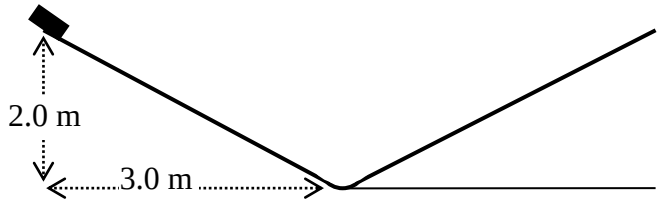
Energy & Momentum

1. A 200 g box is moving on a table with a velocity of 23 m/s. There is a coefficient of friction of 0.032 between the table and the box. A force pushes the box for 1.2 m which increases its velocity to 28 m/s. Calculate the force that was applied.
[21 N]

2. A woman is pulling a suitcase with a force of 100 N. The strap makes an angle of 30^o from the horizontal. If the coefficient of friction is 0.20 and her suitcase is 20 kg, how much work is the woman doing if she manages to pull the suitcase for 10 m?
[866 J]

3. A 1000 kg car travelling at 10.0 m/s is at the top of a 50.0 m high hill with a 30^o slope. If the car coasts down the hill, what will be its speed at the bottom if the coefficient of friction is 0.20? **[27 m/s]**

4. A 2.0 kg block is allowed to slide along a ramp as shown. The coefficient of kinetic friction is 0.30. If the block is released from rest at a height of 2.0 m above the ground, calculate the distance covered along the second ramp as the block comes to a stop. Assume both ramps have the same angles. Ignore the arc length at the bottom (assume a straight path). **[1.36 m]**



5. A pinball machine has a spring with a spring constant of 125 N/m. A 65 g ball is placed on the spring and the spring is compressed 5.0 cm. How far along the playing surface makes a 15^o angle with the horizontal? Ignore friction. **[0.95 m]**

6. A 250 g rock is thrown with a velocity of 15 m/s [50^o from the horizontal] from the top of a 10.0 m tower.
   a) Calculate the speed when the rock is at the maximum height. **[9.6 m/s]**
   b) Calculate the maximum height. **[6.8 m]**
   c) Calculate the velocity when the rock reaches the ground.
[20.5 m/s [62^o from the horizontal]]

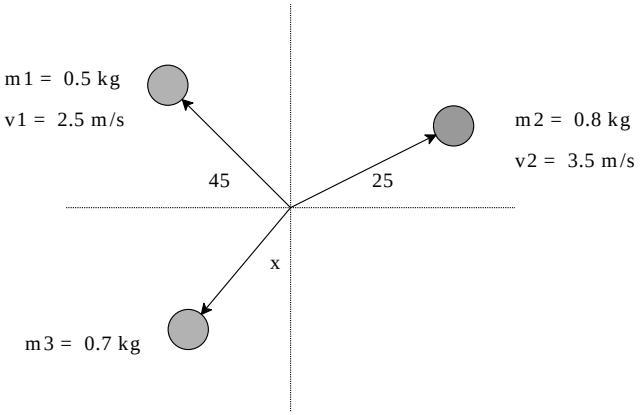
7. A 3.0 kg ball is dropped from a height of 0.80 m onto a vertical spring of force constant 1200 N/m. What is the maximum compression of the spring? **[22 cm]**

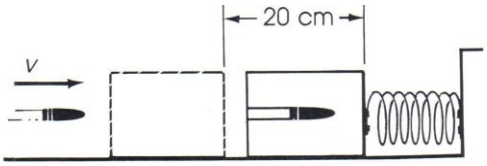
8. The spring in a toy gun has a force constant of 500 N/m. It is compressed 5.0 cm and a ball of mass 10 g is placed next to it in the barrel. Determine the muzzle velocity if an average retarding force of 0.80 N acts on the ball and the barrel is 0.25 m long.
[9.2 m/s]

9. A shell of mass 8.0 leaves the muzzle of a cannon with a horizontal velocity of 600 m/s. Find the recoil velocity of the cannon, if its mass is 500 kg. **[9.6 m/s back]**

10. A 500 g puck sliding across the ice at 20 m/s [E] is struck by a stick and moves at 30 m/s [N30^{o}W]. What is the impulse of the puck? **[22 kgm/s [W37º]]**

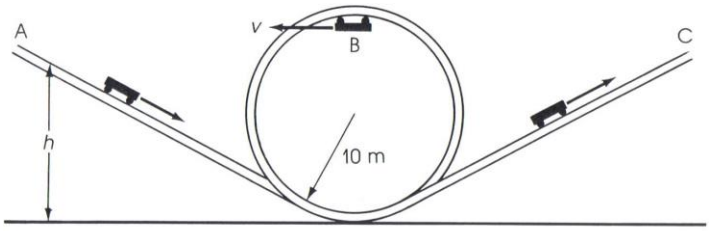
11. In an explosion, three pieces of an object fly off in the directions shown in the diagram below. Calculate the final speed and direction of the third piece. The total momentum of the system before the explosion is 0 kgm/s. **[3.8 m/s [W51º]]**





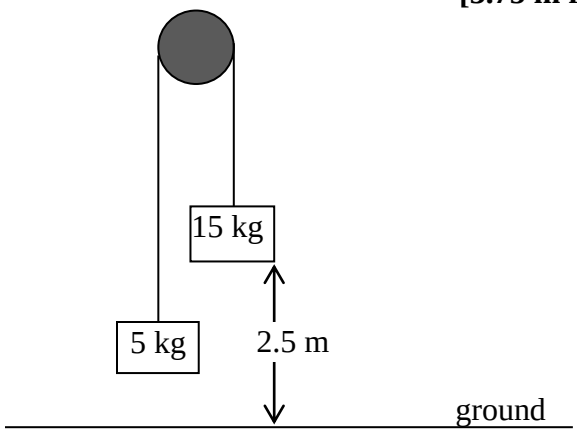
12. A rifle bullet of mass 10.0 g strikes and becomes embedded in a wooden block of mass 490 g, which is at rest on a horizontal frictionless surface and its attached to a spring bumper as shown above. The impact compresses the spring, whose force constant is 100 N/m, by 20 cm.
    a) What is the initial velocity of the bullet? **[400 m/s →]**
    b) Explain why the maximum potential energy of the spring will be different than the initial kinetic energy of the bullet? **[energy used to embed the bullet]**

13. A new amusement park ride is shown in the above below. The mass of the small car, including its contents is 400 kg and the radius of the loop is 10 m. Assume that the track is frictionless and that no mechanism holds the car in contact with the track,
    a) From what minimum height, h, must the car start from rest in order to make it around the loop? **[25 m]**
    b) If **only** the loop part of the track had a total frictional force of 200N, from what minimum height must the car start from rest? **[27 m]**



14. Two masses 5.00 kg and 15.00 kg are attached to a VERY LONG string with negligible mass and strung over frictionless pulley. The two masses start from rest. The 15.00 kg mass is 2.5 above the ground. What will be the maximum height of the 5.00 kg block when the masses are released from rest?

[3.75 m from its original position]



15. A skier starts from rest at the top of the hill and slides down the hill which has an incline of 18^{o}. The hill is 80 m long and then levels off horizontally at the base of the hill. If the coefficient of kinetic friction at a constant 0.080, how far can the skier glide before coming to a stop? **[233 m]**

16. What is the final velocity of a 40 kg child sitting on a 40 kg wagon at rest when it is pushed with a force of 75 N for 2.0 s. Do **NOT** use kinematics. **[3.75 m/s →]**

17. What is the average force to stop a 1 tonne car in 1.5 seconds if the car is moving at 79.2 km/h? Do **NOT** use kinematics. **[15 kN ←]**

18. Calculate the recoil velocity of a rifle of mass 5.0 kg after it shoots a 50 g bullet at a speed of 300 m/s? **[3.0 m/s ←]**

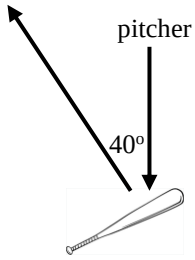
19. A 140 g baseball traveling 30 m/s moves a catcher's glove backwards 15 cm when the ball is caught. What is the average force exerted on the ball? **[420 N]**

20. A skier traveling at 13.8 m/s reaches the foot of a steady upward 20^{o} incline and glides 11.4 m up along this slope before coming to rest. What is the average coefficient of friction? **[0.543]**

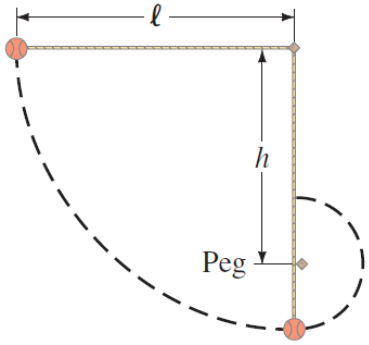
21. A bomb of mass 1.20 kg is at rest explodes into 3 pieces. A 0.50 kg piece flies off horizontally north at 3.0 m/s. A 0.30 kg pieces flies off horizontally southwest at 4.0 m/s. What is the velocity of the 3rd piece? **[2.8 m/s [E37^{o}S]]**

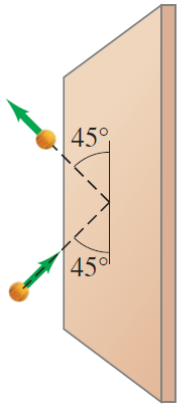
22. A batter strikes a baseball moving horizontally towards him at 15 m/s. The ball leaves the bat horizontally at 24 m/s, 40° to the left of a line from the plate to the pitcher. The ball is in contact with the bat for 0.01 s. What is the average acceleration of the ball while being hit by the bat? See diagram below.

[3.7 x 10^3 m/s^2 [25° L of pitcher]



23. A ball is attached to a horizontal string of length L whose other end is fixed as shown below. A peg is located a distance h directly below the point of attachment of the string. If h = 0.75 L, what will be the speed of the ball when it reaches the top of the its circular path about the peg? **[$\sqrt{gL}$]**





24. A tennis ball of mass *m* and speed *v* strikes a wall at a 45° angle and rebounds with the same speed at 45°. What is the impulse given by the wall? See diagram above.

[2*mv*sin45°[outward]]

Elastic and Inelastic Collisions

1. A 2.4 kg mass moving in a straight line with velocity 10 m/s makes a head-on collision with another mass of 3.6 kg, which is initially at rest. The collision is cushioned by a perfectly elastic bumper. What percent of the 2.4 kg mass's kinetic energy is transferred to the 3.6 kg by the collision? **[96%]**

2. A 2.0 kg trolley moving at 3.0 m/s [E] collides head-on with a 1.0 kg trolley moving 2.0 m/s [W]. After the collision, the 2.0 kg trolley has a velocity of 1.0 m/s [E]. Is the collision elastic or inelastic? **[Inelastic]**

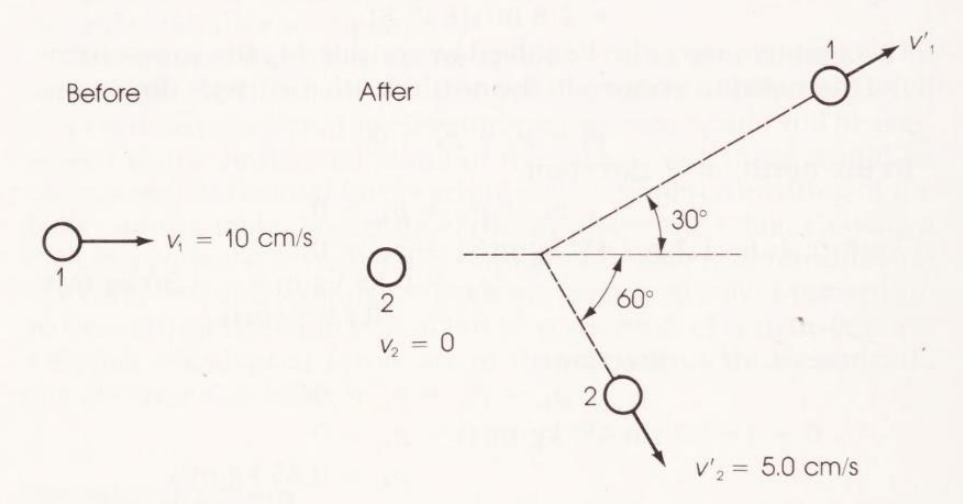
3. Two air tracks gliders of mass 300 g and 200 g are moving towards each other in the opposite directions with speed of 50 cm/s and 100 cm/s, respectively. If the collision was elastic, what are the final speeds of each glider? **[70 cm/s, 80 cm/s]**

4. A 2.4 kg dynamic cart is moving to the right at 1.5 m/s, with a linear elastic spring attached to its front end, when it collides head-on with a stationary car of mass 3.6 kg.
   a) Assuming the collision was elastic, what were the final velocities of the carts? **[0.30 m/s ←, 1.2 m/s →]**
   b) What is the spring constant if the maximum compression of the spring during the collision is 12 cm? **[225 N/m]**

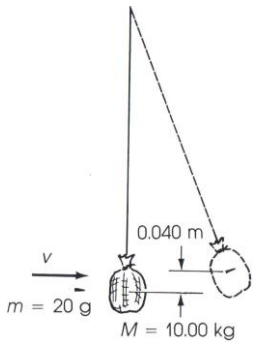
5. Two trolleys of mass 1.2 kg and 4.8 kg are at rest with a compressed spring between them, held that way by a string tied around both. When the string is cut, the trolleys spring apart. If the force constant of the spring is 2400 N/m, by how much must it have been compress in order that the 4.8 kg cart move off at 2.0 m/s?

6. A loaded railway car of mass 6000 kg is rolling to the right at 2.0 m/s when it collides and couples with an empty freight car of mass 3000 kg, rolling to the left on the same track at 3.0 m/s. What is the final velocity of the pair after the collision? **[0.33 m/s →]**

7. The diagram below shows two identical balls before and after a collision. Find the final velocity of ball 1. **[8.7 cm/s]**

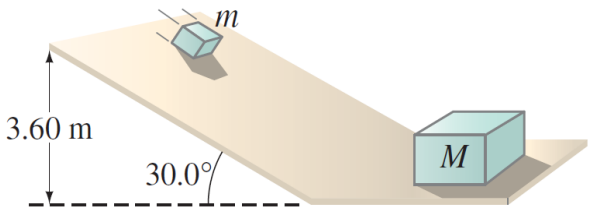


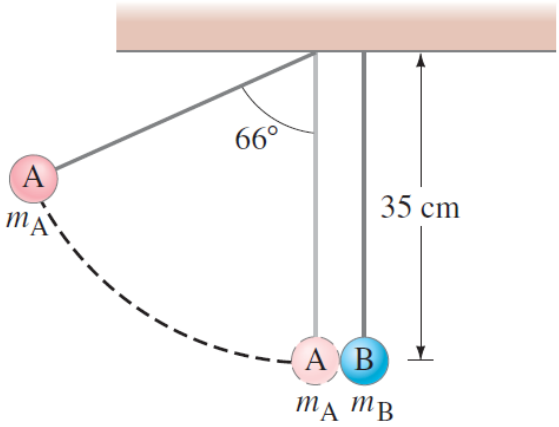
8. A bullet's speed may be determined by firing it into a sandbag pendulum and measuring the vertical height to which the pendulum rises as shown above. Assuming the 20 g bullet stays in the 10 kg sandbag, what is the speed of the bullet before it hits the sandbag? **[444 m/s]**



9. A 1.5 kg hockey puck sliding west across the ice at 6.0 m/s collides with a 2.0 kg stone which is initially at rest. After the collision the stone moves off at 3.2 m/s [W25°N] . What is the velocity of the puck after the collision? **[2.8 m/s [W40°S]]**

10. A block of mass 1.50 kg slides down a 30.0° incline which is 3.60 m high. At the bottom, it strikes a block of mass 6.00 kg which is at rest on a horizontal surface, (Assume a smooth transition at the bottom of the incline.) If the collision is elastic, and friction can be ignored, determine how far back up the incline the smaller mass will go. **[2.6 m]**





11. Two balls, of masses m_A = 45 g and m_B = 65 g are suspended as shown above. The lighter ball is pulled away to a 66° angle with the vertical and released. What will be the maximum height of each ball after the elastic collision.

[h_A = 1.0 mm, h_B = 2.0 cm]