

PQ 8c Q and A

Q1

Calculate the momentum of the following.

- (a) A 1600 kg truck moving at 7.0 m s^{-1} east.
- (b) A 5.3×10^{-26} kg oxygen molecule moving west at $1.3 \times 10^3 \text{ m s}^{-1}$.
- (c) A 1100 kg car being driven at 72 km h^{-1} south.
- (d) A 2.5 kg bird flying north at 12.0 m s^{-1} .
- (e) A 75 kg sprinter running south at 9.5 m s^{-1} .

(a) $p = mv = 1600 \times 7 = 1.12 \times 10^4 \text{ N s E}$

(b) $p = (5.3 \times 10^{-26}) \times (1.3 \times 10^3) = 6.89 \times 10^{-23} \text{ N s W}$

(c) $p = 1100 \times (72 \times 1000/3600) = 22\,000 \text{ N s S}$

(d) $p = 2.5 \times 12 = 30 \text{ N s N}$

(e) $p = 75 \times 9.5 = 712.5 \text{ N s S}$

Q2

Calculate the impulse needed to cause each of the following momentum changes.

- (a) From $10.0 \text{ kg m s}^{-1} \text{ W}$ to $15 \text{ kg m s}^{-1} \text{ W}$.
- (b) From $0.6 \text{ kg m s}^{-1} \text{ W}$ to $15 \text{ kg m s}^{-1} \text{ E}$.
- (c) From $12.0 \text{ kg m s}^{-1} \text{ S}$ to $15 \text{ kg m s}^{-1} \text{ N}$.
- (d) From $10.0 \text{ kg m s}^{-1} \text{ N}$ to $15 \text{ kg m s}^{-1} \text{ N}$.
- (e) from $10 \text{ kg m s}^{-1} \text{ W}$ to $2.5 \text{ kg m s}^{-1} \text{ W}$.
- (f) If each change took 4.0 s , what force was involved?

- (a) $I = \Delta p = 15 - 10 = 5 \text{ N s W}$, $F = \Delta p/t = 5/4 = 1.25 \text{ N W}$
- (b) $I = -15 - 0.6 = -15.6 \text{ N s}$ or 15.6 N s E , $F = -15.6/4 = 3.9 \text{ N E}$
- (c) $I = 15 - (-12) = 27 \text{ N s N}$, $F = 27/4 = 6.75 \text{ N N}$
- (d) $I = 15 - 10 = 5 \text{ N s N}$, $F = 5/4 = 1.25 \text{ N N}$
- (e) $I = 2.5 - 10 = -7.5 \text{ N s}$ or 7.5 N s E , 1.875 N E

Q3

A force of 18 N east acts on a 6.0 kg object for 4.5 s. It was initially moving west at 15 m s^{-1} .

- (a) Find the impulse of the force.
- (b) Find the change in momentum of the object.
- (c) Find the final momentum of the object.
- (d) Find the final velocity of the object.

$$F = 18 \text{ N}; m = 6 \text{ kg}; t = 4.5 \text{ s}; u = -15 \text{ m s}^{-1}$$

$$(a) \quad I = Ft = 18 \times 4.5 = 81 \text{ N s E}$$

$$(b) \quad I = \Delta p = 81 \text{ N s E}$$

$$(c) \quad \Delta p = mv - mu; mv = \Delta p + mu = 81 + (-6 \times 15) = 9 \text{ N s W}$$

$$(d) \quad v = 9/6 = 1.5 \text{ m s}^{-1} \text{ W}$$

Q4

A toy car of mass 4.0 kg is struck horizontally by another car causing it to accelerate from 4.0 m s^{-1} to 10.0 m s^{-1} in 0.1 s. If the car was on a frictionless surface, calculate:

- (a) Its change in momentum.
- (b) The impulse applied to it.
- (c) The average force applied to it.

$$m = 4.0 \text{ kg}; u = 4.0 \text{ m s}^{-1}; v = 10.0 \text{ m s}^{-1}; t = 0.1 \text{ s}$$

- (a) $\Delta p = mv - mu = 4 \times 10 - 4 \times 4 = 24 \text{ N s}$ in direction of force
- (b) $I = \Delta p = 24 \text{ N s}$ in direction of force
- (c) $F = I/t = 24/0.1 = 240 \text{ N}$

Q5

A car of mass 800 kg accelerates from 12 m s^{-1} to 40 m s^{-1} in 7.0 s. Calculate:

- (a) The impulse acting on the car.
- (b) The average force on the car.
- (c) The momentum of the car if the force acts on it for another 5 s.

$$m = 800 \text{ kg}; u = 12 \text{ m s}^{-1}; v = 40 \text{ m s}^{-1}; t = 7.0 \text{ s}$$

$$(a) \quad I = \Delta p = mv - mu = 800 \times 40 - 800 \times 12 = 22\,400 \text{ N s}$$

$$(b) \quad F = I/t = 22400/7 = 3200 \text{ N}$$

$$(c) \quad I = Ft = 3200 \times 5 = 16000; p = 22400 + 16000 = 38400 \text{ N s}$$

Q6

As a result of being hit from behind by a toy truck, a 500 g toy car, initially at rest, rolls 12.0 m across a floor that applies a constant retarding force of 1.2 N to it. The car stops 2.0 s after being hit.

- (a) If the truck was in contact with the car for 0.12 s, find the impulse given to the car.
- (b) Find the momentum of the car just after being hit.
- (c) Calculate the instantaneous speed of the car just after being hit.
- (d) Calculate the average force applied to the car during the collision.

$$m = 0.5 \text{ kg}; u = 0; s = 12.0 \text{ m}; F = -1.2 \text{ N}; t = 2.0 \text{ s}$$

$$\text{Deceleration across floor} = -F/m = -1.2/0.5 = -2.4 \text{ m s}^{-2}$$

$$\text{Velocity after collision: } u = v - at = 0 - (-2.4 \times 2) = 4.8 \text{ m s}^{-1}$$

$$(a) \quad I = \Delta p = mv - mu = 0.5 \times 4.8 - 0 = 2.4 \text{ N s forwards}$$

$$(b) \quad p = 0.5 \times 4.8 = 2.4 \text{ N s forwards}$$

$$(c) \quad 4.8 \text{ m s}^{-1} \text{ forwards}$$

$$(d) \quad F = I/t = (0.5 \times 4.8)/0.12 = 20 \text{ N forwards}$$

Q7

A toy car at rest of mass 250 g is hit by a toy truck and travels horizontally for 50.0 m in 2.0 s.

- Calculate the average speed of the car.
- Calculate its instantaneous speed just after being hit.
- Calculate the momentum of the car just after being hit.
- Find the impulse applied to the car.
- Calculate the average force the truck applied to the car if it was in contact for 0.02 s?

$$m = 0.25 \text{ kg}; s = 50 \text{ m}; t = 2.0 \text{ s}$$

$$(a) \quad v = s/t = 50/2 = 25 \text{ m s}^{-1}$$

$$(b) \quad (v - u)/2 = 25; \text{ if } u = 0 \text{ then } v = 50 \text{ m s}^{-1}$$

$$(c) \quad p = mv = 0.25 \times 50 = 12.5 \text{ N s forwards}$$

$$(d) \quad I = \Delta p = mv - mu = 12.5 - 0 = 12.5 \text{ N s forwards}$$

$$(e) \quad F = I/t = 12.5/0.02 = 625 \text{ N forwards}$$

Q8

A toy truck has a mass of 500 g and hits a stationary toy car at 20.0 m s^{-1} . After impact the truck rebounds at 10 m s^{-1} . Calculate:

- (a) The change in velocity of the truck.
- (b) The change in momentum of the truck.
- (c) The impulse of the truck on the car.
- (d) The average force on the car if the collision lasted 0.05 s.
- (e) The average force on the car if the collision lasted 0.01 s.

$$m = 0.5 \text{ kg}; u_c = 0; u_t = 20.0 \text{ m s}^{-1}; v_t = -10 \text{ m s}^{-1}$$

- (a) $v - u = -10 - 20 = -30 \text{ m s}^{-1}$ or 30 m s^{-1} away from car
- (b) $\Delta p = m\Delta v = 0.5 \times 30 = 15 \text{ N s}$ away from car
- (c) $I = \Delta p = 15 \text{ N s}$ on the car
- (d) $F = I/t = 15/0.05 = 300 \text{ N}$
- (e) $F = I/t = 15/0.01 = 1500 \text{ N}$

Q9

A force of 125 N acts to the left on a 6.0 kg toy truck. A second force of 45 N acts on the same truck to the right. As a result, the speed of the truck changes by 8.0 m s^{-1} . Find how long it takes for this speed change to occur.

$$F = 125 \text{ N left}; m = 6.0 \text{ kg}; F = 45 \text{ N right}; \Delta v = 8.0 \text{ m s}^{-1}$$

$$\text{Resultant force} = 125 \text{ N} - 45 \text{ N} = 80 \text{ N left}$$

$$I = \Delta p = 6 \times 8 = 48 \text{ N s}; t = I/F = 48/80 = 0.6 \text{ s}$$

Q10

The impulse applied to a toy car of mass 200 g at rest is 3.5 N s south. While the force acts on the car it moves 25 m.

- (a) Find its change in velocity.
- (b) What work is done on the car by the force?
- (c) What is the acceleration of the car?
- (d) How long does the force act on the car?
- (e) What is its change in momentum?

$$I = 3.5 \text{ N s S}; m = 0.2 \text{ kg}; s = 25 \text{ m}; u = 0$$

- (a) $I = \Delta p = mv - mu; 3.5 = 0.2v - 0; v = 3.5/0.2 = 17.5 \text{ m s}^{-1}$ south
- (b) $v^2 = u^2 + 2as; 17.5^2 = 0 + 2 \times a \times 25; a = 17.5^2/2 \times 25 = 6.125 \text{ m s}^{-2}$
 $W = Fs = mas = 0.2 \times 6.125 \times 25 = 30.625 \text{ J}$
- (c) From (b) $a = 6.125 \text{ m s}^{-2}$ south
- (d) $t = I/F = I/ma = 3.5/0.2 \times 6.125 = 2.86 \text{ s}$
- (e) $\Delta p = I = 3.5 \text{ N s}$ south