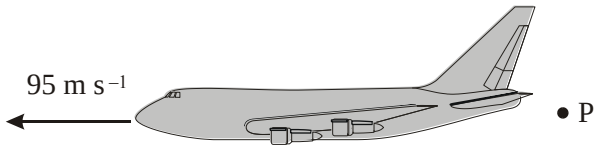
AQA Questions from 2004 to 2006

Mechanics

1. The aeroplane shown in the diagram below is travelling horizontally at 95 m s^{-1}. It has to drop a crate of emergency supplies.
The air resistance acting on the crate may be neglected.



(a) (i) The crate is released from the aircraft at point **P** and lands at point **Q**. Sketch the path followed by the crate between **P** and **Q** as seen from the ground.

(ii) Explain why the horizontal component of the crate's velocity remains constant while it is moving through the air.

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(3)

(b) (i) To avoid damage to the crate, the maximum vertical component of the crate's velocity on landing should be 32 m s^{-1}. Show that the maximum height from which the crate can be dropped is approximately 52 m.

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(ii) Calculate the time taken for the crate to reach the ground if the crate is dropped from a height of 52 m.

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(iii) If **R** is a point on the ground directly below **P**, calculate the horizontal distance **QR**.

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(6)

(c) In practice air resistance is **not** negligible. State and explain the effect this has on the maximum height from which the crate can be dropped.

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(2)

(Total 11 marks)

2. (a) Define the moment of a force.

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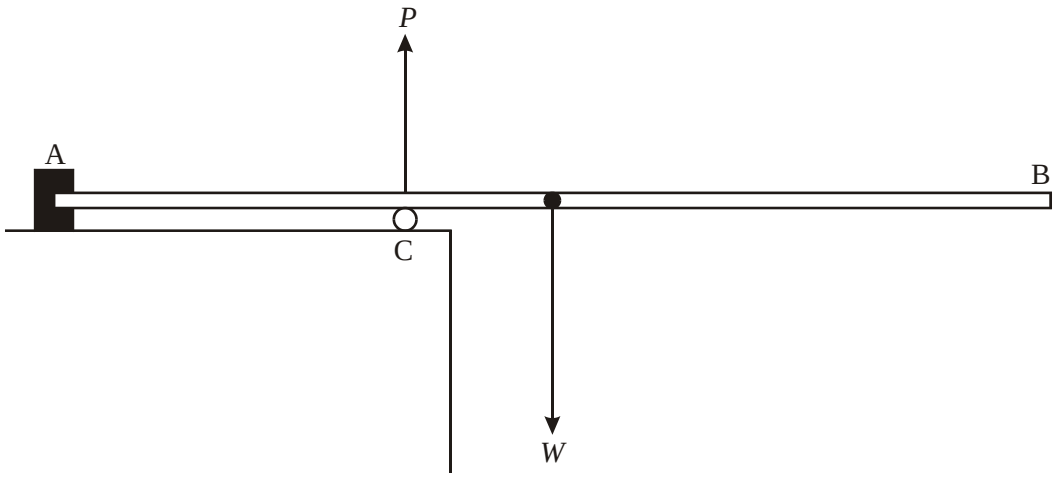
(2)

(b) The diagram shows a uniform diving board of weight, *W*, that is fixed at A. The diving board is supported by a cylinder at C, that exerts an upward force, *P*, on the board.



(i) By considering moments about A, explain why the force *P* must be greater than the weight of the board, *W*.

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(ii) State and explain what would be the effect on the force *P* of a girl walking along the board from A to B.

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(4)
(Total 6 marks)

3. A skydiver of mass 70 kg, jumps from a stationary balloon and reaches a speed of 45 m s^{-1} after falling a distance of 150 m.

(a) Calculate the skydiver's

(i) loss of gravitational potential energy,

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(ii) gain in kinetic energy.

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(4)

(b) The difference between the loss of gravitational potential energy and the gain in kinetic energy is equal to the work done against air resistance. Use this fact to calculate

(i) the work done against air resistance,

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(ii) the average force due to air resistance acting on the skydiver.

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(3)
(Total 7 marks)

4. (a) State the difference between vector and scalar quantities.

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(1)

(b) State **one** example of a vector quantity (other than force) and **one** example of a scalar quantity.

vector quantity .....

scalar quantity .....

(2)

(c) A 12.0 N force and a 8.0 N force act on a body of mass 6.5 kg at the same time. For this body, calculate

(i) the maximum resultant acceleration that it could experience,

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(ii) the minimum resultant acceleration that it could experience.

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(4)
(Total 7 marks)

5. A packing case is being lifted vertically at a constant speed by a cable attached to a crane.

The packing case has a mass of 640 kg.

(a) With reference to one of Newton's laws of motion, explain why the tension, *T*, in the cable must be equal to the weight of the packing case.

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

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(3)

(b) The packing case is lifted through a vertical height of 8.0 m in 4.5 s.

Calculate

(i) the work done on the packing case,

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(ii) the power output of the crane in this situation.

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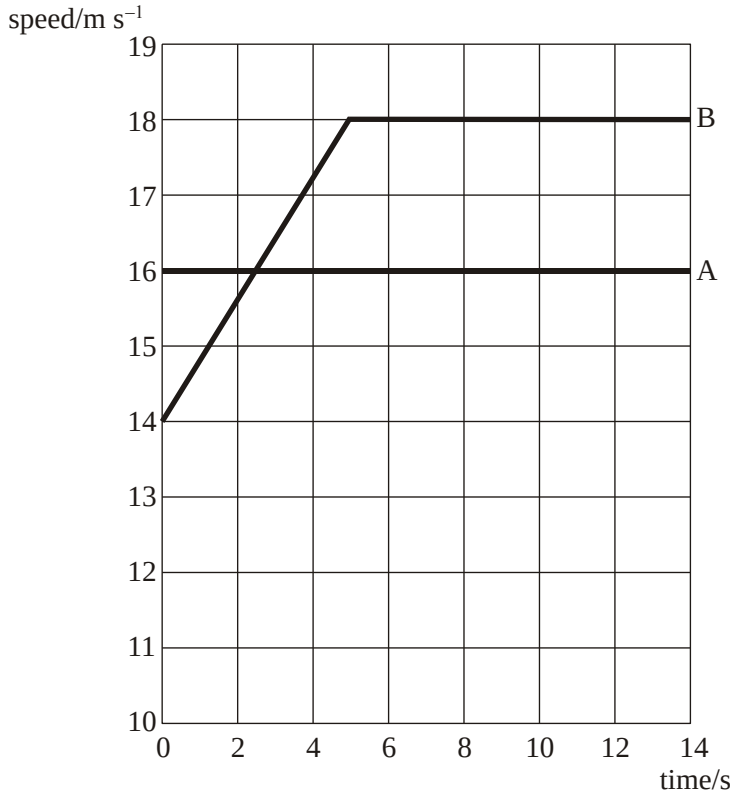
(3)
(Total 6 marks)

6. The graph represents the motion of two cars, A and B, as they move along a straight, horizontal road.



(a) Describe the motion of each car as shown on the graph.

(i) car A:

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(ii) car B:

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(3)

(b) Calculate the distance travelled by each car during the first 5.0 s.

(i) car A:

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(ii) car B:

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(4)

(c) At time t = 0, the two cars are level. Explain why car A is at its maximum distance ahead of B at t = 2.5 s

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(3)
(Total 10 marks)

7. (a) Define the moment of a force about a point.

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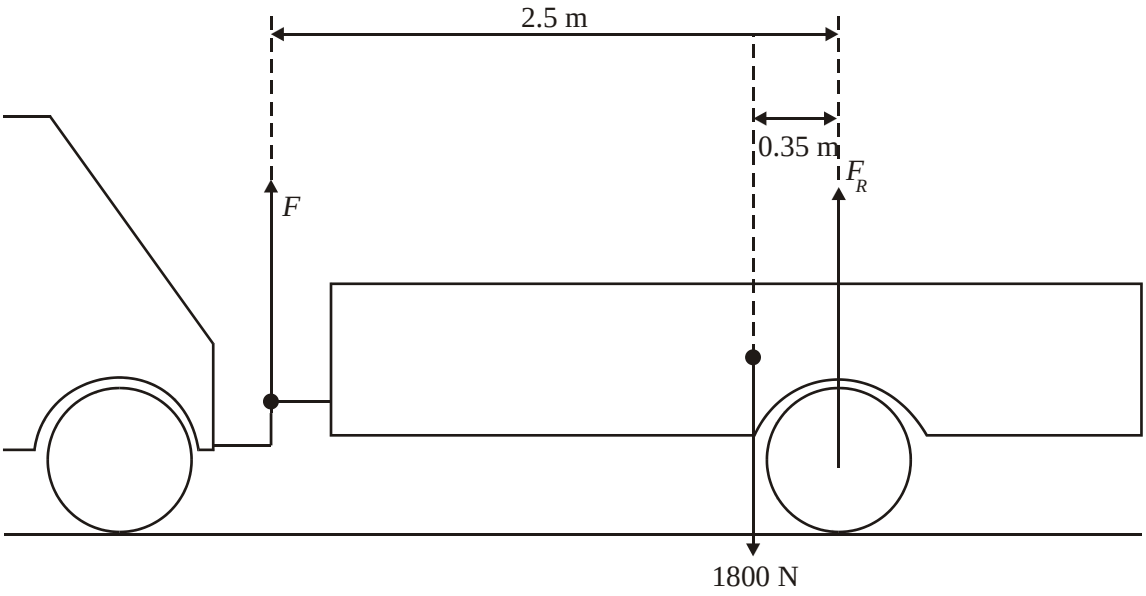
(2)

(b) The diagram shows a trailer attached to the towbar of a stationary car. The weight of the trailer is 1800 N and is shown acting through its *centre of gravity*.
F is the force exerted by the towbar on the trailer. F_R is the **total** normal reaction force experienced by the trailer. When stationary all forces acting on the trailer are vertical.



(i) Explain what is meant by centre of gravity.

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(ii) Calculate the force, F, exerted by the towbar on the trailer.

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(3)

(iii) Calculate F_R.

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(2)

(c) The car starts to move forwards. State and explain what happens to the magnitude and direction of force, *F*.

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

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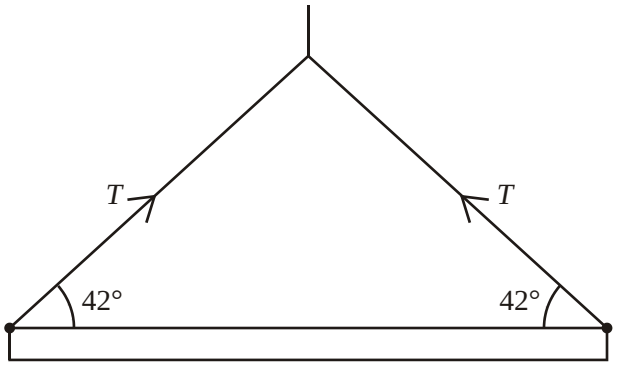
(3)
(Total 10 marks)

8. The figure below shows a uniform steel girder being held horizontally by a crane. Two cables are attached to the ends of the girder and the tension in each of these cables is *T*.



(a) If the tension, *T*, in each cable is 850 N, calculate

(i) the horizontal component of the tension in each cable,

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(ii) the vertical component of the tension in each cable,

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(iii) the weight of the girder.

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(4)

(b) On the figure draw an arrow to show the line of action of the weight of the girder.

(1)

(Total 5 marks)

9. (a) Explain why a raindrop falling vertically through still air reaches a constant velocity. You may be awarded marks for the quality of written communication in your answer.

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(4)

(b) A raindrop falls at a constant vertical velocity of 1.8 m s^{-1} in still air. The mass of the raindrop is 7.2×10^{-9} kg.

Calculate

(i) the kinetic energy of the raindrop,

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(ii) the work done on the raindrop as it falls through a vertical distance of 4.5 m.

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(4)

(c) The raindrop in part (b) now falls through air in which a horizontal wind is blowing. If the velocity of the wind is 1.4 m s^{-1}, use a scale diagram or calculation to determine the magnitude and direction of the resultant velocity of the raindrop.

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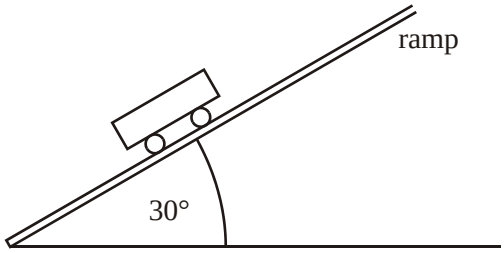
(3)

(Total 11 marks)

10. A fairground ride ends with the car moving up a ramp at a slope of 30° to the horizontal as shown in the figure below.



(a) The car and its passengers have a total weight of 7.2×10^3 N. Show that the component of the weight parallel to the ramp is 3.6×10^3 N.

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(1)

(b) Calculate the deceleration of the car assuming the only force causing the car to decelerate is that calculated in part (a).

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(2)

(c) The car enters at the bottom of the ramp at 18 m s^{-1}. Calculate the minimum length of the ramp for the car to stop before it reaches the end. The length of the car should be neglected.

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(2)

(d) Explain why the stopping distance is, in practice, shorter than the value calculated in part (c).

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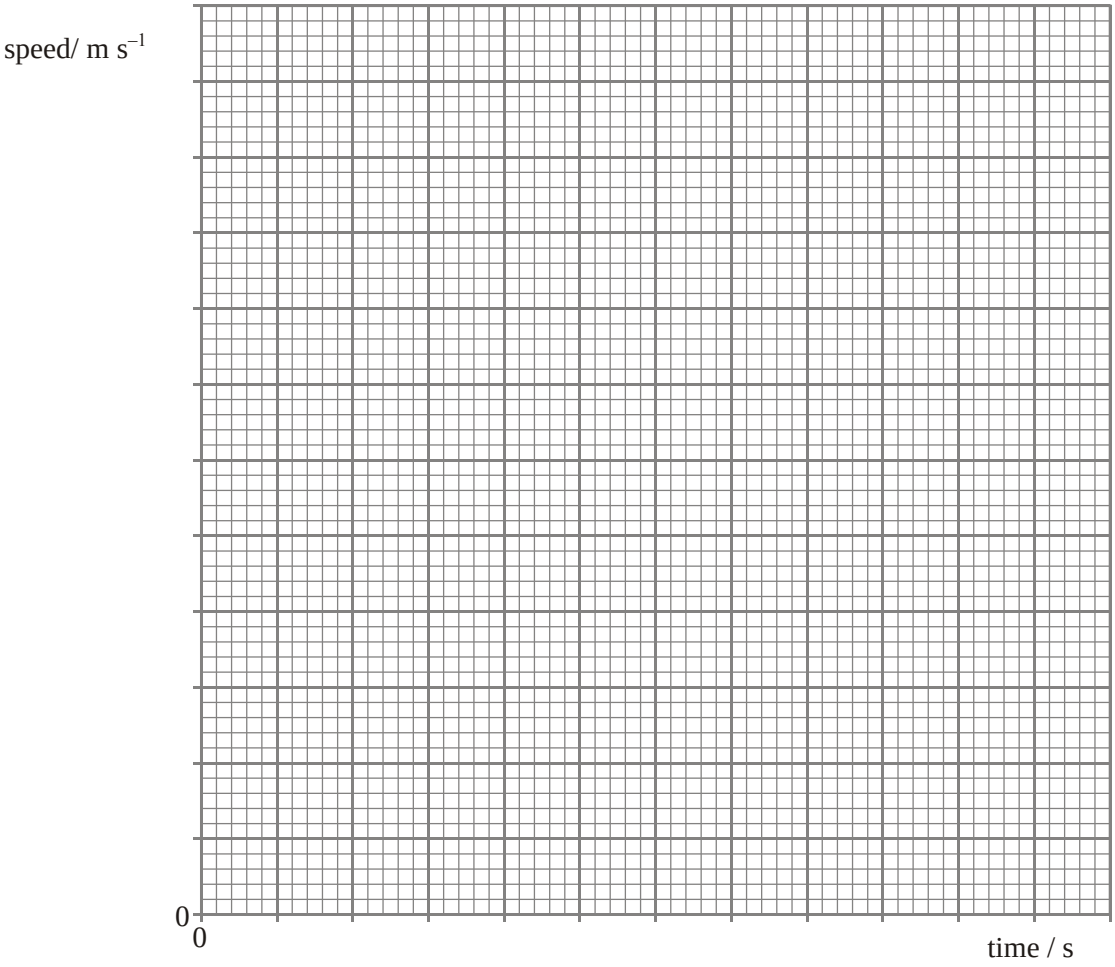
(2)
(Total 7 marks)

11. A car accelerates from rest to a speed of 26 m s^{-1}. The table shows how the speed of the car varies over the first 30 seconds of motion.

time/ s	0	5.0	10.0	15.0	20.0	25.0	30.0
speed/ m s^{-1}	0	16.5	22.5	24.5	25.5	26.0	26.0

(a) Draw a graph of speed against time on the grid provided.



(3)

(b) Calculate the average acceleration of the car over the first 25 s.

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(2)

(c) Use your graph to estimate the distance travelled by the car in the first 25 s.

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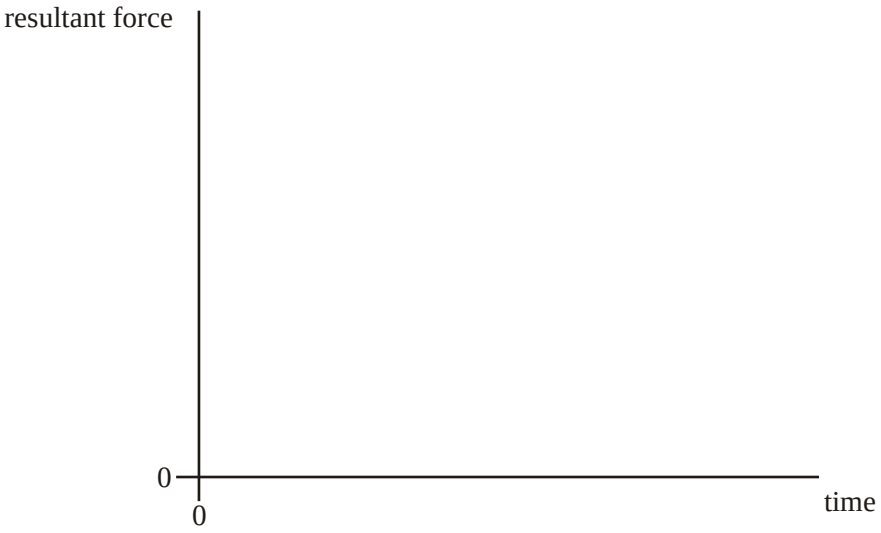
(2)

(d) Using the axes below, sketch a graph to show how the resultant force acting on the car varies over the first 30 s of motion.



(2)

(e) Explain the shape of the graph you have sketched in part (d), with reference to the graph you plotted in part (a).

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(2)

(Total 11 marks)

12. The figure below shows apparatus that can be used to investigate energy changes.

The trolley and the mass are joined by an inextensible string. In an experiment to investigate energy changes, the trolley is initially held at rest, and is then released so that the mass falls vertically to the ground.

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

(a) (i) State the energy changes of the falling mass.

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(ii) Describe the energy changes that take place in this system.

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(4)

(b) State what measurements would need to be made to investigate the *conservation of energy*.

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(2)

(c) Describe how the measurements in part (b) would be used to investigate the conservation of energy.

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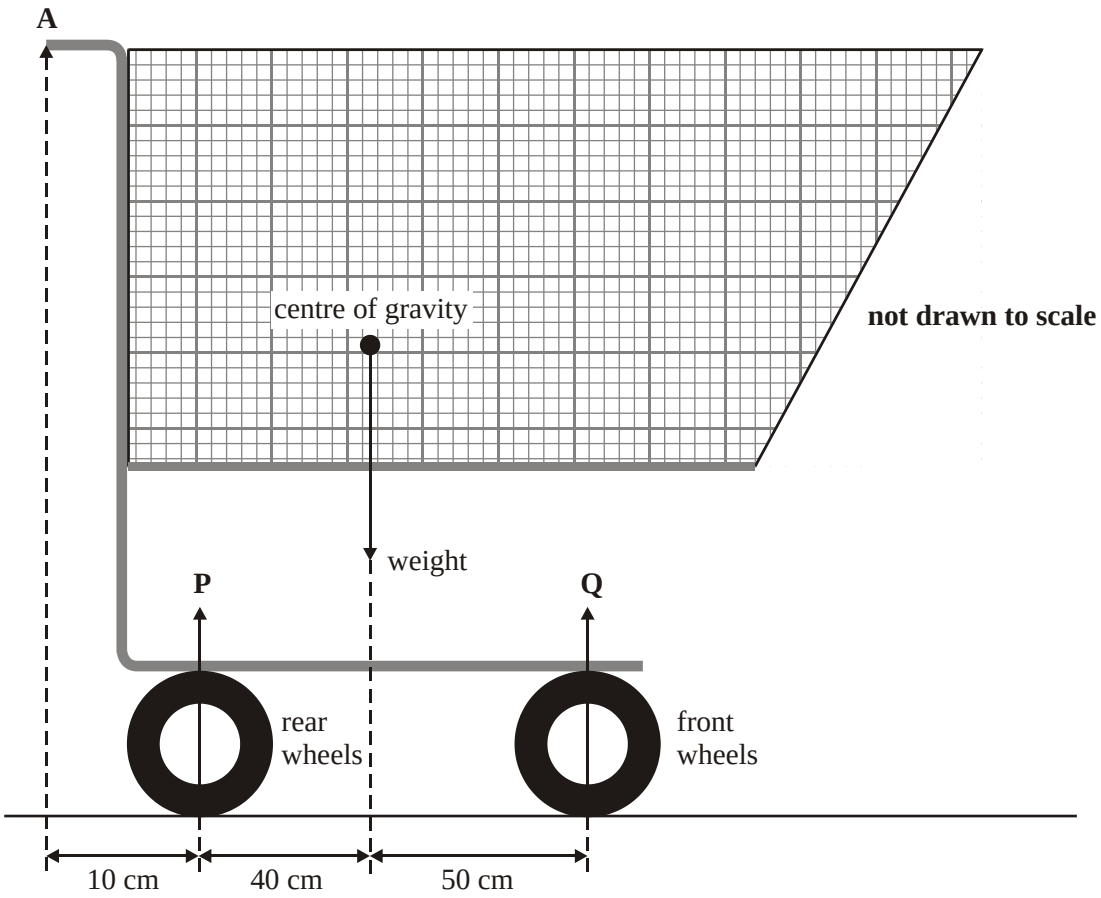
(4)
(Total 10 marks)

13. The figure below shows a supermarket trolley.



The weight of the trolley and its contents is 160 N.

(a) Explain what is meant by centre of gravity.

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(2)

(b) **P** and **Q** are the resultant forces that the ground exerts on the rear wheels and front wheels respectively. Calculate the magnitude of

(i) force **P**,

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(ii) force **Q**.

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(3)

(c) Calculate the minimum force that needs to be applied vertically at **A** to lift the front wheels off the ground.

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(2)

(d) State and explain, without calculation, how the minimum force that needs to be applied vertically at **A** to lift the rear wheels off the ground compares to the force you calculated in part (c).

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

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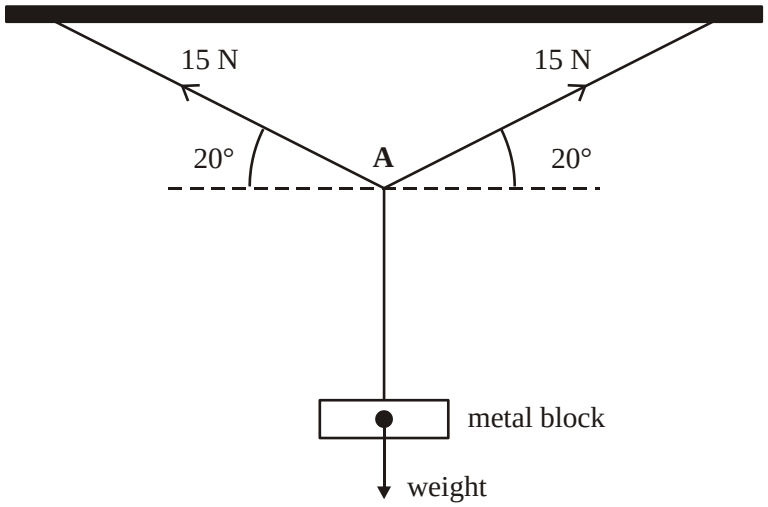
(3)

(Total 10 marks)

14. The figure below shows a stationary metal block hanging from the middle of a stretched wire which is suspended from a horizontal beam. The tension in each half of the wire is 15 N.



(a) Calculate for the wire at **A**,

(i) the resultant horizontal component of the tension forces,

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(ii) the resultant vertical component of the tension forces.

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(3)

(b) (i) State the weight of the metal block.

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(ii) Explain how you arrived at your answer, with reference to an appropriate law of motion.

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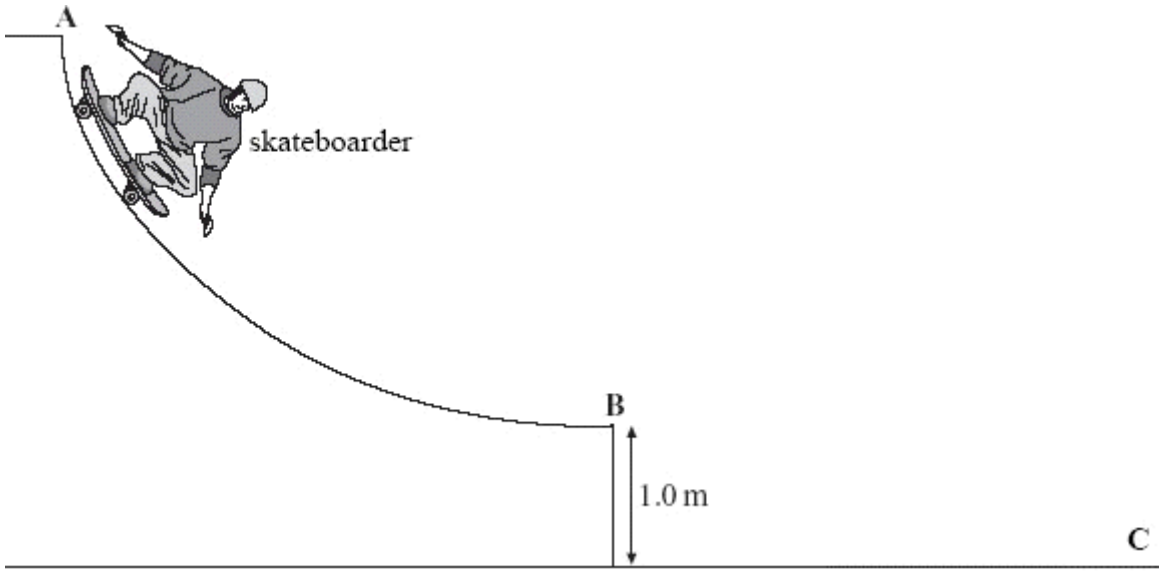
(3)
(Total 6 marks)

15. The figure below shows a skateboarder descending a ramp.



The skateboarder starts from rest at the top of the ramp at **A** and leaves the ramp at **B** horizontally with a velocity *v*.

(a) State the energy changes that take place as the skateboarder moves from **A** to **B**.

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(2)

(b) In going from **A** to **B** the skateboarder's centre of gravity descends a vertical height of
1.5 m. Calculate the horizontal velocity, *v*, stating an assumption that you make.

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(3)

(c) Explain why the acceleration decreases as the skateboarder moves from **A** to **B**.

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(2)

(d) After leaving the ramp at **B** the skateboarder lands on the ground at **C** 0.42 s later.

Calculate for the skateboarder

(i) the horizontal distance travelled between **B** and **C**,

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(ii) the vertical component of the velocity immediately before impact at **C**,

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(iii) the magnitude of the resultant velocity immediately before impact at **C**.

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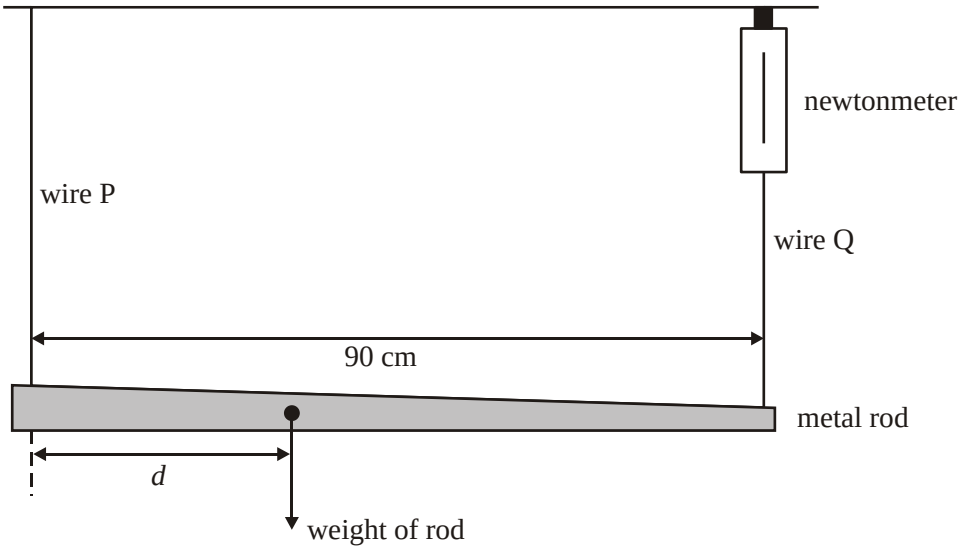
(5)

(Total 12 marks)

16. The figure below shows an apparatus used to locate the centre of gravity of a non-uniform metal rod.



The rod is supported horizontally by two wires, P and Q and is in equilibrium.

(a) State **two** conditions that must be satisfied for the rod to be in equilibrium.

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(2)

(b) Wire Q is attached to a newtonmeter so that the force the wire exerts on the rod can be measured. The reading on the newtonmeter is 2.0 N and the weight of the rod is 5.0 N.
Calculate

(i) the force that wire P exerts on the rod,

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(ii) the distance *d*.

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(3)
(Total 5 marks)

17. A supertanker of mass 4.0×10^8 kg, cruising at an initial speed of 4.5 m s^{-1}, takes one hour to come to rest.

(a) Assuming that the force slowing the tanker down is constant, calculate

(i) the deceleration of the tanker,

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(ii) the distance travelled by the tanker while slowing to a stop.

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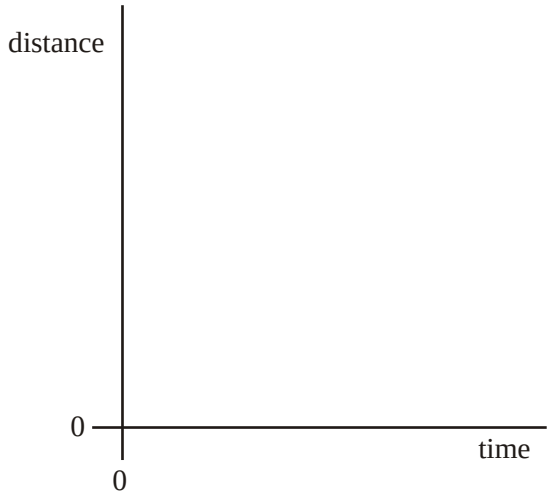
(4)

(b) Sketch, using the axes below, a distance-time graph representing the motion of the tanker until it stops.



(2)

(c) Explain the shape of the graph you have sketched in part (b).

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(2)

(Total 8 marks)

18. (a) (i) State what is meant by a scalar quantity.

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(ii) State **two** examples of scalar quantities.

example 1: .....

example 2: .....

(3)

(b) An object is acted upon by two forces at right angles to each other. One of the forces has a magnitude of 5.0 N and the resultant force produced on the object is 9.5 N. Determine

(i) the magnitude of the other force,

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(ii) the angle between the resultant force and the 5.0 N force.

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(4)
(Total 7 marks)

19. 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

(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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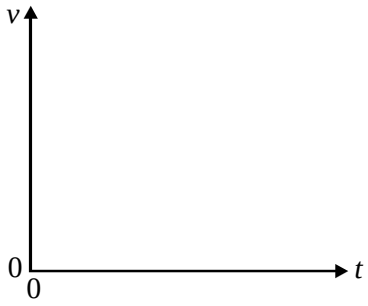
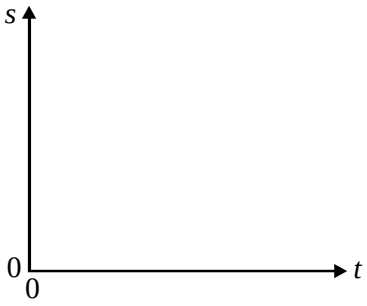
(9)

(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.





(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)
(Total 16 marks)

20. (a) State the principle of moments.

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(b) (i) Draw a labelled diagram of the apparatus you would use to verify the principle of moments.

(ii) Describe the procedure that would be used and state what measurements are taken.

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

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(iii) Explain how the results would be used to verify the principle of moments.

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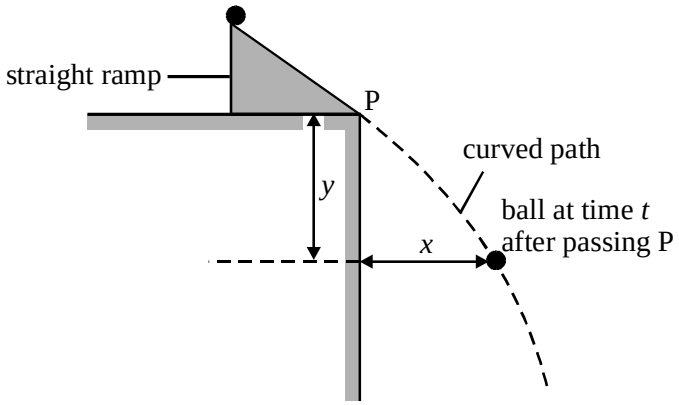
(7)
(Total 10 marks)

21. While investigating projectile motion, a student used stroboscopic photography to determine the position of a steel ball at regular intervals as it fell under gravity. With the stroboscope flashing 20 times per second, the ball was released from rest at the top of an inclined track, and left the foot of the track at P, as shown in the diagram below.



For each of the images on the photograph, the student calculated the horizontal distance, *x*, and the vertical distance, *y*, covered by the ball at time *t* after passing P. Both distances were measured from point P. He recorded his results for the distances *x* and *y* in the table.

image	*x*/cm	*y*/cm	*t*/s	(y/t)/cm s^{-1}
1	11.6	9.3	0.05	
2	22.0	21.0	0.10	
3	32.4	35.0	0.15	
4	44.2	51.8	0.20	
5	54.8	71.0	0.25	
6	66.0	92.2	0.30	

(a) Using two sets of measurements from the table, calculate the horizontal component of velocity of the ball. Give a reason for your choice of measurements.

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(2)

(b) The student worked out that the variables y and t in the experiment could be represented by

$$\frac{y}{t} = u + kt$$

where u and k are constants.

(i) Complete the table above.

(ii) Use the data in the table to plot a suitable graph to confirm the equation.

(Allow one sheet pf graph paper)

(iii) Use your graph to find the values of u and k.

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(9)

(c) State the physical significance of

u .....

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k .....

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(2)

(d) Calculate the magnitude of the velocity of the ball at point P.

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(2)

(Total 15 marks)