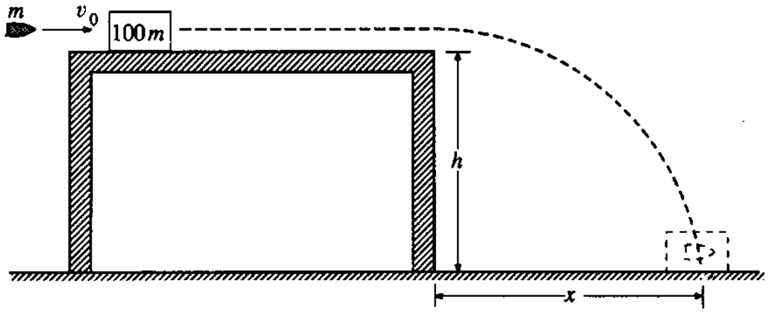
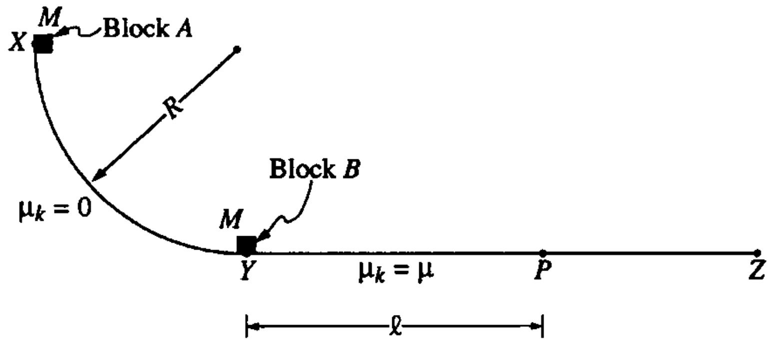



1. A bullet of mass m is moving horizontally with speed $v_o$ when it hits a block of mass 100m that is at rest on a horizontal frictionless table, as shown above. The surface of the table is a height h above the floor. After the impact the bullet and the block slide off the table and hit the floor a distance x from the edge of the table. Derive expressions for the following quantities in terms of m, h, $v_o$, and appropriate constants:

a. the speed of the block as it leaves the table
b. the change in kinetic energy of the bullet-block system during impact
c. the distance x

Suppose that the bullet passes through the block instead of remaining in it.

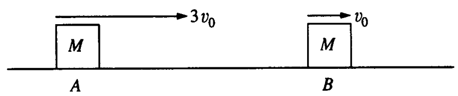
d. State whether the time required for the block to reach the floor from the edge of the table would now be greater, less, or the same. Justify your answer.
e. State whether the distance x for the block would now be greater, less, or the same. Justify your answer.




Side View

2. A track consists of a frictionless arc XY, which is a quarter-circle of radius R, and a rough horizontal section YZ. Block A of mass M is released from rest at point X, slides down the curved section of the track, and collides instantaneously and inelastically with identical block B at point Y. The two blocks move together to the right, sliding past point P, which is a distance *l* from point Y. The coefficient of kinetic friction between the blocks and the horizontal part of the track is $\mu$. Express your answers in terms of M, *l*, $\mu$, R, and g.

a. Determine the speed of block A just before it hits block B.
b. Determine the speed of the combined blocks immediately after the collision.
c. Determine the amount of kinetic energy lost due to the collision.
d. Determine the additional thermal energy that is generated as the blocks move from Y to P
e. Suppose the blocks had a greater mass. Give one reason why they might be expected to slide a lesser distance before stopping. Give one reason why they might be expected to slide a greater distance before stopping.

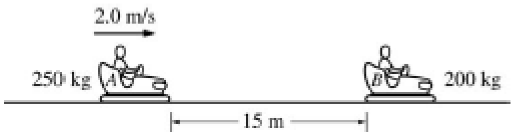



3. Two identical objects A and B of mass M move on a one-dimensional, horizontal air track. Object B initially moves to the right with speed $v_o$. Object A initially moves to the right with speed $3v_o$, so that it collides with object B. Friction is negligible. Express your answers to the following in terms of M and $v_o$.

a. Determine the total momentum of the system of the two objects.
b. A student predicts that the collision will be totally inelastic (the objects stick together on collision). Assuming this is true, determine the following for the two objects immediately after the collision.
   i. The speed
   ii. The direction of motion (left or right)

When the experiment is performed, the student is surprised to observe that the objects separate after the collision and that object B subsequently moves to the right with a speed $2.5v_o$ .

c. Determine the following for object A immediately after the collision.
   i. The speed
   ii. The direction of motion (left or right)
d. Determine the kinetic energy dissipated in the actual experiment.




4. Several Students are riding in bumper cars at an amusement park. The combined mass of car A and its occupants is 250 kg. The combined mass of car B and its occupants is 200 kg. Car A is 15m away from car B and moving to the right at 2.0m/s, as shown, when the driver decides to bump into car B, which is at rest.

a) Car A accelerates at 1.5 m/sec$^2$ to a speed of 5.0 m/sec and then continues at a constant velocity until it strikes Car B. Calculate the total time for car A to travel the 15 meters.

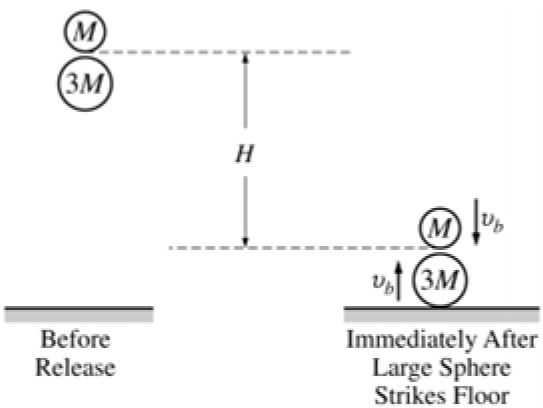
b) After the collision, Car B moves to the right at a speed of 4.8 m/sec.

i. Calculate the speed of car A after the collision.
ii. Indicate the direction of the motion of car A after the collision:
   a. To the left
   b. To the right
   c. None; car A is stationary

c) Is this an elastic collision? Justify your answer.

5. A 70.0 kg woman and her 35.0 kg son are standing at rest on an ice rink, as shown to the right. They push against each other for a time of 0.60 s, causing them to glide apart. The speed of the woman immediately after they separate is 0.550 m/s . Assume that during the push, friction is negligible compared with the forces the people exert on each other.

a. Calculate the initial speed of the son after the push.
b. Calculate the magnitude and direction of the average force exerted on the son by the mother during the push.
c. How do the magnitude and direction of the average force exerted on the mother by the son during the push compare with those of the average force exerted on the son by the mother? Justify your answer.
d. After the initial push, the friction that the ice exerts cannot be considered negligible, and the mother comes to rest after moving a distance of 7.0 m across the ice. If their coefficients of friction are the same, how far does the son move after the push?




6. A small and a large sphere, of mass *M* and 3*M* respectively, are arranged as shown on the left side of the figure above. The spheres are then simultaneously dropped from rest. When the large sphere strikes the floor, the spheres have fallen a height *H*. Assume air resistance is negligible. Express all answers in terms of *M*, *H*, and fundamental constants, as appropriate.
(a) Derive an expression for the speed $v_b$ with which the large sphere strikes the floor.

Immediately after striking the floor, the large sphere is moving upward with speed $v_b$ and collides head-on with the small sphere, which is moving downward with identical speed $v_b$ at that instant. Immediately after the collision, the small sphere moves upward with speed $v_S$ and the large sphere has speed $v_L$ .

(b) Derive an equation that relates $v_b$, $v_S$, and $v_L$.

(c) In this particular situation $v_L = 0$. Use your relationship from part (b) to determine the speed of the small sphere in terms of $v_b$

(d) Indicate whether the collision is elastic. Justify your answer using your results from parts (b) and (c).

(e) Determine the height *h* that the small sphere rises above its lowest position, in terms of the original height *H*.

(f) Describe the situation in terms of conservation of energy. Where is the energy when the balls are dropped? Where is the energy when the large ball strikes the ground? Where is the energy when the small ball peaks?