Antonine Education

A2 Physics

Test on Fields

Examination Time – 70 minutes

Name	

Put your name on the paper. No name, no mark

Answer all the questions on the paper.

You should show all your working.

You will have a data sheet with all the constants and formulae you need.

You are expected to use a calculator where appropriate

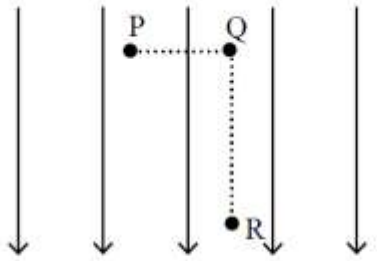
You are reminded of the need for good English and clear presentation.

In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

Turn over

Section A

1. Jun 2009 PA04A Q10



The diagram shows a uniform electric field of strength $10\,V\,m^{-1}$.

A charge of $4.0\,\mu C$ is moved from P to Q and then from Q to R. If the distance PQ is 2.0 m and QR is 3.0 m, what is the change in potential energy of the charge when it is moved from P to R?

A $40\,\mu J$
B $50\,\mu J$
C $120\,\mu J$
D $200\,\mu J$

2. Jan 2009 PA04A Q8

The gravitational field strength at the surface of the Earth, of radius R, is g and the weight of an object on the surface is W. The object is now taken to a distance of $3R$ from the centre of the Earth. Which line, **A** to **D**, in the table gives the weight of the object and the gravitational field strength at this distance?

	weight	**gravitational field strength**
A	$\frac{W}{9}$	$\frac{g}{9}$
B	$\frac{W}{9}$	$\frac{g}{3}$
C	$\frac{W}{4}$	$\frac{g}{4}$
D	$\frac{W}{3}$	$\frac{g}{3}$

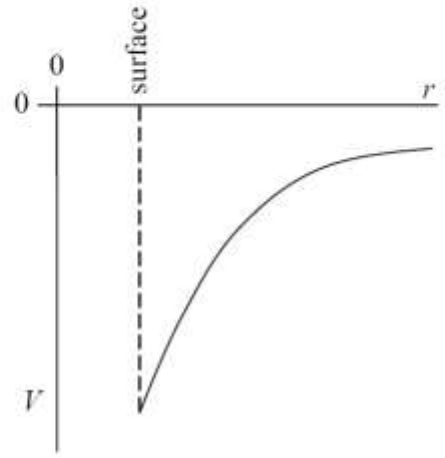
3. Jan 2009 PA04A Q9

Which one of the following is a quantity that can be resolved into different directions?

A electrical potential
B gravitational potential
C electric field strength
D induced emf

4. Jan 2009 PA04A Q10

The graph shows how the gravitational potential, V, varies with the distance, r, from the centre of the Earth.



What does the gradient of the graph at any point represent?

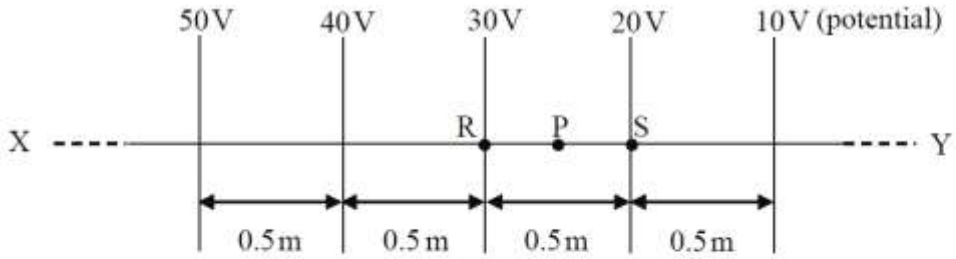
A the mass of the Earth
B the magnitude of the gravitational constant
C the magnitude of the gravitational field strength at that point
D the potential energy at the point where the gradient is measured

5. Jan 2009 PA04A Q11

A positive ion, with a charge/mass ratio of $2.40 \times 10^{7}\,C\,kg^{-1}$, is stationary in a vertical electric field. Which line, **A** to **D**, in the table shows correctly both the strength and the direction of the electric field?

	electric field strength /V m^{-1}	**direction**
A	4.09×10^{-7}	upwards
B	4.09×10^{-7}	downwards
C	2.45×10^{6}	upwards
D	2.45×10^{6}	downwards

6. Jan 2009 PA04A Q12



The diagram shows how the electric potential varies along a line XY in an electric field. What will be the electric field strength at a point P on XY, which is mid-way between R and S?

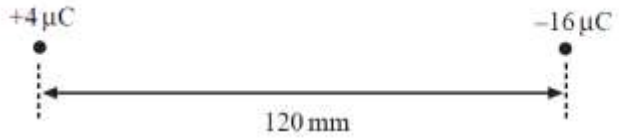
A $5.0\,V\,m^{-1}$
B $10\,V\,m^{-1}$
C $20\,V\,m^{-1}$
D $30\,V\,m^{-1}$

7. Jan 2008 PA04A Q12

When two point charges, each $+Q$, are distance r apart, the force between them is F. What is the force between point charges of $+Q$ and $+2Q$ when they are distance $\frac{r}{2}$ apart?

A F
B $2F$
C $8F$
D $16F$

8. Jun 2005 PA04A q11



The diagram shows two charges, +4 μC and −16 μC, 120 mm apart. What is the distance from the +4 μC charge to the point between the two charges, where the resultant electric potential is zero?

A 24 mm
B 40 mm
C 80 mm
D 96 mm

9. Jun 2005 PA04AQ12

An electron travelling at constant speed enters a uniform electric field at right angles to the field. While the electron is in the field it accelerates in a direction which is

A in the same direction as the electric field.
B in the opposite direction to the electric field.
C in the same direction as the motion of the electron.
D in the opposite direction to the motion of the electron.

10. Jun 2005 PA05A Q7

The Earth has density ρ and radius R. The gravitational field strength at the surface is g. What is the gravitational field strength at the surface of a planet of density 2ρ and radius $2R$?

A g
B $2g$
C $4g$
D $16g$

Total for Section A = 10 marks

Section B

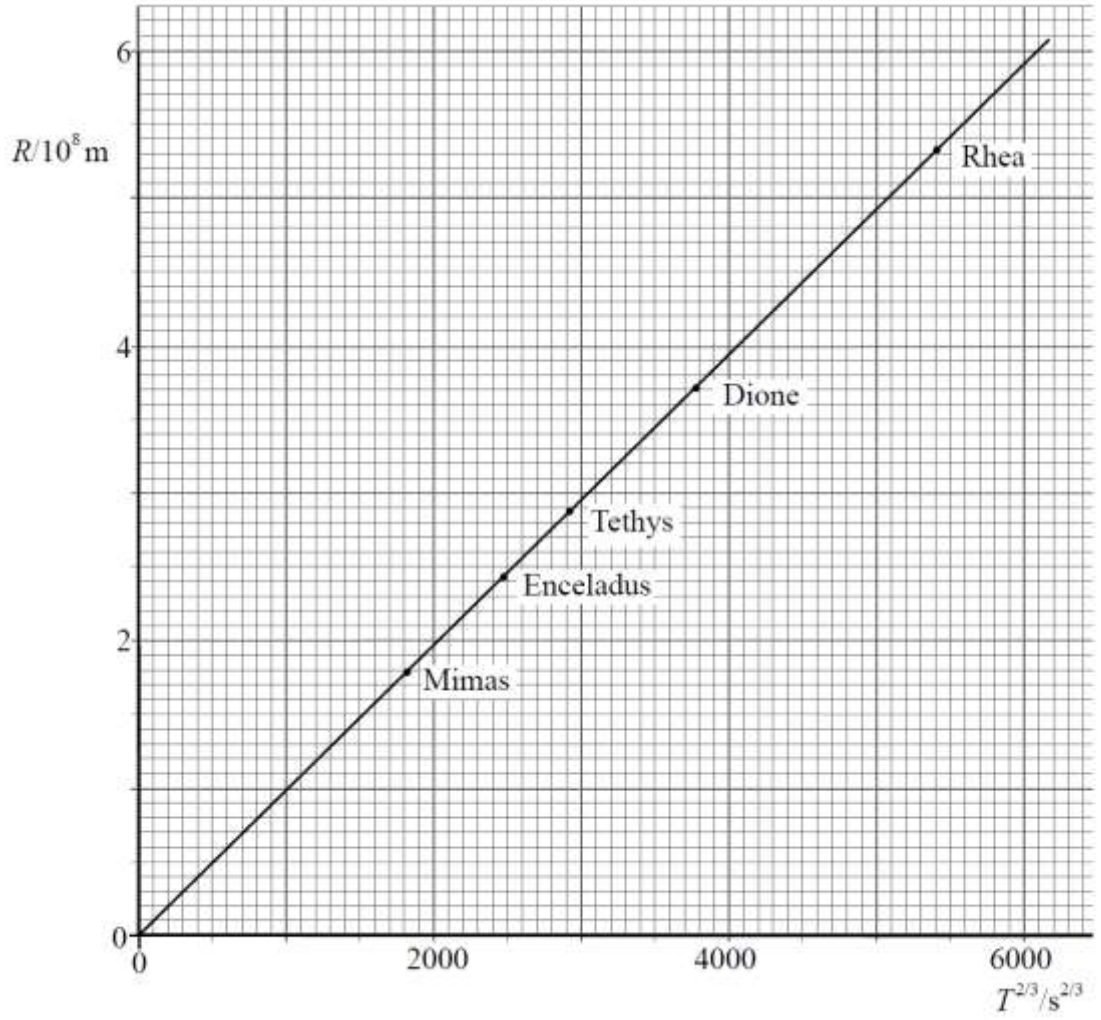
1. Jun 2009 PA04B Q3

(a) For a satellite in orbit around a planet, theory shows that the relationship between the mean orbital radius, R, and the orbital period, T, is

$$R^3 = \frac{GMT^2}{4\pi^2}$$, where M is the mass of the planet.

The graph in **Figure 3**, which is constructed from measurements based on observations shows how R varies with $T^{2/3}$ for five of the inner satellites of the planet Saturn, named Mimas, Enceladus, Tethys, Dione and Rhea.

Figure 3



(a) (i) Determine the gradient of the graph in **Figure 3** in $m s^{-2/3}$.

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(a) (ii) Explain how the relationship between R and T in the equation given in part (a) is supported by this graph.

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(a) (iii) Use your value for the gradient, together with any other necessary data, to calculate the mass of Saturn.

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(6 marks)

(b) It is possible to plot a graph of R against $T^{2/3}$ for the orbits of the planets around the Sun.

State and explain **one** similarity, and **one** difference, between the properties of this graph and the graph shown in **Figure 3**.

Similarity:.....

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Difference:.....

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(2 marks)

8 marks

Turn over

2. Jun 2009 PA04B Q4

(a) (i) With the aid of a diagram, describe the electric field around an isolated point negative charge (shown below as $-Q$).

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(a) (ii) Draw a dashed line (- - - - - - - - - - - -) on your diagram, along which a small charge could be moved without changing its potential energy. Label this line **L**.

(4 marks)

(b) (i) Point P is 40 mm from a point charge of –0.80 nC.

Calculate the magnitude of the electric field strength at P.

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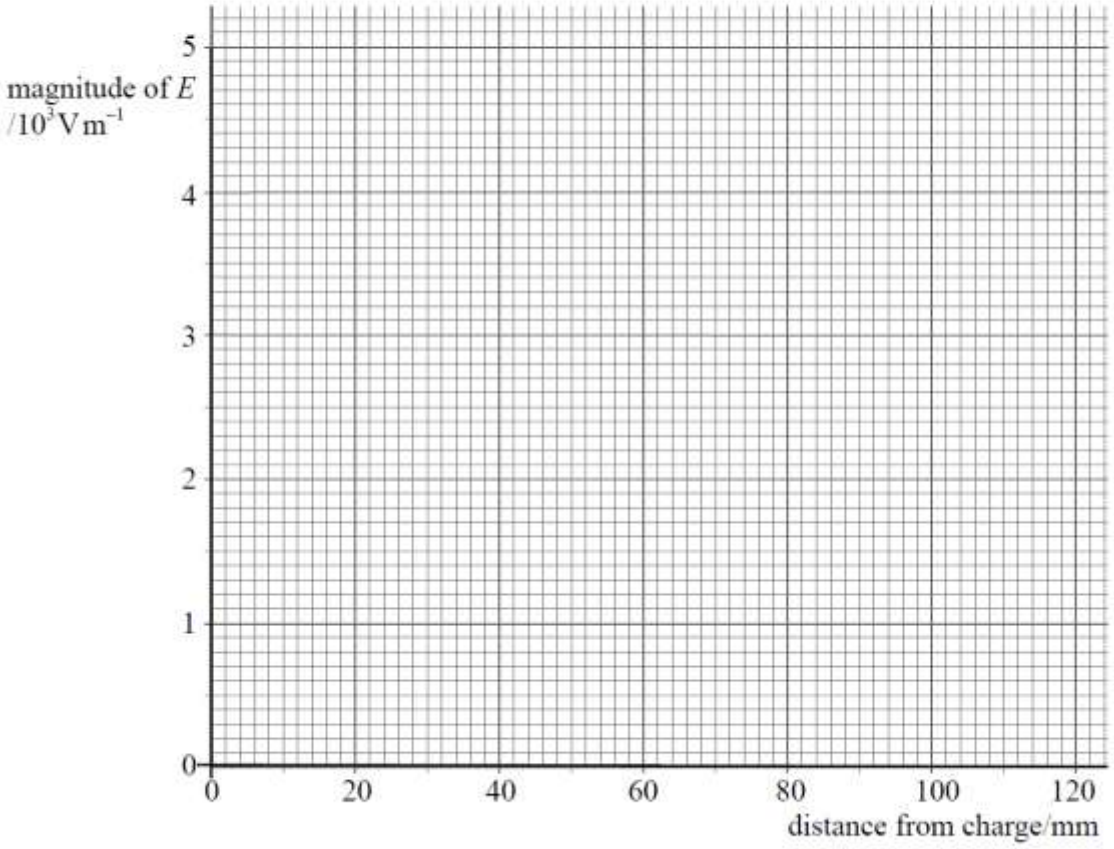
(b) (ii) Insert your value for the electric field strength at P, from part (b)(i), on **Figure 4**. Then complete, as accurately as you can, a graph on **Figure 4** to show how the magnitude of the electric field strength varies with distance, for points which are at distances greater than 40 mm from the −0.80 nC charge.

Figure 4



(5 marks)

9 marks

3. (**Jan 2005 PA04 Q3**)

(a) Explain what is meant by the *gravitational potential* at a point in a gravitational field.

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(2 marks)

(b) Use the following data to calculate the gravitational potential at the surface of the Moon.

mass of Earth = 81 × mass of Moon
radius of Earth = 3.7 × radius of Moon
gravitational potential at surface of the Earth = –63 M Jkg^{-1}

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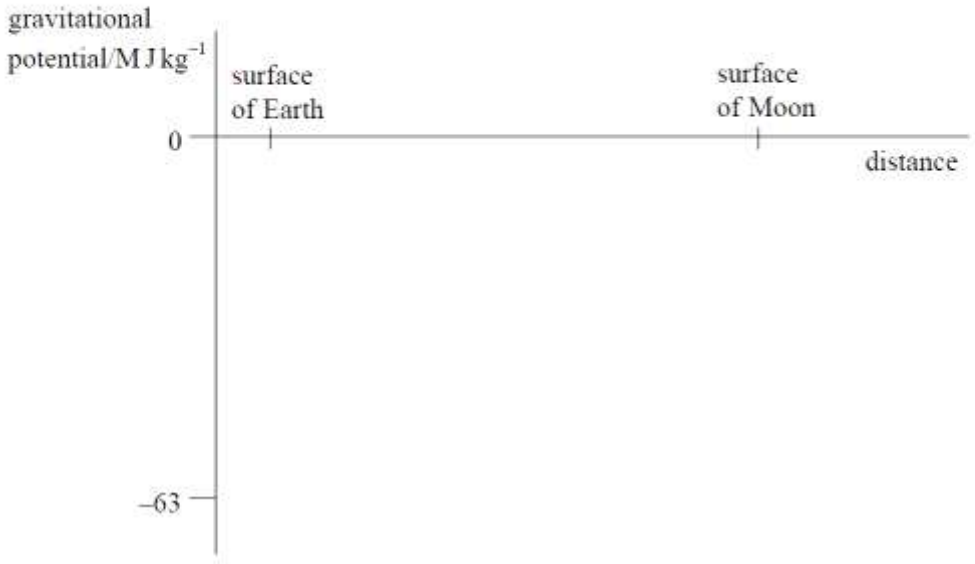
(3 marks)

(c) Sketch a graph on the axes below to indicate how the gravitational potential varies with distance along a line outwards from the surface of the Earth to the surface of the Moon.



(3 marks)

8 marks

4. (**Jan 2005 PA10 Q4**)

A dish on a communications satellite is used to transmit a beam of microwaves of wavelength λ. The beam spreads with an angular width λ/d, in radians, where d is the diameter of the dish.

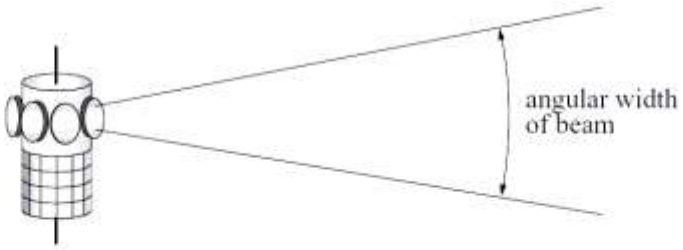


Figure 2

(a) (i) Calculate the angular width, in degrees, of a beam of frequency 1200 MHz transmitted using a dish of diameter 1.8 m.

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(ii) Show that the beam has a width of 2100 km at a distance of 15 000 km from the satellite.

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(4 marks)

(b) (i) Show that the speed, v, of a satellite in a circular orbit at height h above the Earth is given by

$$v = \sqrt{\frac{GM}{(R + h)}}$$

where R is the radius of the Earth and M is the mass of the Earth.

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(ii) Calculate the speed and the time period of a satellite at a height of 15 000 km in a circular orbit about the Earth.

mass of the Earth = 6.00×10^{24} kg
radius of the Earth = 6.40×10^{6} m

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(iii) The satellite passes directly over a stationary receiver at the North Pole. Show that the beam moves at a speed of 1.3 km s^{-1} across the Earth's surface and that the receiver can remain in contact with the satellite for no more than 27 minutes each orbit.

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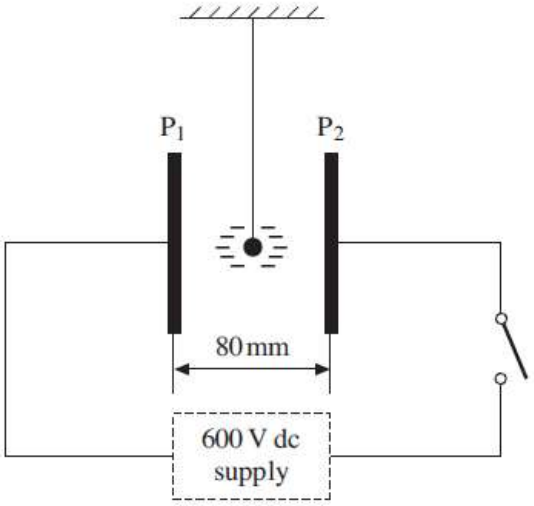
(9 marks)

13 marks

5. (**Jan 2011 PHY4 B Q4**)

4 **Figure 3** shows a small polystyrene ball which is suspended between two vertical metal plates, $\mathbf{P_1}$ and $\mathbf{P_2}$, 80 mm apart, that are initially uncharged. The ball carries a charge of –0.17 μC.

Figure 3



4 (a) (i) A pd of 600 V is applied between $\mathbf{P_1}$ and $\mathbf{P_2}$ when the switch is closed. Calculate the magnitude of the electric field strength between the plates, assuming it is uniform.

answer = ...V m^{-1}

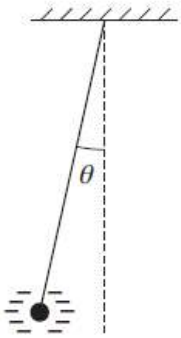
(2 marks)

4 (a) (ii) Show that the magnitude of the electrostatic force that acts on the ball under these conditions is 1.3 mN.

(1 mark)

4 (b) Because of the electrostatic force acting on it, the ball is displaced from its original position. It comes to rest when the suspended thread makes an angle θ with the vertical, as shown in **Figure 4**.

Figure 4



4 (b) (i) On **Figure 4**, mark and label the forces that act on the ball when in this position.

(2 marks)

4 (b) (ii) The mass of the ball is 4.8×10^{-4} kg. By considering the equilibrium of the ball, determine the value of θ.

answer = ...degrees

(3 marks)

8 marks

Total = 55 marks