Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

A420U20-1

S19-A420U20-1

PHYSICS – A level component 2
Electricity and the Universe

FRIDAY, 24 MAY 2019 – MORNING

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**17**	
3.	**15**	
4.	**9**	
5.	**14**	
6.	**11**	
7.	**9**	
8.	**12**	
Total	**100**	

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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.

Write your answers in the spaces provided in this booklet. If you run out of space use the continuation page at the back of the booklet taking care to number the question(s) correctly.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

INFORMATION FOR CANDIDATES

The total number of marks is given in brackets at the end of each question or part-question.

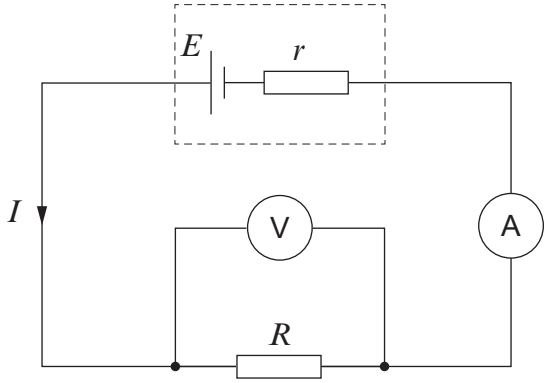
The assessment of the quality of extended response (QER) will take place in **Q4***(a)*.

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Answer **all** *questions.*

1. The following circuit shows a cell of emf, E, and internal resistance, r, connected to a resistor of resistance, R.



(a) An equation which can be applied to the above circuit is:

$$V = E - Ir$$

Explain this equation in terms of energy. [4]

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(b) Two students, Kiera and Tom, set up a circuit using two identical cells in series, each with an emf of 1.5 V, to power a small heating coil. The heating coil dissipates power at the rate of 1 050 mW and the pd across the coil is 2.5 V.

Calculate:

(i) the internal resistance of each cell; [3]

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(ii) the energy dissipated in each cell in **one minute**. [2]

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(c) The students note that the cells get hot when the heater is switched on for long periods. Tom believes that adding an identical heating coil in parallel with the original would halve the energy dissipated in each cell. Kiera disagrees. She believes that the energy dissipated would increase by a factor of 3 if a coil is added in parallel. Investigate whether Kiera or Tom or neither of them is correct. [4]

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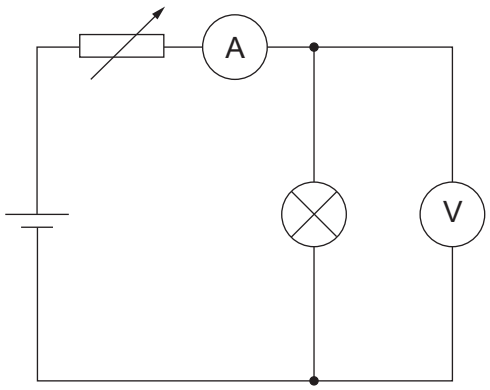
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Turn over.

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2. Jasmine uses the following circuit to investigate how the resistance, R, of a filament lamp varies with the potential difference, V, across it.



(a) Jasmine obtains a range of values for V and I. Describe **briefly** how she does this. [1]

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(b) The relationship between R and V can be expressed as:

$$R = kV^n$$

where k and n are unknown constants. By taking logs of both sides of the equation, show how it can be written in the form $y = mx + c$. [2]

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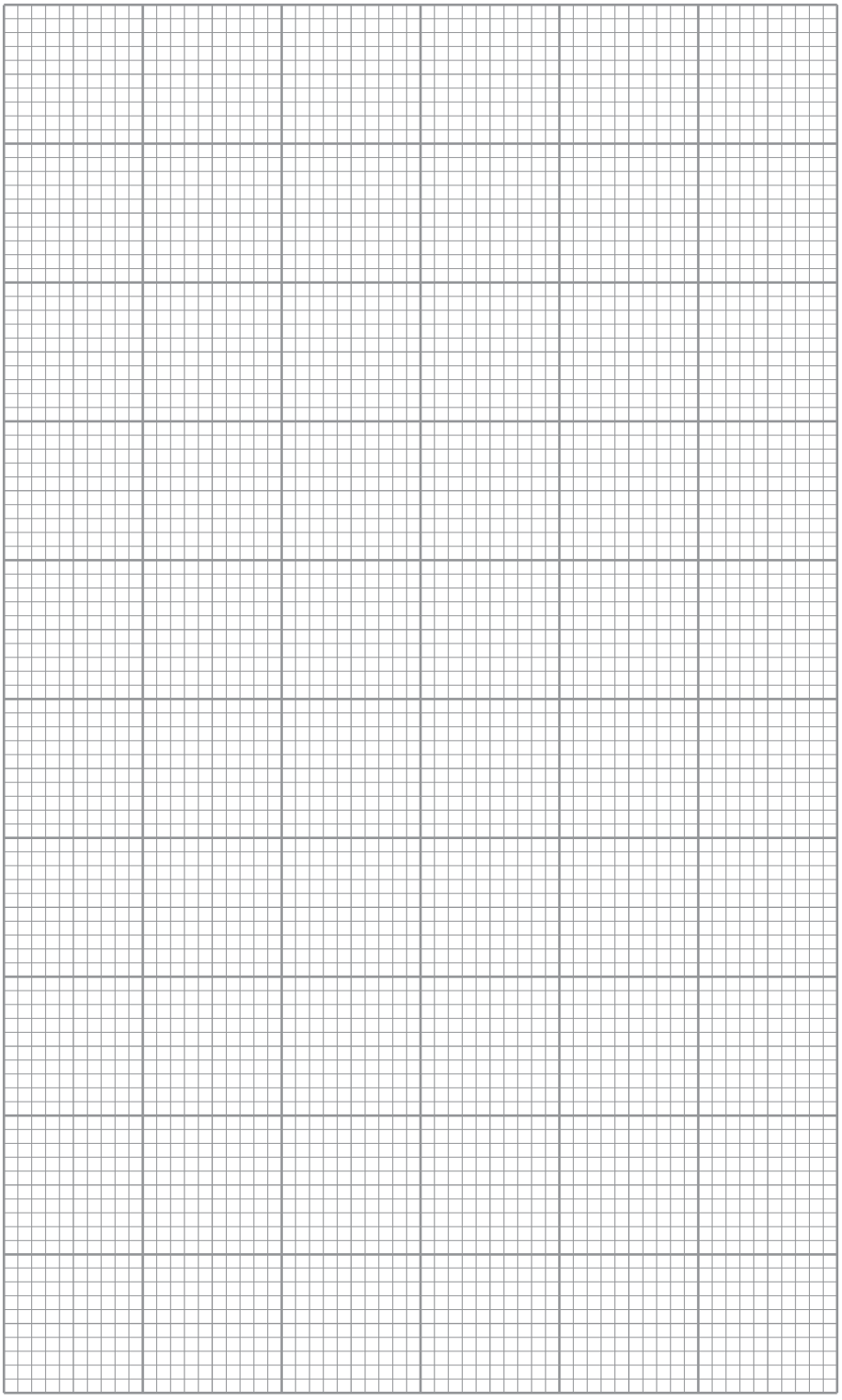
(c) Jasmine records the following data. Complete the table using an appropriate number of significant figures. [3]

V / V	I / A	R / Ω	log(V / V)	log(R / Ω)
1.00	0.52			
2.00	0.72			
4.00	0.98			
6.00	1.20			
8.00	1.40			
10.00	1.54			

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(d) Draw a graph of log R (vertical axis) against log V (horizontal axis) and draw a line of best fit. Error bars are **not** required. [5]



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(e) (i) Use your graph to determine suitable values for k and n. [4]

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(ii) Hence, write down an equation showing the relationship between R and V for this filament lamp. [1]

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(f) Comment on the quality of Jasmine's results. [1]

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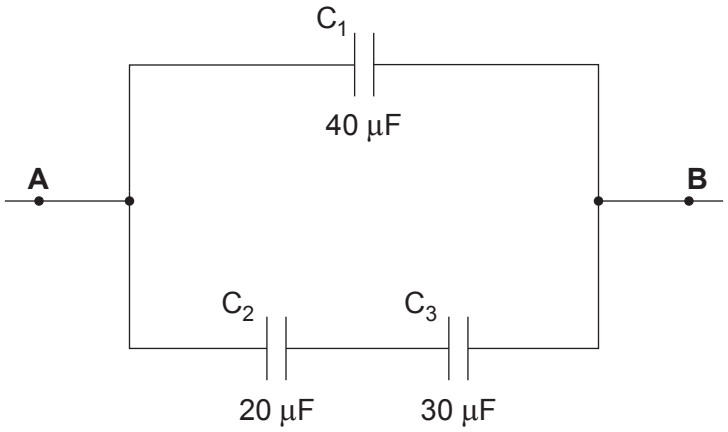
3. *(a)* Two parallel plate capacitors, X and Y, have equal plate areas. The capacitance of X is greater than the capacitance of Y. Suggest **two** possible reasons for the difference. [2]

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(b) The diagram shows an arrangement of 3 capacitors.



(i) Calculate the total capacitance of this combination of capacitors. [3]

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(ii) Explain why:

pd across C_2 = 1.5 × pd across C_3. [2]

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(iii) Hence, calculate the pd across C_3 given that 100 V is applied between A and B. [1]

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(iv) Explain which of the three capacitors stores the greatest charge, and calculate the size of this charge. [2]

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(c) A 1.6 mF capacitor is charged from a 300 V d.c supply. Engineers wish to use the energy stored in this capacitor to heat a small coil embedded in a thermally insulated block of aluminium of mass 0.10 kg. It is required that the heating process be at least 80% efficient. Experiments show that when the capacitor is discharged through the coil, the temperature of the block increases by 0.60 K.

Determine whether this method of heating meets the efficiency specified.
[Specific heat capacity of aluminium, c = 910 J kg^{-1} K^{-1}]. [5]

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4. *(a)* **Describe** how the resistance of a metal varies between 0 K and 1 000 K.
[Assume that the metal is superconducting below a certain temperature.]
Account for this variation in resistance at higher temperatures. [6 QER]

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(b) Superconductors are used in MRI scanners and particle accelerators. Consider which of these two applications has been of greater benefit to society. [3]

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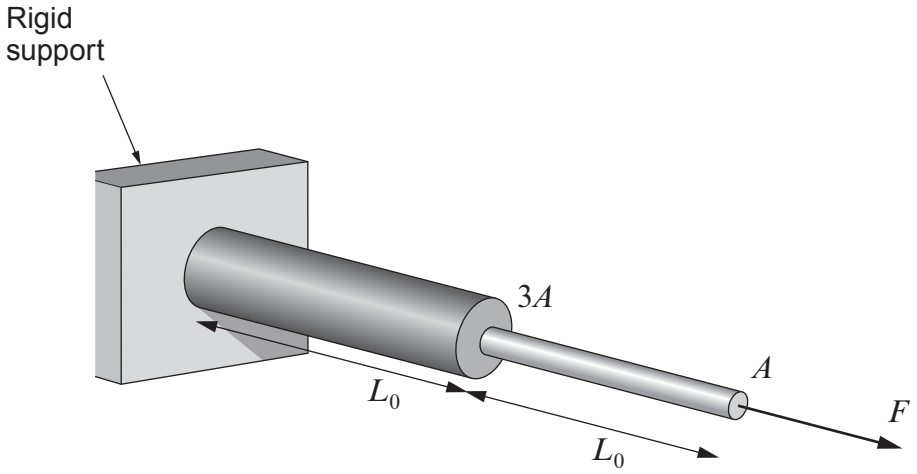
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5. *(a)* The bar in the figure below is made from a **single piece of metal**. It consists of two parts of equal length L_0 and cross-sectional area A and $3A$. The diagram is not drawn to scale.



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

$$\Delta x_{\text{total}} = \frac{4FL_0}{3AE}$$

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

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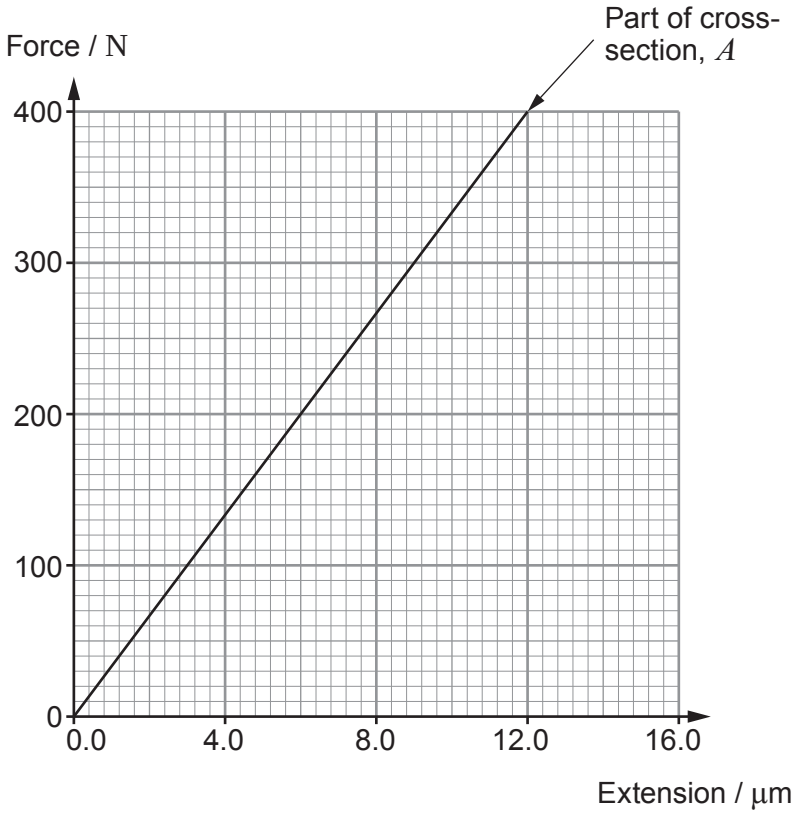
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(ii) The graph shows the variation of extension with applied force for the part of cross-section, A. **Draw** (on the same grid) the expected force-extension graph for the segment of cross-section $3A$. [1]



(iii) Determine the Young modulus of the metal in the bar given that L_0 = 1.2 m and $A = 2.0 \times 10^{-4}\,m^2$. [3]

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(iv) Calculate the elastic potential energy stored in the whole bar when F = 400 N. [2]

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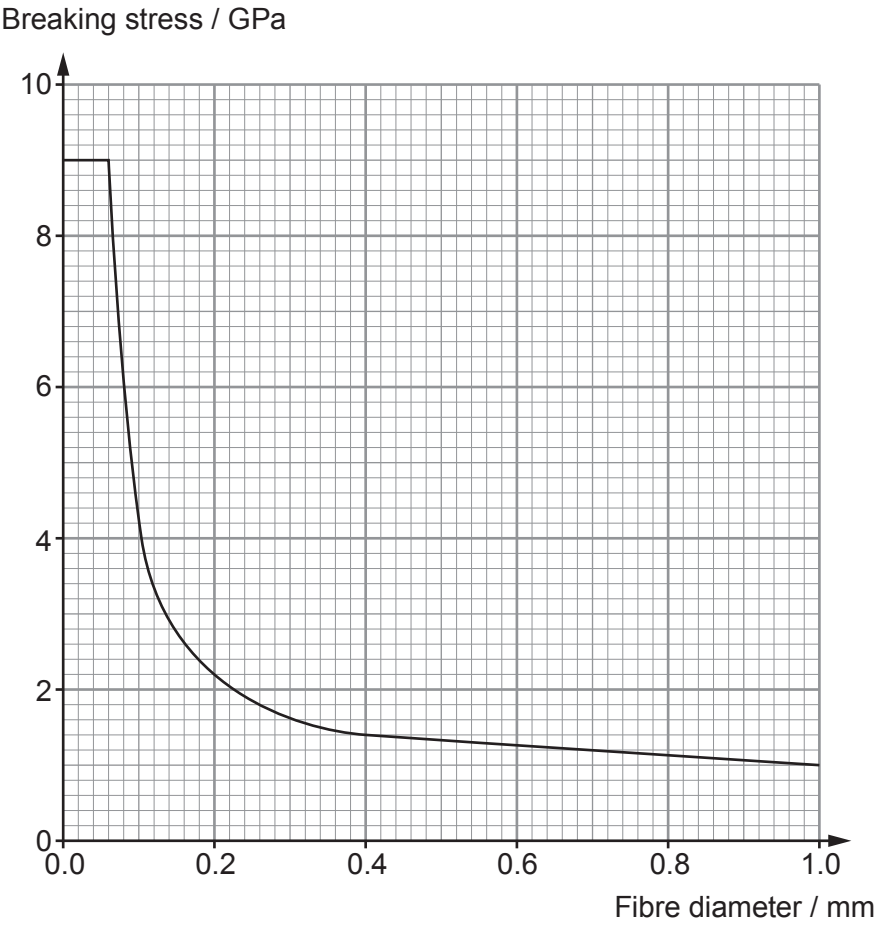
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(b) Glass is a brittle material. The graph shows how the breaking stress of glass, in the form of thin fibres and rods, varies with the diameter of the fibre.



(i) Use the graph to estimate the greatest mass which can be hung from a glass fibre of diameter 0.2 mm. [3]

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(ii) Explain the term *brittle fracture* as it applies to glass and give a reason why very thin fibres have a greater breaking stress than thicker ones. [2]

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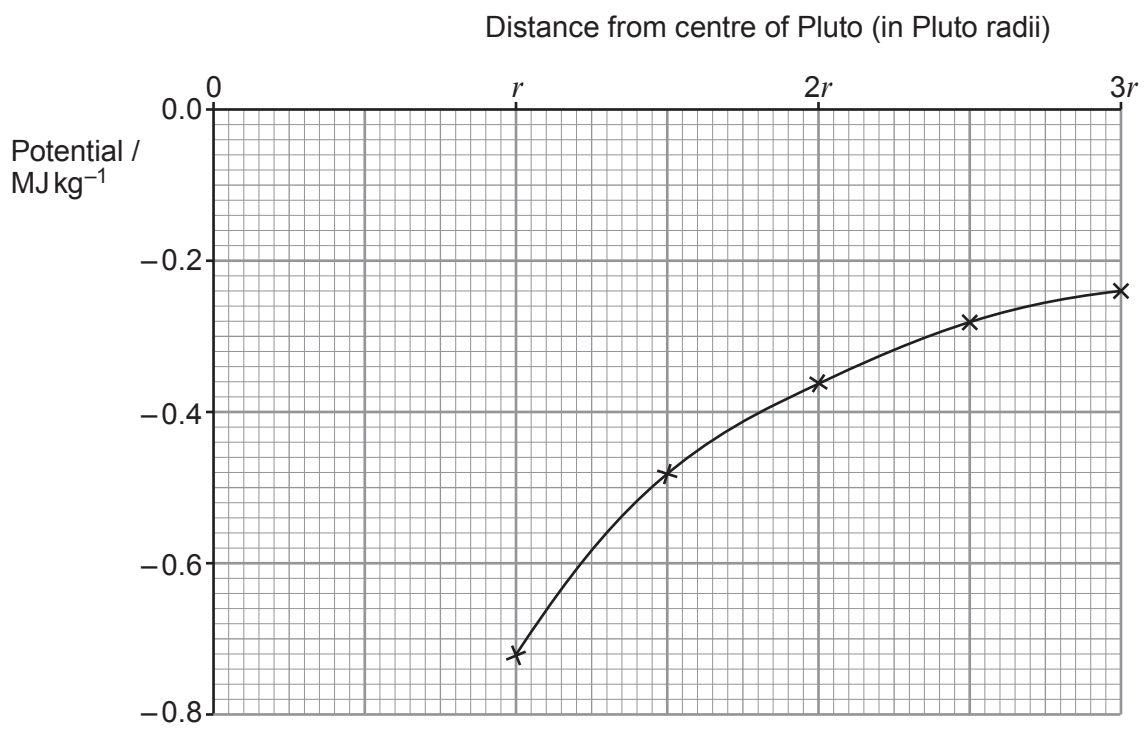
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6. The variation in gravitational potential near Pluto is shown by the graph.



(a) Assuming that the potential at the surface is correct, confirm that the potential at $3r$ is plotted correctly. [2]

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(b) (i) Calculate the gravitational potential energy of a spacecraft of mass 600 kg at rest on the surface. [2]

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(ii) 'Escape velocity' is defined as the minimum velocity required for a body to escape from the gravitational influence of a massive body. Calculate the 'escape velocity' of the spacecraft. [3]

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(c) The radius of Pluto is 1.18×10^6 m and the gravitational field strength at the surface is $0.62\,\text{N kg}^{-1}$. Using this information and by **drawing a suitable tangent** show that the gravitational field strength at $2r$ agrees with the theoretical value given by:

$$g \propto \frac{1}{r^2}$$ [4]

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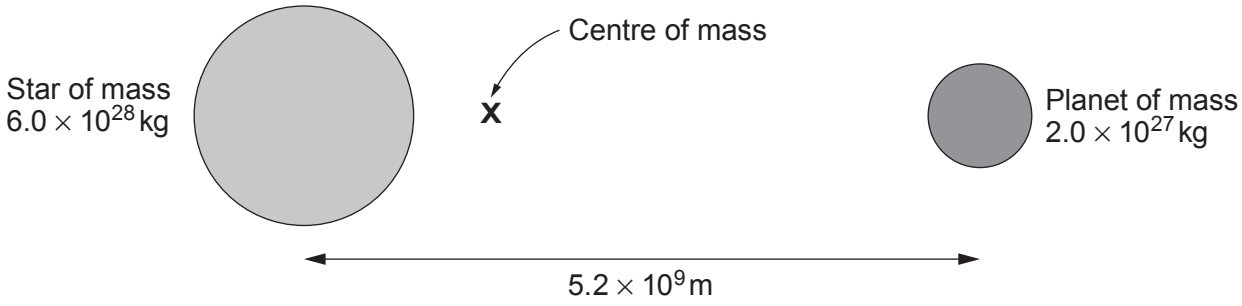
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7. A star and a planet orbit their mutual centre of mass as shown. The diagram is not to scale.



(a) (i) Calculate the period of orbit. [2]

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(ii) Calculate the distance of the centre of mass from the centre of the star. [2]

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(b) The centre of mass of this star-planet system is at rest relative to the Earth and the system is viewed 'edge-on'. When analysing light of wavelength 656.3 nm from the star, astronomers measure a maximum red shift of 2.0 pm. Determine whether this shift is (approximately) consistent with your answers to *(a)*(i) and (ii). [4]

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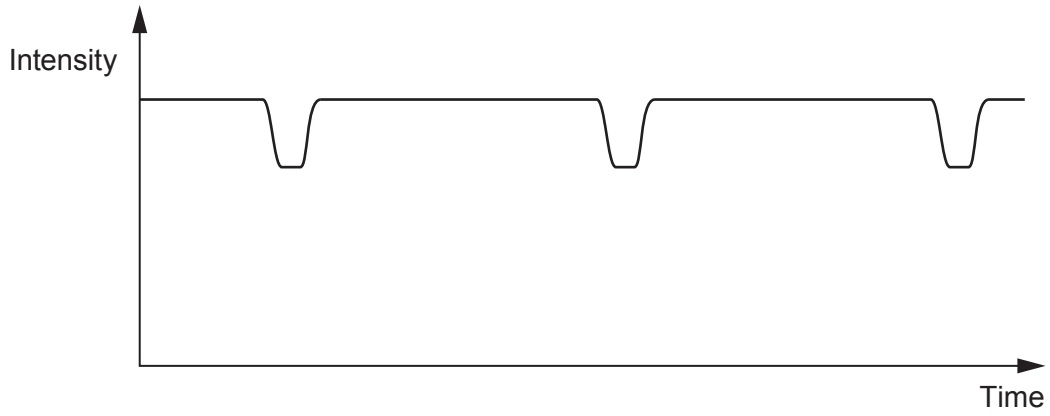
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(c) Astronomers note a periodic dip in the brightness of the star as shown in the sketch graph.



Explain this observation. [1]

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8. *(a)* State **one** similarity and **one** difference between gravitational and electric fields. [2]

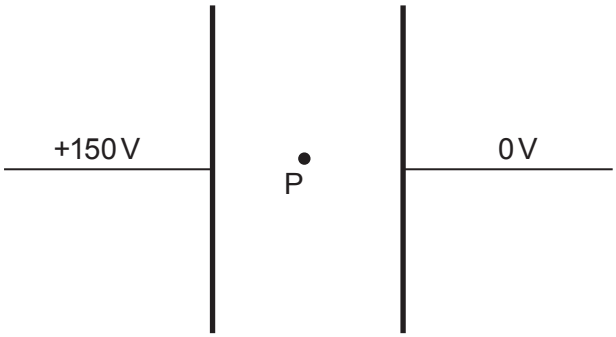
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(b) Two parallel vertical metal plates are placed 5.0 cm apart in a vacuum as shown. A pd of 150 V is placed across the plates and a small sphere of mass 9.6×10^{-15} kg carrying a charge of -2.4×10^{-17} C is placed at point P. A side-on view of the arrangement is shown.



(i) Show that the two forces acting on the sphere are approximately 9×10^{-14} N vertically and 7×10^{-14} N horizontally. [3]

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(ii) Draw, in the space below, a free body diagram for the sphere, showing the magnitude and direction of the two forces acting on it. Determine the direction with which the sphere will move away from P and include this on your diagram. [3]

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(c) Calculate the time taken for the sphere to travel a distance of 2.0 cm. [4]

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