Basic Momentum and Impulse Questions (Level 1)

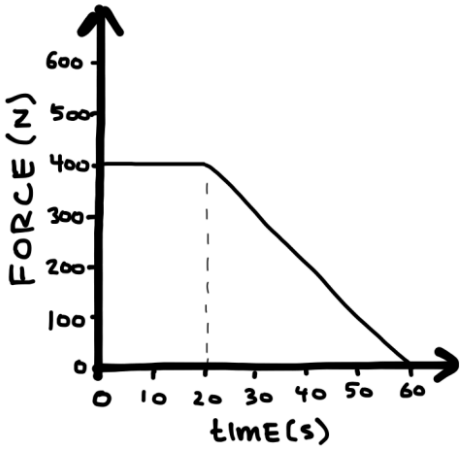
1) A 1.0 kg ball hits the floor with a velocity of 2.0 m/s and he bounces back up with a velocity of 1.6 m/s.
   a) What is the ball's change in momentum?
   b) If the ball is in contact with the floor for 0.060 s, what average force does the ground exert on the ball?

2) A 0.144 kg baseball is pitched horizontally at 38 m/s. The batter hits a horizontal line drive at 38 m/s in the opposite direction. What is the impulse exerted on the ball by the bat?

3) A 1200 kg physics dragster is travelling at 35 km/h east when it hits the gas and accelerates at 12.5 m/s2 for 3.25s. What is its change in momentum during this time?

4) 4 Jolene is pushing a 40.0 kg box with a constant force of 65 N for 5.0 s. If the box is initially moving at 1.5 m/s, what will the speed of the box be after 5.0s. Assume no friction force.

5) The thrust force on a 1750 kg hovercraft is shown on the graph. If the hovercraft is at rest at t=0 s, what is the speed at 60 s?



Conservation of momentum (Level 2)

6) A 95 kg fullback, running at 8.2 m/s, collides in midair with a 128 kg defensive tackle moving in the opposite direction. Both players end up with zero speed. How fast was the tackle moving originally?

7) Ball A (5.0 g) moves at a velocity of 20.0 cm/s to the right. It collides with ball B (10.0 g) moving along the same line with a velocity of 10.0 cm/s to the right. After the collision, ball A is still moving but with a velocity of 8.0 cm/s in the same direction. What is the velocity of ball B after the collision?

8) Before a collision, a 25 kg object is moving at 12 m/s to the right. After a collision with a stationary box, the 25 kg object moves at 8 m/s to the right. What is the resulting momentum of the box?

9) A 2575 kg van runs into the back of a 835 kg compact car at rest. They move off together at 8.5 m/s. Assuming no friction with the ground, find the initial speed of the van.

10) A 15 g bullet is shot into a 5085 g wooden block standing on a frictionless surface. The block, with the bullet in it, acquires a velocity of 1.0 m/s. Calculate the velocity of the bullet before striking the block.

11) A hockey puck, mass 0.115 kg, moving at 35.0 m/s, strikes an octopus thrown on the ice by a fan. The octopus has a mass of 0.265 kg. The puck and octopus slide off together. Find their velocity.

12) A 50 kg woman, riding on a 10 kg cart is moving east at 5.0 m/s. The woman jumps off the cart and hits the ground at 7.0 m/s eastward, relative to the ground. Calculate the velocity of the cart after she jumps off.

13) A car with mass 1245 kg, moving at 29 m/s strikes a 2175 kg car at rest. If the two cars stick together, with what speed do they move?

14) A 92 kg fullback, running at 5.0 m/s, attempts to dive across the goal line for a touchdown. Just as he reaches the goal line, he is met head-on in midair by two 75 kg linebackers, one moving at 2.0 m/s and the other at 4.0 m/s. If they all become entangled as one mass, with what velocity do they travel? Does the fullback score?

15) A 5.00 g bullet is fired with a velocity of 100 m/s toward a 10.00 kg stationary solid block resting on a frictionless surface.
a) What is the change in momentum of the bullet if it is embedded in the block?
b) What is the change in momentum of the bullet if it ricochets in the opposite direction with a speed of 99 m/s?

Momentum in 2D (Level 3)

16) A 0.31 kg baseball moving horizontally at 41 m/s is hit back in the direction of the pitcher at an upward angle of 30° and at a speed of 53 m/s. Find the impulse given to the ball.

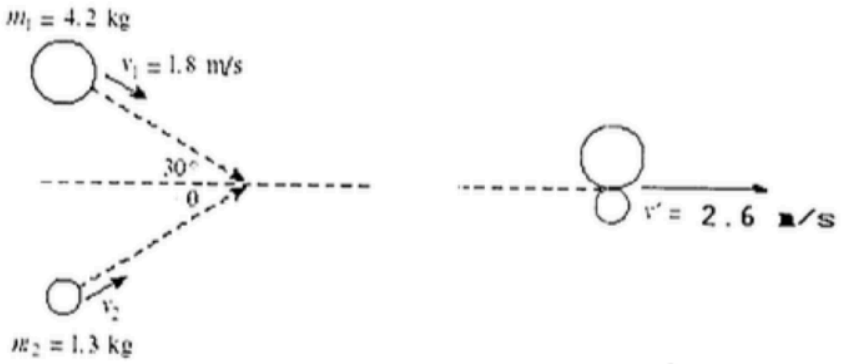
17) A 140 g tennis ball travelling 30° east of north at 15 m/s is struck by a tennis racquet, giving it a velocity of 25 m/s, west. What is the magnitude and direction of the impulse given to the ball?

18) A 12.0 kg shopping cart rolls due south at 1.70 m/s. After striking the bumper of a car, it travels at 0.80 m/s, 30° east of south. What is the magnitude of the change in momentum sustained by the shopping cart?

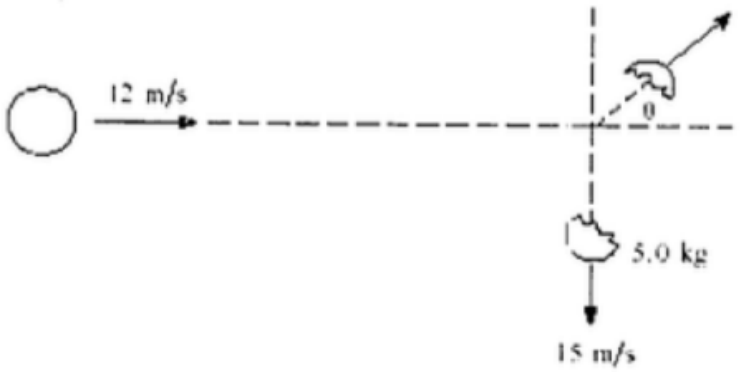
19) A 1100 kg vehicle travelling westward at 17 m/s is subjected to a 1.0 x 104 N·s impulse northward. What is the magnitude of the final momentum of the vehicle?

20) An 850 kg car travelling at 12 m/s due east collides with at 620 kg car travelling at 24 m/s due north. As a result of the collision, the two cars lock together. What is the velocity immediately after the collision?

21) Two steel pucks are moving as shown in the diagram. They collide inelastically. Determine the speed and direction of the 1.3 kg puck before the collision.



22) A 9.0 kg object moving at 12 m/s to the east explodes into two unequal fragments. The larger 5.0 kg fragment moves at 15 m/s south. What is the velocity (speed and direction) of the smaller fragment?



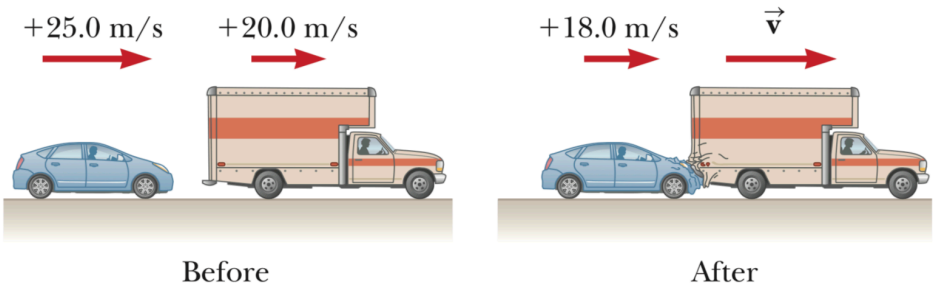
23) A defective 8.5 kg landmine explodes into 3 pieces. A 2.5 kg piece goes northeast at 190 m/s and a 2.9 kg piece goes 30° north of west at 280 m/s. Find the velocity of the third piece.

24) A 310 000 kg meteor is heading directly towards a space shuttle at 35 m/s. It is pushed for a period of 45 seconds after which its velocity is 27 m/s and it has veered 22° from its original course.
a) Find the impulse given to the meteor (magnitude and direction).
b) Find the magnitude of the force applied.

Elastic and Inelastic collisions (Level 4)

25) A railroad car of mass 2.00 × 104 kg moving at 3.00 m/s collides and couples with two coupled railroad cars, each of the same mass as the single car and moving in the same direction at 1.20 m/s.
a) What is the speed of the three coupled cars after the collision?
b) How much kinetic energy is lost in the collision?

26) A 1200 kg car traveling initially with a speed of 25.0 m/s in an easterly direction crashes into the rear end of a 9000 kg truck moving in the same direction at 20.0 m/s. The velocity of the car right after the collision is 18.0 m/s to the east.
a) What is the velocity of the truck right after the collision?
b) How much mechanical energy is lost in the collision?



27) A 90.0 kg fullback running east with a speed of 5.00 m/s is tackled by a 95.0 kg opponent running north with a speed of 3.00 m/s. a) Why does the tackle constitute a perfectly inelastic collision? b) Calculate the velocity of the players immediately after the tackle. c) Determine the mechanical energy that is lost as a result of the collision.

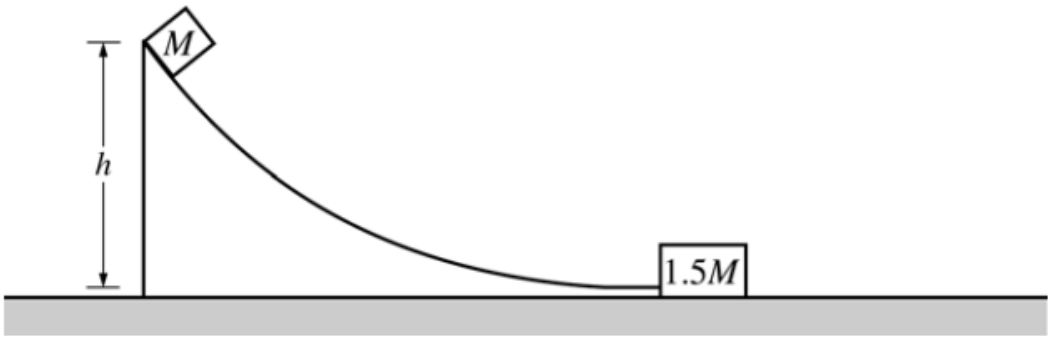
28) A billiard ball moving at 5.00 m/s strikes a stationary ball of the same mass. After the collision, the first ball moves at 4.33 m/s at an angle of 30° with respect to the original line of motion. a) Find the velocity (magnitude and direction) of the second ball after collision. b) Was the collision inelastic or elastic? Justify your answer.

29) A 0.030 kg bullet is fired vertically at 200 m/s into a 0.15 kg baseball that is initially at rest. How high does the combined bullet and baseball rise after the collision, assuming the bullet embeds itself in the ball?

30) In a Broadway performance, an 80.0 kg actor swings from a 3.75 m long cable that is horizontal when he starts. At the bottom of his arc, he picks up his 55.0 kg costar in an inelastic collision. What maximum height do they reach after their upward swing?

31) Two blocks of masses m1 = 2.00 kg and m2 = 4.00 kg are each released from rest at a height of h = 5.00 m on a frictionless track and undergo a totally inelastic head-on collision. Determine the maximum height to which m1 and m2 rise after the collision.

32) A small block of mass M is released from rest at the top of the curved frictionless ramp shown below. The block slides down the ramp and is moving with a speed 3.5v0 when it collides with a larger block of mass 1.5M at rest at the bottom of the incline. The larger block moves to the right at a speed 2v0 immediately after the collision. Express your answers to the following questions in terms of the given quantities and fundamental constants.



a) Determine the height h of the ramp from which the small block was released.
b) Determine the speed of the small block after the collision.
c) The larger block slides a distance D before coming to rest. Determine the value of the coefficient of kinetic friction μ between the larger block and the surface on which it slides.
d) Indicate whether the collision between the two blocks is elastic or inelastic. Justify your answer.

33) A 25.0 g object moving to the right at 20.0 cm/s overtakes and collides elastically with a 10.0 g object moving in the same direction at 15.0 cm/s. Find the velocity of each object after the collision.

34) A tennis ball of mass 57.0 g is held just above a basketball of mass 590 g. With their centers vertically aligned, both balls are released from rest at the same time, to fall through a distance of 1.20 m. a) Find the magnitude of the downward velocity with which the basketball reaches the ground. b) Assume that an elastic collision with the ground instantaneously reverses the velocity of the basketball while the tennis ball is still moving down. Next, the two balls meet in an elastic collision. To what height does the tennis ball rebound?