Physics 120

Worksheet 09 Momentum and Center of Mass

Problem 1

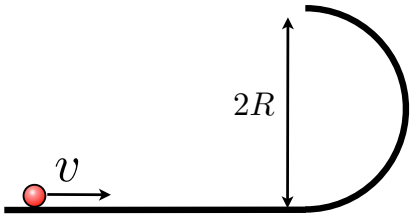
(a) Compare the differences and similarities between the kinetic energy and momentum.

(b) In what situations can we use the conservation of energy to help us solve problems?

(c) In what situations can we use the conservation of momentum to help us solve problems?

Problem 2

A bead is moving on a frictionless surface heading toward a vertical semi-circular loop of radius R with a speed v. Suppose the bead has an initial speed that is fast enough to reach the top of the loop.



(a) If our system includes the bead, Earth, and the gravitational interaction between them, is the energy of this system conserved? Explain.

(b) If our system includes the bead, Earth, and the gravitational interaction between them, is the momentum of this system conserved? Explain.

Problem 3

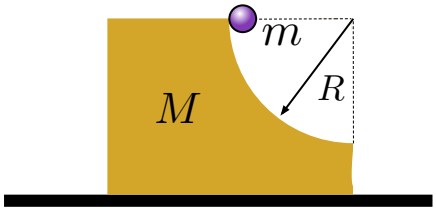
Two blocks of mass m_1 and m_2 respectively are placed on a frictionless surface. The block m_2 is initially at rest, and attached with a spring of spring constant k on its back. The block m_1 is then given an initial speed v_0 and collides head onto the block m_2.

(a) What is the maximum compression of the spring throughout the entire collision process?

(b) Find the velocities v_{1f} and v_{2f} of the two blocks respectively after the collision process. What is the condition on m_1 and m_2 such that the block m_1 will move backwards after the collision?

Problem 4

A rectangular block has its upper right corner carved out. The carved out portion is a quarter of a cylinder, yielding a circular slope of radius R. The remaining block has a mass M. A small bead of mass m is placed at the top of the slope. All contact surfaces are frictionless. Both the small bead and the block are *initially at rest*, and the bead slides down from the top of the circular slope.



(a) Find the displacement of the block, i.e the distance and direction of its movement, when the small bead slides to the bottom of the circular slope and is just about to leave the block.

(b) Find the speed of the small bead **with respect to the ground** when it reaches the bottom of the circular slope.

Problem 5

Two particles of mass m_1 and m_2 respectively, travels with an initial speed v_0 but with different angles as shown in the right figure. After the two collide, they both fly out with an angle 45° with respect to the horizontal. **Find the final speed v_1 and v_2 of the two particles respectively**. You can use $\sin(30^\circ) = \cos(60^\circ) = \frac{1}{2}$, $\cos(30^\circ) = \sin(60^\circ) = \frac{\sqrt{3}}{2}$, and $\sin(45^\circ) = \cos(45^\circ) = \frac{\sqrt{2}}{2}$.