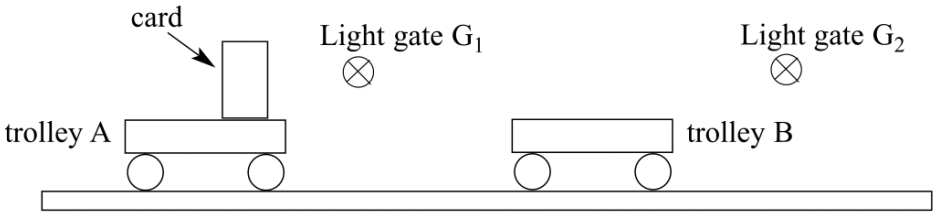
Momentum Paper Questions
Jan 2002—Jun 2008 (old spec)

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

Q4 Jun 2002



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,

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(ii) trolleys A and B after the collision.

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(3 marks)

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

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(2 marks)

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

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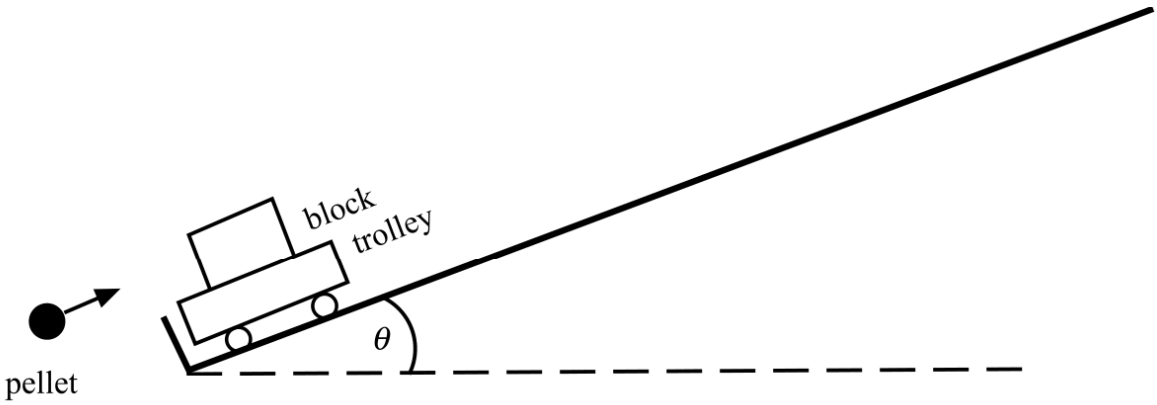
(2 marks)

2 The diagram represents part of an experiment that is being used to estimate the speed of an air gun pellet.

Q2 Jan 2003



The pellet which is moving parallel to the track, strikes the block, embedding itself. The trolley and the block then move along the track, rising a vertical height, *h*.

(a) Using energy considerations explain how the speed of the trolley and block immediately after it has been struck by the pellet, may be determined from measurements of *h*.
Assume frictional forces are negligible.

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(3 marks)

(b) The following data is collected from the experiment

mass of trolley and block	0.50 kg
mass of pellet	0.0020 kg
speed of trolley and block immediately after impact	0.40 m s^{-1}

Calculate

(i) the momentum of the trolley and block immediately after impact,

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(ii) the speed of the pellet just before impact.

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(4 marks)

(c) (i) State what is meant by an inelastic collision.

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(ii) Use the data from part (b) to show that the collision between the pellet and block is inelastic.

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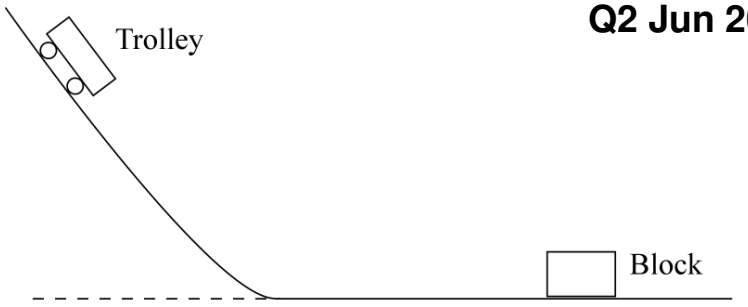
(4 marks)

2 The diagram represents an experiment that can be used to investigate stopping distances for a moving trolley.

Q2 Jun 2003



The trolley is placed on the raised section of the track. When released it moves down the track and then travels along the horizontal section before colliding with the block. The trolley and block join and move together after the collision. The distance they move is measured.

(a) State the main energy changes taking place

(i) as the trolley descends,

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(ii) after the collision, as the trolley and block move together.

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(2 marks)

(b) Describe how the speed of the trolley, just before it collides with the block may be measured experimentally.

You may be awarded marks for the quality of written communication in your answer.

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(3 marks)

(c) State and explain how the speed of the trolley, prior to impact could be varied.

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(2 marks)

2 A constant resultant horizontal force of 1.8×10^3 N acts on a car of mass 900 kg, initially at rest on a level road.

(a) Calculate **Q2 Jan 2004**

(i) the acceleration of the car,

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(ii) the speed of the car after 8.0 s,

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(iii) the momentum of the car after 8.0 s,

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(iv) the distance travelled by the car in the first 8.0 s of its motion,

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(v) the work done by the resultant horizontal force during the first 8.0 s.

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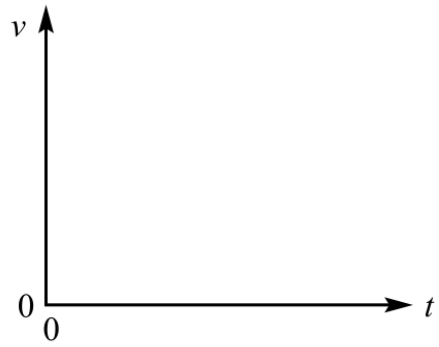
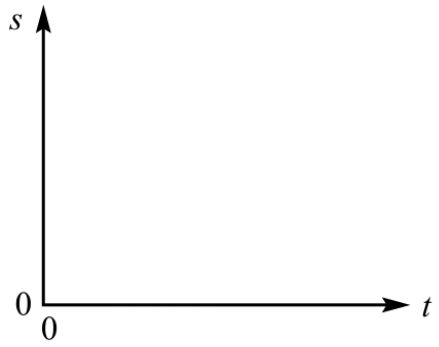
(9 marks)

(b) On the axes below sketch the graphs for speed, v, and distance travelled, s, against time, t, for the first 8.0 s of the car's motion.





(2 marks)

(c) In practice the resultant force on the car changes with time. Air resistance is one factor that affects the resultant force acting on the vehicle.
You may be awarded marks for the quality of written communication in your answer.

(i) Suggest, with a reason, how the resultant force on the car changes as its speed increases.

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(ii) Explain, using Newton's laws of motion, why the vehicle has a maximum speed.

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(5 marks)

6 A golf club undergoes an *inelastic* collision with a golf ball and gives it an initial velocity of $60\,\text{m}\,\text{s}^{-1}$. The ball is in contact with the club for 15 ms and the mass of the ball is $4.5 \times 10^{-2}\,\text{kg}$.

Q6 Jun 2004

(a) Explain what is meant by an inelastic collision.

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(1 mark)

(b) Calculate

(i) the change in momentum of the ball,

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(ii) the average force the club exerts on the ball.

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(4 marks)

(c) (i) State the value of the force exerted by the ball on the club and give its direction.

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(ii) Explain how your answer to part (i) follows from an appropriate law of motion.

You may be awarded marks for the quality of written communication in your answer.

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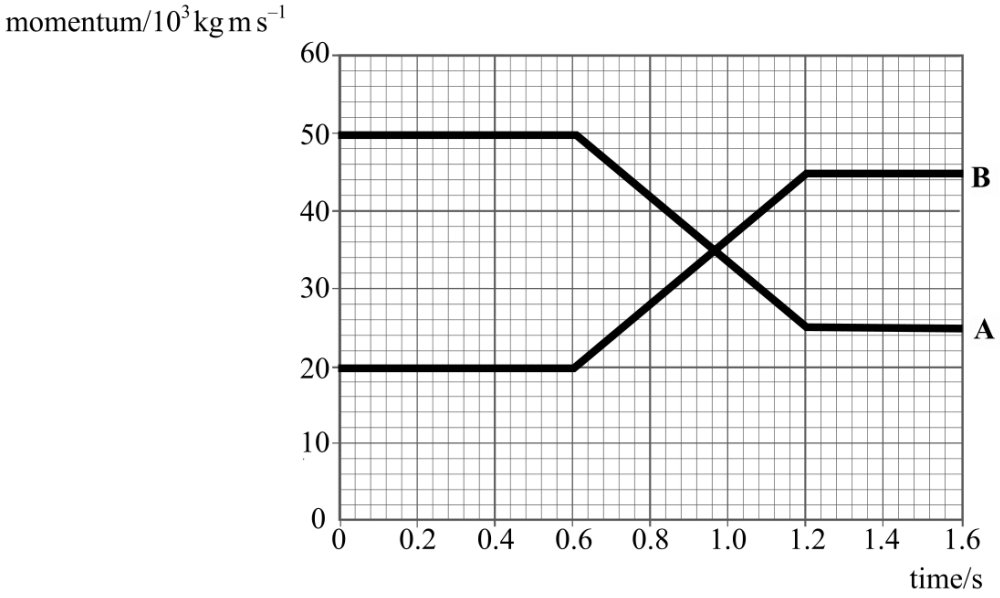
(4 marks)

5 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.

Q5 Jun 2005



(a) Calculate the change in momentum of

(i) truck **A**,

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(ii) truck **B**.

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(4 marks)

(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 marks)

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

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(3 marks)

1 (a) State **two** quantities that are conserved in an elastic collision. **Q1 Jun 2006**

quantity 1: .....

quantity 2: .....

(2 marks)

(b) A gas molecule makes an elastic collision with the walls of a gas cylinder. The molecule is travelling at 450 m s^{-1} at right angles towards the wall before the collision.

(i) What is the magnitude and direction of its velocity after the collision?

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(ii) Calculate the change in momentum of the molecule during the collision if it has a mass of 8.0×10^{-26} kg.

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(4 marks)

(c) Use Newton's laws of motion to explain how the molecules of a gas exert a force on the wall of a container.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(4 marks)

6 **Figure 3** shows two trolleys, A and B, of equal mass, travelling towards each other at the same speed, u.

Figure 3

Q6 Jan 2007

(a) State and explain why the initial total momentum of the trolleys is zero.

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(2 marks)

(b) The trolleys collide and then move apart. If no resultant external forces are acting, explain why

(i) the velocity of trolley A must be equal and opposite to the velocity of trolley B,

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(ii) the speed of each trolley will be smaller as a result of the collision.

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(4 marks)

(c) Describe how you would measure the speed of trolley A after the collision.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3 marks)

3 A steady stream of water strikes a wall horizontally without rebounding and, as a result, exerts a force on the vertical wall.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer to Question 3(a).

Q3 Jan 2008

(a) With reference to Newton's Laws of motion,

(i) state and explain why the momentum of the water changes as it strikes the wall,

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(ii) explain why the water exerts a constant force on the wall.

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(5 marks)

(b) Water arrives at the wall at a rate of $18\,\text{kg}\,\text{s}^{-1}$. It strikes the wall horizontally, at a speed of $7.2\,\text{m}\,\text{s}^{-1}$ without rebounding. Calculate

(i) the change in momentum of the water in **one** second,

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(ii) the force exerted by the water on the wall.

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(3 marks)

(c) State and explain the effect on the magnitude of the force if the water rebounds after striking the wall.

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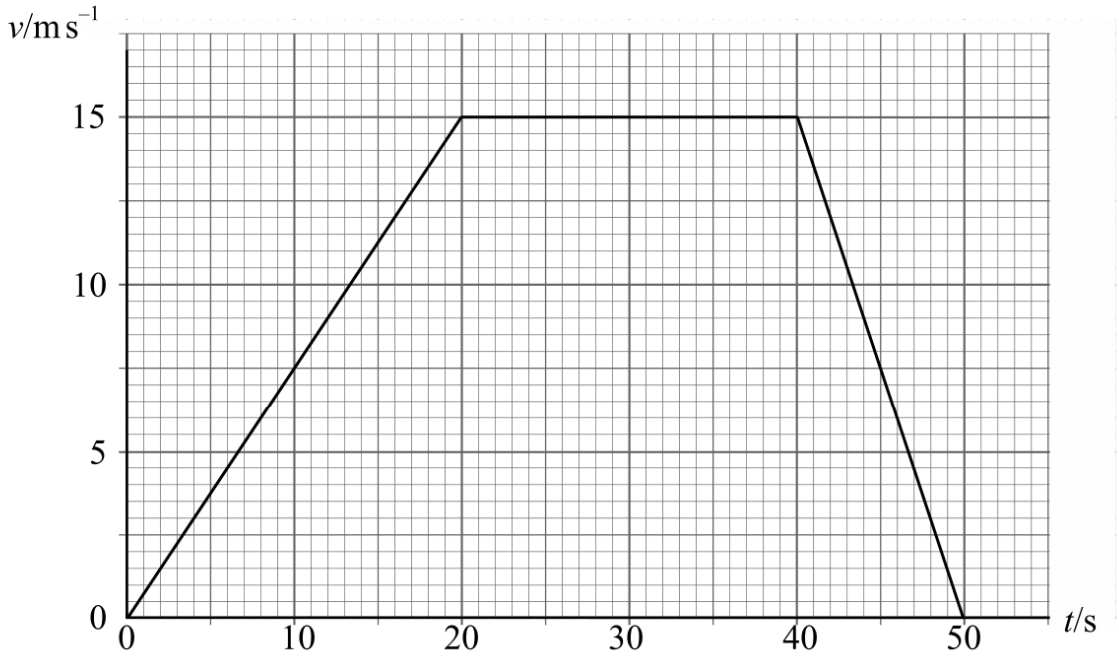
(2 marks)

3 The graph shows how the velocity, v, of a car varies with time, t. **Q3 Jun 2008**



3 (a) Describe the motion of the car for the 50 s period.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(3 marks)

3 (b) The mass of the car is 1200 kg. Calculate for the first 20 s of motion,

3 (b) (i) the change in momentum of the car,

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3 (b) (ii) the rate of change of momentum,

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3 (b) (iii) the distance travelled.

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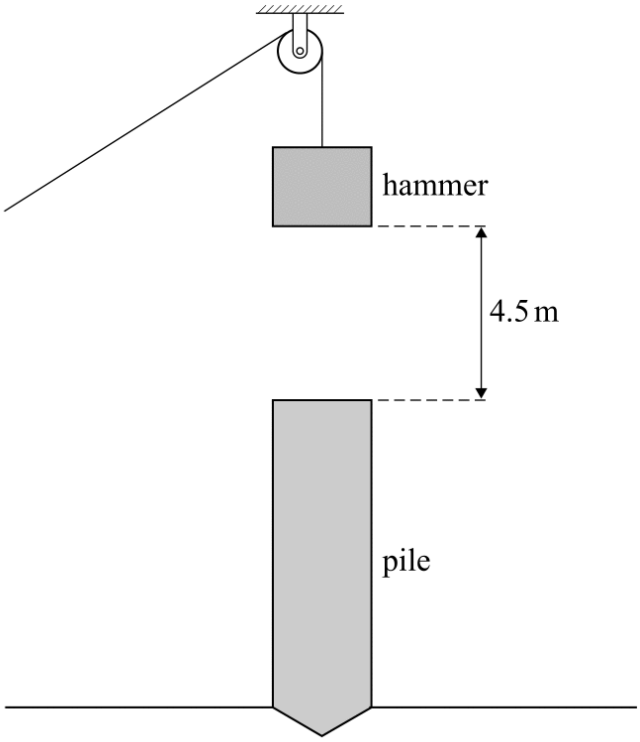
(4 marks)

6 A pile driver is used to drive cylindrical poles, called piles, into the ground so that they form the foundations of a building. **Figure 3** shows a possible arrangement for a pile driver. The hammer is held above the pile and then released so that it falls freely under gravity, until it strikes the top of the pile.

Figure 3 **Q6 Jun 2008**



6 (a) State the main energy changes that take place as the hammer is falling.

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(1 mark)

6 (b) The hammer has a mass of 250 kg and falls 4.5 m before striking the pile. After impact the hammer and pile move downwards together.
Calculate

6 (b) (i) the speed of the hammer just before impact,

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6 (b) (ii) the momentum of the hammer just before the impact,

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6 (b) (iii) the speed of the hammer and pile immediately after impact if the mass of the pile is 2000 kg.

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(4 marks)

6 (c) After an impact the hammer and the pile move so that the pile sinks into the ground to a depth of 0.25 m.

Calcuate

6 (c) (i) the loss of kinetic energy of the hammer and pile,

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6 (c) (ii) the average frictional force the ground exerts on the pile while bringing it to rest.

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(4 marks)

6 (d) The process is repeated several times and each time the hammer is raised 4.5 m above the pile. Suggest why the extra depth of penetration is likely to decrease with each impact.

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(2 marks)