Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED
General Certificate of Education
2013

Physics

Assessment Unit A2 2

assessing

Fields and their Applications

[AY221]

AY221

WEDNESDAY 5 JUNE, MORNING

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	

Examiner Only	
Marks	Remark

1 (a) (i) Define electric field strength.

_____

_____ [1]

(ii) Electric field strength is a vector quantity. Explain how its direction is defined.

_____

_____ [1]

(iii) Calculate the electric field strength at a point 3×10^{-8} m away from an electron.

Electric field strength = _____ N C^{-1} [3]

(iv) The equation to calculate electric field strength contains the term ε_0.

Determine the base units of ε_0.

Base units = _____ [2]

(b) State one similarity and one difference between the **forces** in a gravitational field and an electric field.

_____

_____

_____

_____

_____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

2 **(a)** Kepler's third law states that the ratio of the square of the period of revolution of a planet around the Sun to the cube of its average distance from the Sun is the same for every planet.

The average distance from the Sun to the Earth is 1.50×10^{11} m and from the Sun to the planet Saturn is 1.43×10^{12} m.

(i) In astronomy, distances are often expressed in astronomical units (a.u.). One a.u. is equivalent to the distance between the Sun and the Earth.

Calculate the distance from the Sun to the planet Saturn in astronomical units.

Distance = _____ a.u. [1]

(ii) Use Kepler's third law to calculate the period of revolution of the planet Saturn in Earth years.

Period of revolution = _____ years [3]

(b) (i) State, in words, Newton's law of universal gravitation.

_____

_____

_____ [2]

(ii) Show that the mathematical form of Kepler's third law is consistent with the law of universal gravitation.

[4]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

3 **(a)** **Fig. 3.1** shows a simple circuit that can be used to charge a capacitor.

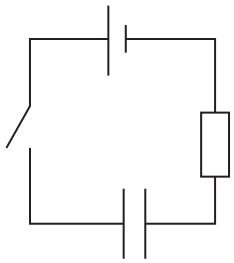
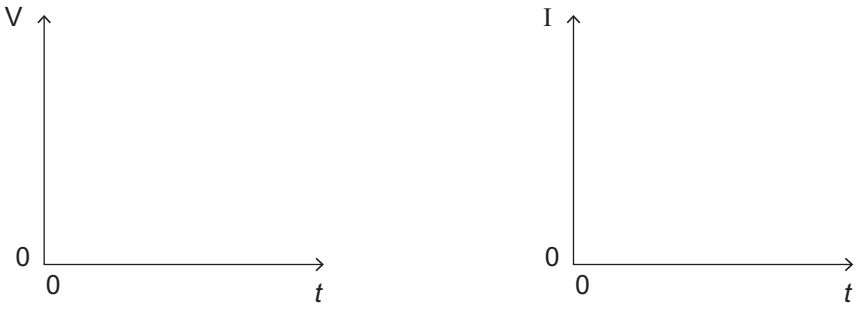


Fig. 3.1

(i) Redraw the circuit in the space below adding an ammeter and a voltmeter into the circuit so that readings of the current through the capacitor and the voltage across the capacitor can be recorded.

[1]

(ii) On **Fig. 3.2** sketch how you would expect the readings on the voltmeter and ammeter to change after the switch is closed. The capacitor is uncharged at time $t = 0$.



[4]

Fig. 3.2

(iii) When the experiment is carried out for the first time, the change in the voltage and current happen **too quickly** to gather a set of accurate results. Suggest one change that could be made to a component in the circuit to allow an accurate set of results to be gathered.

_____

_____ [1]

(b) An electronic flash for a camera produces a flash by using the energy stored in a 185 μF capacitor. The power output of the flash is 1.2 kW and the duration of the flash is 0.8 ms. The efficiency of the energy transfer from the capacitor to the flash is 76%. Calculate the initial charge stored on the capacitor.

Charge = _____ C [4]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

4 **(a)** A conducting wire has a current flowing through it. The wire is placed between the poles of a magnet as shown in **Fig. 4.1**.
The direction of the current is shown.

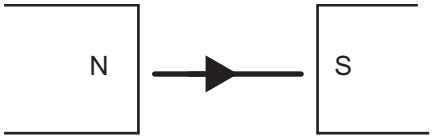


Fig. 4.1

(i) Explain why there is no force acting on the conducting wire when it is placed as shown in **Fig. 4.1**.

_____

_____

_____ [1]

(ii) On **Fig. 4.2** draw the position the wire should be placed in so that the magnetic force it experiences is maximum and in the direction out of the plane of the page. Show the current direction in the wire.

Fig. 4.2 [1]

(iii) The length of the wire in the magnetic field is 5.0 cm and a current of 3.0 A flows through the wire. The maximum magnetic force experienced by the wire is 0.27 N. Calculate the magnetic flux density.

Magnetic flux density = _____ T [2]

Examiner Only	
Marks	Remark

(b) Electrical equipment can usually be left on "standby" mode so that it is available for immediate use. Equipment left in standby mode uses a small amount of power. The internal circuits operate at a low voltage supplied by a step-down transformer.

(i) Describe the structure and function of a step-down transformer.

_____

_____

_____

_____

_____

_____

_____ [3]

(ii) A TV set is connected to a 230 V mains supply. When the TV set is in standby mode the transformer supplies an output current of 300 mA at 9 V to the internal circuit. The number of turns on the primary coil of the transformer is 1380. Calculate the number of turns on the secondary coil of the transformer.

Number of turns = _____ [2]

(iii) Assuming that the transformer is 100% efficient, calculate the current supplied by the 230 V mains supply.

Current = _____ A [2]

Examiner Only	
Marks	Remark

5 Your answer to part (a) of this question should be in continuous prose. You will be assessed on the quality of your written communication.

(a) Faraday and Lenz carried out experiments the results of which led to the formulation of their laws of electromagnetic induction. A simple demonstration of both laws can be shown using a bar magnet and a coil of wire connected to a centre zero meter as shown in **Fig. 5.1**. State both laws and describe how the apparatus can be used to demonstrate each law.

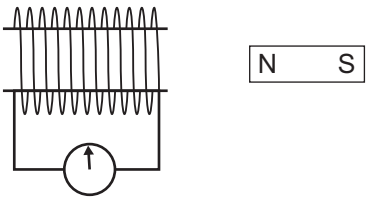


Fig. 5.1

[4]

Quality of written communication [2]

(b) A circular coil of wire is situated in a magnetic field so that its plane is perpendicular to the field. The coil has 15 turns and a radius of 3 cm. The magnetic field changes from 25 T to 10 T in 2 seconds.

Calculate the e.m.f. induced in the coil of wire.

Induced e.m.f. = _____ V [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

6 **(a)** **(i)** Outline the basic structure of a CRO that allows it to release electrons, accelerate them and produce a spot on the screen.

_____

_____

_____ [3]

(ii) The spot on the screen can be moved vertically up. Explain what is happening within the CRO to cause this upward movement.

_____

_____ [2]

(b) **(i)** The variation in an a.c. voltage signal with time is shown on the screen of a CRO in **Fig. 6.1**. The volts/cm setting is as shown in **Fig. 6.2**. Calculate the peak voltage of the recorded signal.

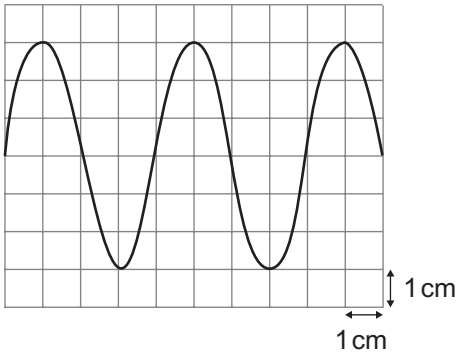


Fig. 6.1

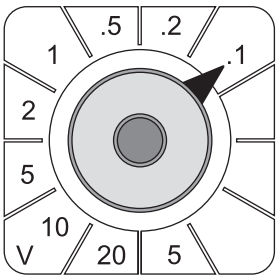


Fig. 6.2

Peak Voltage = _____ V [2]

(ii) The frequency of the signal is 5 kHz. What is the timebase setting on the oscilloscope?

Setting = _____ s cm^{-1} [3]

Examiner Only	
Marks	Remark

7 Three types of particle accelerator are the linear accelerator, the cyclotron and the synchrotron.

(a) The paths followed by the charged particles in these three accelerators are different. Describe the path followed by the accelerated particles in each accelerator.

_____

_____

_____

_____

_____ [3]

(b) The three types of accelerator use the same basic method to accelerate the charged particles. State what this method is.

_____

_____ [1]

(c) State **one** different advantage of each type of accelerator.

_____

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

8 **(a)** **(i)** Explain what is meant by a fundamental particle.

_____

_____ [1]

(ii) There are four fundamental forces that occur in nature. Complete the blank spaces in **Table 8.1** by identifying the fundamental forces and their exchange particles.

Table 8.1

Force	**Exchange Particle**
Strong nuclear	
	Photon

[3]

(b) Hadrons can be categorised as either baryons or mesons. The quark structure of two hadrons is given below. State whether each is a baryon or meson and give the charge on each.

(i) Quark structure: $\bar{u}\bar{u}\bar{d}$

Category of hadron: _____

Charge: _____ [2]

(ii) Quark structure: $\bar{u}d$

Category of hadron: _____

Charge: _____ [2]

Examiner Only	
Marks	Remark

9 The physics of natural phenomena.

(a) A simple model of how lightning occurs is that negative charge builds up on a cloud above the Earth. This causes electrons to be repelled from the surface of the Earth creating positive charge on the Earth's surface. On a small scale, the surface of the Earth and the base of the cloud can be assumed to be parallel to each other so that a uniform electric field is set up. When the charge reaches a certain value breakdown occurs and the charge "jumps" to the ground causing a lightning strike.

(i) **Fig. 9.1** represents the base of the cloud and the Earth's surface. Draw the electric field lines between the cloud and Earth's surface before breakdown occurs.

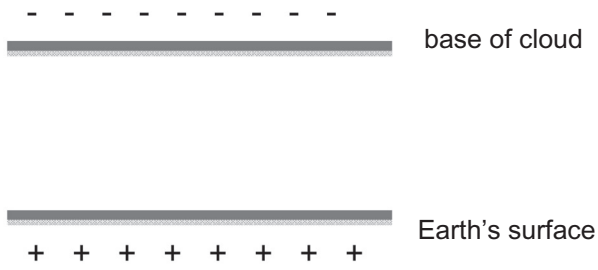


Fig. 9.1 [1]

(ii) For one particular cloud, breakdown occurred when the voltage between the base of the cloud and the Earth's surface reached 120×10^6 V. Breakdown occurs when the electric field strength reaches $2.5 \times 10^6\ \text{V m}^{-1}$. Calculate the height of the base of the cloud above the Earth's surface.

Height = _____ m [2]

(iii) The time taken for the 120×10^6 V to discharge across the air gap is 0.1 s. The current flowing in the bolt of lightning is 300 kA. Calculate the energy that is dissipated in the lightning strike.

Energy = _____ J [2]

Examiner Only	
Marks	Remark

(b) Hailstones are lumps of ice that fall from thunderstorm clouds. A typical hailstone has a diameter of 7.0 mm and can be assumed to be spherical.

The density of ice is 0.92 g cm^{-3}.

(i) Show that the mass of a typical hailstone is 0.17 g.

[2]

(ii) During a hailstorm, 8 typical hailstones fall vertically onto a bird at the same time. The bird has a mass of 300 g and is flying horizontally. If the velocity of the hailstones is 20 m s^{-1}, find the downward velocity of the bird as a result of being bombarded by the hailstones.
Assume that the hailstones come to rest upon hitting the bird.

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

Examiner Only	
Marks	Remark

(c) A tsunami is a wave train generated in a body of water by a disturbance, such as an earthquake, that vertically displaces a column of water.

(i) One tsunami travelling in deep ocean water has a wavelength of 500 km and frequency of 2.7×10^{-4} Hz. Calculate the speed of the tsunami wave.

Speed = _____ $m\,s^{-1}$ [2]

(ii) The energy of a wave depends on both the speed of the wave and the amplitude of the wave. The energy of the wave would increase if either wave speed or wave amplitude increases. As the tsunami wave travels towards land the total energy of the wave remains constant. As water waves move from deep into shallower water their speed reduces. Describe and explain what effect this will have on the amplitude and wavelength of the tsunami wave.

_____

_____

_____

_____

_____

_____ [4]

THIS IS THE END OF THE QUESTION PAPER