NAME: _____ **DATE:** _____
IB Physics

2.4 MOMENTUM AND IMPULSE *Class Lecture Examples*

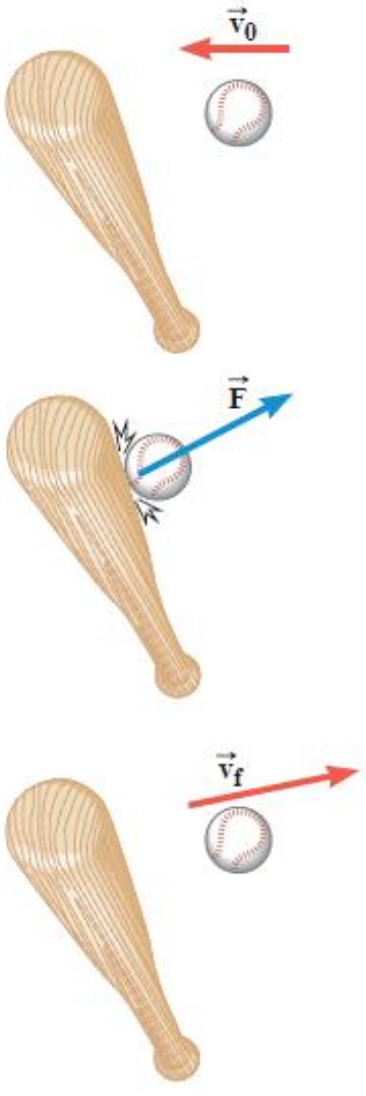
EXAMPLE 1
A ball of mass 200 g travelling at 10 m s^{-1} bounces off a wall. If after hitting the wall it travels at 5 ms^{-1}, what is the impulse?

EXAMPLE 2
Calculate the impulse on a tennis racket that hits a ball of mass 67 g travelling at 10 m s^{-1} so that is comes off the racket at a velocity of 50 m s^{-1}.

EXAMPLE 3
A baseball (m = 0.14 kg) has an initial velocity of **u** = -38 m/s as it approaches a bat. The bat applies an average force that is much larger than the weight of the ball, and the ball departs from the bat with a final velocity of **v** = +58 m/s.
a) Determine the impulse applied to the ball by the bat.

b) Assuming that the time of contact is $t = 1.6 \times 10^{-3}$ s, find the average force exerted on the ball by the bat.

c) Find the average force exerted by the bat on the ball.



Source: Physics, 8th Ed, Cutnell & Johnson

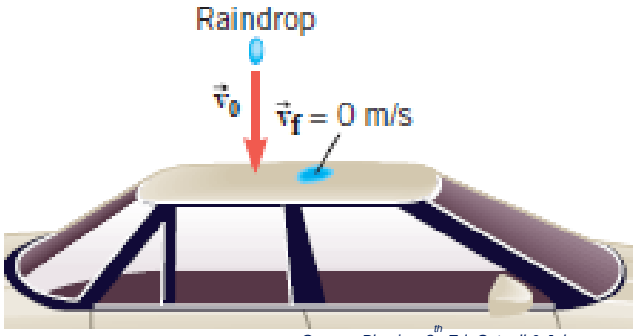
EXAMPLE 4

A tennis ball of mass *m* moving horizontally with speed *u* strikes a vertical tennis racket. The ball bounces back with a horizontal speed *v*. Determine the magnitude of the change in momentum of the ball in terms of the given variables.

EXAMPLE 5

During a storm, rain comes straight down with a velocity of 15 ms^{-1} and hits the roof of a car perpendicularly. The mass of rain per second that strikes the car roof is 0.060 kg s^{-1}.

a) Assuming that the rain comes to rest upon striking the car find the average force exerted by the rain on the roof.



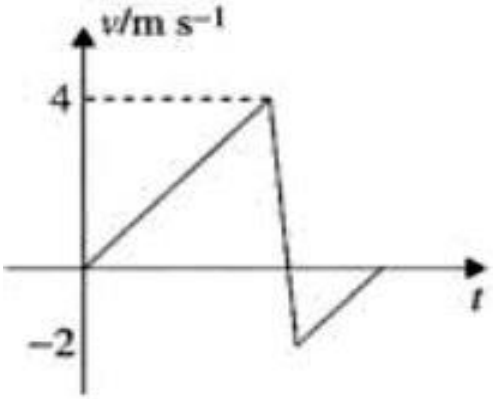
Source: Physics, 8th Ed, Cutnell & Johnson

b) Instead of rain, suppose hail is falling. The hail comes straight down at a mass rate of $m/\Delta t$ = 0.060 kg s^{-1} and an initial velocity of 15 m/s and bounces off the roof perpendicularly. Would the force on the roof of the car be different than in part (a)? Explain.

EXAMPLE 6

A 0.50 kg ball bounces vertically off a hard surface.
A graph of velocity against time is shown.

a) Find the magnitude of the momentum change of the ball during the bounce.



Source: Physics for the IB Diploma, 5th Ed, Tsokos

b) If the ball stayed in contact with the floor for 0.15 s, what average force did the ball exert on the floor?

EXAMPLE 7

Find the velocity of both cars below after the collision shown, assuming that they stick together (inelastic collision). How much kinetic energy is lost?

Source: Physics Course Companion, Kirk and Hodgson

EXAMPLE 8

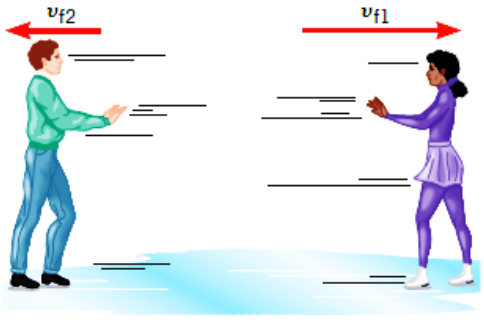
Show that the final velocities of the blocks shown below are as indicated (see lecture for animation).

Source: https://www.wikipedia.org/

EXAMPLE 9

Starting from rest, two skaters push off against each other on smooth level ice, where friction is negligible. One is a woman (m_1 = 54 kg), and one is a man (m_2 = 88 kg). The woman moves away with a velocity of v_2' = 2.5 m/s. Find the "recoil" velocity of the man.

(*a*) Before pushoff

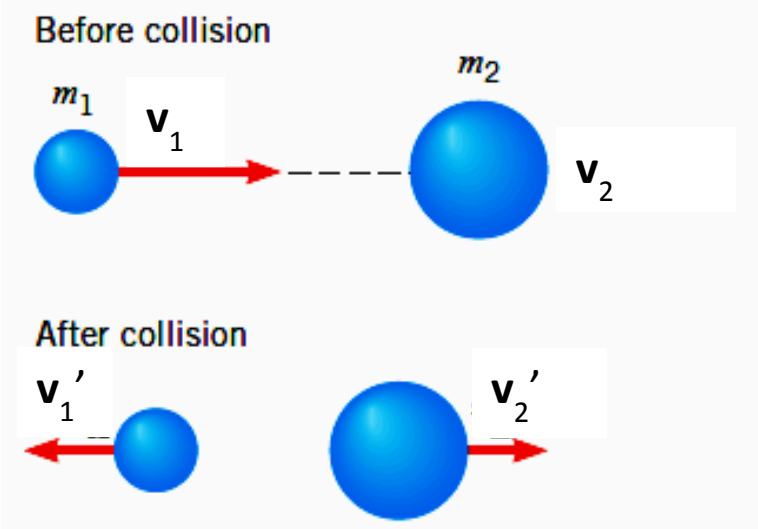


(*b*) After pushoff

Source: Physics, 8th Ed, Cutnell & Johnson

EXAMPLE 10

The drawing shows an elastic head-on collision between two balls. One ball has a mass of m_1 = 0.250 kg and an initial velocity of 5.00 m s^{-1}. The other has a mass of m_2 = 0.800 kg and is initially at rest. No external forces act on the balls. Given that ball 1 rebounds with a speed of 2.62 ms^{-1}, what is the velocity of the ball 2 after the collision?



Source: Physics, 8th Ed, Cutnell & Johnson

EXAMPLE 11

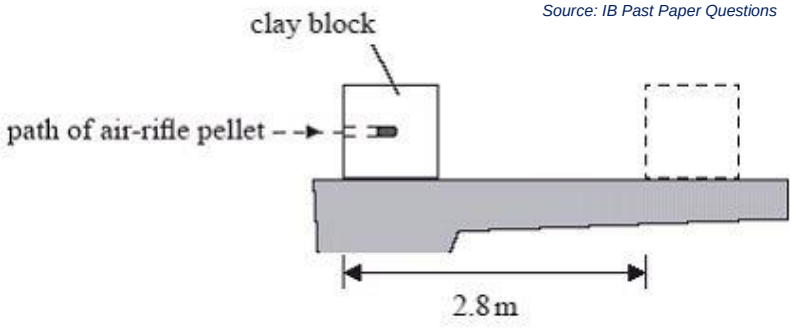
Show that the final velocities of the blocks shown below are as indicated (see lecture for animation).

Source: https://www.wikipedia.org/

EXAMPLE 12

Source: IB Past Paper Questions

In an experiment, an air-rifle pellet is fired into a block of modelling clay that rests on a table (drawing not to scale). The air-rifle pellet remains inside the clay block after the impact. As a result of the collision, the clay block slides along the table in a straight line and comes to rest. Further data relating to the experiment are given below.



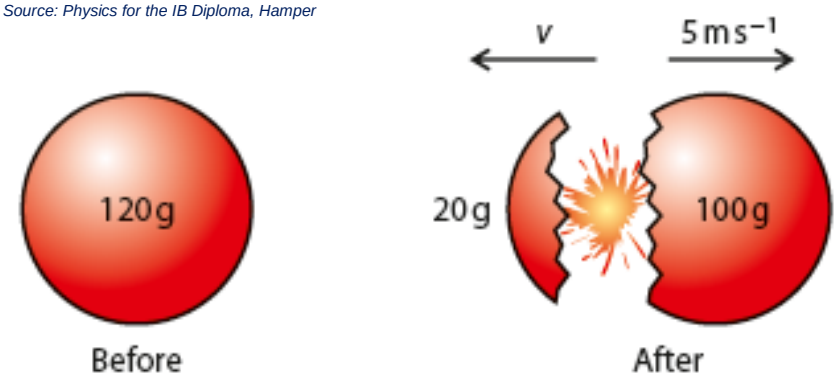
Mass of air-rifle pellet = 2.0 g
Mass of clay block = 56 g
Velocity of impact of air-rifle pellet = 140 m s^{-1}
Stopping distance of clay block = 2.8 m

Calculate the initial speed of the clay block after the air-rifle pellet strikes it.

EXAMPLE 13

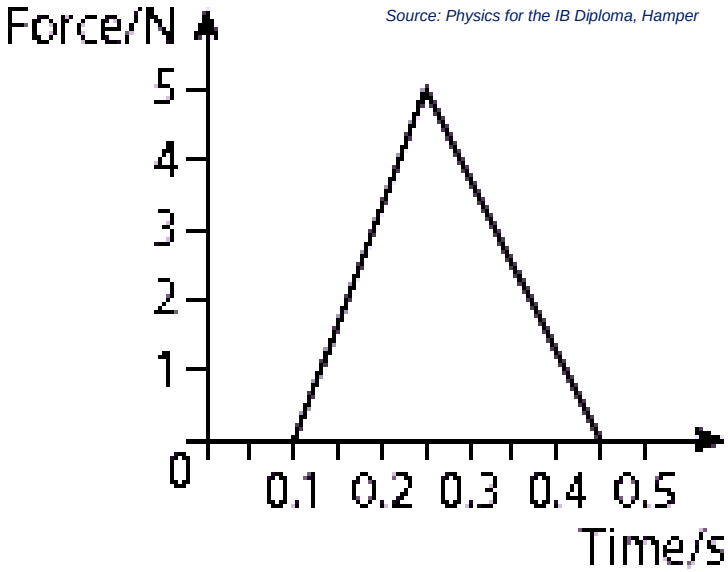
A ball of clay floating around in space suddenly explodes into a big piece and a small piece, as shown. If the bigger piece has a velocity of 5 m s^{-1}, what is the velocity of the small piece?

Source: Physics for the IB Diploma, Hamper



EXAMPLE 14

Calculate the impulse of the body for the motion shown.



Source: Physics for the IB Diploma, Hamper

If the mass of the object is 20 g, what is the change of velocity?