cea

Rewarding Learning

Centre Number

Candidate Number

ADVANCED
General Certificate of Education
2017

Physics

Assessment Unit A2 2
assessing
Fields and their Applications

[AY221]

AY221

THURSDAY 29 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.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all nine** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 90.
Quality of written communication will be assessed in Question **7**.
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.

28AY22101

1 (a) Equations 1.1 and **1.2** represent two laws relating to planetary motion.

$$F = G\frac{Mm}{r^2}$$ **Equation 1.1**

$$T^2 = kr^3$$ **Equation 1.2**

(i) State the name of the law represented by:

Equation 1.1 _____

Equation 1.2 _____ [2]

(ii) Using **Equation 1.1** as a starting point show that the constant k in

Equation 1.2 is equal to $\dfrac{4\pi^2}{GM}$.

[3]

28AY22102

(b) A planet orbits a star. The period of the planet's circular orbit around the star is 870 hours. The radius of the planet's orbit is 5.70×10^{10} m.

(i) Calculate the mass of the star.

Mass = _____ kg [2]

(ii) The planet has a mass three times that of the Earth and a radius twice that of the Earth. Calculate the gravitational field strength on the surface of the planet.

Gravitational field strength = _____ N kg^{-1} [3]

[Turn over

10624.09**R**

28AY22103

2 **(a)** Determine the base units of the permittivity of a vacuum, ε_0.

Base units = _____ [3]

(b) A proton, because of its mass, has a gravitational field surrounding it and, because of its charge, has an electric field surrounding it.

(i) State **two** differences between the gravitational field and the electric field.

_____

_____

_____

_____ [2]

(ii) Describe **one** similarity between the two fields.

_____

_____ [1]

10624.09**R**

(c) (i) State Coulomb's Law.

_____

_____

_____ [2]

(ii) Calculate the force between two point charges of magnitude 3.0 nC and 5.0 nC placed 25 cm apart in a vacuum.

Force = _____ N   [2]

[Turn over

28AY22105

3 A defibrillator is a machine used to restore the heart's normal rhythmic patterns. The most important component of a defibrillator is a capacitor that stores energy, then releases it over a period of time as it discharges through a patient's chest.

(a) Draw a circuit diagram that will allow a capacitor to be charged in the quickest time possible and can be used to show how current varies as a capacitor is discharged.

[3]

(b) In a defibrillator a 32 μF capacitor is charged from a 5000 V supply.

(i) A defibrillator can be battery operated or mains operated. If it is a mains operated defibrillator, what **two** changes must happen to the supply voltage before it can be successfully used to charge the capacitor to the required voltage?

_____

_____

_____ [2]

(ii) Calculate the energy stored in the capacitor when it is fully charged.

Energy stored = _____ J   [3]

(iii) The resistance of the body of the patient is 125 Ω. When the defibrillator is used, calculate the time taken for the current to fall from its initial value to 2.0 A.

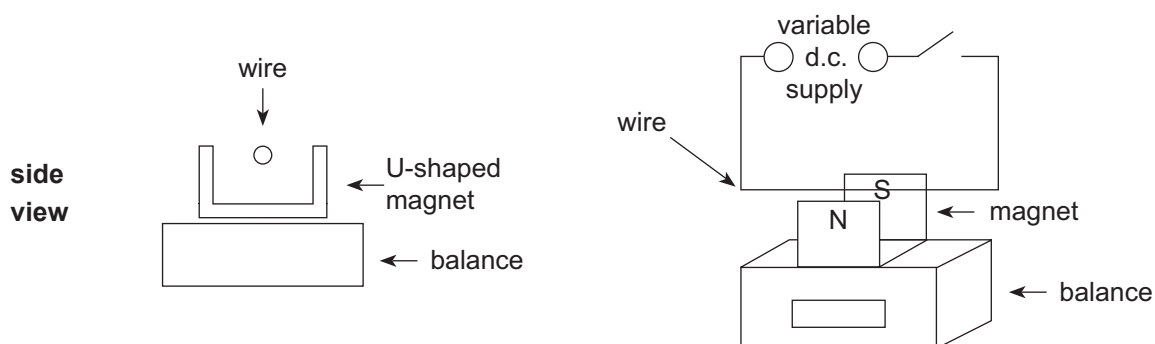Time taken = _____ s   [4]

[Turn over

10624.09**R**

28AY22107

4 An experiment is carried out to find the magnetic flux density of a U-shaped magnet.

The magnet is placed on a balance as shown in **Fig. 4.1**. A wire is held stationary between the poles of the magnet and is connected to a variable d.c. supply and a switch. The length of the wire in the magnetic field is 8.7 cm.

Fig. 4.1

(a) (i) When the switch is closed, the reading on the balance increases. Explain what causes the reading on the balance to increase.
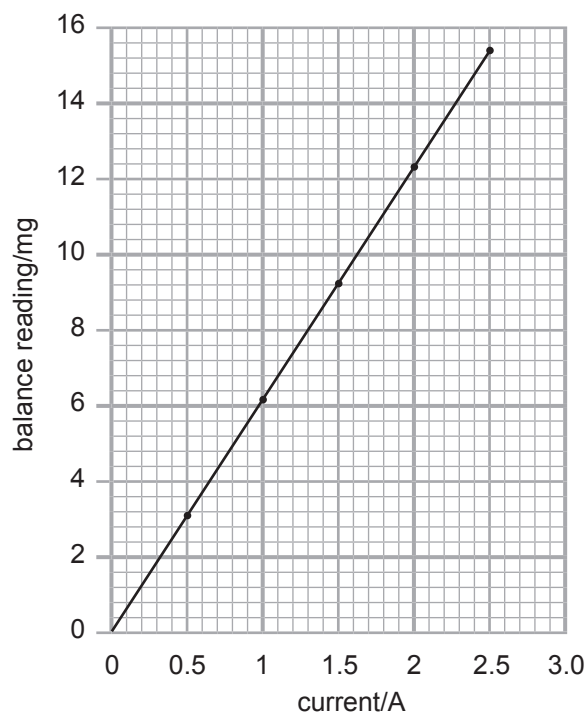
_____

_____

_____

_____ [3]

(ii) Add the symbols + and – to the variable d.c. supply connections to show the correct polarity of the supply that causes the increase in the balance reading. [1]

(b) The balance readings were taken for different values of current and the results used to plot the graph on the grid of **Fig. 4.2**.

Fig. 4.2

Use the graph in **Fig. 4.2** to calculate the value of the magnetic flux density, B.

B = _____ T   [5]

[Turn over

10624.09**R**

28AY22109

(c) (i) A second experiment was performed using a magnet with the same magnetic flux density but the gradient of the graph was found to be less steep. What change had been made to the apparatus to cause this change in gradient?

_____

_____ [1]

(ii) Explain why it is important that the current is not allowed to get too high when performing this experiment.

_____

_____

_____ [1]

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28AY22111

5 **(a)** State Faraday's Law of electromagnetic induction.

_____

_____ [1]
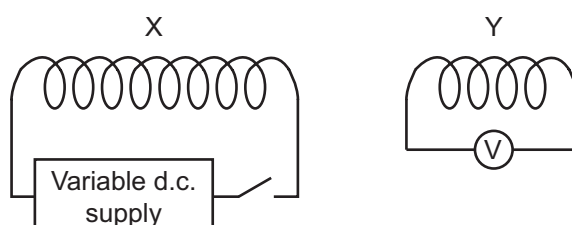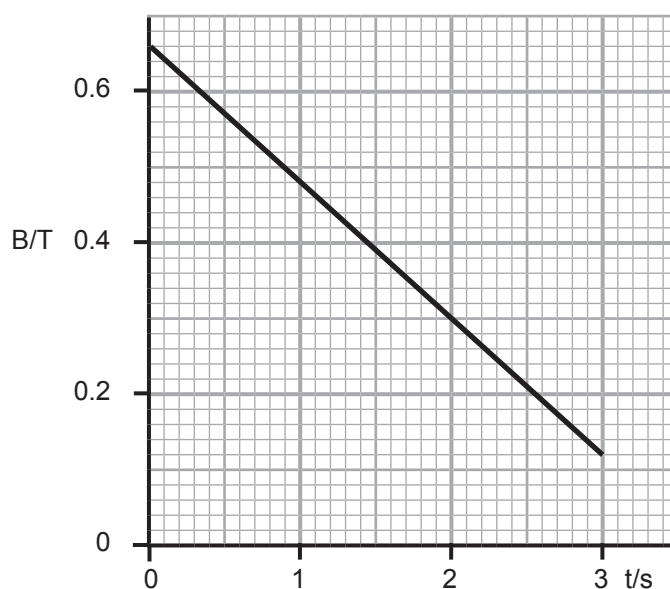
Fig. 5.1 shows an arrangement used to demonstrate electromagnetic induction.

Fig. 5.1

The solenoid X is connected to a variable voltage d.c. supply. The coil Y is attached to a voltmeter and is placed close to the solenoid X.

(b) The current in the solenoid X is reduced causing a change in the magnetic flux density at right angles to the plane of coil Y. The variation of the flux density with time is shown in **Fig. 5.2**.

Fig. 5.2

10624.09**R**

The coil Y has radius 3.2 cm and 220 turns.

Calculate the magnitude of the induced e.m.f. across the ends of coil Y.

Induced e.m.f. = _____ V   [4]

(c) Describe how the variable d.c. supply in **Fig. 5.1** can be used to

(i) increase the magnitude of the e.m.f.

_____

_____ [1]

(ii) reverse the direction of the e.m.f.

_____

_____ [1]

[Turn over

10624.09**R**

28AY22113

(d) A 12 V alternating supply delivers a current of 0.025 A to the primary coil of a transformer. A 20 Ω resistor is connected to the secondary coil. The transformer has a primary coil of 245 turns and a secondary coil of 50 turns.

(i) Calculate the theoretical current produced in the secondary coil, assuming the transformer is 100 % efficient.

Current = _____ A   [2]

(ii) The actual current induced in the secondary coil is 0.113 A. Calculate the efficiency of this transformer.

Efficiency = _____   [4]

10624.09**R**

6 **(a)** State how electrons are produced and accelerated inside a cathode ray oscilloscope (CRO).

_____

_____

_____

_____ [2]

(b) (i) An a.c. voltage is applied across the y-plates of a CRO. Describe what is seen on the screen when the timebase is turned on and when it is turned off.

ON: _____

_____

OFF: _____

_____ [2]

(ii) What additional information about the supply voltage can be deduced when the timebase is turned on that cannot be obtained when it is off?

_____ [1]

[Turn over

10624.09**R**

7 Compare and contrast the structure and method of acceleration of a linear accelerator and a cyclotron.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ [4]

Quality of written communication [2]

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8 **(a)** The history of antimatter began in 1928 when Paul Dirac predicted an antiparticle for the electron.

    (i) What is an antiparticle?

_____ [1]

    (ii) Carl D. Anderson discovered the antiparticle predicted by Dirac in 1932.

What name was given to it?

_____ [1]

    (iii) What happens when a particle meets its antiparticle?

_____ [1]

(b) In pair production, a photon changes into a particle and its antiparticle. The photon's energy becomes the mass of the particles and their initial kinetic energy.

    (i) A photon of frequency 3.6×10^{20} Hz causes pair production. Calculate the kinetic energy of one of the particles produced, each of which has a mass of 9.1×10^{-31} kg.

Kinetic energy = _____ J   [3]

(ii) Considering only up and down quarks and their antiparticles, list the possible combinations of these particles that could make up a meson and deduce the charge of each combination.

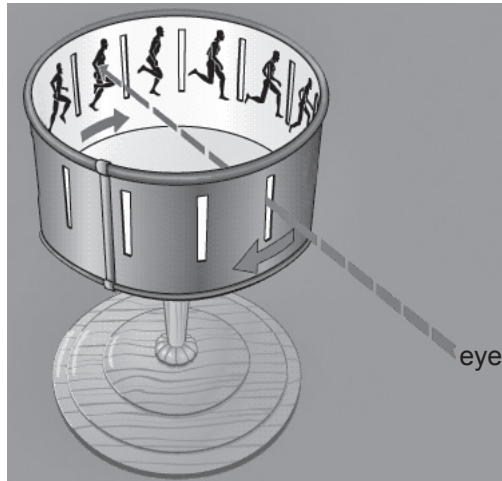| Quark combination	Charge of meson

[3]

10624.09**R**

28AY22119

9 This question describes different ways of displaying moving images.

(a) The zoetrope

A zoetrope is one of the earliest methods used. **Fig. 9.1** shows a simple zoetrope which creates animation of still pictures when it is spun above a suitable frequency.

"Adapted with permission from Encyclopædia Britannica, © 2004 by Encyclopædia Britannica, Inc."

Fig. 9.1

(i) The diameter of the zoetrope in **Fig. 9.1** is 7.6 cm and there are 9 equally spaced slits cut around it. Calculate the distance between slits.

Distance = _____ cm [2]

(ii) To see a steady moving picture at least 18 slits per second must pass the eyes of the person viewing. Calculate the minimum angular velocity that will allow the image to be seen as a steady moving picture.

Angular velocity = _____ rad s^{-1} [1]

[Turn over

10624.09**R**

(b) The film projector

A slide on a film reel, 16.0 mm high, is to be projected so that its image fills a screen 3.0 m high. The slide-to-screen distance is 12.0 m.

(i) Calculate the magnification.

Magnification = _____ [1]

(ii) How far from the slide should the lens of the projector be placed in order to form the image on the screen?

Distance = _____ cm [3]

(iii) Describe the nature of the image formed.

_____

_____ [1]

10624.09**R**

28AY22122

(c) The plasma screen

A plasma screen is made up from millions of tiny cells between two panels of glass. The cells hold a mixture of neon and xenon gases.
A high voltage across the gas causes a plasma to be produced.

(i) What is a plasma?

_____

_____ [1]

The xenon and neon gases are stimulated to release ultraviolet photons. The released ultraviolet photons interact with electrons in phosphor atoms on the inside of the cell.

(ii) Describe what happens when the ultraviolet photons interact with the electrons to cause light to be emitted by the phosphor atoms.

_____

_____

_____ [2]

(iii) How can different colours of light be produced?

_____ [1]

[Turn over

10624.09**R**

28AY22123

(d) The liquid crystal display (LCD)

An LCD screen works by applying a voltage to change the angle of liquid crystals so that they polarise light.

(i) Explain what is meant by polarisation.

_____

_____ [1]

(ii) Describe how you would test that the light from an LCD is polarised.

_____

_____ [1]

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GCE Physics

Data and Formulae Sheet for A2 1 and A2 2

Values of constants

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

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

Mechanics

Conservation of energy $\quad \frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs \quad$ for a constant force

Hooke's Law $\qquad\qquad F = kx \quad$ (spring constant k)

Simple harmonic motion

Displacement $\qquad\qquad x = A \cos \omega t$

Sound

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

Waves

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

Thermal physics

Average kinetic energy of a
molecule $\qquad\qquad\qquad \frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$

Kinetic theory $\qquad\qquad pV = \frac{1}{3}Nm\langle c^2 \rangle$

Thermal energy $\qquad\qquad Q = mc\Delta\theta$

Capacitors

Capacitors in series $\qquad \dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3}$

Capacitors in parallel $\qquad C = C_1 + C_2 + C_3$

Time constant $\qquad\qquad \tau = RC$

Light

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

Magnification $\qquad m = \dfrac{v}{u}$

Electricity

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

Potential divider $\qquad V_{\text{out}} = \dfrac{R_1 V_{\text{in}}}{R_1 + R_2}$

Particles and photons

Radioactive decay $\qquad A = \lambda N$

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

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

de Broglie equation $\qquad \lambda = \dfrac{h}{p}$

The nucleus

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

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