H2 Physics

GCE 'A' Levels

Mock Examination · Total: 100 marks · Generated 30/08/2026

Question 1

[12 marks]

SUPERPOSITION

Fig. 3.1 shows, at time t_0, the positions x of the air particles as a progressive sound wave passes through the air towards a reflector. Fig. 3.2 shows, at a later time t_1, the positions of the same air particles when the reflected sound wave is superposed with the original sound wave to form a stationary wave.

(a) Distinguish between progressive and stationary waves in terms of the amplitudes and the phases of oscillations of the particles. [2]

(b) Use Fig. 3.1 to deduce, with an explanation,

(i) the wavelength of the sound wave, [1]

(ii) the amplitude of the oscillations of the particles. [2]

(c)(i) On Fig. 3.2, indicate all the positions of the displacement nodes (label as N) and displacement antinodes (label as A). [1]

(ii) By considering the positions of the particles in Fig. 3.2, draw on Fig. 3.3 the variation with position x of the pressure p of the air when a stationary wave is set up 1. at time t_1 (label as Y), [1] 2. at time $t_1 + \frac{T}{8}$ (label as Z), where T is the period of the wave. [1]

(d) The sound wave represented in Fig. 3.1 is now continuously projected along a vertical tube that is initially fully immersed in water. As the tube is raised vertically, the first loud note was heard when the air column has a length of 14.4 cm. Determine

(i) the end correction of the tube, [2]

(ii) the length of the air column when the next loud note is heard. [2]

Question 2

[6 marks]

MEASUREMENT

The resistivity ρ of a metal is found from $\rho = \dfrac{RA}{L}$, where R is the resistance of a wire of uniform cross-sectional area A and length L. In an experiment $R = (4.20 \pm 0.05)\,\Omega$, $A = (2.0 \pm 0.1) \times 10^{-7}\,\text{m}^2$ and $L = (1.50 \pm 0.01)\,\text{m}$.

(a) Calculate the resistivity ρ. [2]

(b) Determine the absolute uncertainty in ρ and state your result to an appropriate number of significant figures. [4]

Question 3

[14 marks]

CURRENT OF ELECTRICITY

2 In this experiment, you will investigate the relationship between the potential difference across a resistance wire and a filament bulb. Fig. 2.1 shows a circuit consisting of a resistance wire on a metre rule and a light bulb arranged in series, connected to a 1.5 V d.c. supply through switch S. Voltmeter V_1 reads the p.d. across the resistance wire and voltmeter V_2 reads the p.d. across the light bulb; the sliding clip J sets the length z of resistance wire included in the circuit.

(a)(i) Connect the circuit as shown in Fig. 2.1.

(ii) Position the clip J at a position half way along the wire. Close the switch S. Record the length z, voltmeter reading V_1 across the resistance wire and the voltmeter reading V_2 across the light bulb. [1]

(b) Repeat steps (a)(ii) to obtain further sets of values of z, V_1 and V_2. [5]

(c) It is suggested that z, V_1 and V_2 are related by the equation

$$\frac{V_2}{V_1} = \frac{G}{z} + H$$

where G and H are constants. Plot a suitable graph to obtain values for G and H. [6]

(d) Determine the value of z when $V_1 = 100\,V_2$. Comment on this value of z. [2]

Question 4

[20 marks]

ELECTROMAGNETIC INDUCTION

A uniform magnetic field of flux density B makes an angle θ with a rectangular metal frame PQRS of area A (Fig. 7.1).

(a) Distinguish between magnetic flux density and magnetic flux. [3]

(b) Write an expression, in terms of A, B and θ, for the magnetic flux ϕ linking the frame PQRS. [1]

(c) The frame PQRS has width PQ = 52 cm and length QR = 95 cm, and is suspended by two non-conducting rods (Fig. 7.2). It is rotated at a constant angular speed ω about the vertical axis through the rods. The magnetic flux density B is 1.8 T.

(i) Calculate the magnetic flux ϕ linking the metal frame when $\theta = 90^{\circ}$. [2]

(ii) Explain, using the laws of electromagnetic induction, why there is an induced e.m.f. in the frame. [2]

(iii) State the sides of the frame PQRS between which the e.m.f. is induced. [1]

(iv) Fig. 7.3 shows how the induced e.m.f. varies over one cycle of rotation of the coil. **1.** Explain why the magnitude of the induced e.m.f. is maximum and zero at the values of θ shown in the graph. [3] **2.** Explain why the shape of the graph is sinusoidal. [2] **3.** The angular speed ω is 4π rad s^{-1}. Calculate the maximum value of the induced e.m.f. in the frame. [2] **4.** The resistance of the frame PQRS is 4.8 Ω. Calculate the r.m.s. current in the frame. [2]

(v) State and explain how the graph in Fig. 7.3 would differ if the frame rotated at a slower angular speed. [2]

Question 5

[1 marks]

TEMPERATURE AND IDEAL GASES

When a graph of temperatures in kelvin against temperatures in degrees Celsius is plotted, a linear graph is obtained.

What is the vertical intercept and gradient of this line?

	vertical intercept	gradient
A	–273.15	1
B	0	1 / 273.15
C	0	273.15
D	273.15	1

Question 6

[7 marks]

ELECTROMAGNETISM

A particle of charge -5.0×10^{-6} C undergoes uniform circular motion horizontally in a clockwise direction (Fig. 5.1). The motion occurs in a region containing a uniform magnetic field and a uniform electric field, both directed downwards in the plane of the paper. The magnetic flux density is 0.50 T and the electric field strength is 150 N C^{-1}.

(a)(i) Show that the period of revolution T of the charged particle is given by $T = \dfrac{2\pi E}{Bg}$, where g is the acceleration of free fall. [3]

(a)(ii) Hence determine the period T. [1]

(b) The electric field is now removed. Describe the motion of the charged particle and explain your answer. [3]

Question 7

[1 marks]

GRAVITATIONAL FIELD

An astronaut of mass m in a spacecraft experiences a gravitational force $F = mg$ when stationary on the launchpad. The spacecraft is launched vertically upwards with an acceleration of $0.2g$.

What is the gravitational force on the astronaut immediately after launch?

- A $1.2mg$
- B mg
- C $0.8mg$
- D 0

Question 8

[1 marks]

WAVE MOTION

A sheet of glass transmits 70% of the energy of the incident light.

What is the value of the quantity $\dfrac{\text{amplitude of the transmitted light}}{\text{amplitude of the incident light}}$?

- **A** 0.49
- **B** 0.70
- **C** 0.84
- **D** 1.2

Question 9

[1 marks]

MOTION IN A CIRCLE

9 A turntable consists of a rotating horizontal disc moving at a fixed rotational speed. Two small objects P and Q of the same mass are placed on the turntable, with P at a distance r_1 from the centre O and Q at a distance r_2, where $r_1 > r_2$.

Which of the following correctly relates P and Q's linear speeds and their centripetal forces?

	linear speed	**centripetal force**
A	same for P and Q	greater for Q
B	same for P and Q	greater for P
C	greater for P	greater for Q
D	greater for P	greater for P

Question 10

[1 marks]

WORK, ENERGY AND POWER

An object moves along a frictionless track from A to C, passing through B, the lowest point of the motion. Which graph shows how the kinetic energy of the object varies with the vertical distance fallen from A?

- **A** a straight line decreasing from a maximum at A to zero at B
- **B** a straight line increasing from zero at A to a maximum at B
- **C** a curve rising slowly then steeply (concave up) from A to B
- **D** a curve falling from a high value at A, levelling towards B

Question 11

[1 marks]

D.C. CIRCUITS

The diagram shows a network of three identical resistors connected to a battery of negligible internal resistance: R_1 is in series with the parallel combination of R_2 and R_3.

What is the ratio $\dfrac{\text{power dissipated in } R_1}{\text{power dissipated in } R_2}$?

A 1 **B** 2 **C** 4 **D** 9

Question 12

[1 marks]

FORCES

7 Three cuboids W, X and Y with identical dimensions are fully immersed in water and held by strings in identical orientations, in equilibrium at the same depth. Water has density ρ; cuboid W is made of material of density 4ρ, cuboid X of density 2ρ and cuboid Y of density 1.5ρ.

Which statement is correct?

- **A** The upthrust on cuboid Y is equal to the weight of cuboid Y.
- **B** The upthrust on cuboid W is two times the upthrust on cuboid X.
- **C** The tension of the strings on each cuboid is the same.
- **D** The tension of the string on cuboid W is the greatest.

Question 13

[9 marks]

ALTERNATING CURRENT

(a) A simple iron-cored transformer is illustrated in Fig. 5.1.

(i) Explain why the primary and secondary coils are wound on a core made of iron. [1]

(ii) Suggest why thermal energy is generated in the core when the transformer is in use. [2]

(b) A student is asked to design a circuit by which a direct voltage of peak value 9.0 V is obtained across a load from a 240 V alternating supply, using a transformer that may be considered ideal and a rectifier incorporating an ideal diode (Fig. 5.2).

(i) On Fig. 5.2, insert a symbol for the diode so as to produce the polarity across the load shown on the diagram. [1]

(ii) Calculate the ratio of the number of turns in the secondary coil to the number of turns in the primary coil. [3]

(iii) The load has a resistance of 4.5 Ω. Calculate the mean power dissipated in the load. [2]

Question 14

[6 marks]

DYNAMICS

A stationary object of mass $5.0\ \mathrm{kg}$ explodes into two fragments X and Y that move off in opposite directions along the same straight line. Fragment X has mass $2.0\ \mathrm{kg}$ and moves away at $9.0\ \mathrm{m\ s^{-1}}$.

(a) Determine the speed of fragment Y of mass $3.0\ \mathrm{kg}$. [2]

(b) Calculate the total kinetic energy released in the explosion. [2]

(c) State and explain whether momentum and kinetic energy are each conserved in this explosion. [2]

Question 15

[8 marks]

OSCILLATIONS

2 In this experiment, you will investigate an oscillating system. Two bobs A and B are supported by strings from a stand; the string supporting A has a mark at its midpoint. A long wooden rod is arranged (Fig. 2.1) so that it passes between the stand and the strings and just touches both strings, with the strings hanging vertically.

(a)(i) The angle between the long wooden rod and the string supporting A is θ. Adjust the position of the long wooden rod so that θ is approximately 60° and the rod is behind the mark on the string supporting A. Measure and record θ. [1]

(a)(ii) Pull A and B a short distance away from the long wooden rod, keeping the same separation between A and B, and release them at the same time. B first oscillates in phase with A, then out of phase, and then back in phase again. This takes n oscillations of B. Determine n. [2]

(b) It is suggested that $n = k \tan\theta$, where k is a constant. Calculate k. [2]

(c) Determine n and k for two more values of θ. Tabulate your results. [2]

(d) Explain why you would not select a value of $\theta = 90^\circ$ in (c). [1]

[Total: 8]

Question 16

[9 marks]

KINEMATICS

A ball is kicked from ground level with an initial speed of $18\ \mathrm{m\ s^{-1}}$ at an angle of 40° above the horizontal. A vertical wall of height $3.0\ \mathrm{m}$ stands on horizontal ground at a distance of $25\ \mathrm{m}$ from the point of projection. Air resistance is negligible and $g = 9.81\ \mathrm{m\ s^{-2}}$.

(a) Resolve the initial velocity into horizontal and vertical components, and hence find the time taken for the ball to reach the vertical plane of the wall.

(b) Determine the height of the ball above the ground at this instant, and state with justification whether the ball clears the wall.

(c) Calculate the speed of the ball as it passes the plane of the wall.

(d) Sketch the path of the ball from the point of projection until it passes the wall, indicating the shape of the trajectory.

Question 17

[1 marks]

NUCLEAR PHYSICS

29 An induced nuclear fission reaction may be represented by the equation

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{98}_{40}\mathrm{Zr} + ^{136}_{52}\mathrm{Te} + 2\,^{1}_{0}\mathrm{n}$$

The binding energy per nucleon E for the nuclides involved in the reaction are as shown:

Nuclide	E / MeV
$^{235}_{92}\mathrm{U}$	7.60
$^{98}_{40}\mathrm{Zr}$	8.58
$^{136}_{52}\mathrm{Te}$	8.32

What is the energy released in the reaction?

- **A** 186 MeV
- **B** 196 MeV
- **C** 1970 MeV
- **D** 3760 MeV

Question 18

[1 marks]

ELECTRIC FIELDS

A charged oil droplet of mass m falls, initially freely, in a vacuum between two horizontal plates separated by distance x. Applying a p.d. V reduces the downward acceleration to a. Reversing the polarity (reversing the electric force) increases the downward acceleration to $3a$.

What is the magnitude of the charge on the droplet?

- A $\frac{max}{V}$
- B $\frac{2max}{V}$
- C $\frac{3max}{V}$
- D $\frac{4max}{V}$

Answers

Question 1

(a) Amplitudes: in a progressive wave all particles have the same amplitude; in a stationary wave the amplitude ranges from zero at the nodes to a maximum at the antinodes. Phases: in a progressive wave, particles within one wavelength have different phases; in a stationary wave, particles between adjacent nodes oscillate in phase, and particles in adjacent segments oscillate π rad out of phase (particles at the nodes do not oscillate).

(b)(i) The wavelength is the distance between adjacent particles that oscillate in phase. From Fig. 3.1 this is 0.600 m.

(b)(ii) There are 6 equal intervals between 0.00 m and 0.30 m (half a wavelength), so the equilibrium separation of the particles is 0.05 m. The particle with equilibrium position at 0.15 m is displaced to 0.19 m at t_0, so amplitude $x_0 = 0.19 - 0.15 = 0.04$ m.

(c)(i) Nodes (N) occur where the particles are bunched together (zero displacement) and antinodes (A) midway between, spaced $\frac{\lambda}{4} = 0.15$ m apart: N at $0.0, 0.3, 0.6, 0.9, 1.2$ m and A at $0.15, 0.45, 0.75, 1.05$ m.

(c)(ii) Y: the pressure is maximum or minimum (compared with atmospheric) at the displacement nodes and zero at the displacement antinodes. Z: at $t_1 + \frac{T}{8}$ the positions of the nodes and antinodes are unchanged but the particles have moved, so the pressure curve keeps the same shape with a smaller amplitude than at t_1.

(d)(i) For the first loud note (fundamental) an antinode is at the mouth and a node at the water surface: $L_1 + c = \frac{\lambda}{4}$, so end correction $c = \frac{0.60}{4} - 0.144 = 0.15 - 0.144 = 0.006$ m.

(d)(ii) For the next loud note $L_2 + c = \frac{3\lambda}{4}$, so $L_2 = \frac{3(0.60)}{4} - 0.006 = 0.45 - 0.006 = 0.444$ m.

Question 2

(a) $\rho = \dfrac{RA}{L} = \dfrac{(4.20)(2.0 \times 10^{-7})}{1.50} = 5.6 \times 10^{-7}\ \Omega\,\text{m}$.

(b) $\dfrac{\Delta\rho}{\rho} = \dfrac{\Delta R}{R} + \dfrac{\Delta A}{A} + \dfrac{\Delta L}{L} = \dfrac{0.05}{4.20} + \dfrac{0.1}{2.0} + \dfrac{0.01}{1.50} = 0.069 = 6.9\%$. So $\Delta\rho = 0.069 \times 5.6 \times 10^{-7} \approx 0.4 \times 10^{-7}$, giving $\rho = (5.6 \pm 0.4) \times 10^{-7}\ \Omega\,\text{m}$.

Question 3

(a)(ii) With J halfway, e.g. $z = 50.0$ cm, giving readings such as $V_1 \approx 0.45$ V and $V_2 \approx 1.05$ V (values depend on the particular wire and bulb).

(b) As z is increased (more resistance wire in circuit) V_1 increases and V_2 decreases; take about six sets spread along the wire.

(c) The equation is linear in $\frac{1}{z}$: plot $\frac{V_2}{V_1}$ on the y-axis against $\frac{1}{z}$ on the x-axis. The gradient equals G and the y-intercept equals H.

(d) $V_1 = 100\ V_2$ means $\frac{V_2}{V_1} = 0.010$. Then $0.010 = \frac{G}{z} + H$, so $z = \frac{G}{0.010 - H}$. Substituting the graph values of G and H gives z. Comment: this z lies far outside the physically available length of the wire (0 to 100 cm) — it comes out negative or very large — so the condition $V_1 = 100\ V_2$ cannot actually be reached with this apparatus (it is an extrapolation well beyond the measured range).

Question 4

(a) Magnetic flux density is the force per unit current per unit length acting on a conductor placed perpendicular to the field. Magnetic flux is the product of the magnetic flux density and the area normal to the field ($\phi = BA$ when B is perpendicular to the area).

(b) $\phi = BA \sin \theta$.

(c)(i) $\phi = BA \sin 90^\circ = (1.8)(0.52 \times 0.95)(1) = 0.89$ Wb.

(ii) As the frame rotates, the magnetic flux linkage through it continuously changes (its sides cut field lines). By Faraday's law an e.m.f. is induced equal to the rate of change of flux linkage, and by Lenz's law it acts to oppose that change.

(iii) Sides PS and QR.

(iv) 1. The e.m.f. depends on the rate of change of flux linkage. It is maximum at $\theta = 0^\circ, 180^\circ, 360^\circ$, when the plane of the frame is parallel to the field and the flux linkage changes fastest; it is zero at $\theta = 90^\circ, 270^\circ$, when the plane is perpendicular to the field and the flux linkage is momentarily stationary.

2. The flux linkage is $\phi = BA \sin \omega t$, so the induced e.m.f. = $-\frac{d\phi}{dt} = -BA\omega \cos \omega t$, which varies sinusoidally with time.

3. $E_0 = BA\omega = (0.89)(4\pi) = 11.2$ V.

4. $I_{rms} = \frac{E_0/R}{\sqrt{2}} = \frac{11.2/4.8}{\sqrt{2}} = 1.65$ A.

(v) At a slower angular speed the rate of change of flux linkage is smaller, so the peak (maximum) e.m.f. is reduced; the graph keeps the same shape and the same θ-positions of its peaks and zeros but has a smaller amplitude.

Question 5

D — The relation is $T/\mathrm{K} = T/^{\circ}\mathrm{C} + 273.15$. Comparing with $y = mx + c$, the gradient is 1 and the vertical intercept is 273.15.

Question 6

(a)(i) The magnetic force provides the centripetal force: $BQv = \frac{mv^2}{r}$, which gives the period $T = \frac{2\pi m}{BQ}$. Because the circular motion is horizontal, the net vertical force is zero, so the weight balances the electric force: $mg = QE$, i.e. $\frac{m}{Q} = \frac{E}{g}$. Substituting, $T = \frac{2\pi}{B} \cdot \frac{m}{Q} = \frac{2\pi E}{Bg}$.

(a)(ii) $T = \frac{2\pi(150)}{(0.50)(9.81)} = 192\ \mathrm{s}$.

(b) With the electric field removed, the only vertical force is the weight, so the particle accelerates downward with acceleration g. The magnetic force still provides the centripetal force for horizontal circular motion, so the particle follows a helical path whose pitch (spacing between loops) increases as it falls faster. By Fleming's left-hand rule it continues to circulate clockwise when viewed from above.

Question 7

B. Immediately after launch the spacecraft is still essentially at the Earth's surface, so the gravitational field strength is unchanged and the gravitational force remains mg.

Question 8

C

Intensity (energy) ∝ (amplitude)^2. With $0.70E = ka_1^2$ and $E = ka^2$:

$$\frac{a_1}{a} = \sqrt{0.70} = 0.84.$$

Question 9

D

Both objects share the same angular velocity ω. Linear speed $v = r\omega$, so with $r_1 > r_2$ the speed is greater for P. Centripetal force $F = mr\omega^2$ is also greater for P (same m, larger r).

Question 10

B. As the object descends, the loss in gravitational PE ($mg\Delta h$) is converted to kinetic energy. KE therefore increases linearly with the vertical distance fallen from A, giving a straight line through the origin (graph B).

Question 11

C. The full current I from R_1 splits equally between the identical parallel resistors R_2 and R_3, so each carries $\frac{I}{2}$. $P_{R_1} = I^2R$ and $P_{R_2} = \left(\frac{I}{2}\right)^2 R = \frac{1}{4}I^2R$. Ratio = $\frac{I^2R}{\frac{1}{4}I^2R} = 4$.

Question 12

D

All three cuboids displace the same volume of water, so the upthrust $U = \rho V g$ is identical for all (ruling out A and B). For equilibrium $T = W - U = (\rho_{\text{material}} - \rho)V g$. Since W has the greatest material density (4ρ), it has the greatest tension.

Question 13

(a)(i) Iron has a high permeability, so the core channels the magnetic flux and links (almost) all of the flux produced by the primary through the secondary coil, minimising flux leakage.

(ii) The alternating primary current produces a continually changing flux in the core; this changing flux induces eddy currents in the (conducting) iron core, which dissipate energy as heat through the resistance of the core.

(b)(i) The diode is placed in the secondary/load loop, oriented to conduct only on the half-cycle that makes the marked terminal positive (half-wave rectification giving the shown polarity).

(ii) For an ideal transformer $\frac{N_s}{N_p} = \frac{V_s}{V_p}$. The peak secondary voltage must be 9.0 V, while the peak primary voltage is $\sqrt{2} \times 240$ V, so ratio = $\frac{9.0}{\sqrt{2} \times 240} = 0.027$ (about $\frac{1}{38}$).

(iii) For the half-wave rectified output, $V_{rms} = \frac{V_0}{2} = \frac{9.0}{2} = 4.5$ V. Mean power = $\frac{V_{rms}^2}{R} = \frac{(4.5)^2}{4.5} = 4.5$ W.

Question 14

(a) Total momentum before = 0, so $m_X v_X = m_Y v_Y$: $2.0(9.0) = 3.0\, v_Y \Rightarrow v_Y = 6.0\ \text{m s}^{-1}$ in the opposite direction.

(b) $E_k = \frac{1}{2}(2.0)(9.0)^2 + \frac{1}{2}(3.0)(6.0)^2 = 81 + 54 = 135$ J.

(c) Momentum is conserved: with no external resultant force the total momentum stays zero. Kinetic energy is not conserved: the fragments gain 135 J of KE, supplied by stored chemical/elastic potential energy released in the explosion.

Question 15

(a)(i) $\theta = 60^\circ$ (measured to the nearest degree, repeated).

(a)(ii) $n = 11$ (repeated count).

(b) $k = \dfrac{n}{\tan\theta} = \dfrac{11}{\tan 60^\circ} = 6.4$ (2 s.f.).

(c) Two further angles:

$\theta/^\circ$	n_1	n_2	n	$k = n/\tan\theta$
60	11	11	11	6.4
70	14	14	14	5.1
80	26	26	26	4.6

(d) At $\theta = 90^\circ$ both strings touch the wooden rod at the same length, so the two pendulums have equal effective length and always oscillate in phase. They never go out of phase, so n cannot be determined.

Question 16

(a) $u_x = 18\cos 40^\circ = 13.8\ \text{m s}^{-1}$; $u_y = 18\sin 40^\circ = 11.6\ \text{m s}^{-1}$. Time to reach the wall: $t = \dfrac{25}{13.8} = 1.81$ s.

(b) $y = u_y t - \frac{1}{2}gt^2 = 11.6(1.81) - \frac{1}{2}(9.81)(1.81)^2 = 4.9\ \text{m}$. Since $4.9\ \text{m} > 3.0\ \text{m}$, the ball clears the wall.

(c) $v_x = 13.8\ \text{m s}^{-1}$; $v_y = 11.6 - 9.81(1.81) = -6.2\ \text{m s}^{-1}$. Speed = $\sqrt{13.8^2 + 6.2^2} = 15.1\ \text{m s}^{-1}$.

(d) A parabola rising from the origin to a peak beyond mid-flight, then descending; it is still above 3.0 m and falling as it crosses the wall.

Question 17

A

Energy released = total binding energy of products – binding energy of reactants:

E = (8.58 × 98) + (8.32 × 136) – (7.60 × 235) = 840.8 + 1131.5 – 1786 = 186 MeV

Question 18

A. With the electric force F_E upward: $mg - F_E = ma$. With it reversed (downward): $mg + F_E = 3ma$. Subtracting gives $2F_E = 2ma$, so $F_E = ma$. Since $F_E = \frac{qV}{x}$, $q = \frac{F_E x}{V} = \frac{max}{V}$
.