Mixed Exam Questions – Set 13

1.

A student is asked to determine the density of a metal in the form of a thin sheet.

The sheet is a square of approximately 300 mm × 300 mm and has a thickness of about 0.01 mm.

(a) (i) Explain why a metre rule is suitable to measure the length of each side of the sheet.

(1)

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(ii) Describe how the student should use this rule to make the measurements as accurate as possible.

(1)

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(b) In order to determine the thickness, the student is told to fold the sheet in half five times.

(i) Explain why this technique would make the value for the thickness of the sheet more precise.

(2)

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(ii) State what instrument the student should use to measure the thickness of the folded sheet.

(1)

………

(c) The student makes the following measurements.

		Mean values / mm
Length of sheet/mm	297, 302, 305, 298	301
Width of sheet/mm	303, 297, 299, 301	300
Thickness of folded sheet/mm	0.373, 0.375, 0.362, 0.379, 0.356, 0.369	0.369

(i) The folded sheet is 32 times thicker than a single sheet.

Use these measurements to show that the volume of the sheet is about 1.0×10^{-6} m^3.

(2)

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(ii) Use the measurements to estimate the percentage uncertainty in the volume.

(2)

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Percentage uncertainty = ...

(iii) The student measures the mass of the sheet as 2.49 g with negligible uncertainty.

Calculate the density of the metal.

(1)

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Density = ... kg m^{-3}

(iv) A website gives a value for the density of aluminium as 2750 kg m^{-3}.

Use your calculations to determine whether the sheet might be made from aluminium.

(2)

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2.

This question asks you to consider the force a space cabin exerts on an astronaut from take off until the cabin is docked alongside the International Space Station (ISS). The ISS is in a permanent orbit of radius 6.71×10^6 m around the Earth. The radius of the Earth is 6.37×10^6 m.
The graph in Fig. 2.1 shows how the **magnitude** of the force the cabin exerts on the astronaut varies over a period of time from just before blast off until docking takes place. Fig. 2.2 shows how the gravitational field strength, g, of the Earth varies with distance from the Earth's surface.

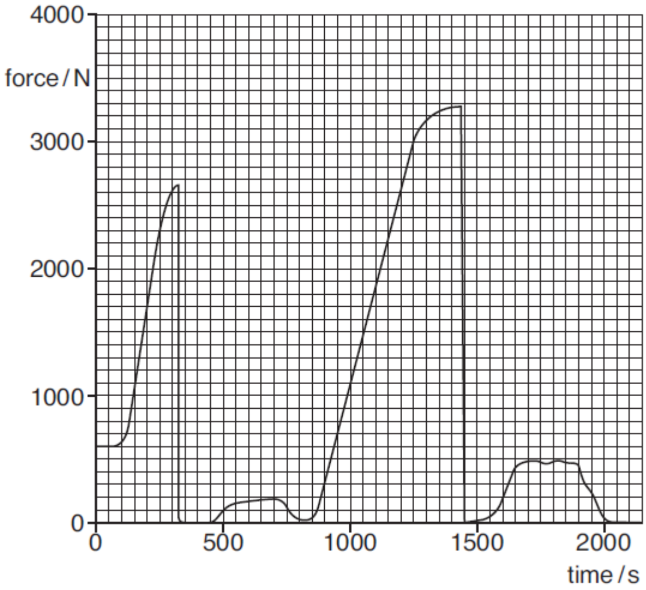

Fig. 2.1

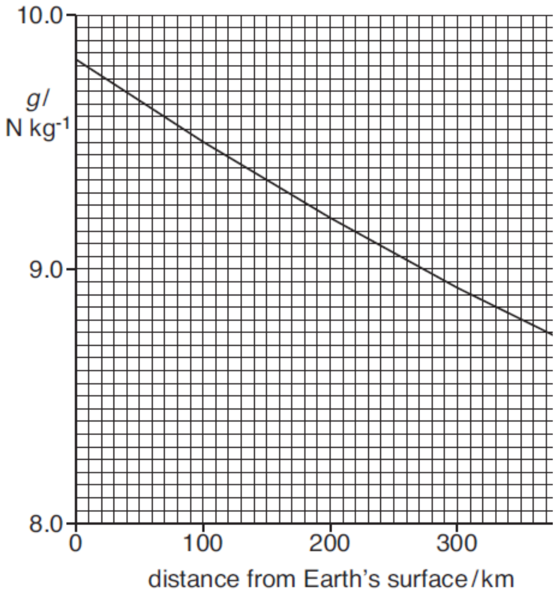

Fig. 2.2

(a) Use the graphs to determine

(i) the mass of the astronaut

mass = ... kg **[1]**

(ii) the maximum force applied to the astronaut

force = ... N **[1]**

(iii) the pull of the Earth on the astronaut when 200 km from the Earth's surface.

pull of Earth at 200 km = ... N **[2]**

(b) Explain why

(i) the rocket does not produce a constant acceleration even when the thrust is constant

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.... **[2]**

(ii) the area under the force–time graph, of Fig. 2.1, will not equal the increase in the momentum of the astronaut.

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.... **[2]**

(c) Show that the value of the centripetal acceleration of the ISS is $8.83\,m\,s^{-2}$.

[1]

(d) Calculate

(i) the speed of the ISS

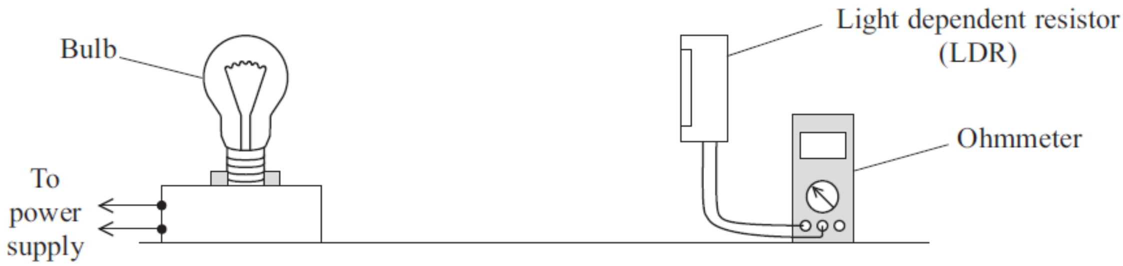
speed = ... $m\,s^{-1}$ **[3]**

(ii) the kinetic energy of the astronaut as she circles the Earth in the ISS.

kinetic energy = ... J **[2]**

3.

A physicist investigates how light intensity varies with distance from a light bulb. He sets up the apparatus as shown.



(a) Mark on the diagram the exact distance d he should measure.

(1)

(b) State why the resistance R of the LDR will increase as it gets further away from the bulb.

(1)

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(c) State the most important quantity to control to ensure a fair test and explain how the physicist might control it.

(2)

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(d) The relationship between R and d is given by

$$R = k\,d^{\mathrm{p}}$$

where k and p are constants.

Explain why a graph of ln R against ln d will give a straight line.

(2)

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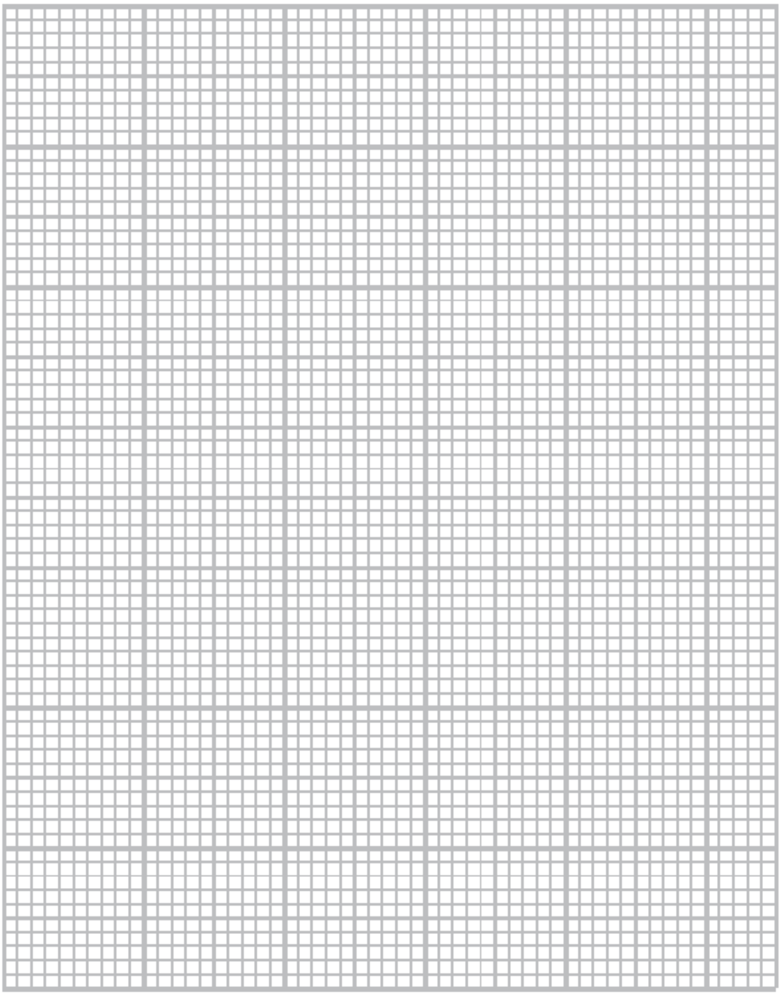
(e) He measures R for different values of d and records the following results.

d/m	R/kΩ		
1.00	1.79		
1.20	2.24		
1.60	3.32		
2.00	4.04		
2.20	4.70		
2.60	5.50		

Plot a graph of ln R against ln d. Use the column(s) provided to show any processed data.

(5)



(f) (i) Use your graph to find a value for p.

(2)

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....

p = ...

(ii) Use your graph to find a value for *k*.

(2)

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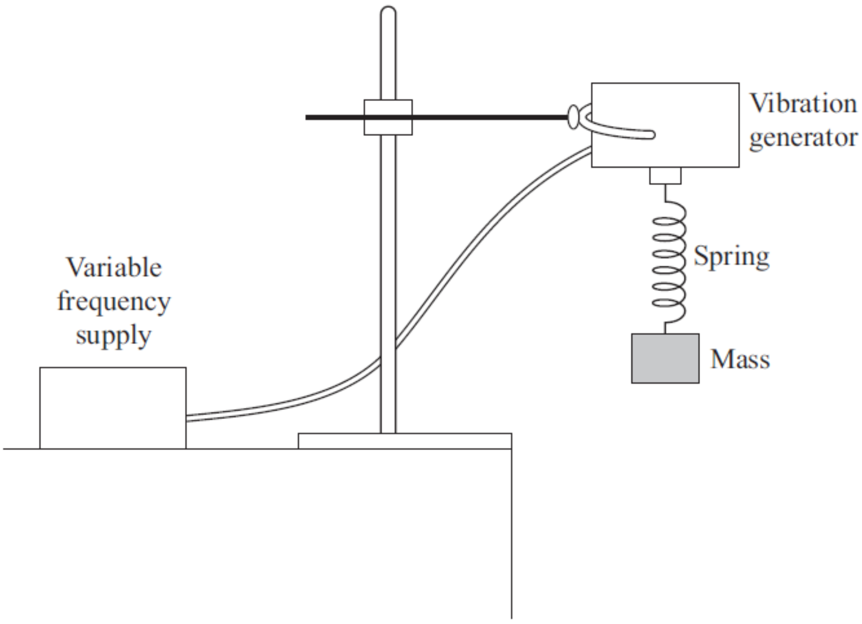
k = ...

4.

A mass is hung on a spring as shown in the diagram. When the mass is pulled down and released, it oscillates at the natural frequency of the system.

When the top of the spring is forced to move up and down at this natural frequency, resonance occurs.

The system below is set up to observe what happens to the oscillations of the mass as the frequency *f* of the vibration generator is varied.



(a) State what you would observe as *f* gets close to the resonant frequency.

(1)

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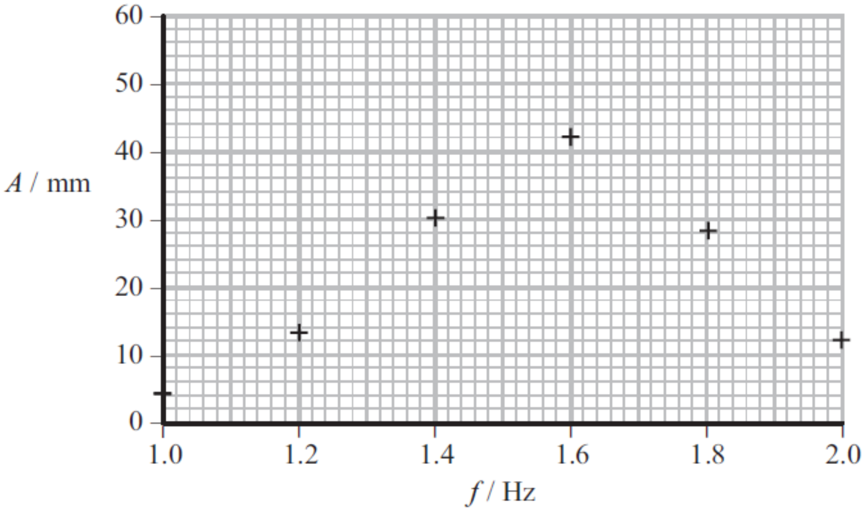
(b) As f is varied, the amplitude of oscillation A of the mass is recorded. The results are shown on the graph.



(i) Use the graph to estimate the resonant frequency.

(1)

Resonant frequency = ... Hz

(ii) Describe how you would improve the experiment to obtain a more accurate value for the resonant frequency.

(2)

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(iii) Suggest why it would be better to use an ultrasound position sensor and data logger to record the position of the mass.

(1)

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5.

A student writes a plan for an experiment to measure the current as a capacitor discharges through a resistor. His aim is to find a value for the time constant for the exponential decay of the current. His outline plan, which includes a circuit diagram, is shown below.

Set up the circuit shown using a multimeter as the ammeter and use a stopwatch with a precision of 0.01 s.

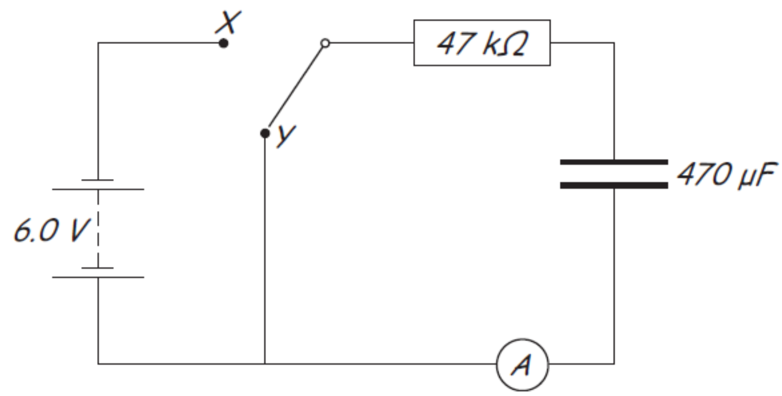
Set the switch to position X.

Move the switch to position Y and record the current at regular time intervals.

The current decays according to the equation

$$I = I_0 e^{-t/RC} \text{ where } RC \text{ is the time constant}$$

Plot the measurements on a graph to find a value for the time constant.



Suggest improvements to the plan that would allow the student to carry out the experiment successfully.

Your improvements should include:

(a) the initial current and the range he should set on the multimeter, **(2)**

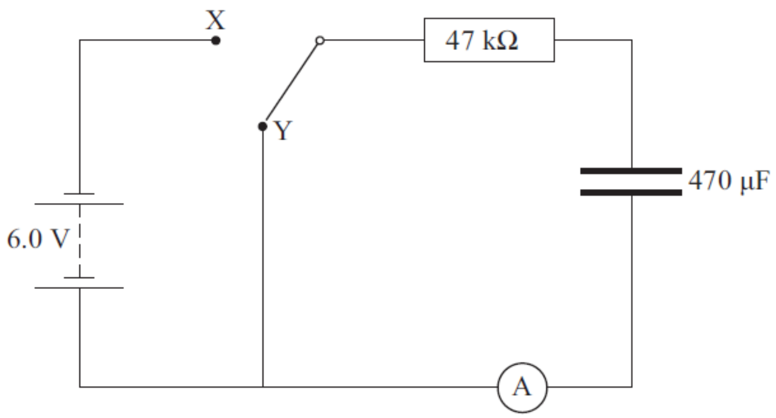
(b) the expected value for the time constant and for how long he should take readings of the current, **(2)**

(c) a reason why this stopwatch is suitable, **(1)**

(d) a technique he should use to ensure his readings are as accurate as possible and one safety precaution that might be necessary, **(2)**

(e) an explanation of why a graph of ln I against t would give a straight line and how he should find a value for the time constant from the graph. **(2)**

(f) A teacher suggests that with this circuit it would be necessary to wait for some time before switching from position X to position Y.



(i) Comment on why this wait is necessary.

(1)

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(ii) Draw below a different arrangement of the circuit components so that there is no time delay.

(1)

6.

The acceleration – time graph for a firework rocket from launch is as shown in Fig. 1.1. The rocket is a plain one with no exploding stars high in the sky. The rocket leaves the ground at time $t = 0$ and the remains of the rocket reach the ground at time $t = 6.0$ s.

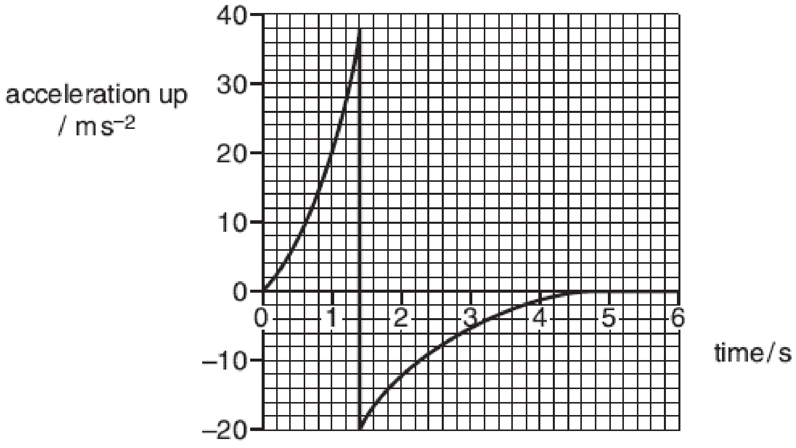

Fig. 1.1

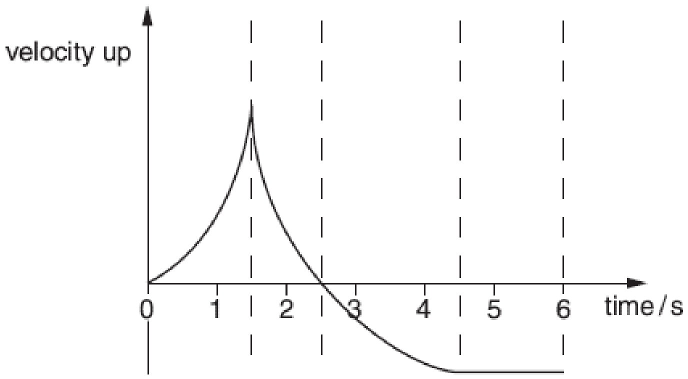

Fig. 1.2

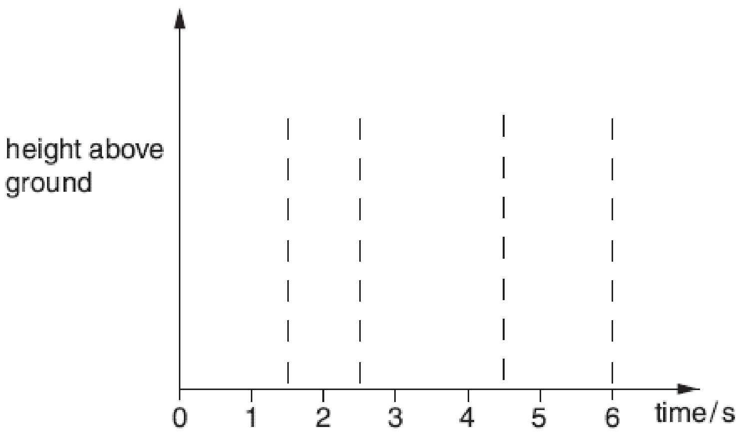

Fig. 1.3

(a) (i) Mark with an **A** on Fig. 1.1 the point at which the acceleration has its maximum value. [1]

(ii) During the first 1.4 s the accelerating force is constant yet the rocket's acceleration increases. Explain how this is possible.

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....[2]

(iii) Explain why the acceleration suddenly changes from positive to negative.

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....[2]

(iv) State the **two** forces acting downwards which cause the negative acceleration of magnitude $20\,\mathrm{m\,s^{-2}}$.

1. .... 2. ....[1]

(b) The corresponding velocity-time sketch graph is shown in Fig. 1.2.

(i) Mark on the sketch graph

1. a point **P** at which the rocket reaches maximum height
2. a region **R** where the remains of the rocket travel with terminal velocity. [2]

(ii) Use the acceleration-time graph, Fig. 1.1, to find an approximate value of the maximum velocity of the rocket.

maximum velocity = ... $\mathrm{m\,s^{-1}}$ [3]

(c) Use the information from Fig. 1.2 to sketch the shape of the height-time graph in Fig. 1.3. [3]