LONDON SCIENCE COLLEGE

Name:

Date:

MOMENTUM
TEST 1

AS-Level

Mark

Grade

PHYSICS

For this paper you must have:

- Ruler
- Pencil and Rubber
- Scientific calculator, which you are expected to use when appropriate

Instructions

- Answer all questions
- Answer questions in the space provided
- All working must be shown

Information

- The marks for the questions are shown in brackets

1 (a) A car, of mass 970 kg, is travelling at 15 m s^{-1} along a level road when its driver performs an emergency stop. The car's braking system applies a constant braking force of 6.1×10^3 N to the car. Assume that the braking force is the resultant force acting on the car.

(i) Calculate the change of momentum of the car during the emergency stop.

change of momentum _____ kg m s^{-1}

(1)

(ii) Calculate the distance the car moves in coming to a halt during the emergency stop.

distance _____ m

(4)

(b) The car is now loaded with passengers and luggage and again travels at 15 m s^{-1}. State and explain how this affects the braking distance of the car. Assume that the car experiences the same braking force as in part (a).

_____

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_____

(3)

(Total 8 marks)

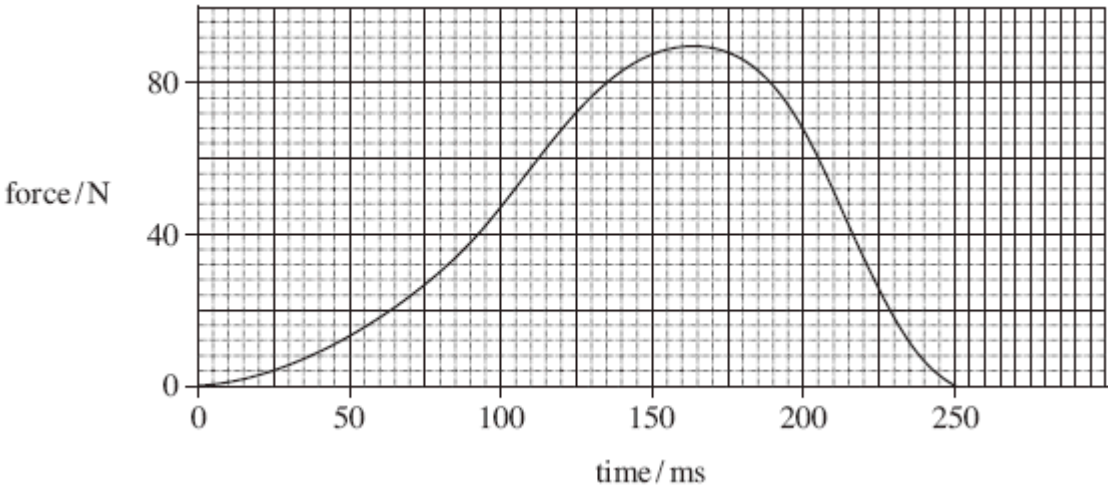
2 (a) State, in words, how the force acting on a body is related to the change in momentum of the body.

_____

_____

(1)

(b) A football of mass 0.42 kg is moving horizontally at 10 m s^{-1} towards a footballer's boot, which then kicks it. The figure below shows how the force between the boot and the ball varies with time while they are in contact.



(i) What is the significance of the area enclosed by the line on a force–time graph and the time axis when a force acts on a body for a short time?

_____

(1)

(ii) Estimate the impulse that acts on the ball, stating an appropriate unit.

answer = _____

(4)

(iii) Calculate the speed of the ball after it has been kicked, assuming that it returns along the same horizontal line it followed when approaching the boot. Express your answer to an appropriate number of significant figures.

answer = _____ m s^{-1}

(4)

(c) Discuss the consequences if the ball had approached the boot at a higher speed but still received the same impulse.

_____

_____

_____

_____

_____

_____

_____

_____

(3)

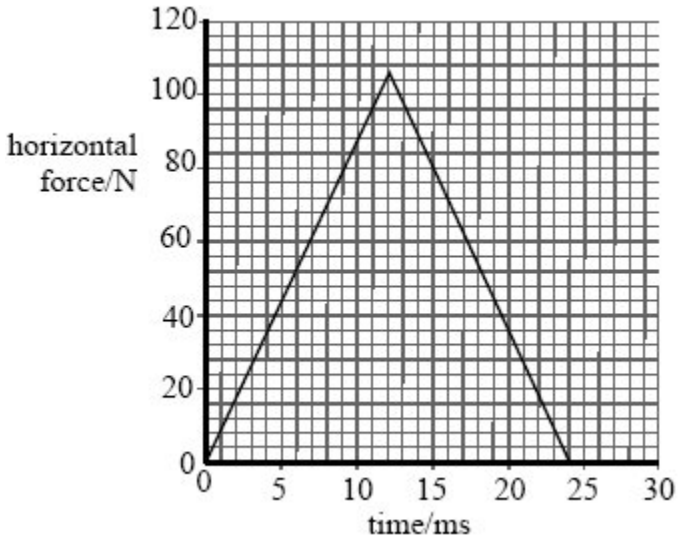
(Total 13 marks)

3 Which row, **A** to **D**, in the table correctly shows the quantities conserved in an inelastic collision?

	mass	**momentum**	**kinetic energy**	**total energy**
A	conserved	not conserved	conserved	conserved
B	not conserved	conserved	conserved	not conserved
C	conserved	conserved	conserved	conserved
D	conserved	conserved	not conserved	conserved

(Total 1 mark)

4 The graph shows the variation in the horizontal force acting on a tennis ball with time whilst the ball is being served.



(a) (i) Use the graph to show that the magnitude of the impulse that acts on the tennis ball is about 1.3 N s.

(2)

(ii) The mass of the tennis ball is 0.057 kg. Show that the impulse in part (a)(i) gives the ball a speed of about 20 m s^{-1} horizontally as the ball leaves the racquet.
Assume that the ball had no horizontal speed before the impulse was applied.

(2)

(b) During flight the ball accelerates due to gravity. When it reaches the ground the vertical component of the velocity is 6.1 m s^{-1}.
Calculate the speed and the angle between the direction of travel of the ball and the horizontal as it reaches the ground.
Assume that air resistance is negligible.

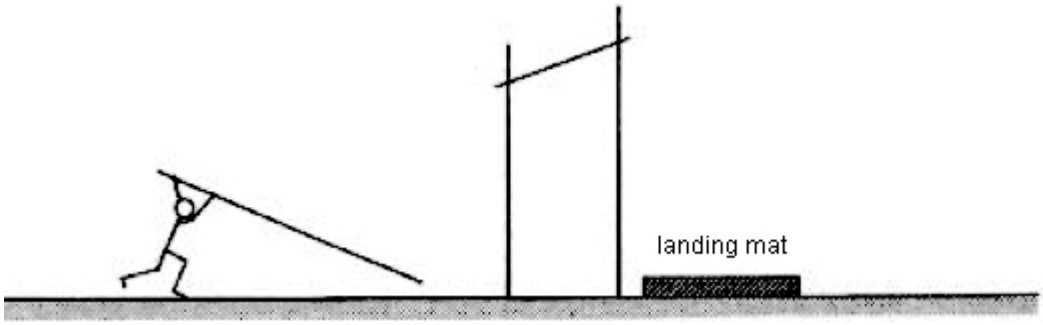
speed _____ m s^{-1}

angle _____ degree

(3)

(Total 7 marks)

5 The following figure shows an athlete of mass 65 kg about to perform a pole vault.



The centre of mass of the athlete rises 4.2 m during the vault.

(a) Calculate the change in potential energy of the athlete between take off and reaching the highest point.

change in potential energy _____ J

(2)

(b) Assuming that the centre of mass falls the same distance when falling. Calculate the vertical speed, in m s^{-1}, of the athlete when he lands.

vertical speed _____ m s^{-1}

(2)

(c) Explain how the landing mat reduces the force experienced by the athlete to an acceptable level when landing.

_____

_____

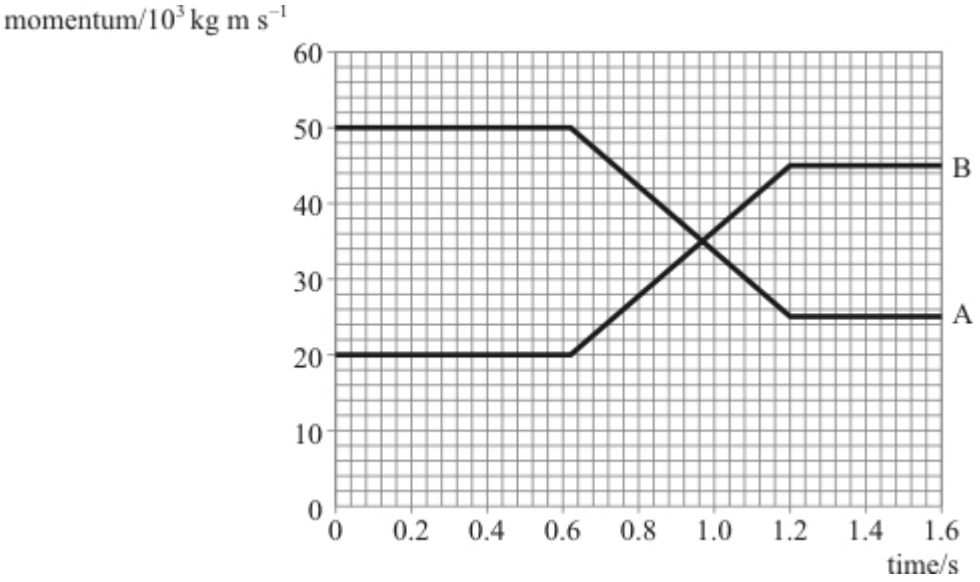
_____

_____

(2)

(Total 6 marks)

6 The graph shows how the momentum of two colliding railway trucks varies with time. Truck **A** has a mass of 2.0×10^4 kg and truck **B** has a mass of 3.0×10^4 kg. The trucks are travelling in the same direction.



(a) Calculate the change in momentum of

(i) truck **A**,

_____

(ii) truck **B.**

_____

(4)

(b) Complete the following table.

	Initial velocity/m s^{-1}	Final velocity/m s^{-1}	Initial kinetic energy/J	Final kinetic energy/J
truck **A**				
truck **B**				

(4)

(c) State and explain whether the collision of the two trucks is an example of an elastic collision.

_____

_____

_____

_____

(3)

(Total 11 marks)

7 (a) State the principle of conservation of momentum.

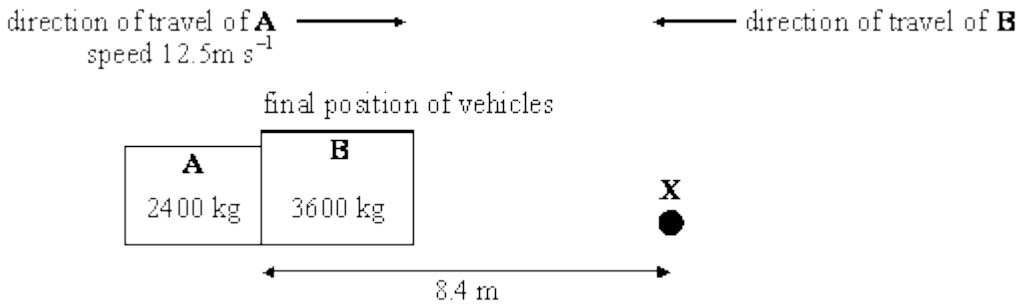
_____

_____

_____

(2)

(b) The diagram below shows a sketch drawn by an accident investigator following a head-on collision between two vehicles.



From the skid marks and debris on the road the investigator knows that the collision took place at the point marked **X.** The vehicles locked together on impact and vehicle **A** was pushed backwards a distance of 8.4 m.

For the road conditions and vehicle masses the average frictional force between the road and the vehicles immediately after the collision was known to be 7500 N.

(i) Calculate the work done against friction in bringing the vehicles to rest.

(2)

(ii) Determine the speed of the interlocked vehicles immediately after impact.

(2)

(iii) Vehicle **A** was known to be moving at 12.5 m s^{-1} just before the impact. Calculate the speed of vehicle **B** just before impact.

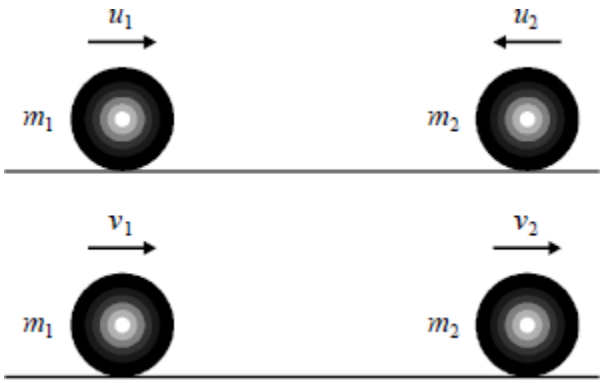
(3)

(iv) The drivers of both vehicles have the same mass. State and explain which driver is likely to experience the higher force during the impact.

(4)

(Total 13 marks)

8 (a) (i) Give an equation showing how the principle of conservation of momentum applies to the colliding snooker balls shown in the diagram.



_____

(ii) State the condition under which the principle of conservation of momentum applies.

_____

_____

(3)

(b) A trolley, A, of mass 0.25 kg and a second trolley, B, of mass 0.50 kg are held in contact on a smooth horizontal surface. A compressed spring inside one of the trolleys is released and they then move apart. The speed of A is 2.2 m s^{-1}.

(i) Calculate the speed of B.

_____

_____

_____

(ii) Calculate a minimum value for the energy stored in the spring when compressed.

_____

_____

_____

(4)

(c) The rotor blades of a helicopter sweep out a cross-sectional area, A. The motion of the blades helps the helicopter to hover by giving a downward velocity, v, to a cylinder of air, density ρ. The cylinder of air has the same cross-sectional area as that swept out by the rotor blades.

Explaining your reasoning,

(i) derive an expression for the mass of air flowing downwards per second, and

(ii) derive an expression for the momentum given per second to this air.

(iii) Hence show that the motion of the air results in an upward force, F, on the helicopter given by

$$F = \rho A v^2.$$

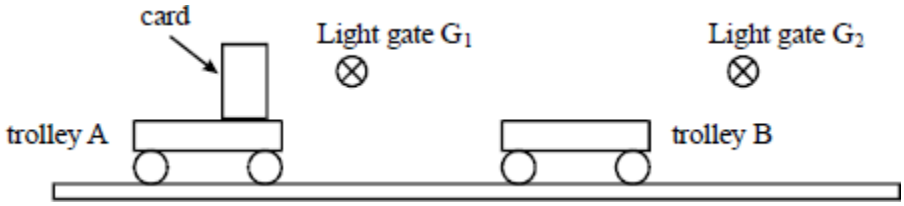
(5)

(d) A loaded helicopter has a mass of 2500 kg. The area swept out by its rotor blades is 180 m^2. If the downward flow of air supports 50% of the weight of the helicopter, what speed must be given to the air by the motion of the rotor blades when the helicopter is hovering? Take the density of air to be 1.3 kg m^{-3}.

(3)

(Total 15 marks)

9 The simplified diagram shows an experimental arrangement to investigate the collision of two trolleys.



In the experiment, trolley A is travelling at speed v. It collides with and sticks to, the initially stationary trolley B.

(a) State the measurements you would need to take so that you could determine the speed of

(i) trolley A before the collision,

_____

_____

(ii) trolleys A and B after the collision.

_____

_____

(3)

(b) Explain how you would verify that momentum was conserved in this collision, indicating what other measurements would be required.

_____

_____

_____

_____

(2)

(c) State and explain what you would do to minimise the effects of friction on the motion of the trolleys.

_____

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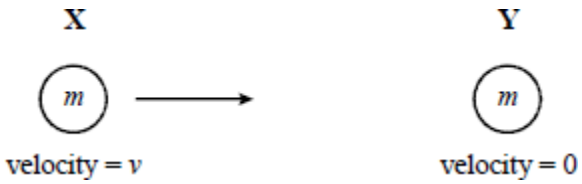
(2)

(Total 7 marks)

10 A body **X**, moving with a velocity v, collides elastically with a stationary body **Y** of equal mass.



Which one of the following correctly describes the velocities of the two bodies after the collision?

	velocity of **X**	velocity of **Y**
A	$\frac{v}{2}$	$\frac{v}{2}$
B	$-\frac{v}{2}$	$\frac{v}{2}$
C	$-v$	0
D	0	v

(Total 1 mark)