Teacher Resource Bank

GCE Physics B: Physics in Context

Additional Sample Questions and Mark Schemes

PHYB2 – Physics Keeps Us Going

ADDITIONAL SAMPLE QUESTIONS

This document provides a directory of past questions from the current AQA GCE Physics (Specification B); these questions may prove relevant/useful to both the teaching of the new AQA GCE Physics B: Physics in Context specification and the preparation of candidates for examined units. It is advisable when using these questions that teachers consider how these questions could relate to the new specification. Teachers should be aware of the different treatment of the Quality of Written Communication between the specifications.
For specific examples of the style and flavour of the questions which may appear in the operational exams, teachers should also refer to the Specimen Assessment Materials which accompany the specification.

A mark scheme has been produced which accompanies this document.

1 Distinguish between a *scalar quantity* and a *vector quantity*.

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(2)

(b) A car travels one complete lap around a circular track at an average speed of 100 km h^{-1}.

(i) If the lap takes 3.0 minutes, show that the length of the track is 5.0 km.

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(ii) What is the magnitude of displacement of the car after 1.5 minutes?

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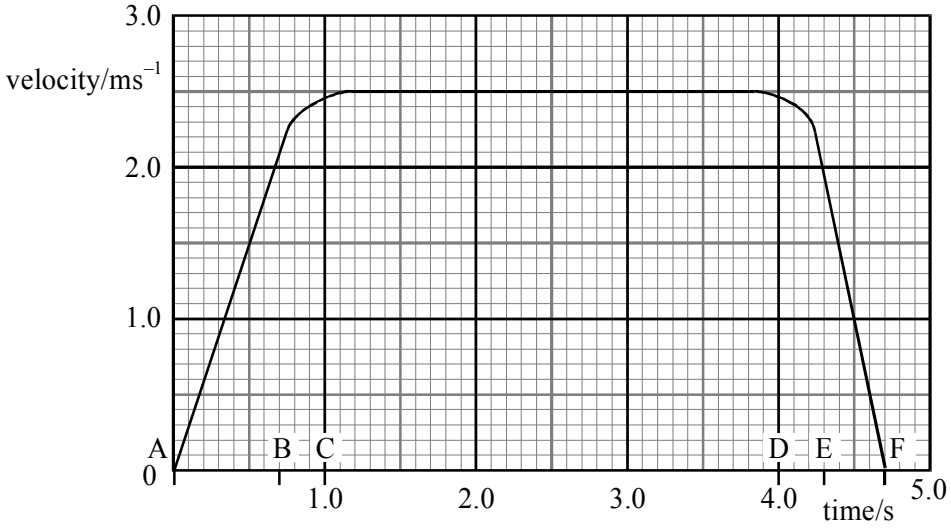
(4)

(Total 6 marks)

2 A mass of 1500 kg is attached to a cable and raised vertically by a crane. The graph shows how its velocity varies with time.



(a) Determine

(i) the initial uniform acceleration of the mass,

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(ii) the distance travelled by the mass while it is accelerating upwards.

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(3)

(b) (i) Calculate the tension in the cable in the intervals

AB, ...

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CD. .....

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(ii) State in which interval of the motion the tension in the cable is least.

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(4)

(c) Calculate the power supplied by the crane during the interval CD.

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(2)

(Total 9 marks)

3 A cyclist rides along a road up an incline at a steady speed of 9.0 m s^{-1}. The mass of the rider and bicycle is 70 kg and the bicycle travels 15 m along the road for every 1.0 m gained in height. Neglect energy loss due to frictional forces.

(a) (i) Calculate the component of the weight of the bicycle and the rider that acts along the incline.

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(ii) Calculate the power developed by the cyclist in riding up the slope.

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(4)

(b) The cyclist stops pedalling and the bicycle freewheels up the incline for a short time.

(i) State the energy change taking place as the bicycle freewheels up the slope.

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(ii) Calculate the distance travelled along the slope from when the cyclist stops pedalling to where the bicycle comes to rest.

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(3)

(Total 7 marks)

4 The Thrust SSC car raised the world land speed record in 1997. The mass of the car was 1.0×10^4 kg. A 12s run by the car may be considered in two stages of constant acceleration. Stage one was from 0 to 4.0 s and stage two 4.0 s to 12 s.

(i) In stage one the car accelerates from rest to 44 m s^{-1} in 4.0s. Calculate the acceleration produced and the force required to accelerate the car.

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(ii) In stage two the car continued to accelerate so that it reached 280 m s^{-1} in a further 8.0 s. Calculate the acceleration of the car during stage two.

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(iii) Calculate the distance travelled by the car from rest to reach a speed of 280 m s^{-1}.

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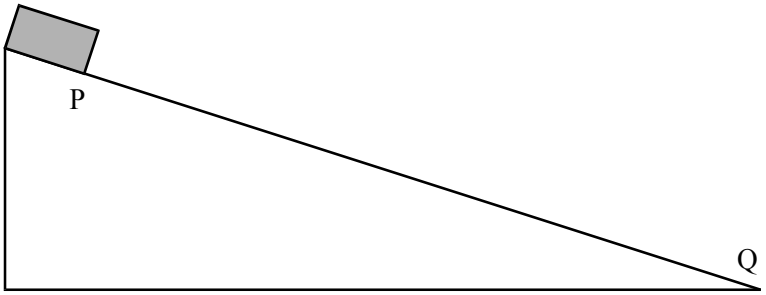
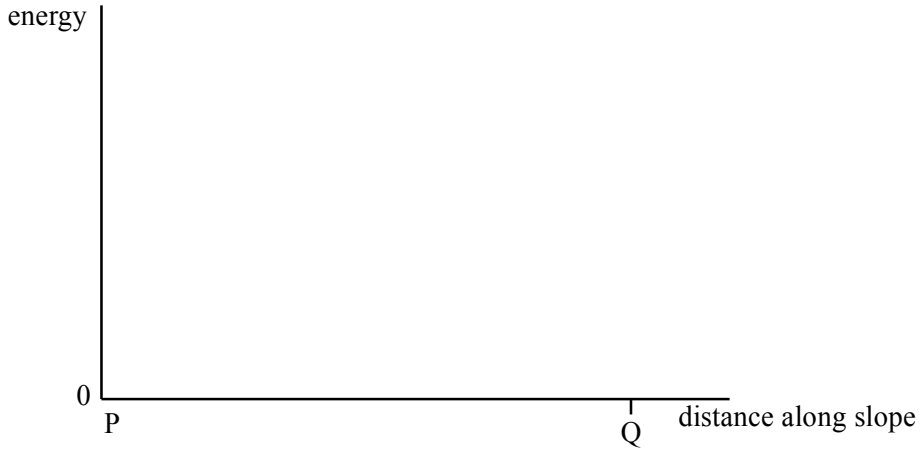
(6)

(Total 6 marks)

5 (a) The diagram shows an object at rest at the top of a straight slope which makes a fixed angle with the horizontal.



(i) The object is released and slides down the slope from P to Q with negligible friction. Assume that the potential energy is zero at Q. Sketch a graph showing the potential energy at different distances measured along the slope, and label it A. On the same set of axes, sketch a second graph showing the kinetic energy of the object at different distances along the slope and label it B.



(ii) Using the same axes as in part (i), sketch a third graph, labelled C, showing the kinetic energy at different distances along the slope when there is a constant frictional force between the object and the surface.

(iii) Use your knowledge of the principle of conservation of energy to explain the important features of the graphs you have drawn in part (i) and part (ii).

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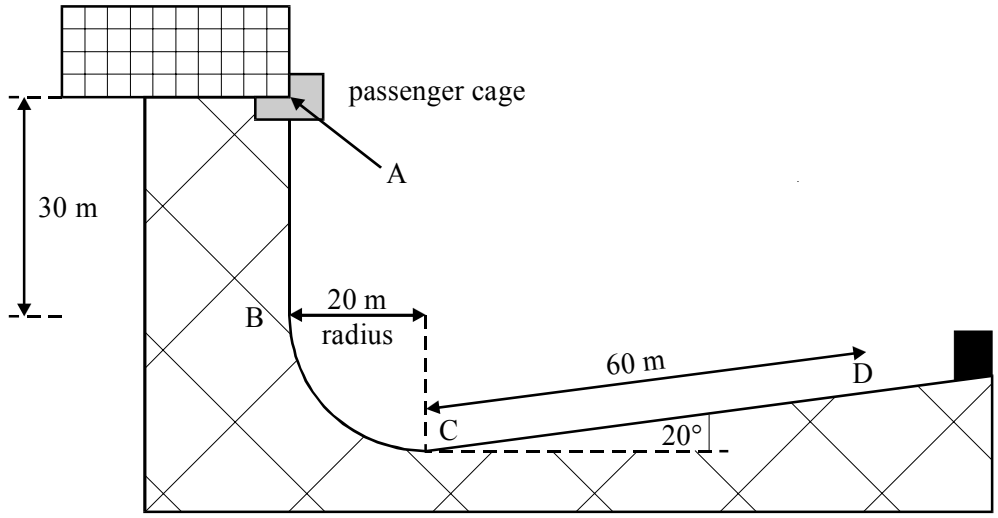
(6)

(b) In a theme park ride, a cage containing passengers falls freely a distance of 30 m from A to B and travels in a circular arc of radius 20 m from B to C. Assume that friction is negligible between A and C. Brakes are applied at C after which the cage with its passengers travels 60 m along an upward sloping ramp and comes to rest at D. The track, together with relevant distances, is shown in the diagram. CD makes an angle of 20° with the horizontal.



(i) Calculate the speed of the cage at C.

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(ii) Calculate the force required on a passenger of mass 80 kg for circular motion at C and state the direction of this force.

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(iii) If the mass of the cage and passengers is 620 kg, determine the gain in gravitational potential energy in travelling from C to D.

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(iv) Calculate the average resistive force exerted by the brakes between C and D.

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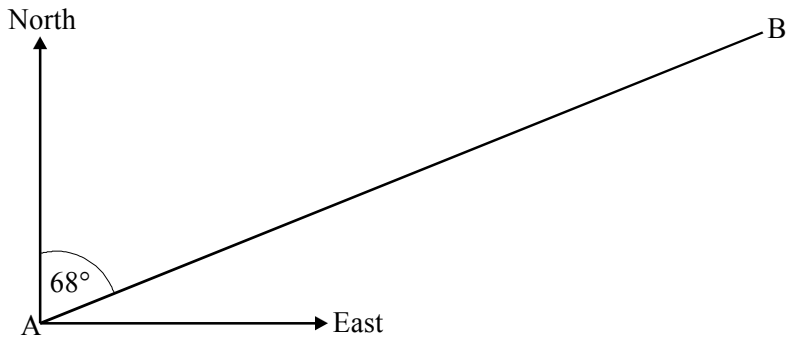
(9)

(Total 15 marks)

6 A microlight is a small aircraft powered by a petrol engine. The diagram represents the flight path, AB, of a microlight on a short horizontal training flight.



(a) On its outward journey, the wind velocity is 7.5 m s^{-1} due North and the resultant velocity of the microlight is 20 m s^{-1} in a direction 68° East of North, so that it travels along AB.

(i) Show that for the aircraft to travel along AB at 20 m s^{-1} it should be pointed due East.

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(ii) The driving force of the aircraft engine is 2.0×10^3 N. Calculate the work done by the engine if the aircraft travels 10 km on its outward journey.

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(iii) Calculate the output power of the aircraft engine for the outward journey.

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(6)

(b) After flying 10 km, the aircraft turns round and returns along the same flight path at a resultant velocity of 14 m s^{-1}. Assuming that the turn-round time is negligible, calculate the average speed for the complete journey.

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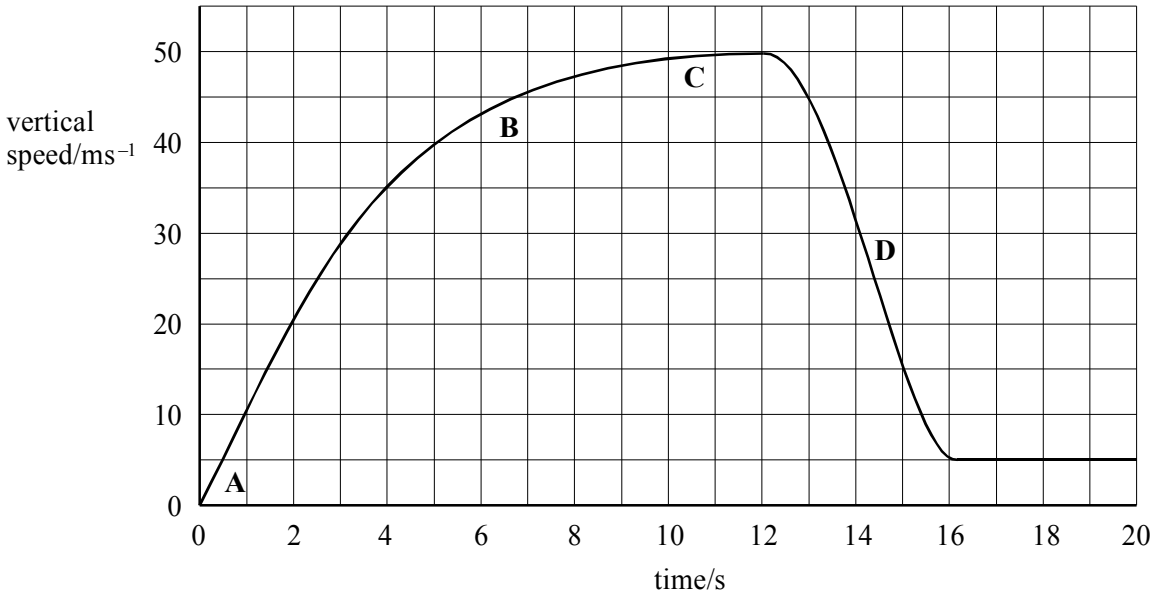
(2)

(Total 8 marks)

7 The graph shows how the vertical speed of a parachutist changes with time during the first 20 s of his jump. To avoid air turbulence caused by the aircraft, he waits a short time after jumping before pulling the cord to release his parachute.



(a) Regions A, B and C of the graph show the speed before the parachute has opened. With reference to the forces acting on the parachutist, explain why the graph has this shape in the region marked,

(i) A,

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(ii) B,

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(iii) C.

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(6)

(b) Calculate the maximum deceleration of the parachutist in the region of the graph marked D, which shows how the speed changes just after the parachute has opened. Show your method clearly.

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(2)

(c) Use the graph to find the total vertical distance fallen by the parachutist in the first 10 s of the jump. Show your method clearly.

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(4)

(d) During his descent, the parachutist drifts sideways in the wind and hits the ground with a vertical speed of 5.0 m s^{-1} and a horizontal speed of 3.0 m s^{-1}. Find

(i) the resultant speed with which he hits the ground,

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(ii) the angle his resultant velocity makes with the vertical.

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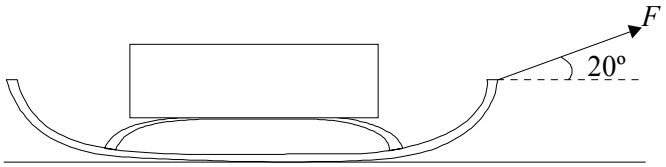
(2)

(Total 14 marks)

8 A heavy sledge is pulled across snowfields. The diagram shows the direction of the force *F* exerted on the sledge. Once the sledge is moving, the average horizontal force needed to keep it moving at a steady speed over level ground is 300 N.



(a) Calculate the force *F* needed to produce a horizontal component of 300 N on the sledge.

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(1)

(b) (i) Explain why the work done in pulling the sledge **cannot** be calculated by multiplying *F* by the distance the sledge is pulled.

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(ii) Calculate the work done in pulling the sledge a distance of 8.0 km over level ground.

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(iii) Calculate the average power used to pull the sledge 8.0 km in 5.0 hours.

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(6)

(c) The same average power is maintained when pulling the sledge uphill. Explain in terms of energy transformations why it would take longer than 5.0 hours to cover 8.0 km uphill.

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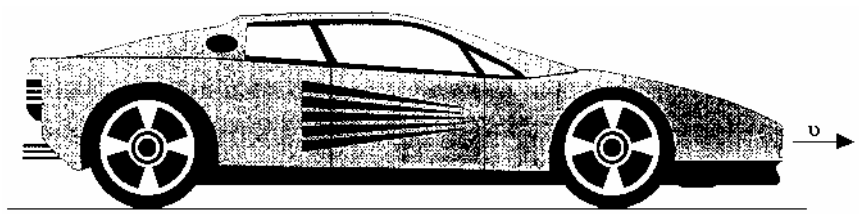
(3)

(Total 10 marks)

9 The diagram shows a car travelling at a constant velocity along a horizontal road.



(a) (i) Draw and label arrows on the diagram representing the forces acting on the car.

(ii) Referring to Newton's Laws of motion, explain why the car is travelling at constant velocity.

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(5)

(b) The car has an effective power output of 18 kW and is travelling at a constant velocity of 10 m s^{-1}. Show that the total resistive force acting is 1800 N.

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(1)

(c) The total resistive force consists of two components. One of these is a constant frictional force of 250 N and the other is the force of air resistance, which is proportional to the square of the car's speed.

Calculate

(i) the force of air resistance when the car is travelling at 10 m s^{-1},

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(ii) the force of air resistance when the car is travelling at 20 m s^{-1},

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(iii) the effective output power of the car required to maintain a constant speed of 20 m s^{-1} in a horizontal road.

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(4)

(Total 10 marks)

10 (a) (i) Define acceleration.

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(ii) State why acceleration is a vector quantity.

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(2)

(b) State what feature of a velocity-time graph may be used to calculate

(i) acceleration,

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(ii) displacement.

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(2)

(c) The graph in **Figure 1** shows how the displacement of a runner from a fixed point, along a straight track, varies with time.

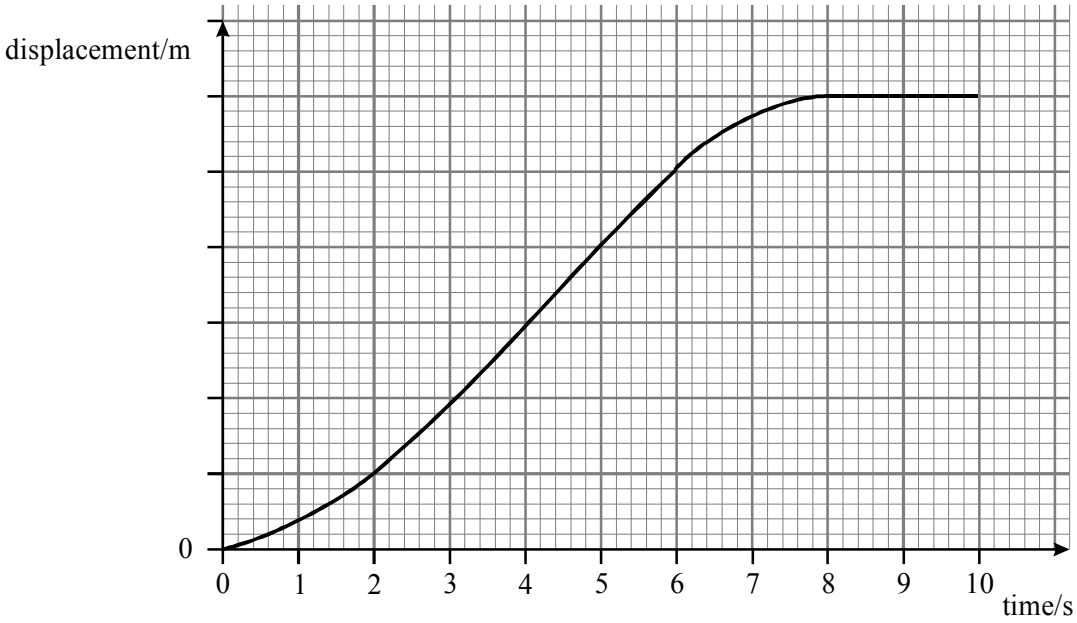


Figure 1

Without calculation, sketch on the grid in **Figure 2** a graph to show how the velocity of the same runner varies over the same period. The time scales are the same on both graphs.

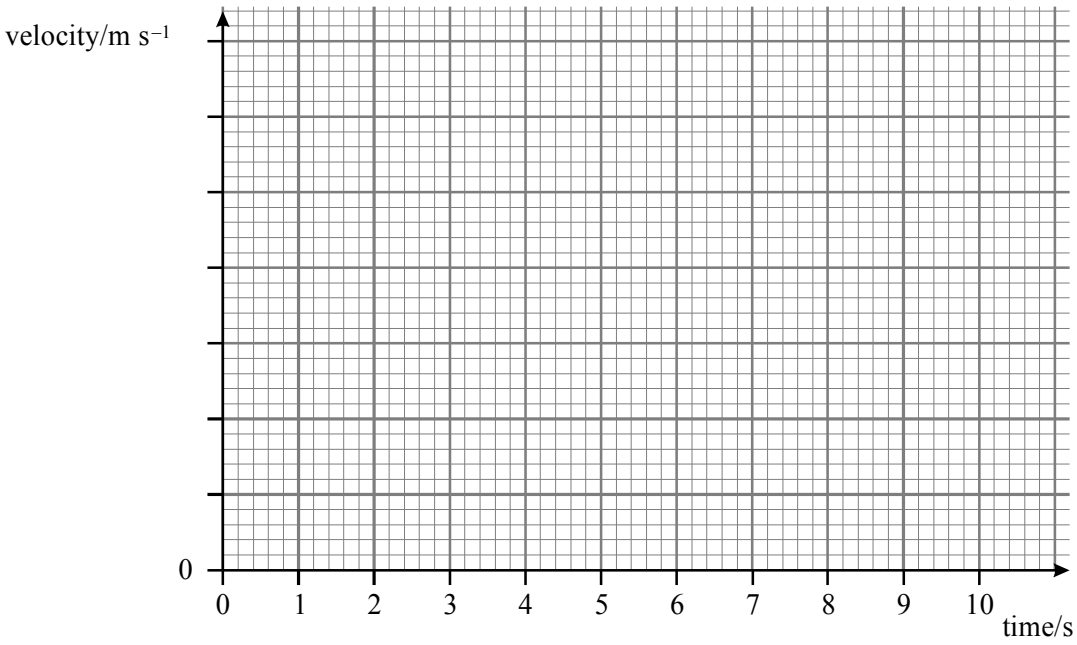
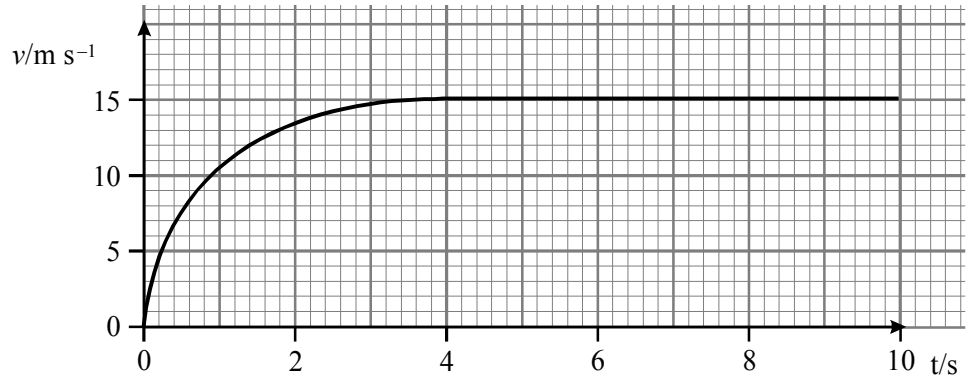


Figure 2

(4)

(Total 8 marks)

11 The graph represents the motion of a car of mass 1.4×10^3 kg, travelling in a straight line.



(a) Describe, without calculation, how the *resultant* force acting on the car varies over this 10 second interval.

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(2)

(b) Calculate the maximum kinetic energy of the car.

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(2)

(c) At some time later, when the car is travelling at a steady speed of 30 m s^{-1}, the useful power developed by the engine is 20 kW. Calculate the driving force required to maintain this speed.

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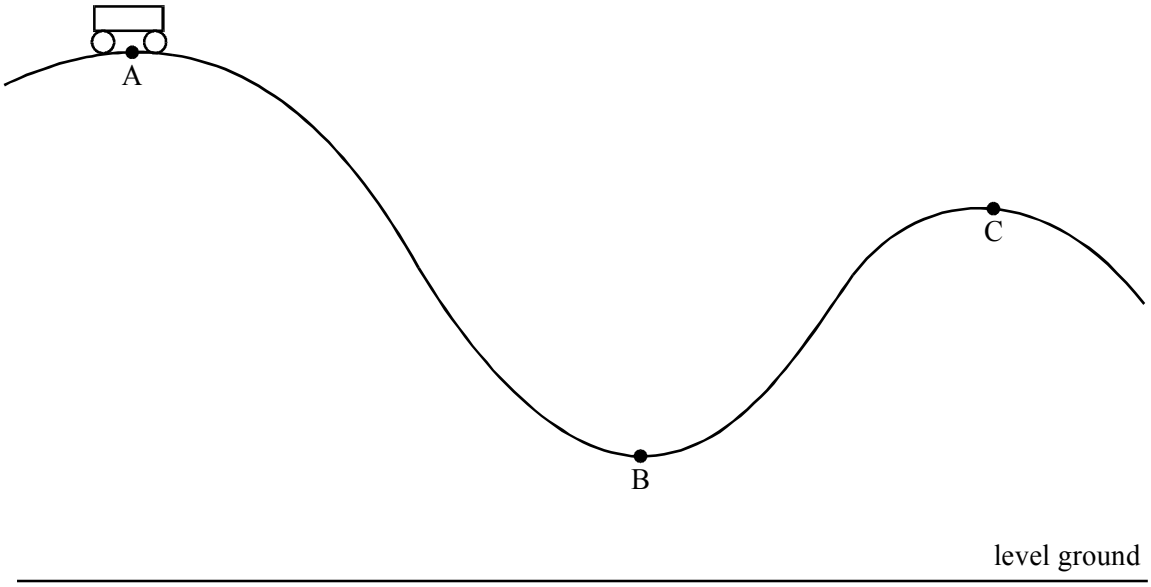
(2)

(Total 6 marks)

12 The figure shows the track of a funfair ride.



Carriages are pulled up to the highest point, A, of the ride and then released so that they follow the path ABC.

(a) Point A is 18 m above the ground and point C is 12 m above the ground. Show that the maximum possible speed of the carriage at C is 11 m s^{-1}.

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(3)

(b) The actual speed at C is less than 11 m s^{-1}. Describe the energy changes that take place as the carriage moves from A to B to C.

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(4)

(Total 7 marks)

13 A ball bearing is released into a tall cylinder of clear oil. The ball bearing initially accelerates but soon reaches terminal velocity.

(a) By considering the forces acting on the ball bearing, explain its motion.

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(3)

(b) How would you demonstrate that the ball bearing had reached terminal velocity?

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(2)

(Total 5 marks)

14 (a) A cricketer throws a ball vertically upwards so that the ball leaves his hands at a speed of 25 m s^{-1}. If air resistance can be neglected, calculate

(i) the maximum height reached by the ball,

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(ii) the time taken to reach maximum height,

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(iii) the speed of the ball when it is at 50% of the maximum height.

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(4)

(b) When catching the ball, the cricketer moves his hands for a short distance in the direction of travel of the ball as it makes contact with his hands. Explain why this technique results in less force being exerted on the cricketer's hands.

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(2)

(Total 6 marks)

15 A car accelerates at a steady rate of 2.5 m s^{-2} along a straight, level road. The mass of the car is 1.3×10^3 kg.

(a) Calculate the magnitude of the resultant force acting on the car.

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(2)

(b) When the accelerating car reaches a speed of 2.2 m s^{-1}, the total force opposing the motion of the car is 410 N.

Calculate

(i) the driving force provided by the wheels,

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(ii) the power delivered to the wheels of the car.

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(3)

(c) Explain how the total force opposing the motion of the car is affected when it is travelling up a hill.

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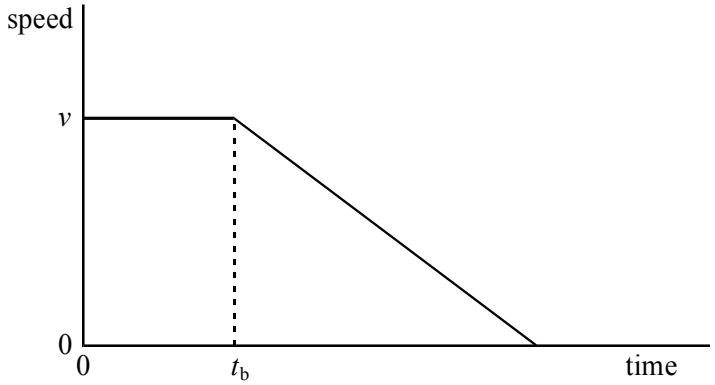
(1)

(Total 6 marks)

16 The driver of a car sees an obstruction ahead and applies the brakes at time t_b later, bringing the car to a halt. The graph shows how the speed of the car varies with time.



The stopping distance, s, of the car which was travelling at speed v before the driver applied the brakes, can be represented by the equation

$$s = vt_b + \frac{v^2}{2a},$$

where a is the magnitude of the deceleration of the car (assumed constant).

(a) State what distance is represented by each of the terms

vt_b .....

$\frac{v^2}{2a}$ .....

(2)

(b) The table includes data on stopping distances of cars. **Column C** gives the total stopping distance for a car travelling at each of the speeds shown in Column A.

column A	**column B**	**column C**	**column D**
speed v/km h^{-1}	speed v/m s^{-1}	stopping distance s/m	$\frac{s}{v}$ / sec
32	8.9	12	
48		23	
64		36	
80		53	
96		73	
112		96	

(i) Complete **Column B**,

(ii) In **Column D**, calculate each of the corresponding values of $\frac{s}{v}$.

(2)

(c) The equation for s can be rearranged as $\frac{s}{v} = t_b + \frac{v}{2a}$.

From the data you have calculated, plot a suitable graph on the grid provided to verify this equation.

(One sheet of graph paper should be provided)

(5)

(d) From your graph determine the value of

(i) t_b .....

(ii) the magnitude of the deceleration, a.

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(4)

(Total 13 marks)

17 (a) A man jumps from a plane that is travelling horizontally at a speed of 70 m s^{-1}. If air resistance can be ignored, determine

(i) his horizontal velocity 2.0 s after jumping,

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(ii) his vertical velocity 2.0 s after jumping,

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(iii) the magnitude and direction of his resultant velocity 2.0 s after jumping.

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(5)

(b) After 2.0 s the man opens his parachute. Air resistance is no longer negligible. Explain in terms of Newton's laws of motion, why

(i) his velocity initially decreases,

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(ii) a terminal velocity is reached.

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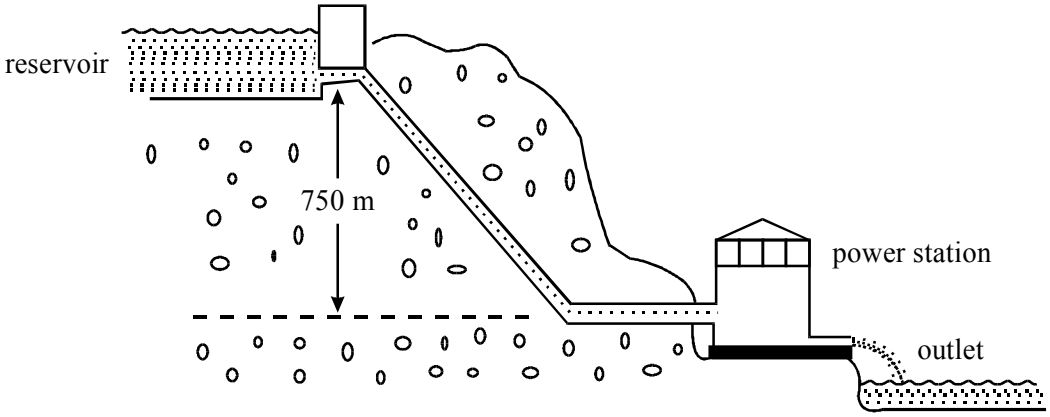
(4)

(Total 9 marks)

18 A hydroelectric power station has a power output of 2.0 MW when water passes through its turbines at a rate of 1.4 m^3 s^{-1}. The water is supplied from a reservoir which is 750 m above the power station turbines, as shown in the diagram below.

density of water = 1000 kg m^{-3}



(a) Calculate

(i) the mass of water passing through the turbines each second,

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(ii) the loss of potential energy per second of the water flowing between the reservoir and the power station turbines,

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(iii) the efficiency of the power station.

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(6)

(b) The turbines drive generators that produce alternating current at an rms potential difference of 25 kV which is then stepped up to an rms potential difference of 275 kV by means of a transformer.

(i) Calculate the rms current supplied by the generators to the transformer when the power output of the generators is 2.0 MW.

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(ii) The transformer has an efficiency of 95%. Calculate the output current of the transformer.

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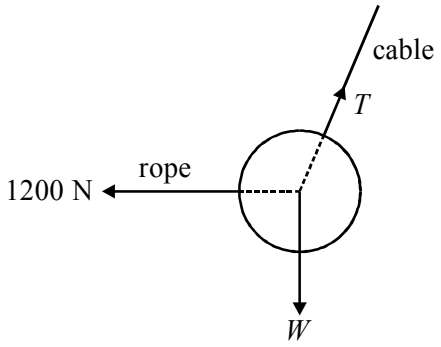
(4)

(Total 10 marks)

19 The diagram shows a 250 kg iron ball being used on a demolition site. The ball is suspended from a cable at point A, and is pulled into the position shown by a rope that is kept horizontal. The tension in the rope is 1200 N.



(a) In the position shown the ball is in equilibrium.

(i) What balances the force of the rope on the ball?

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(ii) What balances the weight of the ball?

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(2)

(b) Determine

(i) the magnitude of the vertical component of the tension in the cable,

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(ii) the magnitude of the horizontal component of the tension in the cable,

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(iii) the magnitude of the tension in the cable,

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(iv) the angle the cable makes to the vertical.

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(6)

(Total 8 marks)

20 (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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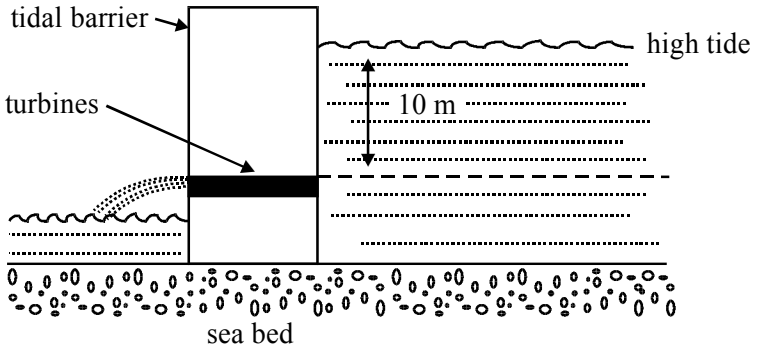
(4)

(Total 7 marks)

21 Tidal power could make a significant contribution to UK energy requirements. This question is about a tidal power station which traps sea water behind a tidal barrier at high tide and then releases the water through turbines 10.0 m below the high tide mark.



(i) Calculate the mass of sea water covering an area of 120 km^2 and depth 10.0 m.

density of sea water = 1100 kg m^{-3}

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(ii) Calculate the maximum loss of potential energy of the sea water in part (i) when it is released through the turbines.

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(iii) The potential energy of the sea water released through the turbines, calculated in part (ii), is lost over a period of 6.0 hours. Estimate the average power output of the power station over this time period. Assume the power station efficiency is 40%.

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(Total 7 marks)

22 In a vehicle impact, a car ran into the back of a lorry. The car driver sustained serious injuries, which would have been much less had the car been fitted with a driver's air bag.

(a) Explain why the effect of the impact on the driver would have been much less if an air bag had been fitted and had inflated in the crash.

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

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(4)

(b) Calculate the deceleration of the car if it was travelling at a speed of 18 m s^{-1} when the impact occurred and was brought to rest in a distance of 2.5 m.

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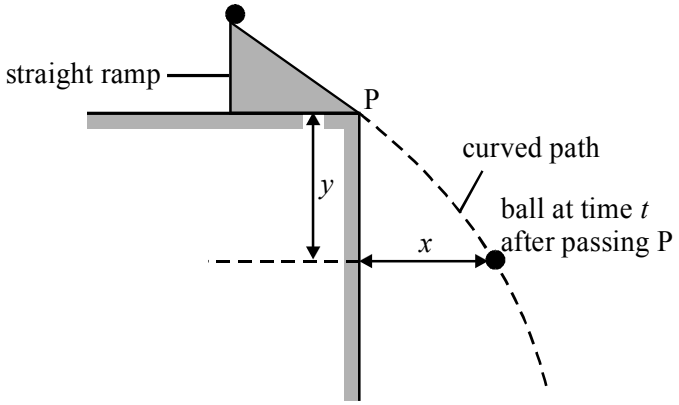
(2)

(Total 6 marks)

23 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)

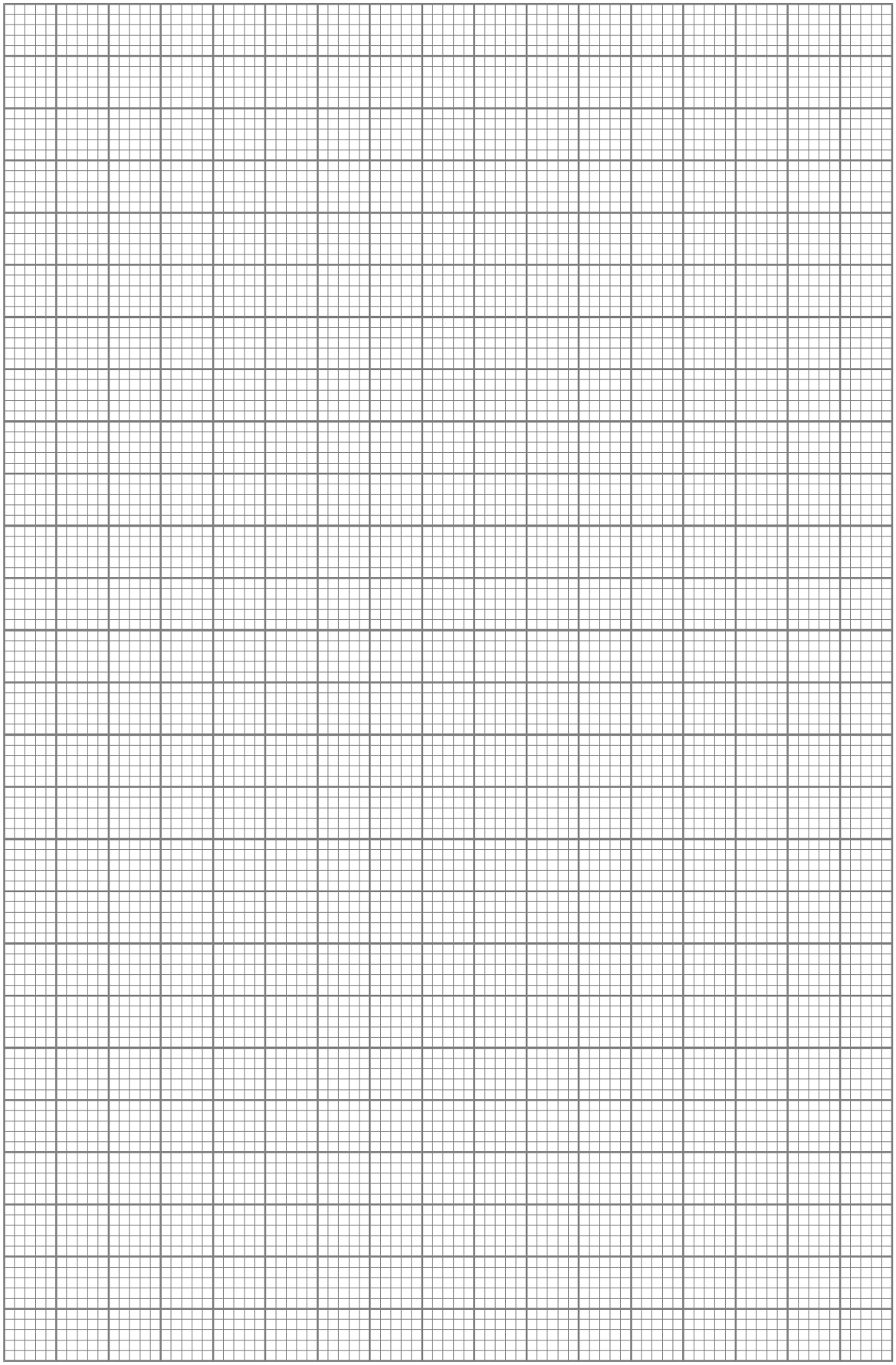
(b) The student worked out that the variables y and t in the experiment could be represented by

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

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.



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

.....

.....

.....

(9)

(c) State the physical significance of

u .....

.....

k .....

.....

(2)

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

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(2)

(Total 15 marks)

24 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)

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

.....

.....

(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,

.....

.....

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

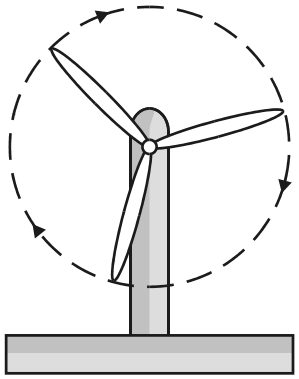
.....

.....

(4)

(Total 7 marks)

26 A wind turbine, as shown in the figure below, has blades of length 22 m. When the wind speed is 15 m s^{-1} its output power is 1.5 MW.



(i) The volume of air passing through the blades each second can be calculated by considering a cylinder of radius equal to the length of the blade.
Show that 2.3×10^4 m^3 of air passes through the blades each second.

.....

.....

.....

(ii) Calculate the mass of air that passes through the blades each second.
density of air = 1.2 kg m^{-3}

.....

.....

(iii) Calculate the kinetic energy of the air reaching the blades each second.

.....

.....

.....

(iv) Assuming that the power output of the turbine is proportional to the kinetic energy of the air reaching the blades each second, discuss the effect on the power output if the wind speed decreased by half.

.....

.....

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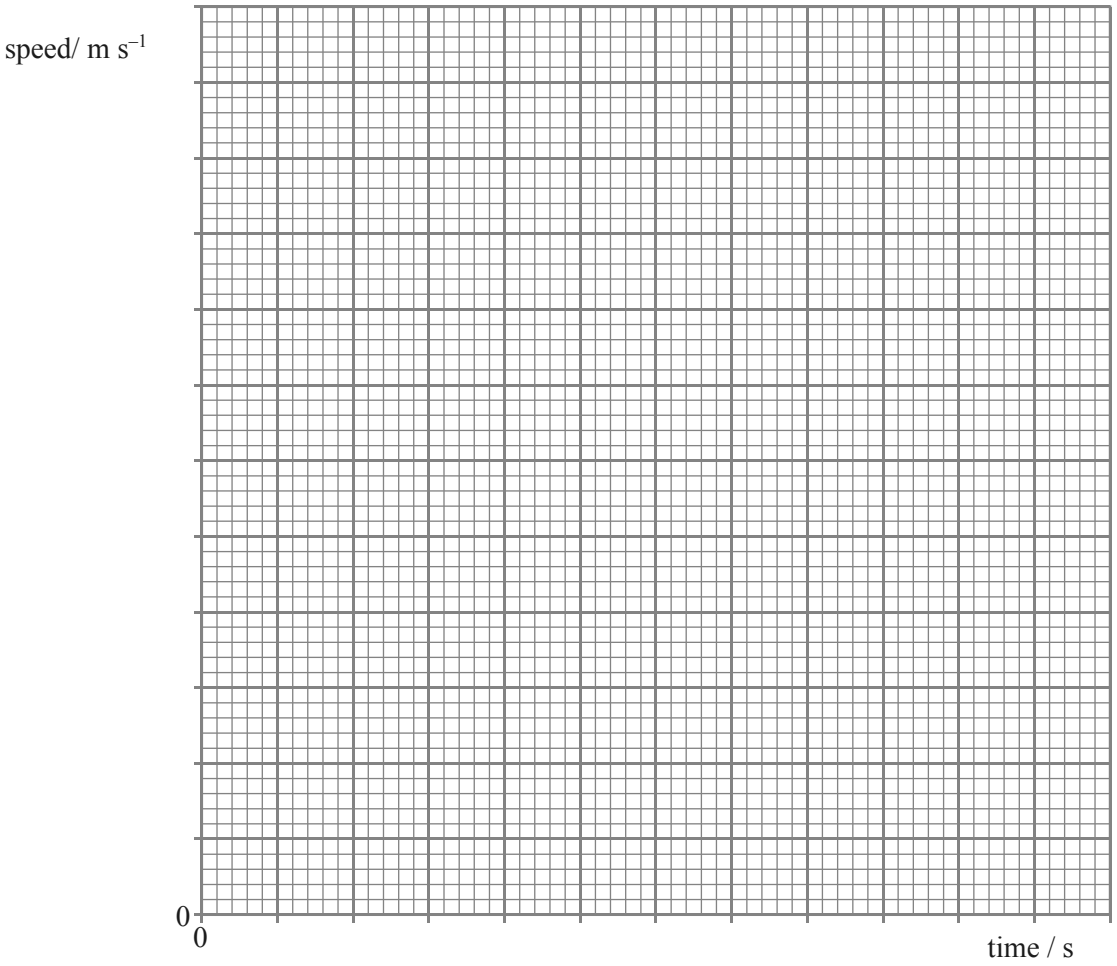
(Total 7 marks)

27 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.

.....

.....

(2)

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

.....

.....

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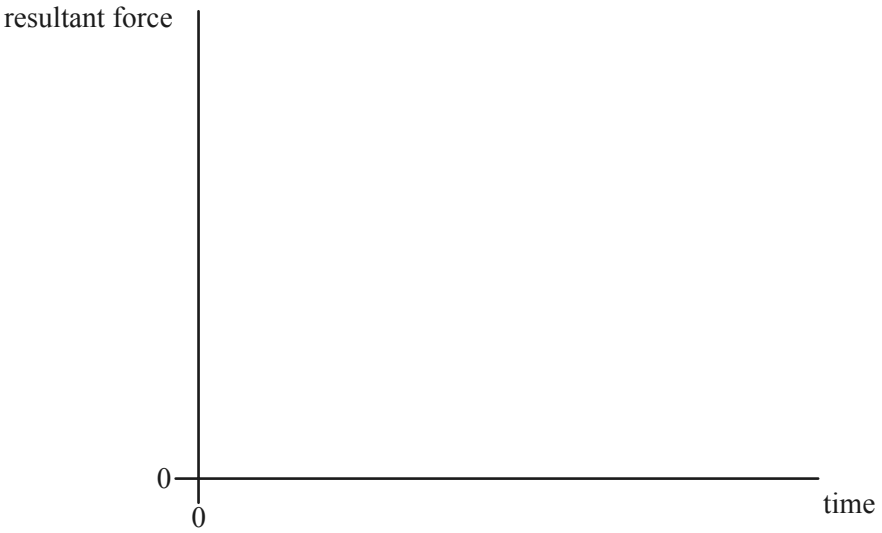
(2)

(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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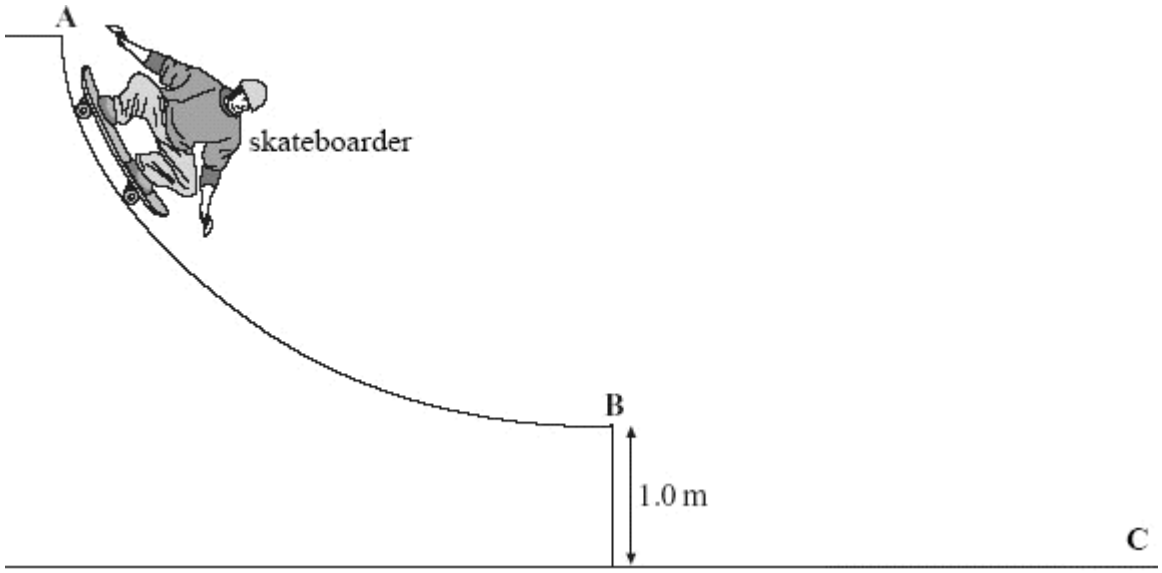
(2)

(Total 11 marks)

28 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**.

.....

.....

(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**,

.....

.....

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

.....

.....

.....

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

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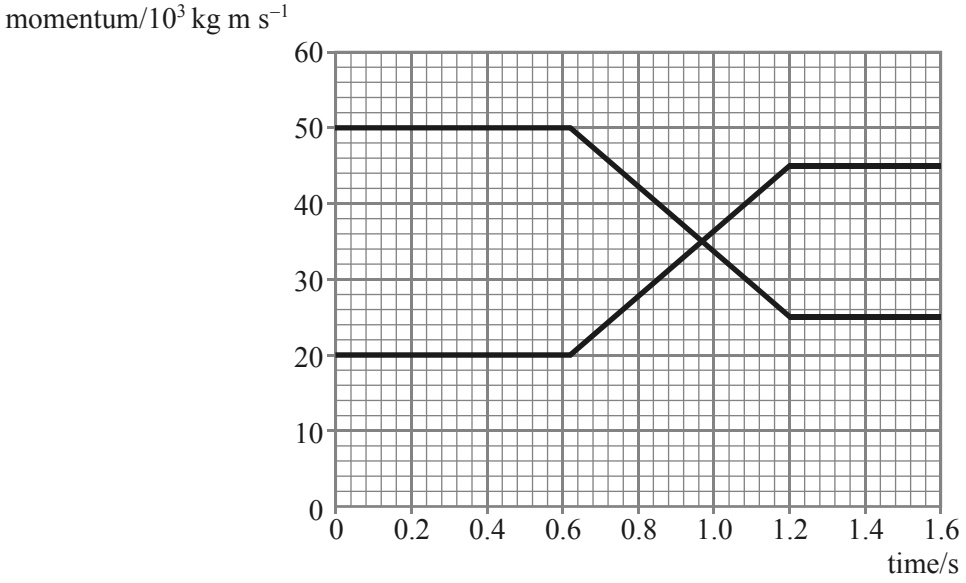
(5)

(Total 12 marks)

29 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)

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

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

.....

.....

(1)

(b) Calculate

(i) the change in momentum of the ball,

.....

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

.....

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(4)

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

.....

.....

(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)

(Total 9 marks)

31 A girl kicks a ball along the ground at a wall 2.0 m away. The ball strikes the wall normally at a velocity of 8.0 m s^{-1} and rebounds in the opposite direction with an initial velocity of 6.0 m s^{-1}. The girl, who has not moved, stops the ball a short time later.

(a) Explain why the final displacement of the ball is not 4.0 m.

.....

.....

(1)

(b) Explain why the average velocity of the ball is different from its average speed.

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.....

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(2)

(c) The ball has a mass of 0.45 kg and is in contact with the wall for 0.10 s. For the period of time the ball is in contact with the wall,

(i) calculate the average acceleration of the ball.

.....

.....

(ii) calculate the average force acting on the ball.

.....

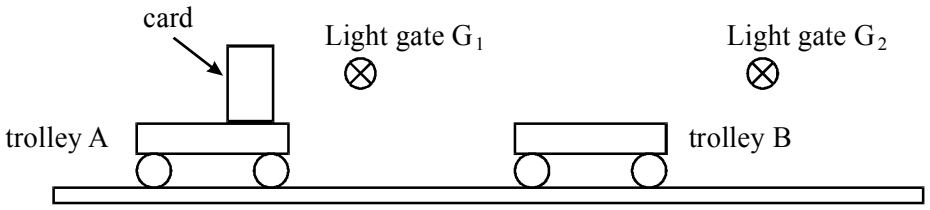
(iii) state the direction of the average force acting on the ball.

.....

(5)

(Total 8 marks)

32 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.

.....

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.....

.....

(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)

33 (a) Collisions can be described as *elastic* or *inelastic*. State what is meant by an inelastic collision.

.....

.....

(1)

(b) A ball of mass 0.12 kg strikes a stationary cricket bat with a speed of 18 m s^{-1}. The ball is in contact with the bat for 0.14 s and returns along its original path with a speed of 15 m s^{-1}.

Calculate

(i) the momentum of the ball before the collision,

.....

.....

(ii) the momentum of the ball after the collision,

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.....

(iii) the total change of momentum of the ball,

.....

.....

(iv) the average force acting on the ball during contact with the bat,

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.....

(v) the kinetic energy lost by the ball as a result of the collision,

.....

.....

(6)

(Total 7 marks)

34 In each of the following circuits the battery has negligible internal resistance and the bulbs are identical.

Figure 1

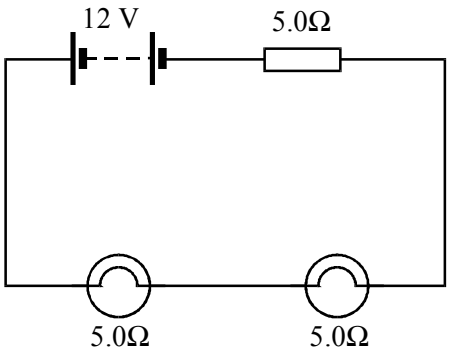
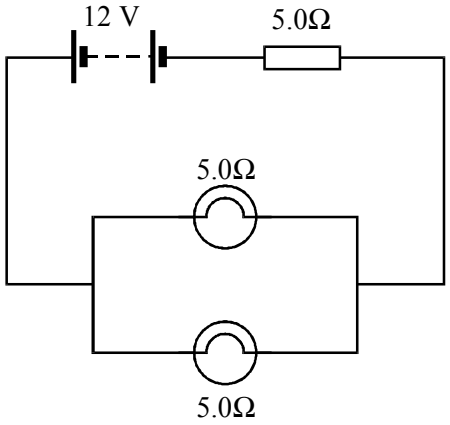


Figure 2



(a) For the circuit shown in **Figure 1** calculate

(i) the current flowing through each bulb,

.....

.....

(ii) the power dissipated in each bulb.

.....

.....

(2)

(b) In the circuit shown in **Figure 2** calculate the current flowing through each bulb.

.....

.....

.....

(3)

(c) Explain how the brightness of the bulbs in **Figure 1** compares with the brightness of the bulbs in **Figure 2**.

.....

.....

(2)

(Total 7 marks)

35 (a) A pencil 'lead' is made from non-metallic material which has a resistivity, at room temperature, of $4.0 \times 10^{-3}\ \Omega$m. A piece of this material has a length of 20 mm and a diameter of 1.40 mm.

Show that the resistance of this specimen, to two significant figures, is 52 Ω.

.....

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.....

.....

(2)

(b) Given a specimen of the pencil 'lead' described in part (a) with similar dimensions, describe an experiment you could carry out in the school or college laboratory to verify that the resistivity of the material is equal to the value quoted in part (a).

Your description should include

- a labelled circuit diagram,
- details of the measurements you would make,
- an account of how you would use your measurements to determine the result.

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(8)

(c) During an experiment such as that described in part (b), a specimen of pencil 'lead' is found to have a resistance of 52 Ω when the current through it is 250 mA.

Calculate the power dissipated in the specimen under these conditions.

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(2)

(Total 12 marks)

36

Figure 1

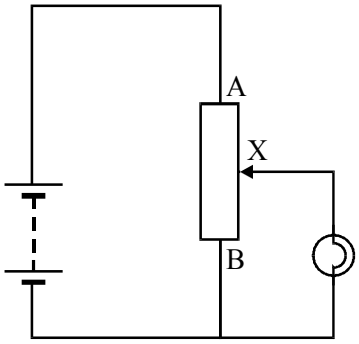
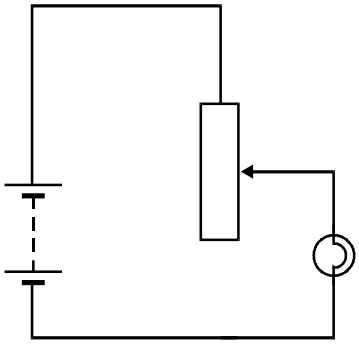


Figure 2



(a) The current flowing through a torch bulb can be controlled by a variable resistor using either of the two circuit arrangements shown above. **Figure 1** is called a potential divider arrangement and **Figure 2** may be called a rheostat arrangement. For each of these two methods explain **one** advantage and **one** disadvantage.

potential divider

advantage .....

.....

disadvantage .....

.....

rheostat

advantage .....

.....

disadvantage .....

.....

(4)

(b) In **Figure 1**, the variable resistor has a total resistance of 16 Ω. When the slider of the variable resistor is set at X, exactly mid-way along AB, the bulb works according to its specification of 2.0 V, 500 mW. Calculate

(i) the current through section XB of the variable resistance,

.....

.....

(ii) the current through section AX of the variable resistance.

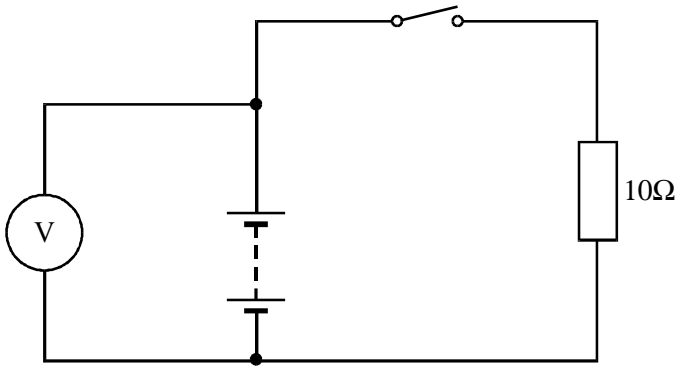
.....

.....

(2)

(Total 6 marks)

37



A battery is connected to a 10 Ω resistor as shown. The emf (electromotive force) of the battery is 12 V.

(a) (i) Explain what is meant by the emf of a battery.

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.....

(ii) When the switch is open the voltmeter reads 12.0 V and when it is closed it reads 11.5 V. Explain why the readings are different.

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.....

.....

(3)

(b) Calculate the internal resistance of the battery.

.....

.....

.....

(3)

(Total 6 mark)

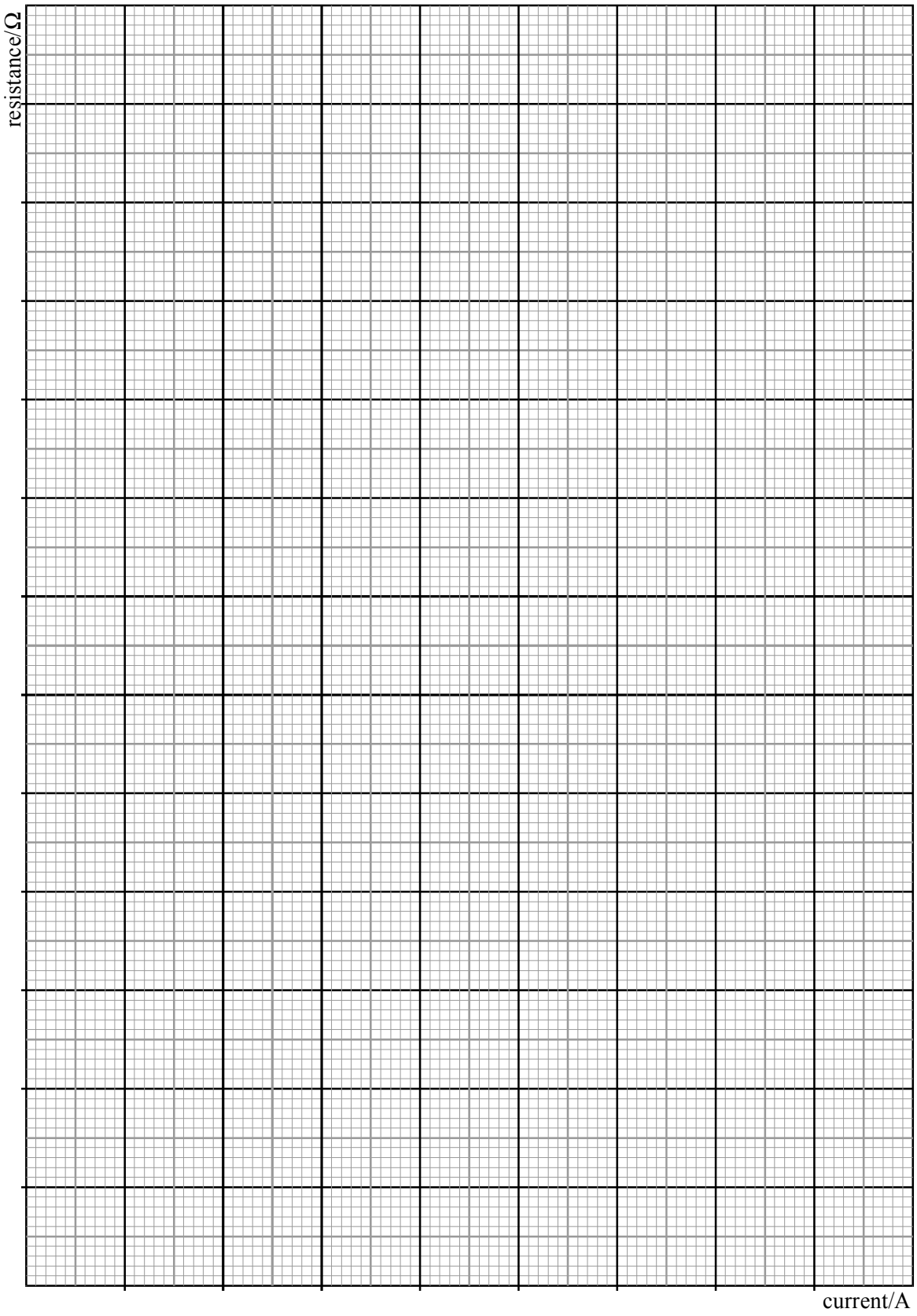
38 In an attempt to investigate how the resistance of a filament lamp varies with current through the lamp, a student obtains the results shown in the table.

voltage /V	0.50	1.50	3.00	4.50	6.00	12.00
current /A	0.51	1.25	2.00	2.55	2.95	4.00
resistance /Ω						

(a) Complete the table by calculating the corresponding values of resistance.

(2)

(b) (i) On the grid below plot a graph of resistance against current for the filament lamp.



(ii) Use your graph to estimate the resistance of the filament lamp when no current flows through the lamp.

.....

(iii) Use your graph to determine the change in the resistance of the filament when the current increases from 0 to 10 A,

.....

.....

from 1.0 A to 2.0 A.

.....

.....

(iv) Calculate the power dissipated in the lamp filament when the current through the filament is 1.0 A and 2.0 A.

1.0 A .....

.....

2.0 A .....

.....

(8)

(c) Using information from part (b)(iv), explain why the change in resistance of the filament is less for a current change of 0 to 1.0 A than for a current change of 1.0 A to 2.0 A. Do **not** attempt any calculation.

.....

.....

.....

(2)

(Total 12 marks)

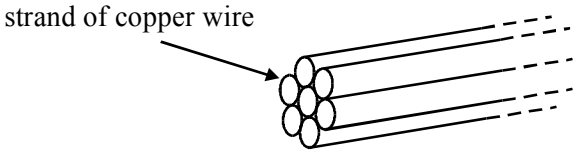
39 (a) Show that the unit of resistivity is Ω m.

.....

.....

(1)

(b) A cable consists of seven straight strands of copper wire each of diameter 1.35 mm as shown in the diagram.



Calculate

(i) the cross-sectional area of **one strand** of copper wire,

.....

.....

(ii) the resistance of a 100 m length of the **cable**, given that the resistivity of copper is 1.6×10^{-8} Ω m.

.....

.....

.....

(4)

(c) (i) If the cable in part (b) carries a current of 20 A, what is the potential difference between the ends of the cable?

.....

.....

(ii) If a single strand of the copper wire in part (b) carried a current of 20 A, what would be the potential difference between its ends?

.....

.....

(2)

(d) State **one** advantage of using a stranded rather than a solid core cable with copper of the same total cross-sectional area.

.....

(1)

(Total 8 marks)

40 A particular heating element consists of a 3.0 m length of a metal alloy wire of diameter 1.2 mm and resistivity 9.3×10^{-6} Ωm at the element's operating temperature. The element is designed for use with a 230 V supply. Calculate the rating, in W, of the heating element when in use.

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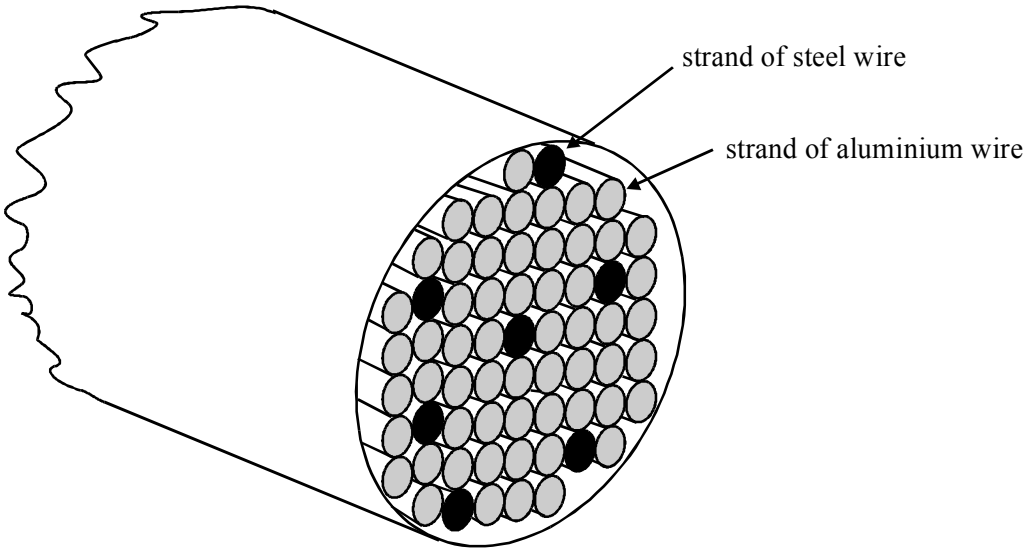
(Total 4 marks)

41 The cable shown in the diagram is used to transmit electricity and is made from strands of steel wire and strands of aluminium wire. The strands of wire are in electrical contact with each other along the length of the cable.



(a) Calculate the resistance of one strand of aluminium wire with a diameter of 3.2 mm and a length of 1.0 km.

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.....

.....

(b) The resistance of one strand of steel wire in a 1.0 km length of cable is 19.9 Ω. Calculate the resistance of 1.0 km of the cable made up of seven strands of steel wire and fifty four strands of aluminium wire.

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(Total 5 marks)

42 Two resistors, A and B, have different resistances but otherwise have identical physical properties. E is a cell of negligible internal resistance.

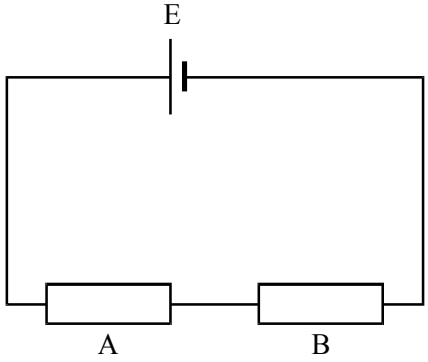

Figure 1

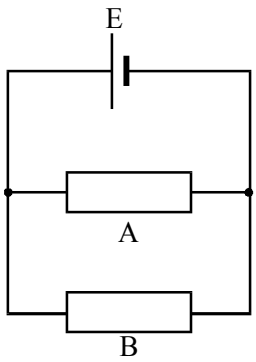

Figure 2

When the resistors are connected in the circuit shown in **Figure 1**, A reaches a higher temperature than B. When connected in the circuit shown in **Figure 2**, B reaches a higher temperature than A.

Explain these observations fully, stating which resistance is greater.

.....

.....

.....

.....

(Total 6 marks)

43 (a) Write down an equation relating the electrical resistivity of a material to the resistance of a particular sample. Define the symbols used.

.....

.....

.....

.....

(2)

(b) (i) A cylindrical sample of graphite 10 mm long and with diameter 6.0 mm has a resistance of 450 Ω. Calculate the electrical resistivity of graphite.

.....

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.....

.....

(ii) Calculate the resistance of a specimen of copper of the same dimensions as that of the graphite specimen in part (b) (i).

.....

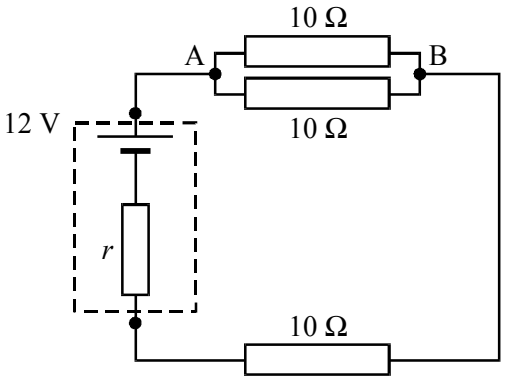
.....

.....

(5)

(Total 7 marks)

44 A battery of emf 12 V and internal resistance *r* is connected in a circuit with three resistors each having a resistance of 10 Ω as shown. A current of 0.50 A flows through the battery.



Calculate

(i) the potential difference between the points A and B in the circuit,

.....

.....

.....

(ii) the internal resistance of the battery,

.....

.....

.....

(iii) the total energy supplied by the battery in 2.0 s,

.....

.....

(iv) the fraction of the energy supplied by the battery that is dissipated within the battery.

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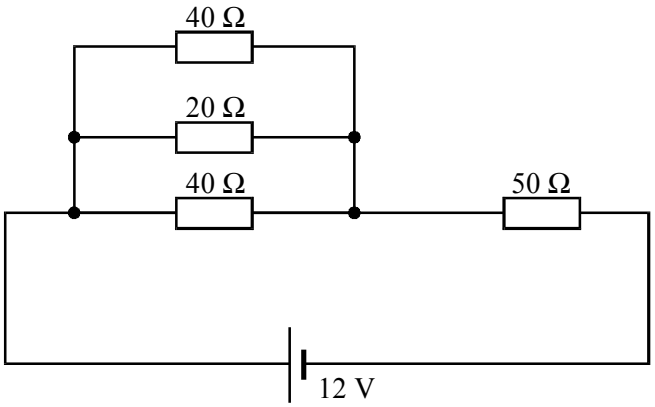
(7)

(Total 7 marks)

45 A battery of e.m.f 12 V and negligible internal resistance is connected to a resistor network as shown in the circuit diagram.



(a) Calculate the total resistance of the circuit.

.....

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.....

.....

(3)

(b) Calculate the current through the 50 Ω resistor.

.....

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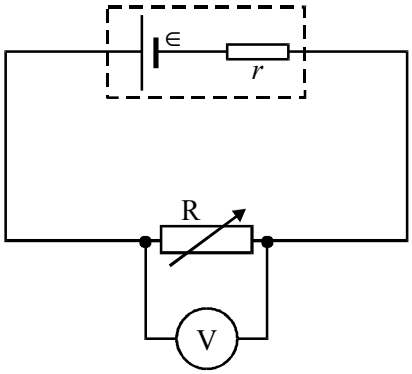
(1)

(Total 4 marks)

46 A battery of emf $\in$ and internal resistance r is connected in series with a variable resistor R as shown in **Figure 1**. A voltmeter is connected as shown.

Figure 1



(a) (i) State what is meant by the e.m.f of a battery.

.....

.....

(ii) The reading V on the voltmeter is the voltage across R.
Why is V less than $\in$?

.....

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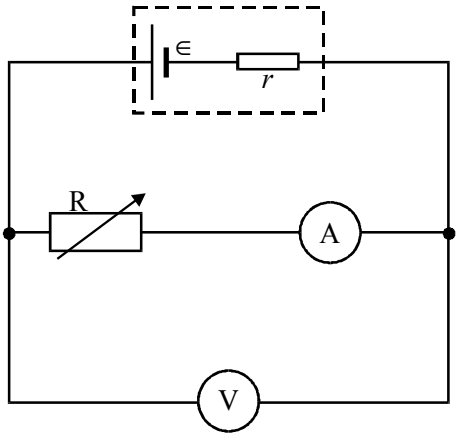
(3)

(b) In order to measure $\in$ and r, an ammeter is used in the circuit, as shown in **Figure 2.**

Figure 2



The value of R is decreased in steps and at each step the readings V and I on the voltmeter and ammeter, respectively, are recorded. These are shown in the table.

reading on voltmeter/V	reading on ammeter/A
4.0	0.07
3.0	0.14
2.0	0.21
1.0	0.28

(i) Plot a graph of V (on y axis) against I (on x axis) and draw the best straight line through the points.

(ii) Determine the values of $\in$ and r from the graph, explaining your method.

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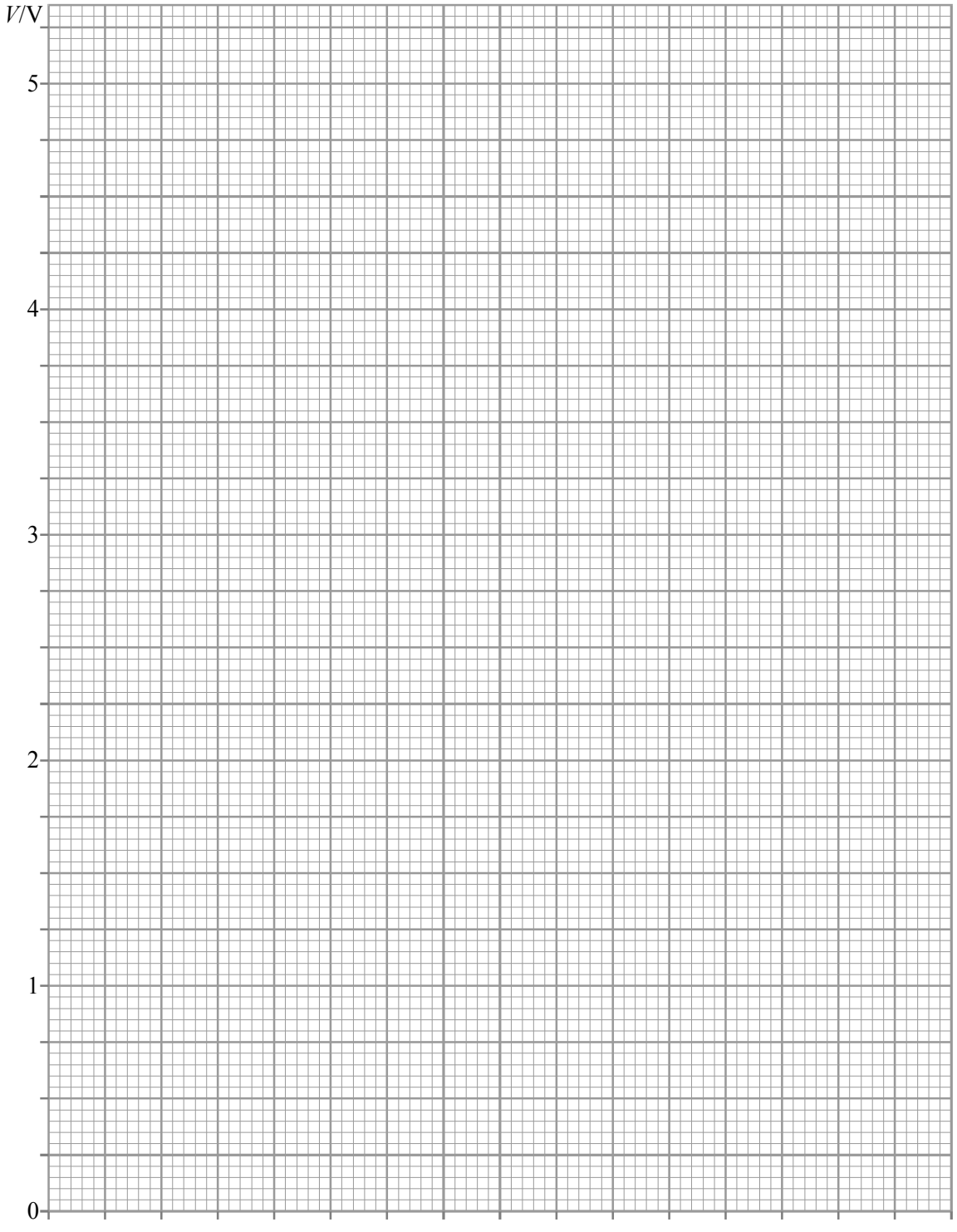

(8)

(Total 11 marks)

47 (a) (i) Give the equation which relates the *electrical resistivity* of a conducting material to its *resistance*. Define the symbols in the equation.

.....

.....

.....

(ii) A potential difference of 1.5 V exists across the ends of a copper wire of length 2.0 m and uniform radius 0.40 mm. Calculate the current in the wire.

resistivity of copper = 1.7×10^{-8} Ω m

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.....

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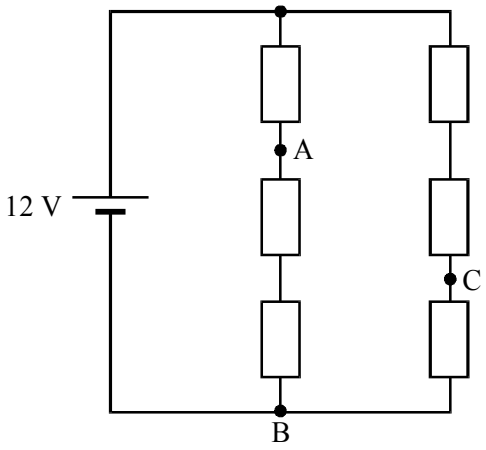
(5)

(b) In the circuit shown, each resistor has the same resistance. The battery has an emf of 12 V and negligible internal resistance.



(i) Calculate the potential difference between A and B.

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.....

(ii) Calculate the potential difference between B and C.

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(iii) A high resistance voltmeter is connected between A and C. What is the reading on the voltmeter?

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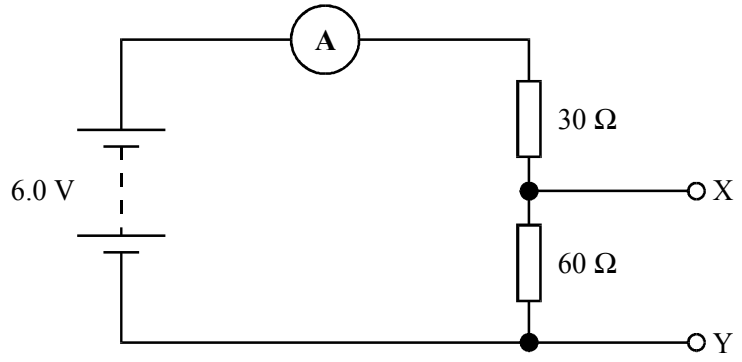
(5)

(Total 10 marks)

48 In the circuit shown, the battery has negligible internal resistance.



Calculate the current in the ammeter when

(a) the terminals X and Y are short-circuited i.e. connected together,

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(2)

(b) the terminals X and Y are connected to a 30 Ω resistor.

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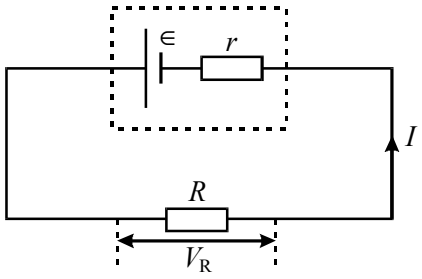
(4)

(Total 6 marks)

49 (a) A cell of emf $\in$ and internal resistance r is connected in series to a resistor of resistance R as shown. A current I flows in the circuit.



(i) State an expression which gives $\in$ in terms of I, r and R.

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(ii) Hence show how V_R, the potential difference across the resistor, is related to $\in$, I and r.

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(2)

(b) A lamp, rated at 30 W, is connected to a 120 V supply.

(i) Calculate the current in the lamp.

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(ii) If the resistor in part (a) is replaced by the lamp described in part (b), determine how many cells, each of emf 1.5 V and internal resistance 1.2 Ω, would have to be connected in series so that the lamp would operate at its proper power.

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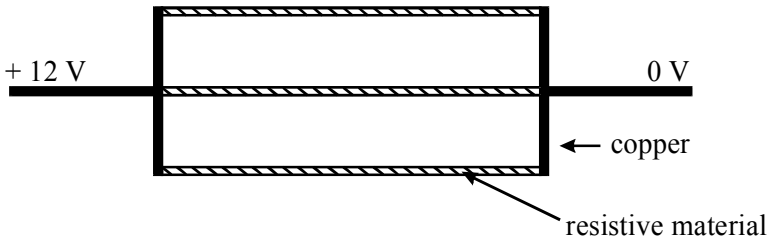
(5)

(Total 7 marks)

50 A heating element, as used on the rear window of a car, consists of three strips of a resistive material, joined, as shown in the diagram, by strips of copper of negligible resistance. The voltage applied to the unit is 12 V and heat is generated at a rate of 40 W.



(a) (i) Calculate the total resistance of the element.

.....

.....

(ii) Hence show that the resistance of a single strip is about 11 Ω.

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(5)

(b) If each strip is 2.6 mm wide and 1.1 mm thick, determine the length of each strip.
resistivity of the resistive material = 4.0×10^{-5} Ω m

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(3)

(Total 8 marks)

51 (a) The resistivity of a material in the form of a uniform resistance wire is to be measured. The area of cross-section of the wire is known.

The apparatus available includes a battery, a switch, a variable resistor, an ammeter and a voltmeter.

(i) Draw a circuit diagram using some or all of this apparatus, which would enable you to determine the resistivity of the material.

(ii) Describe how you would make the necessary measurements, ensuring that you have a range of values.

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(iii) Show how a value of the resistivity is determined from your measurements.

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(9)

(b) A sheet of carbon-reinforced plastic measuring 80 mm × 80 mm × 1.5 mm has its two large surfaces coated with highly conducting metal film. When a potential difference of 240 V is applied between the metal films, there is a current of 2.0 mA in the plastic. Calculate the resistivity of the plastic.

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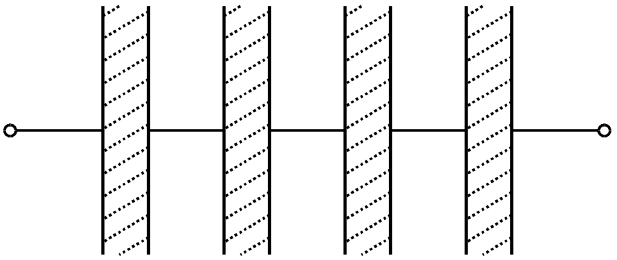
(3)

(c) If four of the units described in part (b) are connected as shown in the diagram, calculate the total resistance of the combination.



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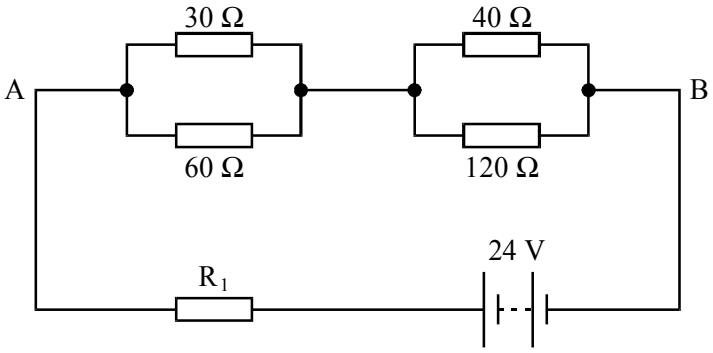
(2)

(Total 14 marks)

52 A battery of emf 24 V and negligible internal resistance is connected to a resistor network as shown in the circuit diagram in the diagram below.



(a) Show that the resistance of the single equivalent resistor that could replace the four resistors between the points A and B is 50 Ω.

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(4)

(b) If R_1 is 50 Ω, calculate

(i) the current in R_1,

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(ii) the current in the 60 Ω resistor.

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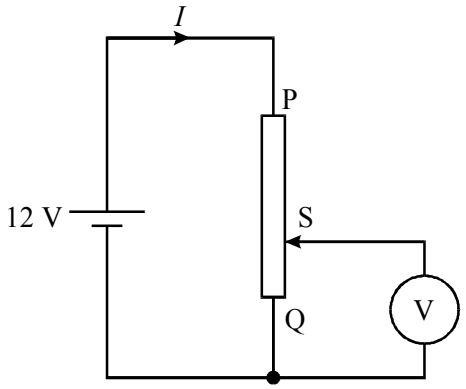
(4)

(Total 8 marks)

53 (a) In the circuit shown in **Figure 1**, the battery has an emf of 12 V and negligible internal resistance.

PQ is a potential divider, S being the position of the sliding contact. In the position shown, the resistance between P and S is 180 Ω and the resistance between S and Q is 60 Ω.

Figure 1



(i) Calculate the current, *I*, in the circuit, assuming that there is no current through the voltmeter V.

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(ii) What property of the voltmeter allows us to assume that no current flows through it?

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(iii) What is the reading on the voltmeter?

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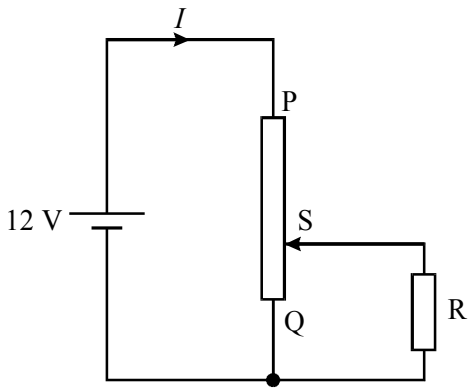
(4)

(b) The circuit in **Figure 1** is modified as shown in **Figure 2**, by exchanging the voltmeter for a load R, whose resistance is about the same as the resistance of section SQ of the potential divider.

Figure 2



Explain, without calculation, why the current through the battery increases in value from that in part (a).

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

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(2)

(Total 6 marks)

54 (a) A metal wire of length 1.4 m has a uniform cross-sectional area = 7.8×10^{-7} m^2. Calculate the resistance, R, of the wire.

resistivity of the metal = 1.7×10^{-8} Ωm

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(2)

(b) The wire is now stretched to twice its original length by a process that keeps its volume constant. If the resistivity of the metal of the wire remains constant, show that the resistance increases to 4R.

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(2)

(Total 4 marks)

55 (a) A solar panel of area 2.5 m^2 is fitted to a satellite in orbit above the Earth. The panel produces a current of 2.4 A at a potential difference of 20 V when solar radiation is incident normally on it.

(i) Calculate the electrical power output of the panel.

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(ii) Solar radiation on the satellite has an intensity of 1.4 kW m^{-2}. Calculate the efficiency of the panel.

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(4)

(b) The back-up power system in the satellite is provided by a radioactive isotope enclosed in a sealed container which absorbs the radiation from the isotope. Energy from the radiation is converted to electrical energy by means of a thermoelectric module.

(i) The isotope has an activity of 1.1×10^{14} Bq and produces α particles of energy 5.1 MeV. Show that the container absorbs energy from the α particles at a rate of 90 J s^{-1}.

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(ii) The isotope has a half-life of 90 years. Calculate the decay constant λ of this isotope.

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(iii) The mass number of the isotope is 239.
Calculate the mass of isotope needed for an activity of 1.1×10^{14} Bq.

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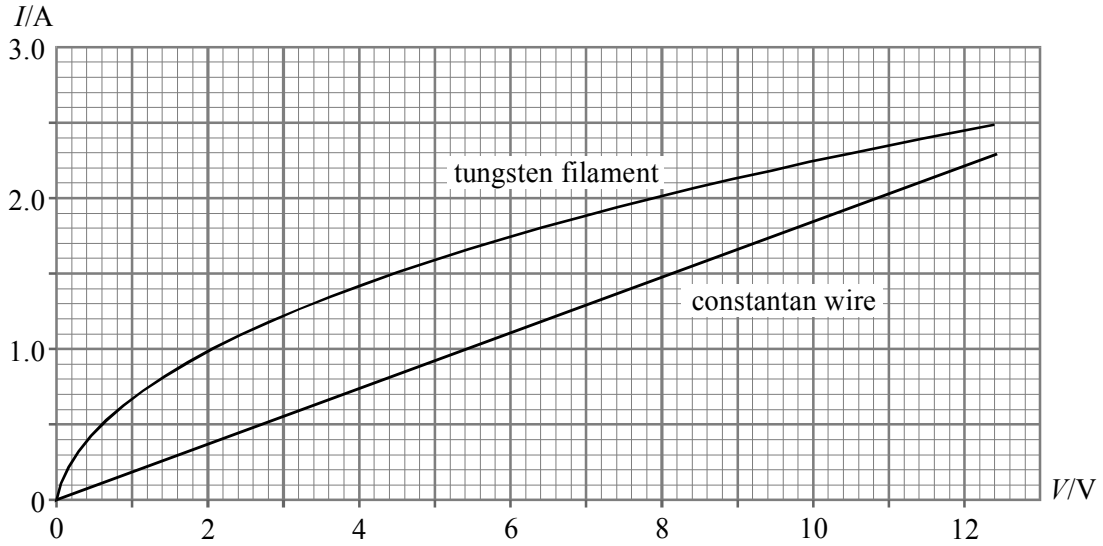
(7)

(Total 11 marks)

56 The graph shows the *I* - *V* characteristics for two conductors, the tungsten filament of a lamp and a length of constantan wire.



(a) State, with a reason, which conductor obeys Ohm's law across the full voltage range.

conductor: .....

reason: .....

(2)

(b) (i) Calculate the resistance of the tungsten filament when $V = 1$ V and $V = 10$ V.

$V = 1$ V: .....

.....

$V = 10$ V: .....

.....

(ii) Explain why the values of resistance, calculated in part (b)(i), differ from each other.

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

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(4)

(c) Use the graph to determine the resistivity of constantan, given that the wire is 0.80 m long with a uniform cross-sectional area of 6.8×10^{-8} m^2.

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(3)

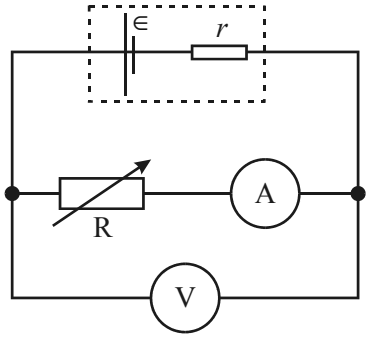
(d) A student is required to obtain the $I - V$ characteristic for a filament lamp using a datalogger, so that the data can be fed into a computer to give a visual display of the characteristic.

Draw a labelled circuit diagram for such an experiment.
(An account of the experiment is not required).

(3)

(Total 12 marks)

57 In the circuit shown, a battery of emf $\in$ and internal resistance r is connected to a variable resistor R. The current I and the voltage V are read by the ammeter and voltmeter respectively.



(a) The emf is related to V, I and r by the equation

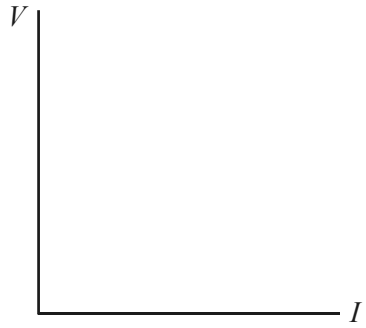
$$\in = V + Ir$$

Rearrange the equation to give V in terms of $\in$, I and r.

.....

(1)

(b) In an experiment, the value of R is altered so that a series of values of V and the corresponding values of I are obtained. Using the axes, sketch the graph you would expect to obtain as R is changed.



(2)

(c) State how the values of $\in$ and r may be obtained from the graph.

$\in$ .....

r .....

(2)

(Total 5 marks)

58 (a) Give an expression for the *resistivity* of a material in the form of a uniform wire. Define all the symbols used.

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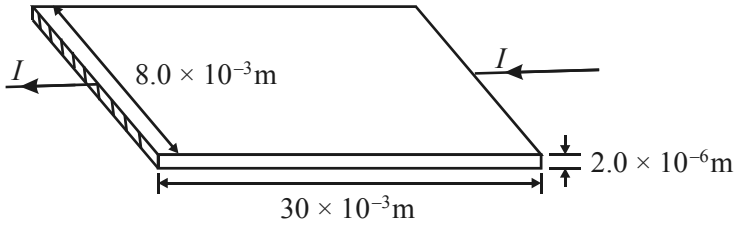
(2)

(b) A thin film of carbon may be used in some electronic systems. Typical dimensions of such a film are shown in **Figure 1**.

Figure 1



(i) Calculate the resistance of the carbon film to a current *I* passing through it as shown in **Figure 1**.

resistivity of carbon = $4.0 \times 10^{-5}\ \Omega$ m

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(ii) Without recalculating the resistance of the carbon film, explain how you would expect the resistance to change if the current flowed as in **Figure 2**. You should consider the numerical ratio or factor by which each dimension affecting the resistance has changed.

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

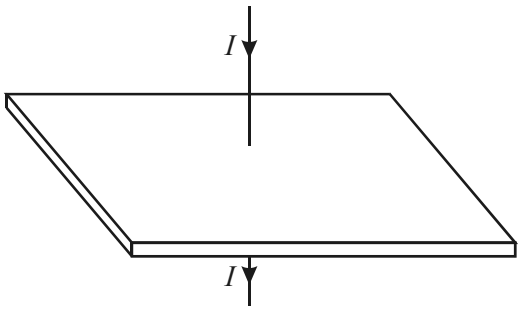

Figure 2

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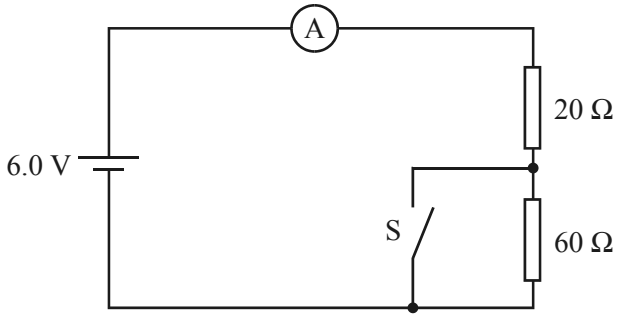
(4)

(Total 6 marks)

59 In the circuit shown in **Figure 1**, the battery, of emf 6.0V, has negligible internal resistance.

Figure 1



(a) Calculate the current through the ammeter when the switch S is

(i) open,

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.....

(ii) closed.

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(3)

(b) The switch S is now replaced with a voltmeter of infinite resistance. Determine the reading on the voltmeter.

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(2)

(Total 5 marks)

60 (a) In the circuit shown in **Figure 1**, the battery has an emf of 6.0 V. With the switch closed and the lamp lit, the reading on the voltmeter is 5.4 V.

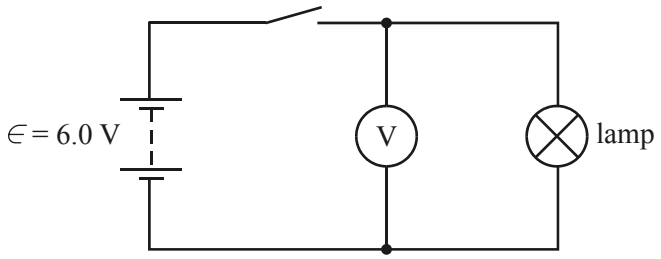

Figure 1

Explain without calculation, why the voltmeter reading is less than the emf of the battery. You may be awarded marks for the quality of written communication in your answer.

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(3)

(b) A torch is powered by two identical cells each having an emf of 1.5 V and an internal resistance *r*. The cells are connected in series. The torch bulb is rated at 1.6 W and the voltage across it is 2.5 V.

(i) Draw the circuit described.

(ii) Calculate the internal resistance of each cell.

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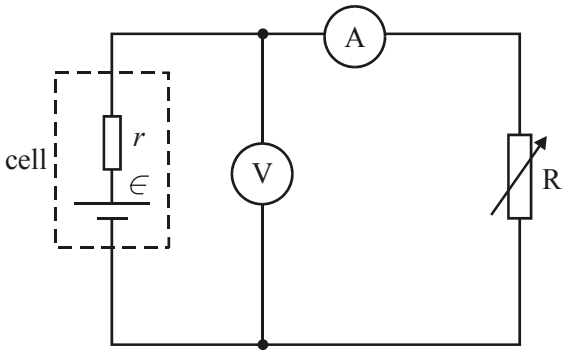
(5)

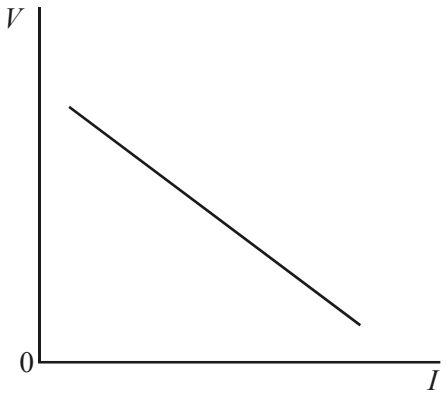
(c) In the circuit in **Figure 2** the cell has emf $\in$ and internal resistance r. The voltage V across the cell is read on the voltmeter which has infinite resistance, and the current I through the variable resistor R is read on the ammeter.

Figure 2



By altering the value of the variable resistor R, a set of values of V and I is obtained. These values, when plotted, give the graph shown in **Figure 3**.

Figure 3



Show how the values of $\in$ and r may be obtained from this graph. Explain your method.

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(3)

(Total 11 marks)

61 (a) A steady current of 0.25 A passes through a torch bulb for 6 minutes. Calculate the charge which flows through the bulb in this time.

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(2)

(b) The torch bulb is now connected to a battery of negligible internal resistance. The battery supplies a steady current of 0.25 A for 20 hours. In this time the energy transferred in the bulb is 9.0×10^4 J. Calculate

(i) the potential difference across the bulb,

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(ii) the power of the bulb.

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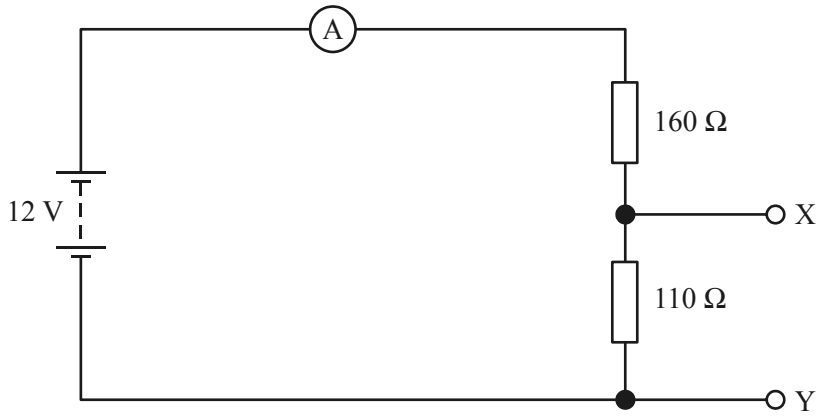
(3)

(Total 5 marks)

62 In the circuit shown in the figure below, the battery, of negligible internal resistance, is connected to two resistors which form a potential divider.



(a) (i) Calculate the current through the ammeter.

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(ii) A 20 Ω resistor is now connected between X and Y. State and explain, without further calculation, whether the current through the ammeter will increase or decrease.

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

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(4)

(b) The 20 Ω resistor is now removed and replaced with a voltmeter. Stating the assumption made, show that the reading on the voltmeter is 4.9 V.

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(2)

(c) The voltmeter is now removed and the terminals X and Y joined together with a wire. Calculate the reading on the ammeter.

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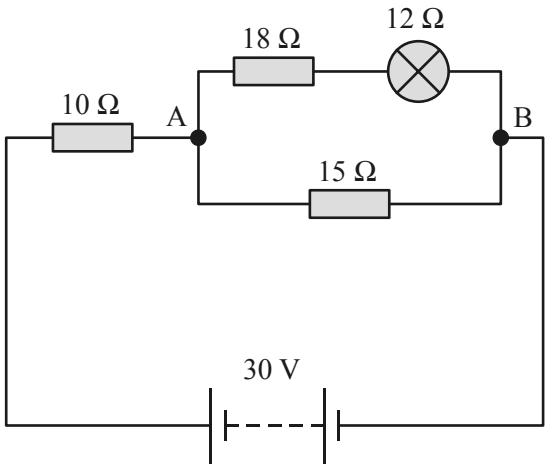
(2)

(Total 8 marks)

63 In the circuit shown in the figure below, the battery, of negligible internal resistance, has an emf of 30 V. The pd across the lamp is 6.0 V and its resistance is 12 Ω.



(a) Show that the total resistance of the circuit is 20 Ω.

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(3)

(b) Calculate

(i) the current supplied by the battery,

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(ii) the pd between the points A and B,

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.....

(iii) the current in the lamp.

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(4)

(c) (i) What is the power of the lamp, in W?

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.....

(ii) What percentage of the power supplied by the battery is dissipated in the lamp?

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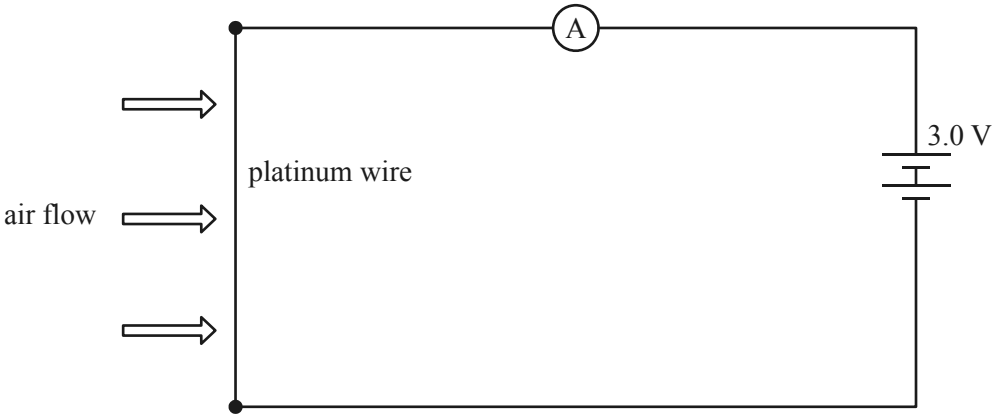
(3)

(Total 10 marks)

64 A hot-wire anemometer is a device used to measure the air-flow speed. The device consists of a thin platinum wire in series with an ammeter and a 3.0 V battery of negligible internal resistance, as shown in the figure below.



(a) The wire is heated by the current passing through it. The flow of air over the surface of the wire reduces the temperature of the wire. Explain why the current increases when the air speed is increased.

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(2)

(b) The table shows how the current I through the wire varies with the speed v of the air flow.

v/mm s^{-1}	I /A	ln (v/ mm s^{-1})	ln (I/A)
2.00	0.357		
4.00	0.448		
6.00	0.508		
8.00	0.556		
10.00	0.602		

(i) Complete the table and plot a graph of ln I against ln v.

(Graph paper should be provided)

(ii) Explain why your graph shows that the current I varies with speed v according to

$$I = kv^n,$$

where k and n are constants.

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(iii) Use your graph to determine the values of k and n.

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(12)

(c) Discuss how the sensitivity of the instrument varies with air-flow speed.

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(2)

(Total 16 marks)

MARK SCHEMES

The following document has been produced to support the Teacher Resource Bank item *GCE Physics B: Physics in Context – Physics Keeps Us Going / Directory of Relevant Questions / Version 1.0*.

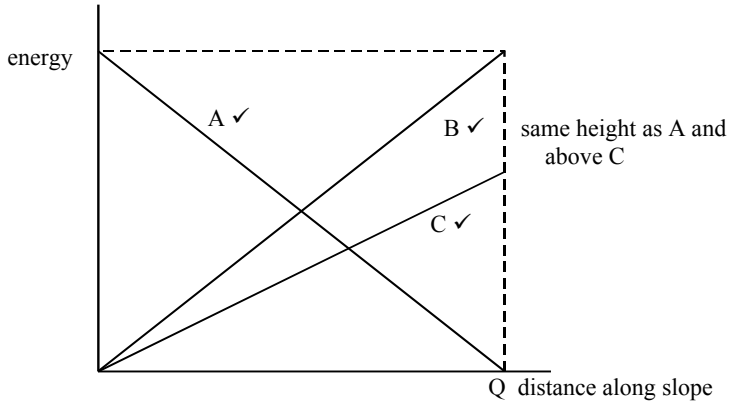
Teachers and students should be aware that the treatment of Quality of Written Communication (QWC) in the new AQA GCE Physics B: Physics in Context specification may differ from that used in some of the questions in this document. Please refer to the latest version of the Specimen Assessment Materials which accompany the new GCE Physics B: Physics in Context specification for the treatment of QWC.

Question 1			
(a)		scalars have *magnitude* (or size) ✓ vectors have *magnitude* and *direction* ✓	**2**
(b)	(i)	$s = vt$ ✓ $s = 100 \times \frac{3}{60} = 5\,\text{km}$ ✓	**4**
	(ii)	1.59 ✓ km (or other correct unit) ✓	
		Total	**6**

Question 2			
(a)	(i)	gradient = $\frac{2.1}{0.7} = 3.0\,\text{m s}^{-2}$ ✓	**3**
	(ii)	distance is area under graph (to $t = 0.1$ s) or $\frac{1}{2} \times 0.7 \times 2.1 \left(\frac{2.1+2.5}{2}\right) 0.3$ ✓ = 1.4(2) m ✓	
(b)	(i)	$T - mg = ma$ [or $T = 1500\ (9.8+3.0)$] ✓ $= 1.9 \times 10^4$ N ✓ $T = mg = 1.5 \times 10^4$ N ✓	**4**
	(ii)	EF ✓	
(c)		power = Fv or $1.5 \times 10^4 \times 2.5$ ✓ $= 3.7\ [3.8] \times 10^4$ W ✓	**2**
		Total	**9**

Question 3			
(a)	(i)	F = W sin $\theta = W \times \frac{1}{15}$ ✓ correct angle ✓ = 46 N ✓ [2 out of 3 if no working shown]	**4**
	(ii)	$P(= Fv) = 410$ W ✓	
(b)	(i)	kinetic energy of bicycle + rider ⇒ gravitational potential energy ✓	**max 3**
	(ii)	initial E_k = gain in gravitational $E_p = 2.8 \times 10^3$ (J) ✓ h = 4.1 m ✓ distance = 62 m ✓ [*alternative:* (F = *ma*) $a = \frac{46}{70} = 0.657\,(\text{m s}^{-2})$ ✓ $v^2 = u^2 = 2as$ ✓ $s = \frac{9^2}{2 \times 0.657} = 62$ m ✓]	
		Total	**7**

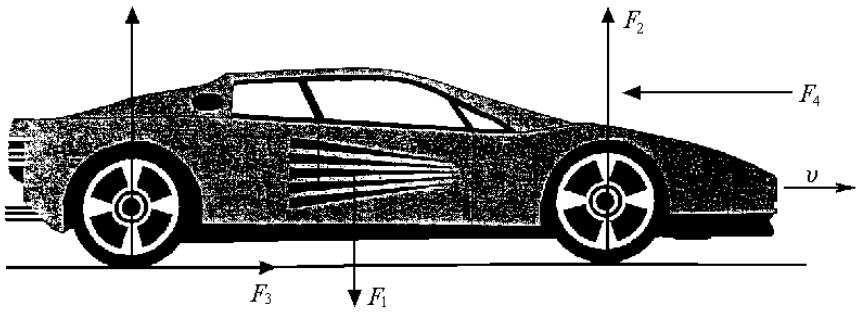
Question 4			
	(i)	$a = \frac{44}{4.0} = 11\,\text{m s}^{-2}$ ✓ $F = ma = 1.1 \times 10^5$ N ✓	**6**
	(ii)	$\Delta v = 236\,\text{m s}^{-1}$ ✓ $a = \frac{236}{8.0} = 29.5\,\text{m s}^{-2}$ ✓	
	(iii)	$s_{\text{one}} = v_{\text{av}} \times t = \left(\frac{44+0}{2}\right) \times 4.0 = 88$ m ✓ $s_{\text{two}} = v_{\text{av}} \times t = \left(\frac{280+44}{2}\right) \times 8.0$ ✓ = 1296 (m) ✓ total distance = 1384 m ✓	
		Total	**6**

Question 5			
(a)	(i) & (ii)		**6**
	(iii)	A + B = constant ✓ loss in potential energy = gain in kinetic energy **for A and B** ✓ [or potential energy at P = kinetic energy at Q **for A and B** ✓] reason for C being below B e.g. transfer to heat ✓ [or work done against friction ✓]	
(b)	(i)	clear reference to energy $v_c(=\sqrt{2gh}) = \sqrt{2\times 9.8\times 50}$ ✓ $= 31(.3)\,\text{m s}^{-1}$ ✓	**max 9**
	(ii)	$F\left(=\frac{mv_c^{\,2}}{r}\right) = \frac{80\times(31.3)^2}{20}$ ✓ $= 3.9(2)\times 10^3\,\text{N}$ ✓ towards centre of circle ✓	
	(iii)	gain in gravitational potential energy $(= mgh\sin\theta) = 620\times 9.8\times 60\times\sin 20°$ ✓ $= 1.25\times 10^5\,\text{J}$ ✓	
	(iv)	$620\times 9.8\times 50 = (F\times 60)$ ✓ $+1.25\times 10^5$ ✓ $F = 3000\,\text{N}$ ✓ [*alternative (iv)* calculation of acceleration $= (-)8.0\ \text{m s}^{-2}$ ✓ use of $F + mg\sin\theta = ma$ ✓ $F = 3000\,\text{N}$ ✓]	
		Total	**15**

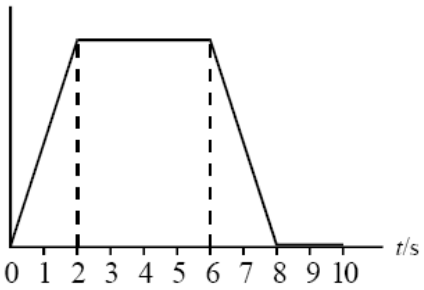
Question 6		
(a) (i)	component velocity North = $20 \cos 68°$ ✓ $= 7.5\,\text{m s}^{-1}$ which is supplied by wind ✓ by triangle of velocities [or by components] (aircraft must point East) ✓ [*alternative (a)(i)* triangle or parallelogram of velocities ✓ find angle between aircraft component and wind using sine and cosine formulae – prove 90° ✓✓]	**max 6**
(ii)	work done = $Fs \cos\theta$ [or force × distance moved in direction of force or $2.0 \times 10^3 \times 10 \times 10^3 \cos 22°$] ✓ $= 1.8(5) \times 10^7\,\text{J}$ ✓	
(iii)	power = $\frac{\text{work done}}{\text{time taken}} = 1.8(5) \times 10^7 \div \left(\frac{10000}{20}\right)$ ✓ $= 3.6 \times 10^4\,\text{W}$ ✓ [*alternative (iii)* power = force × velocity component East $= 2.0 \times 10^3 \times 20 \cos 22°$ ✓ $= 3.6 \times 10^4\,\text{W}$ ✓]	
(b)	return time = $\frac{10000}{14} = 714\,\text{s}$ ∴ total time = 1214 s ✓ average speed = $\frac{20000}{1214} = 16[16.5]\,\text{m s}^{-1}$ ✓	**2**
	Total	**8**

Question 7				
(a)	(i)	**region A**	**uniform** acceleration (or (free-fall) acceleration = g(= 9.8(i) m s^{-2})) force acting on parachutist is entirely his weight (or other forces are very small)	**any 2** ✓✓	**6**
	(ii)	**region B**	speed is still increasing acceleration is decreasing because frictional (drag) forces become significant (at higher speeds)	**any 2** ✓✓	
	(iii)	**region C**	uniform speed (50 m s^{-1}) because resultant force on parachutist is zero weight balanced exactly by resistive force upwards	**any 2** ✓✓	
(b)		deceleration is gradient of the graph (at t = 13 s) ✓ (e.g. 20/1 or 40/2) = 20 m s^{-2} ✓			**2**
(c)		distance = area under graph ✓ suitable method used to determine area (e.g. counting squares) ✓ with a suitable scaling factor (e.g. area of each square = 5 m^2) ✓ distance = 335 m (± 15 m) ✓			**4**
(d)	(i)	speed = $\sqrt{(5.0^2 + 3.0^2)}$ = 5.8 m s^{-1} ✓			**2**
	(ii)	tan $\theta = \frac{3}{5}$ gives θ = 31° ✓			
		the Quality of Written Communication marks were awarded primarily for the quality of answers to (a)			
			Total		**14**

Question 8			
(a)		$F \cos 20 = 300$ gives $F = 319\,\text{N}$ ✓	**1**
(b)	(i)	work done = force × distance moved **in direction of force** ✓ F is not in the direction of motion ✓	**6**
	(ii)	work done = force × distance = $300 \times 8000 = 2.4 \times 10^6\,\text{J}$	
	(iii)	power = $\frac{\text{work done}}{\text{time taken}}$ ✓ $= \frac{2.4}{5.0 \times (60 \times 60)} \times 10^6$ ✓ (allow e.c.f. for work done in (ii)) $= 133\,\text{W}$ ✓ (allow e.c.f. for incorrect time conversion)	
(c)		on the level, work is done only against friction ✓ uphill, more work must be done to **increase in potential energy** ✓ sensible conclusion drawn ✓ (e.g. increased work at constant power requires longer time)	**3**
		Total	**10**

Question 9			
(a)	(i)	 F_1 weight / mg ✓ F_2 reaction or normal contact force ✓ F_3 driving force ✓ F_4 friction or air resistance ✓	**max 5**
	(ii)	zero acceleration ✓ zero resultant force ✓	
(b)		($P = Fv$ gives) $18 \times 10^3 = F \times 10$ ✓ (and $F = 1.8 \times 10^3\,\text{N}$)	**1**

(c)	(i)	$1800 - 250 = 1.6 \times 10^3$ N ✓ (1.55×10^3 N)	**4**
	(ii)	force = $4 \times 1.55 \times 10^3 = 6.2 \times 10^3$ N ✓ (allow e.c.f. from (i))	
	(iii)	total force = 6200 + 250 (N) ✓ ($= 6.45 \times 10^3$ (N)) ($P = Fv$ gives) $P = 6.45 \times 10^3 \times 20 = 1.3 \times 10^5$ W ✓ (1.29×10^5 W) (allow e.c.f. for value of total force)	
		the Quality of Written Communication marks were awarded primarily for the quality of answers to (a) (ii)	
		Total	**10**

Question 10			
(a)	(i)	rate of change of velocity [or $a = \frac{\Delta v}{t}$] ✓	**2**
	(ii)	(acceleration) has (magnitude and) direction ✓	
(b)	(i)	(acceleration) is the gradient (or slope) of the graph ✓	**2**
	(ii)	(displacement) is the area (under the graph) ✓	
(c)		velocity  graph to show: (linear) increase to t = 2.0 ± 0.2 s ✓ uniform velocity between 2.0 s and 6.0 s ✓ (linear) decrease from 6.0 ± 0.2 s to 8.0 s ✓ zero velocity after t = 8.0 s ✓	**4**
		Total	**8**

Question 11		
(a)	decreases for the first four seconds ✓ zero for the remaining six seconds ✓	**2**
(b)	$E_k = ½ \times 1.4 \times 10^3 \times 16^2$ ✓ $= 1.8 \times 10^5$ J ✓ (accept $v = 15\,m\,s^{-1}$ from misleading graph and $E_k = 1.6 \times 10^5$ J)	**2**
(c)	(use of $P = Fv$ gives) $20 \times 10^3 = F \times 30$ ✓ $F = 670$ N ✓	**2**
	Total	**6**

Question 12		
(a)	loss of potential energy = $m \times 9.81 \times 6.0$ ✓ gain in kinetic energy = loss of potential energy ✓ $½\,mv^2 = 58.9\,m$ gives $v = 10.8$ ($m\,s^{-1}$) ($\approx 11\,m\,s^{-1}$)	**3**
(b)	loses potential energy (as it moves to B) ✓ gains kinetic energy (as it moves to B) ✓ regains some potential energy at the expense of kinetic energy as it moves from B to C ✓ some energy lost as heat (due to friction) ✓	**4**
	the Quality of Written Communication marks were awarded primarily for the quality of answers to (b)	
	Total	**7**

Question 13		
(a)	ball bearing accelerates at first as resultant force is downwards ✓ resistive force increases with speed ✓ when resultant force on ball is zero, terminal velocity reached ✓	**3**
(b)	show ball bearing takes same time ✓ to travel equal distances ✓ [or measure velocity at different points ✓ with appropriate method ✓]	**2**
	the Quality of Written Communication marks were awarded primarily for the quality of answers to (a)	
	Total	**5**

Question 14		
(a) (i)	(use of $v^2 = u^2 + 2as$ gives) $0 = 25^2 - 2 \times 9.81 \times s$ ✓ $19.6\,s = 625$ and $s = 32\,\text{m}$ ✓	**max 4**
(ii)	$t = \dfrac{25}{9.81} = 2.5\,\text{s}$ ✓	
(iii)	(use of $v^2 = u^2 + 2as$ gives) $v^2 = 25^2 - 2 \times 9.81 \times 16$ ✓ (allow C.E. from (a)(i)) and $v = 18\,\text{m s}^{-1}$ ✓	
(b)	time to stop the ball is greater ✓ ∴ rate of change of momentum is less ✓ [or work done on ball is the same but greater distance ✓ ∴ less force ✓]	**2**
	Total	**6**

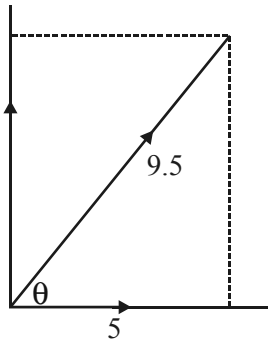
Question 15		
(a)	(use of $F = ma$ gives) $F = 1.3 \times 10^3 \times 2.5$ ✓ $= 3250\,\text{N}$ ✓ (3.25×10^3)	**2**
(b) (i)	driving force = 3250 + 410 = 3660 N ✓ (allow C.E. from (a))	**3**
(ii)	(use of $P = Fv$ gives) $P = 3660 \times 2.2$ ✓ (allow C.E. from (i)) $= 8100\,\text{W}$ ✓ (8.1×10^3)	
(c)	(component of) car's weight opposes motion ✓ [or overcomes gravity or more work is done as car gains potential energy ✓]	**1**
	Total	**6**

Question 16			
(a)		vt_b: distance moved (at speed v) before brakes are applied ✓ [or thinking/reaction distance ✓] $\frac{v^2}{2a}$: distance moved while braking (or after applying brakes) ✓	**2**
(b)	(i)	column B: (8.9) 13.3(5) 17.8 22.2(5) 26.7 31.1(5) (all values correct to 2 or 3 sig. figs ± 0.2) ✓	**2**
	(ii)	column D: 1.3(5) 1.72 2.02 2.39 2.73 3.08 (all values correct to 2 or 3 sig figs ± 0.1) ✓	
(c)		graph of $\frac{s}{v}$ against v [or v against $\frac{s}{v}$] ✓ axes labelled correctly ✓ (column D vs. column B or A) appropriate scales ✓ at least four points plotted correctly to 1 square ✓ acceptable straight line ✓ [note: if chosen graph gives a curve (e.g. s against v) then candidate can only score 2nd, 3rd and 4th marks]	**5**
(d)	(i)	(intercept) $t_b = 0.66\,s$ ✓ (values in range 0.6 to 0.7 accepted)	**4**
	(ii)	gradient = (any triangle e.g. $(3 - 1)/(30 - 4.5)$) $= 7.8 \times 10^{-2}$ $(s^2\,m^{-1})$ ✓ [other answers, if consistent with graph, acceptable] gradient = $(1/2a)$ ✓ gives $a = 6.4\,m\,s^{-2}$ ✓ (values in range 6.1 to 6.7 accepted) (allow C.E. for value of gradient) [if column D vs. column A used, gradient = 0.022 use of conversion factor gives gradient = $0.078\,(s^2\,m^{-1})$] [if graph of v against $\frac{s}{v}$, gradient = $12.8\,m\,s^{-2}$ $= 2a$ for first two marks]	
		Total	**13**

Question 17			
(a)	(i)	$70\,\text{m s}^{-1}$ ✓	**5**
	(ii)	$v = 9.81 \times 2.0$ ✓ $= 20\,\text{m s}^{-1}$ ✓ $(19.6\,\text{m s}^{-1})$	
	(iii)	$v = \sqrt{(70^2 + 19.62^2)} = 73\,\text{m s}^{-1}$ ✓ direction: $\tan\theta = \frac{19.6}{70} = 0.28$ $\theta = 15.6°$ ✓ (± 0. 10) (to horizontal) ✓ (allow C.E. for values of v from (i) and (ii)) [or use of correct scale drawing]	
(b)	(i)	air resistance is greater than weight ✓ (hence) resultant force is upwards ✓ **hence** deceleration (Newton's second law) ✓	**max 4**
	(ii)	air resistance decreases as speed decreases ✓ weight equals air resistance (hence constant speed) (hence) resultant force is zero (Newton's first law) ✓	
		the Quality of Written Communication marks were awarded primarily for the quality of answers to (b)	
		Total	**9**

Question 18			
(a)	(i)	mass per sec (= density × vol per sec) = 1000 × 1.4 ✓ = 1400 kg (s^{-1}) ✓	**6**
	(ii)	loss of E_p per sec (= $\frac{mgh}{t}$) = 1400 × 9.8 × 750 ✓ = 1.0 × 10^7 J (s^{-1}) ✓ (1.03 × 10^7 J s^{-1}) (allow C.E. for value of mass per sec from (i))	
	(iii)	efficiency (= $\frac{\text{power output}}{\text{loss of } E_p \text{ per second}}$) = $\frac{2.0\times10^6}{1.0\times10^7}$ ✓ = 0.2 ✓ (allow C.E. for value (ii))	
(b)	(i)	(use of $P = IV$ gives) $I_{rms} = \frac{2.0\times10^6}{25\times10^3}$ ✓ = 80 A ✓	**4**
	(ii)	power output = (0.95 × power input) = 0.95 × 2.0 (MW) = 1.9 (MW) ✓ $I = \frac{1.9(MW)}{275(kV)}$ = 6.9 A ✓ [or I for 100% efficiency $\left(=\frac{2\times10^6}{275\times10^3}\right)$ = 7.3 (A) ✓ I for 95% efficiency = 95% of 7.3 = 6.9 A ✓]	
		Total	**10**

Question 19			
(a)	(i)	horizontal component of the tension in the cable ✓	**2**
	(ii)	vertical component of the tension in the cable ✓	
(b)	(i)	T_{vert} = 250 × 9.81 = 2500 N ✓ (2452 N)	**6**
	(ii)	T_{horiz} = 1200 N ✓	
	(iii)	$T^2 = (1200)^2 + (2500)^2$ ✓ $T = (1.44 \times 10^6 + 6.25 \times 10^6)^{1/2}$ = 2800 N ✓ (2773 N) (if use of T_{vert} = 2450 N then T = 2730 N) (allow C.E. for values from (b) (i) and (b) (ii))	
	(iv)	tan $\theta = \frac{1200}{2500}$ ✓ $\theta = 26°$ ✓ (allow C.E. for values from (b) (i) and (b) (ii))	
		Total	**8**

Question 20			
(a)	(i)	a quantity that has magnitude only (or has no direction) ✓	**3**
	(ii)	any two, e.g. energy ✓ temperature ✓	
(b)	(i)	 scale ✓ 5 N and 9.5 N ✓ correct answer (8.1 N ± 0.2 N) ✓ [or $9.5^2 = 5.0^2 + F^2$ ✓ $F^2 = 90.3 - 25$ ✓ $F = 8.1\,\text{N}$ ✓ (8.07 N)]	**4**
	(ii)	$\cos\theta = \frac{5.0}{9.5}$ gives $\theta = 58°$ ✓ (± 2° if taken from scale diagram)	
		Total	**7**

Question 21			
	(i)	area = $120 \times 10^6\,(\text{m}^2)$ ✓ mass = $120 \times 10^6 \times 10 \times 1100 = 1.3 \times 10^{12}\,\text{kg}$ ✓	**7**
	(ii)	(use of $E_p = mgh$ gives) $\Delta E_p = 1.3 \times 10^{12} \times 9.8 \times 5 = 6.4 \times 10^{13}\,\text{J}$ ✓ (allow C.E. for incorrect value of mass from (i))	
	(iii)	power (from sea water) = $\frac{6.4 \times 10^{13}}{6 \times 3600}$ ✓ [or correct use of $P = Fv$] $= 3000\,(\text{MW})$ ✓ (allow C.E. for incorrect value of ΔE_p from (ii)) power output = 3000×0.4 ✓ $= 120\,\text{MW}$ ✓ (allow C.E. for incorrect value of power)	
		Total	**7**

Question 22		
(a)	increased impact time ✓ same loss of momentum ✓ force = change of momentum/impact time ✓ ∴ force is reduced ✓ [alternative for 2nd and 3rd: reduced deceleration of body ✓ force = mass × acceleration ✓] [or area of contact increased ✓ force on driver 'spread out' over larger area ✓ pressure or force/unit area on driver reduced] ✓ [or air bag absorbs E_k of driver ✓ over a greater distance ✓ force = $\frac{\Delta E_k}{\text{distance}}$ ✓ force is reduced ✓]	**4**
(b)	(use of $v^2 = u^2 + 2as$ gives) $\alpha\left(=\frac{v^2-u^2}{2s}\right)=\frac{(0)-18^2}{2\times 2.5}$ ✓ $a = -65\,\text{m s}^{-2}$ ✓ $(-64.8\,\text{m s}^{-2})$ (hence deceleration = $65\,\text{m s}^{-2}$)	**2**
	the Quality of Written Communication marks were awarded primarily for the quality of answers to (a)	
	Total	**6**

Question 23			
(a)		suitable calculation using a pair of values of x and corresponding t to give an average of $2.2\,m\,s^{-1}$ ($\pm 0.05\,m\,s^{-1}$) ✓ valid reason given ✓ (e.g. larger values are more reliable/accurate or use of differences eliminates zero errors)	**2**
(b)	(i)	column D (y/t ($cm\,s^{-1}$)) 186 210 233 259 284 307 all values correct to 3 s.f. ✓	**9**
	(ii)	graph: chosen graph gives a straight line (e.g. y/t against t) ✓ axes labelled correctly ✓ suitable scale chosen ✓ minimum of four points correctly plotted ✓ best straight line ✓	
	(iii)	u (= y - intercept) = $162\,cm\,s^{-1}$ ($\pm 4\,cm\,s^{-1}$) ✓ gradient = 495 ($cm\,s^{-2}$) ($\pm 25\,cm\,s^{-2}$) ✓ k = gradient (= $495\,cm\,s^{-2}$) ✓	
(c)	(i)	u: initial vertical component of velocity ✓	**2**
	(ii)	k: = ½ g ✓	
(d)		$v^2 = u^2 + 2.2^2$ ✓ gives $v = (1.62^2 + 2.2^2)^{1/2} = 2.7\,m\,s^{-1}$ ($\pm 0.1\,m\,s^{-1}$) ✓	**2**
		Total	**15**

Question 24			
(a)	(i)	(use of $E_p = mgh$ gives) $E_p = 70 \times 9.81 \times 150$ ✓ $= 1.0(3) \times 10^5$ J ✓	**4**
	(ii)	(use of $E_k = ½mv^2$ gives) $E_k = ½ \times 70 \times 45^2$ ✓ $= 7.1 \times 10^4$ J ✓ (7.09×10^4 J)	
(b)	(i)	work done ($= 1.03 \times 10^5 - 7.09 \times 10^4$) $= 3.2(1) \times 10^4$ J ✓ (allow C.E. for values of E_p and E_k from (a))	**3**
	(ii)	(use of *work done* = *Fs* gives) $3.21 \times 10^4 = F \times 150$ ✓ (allow C.E. for value of *work done* from (i)) $F = 210$ N ✓ (213 N)	
		Total	**7**

Question 25			
(a)		vector quantities have direction (as well as magnitude) and scalar quantities do not ✓	**1**
(b)		vector: e.g. velocity, acceleration, momentum ✓ scalar: e.g. mass, temperature, energy ✓	**2**
(c)	(i)	addition of forces (12 + 8) ✓ (use of $F = ma$ gives) $a = \frac{(12+8)}{6.5} = 3.1\,\text{m s}^{-2}$ ✓ ($3.08\,\text{m s}^{-2}$)	**4**
	(ii)	subtraction of forces (12 – 8) ✓ $a = \frac{(12-8)}{6.5} = 0.62\,\text{m s}^{-2}$ ($0.615\,\text{m s}^{-2}$) ✓	
		Total	**7**

Question 26		
(i)	volume/sec ($= \pi r^2 L$) $= \pi \times 22^2 \times 15$ ($= 2.3 \times 10^4\,m^3\,s^{-1}$) ✓	**max 7**
(ii)	mass of air/(sec) (= vol/sec × density) $= 2.3 \times 10^4 \times 1.2$ ✓	
	$= 2.8 \times 10^4\,kg\,(s^{-1})$ ✓ ($2.76 \times 10^4\,kg\,(s^{-1})$)	
	(allow C.E. for incorrect value of vol/sec from (i))	
(iii)	E_k/(sec) (= ½ × mass/sec × speed^2) $= 0.5 \times 2.76 \times 10^4 \times 15^2$ ✓	
	$= 3.1(1) \times 10^6\,J\,(s^{-1})$ ✓	
	(use of 2.8×10^4 from (ii) gives $3.1(5) \times 10^6\,J\,(s^{-1})$)	
	(allow C.E. for value of mass/(sec) from (ii))	
(iv)	mass/sec is reduced to half ✓	
	E_k reduced to (¼) or $\propto v^2$ (for a given mass/(sec)) ✓	
	(power $\propto E_k$) $\therefore$ power reduced to $(\frac{1}{8})^{th}$ ✓	
	Total	**7**

Question 27		
(a)	scales ✓	**3**
	six points plotted correctly ✓	
	trendline ✓	
(b)	average acceleration $= \frac{26}{25}$ ✓	**2**
	$= 1.0(4)\,m\,s^{-2}$ ✓	
	(allow C.E. for incorrect values used in acceleration calculation)	
(c)	area under graph ✓	**2**
	$= 510 \pm 30\,m$ ✓	
(d)	(graph to show force starting from *y*-axis)	**2**
	decreasing (not a straight line) ✓	
	to zero (at end of graph) ✓	
(e)	(since) gradient of a velocity-time graph gives acceleration ✓	**2**
	first graph shows acceleration is decreasing ✓	
	Total	**11**

Question 28		
(a)	potential energy to kinetic energy ✓ mention of thermal energy and friction ✓	**2**
(b)	(use of ½ $mv^2 = mgh$ gives) ½ $v_h^2 = 9.81 \times 1.5$ ✓ $v_h = 5.4(2)\,\text{m s}^{-1}$ ✓ (assumption) energy converted to thermal energy is negligible ✓	**3**
(c)	component of weight down the slope causes acceleration ✓ this component decreases as skateboard moves further down the slope ✓ air resistance/friction increases (with speed) ✓	**max 2**
(d) (i)	distance (= 0.42 × 5.4) = 2.3 m (2.27 m) ✓ *(allow C.E. for value of v_h from (b))*	**5**
(ii)	$v_v = 9.8 \times 0.42$ ✓ $= 4.1(1)\,\text{m s}^{-1}$ ✓	
(iii)	$v^2 = 4.1^2 + 5.4^2$ ✓ $v = 6.8\,\text{m s}^{-1}$ ✓ ($6.78\,\text{m s}^{-1}$) *(allow C.E. for value of v_h from (b))*	
	Total	**12**

Question 29		
(a) (i) (ii)	(change in momentum of A) = – ✓ 25×10^3 ✓ kg ms^{-1} (or N s) ✓ (change in momentum of B) = 25×10^3 kg m s^{-1} ✓	**4**
(b)	<table><tr><th></th><th>initial vel/ m s^{-1}</th><th>final vel/ m s^{-1}</th><th>initial k.e./J</th><th>final k.e./J</th></tr><tr><td>truck A</td><td>2.5</td><td>1.25</td><td>62500</td><td>15600</td></tr><tr><td>truck B</td><td>0.67</td><td>1.5</td><td>6730</td><td>33750</td></tr><tr><td></td><td>✓</td><td>✓</td><td>✓</td><td>✓</td></tr></table>	**4**
(c)	not elastic ✓ because kinetic energy not conserved ✓ kinetic energy is greater before the collision (or less after) ✓ [or justified by correct calculation]	**3**
	Total	**11**

Question 30			
(a)		kinetic energy not conserved ✓ [or velocity of approach is equal to velocity of separation]	**1**
(b)	(i)	(use of $p = mv$ gives) $p = 4.5 \times 10^{-2} \times 60$ ✓ $= 2.7\,\text{kg m s}^{-1}$ ✓	**4**
	(ii)	(use of $F = \frac{\Delta(mv)}{\Delta t}$ gives) $F = \frac{27}{15 \times 10^{-3}}$ ✓ $= 180\,\text{N}$ ✓ [or $a = \frac{v-u}{t} = \frac{60}{15 \times 10^{-3}} = 4000\,(\text{m s}^{-1})$ $F = (ma) = 4.5 \times 10^{-2} \times 4000 = 180\,\text{N}$]	
(c)	(i)	180 N ✓ (allow C.E. for value of F from (b) (ii)) in opposite direction (to motion of the club) ✓	**max 4**
	(ii)	body A (or club) exerts a force on body B (or ball) ✓ (hence) body B (or ball) exerts an equal force on body A (or club) ✓ correct statement of Newton's third law ✓	
		the Quality of Written Communication marks were awarded primarily for the quality of answers to (c)	
		Total	**9**

Question 31		
(a)	displacement is a vector ✓ ball travels in opposite directions ✓	**max 1**
(b)	**any two from**: velocity is rate of change of displacement ✓ average speed is rate of change of distance ✓ velocity is a vector (or speed is a scalar) ✓ velocity changes direction ✓	**max 2**
(c) (i)	$a = \frac{(-6.0-8.0)}{0.10}$ ✓ $= (-)\ 140\,\text{m s}^{-1}$ ✓ (allow C.E. for incorrect values of Δv)	**5**
(ii)	$F = 0.45 \times (-)\ 140 = (-)\ 63\,\text{N}$ ✓ (allow C.E. for value a)	
(iii)	away from wall ✓ at right angles to wall ✓ [or back to girl ✓✓] [or opposite to direction of velocity at impact ✓✓]	
	Total	**8**

Question 32		
(a) (i)	length of card ✓ [or distance travelled by trolley A ✓] time at which first light gate is obscured ✓ [or time taken to travel the distance ✓]	**3**
(ii)	time at which second light gate is obscured ✓ [or distance travelled after collision **and** time taken ✓]	
(b)	momentum = mass × velocity ✓ mass of each trolley ✓ (check whether) $p_{\text{initial}} = p_{\text{final}}$ ✓	**max 2**
(c)	incline the ramps ✓ until component of weight balances friction ✓ [or identify where the friction occurs ✓ sensible method of reducing ✓]	**2**
	Total	**7**

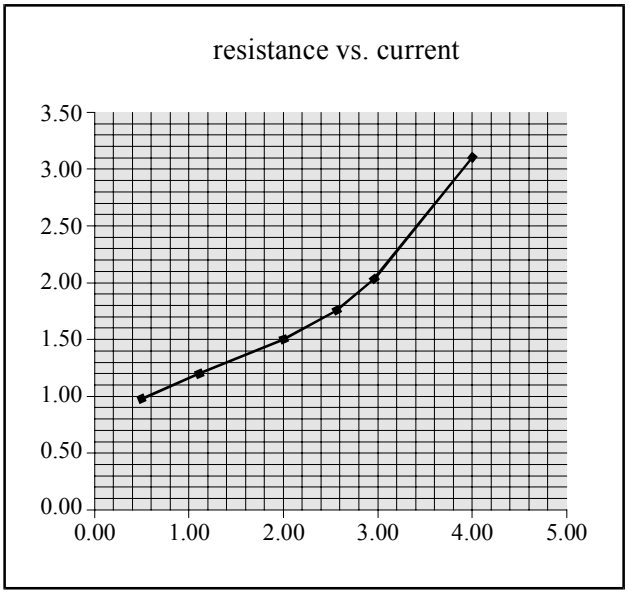
Question 33			
(a)		kinetic energy is not conserved ✓	**1**
(b)	(i)	($p = mv$ gives) $p = 0.12 \times 18 = 2.2\,\text{N s}$ ✓ (2.16 N s)	**6**
	(ii)	$p = 0.12 \times (-15) = -1.8\,\text{N s}$ ✓	
	(iii)	$\Delta p = 2.2 - (-18) = 4.0\,\text{N s}$ ✓ (3.96 N s) (allow e.c.f. from (i) and (ii))	
	(iv)	($F = \frac{\Delta(mv)}{\Delta t}$ gives) $F = \frac{3.96}{0.14}$ ✓ $= 28\,\text{N}$ ✓ (28.3 N) (allow e.c.f. from (iii))	
	(v)	($E_k = \frac{1}{2} mv^2$ gives) $E_k = 0.5 \times 0.12 \times (182 - 152) = 5.9\,\text{J}$ ✓	
			7

Question 34			
(a)	(i)	$I = \frac{12}{15} = 0.80\,\text{A}$ ✓	**2**
	(ii)	$P = (0.80)^2 \times 5 = 3.2\,\text{W}$ ✓ (allow e.c.f. from (a) (i))	
(b)		$I_{tot} = \frac{12}{7.5} = 1.60\,(\text{A})$ ✓ $I = \frac{1.6}{2} = 0.80\,(\text{A})$ ✓ (allow e.c.f. from I_{tot})	**3**
(c)		same brightness ✓ because same current ✓ [or an answer consistent with their current values]	**2**
		Total	**7**

Question 35		
(a)	$R = \frac{\rho l}{A} = \frac{4.0\times10^{-3}\times20\times10^{-3}}{\pi\times(0.70\times10^{-3})^2}$ ✓✓ $= (52\,\Omega)$	**2**
(b)	**method 1** valid labelled circuit ✓ [sample identified and label override circuit symbols] with means of changing I or V ✓ [variable supply may be in text] measure p.d., current and find resistance ✓ [$R = V/I$ or graphically] repeat finding resistance changing potential divider (or variable R or variable supply or length of lead) ✓ **or** **method 2** ohmmeter in circuit diagram ✓ change conditions (e.g. scale, length of lead) ✓ read ohmmeter ✓ repeat readings ✓	**8**
(c)	$P = I^2R = (0.25)^2 \times 52$ ✓ $= 3.25$ W ✓	**2**
	Total	**12**

Question 36			
(a)	**potential divider**		**4**
	advantage	better control from 0 to maximum ✓	
	disadvantage	power wasted because lower half of resistor always carries current (or top half of resistor must be capable of carrying lower half current **and** bulb current) ✓	
	rheostat		
	advantage	easier to connect ✓	
	disadvantage	minimum current through bulb never zero ✓	
(b) (i)	$V_{XB} = V_{lamp} = 2.0V \therefore I_{XB} = \frac{2}{16/2} = 0.25$ A ✓		**2**
(ii)	$I_{AX} = I_{XB} + I_{lamp}$, $I_{lamp} = I_{XB} = 0.25$ A, $\therefore I_{AX} = 0.5$ A ✓		
	Total		**6**

Question 37			
(a)	(i)	the energy provided by a battery ✓ per unit charge ✓ [or when no current flows ✓ it is the potential difference across the battery ✓]	**3**
	(ii)	a potential difference is developed across the internal resistance ✓	
(b)		$I = \frac{11.5}{10} = 1.15\,(\text{A})$ ✓ $12 - 11.5 = 1.15 \times r$ ✓ $r = 0.43\,\Omega$ ✓	**3**
		Total	**6**

Question 38			
(a)		resistance/Ω 0.98 1.20 1.50 1.76 2.03 3.00 ✓✓ (deduct one mark for each incorrect value)	**2**
(b)	(i)	sensible scales chosen ✓ points plotted correctly (deduct one mark for each mistake) ✓✓ line of best fit ✓  	**max 8**
	(ii)	0.90 Ω ✓	
	(iii)	0.22 Ω ✓ 0.38 Ω ✓	
	(iv)	1.12 W ✓ 6.0 W ✓	

(c)	resistance increases with increasing temperature ✓ increase in heat dissipation for 1.0 A to 2.0 A is greater than for 0 to 1.0 A ✓ and so a greater corresponding rise in temperature ✓	**max 2**
	Total	**12**

Question 39			
(a)		$\rho = \frac{RA}{l} \Rightarrow \frac{\Omega m^2}{m}\ \Omega m$ ✓	**1**
(b)	(i)	$A = 1.43 \times 10^{-6}\,m^2$ ✓	**4**
	(ii)	$R_{strand} = \frac{1.6\times10^{-8}\times10^{2}}{1.4\times10^{-6}} = 1.1\ \Omega$ ✓ $R_{cable} = \frac{1.12}{7}$ ✓ $= 0.16\,\Omega$ ✓ [alternative for (ii): $A = 7$ ✓ $\times 1.4 \times 10^{-6}$ substitution ✓ leading to $R_{cable} = 0.16\,\Omega$ ✓]	
(c)	(i)	$V = 3.2$ V ✓	**2**
	(ii)	$V = 7 \times 3.2$ V $= 22$ V ✓	
(d)		**any one from**: cable is flexible ✓ one strand fails, cable continues to conduct ✓ larger surface area so better heat dissipation etc ✓	**max 1**
		Total	**8**

Question 40		
	$A = 1.13 \times 10^{-6}\,(m^2)$ ✓ $R = \frac{\rho l}{A} = 24.7\,(\Omega)$ ✓ $P = \frac{V^2}{R}$ [or $I = 9.32$ A] ✓ $= 2.1(4) \times 10^3\,(W)$ ✓	**4**
	Total	**4**

Question 41		
(a)	$R\left(=\frac{\rho l}{A}\right)=\frac{2.65\times10^{-8}\times1.0\times10^{3}\times4}{\pi\times(3.2\times10^{-3})^{2}}$ ✓ $= 3.3(0)\,\Omega$ ✓	**2**
(b)	$\frac{1}{R_{A1}}=\frac{54}{3.3}$ ✓ $\frac{1}{R_{steel}}=\frac{7}{19.9}$ ✓ $\left(\frac{1}{R_{tot}}=\frac{1}{R_{A1}}+\frac{1}{R_{steel}}\right) = 0.06(0)\,\Omega$ ✓	**3**
	Total	**5**

Question 42		
	power determines heat produced ✓ in series, current is same ✓ $\therefore I^2 R_A$ must be $> I^2 R_B$ ✓ in parallel, p.d. is same ✓ $\therefore \frac{V^2}{R_B}$ must be $> \frac{V^2}{R_A}$ ✓ $\therefore R_A > R_B$ ✓	**6**
	Total	**6**

Question 43			
(a)		$\rho=\frac{RA}{1}$ ✓ R = resistance of specimen, l = length, A = **cross-sectional area** ✓	**2**
(b)	(i)	$A = 2.8 \times 10^{-5}\,m^2$ ✓ $\rho=\frac{450\times2.8\times10^{-5}}{0.010} = 1.3$ ✓ $\Omega\,m$ ✓	**5**
	(ii)	$\rho = 1.7 \times 10^{-8}\,(\Omega\,m)$ ✓ $R = 6.0 \times 10^{-6}\,\Omega$ ✓	
		Total	**7**

Question 44		
(i)	$R_{AB} = 5.0\ (\Omega)$ ✓	**max 7**
	$V\ (= 5.0 \times 0.50) = 2.5\ \text{V}$ ✓	
(ii)	$V_r = 12 - 2.5 + 5.0$ ✓ $= 4.5\ (\text{V})$ ✓	
	$r = \left(\frac{V_r}{I} = \frac{4.5}{0.5}\right) 9.0\ \Omega$ ✓	
(iii)	$W\ (= EIt) = 12\ \text{J}$ ✓	
(iv)	$W_r\ (= V_r It) = 4.5\ (\text{J})$ ✓	
	$\frac{W_r}{W}\left(= \frac{4.5}{12}\right) = 0.375$ ✓	
	Total	**7**

Question 45		
(a)	(three parallel resistors) give $\frac{1}{40} + \frac{1}{20} + \frac{1}{40} = \frac{1}{R}$ ✓	**3**
	$R = 10\ (\Omega)$ ✓	
	$10\ \Omega$ and $50\ \Omega$ in series gives $60\ \Omega$ ✓	
	(allow e.c.f. from value of R)	
(b)	($V = IR$ gives) $12 = I \times 60$ and $I = 0.2\ \text{A}$ ✓	**1**
	(allow e.c.f. from (a))	
	Total	**4**

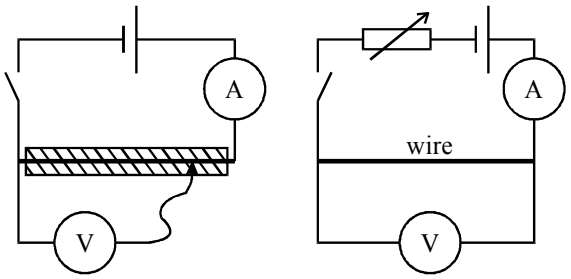
Question 46			
(a)	(i)	energy provided by the battery ✓	**3**
		per unit charge ✓	
		[or potential difference across battery ✓ when no current flows ✓]	
	(ii)	when current flows, work is done inside the battery to overcome the resistance (hence $V < \in$) ✓ (or any correct alternative)	
(b)	(i)	suitable scale for I ✓	**8**
		four correct points ✓✓	
		best straight line ✓	
	(ii)	($\in = Ir + V$ gives) $V = -rI + \in$ ✓	
		intercept = $\in$ = 5 V ✓	
		gradient = $(-)r$ ✓	
		$= \frac{5}{0.35} = 14.(2)\ \Omega$ ✓	
		Total	**11**

Question 47			
(a)	(i)	resistivity defined by $\rho = \frac{RA}{l}$ ✓ symbols defined $\frac{RA}{l}$ ✓	**5**
	(ii)	$R = \frac{\rho l}{A} = \frac{1.7\times10^{-8}\times2}{\pi(0.4\times10^{-3})^2}$ ✓ $= 0.068\,(\Omega)$ ✓ $(0.0676\,\Omega)$ $I = \frac{1.5}{0.068} = 22\,\text{A}$ ✓ (22.2 A) (allow e.c.f. from value of R)	
(b)	(i)	$\text{pd}_{AB} = \frac{2}{3} \times 12 = 8\,\text{V}$ ✓✓	**5**
	(ii)	$\text{pd}_{BC} = (\frac{1}{3} \times 12) = 4\,\text{V}$ ✓	
	(iii)	pd_{AC} = potential at A – potential at C ✓ $= (8 - 4) = 4\,\text{V}$ ✓ (allow e.c.f. from (i) and (ii))	
			10

Question 48		
(a)	only $30\,\Omega$ in the circuit ✓ (use of $V = IR$ gives) $6 = I \times 30$ and $I = 0.20\,\text{A}$ ✓	**2**
(b)	two resistors in parallel gives $\frac{1}{R} = \frac{1}{60} + \frac{1}{30}$ ✓ and $R = 20\,(\Omega)$ ✓ total resistance = 20 + 30 = 50 (Ω) ✓ (allow C.E. for value of R) $I = \frac{6}{50} = 0.12\,\text{A}$ ✓ (allow C.E. for total resistance)	**4**
	Total	**6**

Question 49			
(a)	(i)	$\in = I(R + r)$ ✓	**2**
	(ii)	$V_R = IR$ gives $V_R = \in - I_r$ ✓	
(b)	(i)	$P = VI$ gives $30 = 120\ I$ ✓ $I = 0.25\,\text{A}$ ✓	**5**
	(ii)	I through lamp = 0.25 (A) and p.d. across it = 240 V ✓ p.d. due to 1 cell = $1.5 - (0.25 \times 1.2) = 1.2$ (V) ✓ number of cells = $\frac{120}{1.2} = 100$ ✓ [or R_L given by $30 = 0.25^2\ R_L$ and $R_L = 480\,(\Omega)$ ✓ $1.5n = 0.25\ (480 + 1.2n)$ ✓ $1.2n = 120$ and $n = 100$ ✓] [or $\in = V + Ir$ gives $1.5n = 120 + 0.25 \times 1.2n$ ✓✓ $n = 100$ ✓]	
		Total	**7**

Question 50			
(a)	(i)	$P = \frac{V^2}{R}$ gives $40 = \frac{144}{R_T}$ ✓ $R_T = 3.6\,\Omega$ ✓ [or $P = VI$ to give $I = 3.3$ (A) ✓ and $R = P/I^2 = 3.7\,\Omega$ (3.67 Ω) ✓]	**5**
	(ii)	three resistors in parallel ✓ $\frac{1}{R_T} = \frac{1}{R} + \frac{1}{R} + \frac{1}{R} = \frac{3}{R}$ ✓ $R = 3.6 \times 3 = 10.8\,(\Omega)$ ✓ (allow C.E. for R_T from (i))	
(b)		(use of $R = \frac{\rho l}{A}$ gives) $10.8 = \frac{4.0\times10^{-5} l}{2.6\times10^{-3}\times1.1\times10^{-3}}$ ✓ $l = \frac{10.8\times2.6\times10^{-3}\times1.1\times10^{-3}}{4.0\times10^{-5}}$ ✓ = 0.77 m ✓ (allow C.E. for R from (a) (ii))	**3**
		Total	**8**

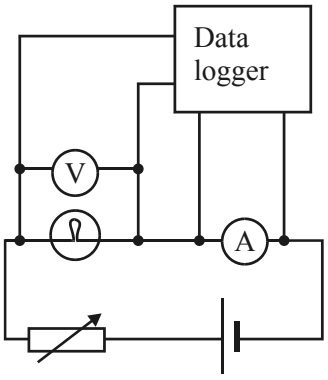
Question 51		
(a) (i)	 battery, wire (variable resistor) and ammeter in series ✓ voltmeter connected across wire ✓	**max 9**
(ii)	**max 4 from:** (α) (with switch closed) measure I and V ✓ move contact along the wire ✓ (or length of wire changed) measure new (I and) V ✓ measure l each time ✓ of (β) measure I and V ✓ change variable resistor ✓ measure new I and V ✓ l known ✓	
(iii)	$R = \frac{\rho l}{A}$ or $\rho = \frac{RA}{l}$ or $\rho = \frac{A}{l} \times \frac{V}{I}$ ✓ (α) obtain gradient of graph of V vs. I ✓ A (and I) known, hence ρ ✓ [**or** (β) gradient of graph of V vs. I ✓ A and l known, hence ρ ✓] [**or**, for both methods, measure $R = \frac{V}{I}$ for each length ✓ take mean and hence ρ ✓]	
(b)	(use of $V = IR$ gives) $R = \frac{240}{2\times10^{-3}}$ ✓ ($= 120 \times 10^3(\Omega)$) $\rho = \left(\frac{RA}{l}\right) = \frac{120\times10^3\times80\times80\times10^{-6}}{1.5\times10^{-3}}$ ✓ (allow C.E. for value of R) $= 5.1 \times 10^5\,\Omega\,\text{m}$ ✓	**3**
(c)	four resistors in series ✓ $R = 4 \times (120 \times 10^3) = 4.8 \times 10^5\,\Omega$ ✓ (allow C.E. for value of R)	**2**
	Total	**14**

Question 52		
(a)	first pair in parallel $\frac{1}{R'} = \frac{1}{30} + \frac{1}{60}$ ✓ $= \frac{3}{60}$ = gives $R' = 20\,(\Omega)$ ✓ second pair in parallel $\frac{1}{R''} = \frac{1}{40} + \frac{1}{120}$ gives $R'' = 30\,(\Omega)$ ✓ resistance between A and B = 20 + 30 ✓ (= 50 Ω) (allow C.E. fro values of R' and R'')	**4**
(b) (i)	total resistance = 50 + 50 = 100 Ω ✓ ($V = IR$ gives) 24 = I 100 and I = 0.24 A ✓	**4**
(ii)	current in 60 Ω = ⅓ I ✓ = 0.080 (A) ✓ [or alternative method] (allow C.E. for value of I from (b) (i))	
	Total	**8**

Question 53		
(a) (i)	total resistance = 180 + 60 = 240 (Ω) ✓ ($V = IR$ gives) 12 = I 240 and I = 0.05 A ✓	**4**
(ii)	very large or infinite resistance ✓	
(iii)	$V = 0.05 \times 60 = 3.0$ V ✓ [or statement that V = ¼ of 12 V] [or use of potentiometer equation $V_{out} = V_{in}\left(\frac{R_2}{R_1 + R_2}\right) = 12 \times \left(\frac{60}{240}\right) = 3.0$ V] (allow C.E. for value of I from (a) (i))	
(b)	parallel resistance gives lower equivalent resistance ✓ [or resistance of lower section of potentiometer reduced ✓] total resistance in circuit needed ✓ current through battery increases since V constant ✓	**max 2**
	the Quality of Written Communication marks were awarded primarily for the quality of answers to (b)	
	Total	**6**

Question 54		
(a)	$R = \frac{\rho l}{A}$ ✓ $= \frac{1.7\times10^{-8}\times1.4}{7.8\times10^{-7}} = 0.031\,\Omega$ ✓ $(0.0305\,\Omega)$	**2**
(b)	constant volume gives $l_1A_1 = l_2A_2$ [or $l_2 = 2l_1$ and $A_2 = A_1/2$] ✓ $R = \frac{\rho 2l}{A/2} = 4R$ ✓ [or calculation with $l_2 = 2.8$ (m) and $A_2 = 3.9$ (m^2) ✓ gives $R = 0.124\,\Omega$ ✓]	**2**
	Total	**4**

Question 55			
(a)	(i)	(use of $P = VI$ gives) P (= 2.4 × 20) = 48 W ✓	**4**
	(ii)	incident (solar) power (= 1.4 × 2.5) = 3.5 (kW) ✓ efficiency = $\frac{48}{3500}$ ✓ = 0.014 ✓ (or 1.4%) [or efficiency = $\frac{48}{2.5}/1400$] (allow C.E. for incorrect values of input and output power)	
(b)	(i)	in 1 s source emits 1.1×10^{14} particles ✓ energy emitted in 1 s = $1.1 \times 10^{14} \times 5.1 \times 1.6 \times 10^{-13}$ (J) ✓ (= 90 J)	**7**
	(ii)	$T_{1/2} = \frac{\ln 2}{\lambda}$ + correct use or $\lambda = \frac{\ln 2}{90\times365\times24\times3600}$ ✓ $= 2.44 \times 10^{-10}\,s^{-1}$ ✓ [or $\lambda = \frac{\ln 2}{90} = 7.7 \times 10^{-3}\,yr^{-1}$]	
	(iii)	no. of nuclei $\left(= \frac{\text{activity}}{\text{decay constant}} = \frac{11\times10^{14}}{2.44\times10^{-10}}\right) = 4.5(1) \times 10^{23}$ ✓ (allow C.E. for incorrect value of λ in (ii)) mass of isotope = $\frac{4.51\times10^{23}\times0.239}{6.02\times10^{23}}$ ✓ = 0.18 kg ✓ (allow C.E. for incorrect no. of nuclei)	
		Total	**11**

Question 56		
(a)	constantan (wire) ✓ $I \propto V$ ✓ [or straight line through origin] [or constant gradient] [of V and I increasing proportionally]	**2**
(b) (i)	(for $V = 1\,\text{V}$, use of $V = IR$ gives) $R = \dfrac{1}{0.68 \pm .01} = 1.5\,\Omega$ ✓ (for $V = 10\,\text{V}$) $R = \dfrac{10}{2.24 \pm .01} = 4.4$ or $4.5\,(\Omega)$ ✓	**max 4**
(ii)	as current increases ✓ greater heating effect (or temperature of filament increases) ✓ R **increases** with temperature ✓	
(c)	$\rho = \dfrac{RA}{l}$ ✓ (R = 1/gradient, or use of values gives) $R = \dfrac{12}{2.2} = 5.5\,(\Omega)$ ✓ $(5.45\,(\Omega))$ $\rho = \dfrac{5.45 \times 6.8 \times 10^{-8}}{0.8} = 4.6 \times 10^{-7}\,\Omega\,\text{m}$ ✓ $(4.63 \times 10^{-7}\,\Omega\,\text{m})$ (allow C.E. for value of R)	**3**
(d)	 variable supply or rheostat, (in series with filament) or pot divider ✓ filament and current sensor in series ✓ voltage sensor across filament ✓ connections to **datalogger** ✓	**max 3**
	the Quality of Written Communication marks were awarded primarily for the quality of answers to (b)	
	Total	**12**

Question 57		
(a)	$V = -Ir + \in$ ✓	**1**
(b)	straight line (within 1st quadrant) ✓ negative gradient ✓	**2**
(c)	$\in$: intercept on voltage axis ✓ r: gradient ✓	**2**
	Total	**5**

Question 58			
(a)		$\rho = \frac{RA}{l}$ ✓ R = resistance (of wire), A = **cross-sectional** area, l = length (of wire) ✓	**2**
(b)	(i)	$R = \frac{\rho l}{A} = \frac{4.0\times10^{-5}\times30\times10^{-3}}{8\times10^{-3}\times2\times10^{-6}}$ ✓ $= 75\,\Omega$ ✓	**max 4**
	(ii)	length has decreased causing resistance to decrease ✓ area increased, causing resistance to decrease ✓ each changed by factor of 1.5×10^3 ✓	
		the Quality of Written Communication marks were awarded primarily for the quality of answers to (b)	
		Total	**6**

Question 59			
(a)	(i)	(total) resistance = (20 + 60) (Ω) ✓ ($V = IR$ gives) $I = \frac{6.0}{80} = 0.075\,\text{A}$ ✓	**max 3**
	(ii)	with S closed, (effective) resistance = 20 (Ω) ✓ $I = \frac{6.0}{20} = 0.3\,\text{A}$ ✓	
(b)		use of same current as in part (i) ✓ voltmeter reading = $0.075 \times 60 = 45\,\text{V}$ ✓ [or use potentiometer equation $6 \times \frac{60}{80} = 4.5\,\text{V}$] (allow C.E. for value of I from (a) (i))	**2**
		Total	**5**

Question 60		
(a)	**battery** has internal resistance ✓ **current** passes through (this resistance) ✓ work done/voltage lost, which reduces the value of the e.m.f. ✓	**3**
(b) (i)	circuit to show: two **cells** in series ✓ two resistors, each labelled r ✓	**5**
(ii)	(use of $P = IV$ gives) $1.6 = 2.5\ I$ ✓ ($I = 0.64$ (A)) (use of $\in = V + Ir$ gives) $3.0 = 2.5 + 0.64 \times 2r$ ✓✓ $0.5 = 1.28r$ and $r = 0.39\,\Omega$ ✓ [or $R_{bulb} = 2.52/1.6 = 3.9\,(\Omega)$ and $2.5 = 3.9 \times I$ gives $I = 0.64$ (A) 'lost volts' = $(3 - 2.5) = 0.5$ (V) i.e. 0.25 (V) per cell $0.25 = 0.64r$ and $r = 0.39\,\Omega$]	
(c)	$\in = V + Ir$ gives $V = -Ir + \in$ (equation of straight line) ✓ intercept on y-axis gives $\in$ ✓ gradient gives $(-)r$ ✓	**3**
	the Quality of Written Communication marks were awarded primarily for the quality of answers to (a)	
	Total	**11**

Question 61		
(a)	$I = \frac{\Delta Q}{\Delta t}\left(or\ I = \frac{Q}{t}\right)$ ✓ $\Delta Q = 0.25 \times 6 \times 60 = 90$ C ✓	**2**
(b) (i)	$V = \frac{W}{Q}$ ✓ [or $E = VIt$] $= \frac{9.0 \times 10^4}{0.25 \times 20 \times 60 \times 60} = 5.0$ V ✓	**3**
(ii)	(use of $P = \frac{W}{t}$ gives) $P = \frac{9.0 \times 10^4}{20 \times 60 \times 60} = 1.2(5)$ W ✓ [or $P = IV$ gives $P = 0.25 \times 5 = 1.2(5)$ W] (allow C.E. in alternative method for value of V from (i))	
	Total	**5**

Question 62		
(a) (i)	(use of $V = IR$ gives) $12 = I \times 270$ and $I = 44.(4)\,\text{mA}$ ✓	**4**
(ii)	two resistors in parallel give resistance less than $110\,\Omega$ ✓ $(\therefore)$ total resistance decreases ✓ current increases ✓	
(b)	$V = 44.4 \times 10^{-3} \times 110$ ✓ $(= 4.9\,\text{V})$ [or $V = 12 \times \left(\frac{110}{110+600}\right)$] (assumption) no current flows through voltmeter ✓ [or voltmeter has very large or infinite resistance]	**2**
(c)	total resistance (in circuit) $= 160\,(\Omega)$ ✓ $12 = I \times 160$ and $I = 75\,\text{mA}$ ✓	**2**
	Total	**8**

Question 63		
(a)	(for lamp and resistor) $18\,(\Omega) + 12\,(\Omega) = 30\,(\Omega)$ ✓ (in parallel) $\frac{1}{30} + \frac{1}{15} = \frac{3}{30}$ ✓ (gives $R = 10\,(\Omega)$) (*allow C.E. for wrong value in first step*) total resistance $= \frac{30}{3} + 10$ ✓ $(= 20\,\Omega)$	**3**
(b) (i)	(use of $V = IR$ gives) $I = \left(\frac{30}{20}\right) = 1.5\,\text{A}$ ✓	**4**
(ii)	$\text{pd}_{AB} = 30 - (10 \times 1.5)$ ✓ $= 15\,\text{V}$ ✓ [or alternative method] (*allow C.E. for value of I from (i)*)	
(iii)	$I_{\text{lamp}} = \frac{6}{12} = 0.5\,\text{A}$ ✓ [or alternative method] (allow C.E. for value of pd_{AB} from (ii))	

(c)	(i)	(lamp power) $(= I^2R) = 0.5^2 \times 12 = 3.0\,(\text{W})$ ✓ (*allow C.E. for value of I_{lamp} from (b) (iii)*)	**3**
	(ii)	power from battery $= 30 \times 1.5 = 45\,(\text{W})$ ✓ $\% = \frac{3 \times 100}{45} = 6.7\,(\%)$ ✓ (*allow C.E. for power in lamp and/or battery in (i)*)	
		Total	**10**

Question 64			
(a)		resistance of wire decreases when temperature decreases ✓ pd across wire is constant, $V = IR$, (current increases) ✓	**2**
(b)	(i)	<table><tr><th>**1n *I***</th><th>**1n *v***</th></tr><tr><td>–1.03(0)</td><td>0.69(3)</td></tr><tr><td>–0.80(3)</td><td>1.39 (or 1.386)</td></tr><tr><td>–0.68 (or 0.677)</td><td>1.79(2)</td></tr><tr><td>–0.59 (or 0.587)</td><td>2.08 (or 2.079)</td></tr><tr><td>–0.51 (or 0.507)</td><td>2.30(3)</td></tr></table> 1 mark for each column correct to 3 or 4 s.f. ✓✓ graph axes labelled correctly ✓ suitable scales ✓ at least 4 points plotted correctly ✓ best fit line drawn ✓	**12**
	(ii)	graph of ln I against ln v is a straight line ✓ ($I = \text{k}\,v^{\text{n}}$ gives) $\ln I = \text{n} \ln v + \ln \text{k}$ (or $\log_{10}$) which is the equation for a straight line graph of ln I against ln v ✓	
	(iii)	y-intercept = ln k = –1.26 (± 0.10) ✓ k = 0.285 (± 0.040) ✓ gradient = n ✓ $\left(= \frac{0.625}{2.0}\right) = 0.31$ (± 0.02) ✓	
(c)		instrument is more sensitive at low speeds ✓ because change of current per unit change of speed is greater at low speeds ✓	**2**
		Total	**16**