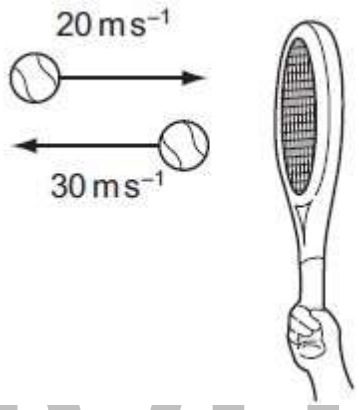
NAME: .....

NEWTONS LAWS OF MOTION

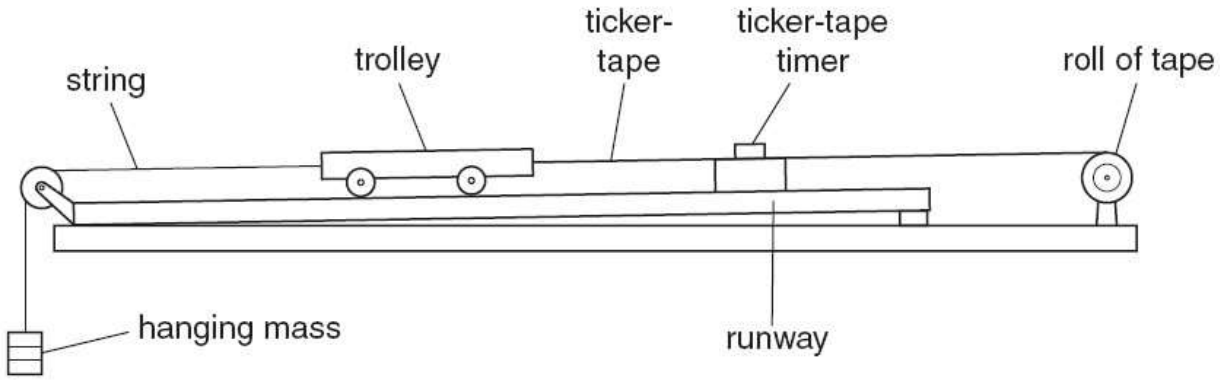
1. A tennis ball of mass 100 g is struck by a tennis racket. The velocity of the ball is changed as shown.



What is the magnitude of the change in momentum of the ball?

[2m]

2. The figure shows apparatus used to find a relationship between the force applied to a trolley and the acceleration caused by the force.



For each mass, hung as shown, the acceleration of the trolley is determined from the tape.
Some of the results are given in the table below.

weight of the hanging mass/N	acceleration of the trolley / m/s^2
0.20	0.25
0.40	0.50
0.70	
0.80	1.0

(a) (i) Explain why the trolley accelerates.

[2]

(ii) Suggest why the runway has a slight slope as shown.

[1]

(b) Calculate the mass of the trolley, assuming that the accelerating force is equal to the weight of the hanging mass.

mass = ... [2]

(c) Calculate the value missing from the table. Show your working.

Value = ... [2]

(d) In one experiment, the hanging mass has a weight of 0.4 N and the trolley starts from rest.
Use data from the table to calculate;

(i) The speed of the trolley after 1.2 s,

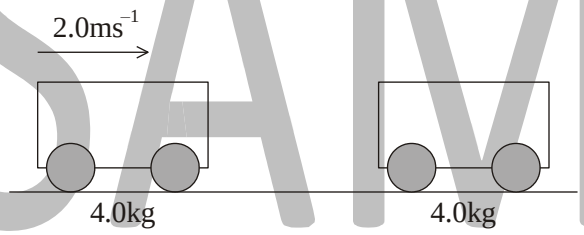
speed = ... [2]

(ii) The distance travelled by the trolley in 1.2 s.

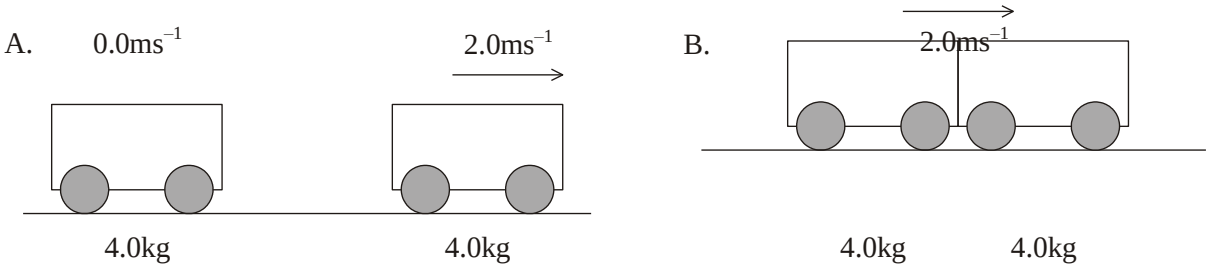
distance = ... [2]

[Total: 11]

3. The diagram below shows a trolley of mass 4.0 kg moving on a frictionless horizontal table with a speed of 2.0 m s^{-1}. It collides with a stationary trolley also of mass 4.0 kg.

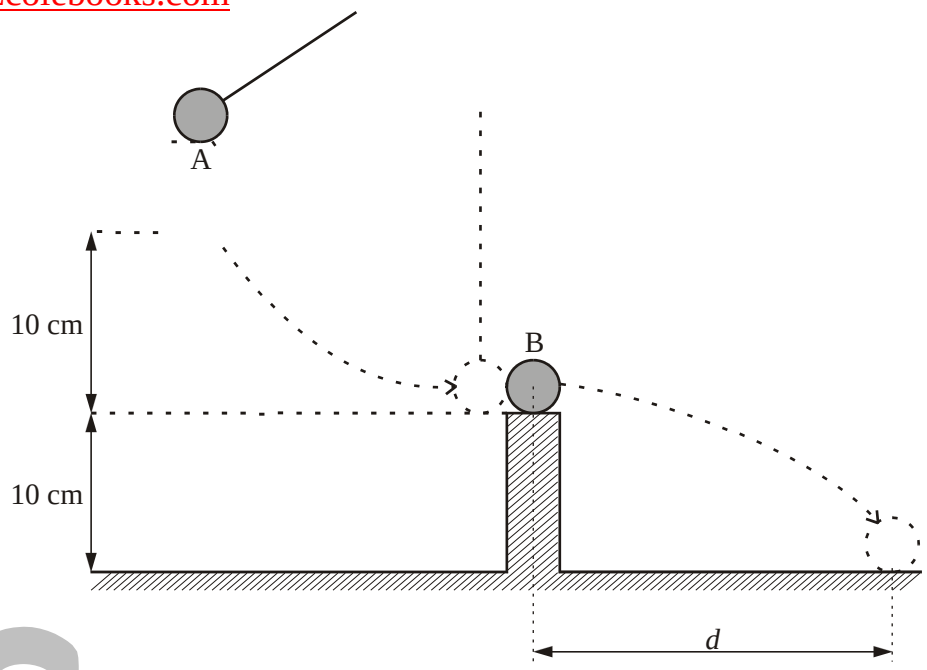


Which of the following diagrams shows a possible outcome?



(1)

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.

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Speed = ...

(4)

How long does B take to fall 10cm?

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.....

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Time= .....

(3)

What is the speed of B just after the collision?

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(1)

Calculate the distance *d*

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Distance = ...

(2)

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

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(2)

(Total 12 marks)

5. This question is about momentum.

(a) Define

(i) *linear momentum*.

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(1)

(ii) *impulse*.

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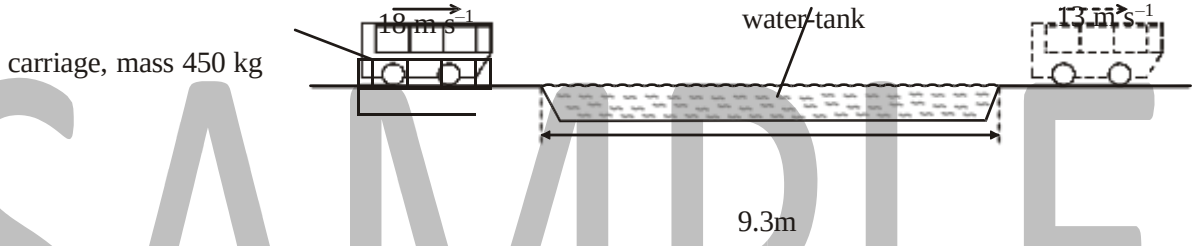
(1)

(b) In a ride in a pleasure park, a carriage of mass 450 kg is travelling horizontally at a speed of 18 m s^{-1}. It passes through a shallow tank containing stationary water. The tank is of length 9.3 m. The carriage leaves the tank at a speed of 13 m s^{-1}.



As the carriage passes through the tank, the carriage loses momentum and causes some water to be pushed forwards with a speed of 19 m s^{-1} in the direction of motion of the carriage.

(i) For the carriage passing through the water-tank, deduce that the magnitude of its total change in momentum is 2250N s.

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(1)

(ii) Use the answer in (b)(i) to deduce that the mass of water moved in the direction of motion of the carriage is approximately 120 kg.

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(2)

(iii) Calculate the mean value of the magnitude of the acceleration of the carriage in the water.

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(3)

(c) For the carriage in (b) passing through the water-tank, determine

(i) its total loss in kinetic energy.

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(3)

(ii) the gain in kinetic energy of the water that is moved in the direction of motion of the carriage.

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(1)

(d) By reference to the principles of conservation of momentum and of energy, explain your answers in (c).

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(3)
(Total 15 marks)

6. This question is about Newton's laws of motion, the dynamics of a model helicopter and the engine that powers it.

(a) Explain how Newton's third law leads to the concept of conservation of momentum in the collision between two objects in an isolated system.

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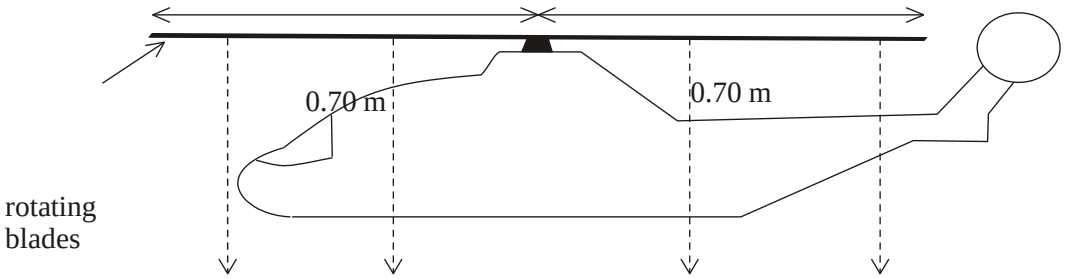
(4)

(b) The diagram illustrates a model helicopter that is hovering in a stationary position.



The rotating blades of the helicopter force a column of air to move downwards. Explain how this may enable the helicopter to remain stationary.

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(3)

(c) The length of each blade of the helicopter in (b) is 0.70 m. Deduce that the area that the blades sweep out as they rotate is 1.5 m^2. (Area of a circle = pr^2)

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(1)

(d) For the hovering helicopter in (b), it is assumed that all the air beneath the blades is pushed vertically downwards with the same

speed of 4.0 m s^{-1}. No other air is disturbed.

The density of the air is 1.2 kg m^{-3}.

Calculate, for the air moved downwards by the rotating blades,

(i) the mass per second;

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(2)

(ii) the rate of change of momentum.

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(1)

(e) State the magnitude of the force that the air beneath the blades exerts on the blades.

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(1)

(f) Calculate the mass of the helicopter and its load.

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(2)

7. (a) State Newton's third law.

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(1)

(b) State the law of conservation of momentum.

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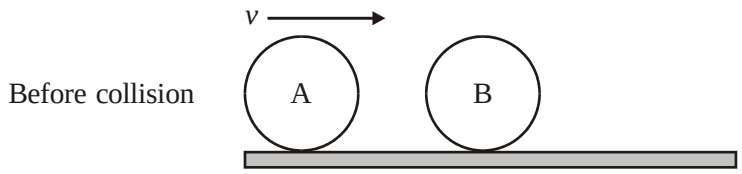
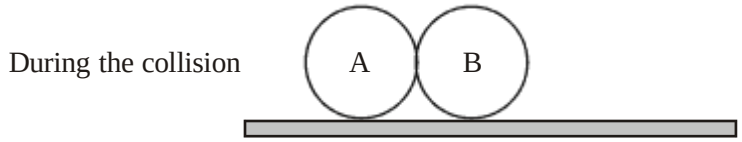
(2)

The diagram below shows two identical balls A and B on a horizontal surface. Ball B is at rest and ball A is moving with speed V along a line joining the centres of the balls. The mass of each ball is M.



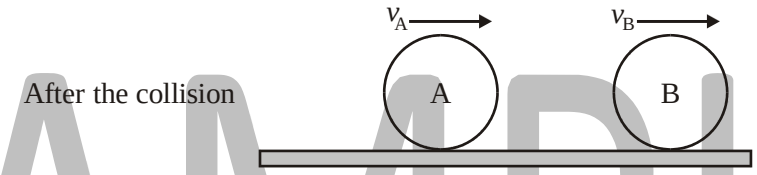
During the collision of the balls, the magnitude of the force that ball A exerts on ball B is FAB and the magnitude of the force that ball B exerts on ball A is FBA.

(c) On the diagram below, add labelled arrows to represent the magnitude and direction of the forces FAB and FBA.



(3)

The balls are in contact for a time Ät. After the collision, the speed of ball A is +vA and the speed of ball B is +vB in the directions shown.



As a result of the collision, there is a change in momentum of ball A and of ball B.

(d) Use Newton's second law of motion to deduce an expression relating the forces acting during the collision to the change in momentum of

(i) ball B.

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(2)

(ii) ball A.

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(2)

(e) Apply Newton's third law and your answers to (d), to deduce that the change in momentum of the system (ball A and ball B) as a result of this collision, is zero.

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(4)

(f) Deduce, that if kinetic energy is conserved in the collision, then after the collision, ball A will come to rest and ball B will move with speed V.

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(3)

(Total 17 marks)