Rewarding Learning

ADVANCED
General Certificate of Education
2015

Centre Number

Candidate Number

Physics

Assessment Unit A2 2
assessing
Fields and their Applications

MV18

[AY221]

THURSDAY 4 JUNE, AFTERNOON

TIME

1 hour 30 minutes, plus your additional time allowance.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **3**.
Figures in brackets printed at the end of each question indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.
Question 8 contributes to the synoptic assessment required of the specification. Candidates should allow approximately 15 minutes to complete this question, this may vary depending on your additional time allowance.

1 (a) The planet Mars has a mean radius of 3.39×10^6 m and a mass of 6.42×10^{23} kg. Calculate the gravitational field strength on the surface of Mars. [3 marks]

Gravitational field strength on Mars = __________ $N\,kg^{-1}$

(b) (i) Show that Kepler's third law (t^2 proportional to r^3) is consistent with Newton's law of universal gravitation; r is the radius of orbit and t is the period of the orbit. [2 marks]

(ii) Mars has two small moons, Phobos and Deimos. Phobos has a period of 7.67 hours and an orbital radius around Mars of 9.38×10^{6} m. Deimos has a period of 30.3 hours.

Calculate the orbital radius of Deimos. [3 marks]

Radius = ____________ m

(iii) Calculate the force of attraction which Mars exerts on the moon Phobos, which has a mass of 1.07×10^{16} kg. [2 marks]

Force = ____________ N

2 A small charged metal sphere **A** is suspended by an insulated thread. The charge on **A** is **–**4.0 nC. **Fig. 2.1** shows this sphere which is deflected by another charged sphere **B** attached to the end of an insulated rod. The thread makes an angle of 30° with the vertical.

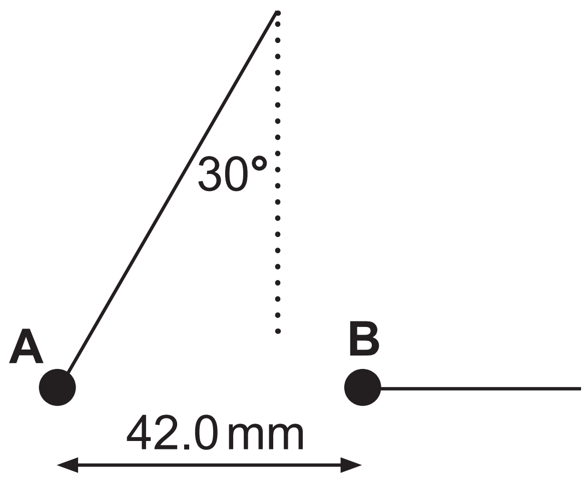

Fig. 2.1

The charge on sphere **B** is **–**7.0 nC. The centres of the two spheres are 42.0 mm apart.

(i) Calculate the magnitude and direction of the electric field strength at a point midway between the charges. [4 marks]

Electric field strength **=** ____________ $N\,C^{-1}$

Direction **=** ______________________

(ii) Calculate the magnitude of the force acting on each sphere. [2 marks]

Force **=** _____________ N

(iii) Find the tension ***T*** in the thread. [2 marks]

Tension = ____________ N

(iv) Hence find the weight of the sphere **A**. [2 marks]

Weight **=** ____________ N

In this question you will be assessed on the quality of your written communication.

3 (a) Show clearly that the product of capacitance and resistance (CR) has the S.I. unit "second". [2 marks]

(b) (i) Draw a diagram of a circuit from which the time constant of a resistor–capacitor network can be determined. The capacitor is initially **uncharged**. [2 marks]

(ii) Describe how the circuit may be used to obtain results from which the time constant may be determined. [2 marks]

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(iii) Explain how the results from **(b)(ii)** may be analysed graphically to obtain an accurate value for the time constant. [2 marks]

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Quality of written communication [2 marks]

(c) (i) Calculate the charge stored in a 300 μF capacitor when it is connected to a 600 V supply. [2 marks]

Charge **=** ____________ C

The 300 μF charged capacitor is then connected to an uncharged capacitor of capacitance 500 μF as shown in **Fig. 3.1**.

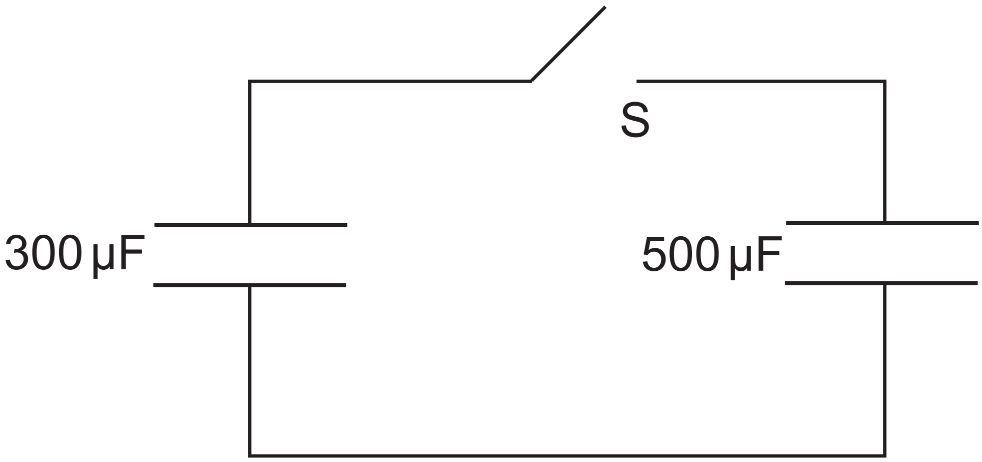

Fig. 3.1

The switch S is then closed.

(ii) Calculate the potential difference across the capacitors. [3 marks]

Potential difference = ____________ V

4 **(a)** A solenoid X is connected to a 50 Hz alternating voltage supply.
A second solenoid Y is positioned 10 cm from the first where the maximum flux density is 1.6 mT. See **Fig. 4.1**.

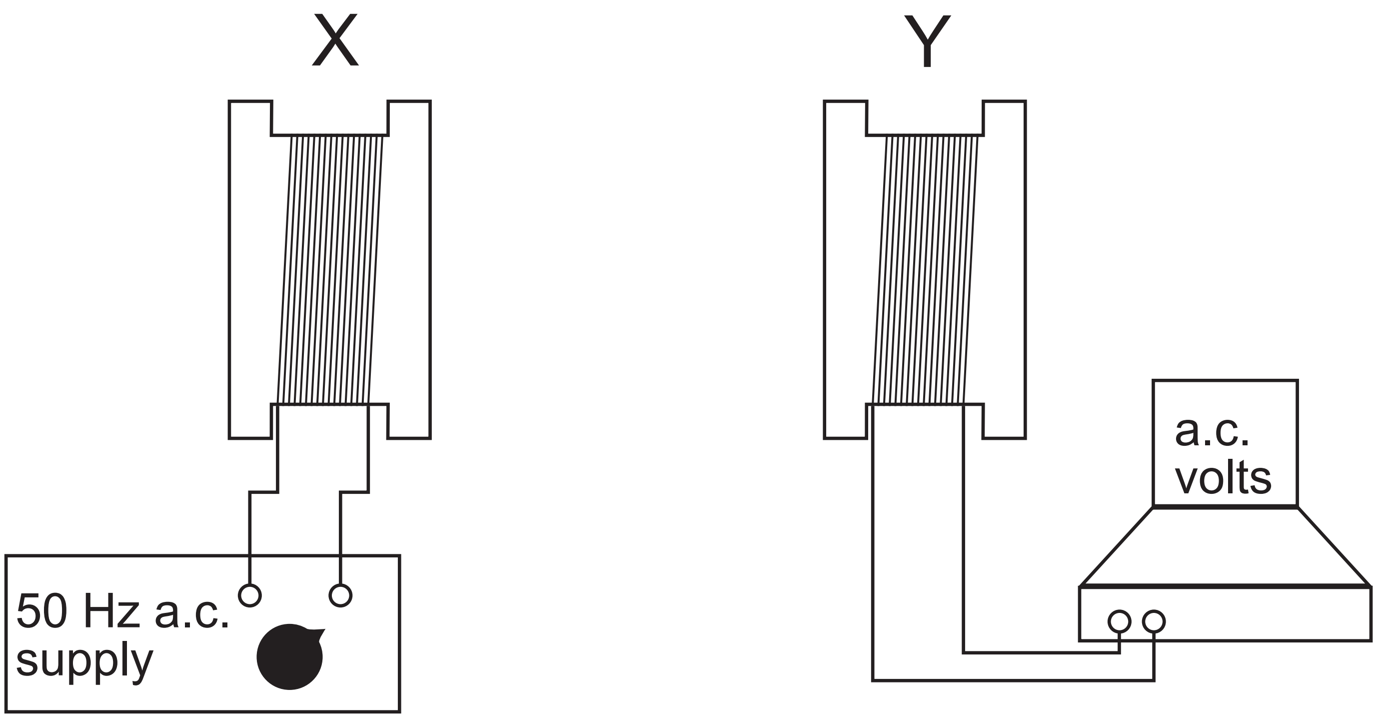

Fig. 4.1

(i) Calculate the electromotive force (EMF) induced in solenoid Y if it has an area of cross section of 0.0048 m^2 and contains 200 turns. [3 marks]

EMF = _______________ V

(ii) Comment on the direction of the magnetic field due to the supply of current in solenoid X and the direction of the magnetic field induced in solenoid Y at any instant in time. Explain your comment.
[2 marks]

An iron core is inserted between solenoid X and solenoid Y, as shown in **Fig. 4.2**.

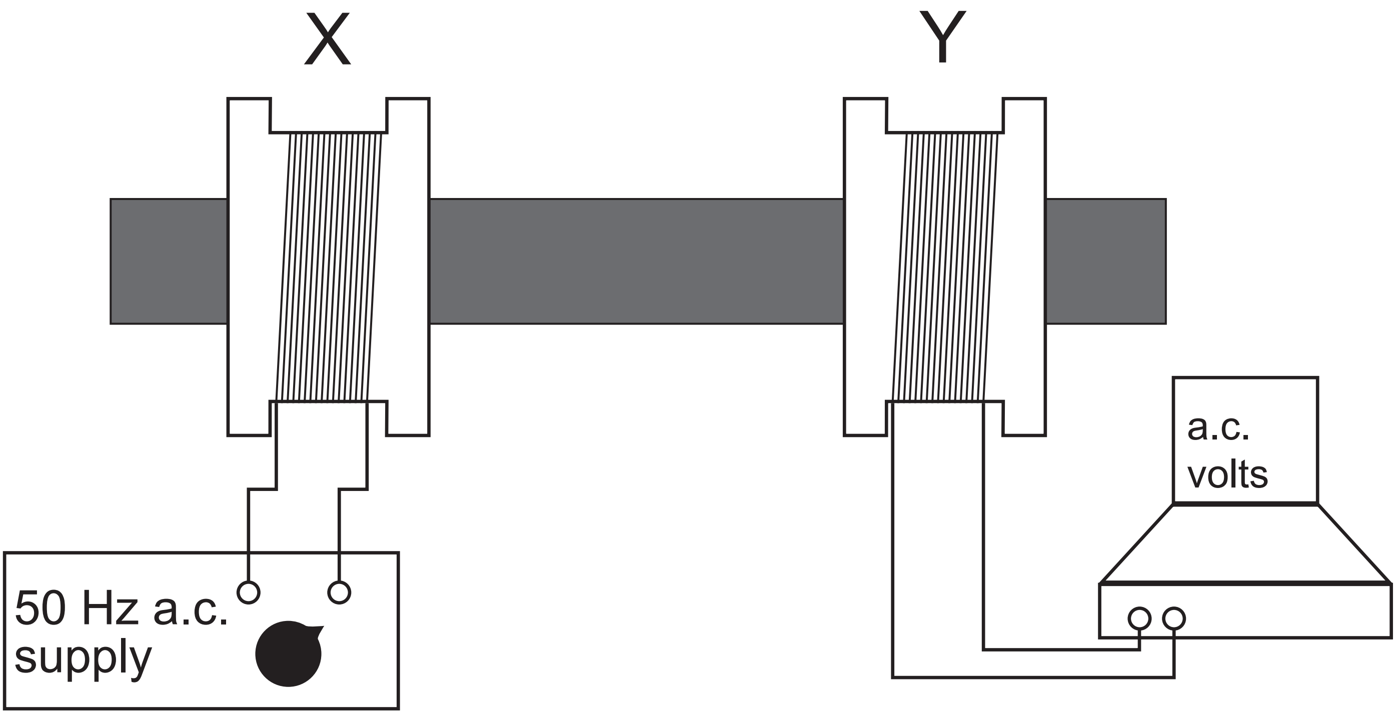

Fig. 4.2

(iii) Describe and explain the effect of inserting the iron core. [2 marks]

(b) In some types of commercial transformer the iron core forms a continuous loop. What additional design feature is incorporated into the core structure? Explain the reason for this additional design feature. [2 marks]

5 **(i)** Show that when electrons in a vacuum are accelerated from rest through a potential difference of 200 V, they acquire a velocity of 8.4×10^6 m s^{-1}. [2 marks]

These electrons now enter a deflection system midway between two parallel metal plates 30 mm apart as illustrated in **Fig. 5.1**. Each plate has a length of 40 mm.

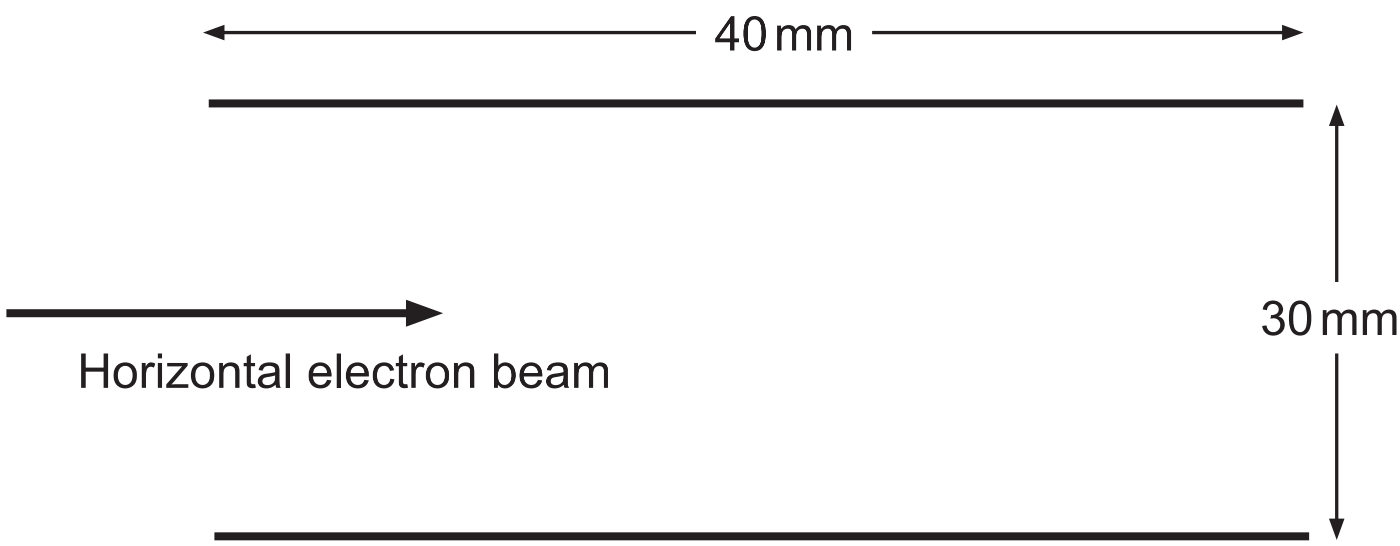

Fig. 5.1

(ii) Calculate the time it would take an electron moving with a horizontal velocity of 8.4×10^6 m s^{-1} to travel through this deflection system. State your answer in nanoseconds. [2 marks]

Time = ____________ ns

(iii) A voltage of 50 V is now applied across the plates, the top plate being positively charged. On **Fig. 5.1** on page 18 draw the electric field lines between the plates and show the path the electrons travel. [2 marks]

(iv) 1. Calculate the vertical force on the electrons produced by this electric field. [2 marks]

Force = __________ N

2. Find the vertical displacement of an electron where it reaches the right hand end of the deflection system. [3 marks]

Displacement = ___________ mm

(v) It is possible to cancel out this displacement by applying a magnetic field. State clearly the direction of the magnetic field. [2 marks]

6 Cyclotrons can be used to accelerate protons. A cyclotron consists of two hollow semicircular metal dees in a vacuum with uniform magnetic field of 0.7 T applied perpendicular to the dees, as shown in **Fig. 6.1**.

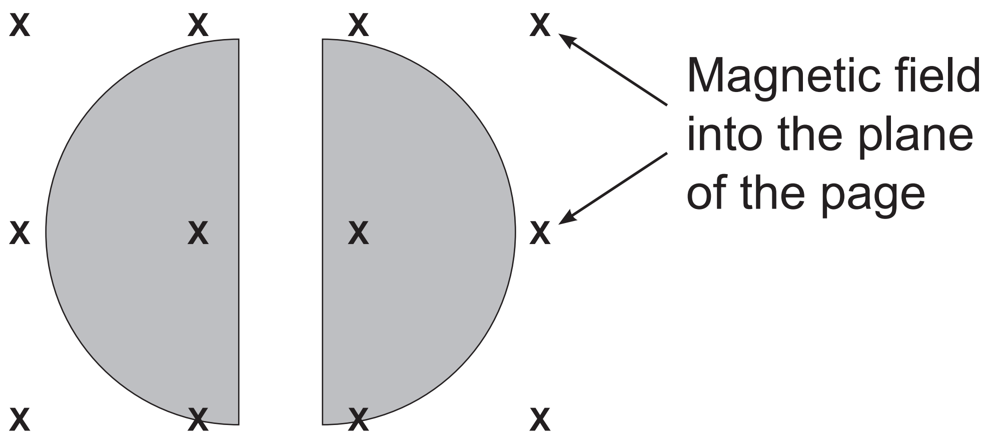

Fig. 6.1

(a) (i) Why is it necessary to have a vacuum in the cyclotron? [1 mark]

(ii) Why do the protons move with a constant speed **inside** each dee? [1 mark]

(iii) Calculate the radius of the circular path of the protons when they have a velocity of 2.0×10^5 m s^{-1} in one of the dees. [3 marks]

Radius = ___________ m

(b) Each time the protons cross the gap between the dees, they are accelerated by a potential difference of 500 V. Calculate the energy they acquire after crossing the gap 120 times. [3 marks]

Energy acquired = ____________ J

7 (a) (i) Explain what is meant by a fundamental particle. [1 mark]

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(ii) Give one example of a fundamental particle other than a type of quark. [1 mark]

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(b) (i) In **Table 7.1** enter the names of two particles that are classified as baryons and insert:

- their quark structure
- the quark charges
- the particle charge. [4 marks]

Table 7.1

Particle	Structure	Quark charges	Particle charge

(ii) Which, if any, of the quantities charge, baryon number and lepton number must be conserved for any reaction to be possible? [1 mark]

(c) (i) Write an equation for beta decay in terms of quarks. [1 mark]

(ii) What is the name of the force responsible for this process? [1 mark]

8 Power from wind turbines

(a) Wind with an air density $\boldsymbol{\rho}$ and speed $\boldsymbol{v}$ blows towards a wind turbine of effective area $\boldsymbol{A}$.

(i) Show that the mass of air delivered to the turbine each second is $\boldsymbol{\rho A v}$. [1 mark]

(ii) It is the kinetic energy of the wind that drives the turbine. Hence show that a power of $\frac{1}{2}\boldsymbol{\rho A v}^3$ is delivered to the turbine. [1 mark]

(iii) If the wind speed increases by 2**%** estimate the percentage increase in power available from the turbine. [1 mark]

Percentage increase = ____________ **%**

(b) Control signals are transmitted to the turbines by an optical fibre of length 20.0 km.

The frequency of the laser light used is 2.29×10^{14} Hz.

(i) 1. Calculate the wavelength of this light. [1 mark]

Wavelength ______________ m

2. To which region of the electromagnetic spectrum does this radiation belong? [1 mark]

____

(ii) Calculate the **minimum time** it would take for a signal of this light to reach a turbine if the speed of light in the fibre was 2.4×10^{8} m s^{-1}. [1 mark]

Time = _______________ s

(c) The electrical power generated by the turbine is transmitted along a multistrand aluminium and steel overhead cable of length 20 km.

(i) Suggest why a multistrand aluminium and steel cable is used instead of a solid aluminium cable of the same resistance with no steel. [2 marks]

The multistrand aluminium and steel cable consists of eight strands of steel surrounding the aluminium core as shown in **Fig. 8.1**.

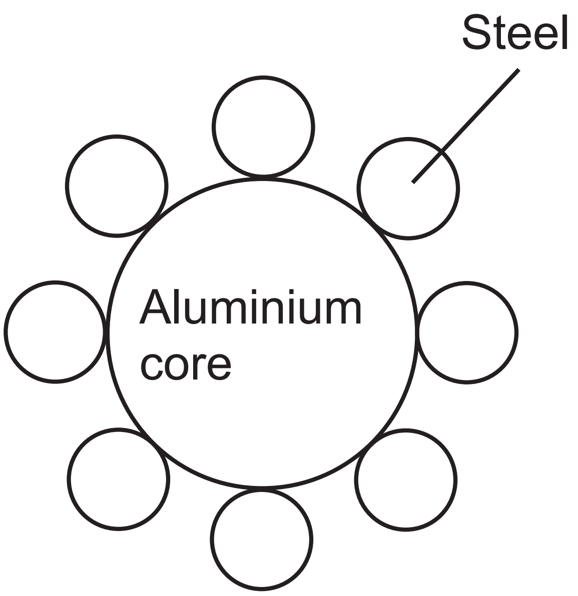

Fig. 8.1

The aluminium core has a diameter 0.22 m and the resistivity of aluminium is $2.7 \times 10^{-8}\,\Omega$ m.

Each steel strand has diameter 0.06 m and resistivity $1.5 \times 10^{-7}\,\Omega$m.

(ii) Calculate the resistance of 20 km of the multistrand cable. [6 marks]

Resistance = ______________ Ω

(iii) Calculate the power loss in this cable if the current is 2000 A. [2 marks]

Power loss = ______________ kW

THIS IS THE END OF THE QUESTION PAPER

For Examiner's use only		
Question Number	Marks	Remark
1		
2		
3		
4		
5		
6		
7		
8		
Total Marks		