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Solution 20

A rockets works on the principle of action and reaction. In a rocket, the hot gases produced by the rapid burning of fuel rush out of a jet at the bottom of the rocket at a very high speed. The equal and opposite reaction force of the downward going gases pushes the rocket upward with a great speed.

Solution 21

Action and reaction act on two different bodies. Action and reaction are equal in magnitude but they act in opposite directions and there is simultaneous action and reaction.

Solution 22

When a man jumps out from a boat, the boat moves backwards due to the fact that to step out of the boat, the man presses the boat with his foot in the backward direction. The push of the man on the boat is action. The boat exerts an equal force on the man in the forward direction and since the boat is not fixed and is floating, it moves backwards due to the action force exerted by the man.

Solution 23

It becomes very difficult to walk on a slippery road because of the fact that on a slippery road, the friction is much less, and we cannot exert a backward action force on slippery ground which would produce a forward reaction force on us.

Solution 24

To start his run, a runner bends forward and pushes the ground with his feet in the backward direction. In turn ground exerts a reaction force on the runner in the forward direction which makes him run.

Solution 25

Mass of bullet, $m_1 = 60g = 0.06$ kg

Velocity of bullet $v_1 = 500$ m/s

Mass of gun $m_2 = 5$ kg

Recoil velocity v_2

According to the law of conservation of momentum

$m_1 \times v_1 = m_2 \times v_2$

$0.06 \times 500 = 5 \times v_2$

$$v_2 = \frac{0.06 \times 500}{5} = 6 \text{ m/s}$$

Solution 26

Mass of bullet, $m_1 = 10g = 0.01$ kg

Velocity of bullet $v_1 = 200$ m/s

Mass of block with the bullet as bullet gets embedded in it, $m_2 = 2+0.01 = 2.01$ kg

Recoil velocity v_2

According to the law of conservation of momentum

$m_1 \times v_1 = m_2 \times v_2$

$0.01 \times 200 = 2.01 \times v_2$

$$v_2 = \frac{0.01 \times 200}{2.01} = 0.99 \text{ m/s}$$

Solution 27

Mass of the body = 2kg
Initial velocity u = 0
Final velocity v = 30 m/s
Time t = 1 s

$$\text{Acceleration } a = \frac{v-u}{t} = \frac{30-0}{1} = 30\ m/s^2$$

Force = m x a =2 x 30 = 60 N

Solution 28

Mass of the body = 5 kg
Initial velocity u = 10 m/s
Final velocity v = 35 m/s
Time t = 25 s

$$\text{Acceleration } a = \frac{v-u}{t} = \frac{35-10}{25} = 1\ m/s^2$$

Force = m x a =5 x 1 = 5 N

Solution 29

Mass of the car = 2400 kg
Initial velocity u = 20 m/s
Final velocity v = 0 m/s
Time t = 10 s

$$\text{Retardation } a = \frac{v-u}{t} = \frac{0-20}{10} = -2\ m/s^2$$

Force = m x a =2400 x -2 = - 4800 N

Solution 30

Mass of the body = 20 kg
Initial velocity u = 0 m/s
Final velocity v = 100 m/s
Force F = 100 N

$$\text{Acceleration } a = \frac{F}{m} = \frac{100}{20} = 5\ m/s^2$$

$$\text{Time } t = \frac{v-u}{a} = \frac{100-0}{5} = 20\ s$$

Solution 31

Mass of the body = 2.5 kg
Initial velocity u = 20 m/s
Final velocity v = 0 m/s
Force F = 10 N

Acceleration $a = \frac{F}{m} = \frac{10}{2.5} = 4\ m/s^2$

Since v < u, so acceleration will have a negative sign $a = -4\ m/s^2$

Time $t = \frac{v-u}{a} = \frac{0-20}{-4} = 5\ s$

Solution 32

Mass of the body = 10 kg
Initial velocity u = 4 m/s
Final velocity v = 8 m/s
Time t = 2 s
a) Momentum before force acts $p_1 = m \times u = 10 \times 4 = 40$ kg.m/s
b) Momentum after force acts $p_2 = m \times v = 10 \times 8 = 80$ kg.m/s
c) Gain in momentum for 2 s = $p_2 - p_1 = 40$ kg.m/s

Gain in momentum per second = $\frac{40}{2} = 20$ kg.m/s

d) Acceleration $a = \frac{v-u}{t} = \frac{8-4}{2} = 2\ m/s^2$

Force = m x a = 10 x 2 = 20 N

Solution 33

Mass of the gun $m_1 = 3$ kg
Mass of bullet $m_2 = 30$ g = 0.03 kg
Velocity of bullet $v_2 = 100$ m/s
i) According to the law of conservation of momentum
$m_1 \times v_1 = m_2 \times v_2$
$3 \times v_1 = 0.03 \times 100$

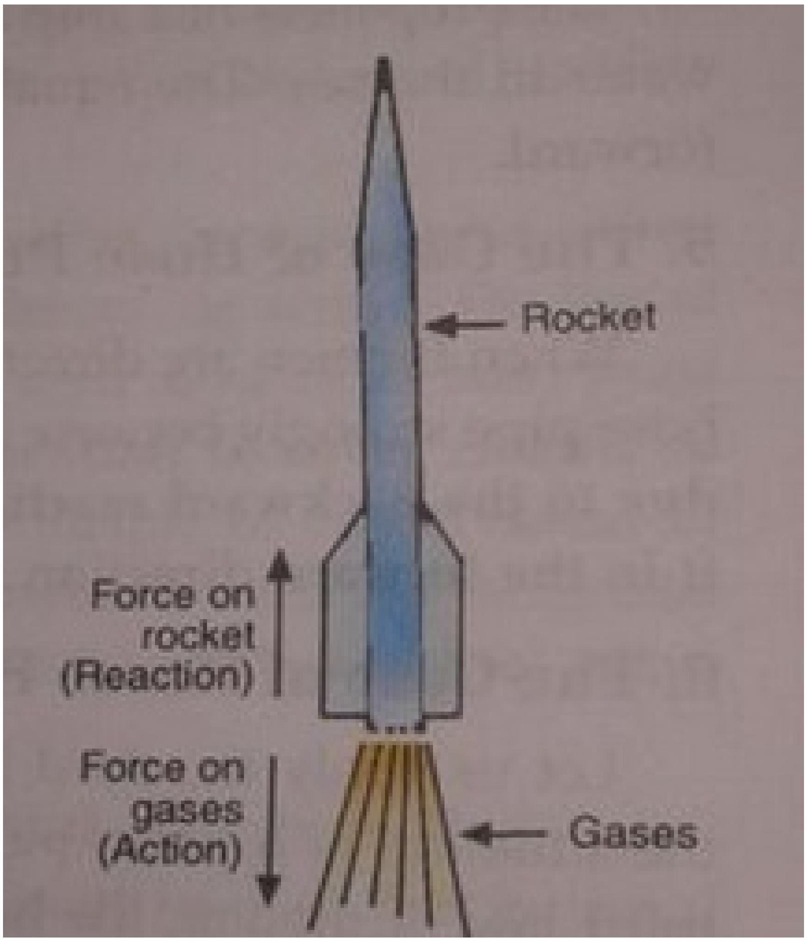
Recoil velocity $v_1 = \frac{100 \times 0.03}{3} = 1$ m/s

ii) Initial velocity of the gun u = 0 m/s
Final velocity of the gun v = 1 m/s
Time t = 0.003 s

Acceleration $a = \frac{v-u}{t} = \frac{1-0}{0.003} = \frac{1000}{3}\ m/s^2$

Force = m x a = $3 \times \frac{1000}{3} = 1000$ N

Solution 34



Solution 35

a) Law of conservation of momentum

b) Newton's second law of motion

c) Newton's third law of motion

d) Newton's first law of motion

Solution 36

(a) According to Newton's second law of motion: The rate of change of momentum of a body is directly proportional to the applied force, and takes place in the direction in which the force acts.

Consider a body of mass m having initial velocity u. the initial momentum of this body will be mu. Suppose a force F acts on this body for time t causing the final velocity to be v. The final momentum of the body will be mv. Now the change in momentum is mv � mu and the time taken for this change is t. So according to Newton's second law of motion,

$$F \propto \frac{mv-mu}{t}$$

$$\propto \frac{m(v-u)}{t}$$

But $\frac{(v-u)}{t}$ represents change in velocity with time i.e. acceleration 'a'. So by replacing $\frac{(v-u)}{t}$ with a in the above relation, we get

$$F \propto m \times a$$

Thus, the force acting on a body is directly proportional to the product of mass and acceleration produced in the body by the action of the force. Thus, Newton's second law gives the relationship between force and acceleration.

(b) Mass of the vehicle, m = 1000kg

Initial velocity u = 20 m/s

Final velocity v = 0 m/s

Distance covered before stopping, s = 50 m

Using third equation of motion

$v^2 - u^2 = 2as$

$0^2 - 20^2 = 2 \times a \times 50$

Acceleration, $a = \frac{-400}{2 \times 50} = -4\ m/s^2$

Unbalanced Force = m x a = 1000 x -4 = -4000 N

Solution 37

a) A player moves his hands backwards while catching a fast ball because a fast moving ball has a large momentum and in stopping this ball, its momentum has to be reduced to zero. Now, when a cricket player moves back his hands on catching the fast ball, then the time taken to reduce the momentum of the ball is increased. So, the rate of change of momentum of ball is decreased and hence a small force is exerted on the hands of the player and the hands of the player do not get hurt.

b) Mass of ball = 150 g = 0.15 kg

Initial velocity u = 30 m/s

Final velocity v = 0 m/s

Time t = 0.05 s

Acceleration $a = \frac{(v-u)}{t} = \frac{0-30}{0.05} = -6000\ m/s^2$

Force = m x a = 0.15 x 6000 = 90 N

Solution 38

a) According to Newton's third law of motion: Whenever one body exerts a force on another body, the second body exerts an equal and opposite force on the first body. In other words, to every action, there is an equal and opposite reaction. Two examples to illustrate this law-

When a man jumps out from a boat, the boat moves backwards. This is due to the fact that to step out of the boat, the man presses

the boat with his foot in the backward direction. The push of the man on the boat is action. The boat exerts an equal force in the forward direction and since the boat is not fixed and is floating, it moves backwards due to the action force exerted by the man. Gunman gets a jerk on firing a bullet from his gun. This is because when a bullet is fired from a gun, the force sending the bullet forward is equal to the force sending the gun backwards but due to high mass of the gun, it moves only a little distance backwards giving a jerk to the gunman.
b) When a fireman directs a powerful stream of water on a fire, the hose pipe tends to go backward due to the reaction force of the water rushing through it in the forward direction at a great speed.

*********** END **********