve the following problems! →

$$dB = k_m \cdot \frac{I \cdot d\vec{l} \times \hat{r}}{r^2} \qquad k_m = \frac{\mu_o}{4\pi} = 10^{-7} \cdot \frac{N}{A^2} \qquad \mu_o = 4\pi \text{ x } 10^{-7}\ N/A^2$$

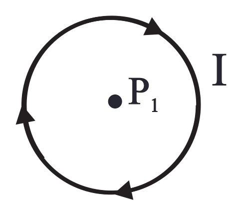
1. Consider conductor bent into the shape shown to the right. The conductor has a current of $I = 5.00$ Amperes flowing through it from right to left as shown. The horizontal segment of the conductor is $x = 12.0$ cm long. There is a point P_1 located a distance $y = 8.00$ cm from the segment as shown and there is a second point P_2 located y from the segment and perpendicular to the corner of the segment. Using the Biot-Savart Law determine:
   a. the direction and magnitude of the magnetic field B at point P_1.
   b. the direction and magnitude of the magnetic field B at point P_2.

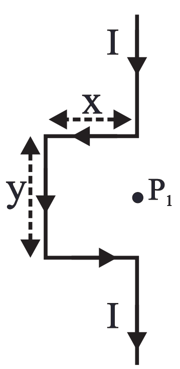




2. A current of $I = 8.00$ Amperes is flowing from left to right through the wire shown above. The central segment D of the wire is in the shape of a semi-circular loop, as shown, with a radius of $R = 12.0$ cm. while segments A and C are straight.
   a. What is the direction and magnitude of the magnetic field B_A at point P_1 as caused by wire segment A?
   b. What is the direction and magnitude of the magnetic field B_D at point P_1 as caused by wire segment D?
   c. What is the direction and magnitude of the magnetic field B_C at point P_1 as caused by wire segment C?
   d. What will be the direction and magnitude of the magnetic field B at point P_1?

3. A current of $I = 3.50$ Amperes is flowing in a circular, closed conducting path which has a radius of $R = 6.00$ cm. as shown to the right.
   a. What will be the direction of the magnetic field at point P_1?
   b. What will be the strength of the magnetic field at the center P_1 of this closed conducting loop?
   c. What will be the strength of the magnetic field B at point P_1 if this loop of wire is actually a coil of wire with $N = 20$ turns, each turn of which has a current of $I = 3.50$ Amperes?





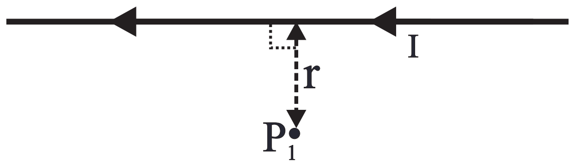
4. A segment of wire is bent into the shape shown to the left. A current of $I = 10.0$ Amperes is flowing through the wire from top to bottom as shown. The segment $x = 4.00$ cm and $y = 8.00$ cm.
   a. What will be the direction of the magnetic field B at point P_1?
   b. What will be the magnitude of the magnetic field B at point P_1?

Answers to opposite side: 5a. out of the paper b. $3.46 \text{ x } 10^{-5}$ Tesla 6a. 9550 A/m^2
6b. down & left c. $3.00 \text{ x } 10^{-5}$ Tesla d. toward the right e. $6.00 \text{ x } 10^{-5}$ Tesla
6f. 2.82 Amperes g. $5.64 \text{ x } 10^{-5}$ Tesla 7a. 3570 turns/m b. none, perpendicular
7c. very little, weak d. none, perpendicular e. B•l f. n•I•l g. $1.57 \text{ x } 10^{-2}$ Tesla
8. $-6.00 \text{ x } 10^{-5}$ Tesla out of the paper

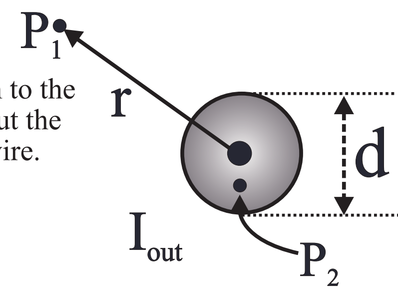
PHYSICS HOMEWORK #126 MAGNETISM
MAGNETIC FIELD AND AMPERE'S LAW

Use Ampere's Law to solve each of the following problems! ⟶ $\boxed{\oint \vec{B} \cdot d\vec{l} = \mu_o I_{enclosed}}$

5. A current of I = 3.80 Amperes is flowing through a long straight conductor as shown below. Point $\mathbf{P_1}$ is located a distance r = 2.20 cm from the wire.

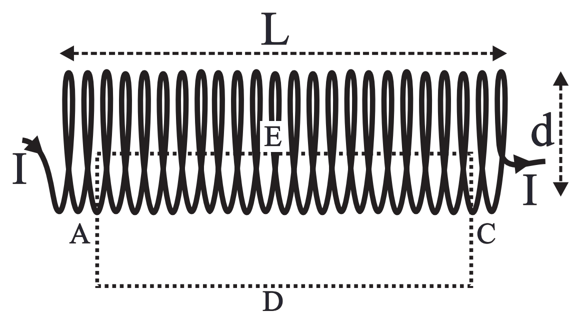


a. What will be the **direction** of the magnetic field **B** at point $\mathbf{P_1}$?
b. What will be the **magnitude** of the magnetic field **B** at point $\mathbf{P_1}$?

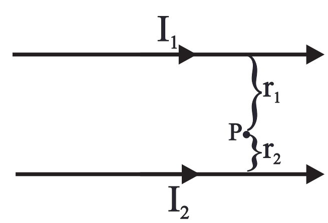


6. Current of I = 12.0 Amperes is flowing through a wire directed out of the paper as shown to the right. The wire has a diameter of d = 4.00 cm. and current density J is uniform throughout the interior of the wire. Point P_1 is located a distance of r = 8.00 cm from the center of the wire.
a. What is the **current density J** within this wire?
b. What will be the **direction** of the magnetic field strength $\mathbf{B_1}$ at point $\mathbf{P_1}$?
c. What will be the **magnitude** of the magnetic field strength $\mathbf{B_1}$ at point $\mathbf{P_1}$?
d. What will be the **direction** of the magnetic field $\mathbf{B_2}$ at point $\mathbf{P_2}$ within the wire?
e. What will be the **magnitude** of the magnetic field strength $\mathbf{B_2}$ at a second point $\mathbf{P_2}$ located only r = 1.00 cm from the center of the wire?
Suppose that the current density within this wire varies with distance from the center of the wire according to the relationship J = (8400 + 86,200r) Amperes/m^2.
f. What will be the total current $\mathbf{I_{enclosed}}$ within the appropriate Ampere's closed path for point $\mathbf{P_2}$?
g.What will be the magnetic field strength $\mathbf{B_2}$ located at point $\mathbf{P_2}$ within this wire?

7. Consider a **solenoid** which contains N = 500 turns, has a diameter of d = 2.50 cm and is L = 14.0 cm. long. An Ampere's closed path is set up according to the diagram to the right. A current of I = 3.50 Amperes is flowing through the solenoid.
a. What is the number of turns per unit length **n** for this solenoid?
b. Based on Ampere's Law, what contribution does segment **A** of the designated Ampere's closed path contribute to the integral? Explain!
c. What contribution does segment **D** make to the integral? Explain!
d. What contribution does segment **C** make to the integral? Explain!
e. What contribution does segment **E** make to the integral? Explain!
f. What is the **total current** enclosed by the Ampere's closed path?
g. What is the magnetic field strength **B** within the solenoid?



8. Two parallel wires are carrying currents of I_1 = 6.00 Amperes and I_2 = 9.0 Amperes respectively as shown in the diagram to the right. There is a point **P** between the two wires which is r_1 = 4.00 cm from the wire carrying the current I_1 and r_2 = 2.00 cm from the wire carrying the current I_2. What will be the **direction** and **magnitude** of the magnetic field $\mathbf{B_P}$ at point **P**?



Answers to opposite side: 1a. 7.50 x 10^{-5} Tesla - out b. 5.20 x 10^{-6} Tesla - out 2a. zero b. 7.08 x 10^{-5} Tesla - out 2c. zero d. 2.09 x 10^{-5} Tesla - out 3a. in b. 3.67 x 10^{-5} Tesla c. 7.33 x 10^{-4} Tesla 4a. out b. 3.54 x 10^{-5} Tesla

PHYSICS HOMEWORK #127 MAGNETISM
MAGNETIC FLUX AND FARADAY'S LAW

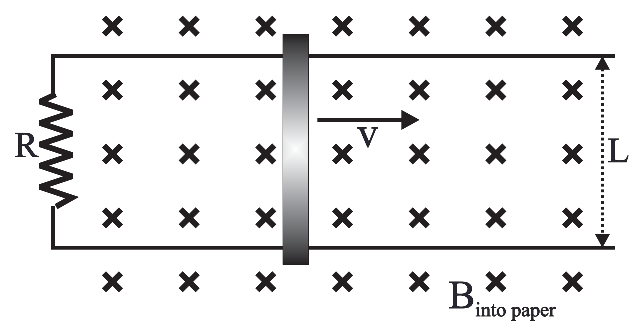
$$EMF = -N \cdot \frac{\Delta\phi}{\Delta t}$$

1. Consider a single loop of wire which is 25 cm by 25 cm. Passing through this loop is a magnetic field which has a magnitude of B = 0.220 Tesla.
   a. Assuming that the magnetic field is parallel to the normal to the loop, what will be the total magnetic flux passing through the loop?
   b. Assuming that the magnetic field meets the normal to the loop at an angle of $\Theta = 35.0^o$, what will be the total magnetic flux passing through the loop?
   c. Assuming that the magnetic field is perpendicular to the normal to the loop, what will be the total magnetic flux ϕ passing through the loop?

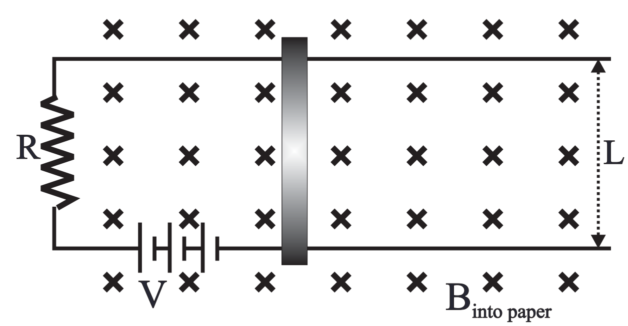
2. Consider a single loop of wire which encloses an area of A = 50.0 square centimeters. A magnetic field, which is parallel to the normal of this loop, initially has an intensity of B = 0.220 Tesla. Over a time period of Δt = 0.200 seconds the magnetic field strength B drops to zero.
   a. What will be the resulting EMF in the loop?
   b. What will be the EMF in this circuit if the loop consists of 1000 turns rather than a single turn as above?

3. Consider a coil of wire which has N = 1200 turns, encloses an area of A = 18.0 cm^2 and contains a magnetic field of B = 3.50 Tesla oriented parallel to the normal to the loop. What will be the induced EMF in this coil if the magnetic field B drops to zero in t = 0.0167 seconds?

4. Two parallel rails are connected together at one end by a resistance of R = 20.0 Ω as shown in the diagram to the right. Across these two rails, which are L = 45.0 cm apart, there lies a conducting metal bar. The magnetic field is uniform, has a strength of B = 2.20 Tesla and is directed out of the paper as shown. A force is applied to the metal bar so as to push the bar to the right with a velocity v = of 8.40 m/s.
   a. What will be the resulting EMF in this circuit?
   b. What will be the direction of the resulting conventional current flowing through this circuit?
   c. What will be the magnitude of the resulting current?
   d. At what rate is electrical energy being generated?
   e. How much force is being applied to this bar?
   f. At what rate is mechanical energy being consumed?



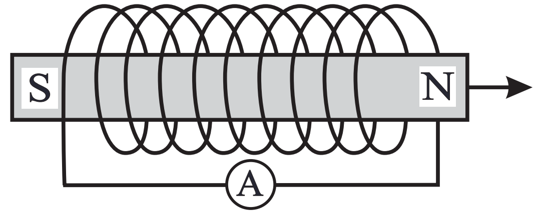
5. Consider the inverse of problem #22 above. Suppose that instead of pushing the metal bar through the magnetic field a battery, which has an EMF of V = 6.00 Volts, is inserted into the circuit as shown. The magnetic field has an intensity of B = 2.20 Tesla and is directed into the paper as shown and the resistance has a value of 20.0 Ω. A current of I = 0.20 Amperes is measured to be flowing through the circuit.
   a. What will be the resulting velocity of the bar?
   b. How much force is being applied to the bar by the the magnetic field as it moves through the field?



Answers to opposite side: 6a. left to right b. left to right c. zero d. left to right e. left to right
7. counterclockwise 8. counterclockwise 9. counterclockwise 10. clockwise 11a. right to left
11b. zero c. counterclockwise d. clockwise

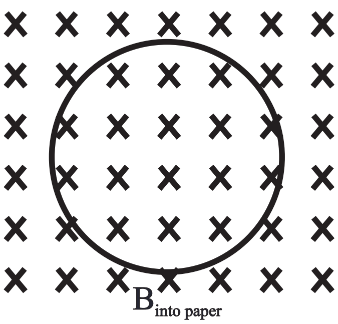
PHYSICS HOMEWORK #128 MAGNETISM
MAGNETIC INDUCTANCE AND LENZ'S LAW

6. Consider a coil of wire formed into a solenoid [a solenoid is a coil whose length is much greater than its diameter] as shown to the right. Initially, a bar magnet is sitting at rest within the solenoid with the polarity as shown. The bar magnet is then quickly removed to the right.



a. What will be the direction of the magnetic field within the solenoid BEFORE the permanent magnet is removed from the solenoid?
b. What will be the direction of the magnetic field within the solenoid IMMEDIATELY after removing the permanent magnet?
c. What will be the direction of the magnetic field within the solenoid a long time after the permanent magnet has been removed from the solenoid?
d. What will be the direction of the resulting current through the ammeter? Explain!
e. Suppose, instead, that the magnet is removed quickly to the left. What will be the direction of the resulting current through the ammeter? Explain!

7. A single loop of wire is lying in the plane of the paper as shown to the right. A bar magnet is approaching the loop from in front of the paper with the North end of the magnet entering the loop first. What will be the direction of the induced current flowing in the loop? Explain!



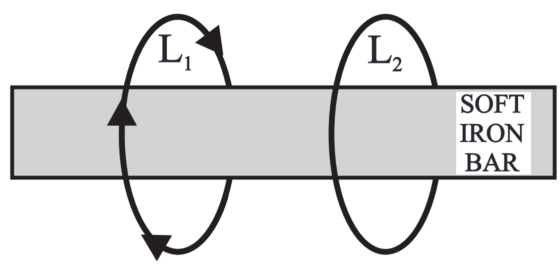
Each of the following 3 problems refers to the diagram to the left which represents a single coil of wire sitting in a uniform magnetic field B directed into the paper.

8. Suppose that this coil is quickly flipped over. What will be the direction of the induced current in the loop immediately after it has been flipped? Explain!

9. Suppose that the magnetic field B is slowly getting stronger with time. What will be the direction of the induced current? Explain!

10. Suppose that the magnetic field B is slowly getting weaker with time. What will be the direction of the induced current? Explain!

11. A soft iron bar is sitting surrounded by two separate loops of wire. The loop on the left, L_1, initially has a current flowing clockwise as viewed from the right and as shown.

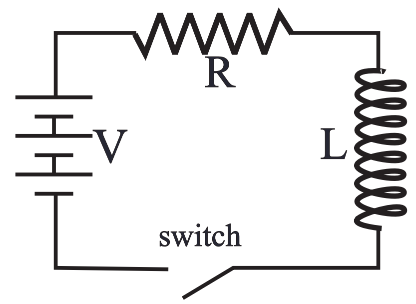


a. What will be the direction of the magnetic field in the soft iron bar? Explain!
b. What will be the direction of the initial current flowing through the right hand loop L_2? Explain!
c. The current flowing through loop L_1 is slowing increasing with time. What will be the direction of the resulting current flow in loop L_2? Explain!
d. The current flowing through loop L_1 is slowing decreasing with time. What will be the direction of the resulting current flow in loop L_2? Explain!

Answers to opposite side: 1a. 0.01375 Webers b. 0.0113 Webers c. 0.0 Webers
2a. 0.0055 Volts b. 5.50 Volts 3. 453 Volts 4a. 8.32 Volts b. clockwise c. 0.416 Amperes
4d. 3.46 Watts e. 0.412 Newtons f. 3.46 Watts 5a. 2.02 m/s b. 0.198 Newtons

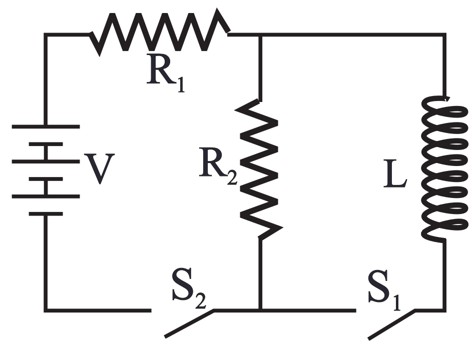
PHYSICS HOMEWORK #129 MAGNETISM
MAGNETIC INDUCTANCE & SIMPLE CIRCUITS

1. An induction coil, which has an inductance of L = 250.0 milliHenrys, is connected in series with a resistance of R = 20.0 Ω and with a battery which has a DC voltage of V = 36.0 Volts. Initially, the switch has been closed for a long time but at t = 0 sec. the switch is opened.



   a. What will be the current $\mathbf{I_o}$ is this circuit **immediately before** the switch is opened? Explain!
   b. What will be the current through the circuit **immediately after** the switch has been opened? Explain!
   b. What is the inductive time constant $\mathbf{t_c}$ for this circuit?
   c. What will be the current $\mathbf{I_t}$ flowing through this circuit t = 15.0 millisec after the switch has been opened?
   d. What will be the current I_f flowing in this circuit a long time after the switch has been opened?

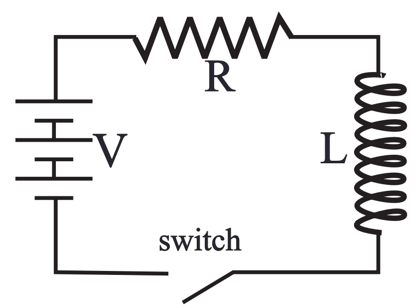
2. An induction coil, which has an inductance of L = 22.0 milliHenrys, is connected with two resistors, R_1 = 100 Ω and R_2 = 1500 Ω, and a battery V = 32.0 Volts as shown in the diagram to the right. At t = 0 seconds both switches are closed simultaneously.



   a. What will be the **current** flowing in the inductor L **immediately** after the switches have been closed?
   b. What will be the **current** flowing through resistor R_2 **immediately** after the switches have been closed?
   c. What will be the **current** flowing through resistor R_2 **a long time** after the switches have been closed?
   d. What will be the **current** flowing through resistor R_1 **a long time** after the switches have been closed?
   e. What will be the **current** flowing through the inductor L **a long time** after the switches have been closed?

   After a long time switch S_2 is re-opened. [S_1 remains closed.]
   f. What will be the **current** flowing through the inductor **L immediately** after switch $\mathbf{S_2}$ has been re-opened?
   g. What will be the **current** flowing through the resistor $\mathbf{R_1}$ **immediately** after switch $\mathbf{S_2}$ has been re-opened?
   h. What will be the **potential difference** across resistor $\mathbf{R_2}$ **immediately** after switch $\mathbf{S_2}$ has been re-opened?
   i. What will be the **potential difference** across the inductor **L immediately** after switch $\mathbf{S_2}$ has been re-opened?
   j. What will be the **current flowing** through the inductor **L** a **long time** after switch $\mathbf{S_2}$ has been re-opened?

3. An induction coil, which has an inductance of L = 12.0 milliHenrys, is connected in series with a resistance of R = 50 Ω and with a battery which has a DC voltage of V = 24.0 Volts. At t= 0 seconds the switch is closed.



   a. What will be the current is this circuit **immediately** after the switch is closed? Explain!
   b. What will be the inductive time constant $\mathbf{t_c}$ for this circuit?
   c. What will be the current $\mathbf{I_t}$ flowing through this circuit t = 50 μsec after the switch has been closed?
   d. What will be the current I_f flowing in this circuit a long time after the switch has been closed?

Answers to opposite side: 4a. 0.437 Henrys b. 9.61 Volts c. 5.24 Henrys d. 115 Volts
5a. 0.91 Amperes b. 0.0174 s c. $I = 0.91\ e^{-t/.0174}$ Amperes d. 0.859 Amperes e. 0.0386 Amperes f. 0.080 sec
6a. 66.3 μH b. 0.445 Ω c. 0.667 Ω d. 0.802 Ω e. 29.9 Amperes f. $I = 29.9 \sin [1.01 \times 10^4 t]$
6g. $3.01 \times 10^5 \cos [1.01 \times 10^4 t]$ h. $-19.9 \cos [1.01 \times 10^4 t]$ i. 4.07 Volts 7a. 415 Ω b. 419 Ω
7c. 0.076 Amperes d. 82.5° e. 0.317 Watts

PHYSICS HOMEWORK #130 MAGNETISM
MAGNETIC INDUCTANCE & IMPEDANCE

4. A given solenoid consists of 7250 turns of wire, has a diameter of 4.4 cm and is 23 cm long.
   a. What is the self inductance of this solenoid?
   b. Suppose that the current flowing through this solenoid is initially 12.5 Amperes and is decreasing at a rate of 22.0 Amperes/second. What will be the EMF generated across this coil as a result of this changing current?
   c. Suppose that this coil is surrounded by a second coil which has the exact same length as the first coil, consists of 87,000 turns and has a radius that is only slightly larger than the first coil. What will be the mutual inductance of these two coils?
   d. What will be the induced EMF in the secondary coil?

5. Consider a coil which has a self inductance of 0.23 Henrys and a resistance of 13.2 Ω. A DC voltage of 12.0 Volts is applied to this coil until a steady state current is flowing through the coil.
   a. What will be the magnitude of this steady state current?
   b. What will be the time constant for this coil?
   c. Suppose that the supply of EMF is suddenly cut off. Write an equation describing the current flowing through this coil as a function of time.
   d. What will be the current flowing through this coil 1.0 milliseconds after the source of EMF is removed?
   e. What will be the current flowing through this coil 55.0 milliseconds after the source of EMF is removed?
   f. How long will it take for the current flowing through the coil to drop to 1.0% of its initial steady state value?

6. Consider a solenoid which consists of 210 turns of wire, has a diameter of 0.8 cm., and is 4.2 cm long. The solenoid is made of gauge 24 [diameter = 0.051cm] copper [r = 1.72×10^{-6} Ω cm] wire. An AC voltage of 24 Volts RMS at 1600 Hz. is applied to this solenoid.
   a. What is the self inductance of this solenoid?
   b. What is the resistance of this solenoid?
   c. What will be the inductive reactance of this solenoid?
   d. What will be the impedance of this solenoid at this frequency?
   e. Based on the applied voltage , what will be the peak current flowing through this solenoid?
   f. Write an equation describing the current flowing through this solenoid as a function of time.
   g. Write the equation describing the rate of change of current in this solenoid as a function of time?
   h. What will be the resulting EMF generated by this coil as a function of time?
   i. What will be the phase angle between the voltage across the solenoid and the current flowing through the solenoid?

7. An AC voltage of 45.0 Volts at a frequency of 880 Hz. is applied to a coil which has a resistance of 55.0 Ω and an inductance of L = 0.075 Henrys.
   a. What is the inductive reactance of this coil?
   b. What is the impedance of this coil at this frequency?
   c. What will be the RMS current flowing through this coil?
   d. What is the phase angle between the current and the voltage across this coil?
   e. At what rate is power being dissipated in this coil?

Answers to opposite side: 1a. 1.80 Amperes b. 1.80 Amperes c. 0.0125 seconds d. 0.542 Amperes 1e. zero 2a. zero b. 0.020 Amperes c. zero d. 0.320 Amperes e. 0.320 Amperes 2f. 0.320 Amperes g. 0.320 Amperes h. 480 Volts i. 480 Volts j. zero 3a. zero 3b. 2.40×10^{-4} seconds c. 0.0903 Amperes d. 0.480 Amperes

PHYSICS HOMEWORK #131 ELECTROSTATICS

ELECTRIC FIELDS

1. A pith ball has a surplus of 4.20×10^{15} electrons. What will be the net charge on this ball is Coulombs?

2. A pith ball has a shortage of 1.85×10^{17} electrons. What is the net charge on this ball in Coulombs?

3. How many electrons will be contained in a net charge of 1250 microCoulombs (μC)?

4. A pith ball , which has a residual charge of -36.0 μC, is brought into contact with a second, identical pith ball which is initially neutral, allowing charge to flow between them. These two ball are then separated.
   a. What will be the final residual charge on each pith ball?
   b. How many extra electrons will be present on each ball after they have been separated?

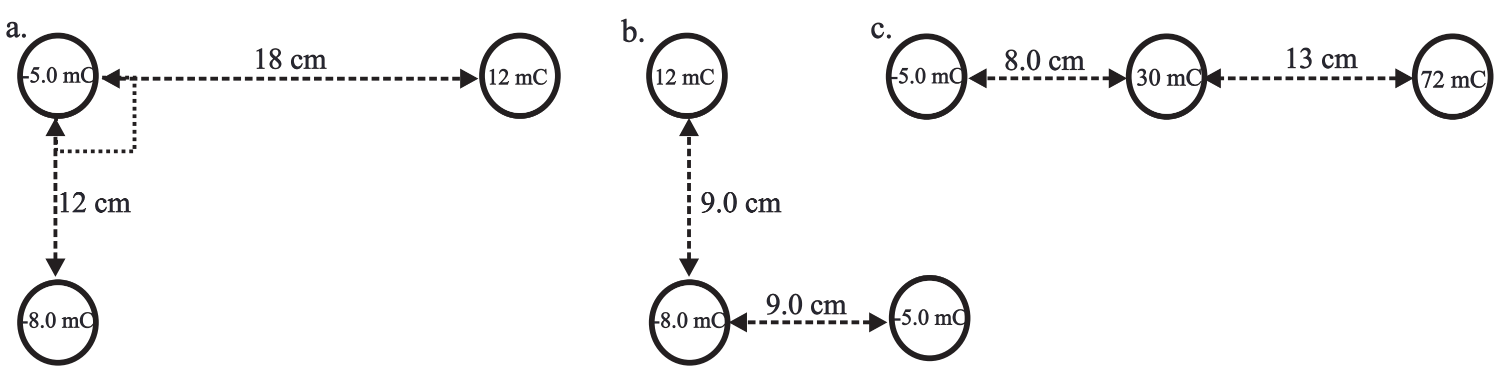
5. A pith ball, which has a residual charge of 54.0 μC is brought into contact with a second, identical pith ball which has an initial residual charge of -38.0 μC. What will be the final residual charge on each pith ball after they have been separated?

6. A pith ball, which has a residual charge of 66.0 μC is brought into contact with a second pith ball, which has an initial residual charge of -33.0 μC and which has twice the surface area of the first pith ball. What will be the final residual charge on each pith ball after they have been separated?

7. What will be the magnitude of the electrostatic force between two identical pith balls, each of which has a residual charge of 24.0 μC, which are 15.0 centimeters apart?

8. What will be the magnitude of the electrostatic force between two pith balls 23.0 centimeters apart if the residual charge on the first ball is -31.0 μC while the residual charge on the second ball is 12.0 μC ?

9. What will be the **direction** and **magnitude** of the net electrostatic force acting **on the -5.0 μC** charge in each of the following sets of charges?



10. What will be the electrostatic force between a proton [$q = 1.6 \times 10^{-19}$ C] and an electron [$q = -1.6 \times 10^{-19}$ C] when they are placed 0.5 Angstroms [1 Å $=10^{-10}$ meters] apart? [0.5 Å is the approximate radius of the Hydrogen atom!]

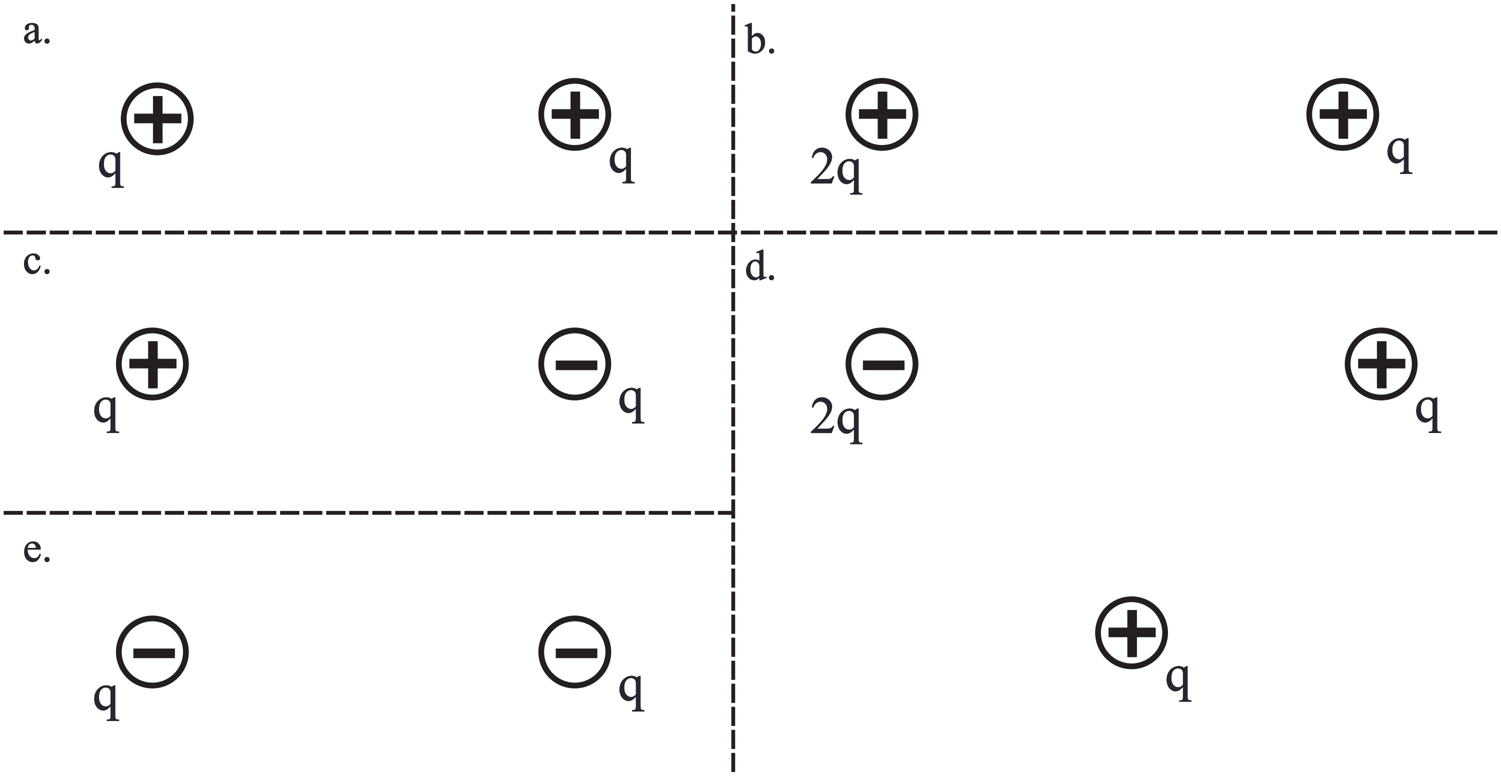
11. What will be the magnitude of the electrostatic force between two protons in the nucleus of an atom, which are approximately 3.0×10^{-15} meters [3.0 Fermi] apart?

Answers to opposite side: 13. 9000 N/C 14. 0.068 N 15a. 1.04×10^{-12} N b. 6.23×10^{14} m/sec^2

PHYSICS HOMEWORK #132 ELECTROSTATICS

ELECTRIC FIELDS

12. Sketch the electric field for each of the following arrangements of charge. Use **at least 8 field lines** for each diagram, indicate the directions of the field lines with arrows pointing in the appropriate directions. [The field lines should always **point away from the positive** charges and **towards the negative** and the number of field lines leaving or converging on a charge should be directly proportional to the intensity of the charge!]



13. What will be the strength of the electric field at a point in space where a 5.00 μC charge feels an electrostatic force of F = 0.045 Newtons?

14. A charge of 8.5 μC is placed in a uniform electric field which has an intensity of E = 8,000 N/C. What will be the magnitude of the resulting force?

15. A proton [$q = 1.6 \times 10^{-19}$ C and $mp = 1.67 \times 10^{-27}$ kg] is placed in a uniform electric field which has an intensity of E = 650,000 N/C.
    a. What will be the magnitude of the resulting electrostatic force?
    b. What will be the resulting acceleration of the proton as a result of this field?

Answers to opposite side: 1. 670 μC 2. 29,600 μC 3. 7.80×10^{15} e- 4a. -18.0 μC b. 1.125×10^{14} e- 5. 8.0.0 μC 6. 22.0 μC & 11.0 μC 7. 230 N 8. 63.3 N 9a. 30.6 N at 56° NE b. 31.5 N at 49° NE 9c. 284 N East 10. -9.2×10^{-8} N 11. 25.6 N

PHYSICS HOMEWORK #133 ELECTROSTATICS
CALCULATING THE ELECTRIC FIELD

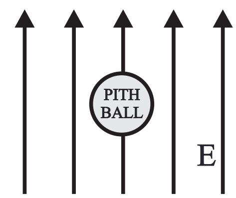
$$E = \frac{k \cdot q}{r^2}$$

where $k = 9.0 \cdot 10^9 \cdot \frac{Nm^2}{C^2}$

16. What will be the electric field strength 45.0 cm from a pith ball which has a residual charge of 5.5 μC?

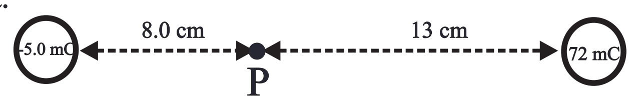
17. What will be the electric field strength a distance of 2450 Å from the nucleus of a Helium atom? a Carbon atom?

18. A small pith ball, which has a mass of 0.056 grams and contains a residual charge of 5.0 μC, is sitting in a vertically oriented electric field as shown at the right, such that the force of gravity acting downward on this ball is exactly balanced by the electric field directed upward.
a. What will be the gravitational force acting on the pith ball?
b. What will be the magnitude of the electrostatic force acting on the pith ball?
c. What is the magnitude of the electric field that is supporting this ball?

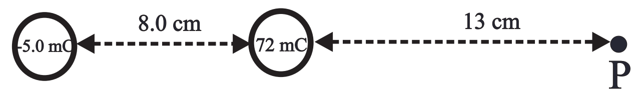


19. What will be the magnitude and direction of the electric field at point x in each of the following diagrams?

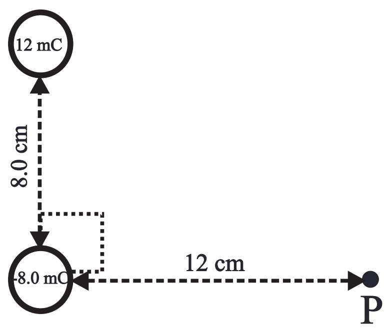
a.



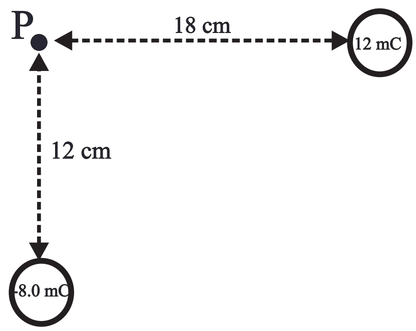
b.



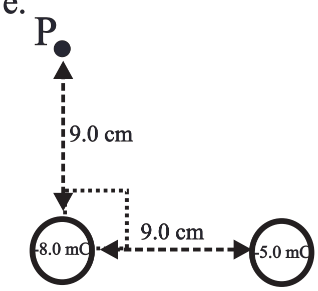
c.



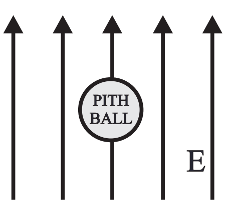
d.



e.



20. A pith ball, which has a mass of 2.2 gm and which contains a residual charge of 1.3 μC, is placed in a uniform electric field, which has a magnitude of E = 85,000 N/C and which is directed upward, as shown below. Assume that the pith ball is initially suspended [neither rising or falling].

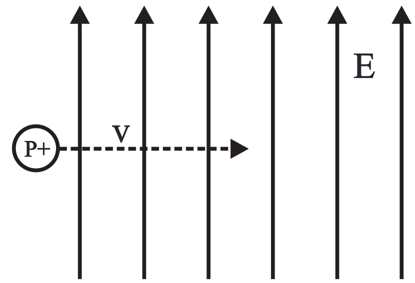


a. What will be the magnitude of the gravitational force acting on this pith ball?
b. What will be the magnitude of the electrostatic force acting on this pith ball?
c. What will be the direction of the net force acting on this pith ball?
d. What will be the magnitude of the net force acting on this pith ball?
e. What will be the magnitude and direction of the resulting acceleration of this pith ball?
f. What will be the displacement of this pith ball after 0.5 seconds?
g, What will be the velocity of the pith ball after 0.5 seconds?

ANSWERS TO THE OPPOSITE SIDE: 21a. -1.64×10^{-26} N j b. 8.96×10^{-14} N j c. 8.96×10^{-14} N j
21d. 5.4×10^{13} m/s^2 j e. 6.8×10^{7} m/s at 85° NE f. 42.5 m at 81° NE 22b. 4.64×10^{-15} N c. 6.03×10^{-9} s
22d. at x = 35 cm & y = 9.3 cm e. 6.56×10^{7} m/s at 28° 23a. 3.65×10^{-4} N b. 0.0133 μC c. 8.33×10^{10} e-
23d. 7.7 nC, 23.1 nC

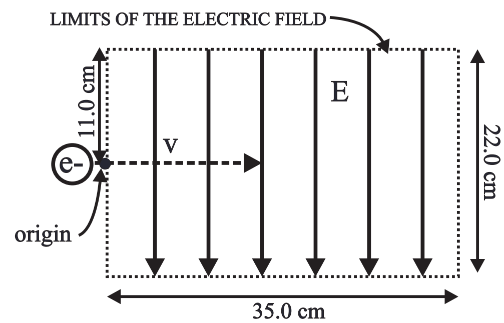
PHYSICS HOMEWORK #134 ELECTROSTATICS
ELECTRIC FORCES IN UNIFORM FIELDS

21. A proton, which has a mass of 1.67×10^{-27} kg and a charge of 1.6×10^{-19} C, is moving with a velocity of 5.6×10^{6} m/s from left to right into a uniform electric field as shown in the diagram to the right. The electric field has a magnitude of 560,000 N/C and is directed upward.

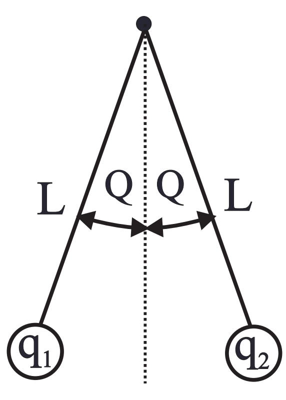


a. What will be the direction and magnitude of the gravitational force acting on this proton?
b. What will be the direction and magnitude of the electrostatic force acting on this proton?
c. What will be the direction and magnitude of the net force acting on the proton?
d. What will be the direction and magnitude of the acceleration of this proton?
e. What will be the velocity of this proton 1.25 microseconds after entering the electric field?
f. What will be the displacement of this proton 1.25 microseconds after entering the electric field?

22. An electron, which has a mass of 9.11×10^{-31} kg and a charge of -1.6×10^{-19} C, enters a uniform electric field with a velocity of 5.8×10^{7} m/s. The electric field has a magnitude of 29,000 N/C, is pointing vertically downward and is contained within a limited area as shown to the right.



a. Sketch the path of this particle through the electric field.
b. What will be the net force acting on this electron?
c. How long will it take for this electron to pass through this field?
d. Where, exactly, will the electron exit the field?
e. What will be the velocity of the electron as it exits the field?



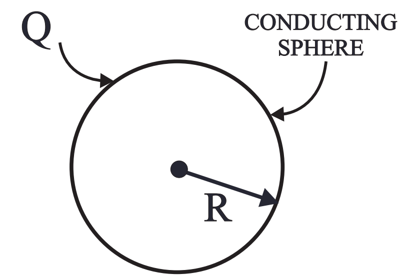
23. Two pith balls, each of which is suspended from the end of a piece of very thin thread, are attached to a common point of suspension as shown to the left. Each pith ball has a mass of 0.13 gm and each piece of thread is L = 12.0 cm long. Each of the two pith balls is given a net charge and as a result the two balls repel one another until the angle between the two balls increases to q = 32o.
a. What will be the magnitude of the electrostatic force between these two balls?
b. Determine the magnitude of the charge on each ball if the charge is distributed evenly between the two balls.
c. Assuming that this charge is negative, how many excess electrons would be found on each ball?
d. Determine the charge on each ball if the charge of q1 is 3x the charge q2.
e. Experimentally, how could you determine if the pith balls were charged positive or negative?

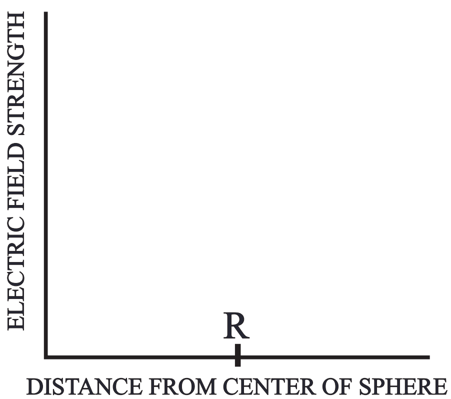
Answers to opposite side: 16. 2.4×10^{5} N/C 17. 4.8×10^{4} N/C, 1.44×10^{5} N/C 18a. -5.5×10^{-4} N 18b. 5.5×10^{-4} N c. 110 N/C 19a. -4.54×10^{7} N/C I b. 3.73×10^{7} N/C I c. 2.96×10^{6} N/C at 76.7° SW 18d. 6.01×10^{6} N/C at 56.3° SW e. 1.10×10^{7} N/C at 80° SE 20a. 2.16×10^{-2} N b. 1.11×10^{-1} N 20c. upward d. 8.89×10^{-2} N e. 40.4 m/s^2 upward f. 5.05 m g. 20.2 m/s

PHYSICS HOMEWORK #135 ELECTROSTATICS
CALCULATING THE ELECTRIC FIELD - GAUSS'S LAW

$$\int E \cdot dA = 4 \cdot \pi \cdot k \cdot q_{enclosed}$$

1. A charge of Q = +25.0 μC is distributed evenly on the surface of a conducting sphere, which has a radius of R = 5.0 cm;
   a. What will be the charge density [s] on this surface?
   b. What should be the shape of a Gaussian surface such that all points on this surface have the same electric field strength and so that the electric field is perpendicular to all points on the surface? Why are these conditions desirable?
   c. What will be the electric field strength 3.0 cm from the center of this sphere?
   d. Using Gauss's Law develop an expression which will predict the electric field strength for any point outside this sphere. [r >R]
   e. What will be the electric field strength 7.0 cm from the center of this sphere?
   f. On the diagram to the right sketch the electric field in the vicinity of this charged sphere.
   g. On the graph below sketch the electric field strength as a function of distance from the center of the sphere.





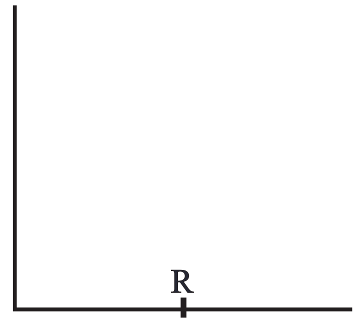
2. A charge of Q = +45.0 μC is distributed uniformly across the surface of an insulating plane [the thickness is insignificant] which is 35.0 cm wide and 55.0 cm high;
   a. What will be the surface charge density σ on this plane?
   b. What should be the shape of a Gaussian surface such that all points on this surface have the same electric field strength and so that the electric field is perpendicular to all points on the surface? Explain!
   c. Using Gauss's Law develop an expression predicting the electric field strength as a function of distance from this finite plane.
   d. What will be the electric field strength R = 2.00 cm from the center of this finite plane?
   e. What will be the electric field strength R = 5.00 cm from the center of this plane?
   f. In general, how does the electric field strength vary with increasing distance from a uniform, planar distribution of charge?
   g. What will be the electric field strength 2,550 meters from the center of this plane?
   h. Why is the answer to **g** different from the answer to **d**? Explain!

3. A charge of -15.0 μC is distributed evenly along a conducting wire which is 70.0 cm long;
   a. What will be the charge density λ along this wire?
   b. Using Gauss's Law, develop an expression predicting the electric field strength as a function of distance from the charged wire.
   c. What will be the strength of the electric field R = 2.00 cm from the center of this wire?
   d. In general, how does the electric field strength vary with distance from a charged, straight wire? Explain!
   e. What will be the electric field strength 1250 meters from the center of this wire?
   f. Why is the answer to **e** different from **c**? Explain!
   g. What general statement can you make about the electric field strength very far away from any **FINITE** charged body? Explain!

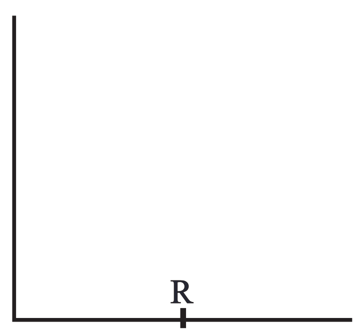
Answers to opposite side: 4a. 1.04×10^{-2} C/m^3 b. sphere c. $^4/_3\, \pi r^3\rho$ d. 1.17×10^{-6} C
4e. $^4/_3\, \pi k\rho r$ f. 1.57×10^7 N/C g. q = Q h. +15 μC i. kQ/r^2 j. 8.0×10^6 N/C 5a. -1.11×10^{-2} C/m^3
5b. cylinder c. $\pi r2L\rho$ d. -8.7×10^{-7} C e. q = Q f. -3.5 μC g. $2\pi kr\rho$ h. 6.28×10^6 N/C i. 2kQ/Lr
5j. 6.3×10^6 N/C

PHYSICS HOMEWORK #136 ELECTROSTATICS
CALCULATING THE ELECTRIC FIELD - GAUSS'S LAW

4. A solid, insulating sphere, which has a radius of R = 7.0 cm, contains Q = +15 μC of charge distributed uniformly throughout its interior.
   a. What will be the charge density ρ contained within this sphere?
   b. What should be the shape of a Gaussian surface such that all points on this surface have the same electric field strength and so that the electric field is perpendicular to all points on the surface?
   c. Develop an expression for the charge contained within any Gaussian surface for which the radius of the Gaussian surface **r** is less than the radius of the solid sphere. [i.e. r <R]
   d. How much charge will be contained within a Gaussian surface which has a radius of r = 3.00 cm?
   e. Using Gauss's Law develop an expression for the electric field strength anywhere within this solid sphere.
   f. What will be the electric field strength r = 4.00 cm from the center of this solid sphere?
   g. Develop an expression for the total charge contained within any Gaussian surface where the radius of the Gaussian surface **r** is greater than the radius of the solid sphere **R**.
   h. How much charge will be contained within a Gaussian surface which has a radius of r = 13.0 cm?
   i. Develop an expression describing the electric field strength anywhere outside this solid sphere. [i.e. r >R]
   j. What will be the electric field strength r = 13.0 cm from the center of this solid sphere?
   k. On the graph at the right sketch the electric field strength as a function of distance from the center of the solid sphere.



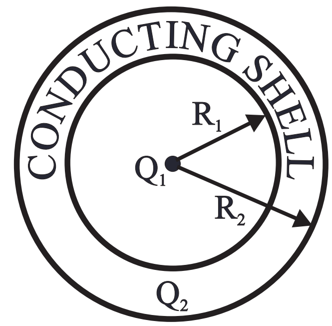
5. Consider an insulating cylinder, which is L = 25.0 cm long, has a radius of R = 2.0 cm. and contains Q = -3.5 mC of charge distributed uniformly throughout its interior.
   a. What will be the charge density ρ contained within this cylinder?
   b. What should be the shape of the Gaussian surface for this solid cylinder so that the electric field strength is uniform at all points on the Gaussian surface and such that the electric field is perpendicular to all points on the Gaussian surface?
   c. Develop an expression describing the charge contained within a Gaussian surface which has a radius **r** that is less that the radius **R** of the cylinder.
   d. How much charge will be contained within a Gaussian surface which has a radius of r = 1.00 cm?
   e. Develop an expression which will predict the charge contained within a Gaussian surface which has a radius **r** that is greater that the radius **R** of the solid cylinder.
   f. How much charge will be contained within a Gaussian surface which has a radius of r = 4.00 cm?
   g. Develop an expression which will predict the electric field strength as a function of distance from the center of the solid cylinder for distances **r** less that the radius **R** of the cylinder.
   h. What will be the electric field strength r = 1.00 cm from the center of this cylinder?
   i. Develop an expression describing the electric field strength for points outside of the solid cylinder. [r > R]
   j. What will be the electric field strength r = 4.00 cm from the center of the solid cylinder?
   k. On the graph at the right plot the electric field as a function of distance from the center of the cylinder.

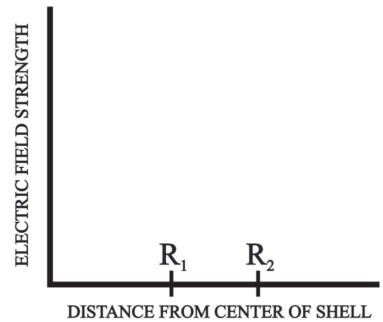


Answers to opposite side: 1a. 7.96×10^{-4} C/m^2 b. sphere c. zero d. kQ/r^2 e. 4.59×10^{7} N/C
2a. 2.34×10^{-4} C/m^2 b. "tin can" c. 2πkσ d. 1.32×10^{7} N/C e. same as d f. E = constant
2g. far away a finite plane looks like a point. 3a. 2.14×10^{-5} C/m b. 2kQ/Lr c. 1.93×10^{7} N/C d. inversely
3e. 8.64×10^{-2} N/C f. far away a finite line looks like a point. g. far enough away any finite object looks like a point!

PHYSICS HOMEWORK #137 ELECTROSTATICS
CALCULATING THE ELECTRIC FIELD - GAUSS'S LAW

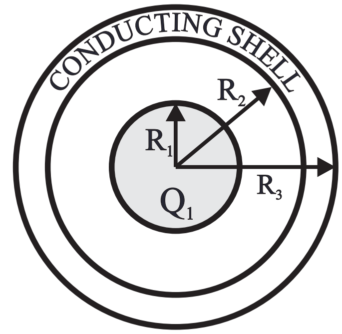
6. Consider a conducting spherical shell, which has an inner radius of R_1 = 7.00 cm, an outer radius of R_2 = 9.00 cm and contains a charge of Q_2 = +18.0 μC. This shell, in turn, encloses a point charge of Q_1 = -6.00 μC located at its center, as shown in the diagram at the right.
   a. Using Gauss's Law develop an expression which will predict the electric field strength inside the spherical shell [for values of $r < R_1$] and evaluate that expression for a value of r = 5.00 cm.
   b. Using Gauss's Law develop an expression which will predict the electric field strength within the spherical shell and evaluate that expression for a point r = 8.00 cm from the center of the shell.
   c. Using Gauss's Law develop an expression which will predict the electric field strength outside of the spherical shell and evaluate that expression for a value of r = 12.0 cm.
   d. What will be the charge density on the inner surface of the spherical shell?
   e. What will be the charge density on the outer surface of the spherical shell?
   f. On the diagram to the right sketch the electric field [lines of force] everywhere.
   g. On the graph to the right sketch the electric field strength as a function of distance from the center of the spherical shell.





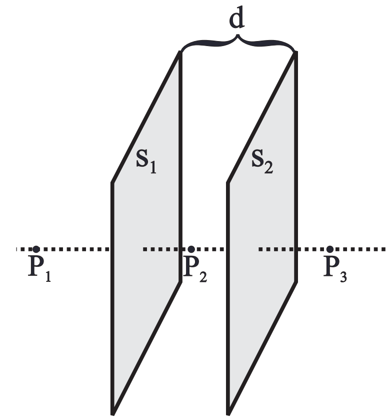
7. An insulating, solid sphere has a radius of R_1 = 3.50 cm and contains a charge of 55.0 μC which is distributed uniformly throughout its volume. This sphere is in turn surrounded by an uncharged, conducting spherical shell, which has an inner radius of R_2 = 6.50 cm and an outer radius of R = 8.00 cm.
   a. Using Gauss's Law develop an expression which will predict the electric field strength everywhere inside of the solid sphere and evaluate that expression for a value of r = 1.0 cm. [$r < R_1$]
   b. Using Gauss's Law develop an expression which will predict the electric field strength outside of the solid sphere but inside the spherical shell and evaluate that expression for a value of r = 4.00 cm. [$R_1 < r < R_2$]
   c. What will be the electric field strength within the spherical shell? Justify! [$R_2 < r < R_3$]
   d. Using Gauss's Law develop an expression which will predict the electric field strength everywhere outside of the spherical shell and evaluate that expression for a value of r = 10.5 cm. [$r > R_3$]
   e. What will be the surface charge density σ_2 on the inner surface of the spherical shell?
   f. What will be the surface charge density σ_3 on the outer surface of the spherical shell?

   Suppose, instead, that the insulating,charged sphere has a charge density which varies as a function of distance from the center of the sphere according to the relationship $\rho = (4.17 \times 10^4 + 1.91 \times 10^7 r^2)\mu C/m^3$
   g. What will be the total charge Q_1 of this insulating, charged sphere?
   h. What will be the strength of the electric field r = 2.0 cm from the center of this insulating sphere?
   i. What will be the strength of the electric field r = 5.0 cm from the center of the insulating sphere?



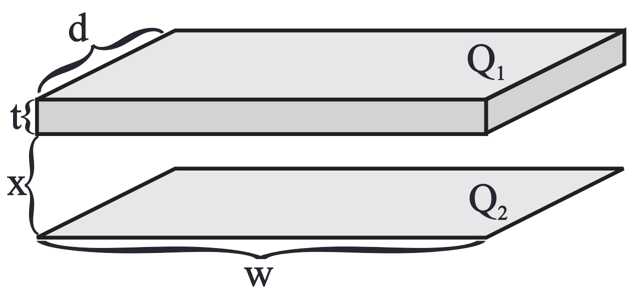
Answers to opposite side: 8a. 7.07×10^4 N/C i b. 2.12×10^5 N/C c. -7.07×10^4 N/C i
9a. -3.37×10^7 N/C j b. 1.81×10^7 N/C j c. -1.51×10^7 N/C j d. -2.42×10^{-12} N j e. 5.13×10^7 N/C j
f. -5.13×10^7 N/C j g. zero h. 1.34×10^{-4} C/m^2, 4.54×10^{-4} C/m^2 10a. zero for [$r < R_1$], $2k\lambda/r$ for [$R_1 < r < R_2$], $2k(\lambda+\rho[R_3^2-R_2^2])/r$ for [$R_2 < r < R_3$], $2k(\lambda_1+\lambda_2)/r$ for [$r > R_3$] c. 3.87×10^6 N/C

PHYSICS HOMEWORK #138 ELECTROSTATICS
CALCULATING THE ELECTRIC FIELD - GAUSS'S LAW



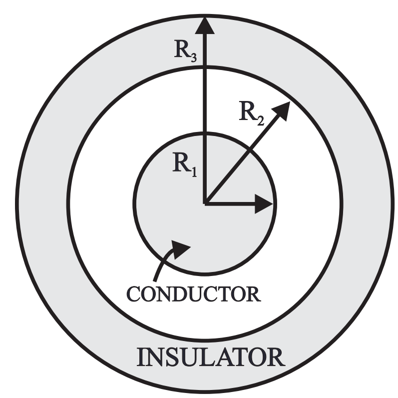
8. Consider two vertically oriented, parallel infinite planes. The left hand plane has a charge density of $\sigma_1 = 1.25\ \mu C/m^2$ while the right hand plane has a charge density of $\sigma_2 = -2.50\ \mu C/m^2$. The two planes are d = 5.0 cm apart as shown to the right.
   a. Using Gauss's Law, determine the electric field strength to the left of the two planes at point P_1.
   b. Using Gauss's Law, determine the electric field strength between the two planes at point P_2.
   c. Using Gauss's Law, determine the electric field strength to the right of the two planes at point P_3.

9. Consider two horizontally oriented, parallel planes as shown below. Each plane has a width of w = 25 cm and a depth of d = 15 cm. The upper plane is a conductor which has a thickness of t = 1.0 cm, while the lower plate is an insulator of negligible thickness. These two plates are a distance of x = 5.0 cm apart. A total charge of $Q_1 = 22\ \mu C$ is placed on the upper plate, while a total charge of $Q_2 = +12\ \mu C$ is placed on the lower plate.



   a. What will be the direction and magnitude of the electric field between these two planes as caused by the upper plane?
   b. What will be the direction and magnitude of the electric field between these two planes as caused by the lower plane?
   c. What will be the direction and magnitude of the electric field between these two planes as caused by both planes?
   d. What will be the direction and magnitude of the electrostatic force acting on a proton placed in the area between these two plates?
   e. What will be the direction and magnitude of the electric field in the area above these two planes?
   f. What will be the direction and magnitude of the electric field in the area below these two planes?
   g. What will be the direction and magnitude of the electric field within the upper plate?
   h. What will be the charge densities σ_1 and σ_1' on the upper and lower surfaces of the upper plate?
   i. Make a sketch showing the electric field everywhere in the vicinity of these plates.

10. Consider a conducting cylinder which has a radius of $R_1 = .05$ cm and which contains a charge density of $\lambda_1 = +2.2\ \mu C/m$ of length and which is surrounded by an insulating cylindrical shell which has an inner radius of $R_2 = 1.5$ cm and an outer radius of $R_3 = 2.25$ cm. This outer cylinder has charge distributed uniformly throughout with a charge density of $\rho_2 = +747\ \mu C/m^3$.
   a. Develop the set of expressions that will predict the electric field everywhere in the area of these two cylinders.
   b. Make a graph showing the electric field strength as a function of distance from the center of the cylinders.
   c. What will be the electric field strength 2.0 cm from the center of the cylinders.



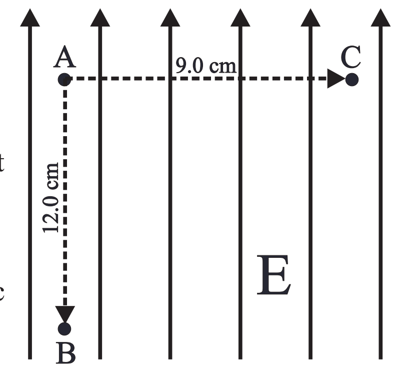
Answers to opposite side: 6a. 2.16×10^7 N/C b. zero c. 7.5×10^6 N/C d. 9.74×10^{-5} C/m^2
6e. 1.18×10^{-4} C/m^2 7a. 1.15×10^8 N/C b. 3.09×10^8 N/C c. zero d. 4.49×10^7 N/C e. -1.04×10^{-3} C/m^2
7f. 6.84×10^{-4} C/m^2 g. $10.0\ \mu C$ h. 3.49×10^7 N/C i. 2.25×10^8 N/C

PHYSICS HOMEWORK #140 ELECTROSTATICS

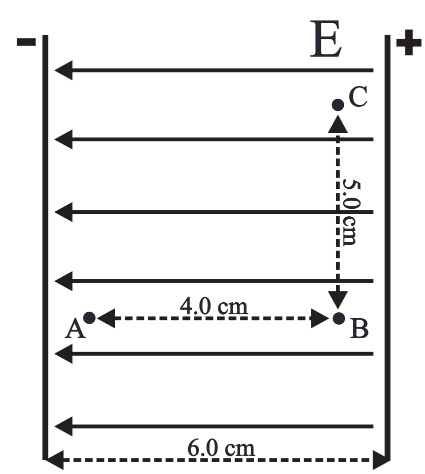
MAGNETIC FORCE ON MOVING CHARGES

PHYSICS HOMEWORK #141 ELECTROSTATIC POTENTIAL
UNIFORM ELECTRIC FIELDS

1. A charge of 15 μC is placed in a uniform electric field which has a field strength of E = 88,000 N/C;
   a. What will be the magnitude of the electrostatic force acting on on this charge?
   b. How much work would be done in moving this charge a distance of 135 cm against the electric field?
   c. What will be the potential difference between these two points?



2. A proton [mp = 1.67 x 10^{-27} kg, q_p = 1.6 x 10^{-19} C] is placed at point A in a uniform electric field which has a field strength of E = 4,500 N/C and which is directed toward the top of the page as shown in the diagram to the right;
   a. What will be the direction of the electrostatic force acting on this proton while at point A?
   b. What will be the magnitude of the electrostatic force acting on this proton while at point A?
   c. How much work will be done in moving this charge a distance of 12.0 cm against this electric field to point B?
   d. How will the electrostatic potential at point B in this field compare with the electrostatic potential at point A?
   e. What will be the potential difference between points A and B?
   Suppose that this proton is then released and is allowed to accelerate back to point A.
   f. What will be the velocity of this proton when it returns to point A?
   Suppose that the proton is again at rest at point A.
   g. How much work would be done in moving this proton from point A to point C?
   h. How will the electrostatic potential at point C compare to the electrostatic potential at point A?
   i. What will be the potential difference between point C and point B?
   j. How much work will have to be done on a proton to move it from point C to point B?

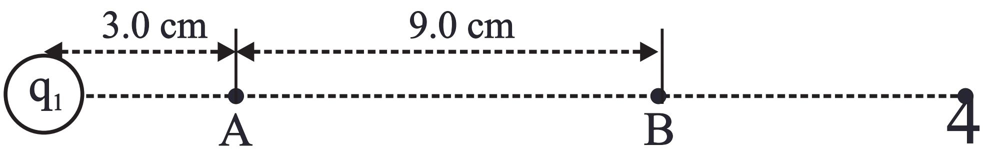


3. Two parallel plates are arranged as shown to the right. The electric field between the plates is uniform and is directed from the positive plate to the negative plate as shown. The electric field strength is E = 60,000 N/C and the two plates are d = 6.00 cm apart. A particle which has a charge of q = - 0.015 μC is initially placed at point A.
   a. How much work would have to be done to move this particle from point A to point B?
   b. What is the potential difference between point A and point B?
   c. How much work would have to be done in moving this particle from point A to point C?
   d. What is the potential difference between points B and C?
   Suppose that another particle, which has a charge of 2.0 μC, is placed, initially, on the negative plate. This particle is then moved from the negative plate to the positive plate.
   e. How much work would be done in moving this particle from the negative plate to the positive plate?
   f. What will be the potential difference between these two plates?

ANSWERS TO THE OPPOSITE SIDE: 4a. right. 5.0 x 10^7 N/C b. right 8.0 x 10^{-12} N c. 1.5 x 10^6 V 4d. right, 3.13 x 10^6 N e. right, 5.0 x 10^{-13} N f. 3.75 x 10^5 Volts g. 1.125 x 10^6 Volts h. 1.8 x 10^{-13} J 4i. -1.8 x 10^{-13} J j. A k. zero l. 3.75 x 10^5 Volts m. 6.0 x 10^{-14} J n. -6.0 x 10^{-14} J 5a. 9.6 x 10^{-19} C 5b. 3.46 x 10^{12} N/C c. 173 Volts d. zero e. 173 Volts f. 2.77 x 10^{-17} J g. 115 Volts h. 1.84 x 10^{-17} J 6a. 4.8 x 10^5 Volts b. zero c. 4.8 x 10^5 Volts d. 7.68 x 10^{-14} J e. 9.59 x 10^6 m/s

PHYSICS HOMEWORK #142 ELECTROSTATIC POTENTIAL
RADIAL ELECTRIC FIELDS

4. A small sphere contains a charge of $q_1 = 5.0\ \mu C$ as shown below.



a. What will be the direction and magnitude of the electric field at point A?
b. What will be the direction and magnitude of the electrostatic force acting on a proton placed at point A?
c. What will be the electrostatic potential at point A?
d. What will be the direction and magnitude of the electric field at point B?
e. What will be the direction and magnitude of the electrostatic force acting on a proton placed at point B?
f. What will be the electrostatic potential at point B?
g. What will be the potential difference between points A and B?
h. How much work would be required to move a proton from point B to point A?
i. How much work would be required to move a proton from point A to point B?
j. Which point is at the higher potential, A or B? Explain!
k. What will be the electrostatic potential at infinity [¥]?
l. What would be the potential difference between infinity and point B?
m. How much work would be required to move a proton from infinity to point B?
n. How much work would be required to bring an electron from infinity to point B?

5. An atom of Carbon 12 contains 6 protons in its nucleus.
a. What will be the total charge of the nucleus of a Carbon 12 atom?
b. What will be the strength of the electric field a distance of 0.5 Å [10^{10} Angstrom = 1 m] from this Carbon nucleus?
c. What will be the electrostatic potential a distance of 0.5 Å from this carbon nucleus?
d. What will be the electrostatic potential infinitely far from this Carbon nucleus?
e. What will be the potential difference between a point 0.5 Å from the Carbon nucleus and infinity?
f. How much work will be done in moving an electron from infinity to a point 0.5 Å from the nucleus of the Carbon nucleus?
g. What will be the potential difference between a point 0.5 Å from the nucleus of a carbon atom and a point 1.5 Å from that same nucleus?
h. How much work will be done in moving an electron from a point 0.5 Å from the nucleus of a Carbon atom to a point 1.5 Å from the same Carbon nucleus?

6. Protons in the nucleus of an atom are on average a distance of 3.0 Fermi [10^{-15} m] apart.
a. What will be the electrostatic potential 3.0 Fermi from a proton?
b. What will be the electrostatic potential infinitely far away from a proton?
c. What will be the potential difference between a point infinitely far away from a proton and a point 3.0 Fermi from a proton?
d. How much work would be required to move a proton from infinity to a point 3.0 Fermi from a second proton?
Suppose that you hold onto one of these protons and allow the other to accelerate away to infinity.
e. What will be the velocity of this proton when it is very far away?

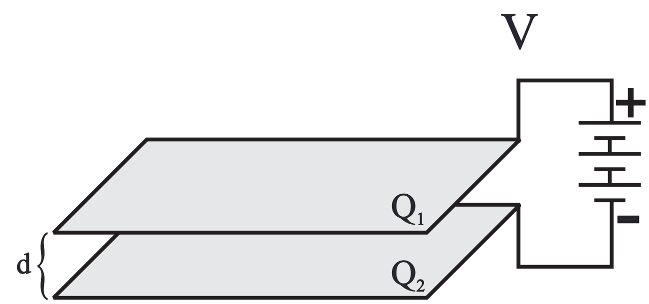
Answers to opposite side: 1a. 1.32 N b. 1.78 J c. 1.2×10^5 Volts 2a. up b. 7.2×10^{-16} N
2c. 8.64×10^{-17} J d. 540 Volts e. 540 Volts f. 3.22×10^5 m/s g. zero h. same i. 540 Volts
2j. 8.64×10^{-17} J 3a. -3.6×10^{-5} J b. 2400 Volts c. -3.6×10^{-5} J d. zero e. 5.4×10^{-5} J e. 3600 V

PHYSICS HOMEWORK #143 ELECTROSTATIC POTENTIAL
CALCULATING POTENTIAL VIA INTEGRATION

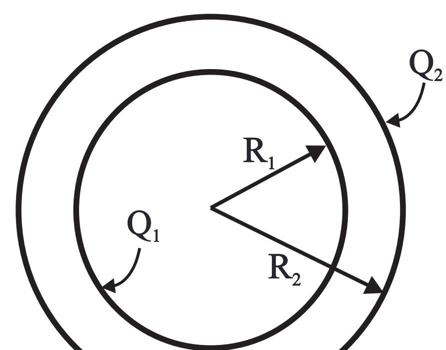
[Unless stated otherwise assume that absolute potential is zero at infinity!]

$$\boxed{\Delta V = \int_b^a \boldsymbol{E} \cdot d\boldsymbol{l}}$$

1. Consider two horizontal, parallel plates, each with an area of 3.0 m^2, separated by a distance of d = 3.5 cm. These two plates are connected to a battery and, as a result, the upper plate gains a charge of Q_1 = 12 μC and the lower plate gains a charge of Q_2 = -12 μC.
   a. What will be the strength of the electric field in the area between these two plates?
   b. What will be the strength of the electric field in the area outside of these two plates?
   c. What will be the potential difference between these two plates?
   d. How much work would be done on an electron in moving it from the positive plate to the negative plate?
   e. Suppose that this electron is then released and is allowed to accelerate back to the positive plate, what will be the velocity of the electron just as it reaches the positive plate?



2. Consider two concentric, conducting spherical shells with radii of R_1 = 4.0 cm and R_2 = 6.0 cm as shown in the diagram to the right. The inner shell contains a charge of Q_1 = -6.0 μC and the outer shell contains a charge of Q_2 = +12.0 μC.
   a. What will be the electrostatic potential of the the outer shell?
   b. What will be the potential difference between the inner shell and the outer shell?
   c. What will be the electrostatic potential of the inner shell?
   d. What will be the electrostatic potential at the center of these two shells?
   e. How much work must be done to transfer a single electron from the inner shell to the outer shell?
   f. How much work would be required to bring a proton from infinity to the outer shell?
   Suppose that the radius of the outer shell increases until R_2 becomes 9.0 cm.
   g. What will be the potentials of the outer and inner shells?
   h. What will be the new potential difference between these two shells?

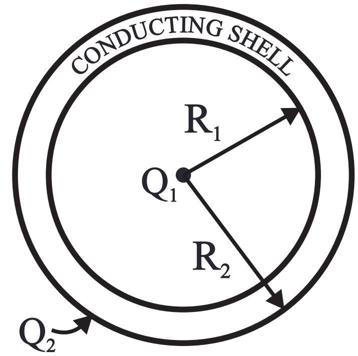


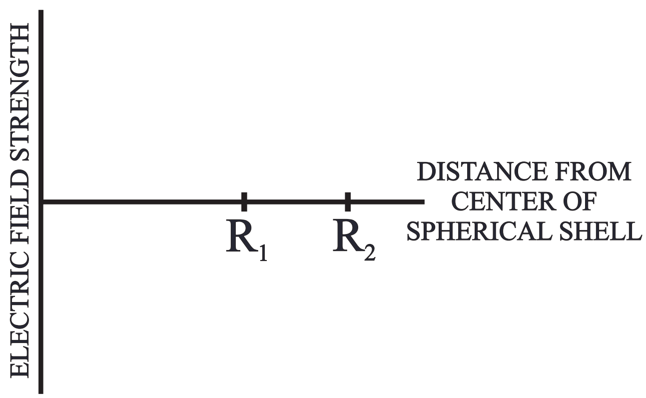
3. Consider two concentric, conducting cylindrical shells which have radii of R_1 = 4.0 cm and R_2 = 6.0 cm and are L = 35.0 m long [same diagram as above]. The inner shell contains a charge of Q_1 = -12.0 μC and the outer shell contains a charge of Q_2 = +12.0 μC.
   a. What will be the electrostatic potential of the the outer shell?
   b. What will be the potential difference between the outer shell and the inner shell?
   c. What will be the electrostatic potential of the inner shell?
   d. What will be the electrostatic potential at the center of these two shells?
   e. How much work must be done to transfer a single electron from the outer shell to the inner shell?
   f. How much work would be required to bring a proton from infinity to the outer shell?

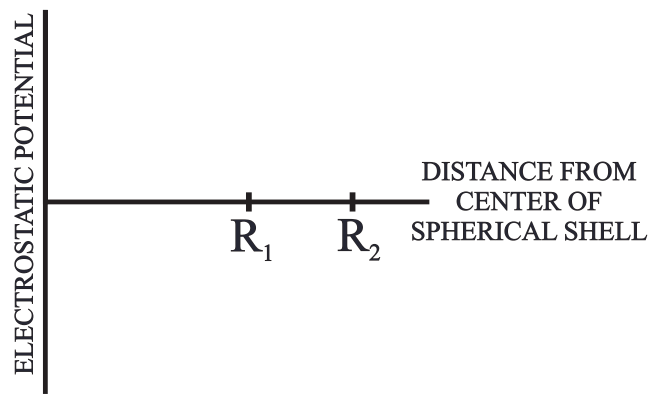
Answers to opposite side: 4a. 1.2 x 10^6 Volts b. zero c. 1.2 x 10^6 Volts d. -3.4 x 10^6 Volts 4e. infinity h. 0.027 m 5a. [L to R] -5.6 x 10^4 N/C, 1.7 x 10^5 N/C, -5.6 x 10^4 N/C, 6 x 10^4 N/C 5b. [L to R] 5.6 x 10^4 Volts, b. -2.8 x 10^4 Volts, 2.8 x 10^4 Volts c. 8.5 x 10^4 Volts d. 4.5 x 10^{-15} J

CALCULATING POTENTIAL VIA INTEGRATION

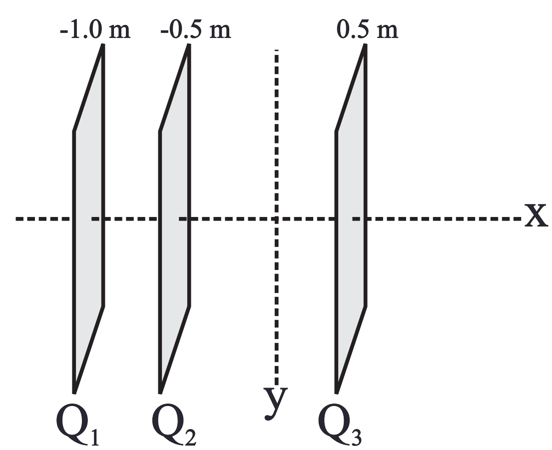
4. Consider a conducting spherical shell, which has an inner radius of R_1 = 7.00 cm, an outer radius of R_2 = 9.00 cm and contains a charge of Q_2 = +18.0 μC. This shell, in turn, encloses a point charge of Q_1 = -6.0 μC located at its center as shown in the diagram at the right.
   a. What will be the electrostatic potential on the outside of the conducting shell?
   b. What will be the potential difference between the inside of the conducting shell and the outside of the conducting shell?
   c. What will be the electrostatic potential on the inside of the conducting shell?
   d. What will be the electrostatic potential at a point 1.0 cm from the central charge?
   e. What will be the electrostatic potential at the location of Q_1?
   f. On the graph below sketch the electric field strength as a function of distance from Q_1.
   g. On the graph below sketch the electrostatic potential as a function of distance from Q_1.
   h. Where, other than infinity, will the absolute potential be zero?







5. Consider three, vertical, parallel, conducting plates as shown to the right. Each plate has an area of 3.0 m^2. The first plate contains a charge of Q_1 = +6.00 μC and is located at x = -1.00 m. The second plate contains a charge of Q_2 = -6.0 μC and is located at x = -0.50 m. The third plate contains a charge of Q_3 = +3.00 μC and is located at x = 0.50 m. Assume that absolute electrostatic potential is zero at the origin.
   a. Determine the electric field everywhere.
   b. What will be the electrostatic potential of each plate?
   c. What will be the potential difference between plate #1 and plate #2?
   d. How much work would be required to move a proton from plate #1 to plate #3?

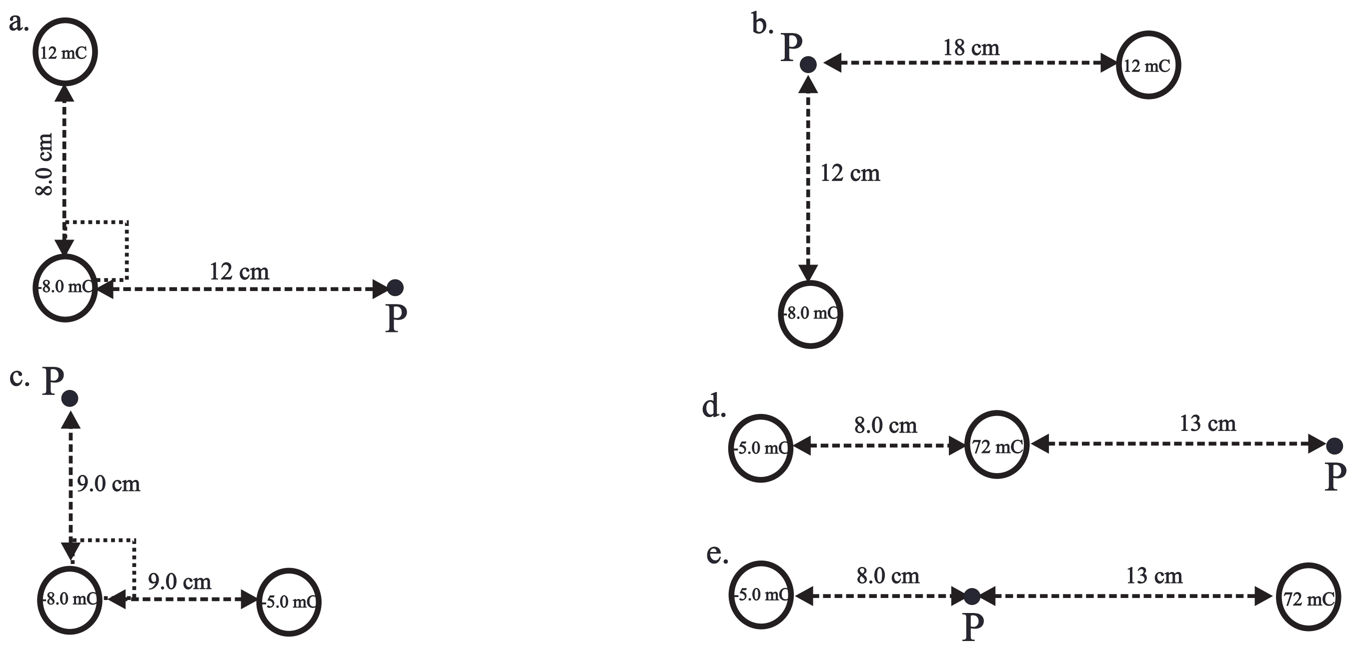


Answers to opposite side #105: 1a. 4.50 x 10^5 N/C b. zero c. 15,800 Volts d. 2.50 x 10^{-15} J e. 7.50 x 10^7 m/s
2a. 900,000 Volts b. -450,000 Volts 2c. 450,000 Volts d. 450,000 Volts e. -7.2 x 10^{-14} J f. 1.44 x 10^{-13} J
2g. 600,000 Volts h. 750,000 Volts 3a. zero b. -2500 Volts c. -2500 Volts d. -2500 Volts e. 4.0 x 10^{-16} J

PHYSICS HOMEWORK #145 ELECTROSTATIC POTENTIAL ELECTROSTATIC POTENTIAL ENERGY

6. What will be the electrostatic potential of a point **P** which is both 12.0 cm from a 25.0 μC charge and 6.0 cm from a 50 μC charge?

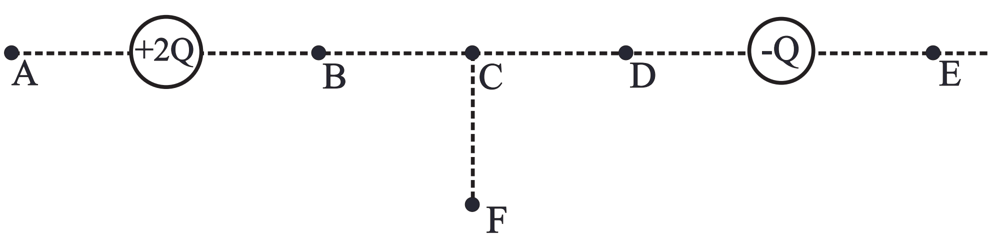
7. Determine the **electrostatic potential** at point **P** in each of the following diagrams.



8. Suppose that in each diagram above a 7.00 μC charge is to be moved from **infinity** to point **X**. In each case above, determine how much **work** would be required to place the 7.00 μC charge at point **X**.

9. What will be the **electrostatic potential energy** of each set of charges above? [including the 7.0 μC charge!]

10. Each of the following questions refers to the diagram below.



a. At which point in the above diagram will the **electric field strength** be the **greatest**?
b. At which point in the above diagram will the **electrostatic potential** be the **greatest**?
c. At which point in the above diagram will the **electric field strength** be the **weakest**?
d. At which point in the above diagram will the **electrostatic potential** be the **least**?

ANSWERS TO THE OPPOSITE SIDE: 1a. 37.5 μF b. 2700 μC 2. 16 μF 3. 1260 μC 4. 30,000 μC 5. 0.015 μF 6. 0.22 μF 7. 20.3 μF 8. 238 m^2 9. 400 μF 10. 155 μF 11. 500 μF 12. 0.030 J 13. 14.4 J 14. 144 Volts 15. 161 μF

PHYSICS HOMEWORK #146 ELECTROSTATIC POTENTIAL
CAPACITORS & CAPACITANCE

$$C = \frac{q}{V} = \frac{\varepsilon \cdot A}{d} \qquad \varepsilon = \varepsilon_o \cdot K \qquad \varepsilon_o = 8.85 \cdot 10^{-12} \cdot \frac{Farad}{m}$$

1. A given capacitor is rated to store 450 μC of charge whenever a potential difference of 12.0 Volts is applied.
   a. What is the capacitance of this capacitor?
   b. How much charge will this capacitor store when a potential difference of 72.0 Volts is applied?

2. What is the capacitance of capacitor which can store 720 μC of charge whenever a potential difference of 45.0 Volts is applied?

3. How much charge can be stored in a capacitor rated at 210 μF, if a potential difference of 6.00 Volts is applied?

DIELECTRIC MATERIAL	DIELECTRIC CONSTANT K
AIR	1.0
PARAFFIN	2.2
POLYETHYLENE	2.3
POLYSTYRENE	2.5
HARD RUBBER	2.8
MICA	6.0
GLASS	8.0

4. How much charge can be stored in a 2000 μF capacitor when a potential difference of 15.0 Volts is applied?

5. A parallel plate capacitor is made of two parallel plates, each of which has an area of 2.0 m^2, and which are separated by 1.20 mm of air. What is the capacitance of this capacitor?

6. What will be the capacitance of a parallel plate capacitor which is made from two parallel plates, each with an area of 3.5 m^2, which are separated by 0.85 mm of mica ?

Series

$$\frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{C_t}$$

Parallel

$$C_1 + C_2 = C_t$$

Energy

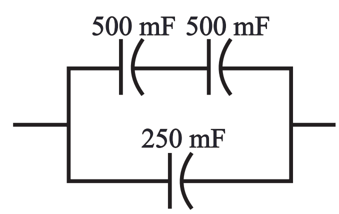
7. What will be the capacitance of a parallel plate capacitor consisting of two two parallel plates, each of which has an area of 13.3 m^2, which are separated by 0.0145 mm of polystyrene?

8. A parallel plate capacitor is to be made from two conducting plates separated by 0.022 mm of polyethylene. This capacitor is to have a total capacitance of 220 μF. What should the area of each plate of this capacitor be?

9. What will be the total capacitance if a 250 μF capacitor is connected in parallel with a 150 μF capacitor?

10. What will be the total capacitance if a 240 μF capacitor is connected in series with a 440 μF capacitor?

11. What will be the total capacitance if two 500 μF capacitors are connected is series with each other but which are connected in parallel with a 250 μF capacitor? See diagram at the right!



12. How much energy will be stored in a 420 μF capacitor to which a potential difference of V = 12.0 Volts has been applied?

13. How much energy would be stored in a 2000 μF capacitor attached to a 120 Volt power supply?

14. A capacitor is rated at 1200 μF. What potential difference should be applied to this capacitor so that the energy stored in this capacitor is 12.4 Joules?

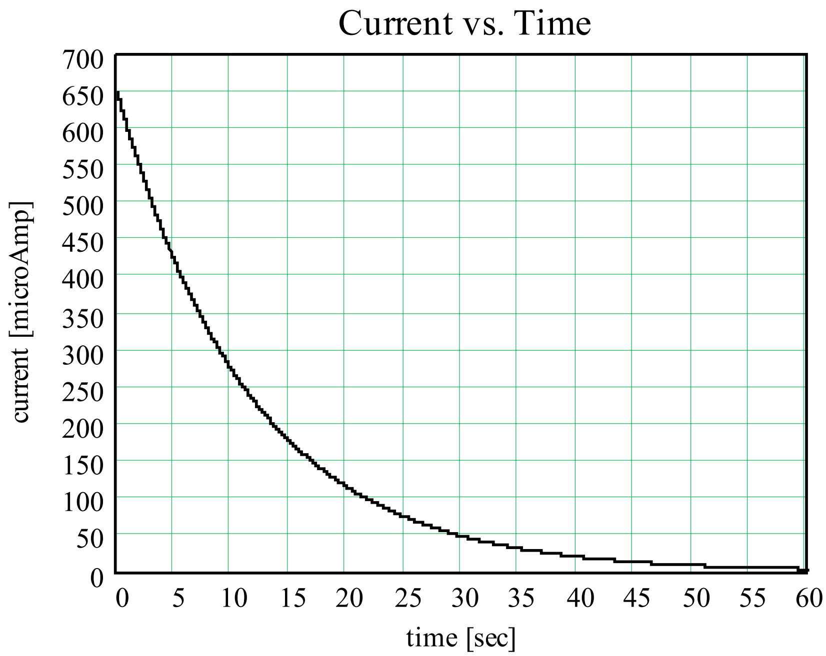
15. What will be the total capacitance if a 350 μF, a 520 μF and a 700 μF capacitor are all connected in series?

Answers to opposite side: 6. 9,400,000 Volts 7a. 1.5 x 10^5 Volts b. 0.0 Volts c. -1.15 x 10^6 Volts d. 4.77 x 10^6 Volts 7e. 4.42 x 10^6 Volts 8a. 1.05 J b. 0.0 J c. -8.08 J d. 33.4 J e. 30.9 J 9a. -9.75 J b. -3.99 J c. -4.08 J 9d. -7.10 J e. 15.5 J 10a. B b. A c. E d. E

PHYSICS HOMEWORK #147 ELECTROSTATIC POTENTIAL
DISCHARGING CAPACITORS

16. A capacitor with a capacitance C is attached to a power supply which has a potential V and is then fully charged. This capacitor is then attached to a simple series circuit consisting of a galvanometer and a 13,000 Ω resistor. The graph to the right represents the current flowing out of this capacitor as a function of time through the galvanometer.

a. What was the initial current flowing out of the capacitor?
b. What was the initial voltage across the capacitor?
c. What is the time constant for this circuit?
d. Write an equation describing the current flowing out of this circuit as a function of time?
e. Using the equation derived in d above predict the current flowing out of this capacitor after t = 30 seconds and compare to the value on the graph.
f. What was the total charge contained in this capacitor?
g. What is the capacitance of this capacitor?
h. How much charge will be stored in this capacitor after t = 20 seconds?
i. What will be the current flowing out of this capacitor after t = 85 seconds?



17. A capacitor, which has a capacitance of 470 μF, is attached to a 6.00 Volt battery and is fully charged. This capacitor is then removed from the battery and is attached in series to a 1500 Ω resistor.

a. What is the time constant for this circuit?
b. What will be the total charge stored in this capacitor?
c. What will be the initial current flowing through this circuit?
d. What will be the current flowing through this circuit after 1.5 seconds?
e. How long will it take for the current flowing in this circuit to fall to 1% of its initial value?

18. A 220 μF capacitor is charged up by a 12.0 Volt battery.

a. What will be the charge stored on this capacitor after being charged up?

This capacitor is then attached to a second capacitor, which is initially uncharged and has a capacitance of 470 μF.

b. What will be the total charge stored on both of these capacitors after being attached together?
c. What will be the charge stored on each of these capacitors after being attached together?
d. What will be the potential difference across each of the these capacitors after being attached together?

ANSWERS TO THE OPPOSITE SIDE:
19a.. 5000 μC, 19,800 μC b. 24,800 μC c. 7750 μC, 17,050 μC d. 7.75 Volts e. 14,800 μC f. 4625 μC,
19f. 10,175 μC g. 4.625 Volts 20a. 3300 μC, 24,750 μC b. 28,050 μC c. 7010 μC, 21,040 μC
20d. 12.75 Volts e. 21,450 μC f. 5360 μC, 16,100 μC g. 9.75 Volts 21a. 2.30 μF b. 27.6 μC c. 166 μJ
21d. 13.8 μF e. 166 μC f. 994 μJ g. 828 μJ 22. 48.0 C

PHYSICS HOMEWORK #148 ELECTROSTATIC POTENTIAL
CAPACITORS CONNECTED TOGETHER

19. A 1000 μF capacitor is charged up by a 5.00 Volt battery while a second capacitor, which has a capacitance of 2200 μF is charged up with a 9.00 Volt battery.
   a. What will be the charge stored on each capacitor after being charged up?
   These capacitors are then attached together, positive to positive, negative to negative.
   b. What will be the total charge stored on these two capacitors after being attached together?
   c. What will be the charge stored on each capacitor after being attached together?
   d. What will be the potential difference across each of the these capacitors after being attached together?
   Suppose instead that these two capacitors had been connected together, positive to negative, positive to negative.
   e. What will be the total charge stored on these two capacitors after being attached together?
   f. What will be the charge stored on each capacitor after being attached together?
   g. What will be the potential difference across each of the these capacitors after being attached together?

20. A C_1 = 550 μF capacitor is charged up by a V_1 = 6.00 Volt battery while a second capacitor, which has a capacitance of C_2 = 1650 μF is charged up with a V_2 = 15.0 Volt battery.
   a. How much charge will be stored on each capacitor after being charged by their respective batteries?
   These two capacitors are then attached together, positive to positive, negative to negative.
   b. What will be the total charge stored on these two capacitors after being attached together?
   c. What will be the charge stored on each capacitor after being attached together?
   d. What will be the potential difference across each of the these capacitors after being attached together?
   Suppose instead that these two capacitors had been connected together, positive to negative, positive to negative.
   e. What will be the total charge stored on these two capacitors after being attached together?
   f. What will be the charge stored on each capacitor after being attached together?
   g. What will be the potential difference across each of the these capacitors after being attached together?

21. A parallel plate capacitor is made up of two plates, each of which has an area of 6.50 m^2, separated by 0.0250 mm of air.
   a. What will be the capacitance of this capacitor?
   b. How much charge will be stored in this capacitor when charged to a potential of 12.0 Volts?
   c. How much energy will be stored in this capacitor when charged up to a potential of 12.0 Volts?
   Suppose that the air between the plates is replaced by mica. [K = 6.0]
   d. What will be the new capacitance of this capacitor?
   e. How much charge will be stored in this capacitor when charged to a potential of 12.0 Volts?
   f. How much energy will be stored in this capacitor when charged up to a potential of 12.0 Volts?
   Suppose that you now attempt to remove the mica from the capacitor.
   g. How much work would be required to remove the mica?

22. A parallel plate capacitor is made of two parallel plates, each with an area A, separated by a distance d and which is filled with air. This capacitor has a capacitance C. Suppose that this capacitor is changed so that the **area** of each plate is **tripled**, the **distance** between the plates is **halved** and the air is replaced with **glass**, which has a dielectric constant of K = 8.00. What is the new capacitance of this capacitor?

Answers to opposite side: 16a. 650 μA b. 8.45 Volts c. 11.5 s d. $I = I_o \bullet e^{-t/tc}$ = 650 μA • $e^{-t/11.5}$
16e. 48.0 μA f. 7475 μC g. 885 μF h. 1300 μC i. 0.40 μA 17a. 0.705 s b. 2820 μC c. 4000 μA
17d. 476 μA e. 3.25 s 18a. 2640 μC b. 2640 μC c. 1800 μC, 840 μC d. 3.82 Volts

PHYSICS HOMEWORK #149 ELECTROSTATIC POTENTIAL
CAPACITORS AND CAPACITIVE REACTANCE

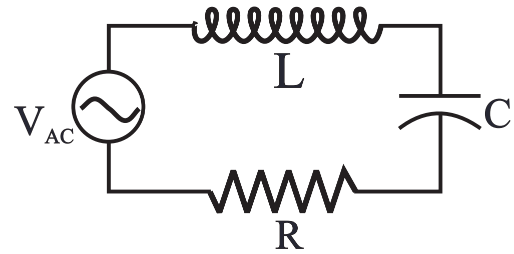
1. Consider a capacitor consisting of two parallel plates, each with an area of 2.35 meters^2, separated by a distance of d = 0.0025 millimeters. Initially, this capacitor is uncharged and at t = 0 seconds it is connected in series with a resistance of 450 Ω and a battery which has an EMF of 12.0 Volts.
   a. What is the capacitance of this capacitor?
   b. What will be the initial current flowing through this circuit?
   c. What will be the initial voltage drop across the resistor?
   d. What will be the initial voltage drop across the capacitor?
   e. What will be the current flowing in this circuit a long time after it has been connected?
   f. What will be the voltage drop across the resistor a long time after this circuit has been connected?
   g. What will be the voltage drop across the capacitor a long time after the circuit has been connected?
   h. What is the time constant for this circuit?
   i. Write an equation describing the current flowing through this circuit as a function of time?
   j. What will be the current flowing through this circuit t = 2.00 milliseconds after it has been connected?
   k. How much charge will be stored in this capacitor t = 2.00 milliseconds after it has been connected?
   Suppose now that the V = 12.0 Volt battery is removed and is replaced by an AC power supply of V_p = 170 Volts at a frequency of f = 320 Hz.
   l. What will be the **capacitive reactance** of this circuit?
   m. What will be the **RMS** current flowing through this circuit?
   n. What will be the **phase angle** in this circuit?
   o. What will be the **power factor** in this circuit?
   p. At what rate is **energy** being consumed in this circuit?

$$X_c = \frac{1}{\omega C}$$
$$Z = \sqrt{R^2 + (X_L - X_c)^2}$$
$$\cos(\phi) = \frac{R}{Z}$$

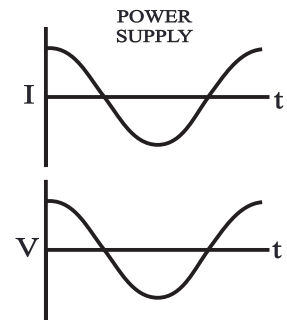
2. Consider a capacitor consisting of two parallel plates, each with an area of 4.25 meters^2, separated by a distance of d = 0.00130 millimeters. Initially, this capacitor is connected in series with a 25,000 Ω resistor and a V = 15.0 Volt DC power supply until the capacitor is fully charged.
   a. What is the capacitance of this capacitor?
   b. What will be the current flowing through this circuit after the capacitor has been fully charged?
   c. What will be the voltage drop across the resistor after the capacitor has been fully charged?
   d. What will be the voltage drop across the capacitor after the capacitor has been fully charged?
   This circuit is then removed from the battery and the two leads are shorted together to form a simple circuit consisting of a capacitor and resistor in series.
   e. What will be the time constant for this circuit?
   f. What will be the current flowing in this circuit immediately after it has been connected?
   g. What will be the voltage drop across the resistor a long time after this circuit has been connected?
   h. What will be the voltage drop across the capacitor a long time after the circuit has been connected?
   i. Write an equation describing the current flowing through this circuit as a function of time?
   j. What will be the current flowing through this circuit 0.3 seconds after this circuit has been connected?
   k. How much charge will remain in this capacitor 0.3 seconds after this circuit has been connected?
   The resistor and capacitor in series are now connected to an AC power supply which has a voltage of V_p = 45.0 Volts at a frequency of f = 1.20 Hz.
   l. What is the capacitive reactance of this capacitor at this frequency?
   m. What will be the impedance of this circuit?
   n. At what rate will energy be dissipated in this circuit?

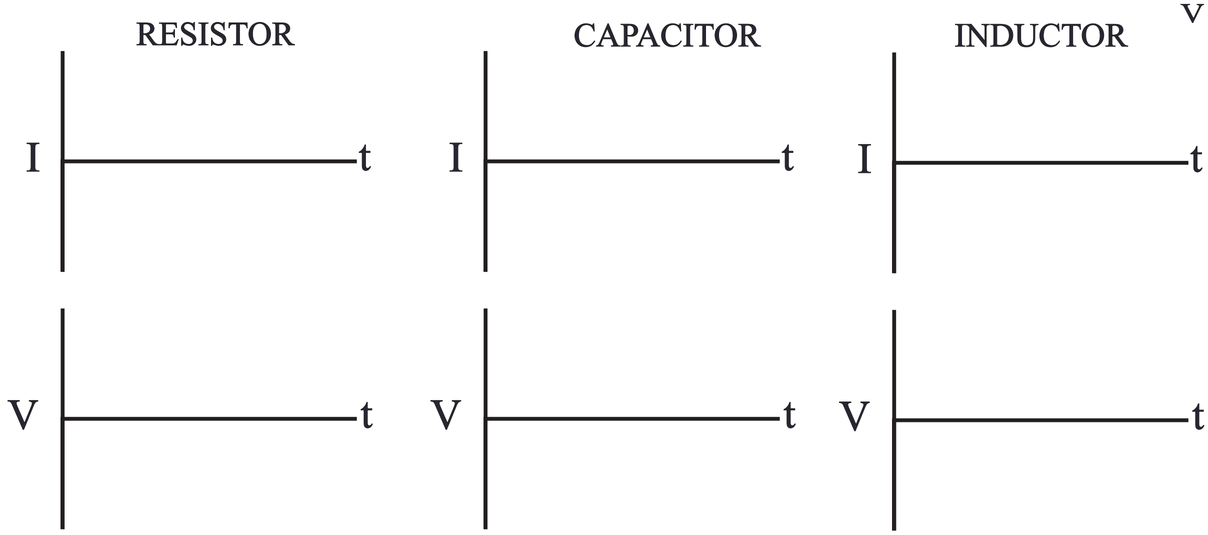
Answers to opposite side: 3a. 44.8 Ω b. 1.51 Ω c. 50.0 Ω d. 31.8 Volts e. 0.900 Amps f. 0.64 Amps 3g. 60.0^o h. 50.0 % i. 10.1 Watts k. 80.7 Hz. l. 8.22 Ω m. 8.22 Ω n. 25.0 Ω o. 100 % p. 40.7 Watts

3. Consider an electrical circuit consisting of a resistor R = 25.0 Ω, an inductor L = 16.2 milliHenry, a capacitor C = 240 μFarads and an AC power supply V_P = 45.0 Volts oscillating at a frequency of f = 440 Hz., all connected together in a simple series circuit as shown to the right.



a. What is the **inductive reactance** of this inductor?
b. What is the **capacitive reactance** of this capacitor?
c. What is the **impedance** of this circuit?
d. What is the **RMS voltage** of this power supply?
e. What will be the **peak current** flowing in this circuit?
f. What will be the **RMS current** flowing in this circuit?
g. What will be the **phase angle** of this circuit?
h. What is the **power factor** for this circuit?
i. What is the **average power** being supplied to this circuit?
j. Assuming that the current and voltage being supplied by the power supply are as shown to the right, sketch below the corresponding currents and voltages across the resistor, the inductor and the capacitor.





Assume, now, that the frequency f of the power supply is varied until the circuit reaches resonance.
k. What is the **resonant frequency f_o** of this circuit?
l. What is the **inductive reactance** of this circuit while at resonance?
m. What is the **capacitive reactance** of this circuit while at resonance?
n. What is the **impedance** of this circuit while at resonance?
o. What is the **power factor** of this circuit at resonance?
p. How much **power** is being dissipated by this circuit while at resonance?

Answers to opposite side: 1a. 8.32 μFarads b. 0.027 Amps c. 12.0 Volts d. 0.0 Volts e. 0.0 Amps f. 0.0 Volts 1g. 12.0 Volts h. 3.74×10^{-3} s i. I = 0.027 $e^{-t/.00374}$ s j. 0.0158 Amperes k. 4.15×10^{-5} Coulombs l. 59.8 Ω 1m. 0.235 Amps n. -7.57° o. 0.99x p. 28.0 Watts 2a. 28.9 μFarads b. 0.0 Amps c. 0.0 Volts d. 15.0 Volts 2e. 0.723 s f. 600 μAmps 2g. 0.0 Volts h. 0.0 Volts i. I = 600 $e^{-t/0.723}$ μAmps j. 396 μAmperes 2k. 286 μCoulombs l. 4590 Ω m. 25400 Ω m. 0.040 Watts

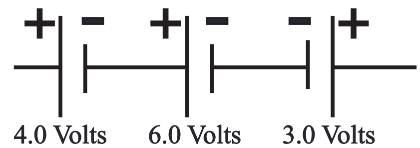
PHYSICS HOMEWORK #151 SIMPLE DC CIRCUITS
VOLTAGES IN SERIES & PARALLEL

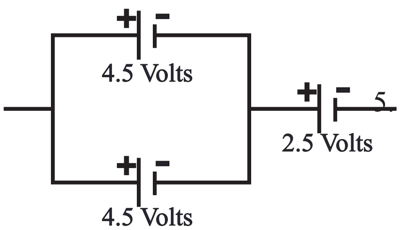
1. Six 2.02 Volt cells are connected in series. What will be the total electromotive force [EMF] produced?

2. What will be the EMF produced by four 1.5 Volt cells connected in series? Justify!

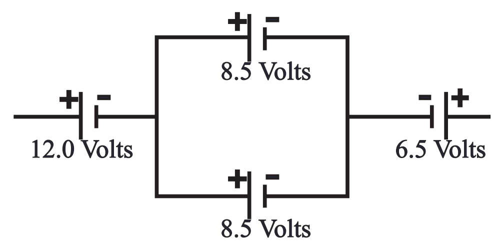
3. What will be the EMF produced by three 6.0 Volt batteries connected in parallel? Justify!

4. What will be the total EMF produced by the combination of cells to the right? Justify!



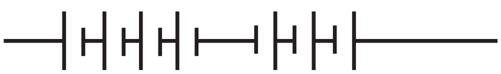


5. What will.be the total EMF produced by the combination of cells to the left?

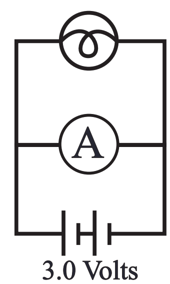


6. What will be the total EMF of the combination of cells in the diagram to the right?

7. What will be the total EMF produced by the following combination of cells where each cell has an EMF of 1.5 Volts? Justify!

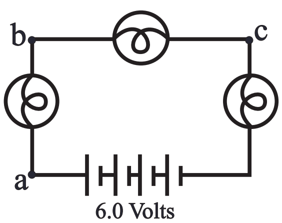


8. In the circuit to the right an ammeter is connected in parallel with a lightbulb. Will the light bulb in the diagram to the right be operating? Explain!

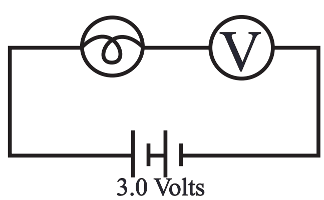


9. What will be the reading on the ammeter in the circuit to the right? Explain!

10. How will the currents at points a, b, and c compare in the diagram below? Explain!

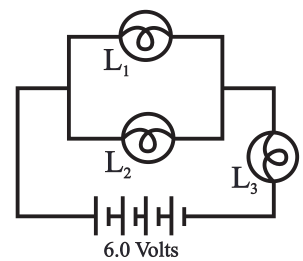


11. A voltmeter is connected in series with a lightbulb as shown in the circuit below. What will be the current flowing through the lightbulb? Explain!



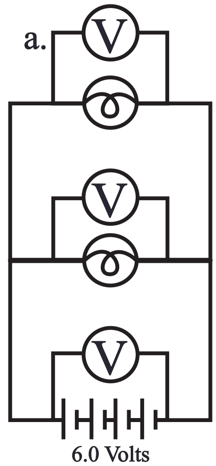
Answers to the opposite side: 12. $I_1+I_2=I_3$ 13a. $V_1=V_2=V_{BATTERY}$ 13b. $V_1+V_2 = V_{BATTERY}$
14. 9.0 Ω 15. 0.17 Amperes 16. 329 Ω 17. 650 Ω 18. 50.0 Ω 19. 131 Ω

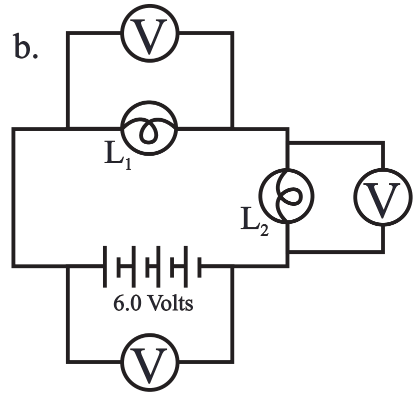
PHYSICS HOMEWORK #152 SIMPLE DC CIRCUITS
RESISTORS IN SERIES & PARALLEL



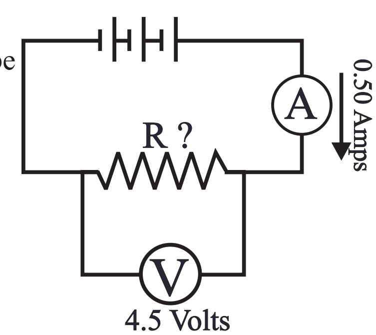
12. How will the currents flowing through light bulbs L_1, L_2, and L_3 compare in the diagram at the right? Justify your answer!

13. How will the reading on the voltmeters in each of the following diagrams compare? Explain!





14. A resistor is connected in a circuit as shown to the right. The current flowing through the ammeter is I = 0.50 Amperes and the reading on the voltmeter is V = 4.5 Volts. What will be the resistance **R ?** of the unknown resistance?



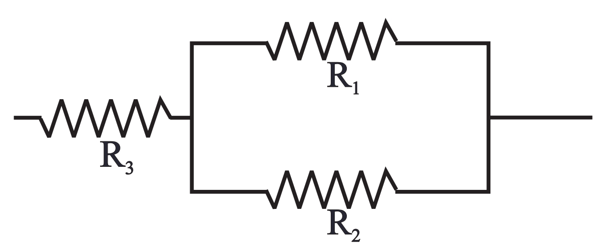
15. A resistor of 120 Ω is connected across an EMF of 20.0 Volts. What will be the resulting current flow through this resistor?

16. You would like to design a light bulb which permits a current of I = 0.35 Amperes to flow through it when attached to a V = 115 Volt source. What should the resistance of the light bulb filament be?

17. A 425 Ω resistance is connected in series with a 225 Ω resistance. What will be the equivalent resistance of this combination? Justify!

18. A 120 Ω resistance is connected is parallel with an 86 Ω resistance. What will be the equivalent resistance of this combination?

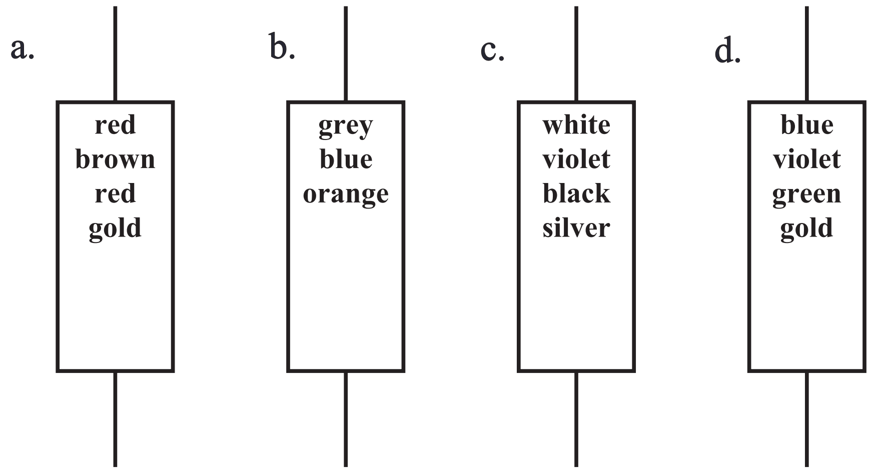
19. A 140 Ω resistor and a 220 Ω resistor are connected in parallel with one another. These two resistors are in turn connected in series with a 45 Ω resistor. What will be the total equivalent resistance?



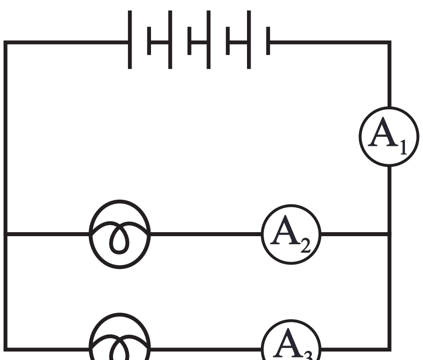
Answers to opposite side: 1. 12.12 Volts 2. 6.0 Volts 3. 6.0 Volts 4. 7.0 Volts 5. 7.0 Volts 6. 14.0 Volts 7. 1.5 Volts 8. No 9. Very high! 10. $I_a = I_b = I_c$ 11. ~ zero

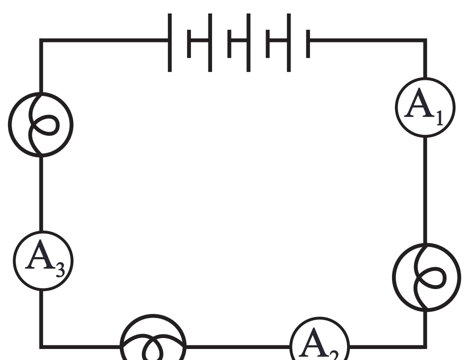
PHYSICS HOMEWORK #153 SIMPLE DC CIRCUITS
RESISTOR CODE, SERIES & PARALLEL CIRCUITS

20. What will be the resistance of each of the following resistors according to the resistor code?



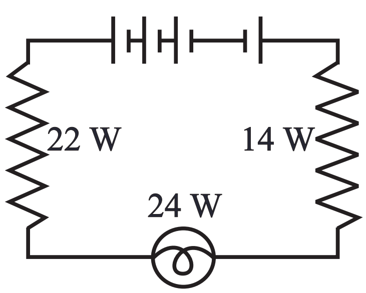
21. What will be the current through ammeter A_3 in each of the following circuits? Justify your answer!
a. Where A_1 = 0.65 Amps & A_2 = 0.25 Amps?
b. Where A_1 = 0.37 Amps ?



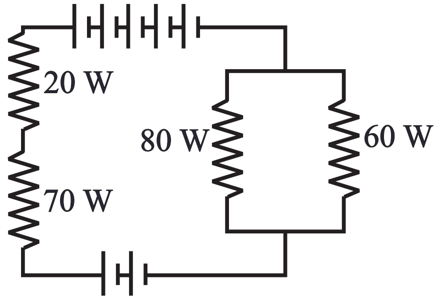


22. For each of the following circuits determine the total resistance, total EMF and total current. Assume each cell to have an EMF of V = 1.5 Volts and a negligible internal resistance.

a.



b.

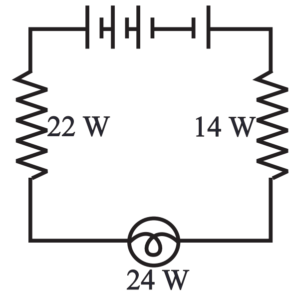


Answers to opposite side: 23. 1.1 Volts 24. 1.2 Volts 25. ~zero 26. 2.5 Volts 27. 1.2 Volts 28. 1.2 Volts 29. 0.036 Amperes 30. 0.021 Amperes 31. 60 Ω 32. 6.6 Volts 33. 0.11 Amperes 34. 0.11 Amperes 35. 2.20 Volts 36. 4.40 Volts 37. 1.5 Volts 38. 0.073 Amperes 39. 0.037 Amperes 40. 0.11 Amperes

PHYSICS HOMEWORK #154 **SIMPLE DC CIRCUITS**

SERIES & PARALLEL CIRCUITS

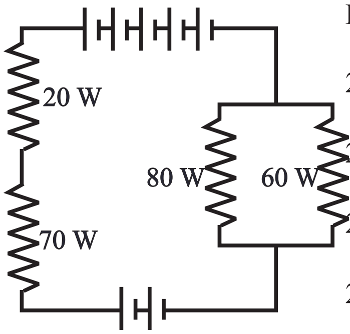
Each of the following questions refers to the diagram at the right where each cell has an EMF of 1.5 Volts and a negligible internal resistance.



23. What will be the reading on a voltmeter connected across the 22 Ω resistor?

24. What will be the reading on a voltmeter connected across the light bulb?

25. What would the current be through the light bulb if the 14 Ω resistor is replaced by a voltmeter? Explain!



Each of the following questions refers to the diagram at the left where each cell has an EMF of 1.5 Volts and a negligible internal resistance.

26. What would be the reading on a voltmeter connected across the 70 Ω resistor?

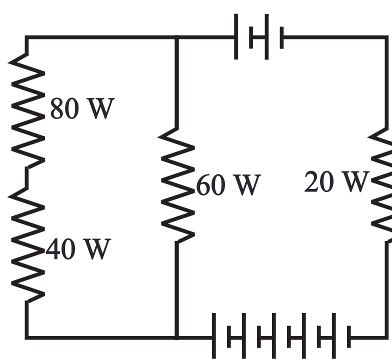
27. What would be the reading on a voltmeter connected across the 80 Ω resistor?

28. What would be the reading on a voltmeter connected across the 60 Ω resistor?

29. What would be the current flowing through the 70 Ω resistor?

30. What would be the current flowing through the 60 Ω resistor?

Each of the following questions refers to the diagram to the right where each cell has an EMF of 2.2 Volts and a negligible internal resistance.



31. What is the total resistance of this circuit?

32. What is the total EMF of this circuit?

33. What will be the total current flowing in this circuit?

34. What will be the current flowing through the lower battery?

35. What will be the potential difference across the 20 Ω resistor?

36. What will be the potential difference across the 60 Ω resistor?

37. What will be the potential difference across the 40 Ω resistor?

38. What will be the current flowing through the 60 Ω resistor?

39. What will be the current flowing through the 40 Ω resistor?

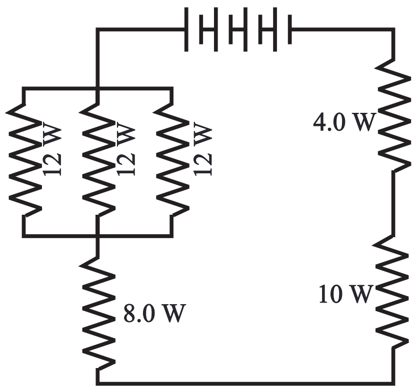
40. What will be the current flowing through the upper battery?

Answers to opposite side: 20a. 2100Ω +/- 5% b. 86 x 10^3 Ω +/- 20% c. 97 x 10^0 W +/- 10%
20d. 67 x 10^5 Ω +/- 5% 21a. 0.40 Amperes b. 0.37 Amperes 22a. 60 Ω, 3.0 Volts, 0.050 Amperes
22b. 124 Ω, 4.5 Volts, 0.036 Amperes

PHYSICS HOMEWORK #155 SIMPLE DC CIRCUITS
INTERNAL RESISTANCE & RESISTANCE OF WIRES

Each of the following questions refers to the diagram at the right where each cell has an EMF of 1.75 Volts and an internal resistance of r = 0.50 Ω.

$$V_t = EMF - Ir$$



41. What is the total **EMF** of the battery?

42. What is the total **resistance** of this circuit?

43. What will be the total **current** flowing through this circuit?

44. What will be the **current** flowing through each 12 Ω resistor?

45. What will be the **voltage drop** across each of the 12 Ω resistors?

46. What will be the **terminal voltage** of the battery?

47. What will be the **voltage drop** across the 10 Ω resistor?

48. While attached to a 2.0 Ω resistance the terminal voltage of a battery is measured to be 5.2 Volts. The open circuit voltage of this same battery is measured to be 6.7 Volts. What is the **internal resistance** of this battery?

49. What will be the **maximum current** that can be delivered by the battery in problem #48 above? Justify!

50. A battery is known to have an EMF of 4.6 Volts and an internal resistance of 2.2 Ω. What will be the **terminal voltage** of this battery while connected to a load of 7.8 Ω question

Gauge	Diameter	Cross Section
10	2.588 mm	5.261 mm^2
12	2.053 mm	3.309 mm^2
14	1.628 mm	2.081 mm^2
16	1.291 mm	1.309 mm^2
18	1.024 mm	0.823 mm^2
20	0.812 mm	0.518 mm^2
22	0.644 mm	0.326 mm^2
24	0.511 mm	0.205 mm^2
26	0.405 mm	0.129 mm^2
28	0.321 mm	0.081 mm^2
30	0.255 mm	0.051 mm^2
32	0.202 mm	0.032 mm^2
34	0.160 mm	0.020 mm^2

Material	Resistivity
Aluminum	2.82 x 10^{-8} W m
Brass	7.00 x 10^{-8} W m
Copper	1.72 x 10^{-8} W m
Gold	2.44 x 10^{-8} W m
Iron	10.0 x 10^{-8} W m
Nichrome	115. x 10^{-8} W m
Nickel	7.80 x 10^{-8} W m
Silver	1.59 x 10^{-8} W m

51. A piece of wire 40 cm long is measured to have a resistance of 7.2 Ω. What will be the **resistance** of an otherwise identical wire which has a length of 120 Ω?

52. A piece of wire, which has a diameter of 0.50 mm, is measured to have a resistance of 8.4 Ω. What will be the **resistance** of an otherwise identical wire which has a diameter of 0.25 mm?

53. What will be the **resistance** of a piece of gauge 30 Nickel wire which is 75 cm long?

54. An unknown sample of gauge 28 wire, which is 5.2 meters long, is measured to have a resistance of 1.57 Ω. What is the **resistivity** of this wire? What is this wire made of?

55. What will be the **resistance** of a piece of gauge 16 copper wire which is 30.0 meters long?

56. A piece of unknown gauge 34 wire 50.0 cm long is attached across a 6.0 Volt battery resulting in a current flow of 0.495 Amperes. What is the **resistivity** of this wire?

57. A current of I = 0.87 Amperes flows through a certain light bulb when it is attached to a 115 Volt power supply. How much **power** does this light bulb dissipate?

58. A 25 Ω resistor is connected to a 5.7 Volt battery [negligible internal resistance].
a. What will be the **current** flowing through this resistor?
b. How much **power** will be dissipated in this resistor?

Answers to opposite side: 59. 28.8 Ω 60. 0.36 Watts 61. 4.12 Volts 62a. 2.62 Watts 62b. 393 J c. 94 Calories d. 26.2◦C 63. 88◦C 64a. 1.5 Amperes b. 5.25 Volts c. 9.0 Watts d. 7.9 Watts e. 1.1 Watts f. 88% 65. 13.2 Watts 66. 92% 67. 7.6 Volts 68. 300 Watts

PHYSICS HOMEWORK #156 SIMPLE DC CIRCUITS
POWER DELIVERY IN DC CIRCUITS

59. A certain light bulb is designed to dissipate 5.0 Watts of power when attached to a 12 Volt source. What is the **resistance** of the light bulb filament?

60. A 25 Ω resistor and a 75 Ω resistor are connected in series across a 12 Volt source. How much **power** will be consumed by the 25 Ω resistor?

61. What would be the **maximum potential difference** you could safely apply to a 68 Ω resistor rated at 1/4 Watt?

62. A 55 Ω resistor is attached to a 12 Volt power supply. This resistor is then immersed in a styrofoam cup containing 25 grams of water, initially at a temperature of 22.5^{o} C, for a period of 150 seconds.

a. How much **power** is being delivered to the resistor?

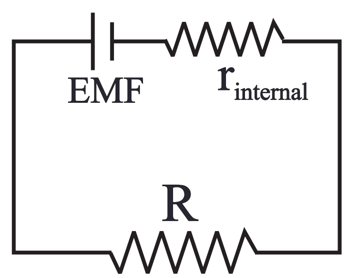
b. How much **energy** will be delivered to the water during these 150 seconds?

c. How much **heat** will be delivered to the water?

d. What will be the **final temperature** of the water?

63. A 95 cm piece of gauge 28 Nichrome wire is embedded in a 655 gram piece of iron [c = .108 Cal/gm^{o}C]. This wire is then attached to a 115 Volt power supply for a period of 20 seconds. Assuming that the initial temperature of the iron is 22.0^{o}C, what will be the **final temperature** of the piece of iron?

64. A battery, which has an EMF of 6.0 Volts and an internal resistance of r = 0.50 Ω, is connected to a load which has a resistance of R = 3.5 Ω.



a. What will be the **current** flowing in this circuit?

b. What will be the **voltage drop** across the load?

c. How much **power** is being supplied by the battery?

d. How much **power** is being consumed by the load?

e. How much **power** is being consumed by the internal resistance of the battery?

f. With what **efficiency** is power being delivered to the load in this circuit?

65. A battery, which has an EMF of 12.0 Volts and an internal resistance of 0.80 Ω, is connected to a load resistance of 9.2 Ω. How much **power** will be delivered to the load?

66. With what **efficiency** is power being delivered to the load in #65 above?

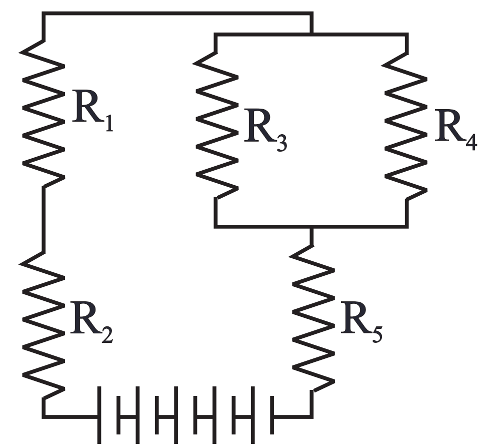
67. A battery, which has an EMF of 9.0 Volts and an internal resistance of 0.70 Ω, is connected to a load resistance of 3.8 Ω. What will be the **terminal voltage** of the battery?

68. A battery, which has an EMF of 12.0 Volts and an internal resistance of 0.12 Ω, is used to power a starter motor for an automobile. What is the **maximum power** that can be delivered to this starter motor by this battery?

Answers to opposite side: 41. 7.0 Volts 42. 28 Ω 43. .25 Amperes 44. 0.083 Amperes 45. 1.0 Volts 46. 6.5 Volts 47. 2.5 Volts 48. 0.58 Ω 49. 11.6 Amperes 50. 3.6 Volts 51. 21.6 Ω 52. 33.6 Ω 53. 1.15 Ω

PHYSICS HOMEWORK #157 SIMPLE DC CIRCUITS
APPLICATIONS OF KIRCHOFF'S RULES

In the circuit at the right each cell has an EMF of 2.2 Volts and an internal resistance of 0.6 Ω. The resistors have the following values; R_1 = 5.0 Ω, R_2 = 4.0 Ω, R_3 = 10 Ω, R_4 = 30 Ω, and R_5 = 2.5 Ω.



69. What will be the **current** flowing through the 5.0 Ω resistor?

70. What will be the **current** flowing through the 10 Ω resistor?

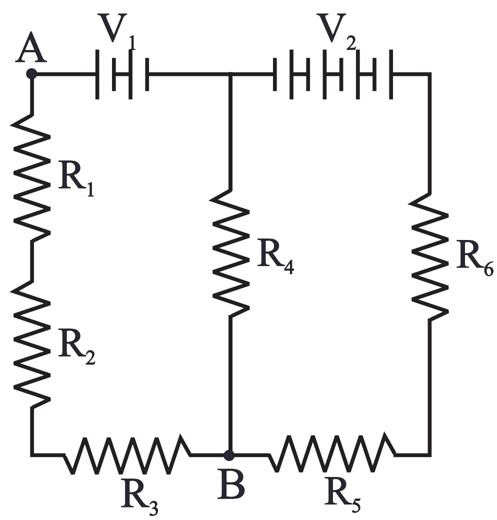
71. How much **power** will be consumed by the 2.5 W resistor?

72. What will be the **terminal voltage** across the battery?

73. What will be the **voltage drop** across the 30 Ω resistor?

74. With what **efficiency** is power being transferred to the loads?

In the circuit at the right the resistors and batteries have the following values; R_1 = 25.0 Ω, R_2 = 35.0Ω, R_3 = 15.0 Ω, R_4 = 20.0 Ω, R_5 = 45.0 Ω, R_6 = 50Ω,
V_1 = 35.0 Volts, and V_2 = 65 Volts.



75. What will be the **current** through R_1?

76. What will be the **current** through R_4?

77. What will be the **current** through R_6?

78. What will be the **voltage** drop across R_1?

79. What will be the **voltage** drop across R_4?

80. What will be the **voltage** drop across R_6?

Assuming that the potential in this circuit is zero at point A:

81. Calculate the **potentia**l at point **B** compared to point **A** through resistors **R_1, R_2, and R_3**.

82. Calculate the **potential** at point **B** compared to point **A** through **battery V_1 and resistor R_4**.

83. Calculate the **potential** at point **B** compared to point **A** through **batteries V_1 and V_2** as well as **resistors R_5 and R_6**.

84. How do the answers to #81, #82 and #83 compare? Explain!

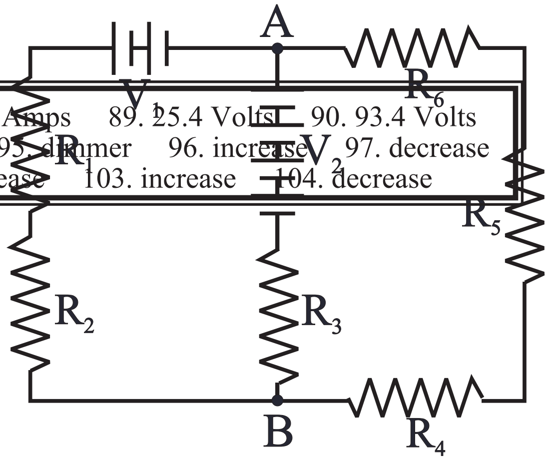
---

85. An electric Iron is designed to operate on household current of 120 Volts RMS [DC equivalent] and is intended to consume 650 Watts of power. The base of the iron consists of 575 grams of iron metal and is to be heated with a length of gauge 28 Nichrome wire. [Ignore the cooling effects of the room in your calculations.]

a. How much wire is required for this Iron?

APPLICATIONS OF KIRCHOFF'S RULES

b. How long after being turned on will the temperature of the iron [c = 0.11 cal/gm^{o}C] reach its operating temperature of 155 ^{o}C if the initial temperature of the iron is 25.0 ^{o}C [room
te
m
pe
ra



Answers to opposite side: 86. 1.41 Amps 87. 1.46 Amps 88. 0.046 Amps 89. 25.4 Volts 90. 93.4 Volts 91. 4.37 Volts 92. -11.6 Volts 93. -11.6 Volts 94. -11.6 Volts 95. dimmer 96. increase 97. decrease 98. increase 99. increase 100. decrease 101. nothing 102. increase 103. increase 104. decrease

Answers to opposite side: 69. 0.50 Amps 70. 0.375 Amps 71. 0.625 Amps 72. 9.50 Volts 73. 3.75 Volts 74. 86% 75. 0.26 Amps 76. 0.78 Amps 77. 0.52 Amps 78. 6.25 Volts 79. 15.6 Volts 80. 26.0 Volts 81. 19.5 Volts 82. 19.5 Volts 83. 19.5 Volts 84. Same, independent of path 85a. 156 cm b. 53 seconds

PHYSICS HOMEWORK #159 SIMPLE DC CIRCUITS
DC CIRCUITS - CONCEPTUAL QUESTIONS

In the circuit at the right the resistors and batteries have the following values: R_1 = 18.0 Ω, R_2 = 22.0 Ω, R_3 = 64.0 Ω, R_4 = 48.0 Ω, R_5 = 110.0 Ω, R_6 = 95.0 Ω, V_1 = 45 Volts, and V_2 = 105.0 Volts.

86. What will be the **current** through R_1?

87. What will be the **current** through R_3?

88. What will be the **current** through R_6?

89. What will be the **voltage drop** across R_1?

90. What will be the **voltage drop** across R_3?

91. What will be the **voltage drop** across R_6?

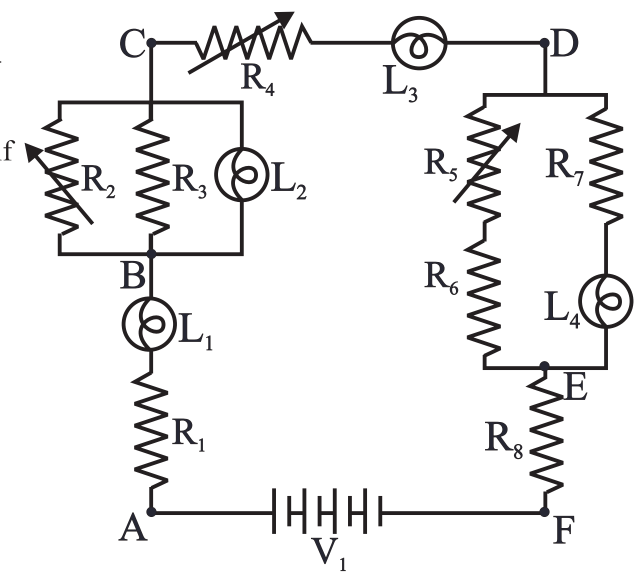
Assuming the potential in this circuit to be zero at point A:

92. Calculate the **potential at point B** compared to point A through resistors R_6, R_5 and R_4.

93. Calculate the **potential at point B** compared to point A through battery V_2 and resistor R_3.

94. Calculate the **potential at point B** compared to point A through battery V_1 and resistor R_2.

Each of the following questions refers to the diagram at the right.



95. What will happen to the **brightness** of light bulb L_1 if the resistance R_4 is increased? Explain!

96. What will happen to the **potential difference** between points A and C if R_4 is decreased? Explain!

97. What will happen to the current through R_2 if resistance R_5 is increased?

98. What will happen to the **brightness** of light bulb L_2 if the value of resistor R_3 is increased? Explain!

99. What will happen to the **current** flowing through the battery V_1 if resistor R_5 is decreased? Explain!

100. What will happen to the **brightness** of light bulb L_4 if resistor R_4 is increased? Explain!

101. What will happen to the **EMF** of battery V_1 is resistor R_1 is increased? Explain!

102. What should you do to resistor R_5 in order to **increase the brightness** of light bulb L_4? Explain!

103. What will happen to the reading on a **voltmeter** connected between points **D** and **F** if resistor R_5 is increased? Explain!

104. What will happen to the **brightness** of light bulb L_3 if light bulb L_4 burns out? Explain!

PHYSICS HOMEWORK #160 SIMPLE DC CIRCUITS
DC CIRCUITS - CONCEPTUAL QUESTIONS

1. What function does a battery serve in an electrical circuit?

2. What is the net electrical charge of a battery?

3. How is a battery different from a cell?

4. How should a voltmeter be used in an electrical circuit?

5. What effect should a meter have on the circuit in which it is used?

6. What will happen if a voltmeter is connected in series with a light bulb and a battery?

7. What is the dominant electrical characteristic of a voltmeter?

8. If you took a voltmeter apart, what would you find inside?

9. What will happen if a light bulb is connected in series with a battery and then a voltmeter is added in parallel with the light bulb?

10. What is the dominant electrical characteristic of an ammeter?

11. A light bulb is connected in series with a battery and everything is operating normally. An ammeter is added in series with the light bulb. What will happen? Why?

12. If you took an ammeter apart, what would you find inside?

13. A light bulb is connected in series with a battery and everything is operating normally. An ammeter is added in parallel with the light bulb. What will happen? Why?

14. Two **different** light bulbs are connected in series with each other and with a battery and everything is operating normally. An ammeter is first inserted between the first light bulb and the battery and then a reading is taken. This ammeter is removed and is then inserted between the two light bulbs and again a reading is taken. How will the two readings on the ammeter compare? Why?

15. Two **different** light bulbs are connected in parallel with each other and both are then connected in series with a battery. An ammeter is connected in series with the battery and a current reading is taken. The ammeter is removed from the circuit and is then reinserted in the circuit in series with the first light bulb and a reading is taken. Finally, the ammeter is again removed from the circuit and is placed in series with the second light bulb and a current reading is taken. How will the currents through the battery, light bulb #1 and light bulb #2 relate to one another? Why?

16. A series circuit consists of a battery and two different light bulbs. One of the light bulbs is much brighter than the other. How are these light bulbs different? Explain!

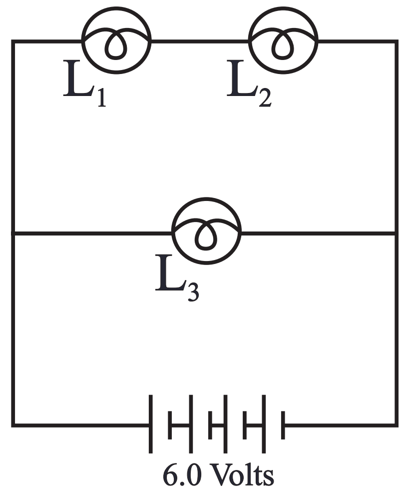
17. Two different light bulbs are connected in parallel with each other and both are then connected in series with a battery. A voltmeter is connected in parallel with the battery and a voltage reading is taken. The voltmeter is removed from the circuit and is then placed in parallel with the first light bulb and a reading is taken. Finally, the voltmeter is again removed from the circuit and is placed in series with the second light bulb and a voltage reading is taken. How will the voltage across the battery, light bulb #1 and light bulb #2 relate to one another? Why?

18. Two different light bulbs are connected in series with each other and with a battery and everything is operating normally. A voltmeter is connected in parallel with the battery and a reading is taken. This voltmeter is then removed from the circuit and is then placed in parallel with the first light bulb and a reading is taken. Finally, the voltmeter is removed from the circuit and is then placed is parallel with the second light bulb and a reading is taken. How will the readings across the battery, light bulb #1 and light bulb #2 all relate to one another? Explain why?

19. Two different light bulbs are connected in parallel with each other and both are then connected in series with a battery. Everything is working normally. One of the two light bulbs is unscrewed and of course goes out. What will happen to the other light bulb? Explain!

20. Two different light bulbs are connected in series with each other and with a battery and everything is operating normally. One of the two light bulbs is unscrewed and it, of course, goes out. What happens to the other light bulb? Explain!

PHYSICS HOMEWORK #161 SIMPLE DC CIRCUITS
VOLTAGES IN SERIES & PARALLEL



21. Three different light bulbs are connected to a battery as shown to the right. All light bulbs are working normally and are properly lit.

    a. What will happen to the brightness of light bulbs L_2 and L_3 if light bulb L_1 is removed? Explain!

    b. What will happen to the brightness of light bulbs L_1 and L_2 if light bulb L_3 is removed? Explain!

    c. How will the currents through light bulbs L_1, L_2 and L_3 be related? Explain!

    d. How will the readings on a voltmeter connected separately across each light bulb L_1, L_2 and L_3 be related? Explain!

22. An 8.0 Volt battery is connected to a low resistance light bulb which burns very brightly. A voltmeter is connected across the battery and the reading on the voltmeter is 7.0 volts. Why is the reading on the voltmeter lower than the battery's rating?

23. What is the cause of the internal resistance of a battery? Explain!

24. What is the primary difference among D cell, C cell and AA cell alkaline battery cells?

25. Why do the headlights on a car get very dim or go out while the engine is being started?

26. A light bulb is connected in series with a rheostat and a battery. The resistance of the rheostat is gradually being turned up. What will happen to the brightness of the light bulb? Explain!

27. Two different light bulbs are connected in series with a battery. Light bulb L_1 is much brighter than light bulb L_2. Which light bulb has the higher resistance? Explain!

28. Two light bulbs are connected in parallel with each other and are in turn connected to a battery. Light bulb L_1 has twice the resistance of light bulb L_2. A voltmeter is connected first across L_1 and a reading is taken, then the voltmeter is connected across L_2 and a reading is taken.

    a. Across which light bulb will the voltmeter reading be higher? Explain!

    b. Which light bulb will be brighter? Explain!

    c. Through which light bulb will the current be greater? Explain! d. Which light bulb will be dissipating the most energy? Explain!

29. A given wire has a length L, a diameter d and a resistance R. [Assume that the wires are cylindrical!]

    a. What will happen to the resistance of this wire if it is stretched to twice its original length? Explain!

    b. What will happen to the resistance of this wire if its diameter is doubled? Explain!

    c. What will happen to the resistance of this wire if the length of the wire is doubled while the diameter is also doubled? Explain!

30. Why is the resistance of a diode higher in one direction [reverse biased] than in the opposite direction [forward biased]?

31. What fundamental property enables a battery to do what it does? Explain!

32. What has happened to a battery when it "dies"? Explain!

33. How is a "primary" battery fundamentally different from a "secondary" [rechargeable] battery? Explain!

PHYSICS HOMEWORK #163 NUCLEAR PHYSICS
NUCLEAR MASS DEFECT

[Please note! If you need additional information or constants not supplied within the homework sheet, feel free to look up the needed information in the text or other source!!]

$$X_Z^A$$

A - Atomic mass number = # protons + # neutrons
Z = Atomic Number = # protons
X = Symbol for element

1. For each of the following isotopes determine;
   a. the number of protons in the nucleus.
   b. the number of neutrons in the nucleus.
   c. the number of electrons in the neutral atom.

   a. Au_{79}^{197} b. Y_{39}^{89} c. Sb_{51}^{121} d. P_{15}^{31}

2. Consider an atom of Chlorine 37.
   a. Determine the number of protons, neutrons and electrons that make up this atom.
   b. Determine the total mass of a Chlorine 37 atom based on the sum of its separate parts.
   c. Look up the atomic mass of the isotope Chlorine 37 in AMU's, convert this to kg. and finally calculate the mass of a single atom of Chlorine 37.
   d. Find the difference between the mass of a single atom of Chlorine 37 and the sum of its parts.
   e. Convert this "mass defect" into energy equivalent through $E = mc^2$.
   f. Convert the resulting "energy defect" into binding energy per nucleon in MeV/nucleon.

3. Calculate the binding energy per nucleon for each of the following isotopes;
   a. Strontium 90 b. Deuterium 2 c. Helium 4 d. Uranium 235

4. For each of the following isotopes;
   a. Look up the atomic number and the atomic mass number of the given element on a periodic table.
   b. Determine the number of protons and neutrons in the stable isotope.
   c. Compare each isotope listed below with the listing on the periodic table and determine if the isotope below has too many neutrons or too many protons compared to the atoms listed on the periodic table and decide what kind of radioactive decay, if any, will likely follow.
      a. Scandium 48 b. Plutonium 244 c. Magnesium 22 d. Aluminum 27
      e. Cobalt 60 f. Carbon 14 g. Potassium 40 h. Bismuth 209

5. Suppose that each of the unstable isotopes above was to change one of its protons into a neutron or one of its protons into a neutron. What would be the resulting element in each case?

USEFUL CONSTANTS

$m_{electron} = 9.109 \times 10^{-31}$ kg = 0.511 MeV = 5.486×10^{-4} AMU

$m_{proton} = 1.673 \times 10^{-27}$ kg = 938.3 MeV = 1.00756 AMU

$m_{neutron} = 1.675 \times 10^{-27}$ kg = 939.6 MeV = 1.008665 AMU

1.0 AMU = 1.6605×10^{-27} kg = 931.5 MeV

Answers to side: 5b. 1.24×10^{-13} J c. 2.82×10^{-12} J d. 9.74×10^{-13} J e. 1.004×10^{-12} J f. 3.92×10^{-12} J

PHYSICS HOMEWORK #164 NUCLEAR PHYSICS
NUCLEAR REACTIONS

1. What types of radioactive decay is each of the following isotopes **most likely** to undergo? [α,**ß,g, ec, fission or fusion?**]

a. S^{35}_{16} b. N^{11}_{7} c. Pu^{239}_{94} d. He^{4}_{2} e. Pb^{201}_{82} f. Fe^{56}_{26} g. Na^{22}_{11} h. Sr^{90}_{38}

2. Each of the following isotopes will undergo ß decay. Determine the type of ß decay and write the properly balanced decay equation indicating the resulting products. [Include all possible types!]

a. $Tc^{99}_{43} \Rightarrow ?$ b. $K^{40}_{19} \Rightarrow ?$ c. $Be^{7}_{4} \Rightarrow ?$ d. $Si^{31}_{14} \Rightarrow ?$

3. Each of the following will undergo a decay. Write the properly balanced decay equation indicating the resulting products.

a. $Rn^{222}_{86} \Rightarrow ?$ b. $Po^{210}_{84} \Rightarrow ?$ c. $U^{238}_{92} \Rightarrow ?$ d. $Th^{232}_{90} \Rightarrow ?$

4. Each of the following isotopes is unstable. For each isotope determine the type of radioactivity and write the appropriate decay equation.

a. $U^{235}_{92} \Rightarrow ?$ b. $Am^{243}_{95} \Rightarrow ?$ c. $Sr^{92}_{38} \Rightarrow ?$ d. $Cu^{59}_{29} \Rightarrow ?$

5. Complete each of the following nuclear equations.

a. $U^{235}_{92} \rightarrow Ru^{112}_{44} + ?$ b. $Cu^{63}_{29} + H^{1}_{1} \rightarrow ?$ c. $H^{3}_{1} + H^{2}_{1} \rightarrow ?$

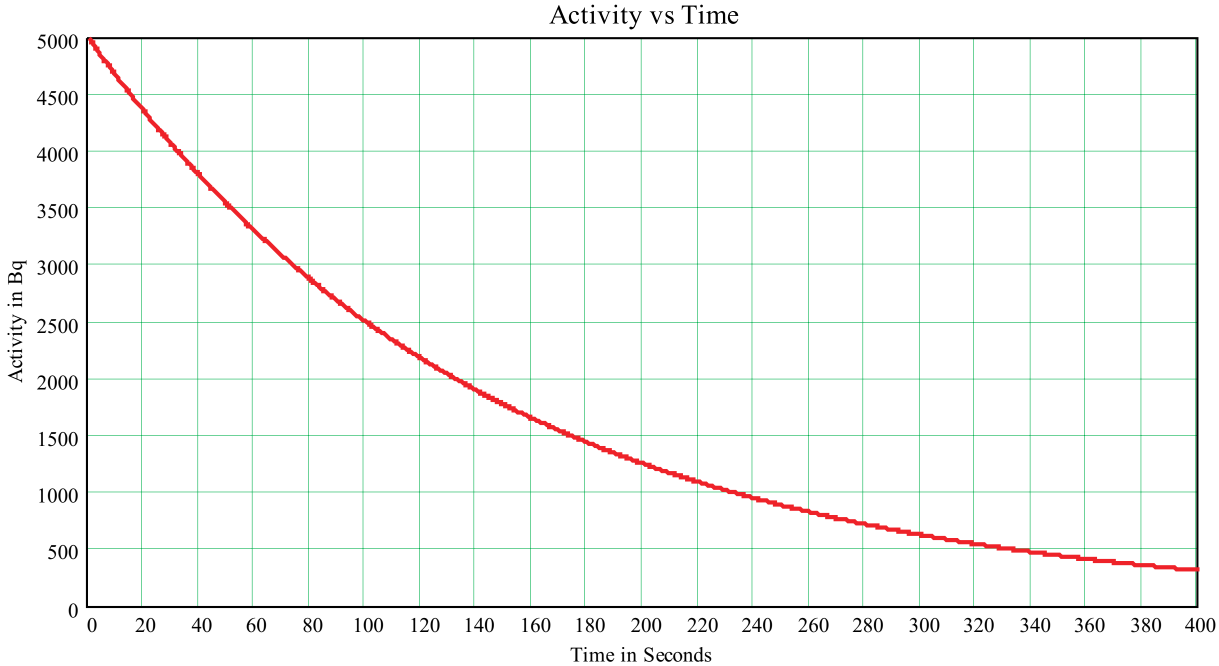
d. $U^{235}_{92} + n^{1}_{0} \rightarrow ?$ e. $H^{2}_{1} + n^{1}_{0} \rightarrow ?$ f. $H^{2}_{1} + H^{2}_{1} \rightarrow ?$

6. Determine how much energy is released in #5 b, c, d, e, & f above. [1 AMU = 1.66044×10^{-27} kg]

Answers to opposite side: 1a. 79,118,79 b. 39,50,39 c. 51,70,51 d. 15,16,15 2a. 17,20,17
2b. 6.19497×10^{-26} kg. 2c. 6.13856×10^{-26} kg. d. 5.64×10^{-28} kg. e. 5.08×10^{-11} J f. 8.58 MeV/nucleon
3a. 8.72 MeV/nucleon b. 1.11 MeV/nucleon c. 7.49 MeV/nucleon d. 7.52 MeV/nucleon 4a. Sc 21, 45
Pu 94, 244 Mg 12, 24 Al 13, 27 Co 27, 59 C 6, 12 K 19, 39 Bi 83, 209
4b. Sc 21,24 Pu 94,150 Mg 12,12 Al 13,14 Co 27,32 C 6,6 K 19,20 Bi 83,126
4c. Sc too many neutrons, Pu stable, Mg too few neutrons, Al stable, Co too many neutrons, C too many neutrons, K too many neutrons, Bi stable. 5. Ti, Am, Na, stable, Ni, N, Ca or Ar, stable

PHYSICS HOMEWORK #165 NUCLEAR PHYSICS
RADIOACTIVE HALF LIFE - GRAPHS

Each of the following questions refers to the graph below which plots the activity of a radioactive sample as a function of time.



1. What is the half-life of this radioactive sample?
2. What is the decay constant of this isotope?
3. How many atoms were initially present in this sample?
4. What will be the activity of this sample after 10.0 minutes?
5. How long will it take for the activity of this sample to drop to 1.0 % of its initial value?
6. How many radioactive atoms will remain after 10.0 minutes?
7. How many radioactive atoms will have decayed during the first 5.0 minutes?

$$A = A_0 \cdot e^{-\lambda t}$$
$$N = N_0 \cdot e^{-\lambda t}$$
$$t_{1/2} = \frac{0.693}{\lambda}$$
$$A = N \cdot \lambda$$
$$A = \frac{-dN}{dt}$$

Answers to opposite side: 8a. ß- b. 2.51×10^{23} atoms c. 0.1315/yr [4.17×10^{-9}/s] d. 1.05×10^{15} Bq 1e. 1.69×10^{23} atoms 1f. 7.1×10^{14} Bq g. 16.8 grams h. Nickel 9a. ß- b. 3.05×10^{23} atoms 9c. 0.0241/yr d. 2.33×10^{14} Bq 2e. 6300 Curies f. 2.74×10^{22} atoms g. 2.09×10^{13} Bq h. 4.09 grams 9i. 566 Curies 10a. 2.65×10^{13} Bq , 3.29×10^{12} Bq b. 0.0464/day, 5.37×10^{-7}/s c. 14.28 days 10d. Phosphorus 32 e. 0.0156 grams 11a. 2.35 days b. Neptunium c. 8.08×10^{-47} µCuries 12. 1.49 grams Sulfur, 8.21 grams Chlorine 13. 7300 years

PHYSICS HOMEWORK #166 NUCLEAR PHYSICS
RADIOACTIVE HALF LIFE

$$A = A_0 \cdot e^{-\lambda t}$$
$$N = N_0 \cdot e^{-\lambda t}$$
$$t_{1/2} = \frac{0.693}{\lambda}$$
$$A = N \cdot \lambda$$
$$A = \frac{-dN}{dt}$$

8. Cobalt 60, which has a half-life of 5.271 years, is frequently used in medicine for radiation therapy;
   a. What type of radiation would this isotope most likely emit? What information leads you to this conclusion?

   Suppose that you begin with 25 grams of this isotope of Cobalt 60;
   b. How many atoms will this sample contain?
   c. What is the decay constant for this isotope?
   d. What will be the initial activity of this sample?
   e. How many atoms of this sample will remain after 3.0 years?
   f. What will be the activity of this sample after 3.0 years?
   g. How many grams of radioactive Cobalt 60 will remain after 3.0 years?
   h. What isotope will be the result of this decay?

9. Strontium 90 has a half-life of 28.8 years. Suppose that you have a sample of Sr 90 which has a mass of 45.5 gm;
   a. What type of radioactivity will this isotope most likely undergo? How do you know?
   b. How many atoms will this sample contain?
   c. What will be the decay constant of this isotope?
   d. What will be the initial activity of this sample?
   e. What will be the radioactive strength of this sample in Curies?
   f. How many radioactive atoms of this isotope will remain after 100 years?
   g. What will be the activity of this sample after 100 years?
   h. How many grams of Sr 90 will remain after 100 years?
   i. What will be the radioactive strength of this sample after 100 years?

Useful Constants
1.0 Curie = 3.7 x 10^{10} dps
REM = RAD x Q_F
Q_F = 1.0 [x rays, g & e-]
Q_F = 3.0 [slow neutrons]
Q_F = 10 [fast neutrons]
Q_F = 20 [α]
1 dps = 1 Bq = 1 Becquerel

10. A sample of an unknown is measured to initially have an activity of 716 Curies. After a period of 45 days the activity of the sample is measured to have dropped to 88.9 Curies.
    a. What are the activities of this sample both at the beginning and at the end in Bq?
    b. What will be the decay constant of this sample?
    c. What is the half-life of this isotope?
    d. What is this isotope?
    e. Given that the atomic weight of this substance is 190 grams/mole, how many grams of this sample were initially present?

11. The radioactivity of a sample drops from 4.5μ±¸ mC to 0.45 mC over a period of 187 hours.
    a. What is the half life of this isotope?
    b. What is this isotope?
    c. What will be the activity of this sample after 1.0 years?

12. Assuming that you begin with 10.0 grams of Sulfur 35, how much will you have left at the end of 8.0 months?

13. In radiocarbon dating the relative abundance of Carbon 14 is living organisms is compared to the abundance of Carbon 14 in organic material long dead. For example the age of a piece of charcoal from a prehistoric fireplace is made from wood long dead. Since the intake of Carbon ceases when the organism dies a comparison of the activity of a prehistoric sample with a modern sample. Modern sample of pure carbon yield activities of 16 decays per minute for each gram of carbon. Suppose that you take a piece of charcoal from an Indian pueblo in Colorado and find that the sample exhibits an activity of 0.11 Bq per gram of carbon. What is the age of this Indian site?

Answers to opposite side: 1. 100 seconds 2. 6.93 x 10^{-3} /second 3. 7.215 x 10^{5} atoms 4. 78.2 Bq 5. 665 seconds 6. 1.128 x 10^{4} atoms 7. 6.313 x 10^{5} atoms

PHYSICS HOMEWORK #167 NUCLEAR PHYSICS

TABLE OF SELECTED ISOTOPES

Atomic #	Name	Symbol	Mass Number	Atomic Mass [amu]	Fractional Abundance	Decay Mode	Half Life
0	Neutron	n	1	1.008665		β−	10.4 min
1	Hydrogen	H	1	1.007825	0.99985		
	Deuterium	D	2	2.014102	0.00015		
	Tritium	T	3	3.016049		β−	12.33 yrs
2	Helium	He	3	3.016029	1.37×10^{-6}		
			4	4.002602	0.99999863		
3	Lithium	Li	6	6.01512	0.175		
			7	7.016003	0.925		
4	Beryllium	Be	7	7.016928		EC,γ	53.29 days
			9	9.012182	1		
5	Boron	B	10	10.012936	0.199		
			11	11.009305	0.801		
6	Carbon	C	11	11.011433		β+, EC	20.385 min
			12	12	0.989		
			13	13.003355	0.011		
			14	14.003242		β−	5730 yr
7	Nitrogen	N	13	13.005738		β+	9.965 min
			14	14.003074	0.9963		
			15	15.000108	0.0037		
8	Oxygen	O	15	15.003065		β+, EC	122.24 s
			16	15.994915	0.9976		
			18	17.99916	0.002		
9	Fluorine	F	19	18.998404	1		
10	Neon	Ne	20	19.992435	0.9048		
			22	21.991383	0.0925		
11	Sodium	Na	22	21.994434		β+. EC, γ	2.6088 yrs
			23	22.989767	1		
			24	23.990961		β−, γ	
12	Magnesium	Mg	24	23.985042	0.7899		
13	Aluminum	Al	27	26.981538	1		
14	Silicon	Si	28	27.976927	0.9223		
			31	30.975362		β−, γ	157.3 min
15	Phosphorus	P	31	30.973762	1		
			32	31.9739		β−	14.262 days
16	Sulfur	S	32	31.972071	0.9502		
			35	34.969033		β−	87.51 days
17	Chlorine	Cl	35	34.968853	0.7577		
			37	36.965903	0.2423		
18	Argon	Ar	40	39.962384	0.996		
19	Potassium	K	39	38.963708	0.932681		
			40	39.964	0.000117	β-,EC	1.3×10^{9} yrs
20	Calcium	Ca	40	39.962591	0.96941		
21	Scandium	Sc	45	44.955911	1		
22	Titanium	Ti	48	47.937947	0.738		
23	Vanadium	V	51	50.943962	0.9975		
24	Chromium	Cr	52	51.940511	0.8379		
25	Manganese	Mn	55	54.938048	1		
26	Iron	Fe	56	55.93494	0.9172		
27	Cobalt	Co	59	58.933198	1		
		60	59.93382		β−, γ	5.2714 yrs	
28	Nickel	Ni	58	57.935346	0.68077		
		60	59.930789	0.26223			
29	Copper	Cu	63	62.929599	0.6917		
		65	64.927791	0.3083			
30	Zinc	Zn	64	63.929144	0.486		
		66	65.920352	0.079			
31	Gallium	Ga	69	68.92558	0.60108		
32	Germanium	Ge	72	71.922079	0.2766		
		74	73.921177	0.3594			
33	Arsenic	As	75	74.921594	1		

PHYSICS HOMEWORK #168 NUCLEAR PHYSICS

TABLE OF SELECTED ISOTOPES

Atomic #	Name	Symbol	Mass Number	Atomic Mass [amu]	Fractional Abundance	Decay Mode	Half Life
34	Selenium	Se	80	79.916519	0.4961		
35	Bromine	Br	79	78.918336	0.5069		
36	Krypton	Kr	84	83.911508	0.57		
37	Rubidium	Rb	85	4.9117937	0.0217		
38	Strontium	Sr	86	85.909266	0.0986		
			88	87.905618	0.8257		
			90	89.907737		β−	29.1 yrs
39	Yttrium	Y	89	88.905847	1		
40	Zirconium	Zr	90	89.904702	0.5145		
41	Niobium	Nb	93	92.906376	1		
42	Molybdenum	Mo	98	97.905407	0.2413		
43	Technicium	Tc	98	97.907215		β−, γ	4.2 x 10^{6} yrs
44	Ruthenium	Ru	102	101.904348	0.316		
45	Rhodium	Rh	103	102.905502	1		
46	Palladium	Pd	106	105.903481	0.2733		
47	Silver	Ag	107	106.905091	0.51839		
			109	108.904754	0.48161		
48	Cadmium	Cd	114	113.903359	0.2873		
49	Indium	In	115	114.903876	95.7%,	β−,γ	4.41 x 10^{14} yrs
50	Tin	Sn	120	119.902197	0.3259		
51	Antimony	Sb	121	120.90382	0.5736		
52	Tellurium	Te	130	129.906228	0.3387		
53	Iodine	I	127	126.904474	1		
			131	130.906111		β−, γ	8.04 days
54	Xenon	Xe	132	131.904141	0.269		
		Xe	136	135.90721	0.089		2.36 x 10^{21} yrs
55	Cesium	Cs	133	132.905436	1		
56	Barium	Ba	137	136.905816	0.1123		
			137m	136.905816		I.T.	156 secretary
			138	137.905236	0.717		
57	Lanthanum	La	139	138.906346	0.999098		
58	Cerium	Ce	140	139.905434	0.8843		
59	Praseodymium	Pr	141	140.907647	1		
60	Neodymium	Nd	142	141.907718	0.2713		
61	Promethium	Pm	145	144.912745		EC, γ, α	17.7 yrs
62	Samarium	Sm	152	151.919728	0.267		
63	Europium	Eu	153	152.921226	0.522		
64	Gadolinium	Gd	158	157.924099	0.2484		
65	Terbium	Tb	159	158.925344	1		
66	Dysprosium	Dy	164	163.929172	0.282		
67	Holmium	Ho	165	164.93032	1		
68	Erbium	Er	166	165.930292	0.336		
69	Thulium	Tm	169	168.934213	1		
70	Ytterbium	Yb1	74	173.938861	0.318		
71	Lutecium	Lu	175	174.940772	0.9741		
72	Hafnium	Hf	180	179.946547	0.351		
73	Tantalum	Ta	181	180.947993	0.99988		
74	Tungsten	W	184	183.950929	0.307		3 x 10^{17} yrs
75	Rhenium	Re	187	186.955746	62.6%	β−	4.35 x 10^{10} yrs
76	Osmium	Os	191	190.960922		β−, γ	15.4 days
		Os	192	191.961468	0.41		
77	Iridium	Ir	191	190.960585	0.373		
		193	192.962916	0.627			
78	Platinum	Pt	195	194.967653	0.038		
79	Gold	Au	197	196.966543	1		
80	Mercury	Hg	199	198.968253	0.1687		
			202	201.970617	0.2986		
81	Thallium	Tl	205	204.9744	0.70476		
82	Lead	Pb	206	205.97444	0.241		
			207	206.975871	0.221		

PHYSICS HOMEWORK #169 NUCLEAR PHYSICS

TABLE OF SELECTED ISOTOPES

Atomic #	Name	Symbol	Mass Number	Atomic Mass [amu]	Fractional Abundance	Decay Mode	Half Life
82	Lead	Pb		208	207.976627	0.524	
			210	209.984163		b-, g,a	22.3 yrs
			211	210.988734		b-, g	36.1 min
			212	211.991872		β–, γ	10.64 hrs
			214	213.999798		β–, γ	26.8 min
83	Bismuth	Bi	209	208.980374	100%		
			211	210.987254		α, γ, β–	2.14 min
84	Polonium	Po	210	209.982848		α, γ	138.376 days
			214	213.995177		α, γ	164.3 msec
85	Astatine	At	218	218.00868		α, β–	1.6 sec
86	Radon	Rn	222	222.017571		α, γ	3.8235 days
87	Francium	Fr	223	223.019733		β–, γ, α	21.8 min
88	Radium	Ra	226	226.025302		α, γ	1600 yrs
89	Actinium	Ac	227	227.027749		β–, γ, α	21.773 yrs
90	Thorium	Th	228	228.028716		α, γ	1.9131 yrs
			232	232.038051	100%;	α, γ	1.405×10^{10} yrs
91	Protactinium	Pa	231	231.03588		α, γ	3.276×10^{4} yrs
92	Uranium	U	232	232.037131		α, γ	68.9 yrs
			233	233.03963		α, γ	1.592×10^{5} yrs
			235	235.043924	0.720%;	α, γ	7.038×10^{8} yrs
			236	236.045562		α, γ	2.3415×10^{7} yrs
			238	238.050784	99.2745%;	α, γ	4.468×10^{9} yrs
			239	239.054289		β–, γ	23.50 min
93	Neptunium	Np	239	239.052932		β–, γ	2.355 days
94	Plutonium	Pu	239	239.052157		α, γ	24,119 yrs
95	Americium	Am	243	243.061373		α, γ	7380 yrs
96	Curium	Cm	245	245.065484		α, γ	8500 yrs
97	Berkelium	Bk	247	247.0703		α, γ	1380 yrs
98	Californium	Cf	249	249.074844		α, γ	351 yrs
99	Einsteinium	Es	254	254.08802		α, γ, β–	275.7 days
100	Fermium	Fm	253	253.085174		EC, α, γ	3.00 days
101	Mendelevium	Md	255	255.09107		EC, α, γ	27 min
102	Nobelium	No	255	255.09324		α, γ, EC	3.1 min
103	Lawrencium	Lr	257	257.0995		α, EC	0.646 sec
104	Rutherfordium	R	f261	261.1086		α	65 sec
105	Hahnium	Ha	262	262.1138		α, fission	34 sec
106			263	263.1182		α, fission	0.8 sec
107			262	262.1231		α	102 millisec
108			264	264.1285		α	0.08 millisec
109			266	266.1378		α	3.4 millisec

PERIODIC TABLE

Periodic Table for the *Table of Isotopes** (1999)

Key to Table: Group; Element; K L M N O P Q (electrons per shell); E_Z; M.P., B.P., C.P.; Ox.States; At.Weight; Abundance%

Group	Element	Symbol	Z	Shells (K L M N O P Q)	M.P. / B.P. / C.P.	Ox. States	At. Weight	Abundance
1 (IA)	Hydrogen	H	1	1	-259.34 / -252.87 / -240.18	+1-1	1.00794	91.0%
18 (VIIIA)	Helium	He	2	2	-272.2 / -268.93 / -267.96	0	4.002602	8.9%
1 (IA)	Lithium	Li	3	2 1	180.5 / 1342	+1	6.941	1.86×10^{-7}%
2 (IIA)	Beryllium	Be	4	2 2	1287 / 2471	+2	9.012182	2.38×10^{-9}%
13 (IIIA)	Boron	B	5	2 3	2075 / 4000	+3	10.811	6.9×10^{-8}%
14 (IVA)	Carbon	C	6	2 4	4492t / 3642s	+2+4-4	12.0107	0.033%
15 (VA)	Nitrogen	N	7	2 5	-210.00 / -195.79 / -146.94	2 3+ +	14.00674	0.0102%
16 (VIA)	Oxygen	O	8	2 6	-218.79 / -182.95 / -118.56	-2	15.9994	0.078%
17 (VIIA)	Fluorine	F	9	2 7	-219.62 / -188.12 / -129.02	-1	18.9984032	2.7×10^{-6}%
18 (VIIIA)	Neon	Ne	10	2 8	-248.59 / -246.08 / -228.7	0	20.1797	0.0112%
1 (IA)	Sodium	Na	11	2 8 1	97.80 / 883	+1	22.989770	0.000187%
2 (IIA)	Magnesium	Mg	12	2 8 2	650 / 1090	+2	24.3050	0.00350%
13 (IIIA)	Aluminum	Al	13	2 8 3	660.32 / 2519	+3	26.981538	0.000277%
14 (IVA)	Silicon	Si	14	2 8 4	1414 / 3265	+2+4-4	28.0855	0.00326%
15 (VA)	Phosphorus	P	15	2 8 5	44.15 / 280.5 / 721	+3+5-3	30.973761	0.000034%
16 (VIA)	Sulfur	S	16	2 8 6	115.21 / 444.60 / 1041	+4+6-2	32.066	0.00168%
17 (VIIA)	Chlorine	Cl	17	2 8 7	-101.5 / -34.04 / 143.8	+1+5+7-1	35.4527	0.000017%
18 (VIIIA)	Argon	Ar	18	2 8 8	-189.35 / -185.85 / -122.28	0	39.948	0.000329%
1 (IA)	Potassium	K	19	2 8 8 1	63.38 / 759	+1	39.0983	0.0000123%
2 (IIA)	Calcium	Ca	20	2 8 8 2	842 / 1484	+2	40.078	0.000199%
3 (IIIB)	Scandium	Sc	21	2 8 9 2	1541 / 2836	+3	44.955910	1.12×10^{-7}%
4 (IVB)	Titanium	Ti	22	2 8 10 2	1668 / 3287	+2+3+4	47.867	7.8×10^{-6}%
5 (VB)	Vanadium	V	23	2 8 11 2	1910 / 3407	+2+3+4+5	50.9415	9.6×10^{-7}%
6 (VIB)	Chromium	Cr	24	2 8 13 1	1907 / 2671	+2+3+6	51.9961	0.000044%
7 (VIIB)	Manganese	Mn	25	2 8 13 2	1246 / 2061	+2+3+4+7	54.938049	0.000031%
8 (VIII)	Iron	Fe	26	2 8 14 2	1538 / 2861	+2+3	55.845	0.00294%
9 (VIII)	Cobalt	Co	27	2 8 15 2	1495 / 2927	+2+3	58.933200	7.3×10^{-6}%
10 (VIII)	Nickel	Ni	28	2 8 16 2	1455 / 2913	+2+3	58.6934	0.000161%
11 (IB)	Copper	Cu	29	2 8 18 1	1084.62 / 2562	+1+2	63.546	1.70×10^{-6}%
12 (IIB)	Zinc	Zn	30	2 8 18 2	419.53 / 907	+2	65.39	4.11×10^{-6}%
13 (IIIA)	Gallium	Ga	31	2 8 18 3	29.76 / 2204	+3	69.723	1.23×10^{-7}%
14 (IVA)	Germanium	Ge	32	2 8 18 4	938.25 / 2833	+2+4	72.61	3.9×10^{-7}%
15 (VA)	Arsenic	As	33	2 8 18 5	817t / 614s / 1400	+3+5-3	74.92160	2.1×10^{-8}%
16 (VIA)	Selenium	Se	34	2 8 18 6	221 / 685 / 1493	+4+6-2	78.96	2.03×10^{-7}%
17 (VIIA)	Bromine	Br	35	2 8 18 7	-7.2 / 58.8 / 315	+1+5-1	79.904	3.8×10^{-8}%
18 (VIIIA)	Krypton	Kr	36	2 8 18 8	-157.36 / -153.22 / -63.74	0	83.80	1.5×10^{-7}%
1 (IA)	Rubidium	Rb	37	2 8 18 8 1	39.31 / 688	+1	85.4678	2.31×10^{-8}%
2 (IIA)	Strontium	Sr	38	2 8 18 8 2	777 / 1382	+2	87.62	7.7×10^{-8}%
3 (IIIB)	Yttrium	Y	39	2 8 18 9 2	1522 / 3345	+3	88.90585	1.51×10^{-8}%
4 (IVB)	Zirconium	Zr	40	2 8 18 10 2	1855 / 4409	+4	91.224	3.72×10^{-8}%
5 (VB)	Niobium	Nb	41	2 8 18 12 1	2477 / 4744	+3+5	92.90638	2.28×10^{-9}%
6 (VIB)	Molybdenum	Mo	42	2 8 18 13 1	2623 / 4639	+6	95.94	8.3×10^{-9}%
7 (VIIB)	Technetium	Tc	43	2 8 18 13 2	2157 / 4265	+4+6+7	[98]	
8 (VIII)	Ruthenium	Ru	44	2 8 18 15 1	2334 / 4150	+3	101.07	6.1×10^{-9}%
9 (VIII)	Rhodium	Rh	45	2 8 18 16 1	1964 / 3695	+3	102.90550	1.12×10^{-9}%
10 (VIII)	Palladium	Pd	46	2 8 18 18 0	1554.9 / 2963	+2+4	106.42	4.5×10^{-9}%
11 (IB)	Silver	Ag	47	2 8 18 18 1	961.78 / 2162	+1	107.8682	1.58×10^{-9}%
12 (IIB)	Cadmium	Cd	48	2 8 18 18 2	321.07 / 767	+2	112.411	5.3×10^{-9}%
13 (IIIA)	Indium	In	49	2 8 18 18 3	156.60 / 2072	+3	114.818	6.0×10^{-10}%
14 (IVA)	Tin	Sn	50	2 8 18 18 4	231.93 / 2602	+2+4	118.710	1.25×10^{-8}%
15 (VA)	Antimony	Sb	51	2 8 18 18 5	630.63 / 1587	+3+5-3	121.760	1.01×10^{-9}%
16 (VIA)	Tellurium	Te	52	2 8 18 18 6	449.51 / 988	+4+6-2	127.60	1.57×10^{-8}%
17 (VIIA)	Iodine	I	53	2 8 18 18 7	113.7 / 184.4 / 546	+1+5+7-1	126.90447	2.9×10^{-9}%
18 (VIIIA)	Xenon	Xe	54	2 8 18 18 8	-111.75 / -108.04 / 16.58	0	131.29	1.5×10^{-8}%
1 (IA)	Cesium	Cs	55	2 8 18 18 8 1	28.44 / 671	+1	132.90545	1.21×10^{-9}%
2 (IIA)	Barium	Ba	56	2 8 18 18 8 2	727 / 1897	+2	137.327	1.46×10^{-8}%
3 (IIIB)	Lanthanum	La†	57	2 8 18 18 9 2	918 / 3464	+3	138.9055	1.45×10^{-9}%
4 (IVB)	Hafnium	Hf	72	2 8 18 32 10 2	2233 / 4603	+4	178.49	5.02×10^{-10}%
5 (VB)	Tantalum	Ta	73	2 8 18 32 11 2	3017 / 5458	+5	180.9479	6.75×10^{-11}%
6 (VIB)	Tungsten	W	74	2 8 18 32 12 2	3422 / 5555	+6	183.84	4.34×10^{-10}%
7 (VIIB)	Rhenium	Re	75	2 8 18 32 13 2	3186 / 5596	+4+6+7	186.207	1.69×10^{-10}%
8 (VIII)	Osmium	Os	76	2 8 18 32 14 2	3033 / 5012	+3+4	190.23	2.20×10^{-9}%
9 (VIII)	Iridium	Ir	77	2 8 18 32 15 2	2446 / 4428	+3+4	192.217	2.16×10^{-9}%
10 (VIII)	Platinum	Pt	78	2 8 18 32 16 2	1768.4 / 3825	+2+4	195.078	4.4×10^{-9}%
11 (IB)	Gold	Au	79	2 8 18 32 18 1	1064.18 / 2856	+1+3	196.96655	6.1×10^{-10}%
12 (IIB)	Mercury	Hg	80	2 8 18 32 18 2	-38.83 / 356.73 / 1477	+1+2	200.59	1.11×10^{-9}%
13 (IIIA)	Thallium	Tl	81	2 8 18 32 18 3	304 / 1473	+1+3	204.3833	6.0×10^{-10}%
14 (IVA)	Lead	Pb	82	2 8 18 32 18 4	327.46 / 1749	+2+4	207.2	1.03×10^{-8}%
15 (VA)	Bismuth	Bi	83	2 8 18 32 18 5	271.40 / 1564	+3+5	208.98038	4.7×10^{-10}%
16 (VIA)	Polonium	Po	84	2 8 18 32 18 6	254 / 962	+2+4	[209]	
17 (VIIA)	Astatine	At	85	2 8 18 32 18 7	302		[210]	
18 (VIIIA)	Radon	Rn	86	2 8 18 32 18 8	-71 / -61.7 / 104	0	[222]	
1 (IA)	Francium	Fr	87	2 8 18 32 18 8 1	27	+1	[223]	
2 (IIA)	Radium	Ra	88	2 8 18 32 18 8 2	700	+2	[226]	
3 (IIIB)	Actinium	Ac‡	89	2 8 18 32 18 9 2	1051 / 3198	+3	[227]	
4 (IVB)	Rutherfordium	Rf	104	2 8 18 32 32 10 2		+4	[261]	
5 (VB)	Dubnium	Db	105	2 8 18 32 32 11 2			[262]	
6 (VIB)	Seaborgium	Sg	106	2 8 18 32 32 12 2			[266]	
7 (VIIB)	Bohrium	Bh	107	2 8 18 32 32 13 2			[264]	
8 (VIII)	Hassium	Hs	108	2 8 18 32 32 14 2			[269]	
9 (VIII)	Meitnerium	Mt	109	2 8 18 32 32 15 2			[268]	
10 (VIII)	Element-110	110	110	2 8 18 32 32 16 2			[271]	
11 (IB)	Element-111	111	111	2 8 18 32 32 17 2			[272]	
12 (IIB)	Element-112	112	112	2 8 18 32 32 18 2			[277]	
14 (IVA)	Element-114	114	114	2 8 18 32 32 20 2			[289]	
16 (VIA)	Element-116	116	116	2 8 18 32 32 22 2			[289]	
18 (VIIIA)	Element-118	118	118	2 8 18 32 32 24 2			[293]	

† Lanthanides

Element	Symbol	Z	Shells	M.P. / B.P.	Ox. States	At. Weight	Abundance
Cerium	Ce	58	2 8 18 19 9 2	798 / 3443	+3+4	140.116	3.70×10^{-9}%
Praseodymium	Pr	59	2 8 18 21 8 2	931 / 3520	+3	140.90765	5.44×10^{-10}%
Neodymium	Nd	60	2 8 18 22 8 2	1021 / 3074	+3	144.24	2.70×10^{-9}%
Promethium	Pm	61	2 8 18 23 8 2	1042 / 3000	+3	[145]	
Samarium	Sm	62	2 8 18 24 8 2	1074 / 1794	+2+3	150.36	8.42×10^{-10}%
Europium	Eu	63	2 8 18 25 8 2	822 / 1596	+2+3	151.964	3.17×10^{-10}%
Gadolinium	Gd	64	2 8 18 25 9 2	1313 / 3273	+3	157.25	1.076×10^{-9}%
Terbium	Tb	65	2 8 18 27 8 2	1356 / 3230	+3	158.92534	1.97×10^{-10}%
Dysprosium	Dy	66	2 8 18 28 8 2	1412 / 2567	+3	162.50	1.286×10^{-9}%
Holmium	Ho	67	2 8 18 29 8 2	1474 / 2700	+3	164.93032	2.90×10^{-10}%
Erbium	Er	68	2 8 18 30 8 2	1529 / 2868	+3	167.26	8.18×10^{-10}%
Thulium	Tm	69	2 8 18 31 8 2	1545 / 1950	+3	168.93421	1.23×10^{-10}%
Ytterbium	Yb	70	2 8 18 32 8 2	819 / 1196	+2+3	173.04	8.08×10^{-10}%
Lutetium	Lu	71	2 8 18 32 9 2	1663 / 3402	+3	174.967	1.197×10^{-10}%

‡ Actinides

Element	Symbol	Z	Shells	M.P. / B.P.	Ox. States	At. Weight	Abundance
Thorium	Th	90	2 8 18 32 18 10 2	1750 / 4788	+4	232.0381	1.09×10^{-10}%
Protactinium	Pa	91	2 8 18 32 20 9 2	1572	+5+4	231.03588	
Uranium	U	92	2 8 18 32 21 9 2	1135 / 4131	+3+4+5+6	238.0289	2.94×10^{-11}%
Neptunium	Np	93	2 8 18 32 22 9 2	644	+3+4+5+6	[237]	
Plutonium	Pu	94	2 8 18 32 24 8 2	640 / 3228	+3+4+5+6	[244]	
Americium	Am	95	2 8 18 32 25 8 2	1176 / 2011	+3+4+5+6	[243]	
Curium	Cm	96	2 8 18 32 25 9 2	1345	+3	[247]	
Berkelium	Bk	97	2 8 18 32 27 8 2	1050	+3+4	[247]	
Californium	Cf	98	2 8 18 32 28 8 2	900	+3	[251]	
Einsteinium	Es	99	2 8 18 32 29 8 2	860	+3	[252]	
Fermium	Fm	100	2 8 18 32 30 8 2	1527	+3	[257]	
Mendelevium	Md	101	2 8 18 32 31 8 2	827	+2+3	[258]	
Nobelium	No	102	2 8 18 32 32 8 2	827	+2+3	[259]	
Lawrencium	Lr	103	2 8 18 32 32 9 2	1627	+3	[262]	

The new IUPAC Group format numbers the groups from 1 to 18. The numbering system used by the Chemical Abstracts Service (CAS) is given in parentheses. For elements that are not naturally abundant, the mass number of the longest-lived isotope is given in brackets. The abundances (atomic %) are based on meteorite and solar wind data. The melting point (M.P.), boiling point (B.P.), and critical point (C.P.)temperatures are given in Celsius. Sublimation and critical temperatures are indicated by s and t.

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PHYSICS HOMEWORK #171 HEAT & THERMODYNAMICS
TEMPERATURE, THERMAL EXPANSION & HEAT CAPACITY

1.Convert each of the following temperatures from Fahrenheit to Centigrade.
a. 35 ^oF b. -85 ^oF c. 220 ^oF d. 2550 ^oF e. 1520 ^oF

2. Convert each of the following temperatures from Centigrade to Fahrenheit.
a. -40 ^oC b. -273 ^oC c. 55 ^oC d. 110 ^oC e. 1220 ^oC

3. Convert each of the following to Kelvin temperatures.
a. 72 ^oF b. -40 ^oC c. -40 ^oF d. 110 ^oC e. 3500 ^oF

4. A piece of copper wire [$\alpha = 1.7 \times 10^{-5}/^oC$] has a length of exactly 50.00 meters when at a temperature of 12.0 ^oC.
a. What will be the increase in length of this wire if it's temperature is raised to 232 ^oC?

b. What will be the length of this wire if its temperature is raised to 232 ^oC?

5. A cylinder, which has a diameter of 0.99985 cm, is to be inserted into a hole in a steel plate [$\alpha = 1.2 \times 10^{-5}/^oC$]. The hole has a diameter of 0.99970 cm at 30.0 ^oC. To what temperature must the plate be heated in order for the cylinder to just barely fit?

6. At 20.0 ^oC a steel ball [$\alpha = 1.20 \times 10^{-5}/^oC$] has a diameter of 0.9000 cm, while the diameter of a hole in an Aluminum plate [$\alpha = 2.50 \times 10^{-5}/^oC$] is 0.8990 cm. At what single temperature will the ball just barely pass through the hole?

7. At 20.0 ^oC a steel ball [$\beta = 3.5 \times 10^{-5}/^oC$] has a diameter of 0.9000 cm. The temperature of this ball is increased to 55.0 ^oC. What will be the new volume for this ball?

8. A cube of Copper [$\rho = 8.9 \times 10^3$ kg/m^3], each edge of which is 3.50 cm., is floating in a container full of Mercury [$\rho = 13.6 \times 10^3$ kg/m^3]. Both are initially at a temperature of 20.0 ^oC.
a. What is the mass of the cube of Copper?
b. What is the weight of the cube of Copper?
c.What percentage of the copper block is submerged below the surface of the Mercury?
Both the Copper [β=5.6 x $10^{-5}/^oC$] and the Mercury [β=1.8 x $10^{-4}/^oC$] are heated to a temperature of 110 ^oC.
d. What percentage of the Copper is now submerged below the surface of the Mercury?

9. How much heat must be added to 120 grams of copper [c_p = 390 J/kg ^oC] in order to increase its temperature by 145 ^oC?

10. 750 Calories of heat are added to 250 grams of Lead [c_p = 0.031 cal/gm^oC] initially at a temperature of 28.0 ^oC. What will be the final temperature of this piece of Lead?

11. How much heat must be added to 65.0 ml of water in order to increase its temperature from 25 ^oC to 95 ^oC?

Answers to opposite side: 12. 6190 cal 13a. 32.2 ^oC b. 5340 J c. 5340 J 14. 34.0 ^oC
15a. 6250 cal b. 39850 cal c. 50,000 cal d. 269,000 cal e. 6250 cal f. 371,350 cal 16. 95,340 cal
17. 0.0 ^oC 18. 72.8 ^oC 19. 52.5 ^oC 20. 534 cal 21. 8420 cal 22. 6.38×10^{-21} J 23. 3020 m/s

PHYSICS HOMEWORK #172 HEAT & THERMODYNAMICS
SPECIFIC HEAT & HEAT CAPACITY

12. How much heat would be required to raise the temperature of 625 grams of Mercury [c_p = 0.033 cal/gm^{o}C] from room temperature [25.0 ^{o}C] to 325 ^{o}C?

13. A ball of Copper [c_p = 390 J/kg^{o}C] has a mass of 165 grams and is initially at a temperature of 115 ^{o}C. This ball is quickly inserted into an insulated cup containing 125 ml of water at a temperature of 22.0 ^{o}C.
   a. What will be the final, equilibrium temperature of the ball and the water?
   b. How much heat did the copper ball lose to the water?
   c. How much heat did the water gain from the ball?

14. A ball of Aluminum [c_p = 0.22 cal/gm^{o}C] has a mass of 82.0 grams and is initially at a temperature of 145 ^{o}C. This ball is quickly inserted into an insulated cup containing 330 ml of water at a temperature of 28.0 ^{o}C. What will be the final, equilibrium temperature of the ball and the water?

15. Assume that you have 500 gm of ice at -25.0 ^{o}C.
   a. How much heat would be required to raise the temperature of this ice to 0.0 ^{o}C?
   b. How much heat is required to melt this ice into water at 0.0 ^{o}C?
   c. How much heat would be required to bring this water to the boiling point 100 ^{o}C?
   d. How much heat would be required to convert this water into steam at 100 ^{o}C?
   e. How much heat would be required to raise the temperature of this steam to 125 ^{o}C?
   f. How much total heat is required to heat 500 gm of ice at -25.0 ^{o}C into 500 gm of steam at 125 ^{o}C?

INFORMATION FOR 15 & 16

ice	c_p = .50 cal/gm^{o}C
water	c_p = 1.0 cal/gm^{o}C
steam	c_p = .50 cal/gm^{o}C
L_{fusion}	= 79.7 cal/gm
L_{vapor}	= 538 cal/gm

16. How much heat would be required to convert 125 grams of ice at -40.0 ^{o}C into steam at 150 ^{o}C?

17. A ball of copper [c_p = .093 cal/gm^{o}C] has a mass of 125 grams and is at a temperature of 145 ^{o}C. This ball is placed into a calorimeter which contains 25.0 grams of ice at -35.0 ^{o}C. What will be the final temperature of the copper ball?

18. What will be the final temperature if 15.0 grams of steam at 125 ^{o}C is mixed with 55.0 grams of ice at -10.0 ^{o}C?

19. What will be the final temperature if 85.0 grams of water at 90.0 ^{o}C is mixed with 22.0 grams of ice at -25 ^{o}C?

20. How much heat would be required to melt a 35.0 gm piece of lead initially at 25.0 ^{o}C?
   [c_p = 0.031 cal/gm^{o}C, L_{fusion} = 5.9 cal/gm, melting point = 327 ^{o}C]

21. How much heat would be required to melt a 115 gm piece of silver initially at 28.0 ^{o}C?
   [c_p = 0.056 cal/gm^{o}C and L_{fusion} = 21.0 cal/gm, melting point = 961 ^{o}C]

22. What will be the average linear kinetic energy of the molecules in an ideal gas at 35.0 ^{o}C?

23. What will be the average RMS velocity of the molecules in Helium gas at 1200 ^{o}C?

Answers to opposite side: 1a. 1.70 ^{o}C b. -65.0 ^{o}C c. 104 ^{o}C d. 1400 ^{o}C e. 827 ^{o}C
2a. -40.0 ^{o}F b. -459 ^{o}F c. 131 ^{o}F d. 230 ^{o}F e. 2230 ^{o}F 3a. 295 ^{o}K b. 233 ^{o}K c. 233 ^{o}K d. 383 ^{o}K
3e. 2200 ^{o}K 4a. 0.19 m b. 50.19 m 5. 42.5 ^{o}C 6. 106 ^{o}C 7. 0.382 cm^3 8a. 0.382 kg b. 3.74 N c. 65.4 %
8d. 66.1 % 9. 6790 J 10. 125 ^{o}C 11. 4550 cal

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS