Additional Exercises

Question A1:

The following is the distance-time table of an object in motion:

Time in seconds	Distance in metres
0	0
1	1
2	8
3	27
4	64
5	125
6	216
7	343

(a) What conclusion can you draw about the acceleration? Is it constant, increasing, decreasing, or zero?

(b) What do you infer about the forces acting on the object?

Answer A1:

(a) There is an unequal change of distance in an equal interval of time.

Thus, the given object is having a non - uniform motion. Since the velocity of the object increases with time, the acceleration is increasing.

(b) According to Newton's second law of motion, the force acting on an object is directly proportional to the acceleration produced in the object. In the given case, the increasing acceleration of the given object indicates that the force acting on the object is also increasing.

Question A2:

Two persons manage to push a motorcar of mass 1200 kg at a uniform velocity along a level road. The same motorcar can be pushed by three persons to produce an acceleration of 0.2 ms^{-2}. With what force does each person push the motorcar? (Assume that all persons push the motorcar with the same muscular effort)

Answer A2:

Mass of the motor car = 1200 kg

Only two persons manage to push the car. Hence, the acceleration acquired by the car is given by the third person alone.

Acceleration produced by the car, when it is pushed by the third person,

$a = 0.2\ m/s^2$

Let the force applied by the third person be F.

From Newton's second law of motion:

Force = Mass x Acceleration

$F = 1200 \times 0.2 = 240$ N

Thus, the third person applies a force of magnitude 240 N.

Hence, each person applies a force of 240 N to push the motor car.

Question A3:

A hammer of mass 500 g, moving at 50 ms^{-1}, strikes a nail. The nail stops the hammer in a very short time of 0.01 s. What is the force of the nail on the hammer?

Answer A3:

Mass of the hammer, m= 500 g = 0.5 kg

Initial velocity of the hammer, u= 50 m/s

Time taken by the nail to the stop the hammer, t = 0.01 s

Velocity of the hammer, v= 0 (since the hammer finally comes to rest)

From Newton's second law of motion:

$$\text{Force, } F = \frac{m(v-u)}{t} = \frac{0.5(0-50)}{0.01} = -2500 \text{ N}$$

The hammer strikes the nail with a force of - 2500 N. Hence, from Newton's third law of motion, the force of the nail on the hammer is equal and opposite, i.e., +2500 N.

Question A4:

A motorcar of mass 1200 kg is moving along a straight line with a uniform velocity of 90 km/h. Its velocity is slowed down to 18 km/h in 4 s by an unbalanced external force. Calculate the acceleration and change in momentum. Also calculate the magnitude of the force required.

Answer A4:

Mass of the motor car, m = 1200 kg

Initial velocity of the motor car, u = 90 km/h = 25 m/s

Final velocity of the motor car, v = 18 km/h = 5 m/s

Time taken, t = 4 s

According to the first equation of motion: $v = u + at$

5 = 25 + a (4)

$a = -5$ m/s^2

Negative sign indicates that its a retarding motion i.e. velocity is decreasing.

Change in momentum = $mv - mu = m(v - u)$

= 1200 (5 – 25) = – 24000 kg m s^{-1}

Force = Mass × Acceleration = 1200 × – 5 = – 6000 N

Acceleration of the motor car = – 5 m/s^2

Change in momentum of the motor car = – 24000 kg m s^{-1}

Hence, the force required to decrease the velocity is 6000 N. (Negative sign indicates retardation, decrease in momentum and retarding force)

Question A5:

A large truck and a car, both moving with a velocity of magnitude *v*, have a head-on collision and both of them come to a halt after that. If the collision lasts for 1s:

(a) Which vehicle experiences the greater force of impact?

(b) Which vehicle experiences the greater change in momentum?

(c) Which vehicle experiences the greater acceleration?

(d) Why is the car likely to suffer more damage than the truck?

Answer A5:

Let the mass of the truck be *M* and that of the car be *m*.

Thus, $M > m$

Initial velocity of both vehicles, *v*

Final velocity of both vehicles, $v' = 0$ (since the vehicles come to rest after collision)

Time of impact, $t = 1$ s

(a) From Newton's second law of motion, the net force experienced by each vehicle is given by the relation:

$$F_{car} = \frac{m(v'-v)}{t} = -mv$$

$$F_{Truck} = \frac{M(v'-v)}{t} = -Mv$$

Since the mass of the truck is greater than that of the car, it will experience a greater force of impact.

(b) Initial momentum of the car = mv

Final momentum of the car = 0

Change in momentum = mv

Initial momentum of the truck = Mv

Final momentum of the truck = 0

Change in momentum = Mv

Since the mass of the truck is greater than that of the car, it will experience a greater change in momentum.

(c) From the first equation of motion, acceleration produced in a system is independent of the mass of the system. The initial velocity, the final velocity, and the time of impact remain the same in both cases. Hence, both the car and the truck experience the same amount of acceleration.

(d) According to Newton's third law of motion, for every action there is an equal and opposite reaction that acts on different bodies. Since the truck experiences a greater force of impact (action), this larger