Pages 195–198 Exam practice questions

1 A

2 C

3 B

4 D

5 C

6 D

7 D

8 C

9 B

10 D

11 a) The change of momentum is the area under the graph: (1)

Area = 2 × $\frac{1}{2}$ × 260 kN × 0.1 s (1)

= 26 000 N s (or 26 000 kg m s^{-1}) (1)

b) Change of momentum = *mv*

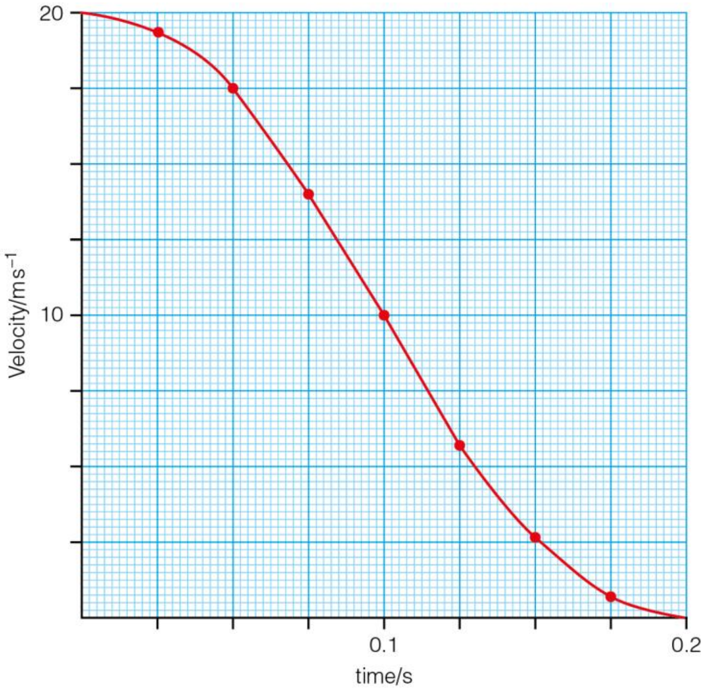
26 000 N s = 1300 kg × *v* (1)

v = 20 m s^{-1} (1)

c) The passenger with the seat belt travels at the same speed as the car. He/she stops in 0.2 s. The unstrapped passenger does not use all that time; he keeps moving until stopped by the car and he stops in a shorter time. (1)

$$F = \frac{\Delta(mv)}{\Delta t}$$

So the average force acting on the passenger is greater. (1)



d) See the above diagram;

axes (1)

straight line from 20 m s^{-1} to 0 (1)

or S shaped curve (passing through 10 m s^{-1}, 0.1 s) (2)

12 a) $m_1v_1 = m_2v_2$ (1)

6.8×10^{-27} kg $\times 1.5 \times 10^{7}$ m s^{-1} = 4.0×10^{-25} kg $\times v$ (1)

$v = 2.6 \times 10^{5}$ m s^{-1} (1)

b) KE (alpha) = $\frac{1}{2} \times 6.8 \times 10^{-27}$ kg $\times (1.5 \times 10^{7})^2$ (m $s^{-1})^2$ (1)

= 7.65×10^{-13} J (1)

= 4.78 MeV (1)

KE (nucleus) = $\frac{1}{2} \times 4.0 \times 10^{-25}$ kg $\times (2.6 \times 10^{5})^2$ (m $s^{-1})^2$

= 1.35×10^{-14} J

= 0.08 MeV (1)

Total energy released = 4.86 MeV (1)

c) The initial momentum of the two particles was zero and it still is after the alpha emission as the nucleus and alpha particle have equal and opposite momentum.

(1

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The kinetic energy of the two particles has come from the nuclear binding energy, which is reduced by the emission of the alpha particle. (1)

13 a) In this example, the momentum of the vehicle as it hits the water will be the same as the momentum of the vehicle and the water after the splash has occurred. (2)

b) Momentum change of vehicle = 240 kg (14 – 5) m s^{-1}

= 2160 kg m s^{-1} (1)

So 2160 kg m s^{-1} = m × 18 m s^{-1} (1)

m = 120 kg (1)

c) Vehicle: $\Delta(\mathrm{KE}) = \frac{1}{2} \times\ 240\ \mathrm{kg}\ \times 14^2\ (\mathrm{m\ s^{-1}})^2 - \frac{1}{2} \times\ 240\ \mathrm{kg}\ \times 5^2\ (\mathrm{m\ s^{-1}})^2$

= 20.5 kJ (2)

Water: $\Delta(\mathrm{KE}) = \frac{1}{2} \times\ 120\ \mathrm{kg}\ \times 18^2\ (\mathrm{m\ s^{-1}})^2$

= 19.4 kJ (2)

d) There may also be some water moving sideways with kinetic energy. This will be symmetrical so that there is no resultant momentum sideways. Or energy has been transferred to thermal energy – eventually all the kinetic energy in the water will be transferred to thermal energy. (2)

e) $a = \frac{\Delta v}{\Delta t}$

= $\frac{14\ \mathrm{m\ s^{-1}} - 5\ \mathrm{m\ s^{-1}}}{0.6\ \mathrm{s}}$ (1)

= 15 m s^{-2} (1)

14 a) 0.1 s (1)

b) $\Delta(mv) = \ 0.08\ \mathrm{kg}\ \times\ 8\ \mathrm{m\ s^{-1}} - 0.08\ \mathrm{kg}\ \times\ (-5\ \mathrm{m\ s^{-1}})$ (1)

= 0.08 kg × 13 m s^{-1} (1)

= 1.0 kg m s^{-1} (2 s.f.)

c) $F = \frac{\Delta(mv)}{\Delta t}$ (1)

= $\frac{1.0\ \mathrm{kg\ m\ s^{-1}}}{0.1\ \mathrm{s}}$

= 10 N (1)

d) The force on the ground is 10 N. (Newton's third Law) (1)

e) The time of contact will be shorter. (1)

The return speed will be greater. (1)

Since $F = \frac{\Delta(mv)}{\Delta t}$

both a larger Δv and a smaller Δt increase the force. (1)

15 a) $m = \frac{4}{3}\pi\,\rho\,r^3$

= $\frac{4}{3}\pi\ \times\ 9\,000\ \mathrm{kg\ m^{-3}}\ \times\ (0.05\ \mathrm{m})^3$ (1)

= 4.71 kg (1)

b) $v^2 = 2gh$

= 2 × 9.8 N kg^{-1} × 2.0 m (1)

= 39.2 (m s^{-1})^2

v = 6.3 m s^{-1} (1)

c) Momentum before the collision = momentum after the collision

4.7 kg × 6.3 m s^{-1} = (4.7 kg + 2.6 kg) v (1)

v = 4.1 m s^{-1} (1)

d) Initial KE of ball = $\frac{1}{2}\, m_\text{b} v_\text{b}^2$

= $\frac{1}{2}$ × 4.7 kg × (6.3 m s^{-1})^2 (1)

= 93 J

KE of ball and spike = $\frac{1}{2}\,(m_\text{b} + m_\text{s})\,v^2$ (1)

= $\frac{1}{2}$ × 7.3 kg × (4.1 m s^{-1})^2

= 61 J (1)

So it is inelastic

e) $F \times s = \Delta\,(\frac{1}{2}mv^2)$ (1)

$F = \frac{61\text{ J}}{0.035\text{ cm}}$ (1)

= 1 800 N (2 s.f.) (1)

16 a) Momentum of neutron before = momentum of neutron and nucleus after the collision

(1

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1 × 1.2 × 10^7 = 239 × v (1)

v = 5.0 × 10^4 ms^{-1} (1)

b) Momentum of alpha = momentum (equal and opposite) of nucleus (1)

4 × 1.5 × 10^7 = 204 × v (1)

v = 2.9 × 10^5 m s^{-1} (1)

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17 a) $F = \frac{\Delta(mv)}{\Delta t} = \rho\, A\, v^2$

= 1.2 kg m^{-3} × π × (9 m)^2 × (5.0 m s^{-1})^2

= 7.63 kN (3 s.f.)

b) $m = \frac{W}{g}$

= $\frac{7.63\text{ kN}}{9.8\text{ N kg}^{-1}}$

= 778 kg

c) i) $\rho\, A\, v^2 \cos 14^\text{o} = 7.63\text{ kN}$

$\Longrightarrow v^2 = \frac{6\,030\text{ N}}{1.2\text{ kg m}^{-3} \times \pi \times (9\text{ m})^2 \times \cos 14}$

v^2 = 25.8 (m s^{-1})^2

v = 5.1 m s^{-1}

ii) The total force from the rotors = $\frac{7.63\text{ kN}}{\cos 14}$

= 7860 N

So resultant forwards force = 7 860 × sin 14

= 1900 N

$$a = \frac{F}{m}$$

$$= \frac{1900\ \text{N}}{778\ \text{kg}}$$

= 2.4 m s^{-2}

18 Momentum is conserved, so all the fragments have the same speed as they are distributed spherically. Each fragment therefore has 1.6 kJ ÷ 100 = 16 J.

$$16 = \frac{1}{2}mv^2$$

$$v^2 = \frac{2 \times 16}{0.02}$$

v = 40 m s^{-1}

19 a) The field direction is out of the paper. Use Fleming's left hand rule; remember that the conventional current is in the opposite direction to the electron movement.

b) The track thickness depends on the amount of ionisation per metre produced by the particle. The ionisation is greater when the particle has more charge, q, and it is greater when the particle has low speed, v. The energy transfer per metre is proportional to $\frac{q^2}{v^2}$. The ß–particle travels close to the speed of light, so is weakly ionising. The lithium nucleus has 3 charges and travels relatively slowly, so is strongly ionising over a short distance, over which it transfers its kinetic energy.

c) For momentum to be conserved, there must be another particle which has momentum equal to the vector sum of $-p_1 + -p_2$.

d) $p = \{(p_1)^2 + (p_2)^2\}^{1/2}$ at an angle Ø, where tan Ø = p_2/p_1 (see diagram).