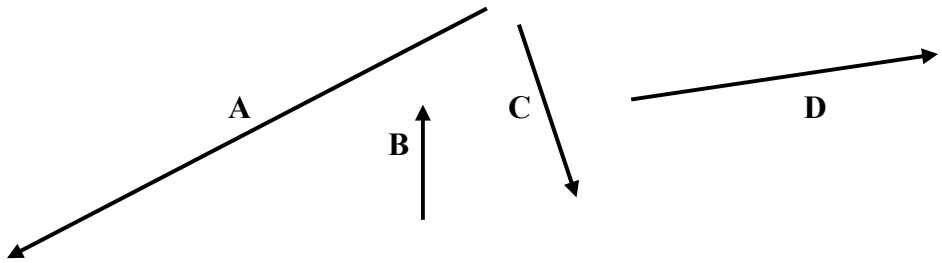
PHYSICS 12 VECTORS WORKSHEET

1. Label each quantity as being **vector** or **scalar**: distance, time, mass, area, energy, impulse, temperature, displacement, volume, speed, acceleration, momentum, work, velocity, force.

2. Sketch the following vectors on a separate piece of paper and draw the resultant:
   a) C+A
   b) D-B
   c) A+D+B
   d) B-(C+D)
   e) C-2B
   f) 3C-2D+A



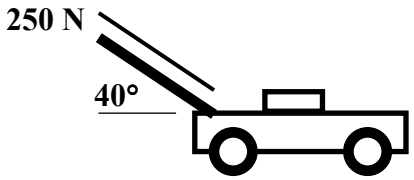
3. A jogger runs 300 m due west and then turns and runs 500 m due south.
   a) What is the total distance that she ran?
   b) What is her total displacement?
   c) If it takes her 135 s to complete the route, calculate her speed and velocity.

4. Two ropes are attached to a heavy object. The ropes are given to two strong physics students (is there any other kind?) with instructions for each to pull with 1000 N of force. Determine the resultant force if the two students pull:
   a) in the same direction east. b) in opposite directions. c) at right angles, south and east.

5. A force of 200 N due South and another force of 300 N due East each act on an object sinultaneously.
   a) Determine the resultant net force.
   b) A third force now acts on the object so that the net force is 0. Determine its magnitude and direction.

6. A pilot flies a plane 10 000 km in a direction 30° N of W. How much farther: a) north and b) west has he gone from his starting point?

7. An environmentally conscious physics student mows her lawn with a push mower, exerting a force of 250 N along the handle as shown. How much force is actually being used to push the mower along the ground?

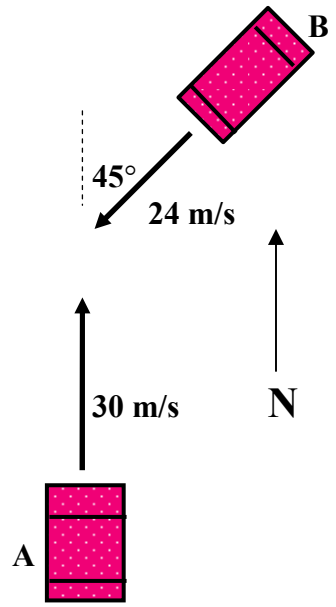


8. Phreddie Physics, while driving his turbo scooter, is exactly 5000 m due west from the line marking the eastern time zone. He travels at 30.0 m/s along a straight road that runs in a direction 30° N of E. How much time does it take Phreddie to get to the eastern time zone?

9. A boat heads due east across a 100. m-wide stream with a velocity of 20.0 m/s. The stream is flowing from north to south at a rate of 5.00 m/s.
   a) What is the resultant velocity of the boat?
   b) How long does it take the boat to reach the other side?
   c) How far downstream is the boat when it reaches the other side?
   d) In which direction should the boat head in order to end up directly across the stream?

10. A plane that is capable of travelling at 140 m/s wishes to travel due north from City A to City B, 500 km away, but encounters a constant crosswind that blows 25 m/s due west.
a) What must the plane's heading be in order to reach its destination?
b) Suppose the pilot has no navigational expertise and decides to aim straight for City B. How far west of City B will the plane end up?

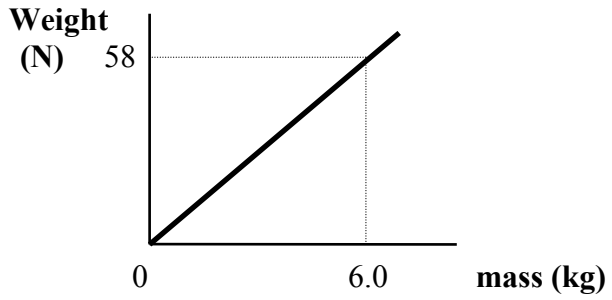
11. In a large parking lot, two vehicles head toward each other as shown to the right, with speeds and directions as indicated.
a) Relative to the driver in vehicle **A**, what is the velocity of vehicle **B**?
b) Relative to the driver in vehicle **B**, what is the velocity of vehicle **A**?



1. s,s,s,s,s,s,v,s,v,s,s,v,v,s,v,v 2. check with wise and humble instructor 3. a) 800 m b) 583 m @ 59° S of W c) 5.93 m/s, 4.32 m/s @ 59° S of W 4. a) 2.0×10^3 N, due E b) 0 N c) 1.4×10^3 N @ 45° S of E 5. a) 361 N @ 56.3° E of S b) 361 N @ 56.3° W of N (opposite direction to resultant) 6. a) 5000 km b) 8660 km 7. 192 N 8. 190 s 9. a) 21 m/s @ 14.0° S of E b) 4.9 s c) 24 m d) 14.5° N of E 10. a) 10° E of N b) 89 km 11. a) 50 m/s @ 20° W of S b) 50 m/s @ 20° E of N

PHYSICS 12 DYNAMIC EQUILIBRIUM WORKSHEET 1

1. a) Determine the slope of the graph to the right.
   b) What slope would you *expect* from this graph? Explain your answer.



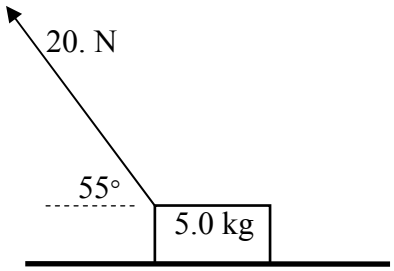
2. In an experiment, a student compares the normal force of a block of wood with the friction force that acts when the block is pulled along a countertop. She plots a graph of $\mathbf{F_f}$ vs. $\mathbf{F_N}$, draws a straight line through the points, and calculates the slope. What does this slope represent? Explain your answer.

3. A force of 18.0 N is used to pull a 2.0 kg block on a horizontal table where the coefficient of friction is 0.56. If the mass starts from rest,
   a) what is the acceleration?
   b) what is the velocity 2.6 s after the force starts acting?

4. A vertical rope is attached to a 35 kg mass. If the mass starts from rest and acquires an upward velocity of 1.6 m/s in 0.50 s,
   a) what is its acceleration?
   b) what is the tension in the rope?

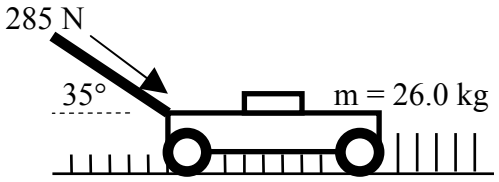
5. A 1.00×10^4 kg rocket is acted upon by an upward thrust of 1.18×10^5 N. If the rocket is 16.0 m tall, how much time is required for it to rise off the launching pad a distance equal to its own height?

6. A 55 kg student stands on a bathroom scale in an elevator of <u>total</u> mass 7.0×10^2 kg that is accelerating *upward* at 1.5 m/s^2.
   a) What is the tension in the cable that is pulling the elevator up?
   b) What would the student's apparent weight be in the elevator (i.e. the reading on the scale)?
   c) How would the student's apparent weight change if the elevator was accelerating *downward*?

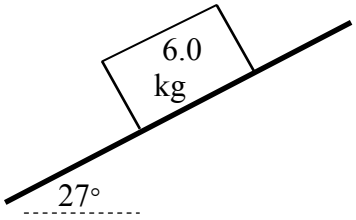
7. 

   Examine the diagram to the left.
   a) Find the normal force acting on the 5.0 kg block.
   b) If the block slides at constant speed,
      i) how large is the friction force?
      ii) what is the coefficient of friction between the block and the floor?

8. Groundskeeper Willie is out mowing the lawn. He pushes on the handle with a force as shown, and manages to accelerate the mower at a rate of 0.380 m/s^2. What is the coefficient of friction between mower and ground?

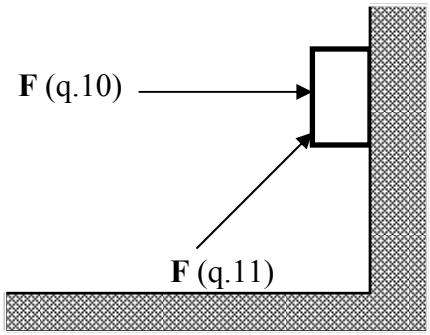


9. Examine the diagram to the right.
   a) Find the normal force acting on the 6.0 kg block.
   b) If the block slides downslope at constant speed,
      i) how large is the friction force?
      ii) what is the coefficient of friction between the block and the sloping surface?
   c) The slope angle is now increased to 40°. What is the acceleration of the system?



10. What *minimum* horizontal force **F** is needed to hold the 14.0 kg box stationary against the wall where the coefficient between box and surface is 0.19?

11. The wall is now scuffed with sandpaper so that the new coefficient of friction is 0.25. A new force of 310 N is applied on the box at an angle of 45° to the horizontal. Determine the magnitude and direction of the acceleration of the 14.0 kg box.



12. A 12 kg box is released from the top of an incline that is 5.0 m long and makes an angle of 40° to the horizontal. A 60. N friction force impedes the motion of the box.
   a) What will be the acceleration of the box
   b) How long will it take to reach the bottom of the incline?
   c) What is the coefficient of friction between the box and incline?

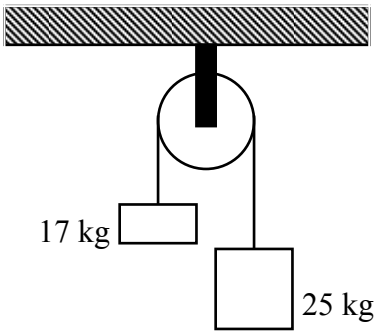
13. An inclined plane makes an angle of 30° with the horizontal. Neglecting friction, find the constant force, applied parallel to the incline, required to cause a 15 kg box to slide:
   a) up the incline with acceleration 1.2 m/s^2.
   b) down the incline with acceleration 1.2 m/s^2.

14. A 115 kg stationary crate is pulled by a horizontal force of 350 N. The coefficient of friction between crate and surface is as follows: $\mu_k = 0.170$; $\mu_s = 0.290$.
   a) Show that this force is large enough to begin moving the crate.
   b) Find the acceleration of the crate once it does move.
   c) If the force is now pulled at an angle of 12° to the horizontal, what is the new acceleration?

1. a) 9.7 N/kg b) 9.8 N/kg; eqn of line is $F_g = mg$ 2. slope = coefficient of friction; $F_f/F_N = \mu$ 3. a) 3.5 m/s^2 b) 9.1 m/s
4. a) 3.2 m/s^2 b) 460 N 5. 4.0 s 6. a) 7.9 x 10^3 N b) 6.2 x 10^2 N c) 4.6 x 10^2 N 7. a) 33 N b) i) 11.5 N; ii) 0.35
8. 0.53 9. a) 52 N b) i) 27 N; ii) 0.51 c) 2.5 m/s^2 10. 720 N 11. 1.9 m/s^2 12. a) 1.3 m/s^2 b) 2.8 s c) 0.67
13. a) 92 N b) 56 N 14. a) F_{Net} = 23.2 N, so movement <u>will</u> occur b) 1.38 m/s^2 c) 1.42 m/s^2

PHYSICS 12 DYNAMIC EQUILIBRIUM WORKSHEET 2

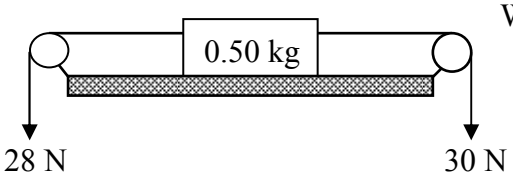
1.



In this diagram, a cord of negligible mass connects the two masses as shown. There is negligible friction.

a) At what rate will the masses accelerate?
b) What is the tension in the cord while the masses are accelerating?
c) If the pulley exerts a 9.6 N friction force, what is the acceleration now?

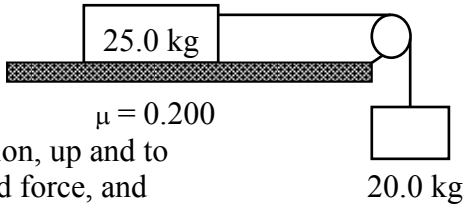
2.



Will the 0.50 kg block be in static equilibrium if:

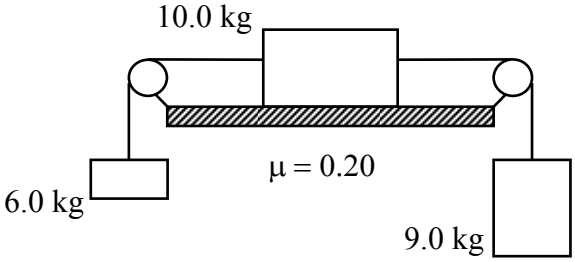
a) the coefficient of friction between block and table is 0.60?
b) the table is frictionless, but each pulley can exert a friction force of 0.5 N?

3.



a) Find the acceleration of the system to the right as well as the tension in the string.
b) The 25.0 kg mass is now pulled to the *left*, giving the connected system an acceleration, up and to the left, of 1.50 m/s^2. How large is this applied force, and what is the *new* tension in the cord?

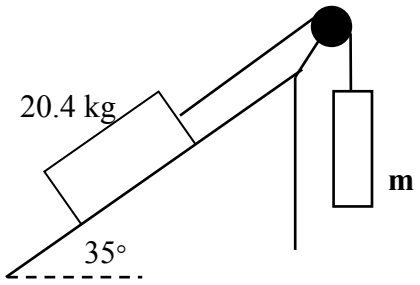
4. Three blocks with masses 6.0 kg, 9.0 kg and 10.0 kg are connected as shown below:



Calculate the following:

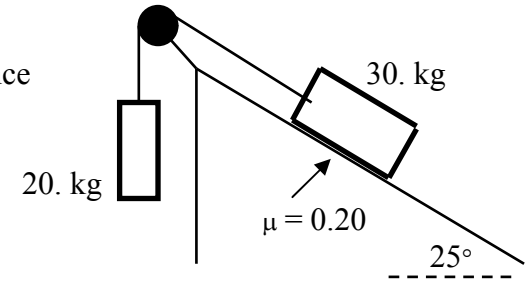
a) the acceleration of the system.
b) the tensions in each of the cords connecting the masses.

5. Examine the diagram to the right.

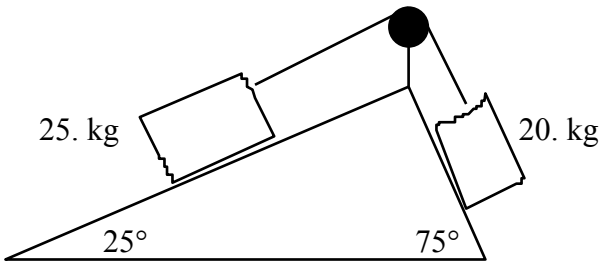


a) In the absence of friction, what mass **m** is needed to keep the system in static equilibrium?
b) Now assume there *is* friction. If the hanging mass **m** is increases to 30.0 kg, causing an acceleration of 1.63 m/s^2,
   i) what is the magnitude and direction of the friction force on the 20.4 kg block?
   ii) what is the coefficient of friction between block and inclined surface?

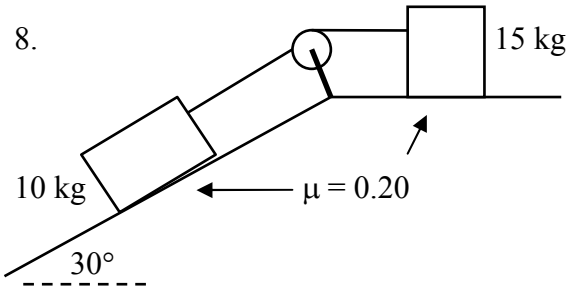
6. Examine the system to the left. Determine the acceleration of the system and the distance the 20.0 kg block will fall in 2.0 s starting from rest.



7. Determine the acceleration of the system and the direction of the 20. kg mass. There is negligible friction in the system.



8.

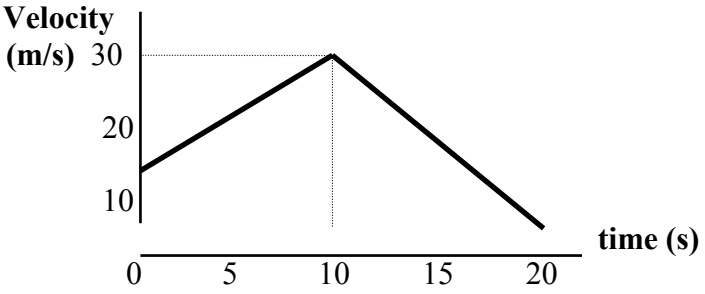


Find the acceleration in the system and the tension in the cord.

1. a) 1.9 m/s^2 b) 2.0 x 10^2 N c) 1.6 m/s^2 2. a) F_f = 2.9 N, ∴ yes b) F_f = 1.0 N, ∴ no 3. a) 3.27 m/s^2, 131 N b) F_{App} = 313 N, T = 226 N 4. a) 0.39 m/s^2 b) left: 61 N, right: 85 N 5. a) 11.7 kg b) i) 96.8 N downslope ii) 0.59 6. 0.37 m/s^2, 0.74 m 7. 1.9 m/s^2, downward 8. 0.10 m/s^2, 31 N

PHYSICS 12 PROJECTILE MOTION WORKSHEET 1

1. Determine the acceleration for the two segments shown as well as the total distance travelled in the 20 s period.



2. Normie Neutron rides a super-streamline go-cart from rest down a street that has an incline of 9.5°. The total vertical drop in elevation from the top of the street to bottom is 48 m.
   a) How far did the go-cart travel?
   b) Assuming negligible friction or wind resistance, how fast was Normie travelling when he reached the bottom of the street?
   c) The brakes are then applied, bringing the cart to a stop in 4.7 s. How far does the go-cart travel in that time?

3. Two physics students attempt to play vertical catch with a baseball. Student **A** holds the ball at street level, while student **B** is on an apartment balcony, 17.0 m up from the street.
   a) What is the *minimum* speed at which student **A** must throw the ball in order for student **B** to <u>just</u> be able to catch it?
   b) Student **A**, who has rippling biceps, actually tosses the ball straight up at 25.0 m/s.
      i) How high does the ball go?
      ii) At what times is student **B** able to catch the baseball?

4. Student **B**, still on the balcony *and* with the baseball, throws the ball straight up at 21.7 m/s.
   a) How long will student **A**, still at street level, have to wait until the ball reaches him?
   b) How fast will it be going?

5. A ball rolls with a speed of 2.0 m/s across a table top that is 1.0 m above the ground. Upon reaching the edge of the table, it follows a parabolic path to its landing spot on the floor. How far along the floor is this spot from the table?

6. A rescue pilot drops a survival kit while her plane is flying at an altitude of 2000 m with a forward velocity of 100 m/s. If air friction is ignored, how far in advance of the starving explorer's drop zone should she release the package?

7. A rifle is fired horizontally from 1.90 m above the ground. The bullet is found to have travelled 200 m. Ignoring air friction, at what speed must the bullet have been travelling as it left the barrel?

8. A ski jumper leaves the horizontal end of the ramp with a velocity of 25 m/s and lands 70 m from the base of the ramp. How high is the end of the ramp above the landing area?

9. An astronaut stands on the edge of a lunar crater 100 m deep and throws a half-eaten moon-pie

horizontally with a speed of 5.00 m/s. If gravity on the Moon is 1/6 that on Earth, what horizontal distance will the moon-pie travel before hitting the floor of the crater?

10. A ball is projected horizontally at 21 m/s from a point 40 m above the ground. Determine:

a) the horizontal distance travelled by the ball before hitting the ground.

b) the ball's instantaneous velocity as it hits the ground.

1. 2 m/s^2, -3 m/s^2, 350 m 2. a) 290 m b) 31 m/s c) 73 m 3. a) 18.3 m/s b) i) 31.9 m ii) after 0.81 s and 4.30 s
4. a) 5.11 s b) -28.4 m/s 5. 0.90 m 6. 2020 m 7. 321 m/s 8. 38 m 9. 55.5 m 10. a) 60 m b) 35 m/s at 53° down

PHYSICS 12 PROJECTILE MOTION WORKSHEET 2

1. A rock is thrown horizontally from a cliff at 25 m/s.
   a) What will its horizontal and vertical velocities be after 2.0 s?
   b) What will its velocity be (magnitude and direction) after 3.0 s?
   c) What will its displacement be after 3.0 s?

2. A ball is projected horizontally with velocity 'v' m/s from a point 245 m above the ground.
   a) How long does it take to reach the ground?
   b) If it strikes the ground 84 m horizontally from the point of projection, what is the value of **v**?

3. A boy standing on top of a hill throws a stone horizontally. The stone hits the ground at the foot of the hill 2.5 s later. How high is the hill?

4. A projectile is shot upward at a 60° angle with the ground at 65 m/s.
   a) What are the vertical and horizontal components of its velocity?
   b) How far has the projectile gone horizontally after 4.0 seconds?

5. The muzzle velocity of a projectile fired from a gun has an upward component of 49 m/s and a horizontal component of 60 m/s.
   a) What maximum height does the projectile reach?
   b) How far forward does it go? (assume a level surface)

6. A bullet is fired from a height of 45 m and hits the ground 2000 m away. With what velocity does the bullet leave the gun?

7. A projectile is fired at 12.5 m/s at an angle of 53.1° with the horizontal from a point 75.0 m above the ground.
   a) How long does it take to reach the ground?
   b) What maximum height does it reach?
   c) What horizontal distance does it travel before striking the ground?
   d) With what velocity does it strike the ground?

8. A projectile is fired at an angle θ above the horizontal from a point 80 m above the ground. If the vertical component of the initial velocity is 30 m/s upwards,
   a) how long does the projectile take to land?
   b) calculate the angle θ if the projectile travels 576 m.

9. A stone is projected upwards at 30° to the horizontal from a point 175 m above the ground, with initial velocity 20 m/s.
   a) How long does the stone take to reach the ground?
   b) What is the range of the projectile?
   c) What is the velocity of the object when it strikes the ground?

1 a) 25 m/s, 19.6 m/s down b) 38.6 m/s @ 49.6° down c) 87 m @ 30.5° down 2 a) 7.1 s b) 12 m/s 3. 31 m

4. a) 32.5 m/s, 56 m/s b) 130 m 5. a) 123 m b) 600 m 6. 660 m/s 7. a) 5.1 s b) 80 m c) 38 m d) 40.3 m/s @ 79.3° down 8. a) 8.1 s b) 23° 9. a) 7.1 s b) 122 m c) 62 m/s @ 74° down

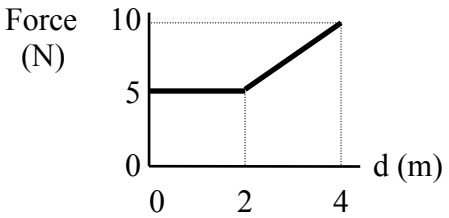
PHYSICS 12 WORK & ENERGY WORKSHEET 1

1. Find the kinetic energy of an electron when it is moving at one-tenth the speed of light.

2. Calculate the gain in kinetic energy of a cart that has an unbalanced force of 25 N acting through a distance of 6.8 m.

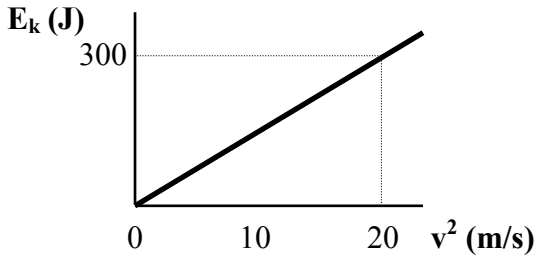
3. a) What is the kinetic energy of a mass of 10 kg moving at 5.0 m/s?
   b) If the mass were accelerated to this speed from rest by a force of 20 N, over what distance would this force act?

4. A 2.0 kg block of iron slides along a floor, decreasing its speed from 4.0 m/s to 1.0 m/s.
   a) How much work does the frictional resistance of the floor do on the block?
   b) If the reduction in velocity occurred over a distance of 10 m, what was the force of friction acting on the block?
   c) What impulse was delivered to the block?

5. 

   What is the amount of work done by the force, acting according to the graph, over the 4.0 m distance?

6. Examine the graph to the right, comparing an objects's speed with its kinetic energy.
   a) If the speed of the object represented by the graph is tripled, by what factor will the kinetic energy increase? Explain your answer.
   b) What is the mass of the object here?



7. The applied horizontal force which will just keep a 0.50 kg mass moving at a constant speed of 4.8 m/s along a rough horizontal surface is 0.30 N.
   a) What power was used to move the mass?
   b) The mass is now pulled from rest by a horizontal force of 0.80 N for 12 s What kinetic energy will it gain? Hint: first find the acceleration of the mass.
   c) Referring to (b), what power was used to accelerate the mass?

8. a) What work is done in raising a 3.0 kg mass from a 2.5 m high ledge to a 6.5 m high shelf?
   b) How much $\mathbf{E_p}$ does the mass now possess?

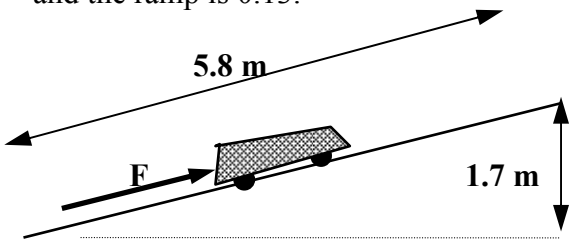
9. Describe what happens to the energy when work is done against:
   a) gravity b) inertia c) friction

10. An archer pulls the middle of his bowstring back a distance of 0.45 m. If the average force he exerts is 6.2 N, what potential energy is stored in the stretched string and bow?

11. A man pushes a 40 kg box from rest along a horizontal floor by exerting a force of 113 N horizontally. The friction force acting is 50 N. Calculate:

a) the unbalanced force.
b) the acceleration of the box.
c) the speed after 2.0 s.
d) the displacement after 2.0 s.
e) the $\mathbf{E_k}$ gained by the box in 2.0 s.
f) the energy lost as heat.
g) the total work done.
h) the total power used in 2.0 s.

12. A 45 kg cart is pushed up a ramp a length of 5.8 m from rest, attaining a speed of 2.6 m/s at the top of the ramp, which is 1.7 m high. The coefficient of friction between the cart and the ramp is 0.13.



a) Determine the work done against:
i) gravity. ii) inertia. iii) friction.

b) What force was used to push the cart?

c) What power was used to move the cart?
Hint: how long did this work take?

13. Solve for **12(b)** in the previous question by finding the acceleration and using a free-body diagram to analyze forces acting on the cart.

14. A 180 kg crate is lifted 23.0 m vertically by a single cable, accelerating upward at a rate of 1.47 m/s^2, starting from rest. Determine the following:

a) the tension in the cable.
b) the total work done on the crate. (Hint: what is the applied force here?)
c) the work done against inertia.
d) the final speed of the crate.

1. 4.1 x 10^{-16} J 2. 170 J 3. a) 125 J b) 6.25 m 4. a) 15 J b) 1.5 N c) 6.0 Ns 5. 25 J 6. a) 9x; $E_k \alpha v^2$ b) 30 kg
7. a) 1.4 W b) 36 J c) 3.0 W 8. a) 120 J b) 190 J 9. converts to: a) E_p b) E_k c) heat 10. 2.8 J
11. a) 63 N b) 1.6 m/s^2 c) 3.2 m/s d) 3.2 m e) 200 J f) 160 J g) 360 J h) 180 W
12. a) i) 750 J ii) 150 J iii) 320 J b) 210 N c) 271 J 13. 210 N
14. a) 2.03 x 10^3 N b) 4.67 x 10^4 J c) 6.09 x 10^3 J d) 8.22 m/s

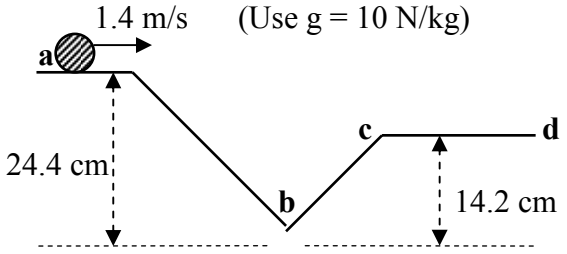
PHYSICS 12 WORK & ENERGY WORKSHEET 2

NOTE: Assume 100% efficiency for questions 1-7 only.

1. A 250 g projectile is fired directly upwards from a cannon and rises to a height of 150 m.
   a) What is its E_p at the top of its flight?
   b) With what E_k did it leave the cannon?
   c) What was its kinetic energy at the moment it reached an altitude of 100 m?

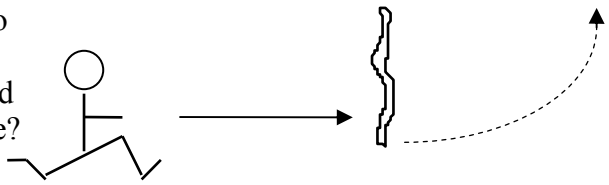
2. A projectile is fired from the ground and reaches a maximum height of 16.8 m. If its speed at the maximum height is 8.0 m/s, with what speed will it hit the ground?

3. (Use g = 10 N/kg)

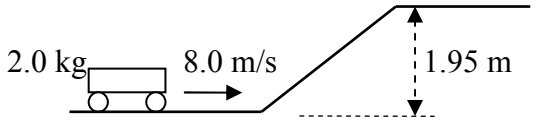


   a) Section **abc** is a frictionless track. What will the ball's speed be at **c**?
   b) Section **cd** exerts a constant friction force equal to 1/8 the weight of the ball. How far will the ball travel before it comes to a stop? (Hint: use $\mathbf{F_{Net} = F_f}$ to find acceleration)

4. Tarzan wishes to use a light vine to swing from the ground onto a tree branch 3.5 m high. How fast should he be going when he grabs the vine?



5.



   Calculate the speed of the cart in the diagram once it reaches the higher level of the frictionless track.

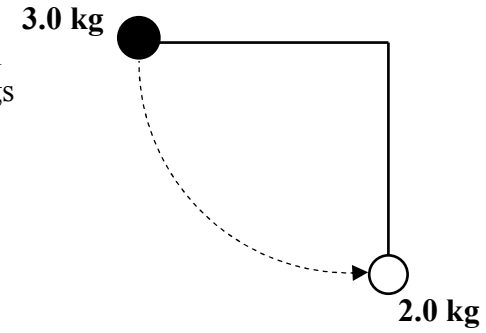
6. A 0.20 kg stone falls from a height of 50 m to a point 40 m above the ground. Neglecting wind resistance,
   a) How much E_p has it lost? b) How much E_k has it gained?

7. A mass of 10.0 kg is dropped from a height of 10 m. Neglecting wind resistance, determine its E_p, E_k and *total* energy when it is: a) 10.0 m b) 8.0 m c) 5.0 m d) 0 m from the ground.

8. A 10 kg pendulum mass is held, then released from a height of 0.35 m. At the bottom of its swing the speed of the pendulum is measured as 2.4 m/s.
   a) What is the total energy of the pendulum before it is released?
   b) How much kinetic energy does the pendulum have at the bottom of the swing?
   c) How much energy was lost to heat in this situation?
   d) How efficient was the pendulum at converting its potential energy to kinetic energy?
   e) If the pendulum was 100% efficient, how fast *would* the mass have been moving at the bottom of the swing?

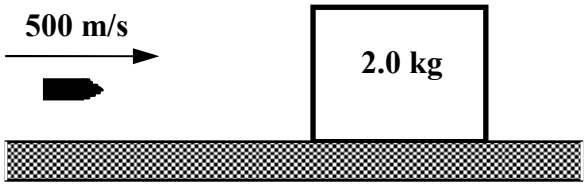
9. A 2.0 kg mass moving to the right at 2.0 m/s collides head-on with a 1.0 kg mass initially at rest. After the collision the 2.0 kg mass is moving to the right at 1.0 m/s. Calculate the loss in energy of the system to heat. (Hint: use cons. of momentum first to find speed <u>after</u> the collision)

10. Two compact masses of 2.0 and 3.0 kg each are suspended from the same point by strings each 4.0 m long. The 3.0 kg mass is pulled back until its string is horizontal, and then released. When it collides with the 2.0 kg mass, the two stick together.



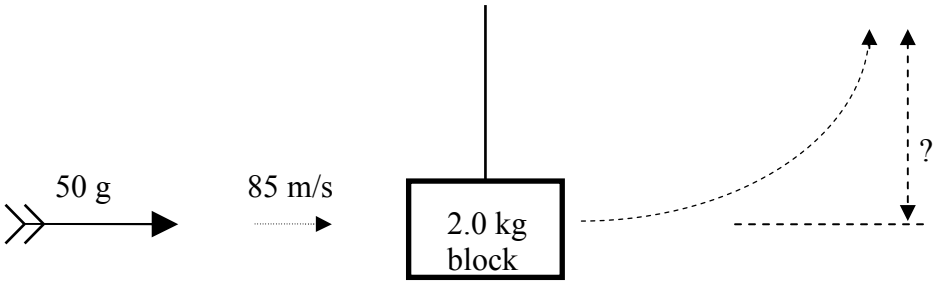
a) Calculate the vertical height to which the combined masses will rise.
b) How much kinetic energy is lost in the collision?

11. A 4.0 g bullet, moving horizontally with a speed of 500 m/s, strikes a motionless 2.0 kg wooden block sitting on a rough, horizontal surface. The bullet passes through the block in a negligible time interval, emerging with a speed of 100 m/s and causing the block to slide 0.40 m along the surface before coming to rest.



a) Determine the speed of the block just after the bullet exits.
b) Calculate the maximum kinetic energy of the block.
c) Find the average frictional force stopping the block.
d) Find the work done on the bullet by the block to slow it down.
e) Explain why your answers to (b) and (d) are not equal.

12.

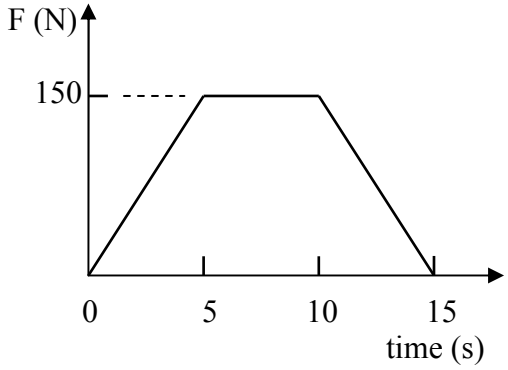


Examine the diagram. If the arrow embeds in the hanging wood block, how high will the block and arrow rise?

1. a) 368 J b) 368 J c) 123 J 2. 19.8 m/s 3. a) 2.0 m/s b) 1.6 m 4. 8.3 m/s 5. 5.1 m/s 6. a) 20 J b) 20 J 7. a) 980, 0, 980 b) 784, 196, 980 c) 490, 490, 980 d) 0, 980, 980 8. a) 34 J b) 29 J c) 5 J d) 85% e) 2.6 m/s 9. 1.0 J 10. a) 1.4 m b) 47 J 11. a) 0.80 m/s b) 0.64 J c) -1.6 N d) -480 J e) collision not 100% elastic; loss of energy to heat, sound etc. 12. 0.22 m

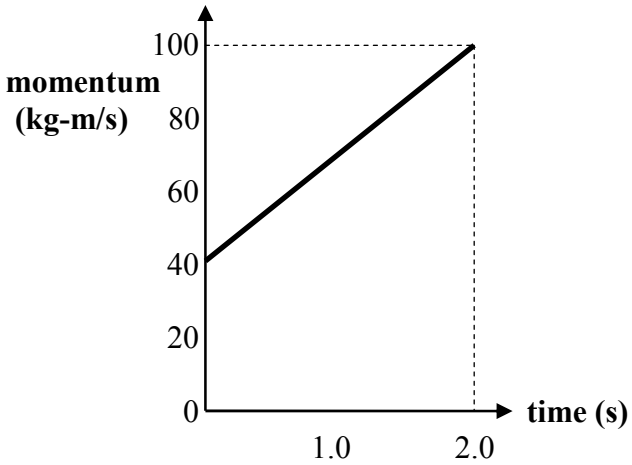
PHYSICS 12 IMPULSE & MOMENTUM WORKSHEET 1

1. A 75 kg cart that is travelling at a constant speed has a force applied to it which brings the cart to a stop in 15 s. A Force vs. Time graph of this event is shown to the right:



a) What impulse was delivered to the cart?
b) At what speed was the cart moving when the force was applied?
c) If the applied force was reduced by 1/3 for the duration of the event, how much time would be taken to bring the cart to a stop?

2. The motion of another cart of mass 25 kg is depicted in a momentum-time graph.



a) Determine the impulse delivered to the 40 kg cart.
b) What overall force acted on the cart?
c) What was the change in velocity of the cart?

3. A 3.8 kg object was accelerated from 12 m/s to 19 m/s by a force of 16 N.
a) What impulse acted on the object?
b) How long did the force act?

4. A sandbag stops a 0.012 kg bullet which was travelling at 860 m/s. The bullet penetrated a distance of 0.24 m into the sand.
a) What was the original momentum of the bullet?
b) How long did it take to stop the bullet?
c) What average force acted on the bullet?

5. A smallish physics student of mass 36.0 kg slides across smooth ice at 6.80 m/s. She then slides onto rough ice for 2.40 s, changing her velocity to 2.20 m/s.
a) What is the momentum of the student as she slides across the smooth ice?
b) What is the size and direction of the force acting on the student after hitting the rough ice?

6. A 45 kg crash test dummie travels without a seat belt in a test car at 16 m/s. When the car is deliberately run into a wall, the dummie is stopped by the windshield in a distance of 0.024 m.
   a) How much time is taken for the dummie to stop?
   b) What force does the windshield exert on the dummie?
   c) The identical test is performed on a second dummie (same mass), but with a seat belt fastened that causes this dummie to stop (without hitting the windshield) in a distance of 0.68 m. What force acts on this second dummie?
   d) What is the ratio of force found in (b) to that found in (c)?

7. A 60 g bullet is fired from a 5.0 kg gun with a speed of 600 m/s. Find the gun's recoil speed.

8. If a 1.0 kg ball travelling south at 7.0 m/s collides with a 2.0 kg ball travelling in the same direction at 3.0 m/s, the velocity of the 2.0 kg ball is increased to 4.5 m/s in the original direction. What happens to the 1.0 kg ball?

9. A mini car of mass 600 kg is involved in a head-on collision with a 3000 kg truck travelling at 15 m/s towards it. The mini is thrown onto the hood of the truck (don't ask how) which continues on at 5.0 m/s in the original direction. How fast was the mini moving?

10. A proton (mass = 1.67×10^{-27} kg) travelling at 10^7 m/s collides with a stationary particle and bounces back at 6.0×10^6 m/s. If the particle moves forward at 4.0×10^6 m/s, what is its mass?

11. A small car, mass 500 kg, fails to stop at a 'T' junction until it is in the middle of the road. It is then struck by a 1000 kg sports car, with the two cars locking together. The skid marks stretch for 40 m. Assuming that the frictional force on the two vehicles was a constant 7.5×10^3 N, find:
   a) the acceleration of the wreckage. (Hint: the net force *after* the collision = ?)
   b) the speed of the two cars <u>just</u> after impact.
   c) the speed of the sports car <u>just</u> before impact.

1. a) 1500 N•s b) 20 m/s c) 45 s 2. a) 60 N•s b) 30 N c) 2.4 m/s 3. a) 27 N•s b) 1.7 s 4. a) 10 kg•m/s b) 5.6×10^{-4} s c) 1.8×10^4 N 5. a) 245 kg•m/s b) 69 N backwards 6. a) 0.0030 s b) 2.4×10^5 N c) 8470 N d) about 28:1 7. 7.2 m/s 8. vel. reduces to 4.0 m/s <u>south</u> 9. 45 m/s 10. 6.68×10^{-27} kg
11. a) -5.0 m/s^2 b) 20 m/s c) 30 m/s

PHYSICS 12 IMPULSE & MOMENTUM WORKSHEET 2

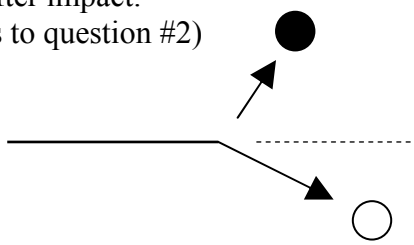
1. A 95.0 kg football player carrying the ball and travelling at 8.50 m/s due South is pursued and tackled by a 110 kg defensive lineman who was approaching at 9.10 m/s from 60° E of N. Assuming that the lineman holds on, what is the resultant momentum and velocity of the two players immediately after the tackle is made?

2. A 0.050 kg bullet, fired at 320 m/s due East, collides with a target 2.0 kg steel weight and deflects off at 260 m/s, 40° S of E. Determine the momentum and velocity of the steel weight directly after the collision.

3. Two cars approaching each other collide at right angles and stick together. Car **A** has a mass of 1200 kg and was travelling due East at 15 m/s, while Car **B** has a mass of 1500 kg and was travelling due North. After the collision, they move off at 64° N of E. Calculate:
   a) their momentum and common velocity after the collision.
   b) the velocity of Car **B** *before* the collision.

4. A frictionless projectile puck of mass 0.80 kg travels at 4.0 m/s due South and strikes obliquely a stationary target puck of equal mass. After the collision, the projectile puck moves at 2.0 m/s in a direction that is 60° W of S.
   a) Find the momentum and velocity of the original target puck after the collision.
   b) What angle would you <u>*expect*</u> from two objects that collide obliquely? Is this the case here?
   c) Was mass needed to determine the velocity in thisproblem? Explain.

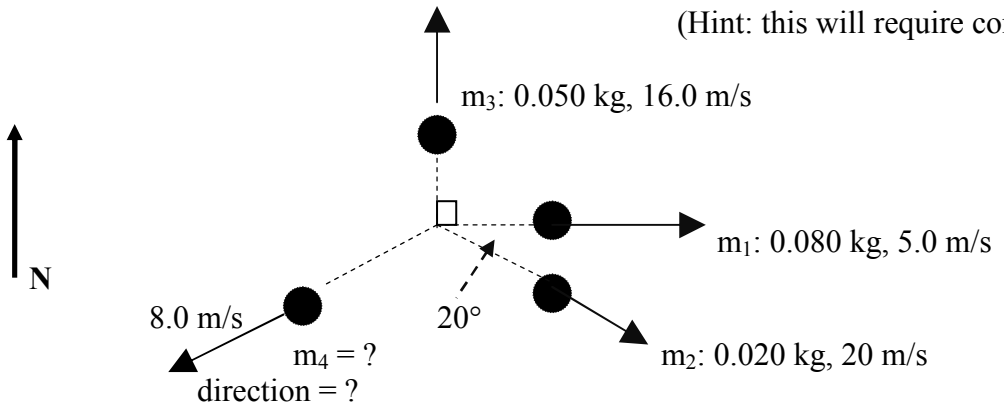
5. A billiard ball collides obliquely with another of equal size and mass. After impact, the two balls move off, with the incident ball travelling at 8.0 cm/s at 30° to its original path. Find the velocity of the target ball after impact.
   (Hint: consider the answers to question #2)



6. A 0.10 kg rubber ball traveling at 20. m/s strikes a vertical wall at 45° and rebounds off with no loss of speed.
   a) Sketch the momentum vectors in a diagram, showing the vectors $\mathbf{p_i}$, $\mathbf{p_f}$ and $\mathbf{\Delta p}$ clearly.
   b) Find the total change in momentum of the ball, in magnitude and direction.

7. A firecracker explodes into 4 pieces and they move as shown in the diagram. Find the mass of the piece m_4 and the direction in which it travels if its velocity is 8.0 m/s.

(Hint: this will require components)



1. 920 kg•m/s, 4.5 m/s @ 70° E of S 2. 5.1 m/s @ 55° N of E 3. a) 4.1 x 10^4 kg•m/s, 15 m/s b) 25 m/s
4. a) 2.8 kg•m/s, 3.5 m/s @ 30° E of S b) 90°; yes, 30° + 60° = 90° here c) no; if all masses are equal, 'm' cancels out
5. 4.6 cm/s @ 60° from original line of motion 6. b) 2.8 kg•m/s straight back, ⊥ to wall 7. 0.13 kg @ 41° S of W