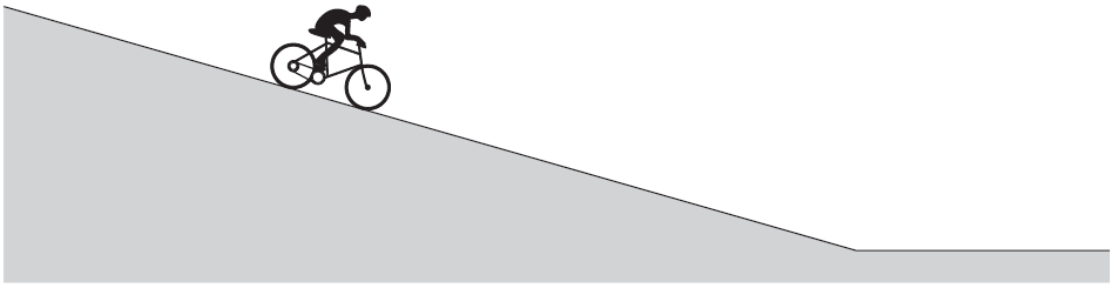
Selected Questions – Set 3

1.

A cyclist **pedals** downhill on a road, as shown in **Figure 1**, from rest at the top of the hill and reaches a horizontal section of the road at a speed of $16\,m\,s^{-1}$. The total mass of the cyclist and the cycle is 68 kg.

Figure 1



(a) (i) Calculate the total kinetic energy of the cyclist and the cycle on reaching the horizontal section of the road.

answer.....J

(2 marks)

(a) (ii) The height difference between the top of the hill and the horizontal section of road is 12 m.
Calculate the loss of gravitational potential energy of the cyclist and the cycle.

answer.....J

(2 marks)

(a) (iii) The work done by the cyclist when pedalling downhill is 2400 J. Account for the difference between the loss of gravitational potential energy and the gain of kinetic energy of the cyclist and the cycle.

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(3 marks)

(b) The cyclist stops pedalling on reaching the horizontal section of the road and slows to a standstill 160 m further along this section of the road. Assume the deceleration is uniform.

(b) (i) Calculate the time taken by the cyclist to travel this distance.

answer.....s

(3 marks)

(b) (ii) Calculate the average horizontal force on the cyclist and the cycle during this time.

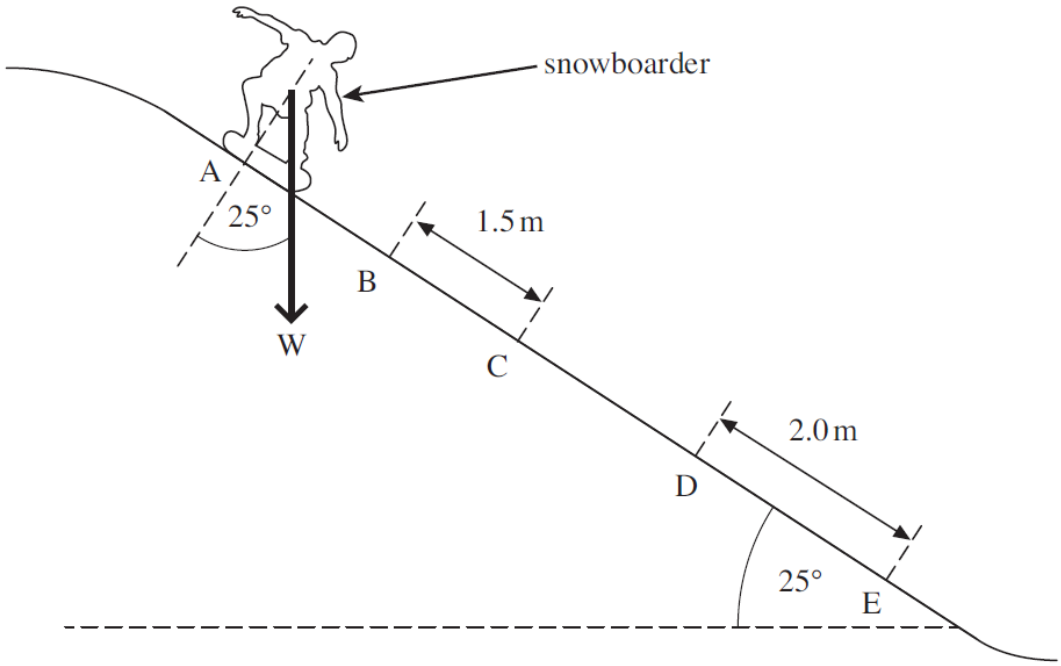
answer.....N

(3 marks)

2.

A snowboarder slides down a slope, as shown in **Figure 1**. Between **B** and **C** her acceleration is uniform.

Figure 1



(a) The snowboarder travels 1.5 m from B to C in a time of 0.43 s and her velocity down the slope at C is 5.0 m s^{-1}.

Calculate her velocity down the slope at B.

velocity = ... m s^{-1}

(3 marks)

(b) The combined mass of the snowboarder and snowboard is 75 kg and the angle of the slope is 25°.

(b) (i) Calculate the component of the weight of the snowboarder and snowboard acting down the slope.

weight component = ... N

(b) (ii) At D the snowboarder has reached a constant velocity. She moves a distance of 2.0 m at constant velocity between D and E.

Calculate the work done against resistive forces as she moves from D to E.

work done = ... J

(1 mark)

(c) State and explain what happens to the gravitational potential energy lost between D and E.

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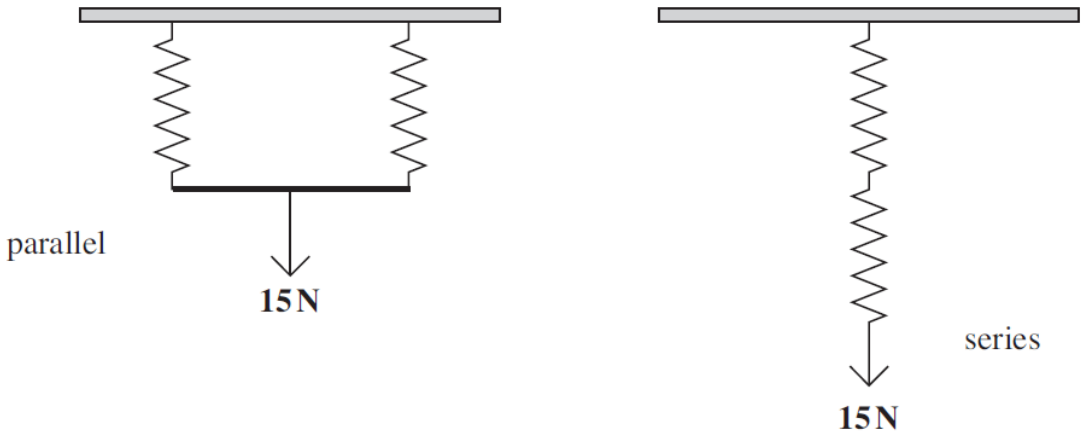
(3 marks)

3.

Two identical springs, each having a spring constant of 85 N m^{-1}, are shown arranged in parallel and series in **Figure 7**.

Figure 7



A load of 15 N is attached to each arrangement.

(i) Calculate the extension for the parallel arrangement when the load is midway between the lower ends of the springs.

answer = ... m

(2 marks)

(ii) Calculate the extension for the series arrangement.

answer = ... m

(2 marks)

(iii) Calculate the energy stored in the parallel arrangement.

answer = ... J

(2 marks)

(iv) Without further calculation, discuss whether the energy stored in the series arrangement is less, or greater, or the same as in the parallel arrangement.

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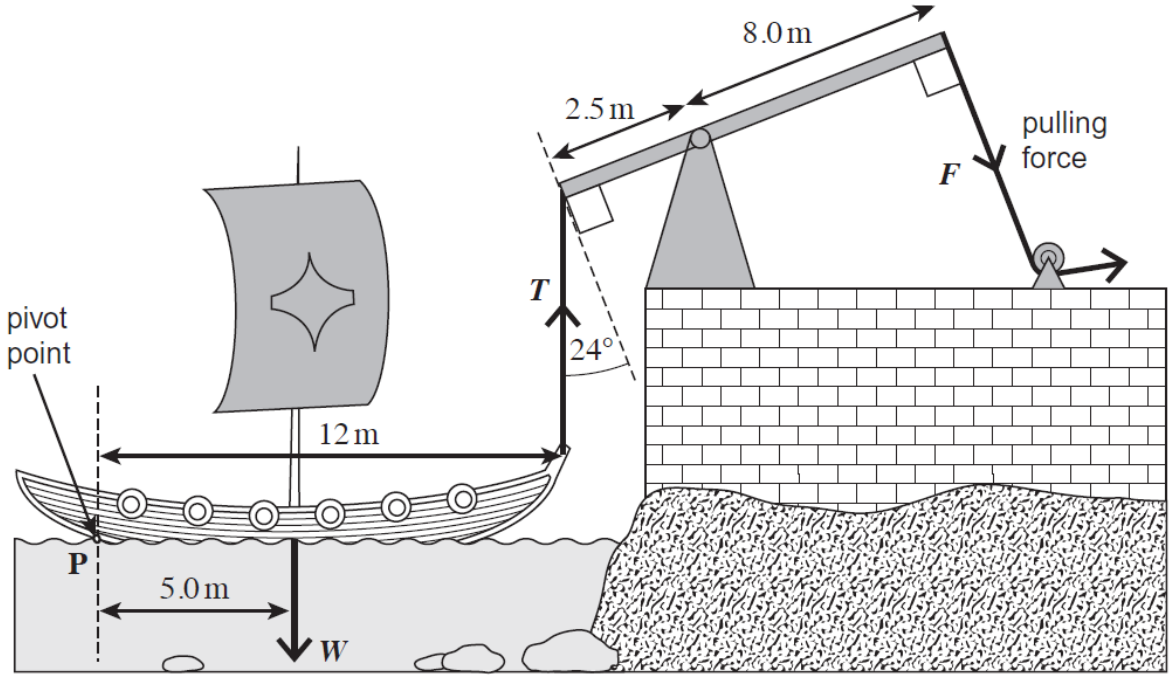
(3 marks)

4.

It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in **Figure 3** where a rope is hooked on to the front of the ship and the lever is pulled by several men.

Figure 3



(a) (i) Calculate the mass of the ship if its weight was 3.4×10^4 N.

[1 mark]

mass ..... kg

(a) (ii) Calculate the moment of the ship's weight about point **P**. State an appropriate unit for your answer.

[2 marks]

moment ..... unit .....

(a) (iii) Calculate the minimum vertical force, T, required to start to raise the front of the ship. Assume the ship pivots about point **P**.

[2 marks]

minimum vertical force ..... N

(a) (iv) Calculate the minimum force, F, that must be exerted to start to raise the front of the ship.

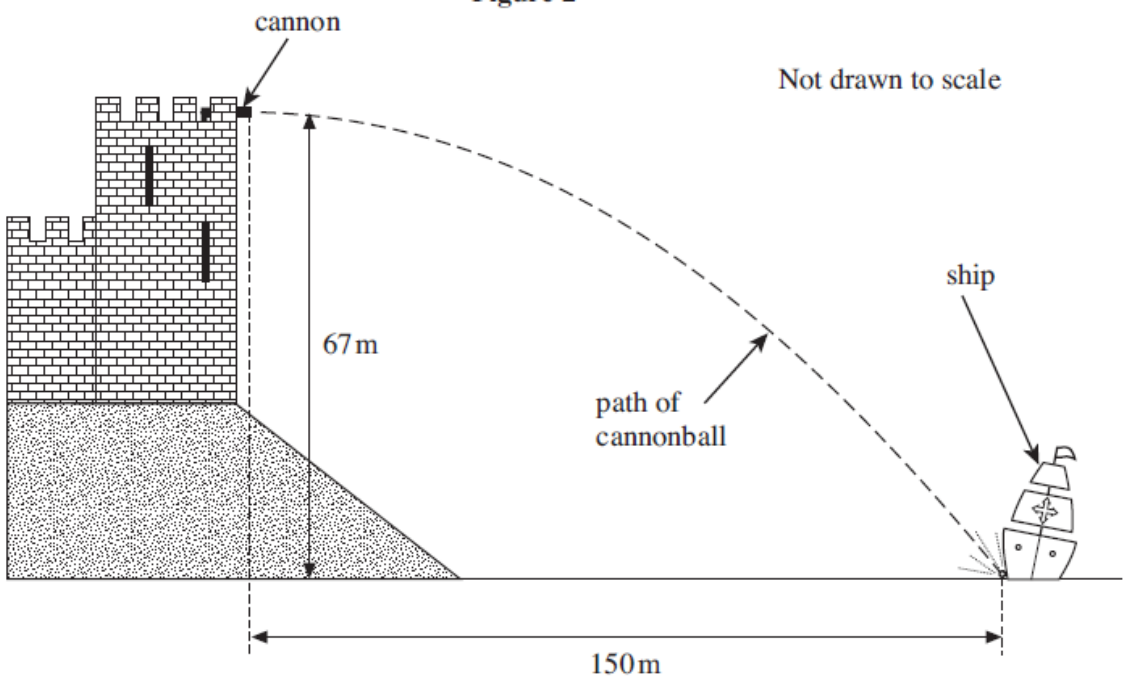
[3 marks]

force ..... N

5.

In a castle, overlooking a river, a cannon was once employed to fire at enemy ships. One ship was hit by a cannonball at a horizontal distance of 150 m from the cannon as shown in **Figure 2**. The height of the cannon above the river was 67 m and the cannonball was fired horizontally.

Figure 2



(a) (i) Show that the time taken for the cannonball to reach the water surface after being fired from the cannon was 3.7 s. Assume the air resistance was negligible.

(2 marks)

(a) (ii) Calculate the velocity at which the cannonball was fired. Give your answer to an appropriate number of significant figures.

answer = ... $m\,s^{-1}$

(2 marks)

(a) (iii) Calculate the vertical component of velocity just before the cannonball hit the ship.

answer = ... $m\,s^{-1}$

(2 marks)

(a) (iv) By calculation or scale drawing, find the magnitude and direction of the velocity of the cannonball just before it hit the ship.

velocity = ... $m\,s^{-1}$

direction = ...

(4 marks)

(b) (i) Calculate the loss in gravitational potential energy of the cannonball.
mass of the cannonball = 22kg

answer = ... J

(1 mark)

(b) (ii) Describe the energy changes that take place from the moment the cannonball leaves the cannon until just before it hits the water. Include the effects of air resistance.

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(2 marks)

6.

(a) Name a quantity that has the same unit as potential difference or voltage.

..... [1]

(b) State the electrical unit defined as 'a potential difference of 1 volt per ampere'.

..... [1]

(c) State the SI unit for electrical charge.

..... [1]

(d) State Kirchhoff's first law.

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..... [2]

(e) Fig. 4.1 shows an electrical circuit.

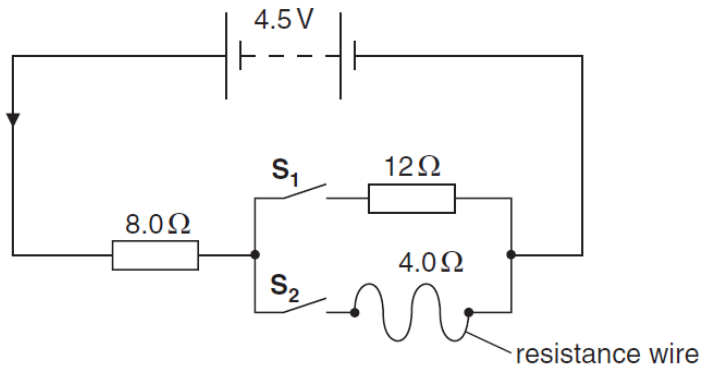

Fig. 4.1

The battery has e.m.f. 4.5 V and has negligible internal resistance. The resistance wire has resistance 4.0 Ω, length 15 cm and cross-sectional area 2.3×10^{-8} m^2.

(i) Suggest how you can arrange switches S_1 and S_2 (e.g. opened or closed) so that the circuit has a total resistance of 12 Ω.

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..... [1]

(ii) Calculate the resistivity of the material of the resistance wire.

resistivity = ... unit ..... [4]

(iii) When both switches are **closed**, calculate

1 the **total** resistance of the circuit

resistance = ... Ω [3]

2 the **total** electrical power delivered by the battery

power = ... W [3]

3 the ratio

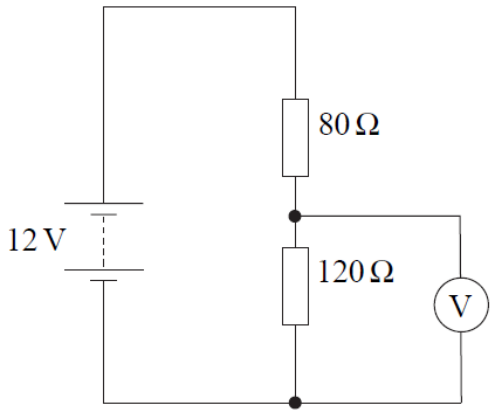
$$\frac{\text{current in the } 12\,\Omega \text{ resistor}}{\text{current in the resistance wire}} .$$

ratio = ... [1]

7.

(a) In the potential divider circuit shown in **Figure 2**, the battery has negligible internal resistance.

Figure 2



Calculate the reading on the voltmeter, stating the assumption made.

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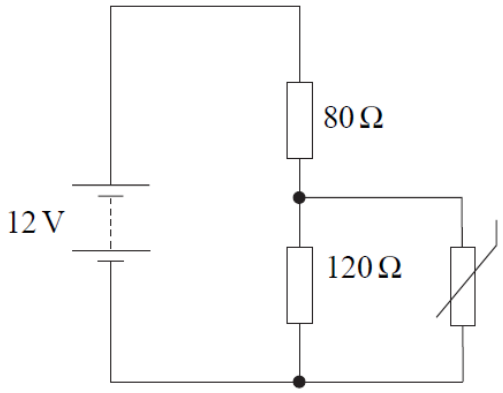
(3 marks)

(b) The voltmeter in **Figure 2** is replaced by a thermistor, giving the circuit shown in **Figure 3**.

Figure 3



The resistance of the thermistor at 0 °C is 120 Ω. As the temperature increases, its resistance decreases. Explain, without calculation, whether the current through the battery increases or decreases as the temperature of the thermistor is increased from 0 °C.

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

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(3 marks)