Candidate Name	Centre Number					Candidate Number				

A LEVEL PHYSICS

COMPONENT 2

Electricity and the Universe

SPECIMEN PAPER

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	10	
2.	12	
3.	10	
4.	15	
5.	10	
6.	10	
7.	10	
8.	8	
9.	15	
Total	100	

ADDITIONAL MATERIALS

In addition to this examination paper,
you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.
Answer **all** questions.
Write your name, centre number and candidate number in the spaces at the top of this page.
Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question 2*(a)*(i).

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

*Answer **all** questions.*

1. The current I in a metal conductor of cross-sectional area A is given by:

$$I = nAve$$

(a) State the meanings of n and v. [2]

n : ....

v : ....

(b) (i) A copper wire is 2.0 m long and has a cross-sectional area of 2.0×10^{-6} m^2. Determine the **total** number of free electrons in this wire given that an atom of copper has a mass of 1.05×10^{-25} kg and each atom contributes, on average, 1.5 free electrons.
[Density of copper = 8 920 kg m^{-3}.] [2]

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(ii) Calculate the mean drift velocity of the electrons in the wire when there is a current of 1.2 A. [3]

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(c) The table shows some properties of 3 different wires. Only two of the wires are made from the same material. Determine which wire is made from a different material to the others. [3]

Material	A (m^2)	v ($m\,s^{-1}$)	I (A)
A	1.0×10^{-6}	4.2×10^{-6}	0.04
B	1.5×10^{-6}	1.1×10^{-5}	0.22
C	2.0×10^{-6}	3.6×10^{-5}	0.68

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2. (*a*) (i) An experiment is carried out to determine the resistivity of a metal using variable lengths of the metal in the form of a wire. Explain how the experiment should be carried out and how an accurate value of the resistivity could be obtained from the results. [6 QER]

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(ii) A platinum wire has a cross-sectional area of 3.46×10^{-9} m^2, length 2.30 m and resistance 73.5 Ω. Calculate the resistivity of platinum. [2]

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(*b*) The experiment is repeated using a **thinner** wire made from the **same metal**. All other aspects of the experimental set-up are unchanged. Comment, with justification, on what would happen to the:

- resistance per metre;
- gradient of the graph;
- value of the resistivity of the metal in the wire. [4]

(No calculations are required.)

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3. *(a)* An equation which can be applied to a cell of emf E and internal resistance r is:

$$V = E - Ir$$

(i) What does V represent? [1]

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(ii) What does Ir represent? [1]

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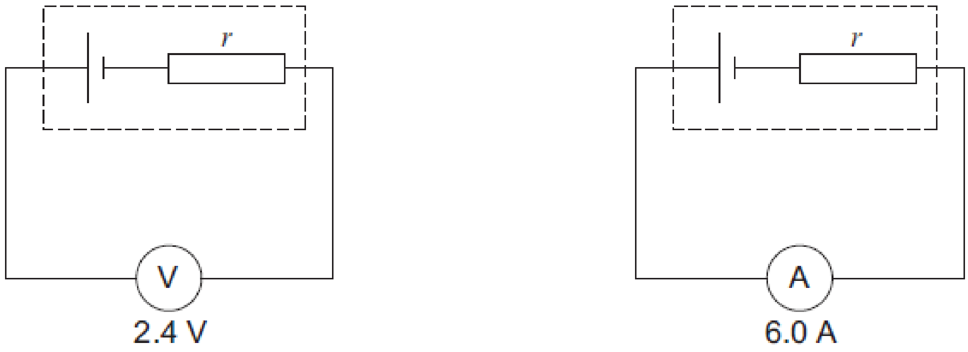
(b) A voltmeter connected across the terminals of a cell reads 2.4 V. An ammeter (whose resistance is zero) reads 6.0 A when connected briefly across the cell.



(i) Write down the emf of the cell. [1]

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(ii) Calculate the internal resistance of the cell. [1]

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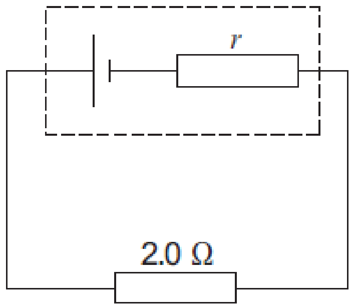
(c) Calculate the current through a 2.0 Ω resistor when it is connected across the cell. [2]



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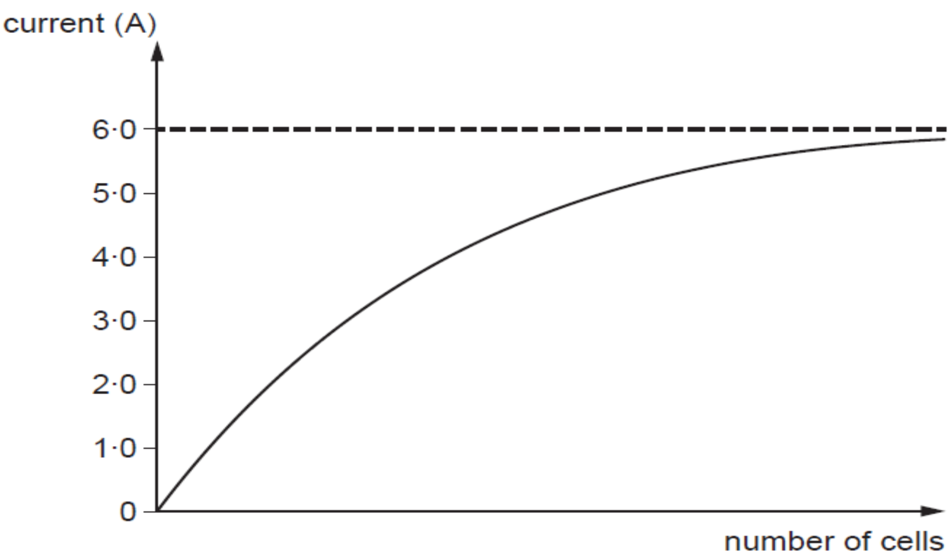
(d) The number of cells in series with the 2.0 Ω resistor is increased and the following graph is obtained. Explain, without further calculation why this variation is to be expected. [4]



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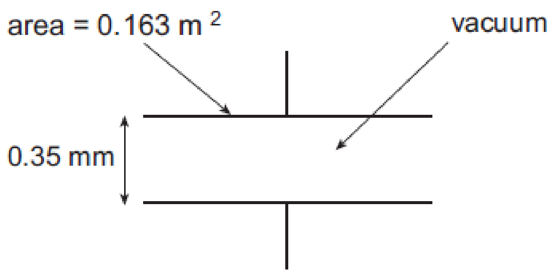
4. *(a)* Calculate the capacitance of the capacitor shown. [2]



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(b) The capacitor is charged so that there is a pd of 1.2 kV across the plates.

Calculate:

(i) the charge stored; [1]

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(ii) the energy stored in the capacitor. [1]

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(c) The capacitor is discharged through a 670 kΩ resistor. Calculate the time the capacitor takes to lose half its charge. [3]

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(d) Explain briefly whether or not the time the capacitor takes to lose half its energy is longer or shorter than your answer to *(c).* [1]

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(e) (i) You are to carry out an experiment to confirm that the charge held on the capacitor in part *(c)* decreases exponentially. Draw a circuit diagram of the apparatus you would use. State what data you would collect and how you would collect it (remembering that the time in part (*c*) was measured in ms). [4]

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(ii) Explain what graph you would plot to confirm that the charge on the capacitor decreases exponentially ($Q = Q_0 e^{-\frac{t}{RC}}$) and explain how you would know if your graph was in good agreement with this theory. [3]

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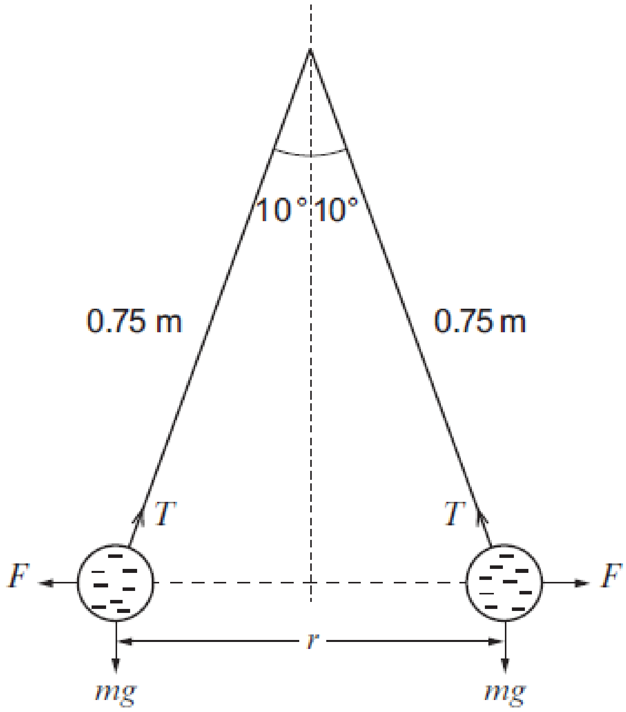
5. Two spherical balloons each of mass 5×10^{-3} kg carry equal numbers of excess electrons distributed uniformly over their surfaces.

When both balloons are hung from the same point by light strings of lengths 0.75 m, each string makes an angle $\theta = 10^{o}$ with the vertical.



The weight, mg of each balloon, the electrostatic forces, F, acting on each balloon and the tensions, T, in the strings are shown in the diagram.

(a) Use the information in the diagram to show that the separation, r, of the centres of the balloons is approximately 0.26 m. [2]

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(b) A student suggests that the set-up may be used to determine the excess charge on each balloon and calculates a value of 2.5×10^{-7} C. Justify whether or not this answer is consistent with the data. [4]

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(c) In practice this experiment requires 3 measurements – a length, a mass and an angle. The uncertainty of the final charge value is approximately 10%. Justify how this uncertainty can be reduced by improving the accuracy of one of these readings especially. [4]

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(d) The separation of the balloons is increased while the charge remains constant and the balloons are then released. Describe briefly the resulting oscillations of the balloons and explain why you would expect this motion. [3]

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6. Information about the Earth, Jupiter and the Sun is given in the table:

	Radius (m)	Mass (kg)	Distance from the Sun (m)	Period of orbit (s)
Earth	6.37×10^6	5.97×10^{24}	1.50×10^{11}	3.16×10^7
Jupiter	6.99×10^7	1.90×10^{27}	7.79×10^{11}	3.74×10^8
Sun	6.96×10^8	1.99×10^{30}	–	-

(a) Determine the following at the position of the Earth:

(i) the gravitational field strength of the Sun; [2]

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(ii) the gravitational potential due to the Sun. [2]

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(b) Determine whether or not these data are in good agreement with Kepler's 3rd law ($r^3 \alpha T^2$). [3]

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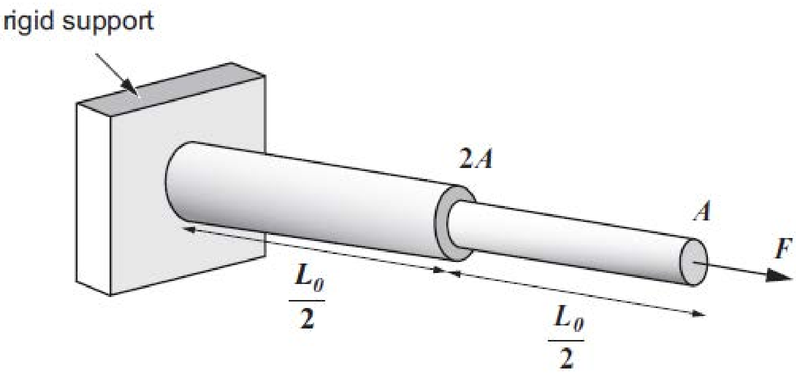
7. The bar in the figure below is made from a single piece of material. It consists of two segments of equal length $\frac{L_0}{2}$ and cross-sectional area A **and** $2A$. *The diagram is not drawn to scale.*



(a) Show that the **total** extension, Δx, of the bar under the action of an applied force, F, as shown in the diagram, can be given by:

$$\Delta x = \frac{3FL_0}{4AE}$$

where E represents the Young modulus of the material in the bar. [3]

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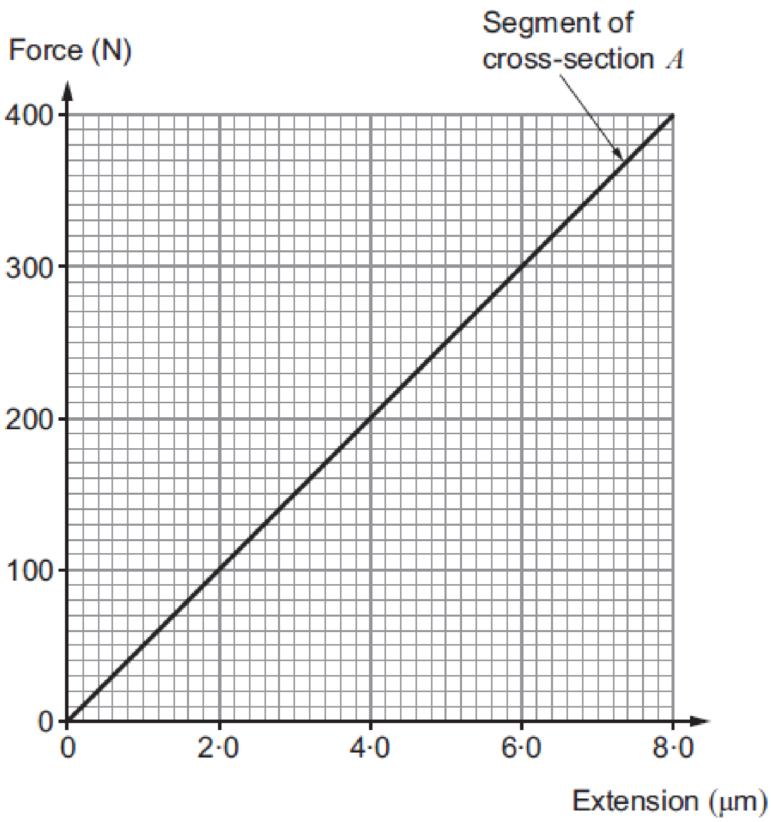
(b)



(i) The graph shows the variation of extension with applied force for the segment of cross-section A. Draw (on the same grid) the expected force-extension graph for the segment of cross-section $2A$. [1]

(ii) Determine the Young modulus of the metal in the bar given that $L_0 = 4.0\,\text{m}$ and $A = 5 \times 10^{-4}\,\text{m}^2$. [3]

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(iii) A mass of 20 kg is hung vertically from the segment of cross-section A. When released the mass performs simple harmonic motion with a very small amplitude. By calculating the gradient of the above graph (or otherwise), determine the period of oscillation of the mass. [3]

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8. *(a)* State what is meant by a black body. [1]

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(b) A table of astronomical data includes the following about the star *Alpha Centauri A*:
Radius = 8.54×10^{8} m, Temperature = 5 790 K, Luminosity = 5.83×10^{26} W.

(i) Justify whether the data above are consistent with the star radiating as a black body. Show your working clearly and give your conclusion. [3]

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(ii) Calculate the wavelength of the star's peak spectral intensity, and sketch the spectrum on the axes provided. [4]

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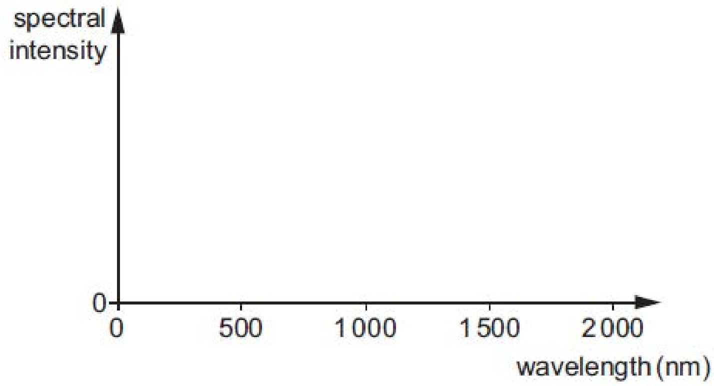

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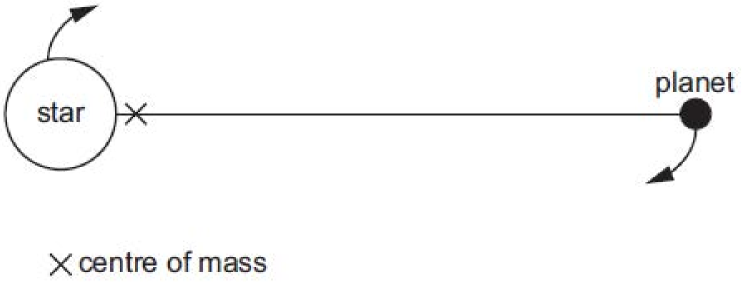
9. (a) A star of mass 2×10^{30} kg has a companion planet. The star and planet orbit a common centre of mass with an orbital period of 1 090 days. The star's orbital speed is 45.5 m s^{-1}. *The diagram is not drawn to scale*.



(i) Determine the radius of the star's orbit. [3]

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(ii) Estimate the distance from the planet to the star, specifying clearly any assumptions made. [3]

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(iii) Hence determine the mass of the planet. [2]

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(b) Edwin Hubble's original data from 1929 is shown in Figure 1.

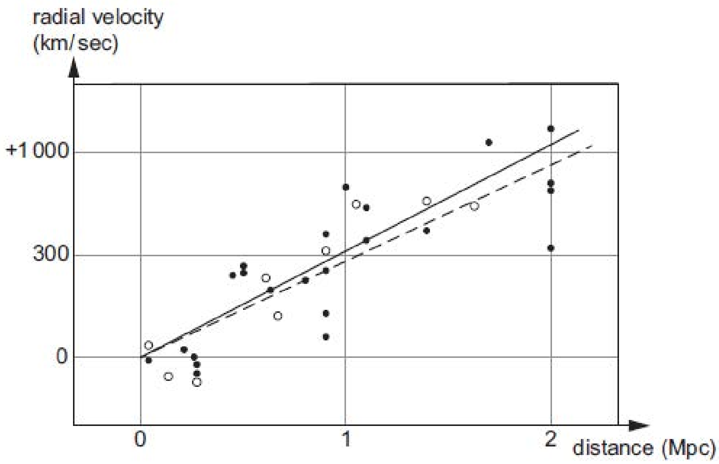

Figure 1

Figure 2 is an improved graph of radial velocity against distance based on more recent measurements.

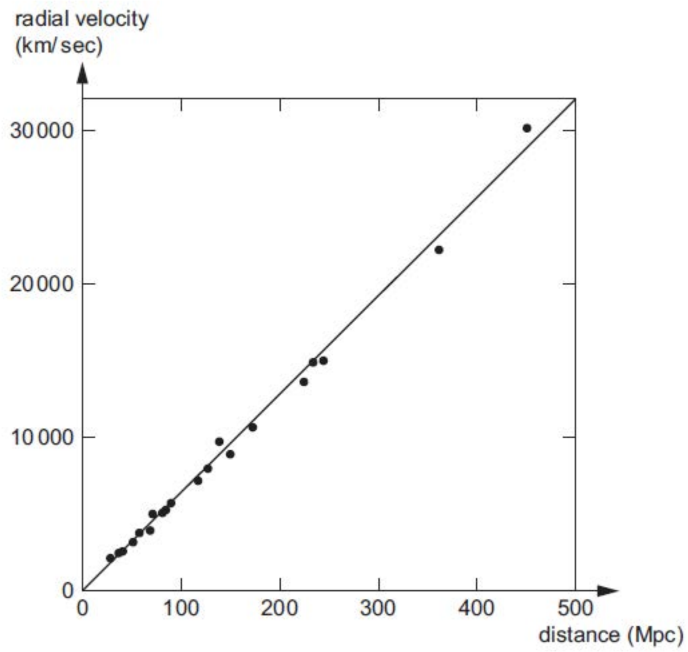

Figure 2

(i) The scientific community had less confidence in Hubble's law in 1929 than it currently has. Use Figure 1 and Figure 2 to justify this statement. [3]

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(ii) Use Figure 2 to calculate Hubble's constant in the unit km s^{-1} Mpc^{-1}. [2]

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(iii) Calculate the age of the universe in years given that a Mpc is 3.09×10^{22} m. [2]

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