NEWTONS LAWS OF MOTION

1.

Change = mv-(-mv)

= 0.1kg x 20 - (- 0.1x 0.1 x 30) [1m]

= 5Kgm/s [1m]

2.

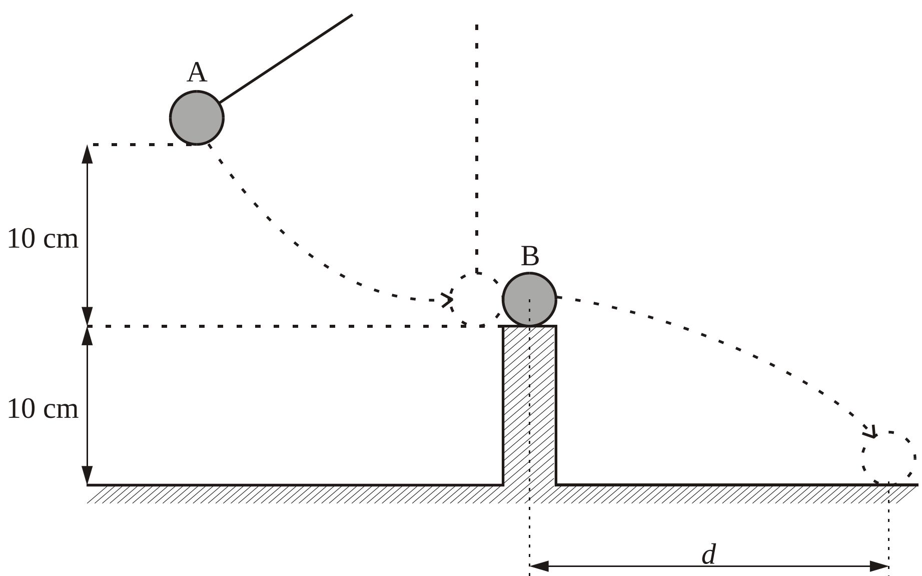
(a) (i) any mention of force or weight ignore mass C1
Force to left > force to right)
OR resultant force) any 1 A1
OR unbalanced force)
OR weight > friction)
(ii) to overcome/compensate for friction/resistance B1
(b) 2/2.5 or 4/5 etc. or F/a or F = ma C1
0.8 kg A1
(c) 0.7/0.8 e.c.f. from (b) B1
0.875 (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 × time or speed × 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.

Gain of kinetic energy = loss in potential energy (1)

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

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

Speed =1.4 m s^{-1} (1)

(4 marks)

How long does B take to fall 10cm?

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

= $\sqrt{2 \times (0.10\ \mathrm{m})/(9.8\ \mathrm{m\ s^{2}})}$ **(1)**

Time = 0.14 s (1)

(3 marks)

What is the speed of B just after the collision?

1.4 m s^{-1} (1)

(1 mark)

Calculate the distance *d*

Distance = speed × time = (1.4 ms^{-1}) (0.14s) (1)

Distance = 0.20 m (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 × <u>velocity</u>; 1

(ii) impulse is force × time / change in momentum; 1
In each case allow an equation, with symbols explained.

(b) (i) D*p* = 450 (18 – 13); 1
= 2250 kg m s^{-1}

(ii) idea of equating D*p* to change in momentum of water;

m = $\frac{2250}{19}$ = 118 kg (» 120kg); 2

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

a = $\frac{(18-13)}{0.60}$ *or* force = $\frac{2250}{0.60}$ (= 3750 N);

a = 8.3 m s^{-2} *a* = $\frac{3750}{450}$ = 8.3 m s^{-2}; 3

or

$v^2 = u + 2as$

a = $\frac{13^2 - 18^2}{2 \times 9.3}$;

a = 8.3 m s^{-2};

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

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

= 35000 J; 3

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

= 21000 J; (*allow 22 000 J for use of m=120 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 3 $F_{12} = -F_{21}$; *(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 = p0.7^2;

= 1.5 m^2 1

(d) (i) volume of air per second = 1.5 ´ 4.0(m^3s^{-1});

mass = volume ´ density = (1.2 ´ 1.5 ´ 4.0) = 7.2kgs^{-1}; 2
No unit error for 7.2 kg.

(ii) momentum per second = (7.2 ´ 4.0) = 29N; 1

(e) 29 N; 1

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

7.

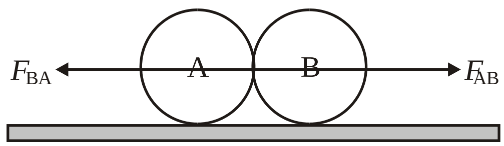
(a) when two bodies A and B interact, the force that A exerts on B is equal and opposite to the force that B exerts on A;
or
when a force acts on a body an equal and opposite force acts on another body somewhere in the universe; 1 max

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 = MvB;
hence FABΔt = MvB; 2

(ii) Ball A:
change in momentum = M (vA –V);
hence from Newton 2, FBAΔt = M(vA – V); 2

(e) from Newton 3, FAB + FBA = 0, or FAB = –FBA;
therefore –M(vA – V) = MvB;
therefore MV = MvB + MvA;
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 = vB + vA;
from conservation of energy V2 = vB2 + vA2;
if vA = 0, then both these show that vB = V;
or
from conservation of momentum V = vB + vA;
from conservation of energy V2 = vB2 + vA2;
so, V2 = (vB + vA)2 = vB2 + vA2 + 2vAvB therefore vA 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]