

NEWTONS LAWS OF MOTION

1.

$$\begin{aligned} \text{Change} &= mv - (-mv) \\ &= 0.1\text{kg} \times 20 - (-0.1 \times 0.1 \times 30) \text{ [1m]} \\ &= 5\text{Kgm/s [1m]} \end{aligned}$$

2.

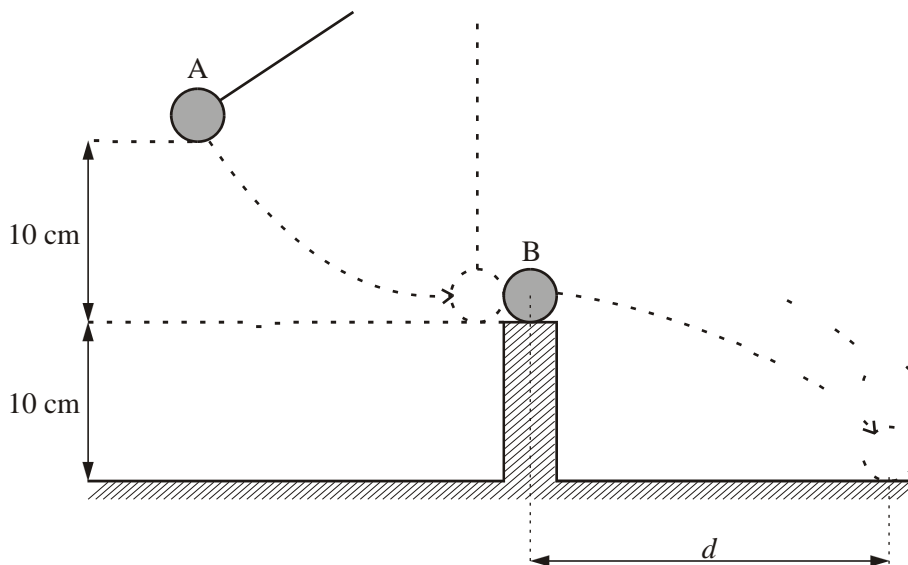
- (a) (i) any mention of force or weight ignore mass C1
Force to left > force to right)
OR resultant force) any 1 A1
OR unbalanced force)
OR weight > friction)
- (ii) to overcome/compensate for friction/resistance B1
- (b) 2/2.5 or 4/5 etc. or F/a or $F = ma$ C1
0.8 kg A1
- (c) 0.7/0.8 e.c.f. from (b) B1
0.875 (m/s²) e.c.f. from (b) could be scored on table (no unit needed) B1
- (d) (i) $v = at$ or 0.5×1.2 C1
0.6 m/s A1
- (ii) any velocity \times time or speed \times time C1
0.36 m c.a.o. (note: 0.72 m gets C1, A0) A1 [11]

3.

A

4.

The diagram illustrates an elastic collision between two spheres, A and B, of equal mass.



Sphere A is tied to the end of a long vertical thread and pulled to one side until it has risen a distance of 10 cm. It is then released and comes to rest when it strikes the sphere B

which is resting on a smooth flat support.

Sphere B travels a horizontal distance d before it hits the ground after falling 10 cm.

Calculate the speed of A as it strikes B.

$$\text{Gain of kinetic energy} = \text{loss in potential energy} \quad (1)$$

$$v = \sqrt{2gh} \quad (1)$$

$$\sqrt{2 \times (9.8 \text{ m s}^{-2}) \times (0.10 \text{ m})} \quad (1)$$

$$\text{Speed} = 1.4 \text{ m s}^{-1} \quad (1)$$

(4 marks)

How long does B take to fall 10cm?

$$t = \sqrt{2s/g} \quad (1)$$

$$= \sqrt{2 \times (0.10 \text{ m}) / (9.8 \text{ m s}^{-2})} \quad (1)$$

$$\text{Time} = 0.14 \text{ s} \quad (1)$$

(3 marks)

What is the speed of B just after the collision?

$$1.4 \text{ m s}^{-1} \quad (1)$$

(1 mark)

Calculate the distance d

$$\text{Distance} = \text{speed} \times \text{time} = (1.4 \text{ ms}^{-1}) (0.14\text{s}) \quad (1)$$

$$\text{Distance} = 0.20 \text{ m} \quad (1)$$

(2 marks)

Explain briefly why B drops a distance of 10 cm much more quickly than A.

B is in free fall (1)

while the downwards acceleration of A is inhibited by the upward tension in the string (1)

(2 marks)

[Total 12 marks]

5.

- | | | | |
|-----|------|--|---|
| (a) | (i) | momentum is mass \times <u>velocity</u> ; | 1 |
| | (ii) | impulse is force \times time / change in momentum;
<i>In each case allow an equation, with symbols explained.</i> | 1 |
| (b) | (i) | $Dp = 450 (18 - 13);$
$= 2250 \text{ kg m s}^{-1}$ | 1 |

(ii) idea of equating Dp to change in momentum of water;

$$m = \frac{2250}{19} = 118 \text{ kg } (\approx 120\text{kg});$$

2

$$(iii) \text{ time of trolley in tank} = \frac{9.3}{\frac{15.5}{(18-13)}} = 0.60 \text{ s};$$

$$a = 0.60 \quad \text{or} \quad \text{force} = 0.60 (= 3750 \text{ N});$$

$$a = 8.3 \text{ m s}^{-2} \quad a = \frac{3750}{450} = 8.3 \text{ m s}^{-2};$$

3

or

$$v^2 = u + 2as$$

$$\frac{13^2 - 18^2}{2}$$

$$a = \frac{2 \times 9.3}{2};$$

$$a = 8.3 \text{ m s}^{-2};$$

(c) (i) $E_k = \frac{1}{2}mv^2;$

$$= \frac{1}{2} \times 450 \times (18^2 - 13^2);$$

$$= 35000 \text{ J};$$

3

(ii) $E_k = \frac{1}{2} \times 118 \times 19^2$

$$= 21000 \text{ J}; \text{ (allow } 22\,000 \text{ J for use of } m=120 \text{ kg)}$$

1

- (d) some water will be thrown “sideways”;
 this will account for the difference in the kinetic energies;
 this will not have any momentum in the forward direction / equal
 masses of water to left and right;

3

[15]

6.

- (a) before and after collision there are no forces acting on the objects;
 from Newton 3 when the two bodies are in contact the forces that they
 exert on each other are equal and opposite / OWTTE;
 therefore, the net force on the two balls is always zero;
 therefore, there is no change in momentum (of the objects) /
 momentum is conserved;

or

Accept an argument based on change in momentum of each individual object.

eg

from Newton $3F_{12} = -F_{21}$; (*accept statement in words*)

$$F_{12} = \frac{\Delta p_1}{\Delta t} \text{ and } F_{21} = \frac{\Delta p_2}{\Delta t};$$

$$\frac{\Delta p_1}{\Delta t} = - \frac{\Delta p_2}{\Delta t} ;$$

therefore, $Dp_1 + Dp_2 = 0$; 4

- (b) the blades exert a force on the air and by Newton's third law the air exerts an equal and opposite force on the blades / air has change in momentum downwards giving rise to a force and from Newton 3 there will a force upwards;
if this force equals the weight of the helicopter;
the net vertical force on the helicopter will be zero / *OWTTE*; 3

- (c) area = $\rho 0.7^2$;
= 1.5 m^2 1

- (d) (i) volume of air per second = $1.5 \times 4.0 (\text{m}^3 \text{s}^{-1})$;
mass = volume \times density = $(1.2 \times 1.5 \times 4.0) = 7.2 \text{ kgs}^{-1}$; 2
No unit error for 7.2 kg.

- (ii) momentum per second = $(7.2 \times 4.0) = 29\text{N}$; 1

- (e) 29 N; 1

- (f) recognize that the force on the blades = Mg;
to give 3.0 kg; 2

7.

- (a) when two bodies A and B interact, the force that A exerts on B is equal and opposite to the force that B exerts on A;
or
when a force acts on a body an equal and opposite force acts on another body somewhere in the universe; 1 max

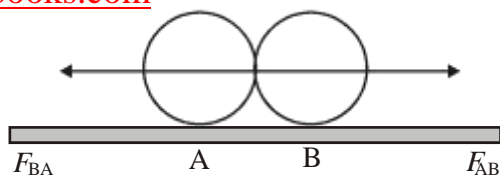
Award [0] for "action and reaction are equal and opposite"
unless they explain what is meant by the terms.

- (b) if the net external force acting on a system is zero;
then the total momentum of the system is constant (or in any one direction, is constant); 2

To achieve [2] answers should mention forces and should show what is meant by conserved. Award [1 max] for a definition such as "for a system of colliding bodies, the

momentum is constant” and [0] for “a system of colliding bodies, momentum is conserved”.

(c)



arrows of equal length;
 acting through centre of spheres;
 correct labelling consistent with correct direction;

3

- (d) (i) Ball B:
 change in momentum = Mv_B ;
 hence $F_{AB}\Delta t = Mv_B$; 2
- (ii) Ball A:
 change in momentum = $M(v_A - V)$;
 hence from Newton 2, $F_{BA}\Delta t = M(v_A - V)$; 2

- (e) from Newton 3, $F_{AB} + F_{BA} = 0$, or $F_{AB} = -F_{BA}$;
 therefore $-M(v_A - V) = Mv_B$;
 therefore $MV = Mv_B + Mv_A$;
 that is, momentum before equals momentum after collision such that the
 net change in momentum is zero (unchanged) / OWTTE; 4

Some statement is required to get the fourth mark ie an
 interpretation of the maths result.

- (f) from conservation of momentum $V = v_B + v_A$;
 from conservation of energy $V^2 = v_B^2 + v_A^2$;
 if $v_A = 0$, then both these show that $v_B = V$;
 or
 from conservation of momentum $V = v_B + v_A$;
 from conservation of energy $V^2 = v_B^2 + v_A^2$;
 so, $V^2 = (v_B + v_A)^2 = v_B^2 + v_A^2 + 2v_Av_B$ therefore v_A has to be zero; 3 max

Answers must show that effectively, the only way that both
 momentum and energy conservation can be satisfied is that
 ball A comes to rest and ball B moves off with speed V .

[17]