Rewarding Learning

ADVANCED
General Certificate of Education
2012

Centre Number

71	

Candidate Number

Physics

Assessment Unit A2 2

assessing

Fields and their Applications

[AY221]

AY221

FRIDAY 25 MAY, AFTERNOON

TIME

1 hour 30 minutes.

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 **5(a)**.
Figures in brackets printed down the right-hand side of pages 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 9 contributes to the synoptic assessment required of the specification. Candidates should allow approximately 15 minutes to complete this question.

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total Marks	

7565

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Examiner Only	
Marks	Remark

1 **(a)** State Newton's Law of gravitation in words.

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____ [3]

(b) **(i)** Explain what is meant by a geostationary satellite.

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____ [2]

(ii) A satellite is to be placed in geostationary orbit around the planet Mars. The length of a day on Mars is 24.6 hours. The mass of Mars is 6.42×10^{23} kg and its mean radius is 3.39×10^{3} km. Calculate the distance of the satellite **above the surface** of Mars when it is in geostationary orbit.

Distance = ________________ km [4]

Examiner Only	
Marks	Remark

2 **(a)** Two point charges are positioned so that they are 20 mm apart in a vacuum as shown in **Fig. 2.1**.

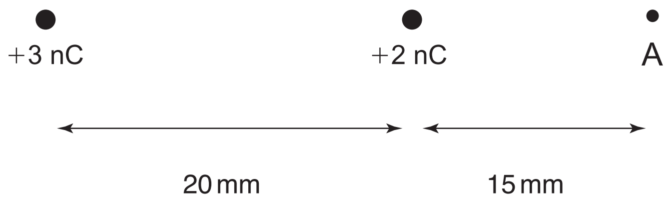


Fig. 2.1

(i) Calculate the force between the charges and state whether it is attractive or repulsive.

Force = ________________ N ________________________ [3]

(ii) Calculate the electric field strength at point A and state its direction. A is 15 mm to the right of the +2 nC charge as shown in **Fig. 2.1**.

Field strength = ___________ $N\ C^{-1}$ Direction ___________ [4]

Examiner Only	
Marks	Remark

(b) Describe one difference and one similarity between gravitational and electric fields.

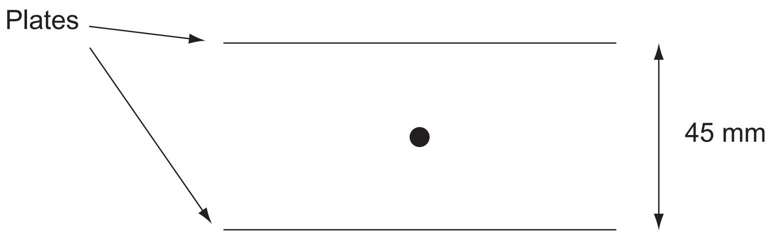
Difference: ____

____

Similarity: ____

____ [2]

(c) Two parallel plates, 45 mm apart, are placed in a vacuum. A point charge is placed midway between the plates. When the potential difference between the plates is 200 V the charge experiences an electrostatic force of 1.1 mN. Calculate the magnitude of the point charge.



Charge = ________________ C [2]

3 (a) (i) A student is asked to measure the voltage across a capacitor at different times while it is charged through a resistor. Draw the circuit diagram of an arrangement that could be used to perform this experiment and will ensure the capacitor is initially uncharged.

Examiner Only	
Marks	Remark

Circuit diagram

[3]

Describe how the experiment should be performed.

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____ [3]

Examiner Only	
Marks	Remark

(ii) On **Fig. 3.1** sketch the expected graph when the student plots the voltage across the capacitor against time.

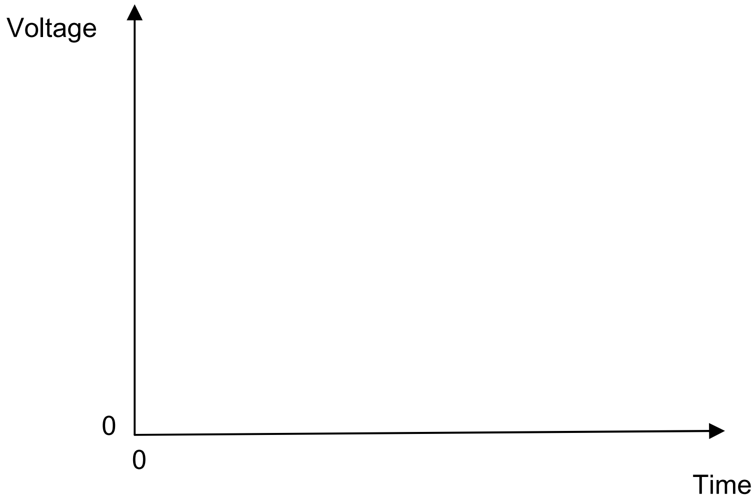

Fig. 3.1

[1]

(iii) On **Fig. 3.2** sketch a graph to show how the current that flows into the capacitor varies with time.

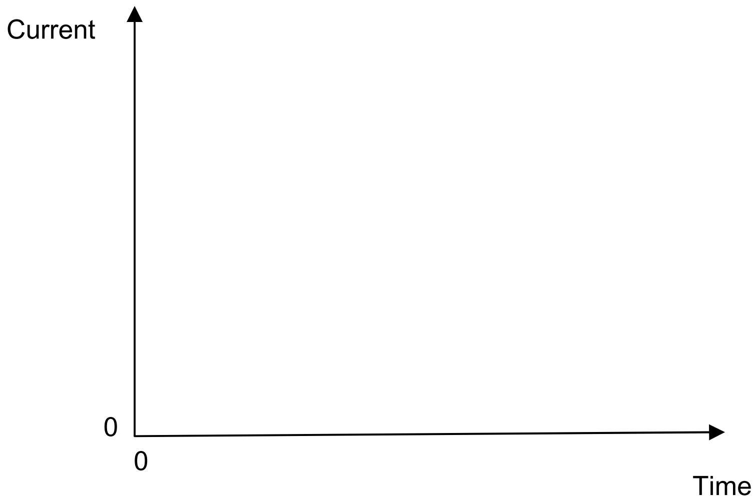

Fig. 3.2

[1]

Examiner Only	
Marks	Remark

(b) Two uncharged capacitors of capacitance 300 μF and 600 μF, are joined in series.

(i) Calculate their combined total capacitance.

Total capacitance = ________________ μF [1]

(ii) This arrangement is then connected to a 15 V supply. Calculate the voltage across the 300 μF capacitor.

Voltage across 300 μF capacitor = ________________ V [2]

Examiner Only

Marks	Remark

4 **(a)** Define the tesla.

____

____

____ [2]

(b) (i) Draw the magnetic field lines between the facing poles in **Fig 4.1**. Include arrows to show the direction of the field.

Fig. 4.1

[1]

(ii) A current carrying conductor is now placed in the field. The direction of the current in the conductor is out of the page.

Mark clearly, on **Fig. 4.2**, the direction of the force on the conductor.

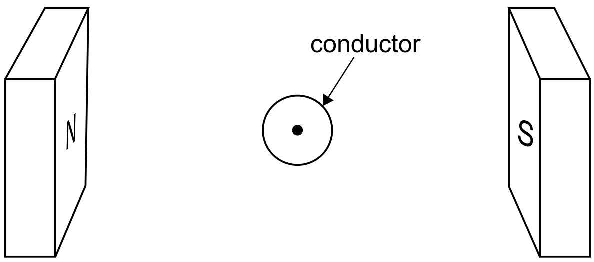

Fig. 4.2

[1]

(iii) When the magnitude of the force on the conductor is 1.44 mN the current is 2.40 A. The length of the conductor in the field is 4.00 cm. Calculate the magnetic flux density of the field.

Flux density = ______________ T [3]

5 Where appropriate in this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only	
Marks	Remark

(a) Describe an experiment to demonstrate Faraday's Law of electromagnetic induction.

Your description should include:

- a sketch of the arrangement
- a description of the method
- the expected observations
- a statement of Faraday's law.

Sketch

[6]

Quality of written communication [2]

Examiner Only	
Marks	Remark

(b) To transmit electricity across country necessitates the use of high voltage transmission lines. Explain, with reference to the appropriate equations, why high voltage lines are more efficient at transmitting electrical energy.

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____ [3]

6 A beam of electrons is accelerated from rest through a potential difference of 800 V.

(i) Calculate the velocity of the electrons after acceleration through the potential difference of 800 V.

Velocity = ________________ m s^{-1} [3]

The beam then enters a uniform magnetic field of flux density 20 mT. The field is at right angles to the beam, as depicted in **Fig. 6.1**, the whole arrangement being in a vacuum.

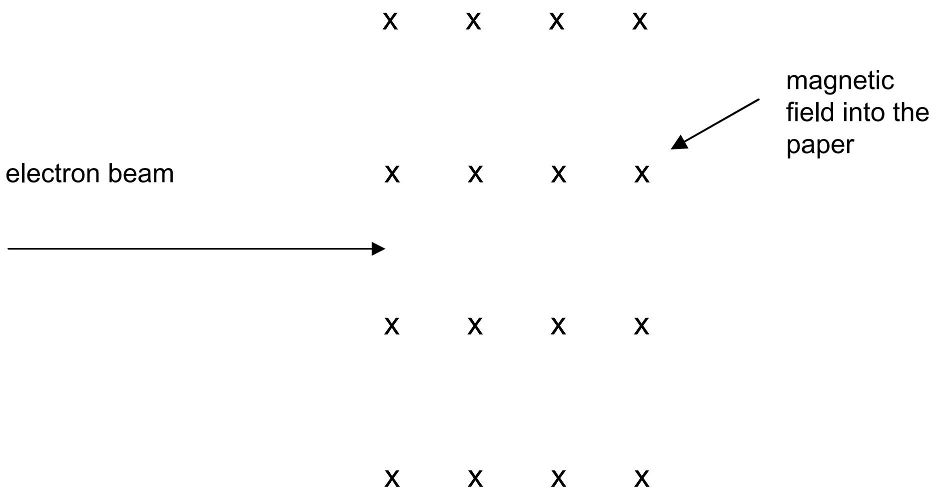

Fig. 6.1

(ii) On entering the magnetic field the electrons experience a force. On **Fig. 6.1** sketch the path of the electrons in the magnetic field. [1]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(iii) Calculate the force on each electron.

Force = _______________ N [2]

(iv) Determine the radius of the path of the deflection of each electron.

Radius = _______________ mm [3]

7 **(a)** Three accelerators used to accelerate charged particles are the linear accelerator (Linac), the cyclotron and the synchrotron. Complete **Table 7.1** which compares and contrasts their properties in terms of the path, electrode frequency, deflection field type and maximum energy achieved.

Table 7.1

Accelerator	Linac	Cyclotron	Synchrotron
Path of charged particles			circle of fixed radius
Accelerating electrode frequency	constant		
Deflection field type		Magnetic, constant B	
Maximum energy		100 MeV	

[4]

(b) One type of tomography used in medical diagnosis is positron emission tomography (PET). A chemical, such as glucose which contains a radioactive isotope, is injected into the body where it centres on possible tumorous tissue. The isotope emits a positron, which then may cause annihilation with an electron resulting in the emission of two gamma rays. These gamma rays can be used to locate the tumour.

(i) Find the wavelength of the emitted photons.

Wavelength = ________________ m [3]

(ii) Explain how momentum is conserved when annihilation occurs.

____

____ [1]

Examiner Only	
Marks	Remark

8 **(i)** There are four fundamental forces, each of which is carried by a virtual exchange particle called a gauge boson. Complete **Table 8.1** to identify the four fundamental forces and a gauge boson which carries each.

Examiner Only	
Marks	Remark

Table 8.1

Fundamental force	Gauge boson

[4]

(ii) What is meant by a fundamental particle?

____

____ [1]

(iii) What are the differences between leptons and hadrons?

____

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____

____ [3]

Examiner Only	
Marks	Remark

9 For safety, decorative garden lamps are operated at a low voltage and often use light emitting diodes (LEDs). A transformer in the home is used to convert the 230 V mains voltage to 12 V.

(a) (i) Calculate the turns ratio (number of turns in the secondary N_s, to the number of turns in the primary N_p) of such a transformer.

N_s/N_p = ________________ [2]

From the transformer, power is sent to a garden lamp by a flexible cable. The cable consists of two conductors, each of length 6.5 m, in series. Each conductor has 27 strands of thin copper wire, each with diameter 0.1 mm. The resistivity of copper is $1.7 \times 10^{-8}\ \Omega$ m.

(ii) Calculate the **total** resistance of the cable.

Resistance = ________________ Ω [3]

(iii) The lamp draws a current of 740 mA from the secondary winding of the transformer. Assuming it to be 100% efficient, calculate the primary current in the transformer.

Primary current = ________________ mA [2]

(iv) Calculate the total energy loss in the cable if the lamp is switched on for eight hours.

Energy loss = ________________ J [3]

(b) The lamp consists of a large number of light emitting diodes with a range of wavelengths which together produce the perception of white light.

(i) At one end of the visible spectrum are diodes emitting red light of wavelength 627 nm and at the other end are diodes emitting blue light of wavelength 470 nm. Of the photons emitted by these diodes, which are the most energetic?

______________________________ [1]

(ii) 1. Calculate the frequency of the photons of wavelength 470 nm.

Frequency = ________________ Hz [1]

2. The optical output power of one of these diodes (470 nm) is typically 12.0 mW. Calculate the number of photons emitted by such a diode per second.

Number = ________________ [2]

Examiner Only	
Marks	Remark

(iii) Light emitting diodes need external resistors to limit the current flowing through them. **Fig. 9.1** shows a typical arrangement.

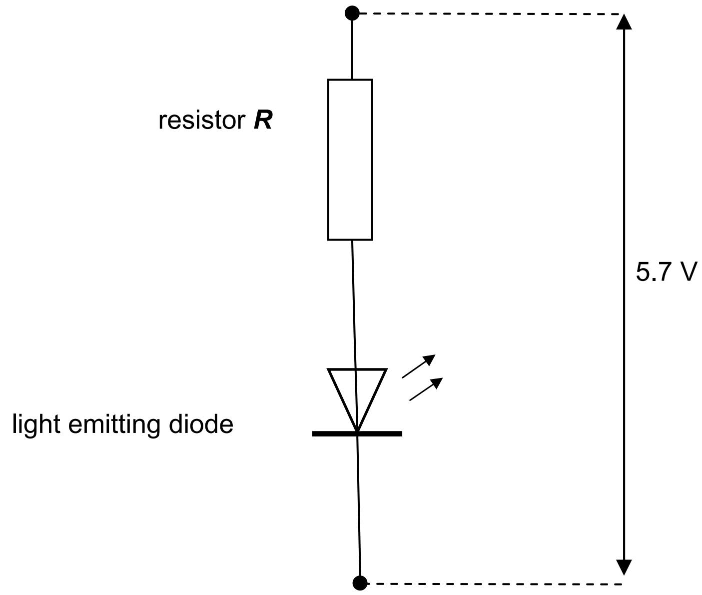

Fig. 9.1

In this arrangement the applied external voltage is 5.7 V. When the current through the diode is 30 mA the voltage across the diode is 3.6 V. Calculate the resistance of the resistor ***R*** needed to limit the current to this value.

R = ________________ Ω [2]

Examiner Only	
Marks	Remark

THIS IS THE END OF THE QUESTION PAPER

GCE Physics

Data and Formulae Sheet for A2 1 and A2 2

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
permittivity of a vacuum	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \text{F}^{-1}\ \text{m}\right)$
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
(unified) atomic mass unit	1 u $= 1.66 \times 10^{-27}$ kg
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	1 eV $= 1.60 \times 10^{-19}$ J

AY221INS

The following equations may be useful in answering some of the questions in the examination:

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force
Hooke's Law	$F = kx$ (spring constant k)

Simple harmonic motion

Displacement	$x = A \cos \omega t$

Sound

Sound intensity level/dB	$= 10 \lg_{10} \frac{I}{I_0}$

Waves

Two-source interference	$\lambda = \frac{ay}{d}$

Thermal physics

Average kinetic energy of a molecule	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
Kinetic theory	$pV = \frac{1}{3}Nm\langle c^2\rangle$
Thermal energy	$Q = mc\Delta\theta$

Capacitors

Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
Capacitors in parallel	$C = C_1 + C_2 + C_3$
Time constant	$\tau = RC$

Light

Lens formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Magnification $m = \frac{v}{u}$

Electricity

Terminal potential difference $V = E - Ir$ (e.m.f. E; Internal Resistance r)

Potential divider $V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

Radioactive decay $A = \lambda N$

$A = A_0 e^{-\lambda t}$

Half-life $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

de Broglie equation $\lambda = \frac{h}{p}$

The nucleus

Nuclear radius $r = r_0 A^{\frac{1}{3}}$