# WAEC PHYSICS — PAPER 2 (ESSAY)

## WASSCE (SC) 2015

## Time: 1½ hours | 60 marks

***Answer eight questions in all. Five questions from Part I and three questions from Part II.***

**PART I**

***[15 marks] — Answer any five questions from this part. All questions carry equal marks.***

1. (a) What is a projectile?

(b) Give the reason why the horizontal component of the velocity of a projectile remains the same at every point of its flight.

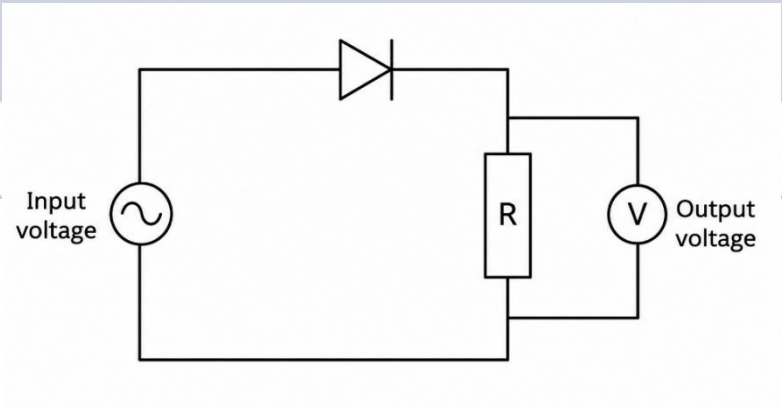
2. A body is projected at an angle of 30° to the horizontal with a velocity of 150 $ms^{-1}$. Calculate the time it takes to reach the greatest height. [Take g = 10 $ms^{-2}$ and neglect air resistance]

3. A wire of length 2.00 m and radius 1.0 mm is stretched by 25.0 mm on application of a force of $10^3$ N. Calculate the Young's modulus for the wire.

4. State three ways of increasing the rate of cooling of a cup of hot tea.

5. (a) What is doping in a semi-conductor?

(b) Draw the symbol for OR gate. SEE DIAGRAM




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6. The circuit above consists of an a.c voltage input, a diode, a resistor and a voltmeter. SEE DIAGRAM

(a) Identify the circuit.

(b) Draw the waveform for the output voltage.

7. (a) Write the de-Broglie equation.

(b) Explain the significance of the equation.

PART II [45 marks] — Answer three questions from this part. All questions carry equal marks.

8. (a) (i) Define uniform acceleration. [2 marks]

(ii) Write an equation that relates linear velocity, angular velocity and radius of path in circular motion. [1 mark]

(b) Two forces 30 N and 40 N act at right angles to each other. Determine by scale drawing, the magnitude and direction of the resultant force, using a scale of 1 cm to 5 N. [4 marks]

(c) Explain why ships are usually refilled with sand and water after they have been emptied of their cargo. [3 marks]

(d) A crate of drinks of mass 20 kg is placed on a plane inclined at 30° to the horizontal. If the crate slides down with a constant speed, calculate the:

(i) co-efficient of kinetic friction;

(ii) magnitude of the frictional force acting on the crate. [g = 10 $ms^{-2}$] [5 marks]

9. (a) Define specific latent heat of vaporization. [2 marks]

(b) (i) What are renewable energy sources? [2 marks]

(ii) List four renewable energy sources. [2 marks]

(c) Explain why tomatoes keep longer when kept in a moist jute bag in a clay pot. [3 marks]

(d) A box has a volume of 0.28 $m^3$ and is 70% filled with iron fillings at 25°C. Calculate the:

(i) total mass of the iron fillings;

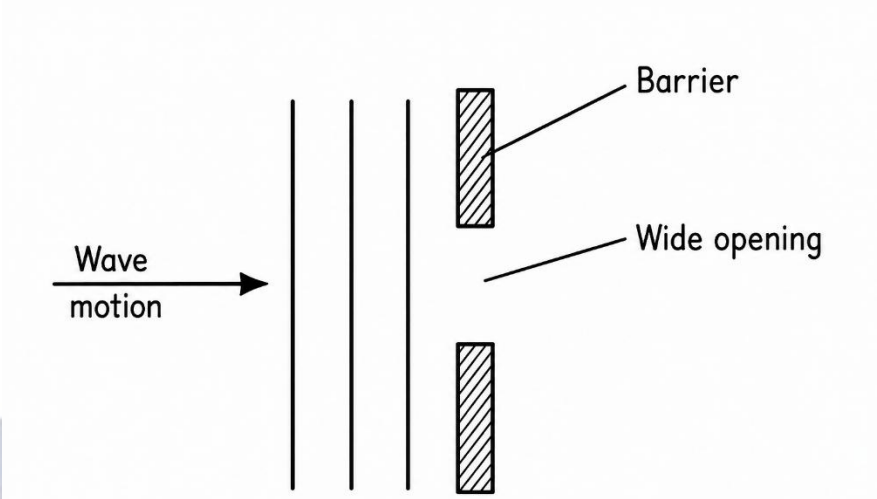
(ii) energy required to melt 10% of the iron fillings.

[Density of iron = $8.00 \times 10^3$ kg $m^{-3}$; specific latent heat of fusion of iron = $1.38 \times 10^5$ $Jkg^{-1}$, specific heat capacity of iron = 460 $Jkg^{-1}K^{-1}$, melting point of iron = 1500°C] [6 marks]

10. (a) (i) What is resonance? [2 marks]

(ii) State two examples of resonance. [2 marks]

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(iii) Differentiate between loudness and intensity of sound. [1 mark]

(b) When a ray is refracted through a rectangular glass prism, which of the following properties of the ray will change? Wavelength, frequency and speed. [2 marks]

(c) SEE DIAGRAM (wave motion through a barrier with a wide opening)

(i) Copy the diagram above in your answer booklet.

(ii) On the copied diagram, sketch the pattern of the waves immediately after passing through the opening. [2 marks]

11. (d) A diverging lens of focal length 18.0 m is used to view a shark that is 90.0 m away from the lens. If the image formed is 1.0 m long, calculate the:

(i) image distance;

(ii) length of the shark. [6 marks]

(11.) (a) Define:

(i) the coulomb; [2 marks]

(ii) resistance. [1 mark]

(b) State the three effects of an electric current. [3 marks]

(c) State the standard international colour convention for the

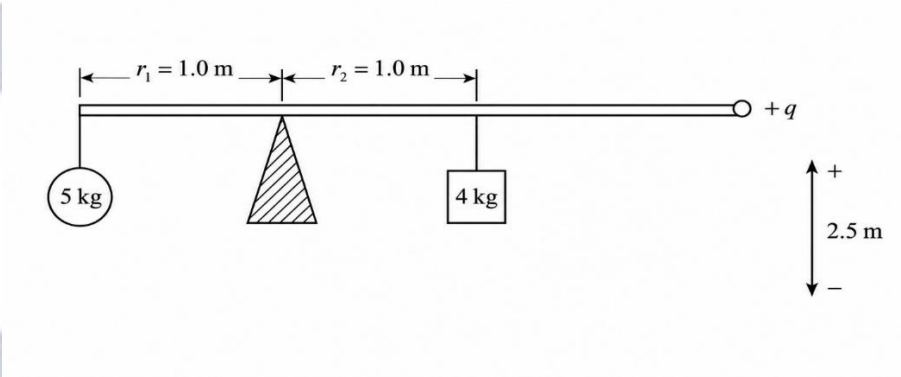
insulating material covering the following electrical wires in a three-pin plug:

(i) live;

(ii) neutral;

(iii) earth. [3 marks]

(d) SEE DIAGRAM (rod suspended with charges +q and -q, weights 5kg and 4kg)




A water melon of mass 5.0 kg is suspended on a uniform rod of mass 4.0 kg and 4.0 m long as illustrated in the diagram above. If the rod is in equilibrium by the action of the force between the charges +q and −q, calculate the:

(i) anticlockwise moment;

(ii) value of q. [g = 10 $ms^{-2}$] [6 marks]

12. (a) Define nucleon number. [2 marks]

(b) A radioactive isotope of Americium (Am − 241) decays into a nucleus of Neptunium (Np − 237) and an alpha (α) particle as shown in the nuclear equation below:

$^{241}_{95}Am \rightarrow {}^{237}Np + {}^{b}_{a}\alpha$

(i) State the number of neutrons in the nucleus of Americium − 241.

(ii) Determine the values of a, b and c. [4 marks]

(c) (i) Why are γ-rays not deflected by electromagnetic fields? [2 marks]

(ii) State two properties of gamma rays that make them suitable for sterilising medical equipment. [2 marks]

(d) A sample of radioactive substance was found to be left with 1/32 of its initial count rate after 110 years. Calculate its decay constant. [5 marks]

# WASSCE 2015 — PHYSICS 2 THEORY

## PART I & PART II — WORKED ANSWERS

QUESTION 1

(a) A projectile is any object that is thrown into the air and left to move under the influence of gravity.

(b) The horizontal component velocity of a projectile remains the same because the acceleration of free fall due to gravity does not act in the horizontal direction.

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QUESTION 2 — Projectile Calculation

Given: $u = 150$ m/s, $\theta = 30°$, $g = 10$ m/s²

Using: $t = u \sin\theta / g$

$= 150 \sin 30° / 10$

$= 150 \times 0.5 / 10$

$= 7.5$

$\therefore t = 7.5$ seconds

QUESTION 3 — Young's Modulus

Given:

$L = 2.00$ m

$r = 1.0$ mm $= 1/1000$ m

$F = 10^3$ N

$\pi = 3.14$

$e = 25/1000$ m

Young's Modulus $= FL / Ae$, where $A = \pi r^2$

$E = (1000 \times 2.00) / (3.14 \times 1/1000 \times 1/1000 \times 25/1000)$

$= 40{,}000{,}000{,}000 / 1.57$

$\therefore E = 2.55 \times 10^{10}$ N/m²

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QUESTION 4 — Cooling of Tea

Ways of increasing the rate of cooling of a cup of tea:

(a) By increasing the rate of evaporation

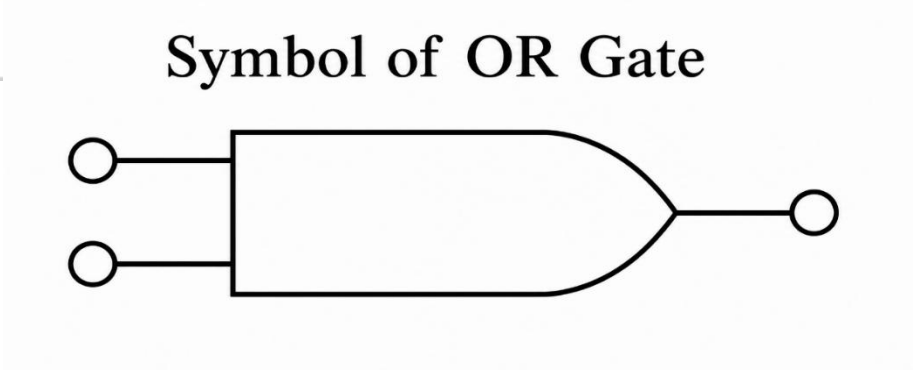
(b) By reducing the ambient temperature

(c) By stirring the tea continuously

QUESTION 5

(a) Doping in a semiconductor is the addition of impurity to a pure semiconductor to raise its electrical conductivity through increase in the number of holes and electrons or charge carriers.

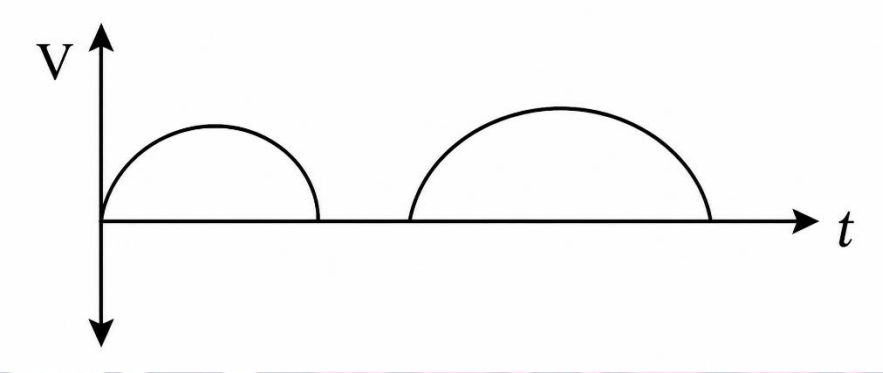
(b) Symbol of OR Gate (SEE DIAGRAM)




QUESTION 6

(a) The circuit drawn is a half-wave rectifier.

(b) Waveform for the output voltage (SEE DIAGRAM)




QUESTION 7

(a) De-Broglie equation is thus:

$\lambda = h/p$ or $\lambda = h/mv$

(b) The significance of de-Broglie equation: a particle of mass M, moving with a speed or velocity V, has an associated wavelength λ, given by $\lambda = h/mv$.

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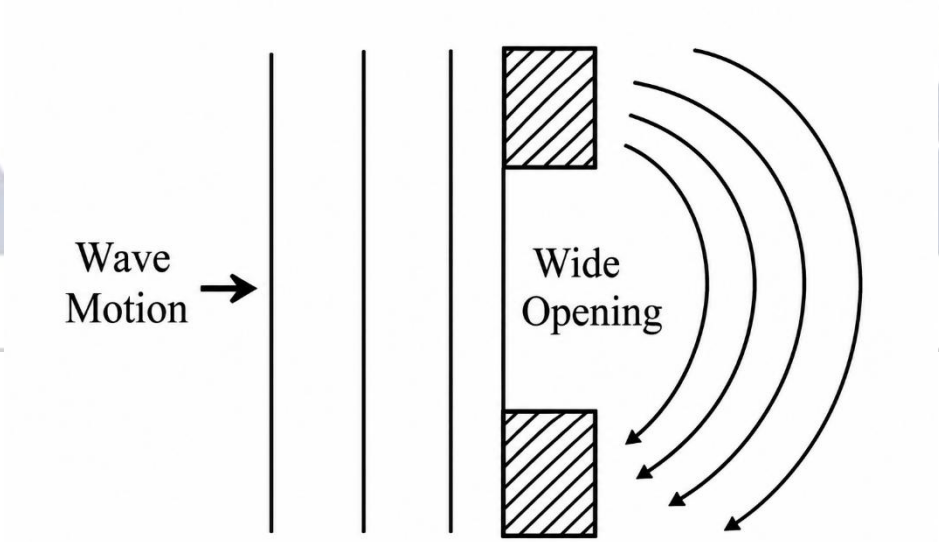
The wavelength decreases with increase in momentum p or velocity.

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PART II

QUESTION 8

(a)(i) Uniform acceleration can be defined as a constant time rate of increase in velocity. Hence, uniform acceleration does not change with time.




(ii) Linear velocity V = ωr

where ω = angular velocity

r = radius of the path (circle)

(b) Scale of 1 cm to 5 N

→ 30 N = 6 cm

→ 40 N = 8 cm

(SEE DIAGRAM — Vector triangle showing resultant = 10 cm = 50N)

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QUESTION 8(c) — Ships and Sand

After emptying ships of their cargo, they are filled with sand and water because a floating ship is balanced by its weight and the upthrust on it. Hence, when off-loaded the upthrust becomes greater than the weight of the ship. Therefore, when refilled with sand and water, equilibrium is restored for stability.

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QUESTION 8(d) — Friction

Given: m = 20 kg, θ = 30°, g = 10 m/s²

(i) Using μ = tan θ = tan 30° = 0.5774

→ Coefficient of kinetic friction = 0.5774

(ii) Frictional force f = μmg cos θ

= 0.5774 × 20 × 10 × cos 30°

= 0.5774 × 200 × 0.8660

= 100.00568

Alternative method:

Frictional force f = mg sin θ

= 20 × 10 × sin 30°

= 200 × 0.5

= 100

∴ Frictional force = 100 N

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QUESTION 9

(a) Specific latent heat of vaporization refers to the quantity of heat required to change a unit mass of a liquid at its boiling point to gas.

(b)(i) Renewable energy sources are the sources of energy that cannot be exhausted.

(ii) Renewable energy sources include:

Sun or Solar

Wind

Ocean wave

Tidal

Biomass or vegetable oils

Geothermal etc.

(c) Tomatoes keep longer when kept in a moist jute bag in a clay pot because the clay pot is porous. Hence, molecules of water in the moist jute bag will extract latent heat of vaporization from the tomatoes which will escape through the pores of the pot, thereby causing cooling of the tomatoes.

(d)(i) Density = Mass / Volume

→ Mass = Density × Volume

= 8.00 × $10^3$ × 70/100 × 0.28

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= 8000 × 70 × 0.28 / 100

= 1568

∴ Mass of iron filings = 1568 kg

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QUESTION 9(d)(ii) — Energy to Melt 10% of Iron

$Q = MC(\theta_2 - \theta_1) + ML$

$= 10/100 \times 1568 \times 460(1500 - 25) + 10/100 \times 1568 \times 1.38 \times 10^5$

$= 15680/100 \times 460(1475) + 15680/100 \times 1.38 \times 10^5$

$= 1568 \times 46 \times 1475 + 1568000000 \times 1.38 / 100$

$= 106,388,800 + 21,638,400$

$= 128,027,200$ J

∴ Energy required = $1.28 \times 10^8$ J

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QUESTION 10

(a)(i) Resonance refers to a phenomenon which occurs whenever a body is set into oscillation at its own natural frequency as a result of impulses received from another vibrating body, vibrating with the same frequency.

(ii) Examples of Resonance:

A radio receiver is tuned to a station when an electrical vibrating circuit inside is set into resonance by the incoming radio waves.

The body of a lorry resonates when its frequency matches the natural frequency of the engine.

A chorister may crack a glass if he produces a note whose frequency is equivalent of oscillation of the glass.

QUESTION 10(a)(iii) — Soldiers Marching on a Bridge

If the frequency of footsteps of soldiers marching over a bridge matches the natural frequency of the bridge, resonance will occur and the bridge will collapse.

5. A sonometer wire may be set vibrating by placing a vibrating tuning fork near and adjusting the tension in the wire. When the natural frequency of the wire becomes equal to that of the tuning fork, the wire begins to vibrate due to resonance.

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QUESTION 10(a)(ii) — **Loudness vs Intensity of Sound**

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| Loudness | Intensity |
|---|---|
| **It depends on the individual's hearing ability** | Sensation depends on physical quantities of energy, time and area |
| **The magnitude of the sensation emanates from sound reaching the ear** | The time rate of flow of energy per unit area is perpendicular to the direction of propagation of the sound |

QUESTION 10(b)

When a ray is refracted through a rectangular glass prism, there would be a change in its speed and wavelength.

**QUESTION 10(c) — Diffraction**

d. Using 1/u + 1/v = 1/f (for diverging lens, f = negative)

(i) → $1/v = 1/f - 1/u$

$= -1/18 - 1/90$

→ $1/v = (-5 - 1) / 90$

$-6v = 90$

∴ $v = 90/6 = -1.5$ m

→ Image distance = 1.5 m

(ii) But $M = v/u = h_i/h_o$

Hence, $h_o = h_i \times u / v$

$= 1 \times 90 / 15$

$= 6.0$ m

∴ Length of the shark = 6.0 m

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QUESTION 11(a)

(i) The Coulomb is the quantity of electric charge transferred by a current of one ampere in one second.

(ii) Resistance is a measure of the electrical component's opposition to the flow of electric charge. It is the ratio of the

potential difference across an electrical component to the current passing through it.

(b) The effects of electric current are:

(i) Heating or thermal

(ii) Magnetic

(iii) Chemical

(iv) Electromagnetic

(c) The standard international colour for insulating cover for a three-pin plug are:

(i) Live is brown or red colour

(ii) Neutral is blue or black colour

(iii) Earth is green/yellow colour

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QUESTION 11(d) — Moments

Given: $m_1 = 5\ kg = 50\ N$; $m_2 = 4\ kg = 40\ N$; $k = 8.99 \times 10^9\ Nm^2/kg^2$; $g = 10\ m/s^2$

(i) Anticlockwise Moment = $5 \times 10 \times 1 = 50\ Nm$

(ii) Clockwise Moment = $4gL_2 + kg^2L_3/L^2$

$= 4 \times 10 \times 1 + 8.99 \times 10^9 \times q^2 \times 3 / (2.5)^2$

$= 40 + 4.315 \times 10^9 \times q^2$

For equilibrium of the rod:

Clockwise moment = Anticlockwise moment

$\rightarrow 40 + 4.315 \times 10^9 \times q^2 = 50$

Such that $q^2 = (50 - 40) / (4.315 \times 10^9)$

$= 10 / (4.315 \times 10^9)$

$\therefore q = \sqrt{(10 / 4.315 \times 10^9)}$

$= 4.814 \times 10^{-5}\ C$

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QUESTION 12

(a)(i) Nucleon number can be defined as the total number of protons and neutrons in the nucleus of an atom.

(b)(i) Number of neutrons in the nucleus of Americium = 241 − 95 = 146

(ii) In: $^{241}_{95}Am \rightarrow {}^{237}_c\ Np + {}^{b}_{a}\alpha$

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a = 2

b = 4

c = 95 − 2 = 93

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QUESTION 12(c)(i)

Gamma rays (γ-rays) are not deflected by electromagnetic field because they are electrically neutral.

(ii) Properties of gamma rays that make them suitable for sterilizing medical equipment are thus:

Gamma rays possess low ionizing power.

They possess strong penetrating power.

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QUESTION 12(d) — Decay Constant

$N/N_o = (1/2)^n = 1/32$

Hence, $(1/2)^n = (1/2)^5$

$\therefore n = 5$

But $T½ = t/n = 110/5 = 22$ years

Using $\lambda = 0.693 / T½$

$\rightarrow \lambda = 0.693 / 22$

$= 3.2 \times 10^{-2}$

$\therefore$ Decay Constant $\lambda = 3.2 \times 10^{-2}$ per year

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# WASSCE 2016

# PHYSICS PAPER 2 (ESSAY)

## PART I

***All questions carry equal marks***

1. State the dimensions of (a) impulse (b) acceleration (c) work.

2. A projectile is fired with a velocity of $20ms^{-1}$ at an angle of 40° to the horizontal. Determine the components of the velocity of the projectile at its maximum height.

3. State three different materials that can be used to demonstrate Brownian motion.

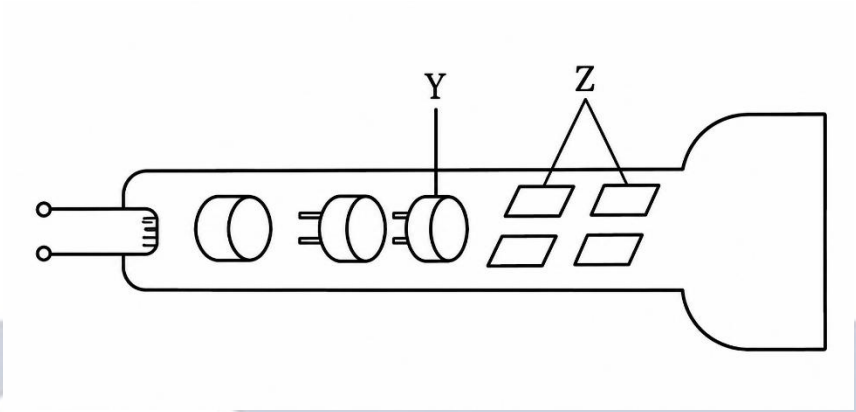
4. An electron enters perpendicularly into a uniform magnetic field which has a flux density of 0.12T. This results in a magnetic force of $9.6 \times 10^{-12}$N on the electron. Calculate the speed of the electron as it enters the magnetic field. ($c = 1.6 \times 10^{-19}$C).

5. List three uses of rockets.

6. (a) What is doping? (b) Explain how doping improves the conductivity of a semiconductor.

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**PART II**




8. The diagram above illustrates a cathode ray tube. SEE DIAGRAM

Identify the components X, Y, and Z.

9. (a) Explain the term net force. [2 marks]

(b) Define the principle of conservation of linear momentum and state one example of it. [3 marks]

(c) A ball of mass 200g released from a height of 2.0m hits a horizontal floor and rebounds to a height of 1.8m. Calculate the impulse received by the floor. ($g = 10ms^{-2}$) [4 marks]

10. A body of mass 20g performs a simple harmonic motion at a frequency of 5Hz. At a distance of 10cm from the mean position, its velocity is $200ms^{-1}$. Calculate its:

(i) maximum displacement from the mean position;

(ii) maximum velocity;

(iii) maximum potential energy.

($g = 10ms^{-2}$; $\pi = 3.14$) [6 marks]

a) Explain the terms:

(i) thermal equilibrium;

(ii) fundamental interval [4 marks]

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b) List two uses of the hydraulic press. [2 marks]

c) Name the material used to reset the steel index in the Six's maximum and minimum thermometer. [1 mark]

d) A nursing mother prepared her baby's milk mixture at 85°C, in a feeding bottle. In order to cool it to 40°C, she immersed the bottle in an aluminium bowl of heat capacity $90JK^{-1}$ containing 500g of water at 26°C. If the mass of the mixture is 300g, calculate the specific heat capacity of the mixture.
[Neglect heat losses and heat capacity of the bottle; specific heat capacity of the water = $4200Jkg^{-1}K^{-1}$] [4 marks]

(ii) (α) Name two ways through which the bottle losses heat. [2 marks]
(β) Name two industrial processes in which heat exchanger is used. [2 marks]

(a) Define critical angle. [2 marks]

How are anti-nodes created in a stationary wave? [2 marks]

The angle of minimum deviation of an equilateral triangular glass prism is 46.2°. Calculate the refractive index of the glass. [3 marks]

An illuminated object is placed in front of a concave mirror and the position of a screen is adjusted in front of the mirror but no image is obtained on the screen. Give two possible reasons for this observation. [2 marks]

(e) An illuminated object is placed at a distance of 75cm from a converging lens of focal length 30cm:
(i) Determine the image distance.
(ii) If the lens is replaced by another converging lens, the object has to be moved 25cm further away to have its sharp image on the screen. Determine the focal length of the second lens. [6 marks]

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11.(a) Explain briefly dielectric strength. [2 marks]

(b) An electromagnetic wave has its wavelength shorter than those of the radiowave and microwave but longer than that of visible light.

(i) Identify the wave.

(ii) Name one suitable detector for the wave.

(iii) Name one source of the wave. [3 marks]

(c) An oil drop carrying a charge of $1.0 \times 10^{-19}$C is found to remain at rest in a uniform electric field of intensity 1200NC$^{-1}$. Calculate the weight of the oil drop. [3 marks]

(d) An RLC series circuit consists of a 100Ω resistor, 0.05H inductor and a 25μF capacitor. A 220V, 50Hz mains voltage is applied across the circuit. Calculate the:

(i) impedance;

(ii) current.

($\pi = 3.14$) [7 marks]

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12.(a) Explain the following terms:

(i) mass defect;

(ii) binding energy of nucleus. [4 marks]

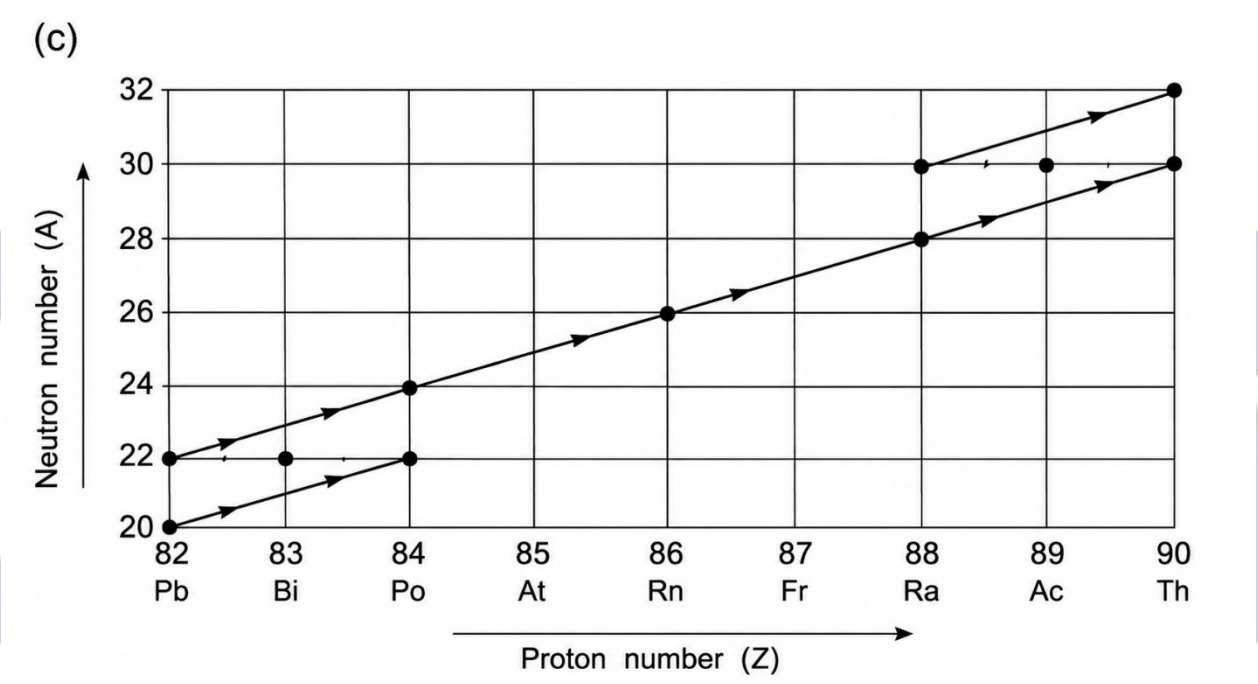
(b) (i) Assuming the wave nature of an electron, what is the effect of decreasing the speed of a photoelectron on its:

(α) wavelength?

(β) energy? [2 marks]

(ii) A particle of mass $4.4 \times 10^{-23}$kg moves with a velocity of $10^5$ $ms^{-1}$. Calculate its wavelength. ($h = 6.6 \times 10^{-34}$Js) [3 marks]

(c) SEE DIAGRAM (graph — Neutron number (Z) plotted against Proton number)




The diagram above shows part of a radioactive decay series. Use it to answer the following questions.

(i) Name a pair of isotopes.

(ii) Name the isotopes with which the series starts.

(iii) Write down a nuclear equation for two examples of each of:

(α) alpha decay;

(β) beta decay. [6 marks]

# ANSWERS TO WASSCE JUNE 2016

# PHYSICS 2 — THEORY

**PART I (THEORY)**

1. Dimension of:

(a) Impulse: Force × time = Ma × t = $MLT^{-2} \times T = MLT^{-1}$

(b) Acceleration = $\Delta v/\Delta t = LT^{-2}$

(c) Work = Force × distance = $MLT^{-2} \times L = ML^2T^{-2}$

2. u = 20m/s, θ = 40°

Horizontal component of velocity: $V_x = u \cos \theta = 20 \cos 40° = 20 \times 0.7660$

∴ $V_x = 15.32$ m/s

Vertical component of velocity at maximum height, Vy = 0

3. Materials that can be used to demonstrate Brownian motion include:

Smoke particles

Carbon particles

Dust particles

Pollen grains

Chalk particles

Potassium permanganate crystals

4. $F = 9.6\times10^{-12}$ N, $e = 1.6\times10^{-19}$, B = 0.12, θ = 90°

Using $F = evB \sin \theta$

$9.6\times10^{-12} = 1.6\times10^{-19} \times V \times 0.12 \times \sin 90°$

$9.6\times10^{-12} = 1.6\times10^{-19} \times 0.12 \times 1 \times V$

Such that $V = 9.6\times10^{-12} / (1.6\times10^{-19} \times 0.12 \times 1)$

$= 5.0\times10^{3}$

∴ Speed of the electron = $5.0\times10^{8}$ m/s

5. Uses of rockets:

i. For space exploration

ii. For fireworks and entertainment

iii. For warfare

iv. For launching satellites into orbits

v. For space travel

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6.(a) Doping refers to the introduction of impurity atoms into a semiconductor.

(b) Doping improves the conductivity of a semiconductor by reducing the energy gap between the conduction band and the valence band, so that charges of minimum energy can enter the conduction band. Doping increases the number of charge carriers (electrons and holes), thereby increasing the conductivity of the semiconductor.

7. Components of X, Y, Z in the Cathode Ray Tube are thus:

X = Heater/Filament/Cathode

Y = Anode

Z = Deflectors/Plates

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PART II

8. (a) Net force refers to an unbalanced force that produces acceleration of a body.

(b)(i) The principle of conservation of linear momentum states that in any closed system of colliding bodies, the total momentum is always conserved provided that there is no net external force acting on the system.

OR: The total momentum of an isolated or closed system of colliding bodies remains constant.

OR: If two or more bodies collide elastically in a closed system, the total momentum before the collision is equal to the total momentum after the collision.

(ii) Examples of bodies exhibiting conservation of linear momentum are:

Recoil of a gun

Colliding trolleys

Rocket propulsion

(c) Using $V^2 = u^2 + 2gh$

Before impact: $V_1^2 = u_1^2 + 2gh_1 = 0 + 2\times10\times2 = 40$

$\therefore V_1 = \sqrt{40} = 6.325$ m/s

After impact: $V_2^2 = u_2^2 - 2gh_2$

$0 = u_2^2 - 2\times10\times1.8$

$0 = u_2^2 - 36.0$

Such that $u_2^2 = 36.0$

$\therefore u_2 = \sqrt{36.0} = 6.0$ m/s

But Impulse = change in momentum = $mV_1 - (-mu_2) = m(V_1 + u_2)$

$= 0.2(6.325 + 6.0)$

$= 0.2(12.325)$

$\therefore$ Impulse = 2.465 Ns

(d) m = 20g = 20/1000 kg, f = 5Hz, V = 200cm/s, y = 10cm = 10/100 m, $\pi = 3.14$

(i) Recall that:

$V = \omega\sqrt{(r^2 - y^2)} = 2\pi f\sqrt{(r^2 - y^2)}$

$2 = 2\times3.14\times5\times\sqrt{(r^2 - 0.1^2)}$

$2 = 31.4\times\sqrt{(r^2 - 0.1^2)}$

Squaring through, we have:

$2^2 = (31.4)^2(\sqrt{(r^2 - 0.1^2)})^2$

$4 = 985.96(r^2 - 0.1^2)$

$4 = 985.96r^2 - 9.8596$

$4 + 9.8596 = 985.96r^2$

$13.8596 = 985.96r^2$

$r^2 = 13.8596/985.96$

$r = \sqrt{(13.8596/985.96)} = 0.12$

$\therefore$ Maximum displacement from the mean position = 0.12m

(ii) $V_{max} = \omega r = 2\pi fr$

$= 2\times3.14\times5\times0.12$

$= 3.768$

$\therefore$ Maximum velocity = 3.768 m/s

(iii) $E_{p(max)} = \frac{1}{2}M\omega^2r^2 = \frac{1}{2}M(2\pi f)^2r^2$

$= \frac{1}{2}\times0.02\times(2\times3.14\times5)^2\times(0.12)^2$

$= 1.42\times10^{-1}$

$\therefore$ Maximum potential energy = $1.42\times10^{-1}$ J

9.(a)(i) Thermal equilibrium is a condition in which two bodies in contact have no net flow of heat between them. Hence, a body is said to be in thermal equilibrium if no net heat exchange is taking place within it or between it and its surroundings.

(ii) Fundamental interval is the difference in temperature between the ice point and steam point of a thermometer.

(Continues:) Uses [of the thermometer/effect — continued from prior page]:

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2. In refrigeration

3. In air conditioning

4. In sewage treatment

5. In cooling by radiators

6. In generating electricity, etc.

10.(a) Critical angle can be defined as the angle of incidence in the denser medium for which the angle of refraction in the less dense medium is 90°.

(b) Creation of antinodes in stationary waves: Antinodes are created when an incident and its reflected waves are superimposed and 180° out of phase.

(c) n = sin[(A + Dm)/2] ÷ sin(A/2)

= sin[(60+46.2)/2] ÷ sin(60/2)

= sin(106.2/2) ÷ sin 30

= sin 53.1 / sin 30

= 1.5782

∴ A = 1.6

(d) No image on screen if:

(i) the object is placed between the focus and pole of the mirror.

(ii) the object is placed at the focal point of the mirror.

(iii) the object, screen and mirror are not coaxial.

(iv) the screen is located at a distance less than or greater than the actual image distance.

(e)(i) 1/u + 1/v = 1/f

1/75 + 1/v = 1/30

1/v = 1/30 − 1/75

1/v = (5−2)/150

1/v = 3/150

3v = 150

∴ v = 150/3 = 50cm

(ii) If u = 75+25 = 100cm

Using 1/u + 1/v = 1/f

1/100 + 1/50 = 1/f

(1+2)/100 = 1/f

Such that 1/f = 3/100

3f = 100

∴ f = 100/3 = 33.3 cm

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11.(a) Dielectric strength refers to the maximum potential gradient/electric field strength an insulator can withstand without breaking down. It is measured in V/m.

(b)(i) It is Infra-red wave/radiation

(ii) Suitable detectors are:

Infra-red camera

Thermopile

Photographic film

Bolometer

(b) [continued] Uses of the Hydraulic Press:

(i) In compressing paper in printing industry

(ii) In lifting objects

(iii) In compressing soft materials into bales

(iv) In compressing metal sheets

(c) The material used to reset the steel index in the Six's Maximum and Minimum thermometer is Magnet.

(d)(i) Heat lost by mixture = Heat gained by water + Heat gained by Aluminium

$(Mc\ \Delta\theta)$ mixture = $(Mc\ \Delta\theta)$water + $(C\ \Delta\theta)$Aluminium

$0.3 \times Cm(85-40) = 0.5 \times 4200(40-26) + 90(40-26)$

$0.3 \times Cm(45) = 2100(14) + 90(14)$

$13.5\ Cm = 29400 + 1260$

$Cm = (29400+1260)/13.5$

$= 30,660/13.5$

$= 2271.11$

$\therefore Cm = 2271.11$ J/kg/K

(ii) α = By Conduction, By Convection

β = Heat Exchangers are used industrially in the following processes:

In Incubation

8.(ii) Source of the Wave:

✱ Sun

✱ Heated objects/Hot bodies

(c) $E = F/q = W/q$

$\Rightarrow W = Eq$

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= 1200 × $1.0\times10^{-19}$

= $1.2\times10^{-16}$ N

∴ Weight of the oil drop = $1.2\times10^{-16}$ N

(d) $X_L = 2\pi fL$

= $2\times3.14\times50\times0.05$

= 15.7 Ω

$X_C = 1/(2\pi fC)$

= $1/(2\times3.14\times50\times25\times10^{-6})$

= 127.4 Ω

(i) $Z = \sqrt{(R^2 + (X_C - X_L)^2)}$

= $\sqrt{(100^2 + (127.4-15.7)^2)}$

∴ Impedance = 149.9 Ω

(ii) I = V/Z = 220/149.9 = 1.4676

∴ Current, I ≈ 1.47 A

12.(a)(i) Mass defect is the difference between the rest mass of an atomic nucleus and the sum of the rest masses of its individual nucleons in the unbound state.

It is the mass equivalent of the binding energy on the basis of the mass-energy equation.

It is expressed in atomic mass unit.

It is total mass of nucleons − Mass of nucleus.

(ii) Binding energy is the energy equivalent to the mass defect when nucleons bind together to form an atomic nucleus. In other words, it is the work or energy required to separate the nucleons in a nucleus. It is measured in electron volt or Joule (eV or J).

(b)(i) Effect of decreasing the speed of a photoelectron on its:

Wavelength — brings about an increase in the wavelength.

Energy — decreases the energy.

(ii) $\lambda = h/mv$

= $6.6\times10^{-34} / (4.4\times10^{-23} \times 10^{5})$

= $6.6\times10^{-34} / 4.4\times10^{-18}$

= $1.5\times10^{-16}$

∴ Its Wavelength = $1.5\times10^{-16}$ m

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13.(i) The pairs of isotopes are:

$^{208}_{82}Pb$ and $^{212}_{82}Pb$, or $^{212}_{84}Po$ and $^{216}_{84}Po$

$^{224}_{88}Ra$ and $^{228}_{88}Ra$, or $^{228}_{90}Th$ and $^{232}_{90}Th$

(ii) The isotope that starts the series is $^{232}_{90}Th$.

(iii) Nuclear equation for alpha decay:

$^{232}_{90}Th \rightarrow {}^{228}_{88}Ra + {}^{4}_{2}He + Energy$

$^{228}_{90}Th \rightarrow {}^{224}_{88}Ra + {}^{4}_{2}He + Energy$

$^{224}_{88}Ra \rightarrow {}^{220}_{86}Rn + {}^{4}_{2}He + Energy$

$^{212}_{84}Po \rightarrow {}^{208}_{82}Pb + {}^{4}_{2}He + Energy$

$^{220}_{84}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}He + Energy$

$^{216}_{84}Po \rightarrow {}^{212}_{82}Pb + {}^{4}_{2}He + Energy$

Nuclear equation for beta decay:

$^{224}_{88}Ra \rightarrow {}^{224}_{89}Ac + {}^{0}_{-1}e + Energy$

$^{228}_{89}Ac \rightarrow {}^{228}_{90}Th + {}^{0}_{-1}e + Energy$

$^{212}_{82}Pb \rightarrow {}^{212}_{83}Bi + {}^{0}_{-1}e + Energy$

$^{212}_{83}Bi \rightarrow {}^{212}_{84}Po + {}^{0}_{-1}e + Energy$

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# WAEC PHYSICS

## 2017 PAPER 2 (ESSAY)

## Time: 1½ hours | 60 marks

***Answer eight questions in all: five questions from Part I and three questions from Part II. All questions carry equal marks.***

**PART I [15 marks] — Answer any five questions from this part**

1.

(a) What is a projectile? *[2 marks]*

(b) Give the reason why the horizontal component of the velocity of a projectile remains the same at every point of its flight. *[1 mark]*

2. A body is projected at an angle of 30° to the horizontal with a velocity of 150 $ms^{-1}$. Calculate the time it takes to reach the greatest height. *[Take g = 10 $ms^{-2}$] [3 marks]*

3. A wire of length 2.00 m and radius 1.0 mm is stretched by 25.0 mm on application of a force of $10^3$ N. Calculate the Young's modulus for the wire. *[3 marks]*

4. State three ways of increasing the rate of cooling of a cup of hot tea. *[3 marks]*

5.

(a) What is doping in a semi-conductor?

(b) Draw the symbol for OR gate.

6. The circuit below consists of an a.c. voltage input, a diode, a resistor, and a voltmeter.

(a) Identify the circuit.

(b) Draw the waveform for the output voltage.

*(See circuit diagram — Diagram 1)*

7.

(a) Write the de-Broglie equation.

(b) Explain the significance of the equation.

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PART II — [45 marks] — Answer three questions from this part

8.(a) (i) Define uniform acceleration. *[2 marks]*

(ii) Write an equation that relates linear velocity, angular velocity, and radius of path in circular motion. *[1 mark]*

(b) Two forces, 30 N and 40 N, act at right angles to each other. Determine, by scale drawing, the magnitude and direction of the resultant force, using a scale of 1 cm to 5 N. *[4 marks]*

(c) Explain why ships are usually refilled with sand and water after they have been emptied of their cargo. *[3 marks]*

(d) A crate of drinks of mass 20 kg is placed on a plane inclined at 30° to the horizontal. If the crate slides down with a constant speed, calculate the:

(i) co-efficient of frictional force acting on the crate;

(ii) magnitude of frictional force.

*[Take $g = 10\ ms^{-2}$] [5 marks]*

9.

(a) Define specific latent heat of vaporization. *[2 marks]*

(b) (i) What are renewable energy sources? *[2 marks]*

(ii) List four renewable energy sources. *[2 marks]*

(c) Explain why tomatoes keep longer when kept in a moist jute bag in a clay pot. *[3 marks]*

(d) A box has a volume of 0.28 $m^3$ and is 70% filled with iron fillings. *[Density of iron = $8.00 \times 10^3\ kg\ m^{-3}$; specific latent heat of fusion of iron = $1.38 \times 10^5\ J\ kg^{-1}$; specific heat capacity of iron = $460\ J\ kg^{-1}\ K^{-1}$; melting point of iron = 1500 °C]*

Calculate the:

(i) total mass of the iron fillings;

(ii) energy required to melt 10% of the iron fillings.

*[6 marks]*

10.

(a) (i) What is resonance? *[2 marks]*

(ii) State two examples of resonance. *[2 marks]*

(iii) Differentiate between loudness and intensity of sound. *[1 mark]*

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(b) When a ray is refracted through a rectangular glass prism, which of the following properties of the ray will change: Wavelength, frequency and speed. *[2 marks]*

(c) (i) Copy the diagram below into your answer booklet.

(ii) On the copied diagram, sketch the pattern of the waves immediately after passing through the opening. *[2 marks]*

*(See wave diagram — Diagram 2)*

11.

(a) Define:

(i) the coulomb; *[2 marks]*

(ii) resistance. *[1 mark]*

(b) State the three effects of an electric current. *[3 marks]*

(c) Describe the standard international colour convention for the insulating material covering the following electrical wires in a three-pin plug:

(i) live;

(ii) neutral;

(iii) earth. *[3 marks]*

(d) A watermelon of mass 5.0 kg is suspended on a uniform rod of mass 4.0 kg and 4.0 m long, as illustrated in the diagram below. If the rod is in equilibrium by the action of the charges +q and −q, calculate the:

(i) anticlockwise moment;

(ii) value of q.

*[Take g = 10 $ms^{-2}$] [6 marks]*

*(See rod/equilibrium diagram — Diagram 3)*

11 (previous, continued from Part I overflow — Question on diverging lens):

A diverging lens of focal length 18.0 m is used to view a shark that is 90.0 m away from the lens. If the image formed is 1.0 m long, calculate the:

(i) image distance;

(ii) length of the shark.

*[6 marks]*

12.

(a) Define nucleon number. *[2 marks]*

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(b) A radioactive isotope of Americium (Am−241) decays into a nucleus of Neptunium (Np−237) and an alpha (α) particle, as shown in the nuclear equation below:

$$^{241}_{95}Am \rightarrow {}^{237}_{93}Np + {}^{4}_{2}\alpha$$

Determine the values of a, b and c. *[2 marks]*

(c) (i) Why are γ-rays not deflected by electromagnetic fields? *[4 marks]*

(ii) State two properties of gamma rays that make them suitable for sterilising medical equipment. *[2 marks]*

(d) A sample of radioactive substance was found to be left with 1/32 of its initial count rate after 110 years. Calculate its decay constant. *[5 marks]*

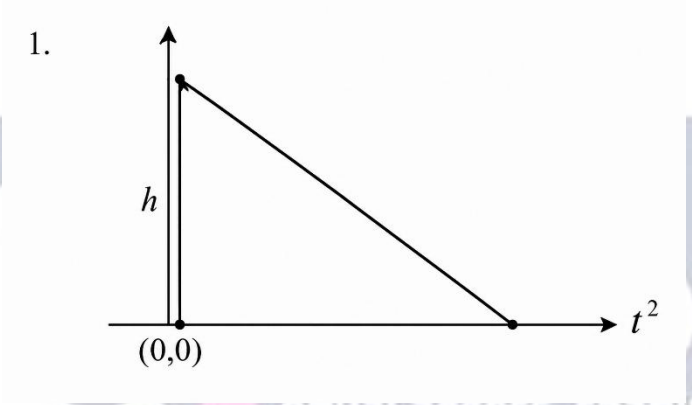
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# ANSWERS TO WASSCE JUNE 2017

## PHYSICS 2 — THEORY

**PART I**

1.

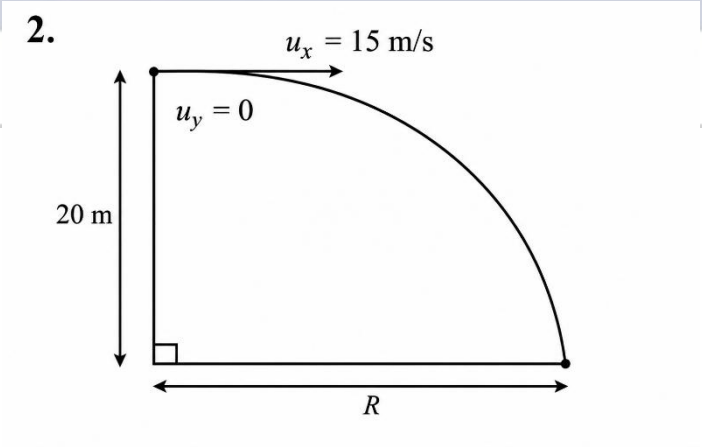



1. [Sketch: graph of h vs $t^2$, straight line from origin]

The above sketch indicates that the height of the particle decreases heavily with time ($t^2$).

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2.




2. [Diagram: projectile motion, Ux=15m/s, Uy=0, height 20m, curved path to range R]

Using $h(max) = Ut + \frac{1}{2}gt^2$

Since Uy = 0 at maximum height,

$h = 0 \times t + \frac{1}{2}gt^2$

$\Rightarrow h = \frac{1}{2}gt^2$

$20 = \frac{1}{2} \times 10 \times t^2$

or $20 = 5t^2$

$\Rightarrow t^2 = 20/5 = 4$

$\therefore t = 2s$

Now Range = $U_x \times t = 15 \times 2 = 30m$

OR: $R = U_x\sqrt{(2h/g)} = 15\times\sqrt{(2\times20/10)} = 15\sqrt{4} = 15\times2 = 30m$

3. Phenomena that can be explained by molecular theory of matter are thus:

Brownian motion

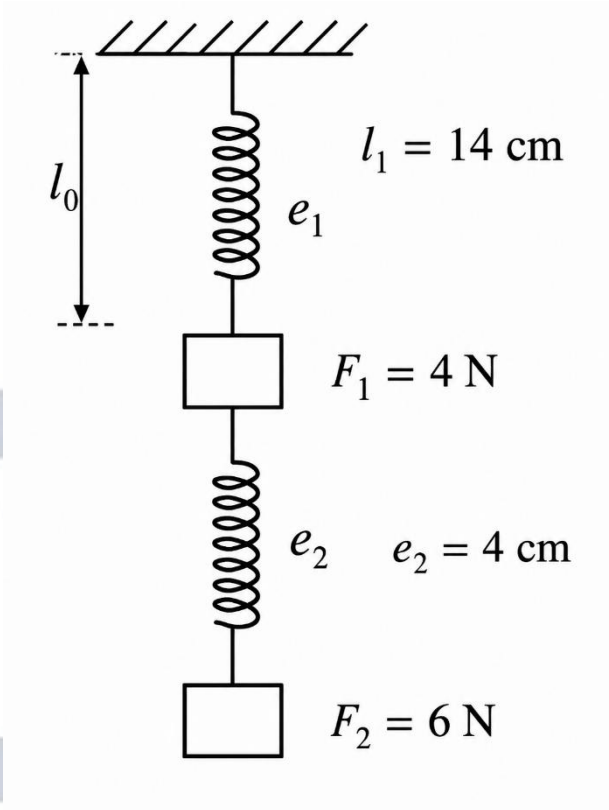
Diffusion

Osmosis

Viscosity

Capillary action (capillarity)

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4. [Diagram: spring system, natural length $L_o$, extension $e_1$ to $F_1$=4N, extension $e_2$=4cm to $F_2$=6N, total length $L_1$=14cm]

Applying Hooke's law:

$F_1/e_1 = F_2/e_2$ (But $e_1 = L_1 - L_o$)

Hence, $F_1/(L_1-L_o) = F_2/e_2$

$\Rightarrow 4/(14-L_o) = 6/4$

$\Rightarrow 6(14-L_o) = 4(4)$

$16 - 8L_o$... (equation continues onto next page)

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**PART II**

5.(a) [Diagram: light rays through a liquid surface]

Surface tension depends on the following factors:

(i) Temperature of the liquid

(ii) Nature of the liquid

(iii) Purity of the liquid

(b) Mosquito larvae can be made to sink by the addition of any of the following:

(i) Camphor

(ii) Alcohol

(iii) Soap or Detergent

(iv) Heat

6. $l_o = -68/6 = 11.33$ cm

7. Advantages of P-N junction diode over Fluorescent tubes are thus:

a. They consume less electrical energy.

b. They produce less heat energy.

c. They last longer while in use.

Advantages of P-N junction diodes are as follows:

i. P-N junction diode requires low voltage to operate.

ii. It is more economical (cheaper) and not bulky.

iii. It is portable

iv. It manufactures in large quantities

It does not require time to warm up.

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PART II (continued)

8.(a) Deductions from displacement-time graph are thus:

(i) Displacement-time graphs have uniform velocity.

(ii) They possess initial displacement.

(iii) They have instantaneous velocity.

(b) Doubling the distance between two equal masses and their masses would make the force to remain the same.

Hence, $F_1 = GMm/R^2$ (From Newton's law of Gravitation)

and $F_2 = G(2M \times 2m)/(2r)^2 = G4m^2/4r^2$ (if M=m)

$\Rightarrow F_2 = GM^2/R^2 = GMm/R^2$

Hence, $F_1 = F_2$

(c) Factors affecting the maximum height of a projectile are thus:

Initial speed or velocity

Air resistance

Angle of projection (elevation)

Acceleration of free fall due to gravity

(d) Practical Examples of Mechanical Resonance:

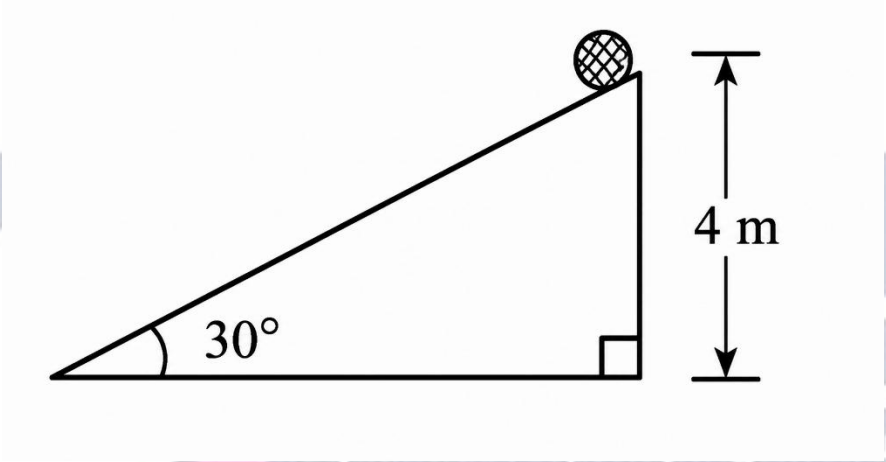
(i) Collapse of a bridge by marching soldiers.

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(ii) Rattling of car bodies at very high speed.

(iii) Shattering of glass due to high pitch note.

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9.(e) [Diagram: incline plane at 30°, height 4m]

h = 4m, g = 10m/s², μ = 0.3, θ = 30°

Acceleration = g sinθ − μg cosθ

⇒ a = 10×sin30 − 0.3×10×cos30

⇒ a = 10×0.5 − 0.3×10×0.8660

⇒ a = 5.0 − 2.598

= 2.402

⇒ a ≈ 2.4 m/s²

Now distance covered = 4/sin30

= 4/0.5 = 8m

Using S = ut + ½at²

⇒ 8 = 0×t + ½×2.4×t²

⇒ 8 = 2.4t²/2

Hence, t² = 8×2/2.4 = 8/1.2

∴ t = √(8/1.2) = √6.6667

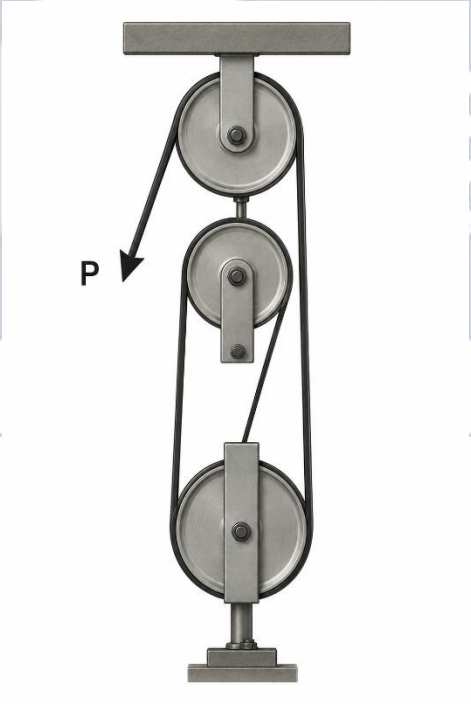
⇒ t = 2.581995

≈ 2.58 seconds

∴ The time to reach the bottom of the plane = 2.58 sec

---

9.(a) A body is said to be in stable equilibrium if it tends to return to its original position after being slightly displaced.




[Diagram: block and tackle pulley system, 3 pulleys, P labelled at top]

For a block and tackle system of pulleys with a velocity ratio of 3, the number of pulleys in the system could be equal to three (3).

(c) Applying the pressure law: $P_1/T_1 = P_2/T_2$

Where $P_1 = 4.5\times10^5$, $P_2 = 4.6\times10^5$, $T_1 = 20+273 = 293K$; $T_2 = ?$

⇒ $4.5\times10^5/293 = 4.6\times10^5/T_2$

Such that $T_2\times4.5\times10^5 = 293\times4.6\times10^5$

⇒ $T_2 = (293\times4.6\times10^5)/(4.5\times10^5) = 299.511$

∴ $T_2 = 299.51K$ or $26.51°C$

10.(a) A wavefront is a line or surface within a two or three-dimensional medium through the locus of all adjacent points which are passing at which the disturbances are in phase, in other words, a wavefront refers to a surface over which a particle simply vibrates in the same phase.

(b)(i) For the resistance thermometer:

$R_T - R_o / R_{100} - R_o = \theta - 5.67 / 373 - 273$

$\Rightarrow 7.5 - 5.67 = \theta - 273 / 373 - 273$

$K.\theta - 5.67 = \theta - 273 / 100$

$1.88 = \theta - 273 / 100$

(ii) For the gas thermometer:

$G\theta - (7.13)\times10^4 / (1.94-7.13)\times10^4 = \theta - 273 / 373-273$

$G\theta - 7.13/2.16 = \theta-273/100$

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(calculation continues off-page)

(b)(ii) Practical uses of glass prisms:

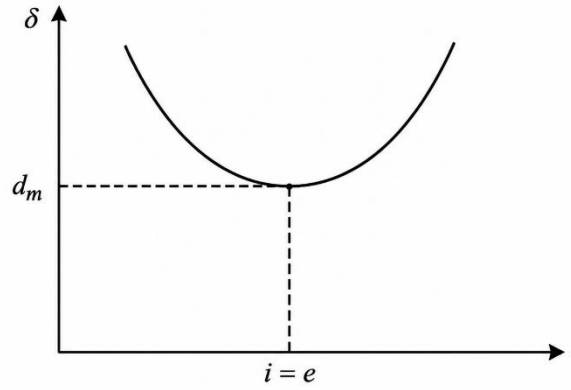
For viewing objects over obstacles.

To determine the refractive index of glass material.

To determine the dispersion of light.

Used in Binoculars to see distant objects.

(ii) Variation of the angle of deviation and angle of incidence :



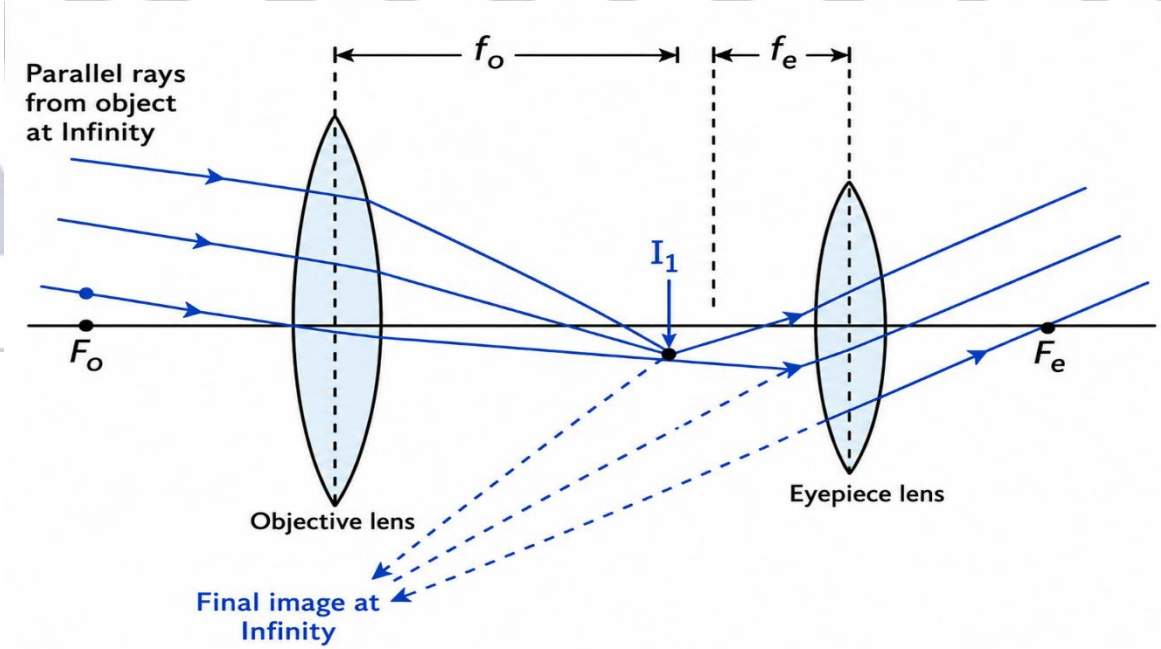

11. [Diagram: light rays through triangular prism, angle of incidence i, angle of deviation Dm]

(ii) Factors that determine the deviation of light from Air to triangular Prism are thus:

The refractive index of the prism.

The angle of incidence.

The refracting angle of the prism.




(iii) Variation of the angle of deviation and angle of incidence: [graph showing Dm vs i, with i=e marked]

(c)(i) Astronomical Telescope in normal adjustment: [Diagram: parallel rays from object at infinity, through objective lens (Fo), forming image I, through eyepiece lens (Fe), final image at infinity]

(ii) Magnification, M = Fo/Fe

S = 100

5Fe = 100

∴ Fe = 100/5 = 20cm

Length of Telescope = Fo + Fe

= 100 + 20

= 120cm

11.(a)(ii) A dielectric is a nonconductor or an insulating material which separates two parallel plate conductors (capacitors).

(ii) $C = \varepsilon_r\varepsilon_o A/d$

$= (900\times8.85\times10^{-12}\times9.6\times10^{-3}) / (2.25\times10^{-4})$

$= 76464\times10^{-15} / 2.25\times10^{-4}$

$= 33984\times10^{-11}$

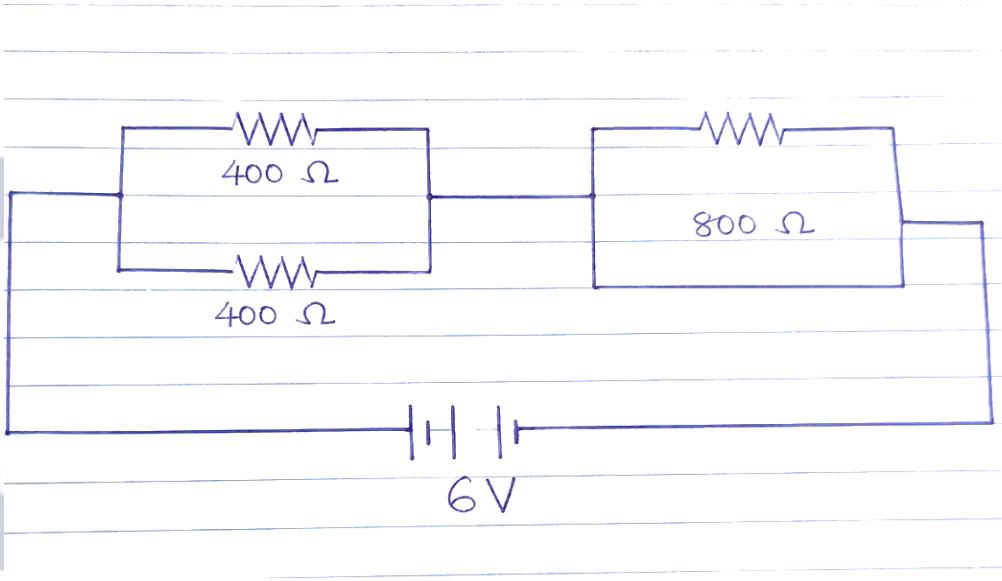
$C = 3.3984\times10^{-7}$ F

∴ Capacitance of the Capacitor = $3.4\times10^{-7}$ F

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(b) Between an ammeter and a Voltmeter, the Voltmeter has a higher resistance.

Reason: A voltmeter is usually connected in parallel in a circuit to allow passage of a small (minimal) current, hence the current through the circuit is not significantly affected.




[Diagram: circuit with 6V source, 400Ω and 800Ω resistors, and an ammeter/voltmeter arrangement]

$1/R_1 = 1/400 + 1/400 = 2/400$

$\therefore R_1 = 200\Omega$

$1/R_2 = 1/800 + 1/800 = 2/800$

$\therefore R_2 = 400\Omega$

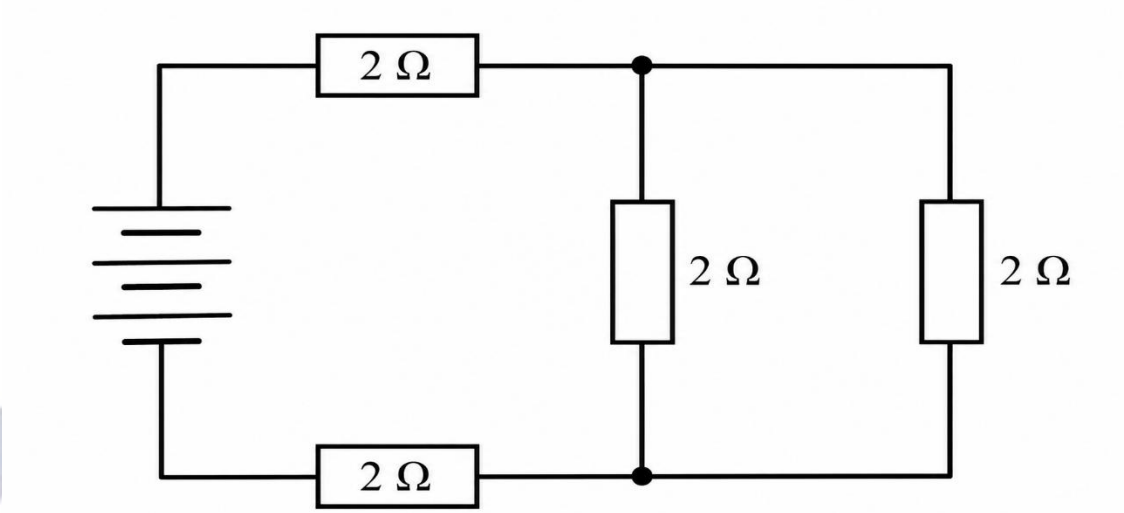
$\Rightarrow R_total = 200 + 400 = 600\Omega$

But $I = V/R_1 = 6/600 = 0.01A$

Voltmeter reading = p.d. across $R_2$

$= 0.01 \times 400$

$= 4.00$ V




12.(c) [Circuit diagram: EMF source E, 2Ω resistors — one in series, three in parallel arrangement]

Using $1/Rp = 1/R_1 + 1/R_2$ (for parallel connection)

$\Rightarrow 1/Rp = 1/2 + 1/2$

$\Rightarrow Rp = 1\Omega$

Total Resistors in Series and Parallel:

R_T = 2 + 1 + 2 = 5Ω

12.(a)(i) Nuclear fission refers to the splitting up of a heavy nucleus into lighter nuclei with the release of a large amount of energy and neutrons.

(ii) Functions of Graphite, Boron rods and liquid Sodium:

✱ Graphite helps in slowing down high energetic neutrons in the reaction chamber.

✱ Boron rods are used to absorb excess neutrons so as to control the fission rate.

✱ Liquid sodium is used extensively in the extraction and conduction of excess heat from the reaction chamber.

---

12.(b)(i) Energy levels:

$E_{\infty}$, $n=\infty = 0$ eV

$E_5$, $n=5 = -0.54$ eV

$E_4$, n=4 = −0.85 eV

$E_3$, n=3 = −1.51 eV

$E_2$, n=2 = −3.39 eV

$E_1$, n=1 = −13.60 eV

(ii) Using $\lambda = hc/\Delta E$

$= (6.6\times10^{-34} \times 3.0\times10^{8}) / [(-1.51-(-13.60))\times1.6\times10^{-19}]$

$= 19.8\times10^{-26} / 19.344\times10^{-19}$

$= 1.02357\times10^{-7}$

∴ Wavelength of the photon = $1.02\times10^{-7}$ m

(c) $\lambda = 0.693/T½ = 0.693/5572 = 0.0001244$/yr

Recall: $N = N_o e^{(-\lambda t)}$

⇒ $e^{(-0.0001244t)} = 1.2632$

⇒ $0.0001244t = 0.234$

∴ $t = 0.234/0.0001244 = 1881$ years

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# WASSCE JUNE 2018

# PHYSICS 2 THEORY QUESTIONS

**PART I**

1. (a) Define strain. (b) A rubber band is stretched to twice its original length. Calculate the strain on the rubber band.

2. State three materials used for making optical fibres.

3. Name three classes of magnetic materials.

4. (a) What is an intrinsic semiconductor? (b) Distinguish between the p-type and n-type semiconductors.

5. A missile is projected to attain its maximum range. Calculate the maximum height attained if the initial velocity of projection is 200 $ms^{-1}$. [g = $10ms^{-2}$]

6. A black body radiates maximum energy when its surface temperature T and the corresponding wavelength λmax are related by the equation, λmax T = constant. Given the values of the constant and surface temperature as $2.9 \times 10^{-3}$ mK and 57°C respectively, calculate the frequency of the energy radiated.

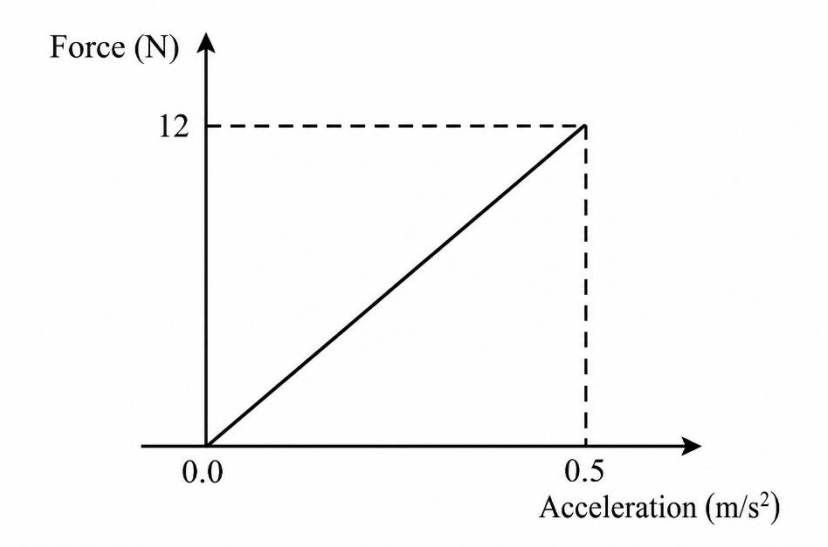
7. (a) What does the acronym LASER stand for?

(b) What is a laser?

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PART II

8. (a) Define uniform acceleration. (b) Forces act on a car in motion. List the: (i) horizontal forces and their directions; (ii) vertical forces and their directions. (c) A car starts from rest and accelerate uniformly for 20 s to attain a speed of 25 $ms^{-1}$. It maintains this speed for 30 s before decelerating uniformly to rest. The total time for the journey is 60 s. (i) Sketch a velocity-time graph for the motion. (ii) Use the graph to determine the: (α) total distance travelled by the car; (β) deceleration of the car.




(d) SEE DIAGRAM — The figure shows a force-extension graph for a stretched spiral spring (Force/N on y-axis up to 12, Extension/cm on x-axis up to 0.5). Determine the work done on the spring.

9. (a) List two factors each that affect heat loss by: (i) radiation; (ii) convection.

(b) State two factors that determine the quantity of heat in a body.

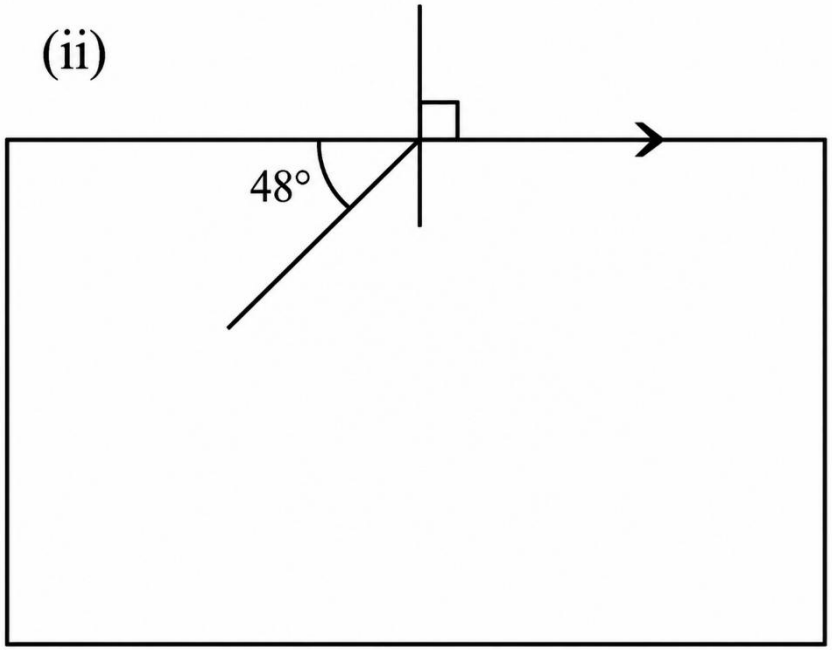
(c) Explain the statement: The specific latent heat of vaporization of mercury is $2.72 \times 10^5$ J $kg^{-1}$.

(d) A jug of heat capacity 250 J $kg^{-1}$ contains water at 28°C. An electric heater of resistance 35 Ω connected to a 220 V source is used to raise the temperature of the water until it boils at 100°C in 5 minutes. After another 5 minutes, 300 g of water has evaporated. Assuming no heat is

lost to surroundings, calculate the: (i) mass of water in jug before heating; (ii) specific latent heat of vaporization of steam.

[Specific heat capacity of water = 4200 J $kg^{-1}$]

10. (a) Define diffraction. (b)(i) Explain critical angle.




(ii) **SEE DIAGRAM** — The diagram shows a ray of light passing through a rectangular transparent plastic block at an angle of 48°. (α) Determine the value of the critical angle. (β) Calculate the refractive index of the block.

(c) A pipe closed at one end has fundamental frequency of 200 Hz. The frequency of the first overtone of the closed pipe is equal to the frequency of the first overtone of an open pipe. Calculate the:

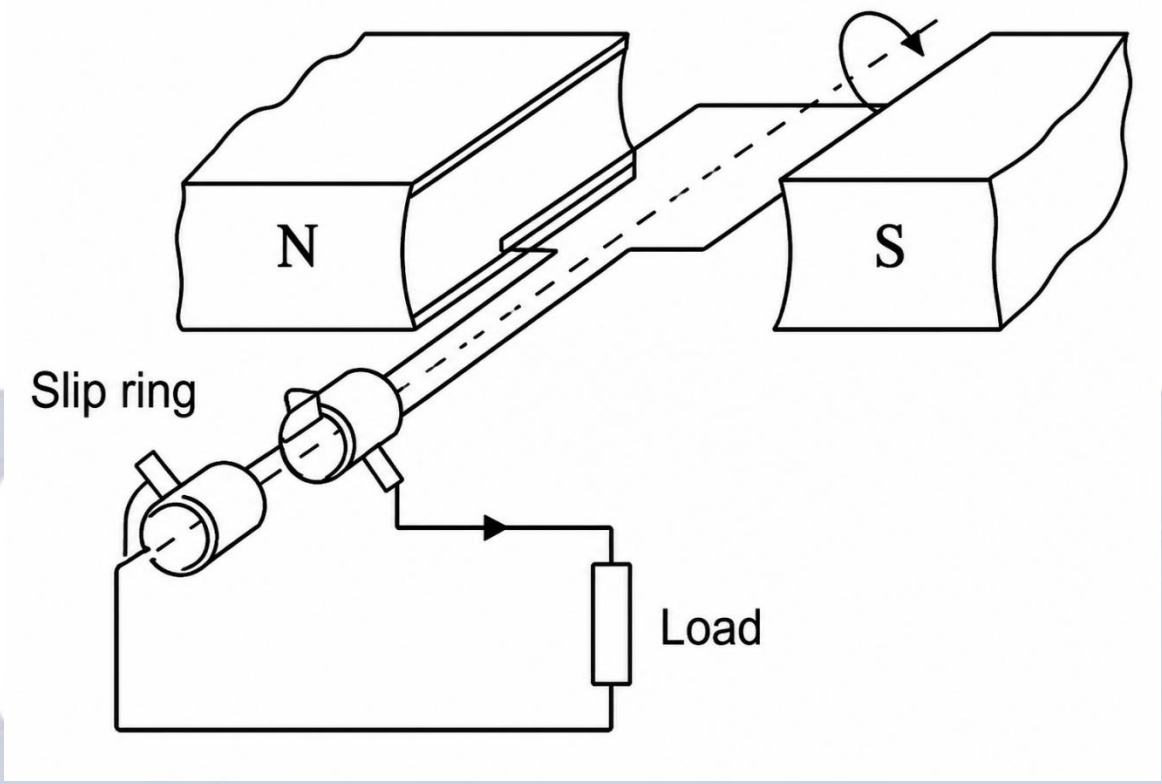
(i) fundamental frequency of the open pipe;

(ii) length of the closed pipe;

(iii) length of the open pipe.

[Speed of sound in air = 330 $ms^{-1}$]

11. (a) Define: (i) reactance; (ii) impedance in an a.c. circuit.




**SEE DIAGRAM** — The diagram illustrates an a.c. generator with N and S magnetic poles, a coil, slip rings, and a load connected in a circuit. When the coil is rotated, an e.m.f. is induced in the coil.

(i) Explain why an e.m.f. is induced.

(ii) State the purpose of the slip-rings.

(iii) Name and state the law used to determine the direction of the induced current.

(iv) State two ways to increase the induced e.m.f.

(c) A lamp is rated 12 V, 6 W. Calculate the amount of energy transformed by the lamp in 5 minutes.

12. (a) Define binding energy in an atom.

(b) List three evidence to support the claim that X-rays are electromagnetic waves.

(c) List three peaceful uses of nuclear energy.

(d) Light of wavelength $4.5 \times 10^{-7}$ m is incident on a metal resulting in the emission of photo electrons. If the work function of the metal is $3.0 \times 10^{-9}$ J, calculate the: (i) frequency of the incident light; (ii) energy of the incident light; (iii) energy of the photoelectrons.

[Speed of light = $3.0 \times 10^{8}$ $ms^{-1}$, h = $6.6 \times 10^{-34}$ Js]

# ANSWERS TO WASSCE JUNE 2018

## PHYSICS 2 (ESSAY)

**PART I**

1(a). Strain refers to the ratio of the change in length (extension) of a body to the original length.

1(b). Strain = extension/original length

Strain = $e/L_o = (2L_o - L_o)/L_o = L_o/L_o = 1$

2. Materials used in making optical fibre are:

Silica

Quartz

Silicon

Polycarbonate

Teflon sheet

Glass

Sapphire

3. Classes of Magnetic Materials are thus:

(i) Diamagnetic

(ii) Paramagnetic

(iii) Ferromagnetic

4(a). An intrinsic semiconductor is one in which the concentration of charge carriers is a characteristic of the material itself. Hence, an intrinsic semiconductor contains equal number of free electrons and holes.

4(b). Differences between P-type and N-type Semiconductors:

| **P-type** | **N-type** |
|---|---|
| **(i) The impurity is trivalent** | The impurity is pentavalent |
| **(ii) The majority carrier of electricity is holes** | The majority carrier of electricity is electrons |

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| | |
|---|---|
| **(iii) P-type carries a net positive charge** | N-type carries a net negative charge |

5. For a projectile to attain its maximum range, its angle of projection must be equal to 45°.

If $\theta=45°$, $u=200m/s$, $g=10m/s^2$

Using $H_{max} = u^2\sin^2\theta/2g$

$= (200)^2(\sin45)^2/2\times10$

$= 200\times200\times0.7071\times0.7071/20$

$= 40{,}000\times0.49999041/20$

$= 19{,}999.6164/20$

$= 999.98$

∴ Maximum Height attained = 999.98 m

6. $\lambda_{max} = 2.9\times10^{-3}/330 = 8.787878\times10^{-6}$

$\therefore \lambda \approx 8.8\times10^{-6}$ m

Recall $V = f\lambda$ (where $V = 3.0\times10^8$ m/s)

Now $f = V/\lambda = 3.0\times10^8/8.8\times10^{-6}$

$= (3.8/8.8)\times10^{8-(-6)}$

$= 0.340909090\times10^{14}$

$\rightarrow f = 3.4\times10^{-1}\times10^{14}$

∴ Frequency, $f = 3.4\times10^{13}$ Hz

7(a). LASER stands for Light Amplification by Stimulated Emission of Radiation.

7(b). A laser refers to a device that generates an enormous beam of coherent monochromatic light.

**PART II**

8(a). Uniform acceleration is the consistent time rate of increase in velocity.

8(b). Horizontal Force: Forward force — Thrust

8(c). Backward force — Frictional force

Upward force = Normal reaction

8(d)(i). **SEE DIAGRAM**— velocity-time graph showing points O, A, B(20), C(50), and 70 on the time axis, forming a trapezium ABCD shape.

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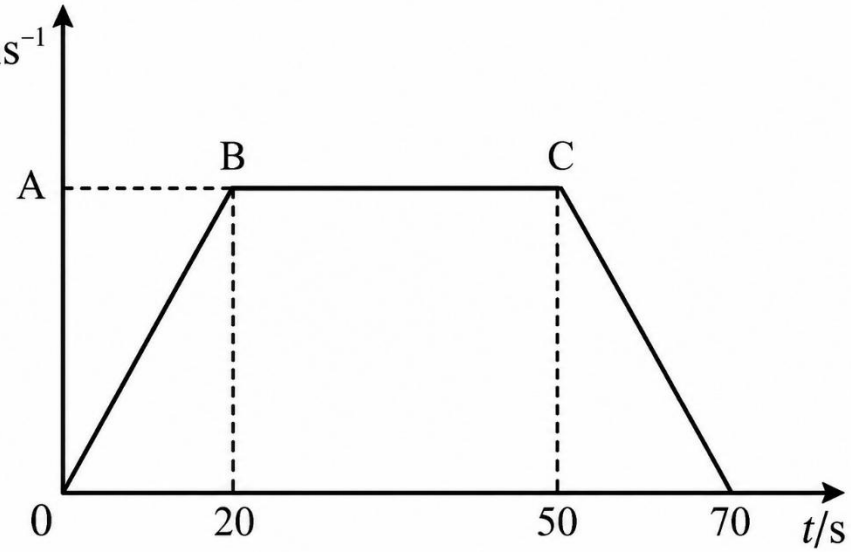
8(d)(ii)(α). Total distance covered = Area of Trapezium

Total = ½[Area of Trapezium] = ½[AB+OC]×D

= ½(60+30)×25

= ½(90)×25

(iv)




= 1125 m

8(d)(ii)(β). Deceleration: slope = slope of BC

= |BE|/|CE| = 25/10 = 2.5 m/s²

8(d). (Force-extension graph question) Work done = slope

W.D = ½Fe

= ½×12×0.5/100

= 6×0.5/100

= 0.03 J

∴ Work done = 0.03 J

9(a)(i). Factors affecting loss of heat:

Radiation:

Surface Area

Temperature

Convection:

Nature of the body

Density/Viscosity of fluid

Thermal conductivity

Specific heat capacity of fluid

Exposed Surface Area

9(b). Factors that determine the quantity of heat in a body:

Heat/Thermal capacity

Temperature

Nature of the body

9(c). The statement means that $2.72\times10^5$ J of heat energy is required to change 1kg of mercury at its boiling point to vapour without a temperature change.

9(d)(i). Heat supplied by heater = $IVt = V^2t/R$

Heat gained by Water = $MwC(\Delta\theta)$

→ $V^2t/R = MwC\Delta\theta$

$(220)^2\times4\times60/35 = Mw\times4200(100-28) + 250(100-28)$

$48,400\times240/35 = Mw\times4200(72) + 250(72)$

$11,616,000/35 = (4200\times72)Mw + 250\times72$

$331,885.71428 - 18,000 = 302,400\ Mw$

$313,885.714 = 302,400\ Mw$

→ $Mw = 313,885.714/302,400$

$= 1.03798$

∴ $Mw = 1.038$ kg

9(d)(ii). $MvLv = V^2t/R$

[N.B: Mass of water = 300g = 0.3kg]

→ $Lv = V^2\times t/(R\times Mv)$

$= (220)^2\times5\times60/(35\times0.3)$

$= 48,400\times300/10.5$

$= 14,520,000/10.5$

$= 1,382,857.143$

∴ Specific Latent Heat of Vaporisation = $1.38\times10^6$ J/kg

10(a). Diffraction is the spreading or bending of waves as they pass through an aperture or round the edge of a barrier.

10(b)(i). Critical angle is the angle of incidence in the denser medium when an angle of refraction in the less dense medium is 90°.

10(b)(ii)(α). Critical angle = 90−44 = 46°

10(b)(ii)(β). $n = 1/\sin C = 1/\sin46° = 1.39$

10(c)(i). Closed Pipe: 1st Overtone = $3f_o = 3\times200 = 600$ Hz

Open Pipe: All harmonics are possible; 1st Overtone = $2f_o$

→ $2f_o = 600$

∴ $f_o = 600\div2 = 300$ Hz

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10(c)(ii). Closed Pipe: $f_o = V/4L$

→ $L = V/4f_o = 330/(4\times200) = 0.4125$

≈ 0.413 m

Open Pipe: $f_1 = V/L$ or $f_o = V/2L$

→ $600 = 330/L$ or $300 = 330/2L$

→ $L = 330/600 = 0.55$ m (confirmed both ways: $600L=330$ → $L=330/600=0.55$m)

11(a)(i). Reactance refers to the opposition to the flow of alternating current offered by a capacitor or an inductor or both.

11(a)(ii). Impedance is the overall opposition of a mixed circuit containing a resistor, an inductor and/or a capacitor.

11(b)(i). An e.m.f. is induced because the coil rotates at a steady speed about a fixed axis in the magnetic field of the electromagnet. Hence, it cuts through the magnetic lines of force.

11(b)(ii). The direction of current is reversed in each half of the rotation of the coil.

11(b)(iii). The law used to determine the direction of the induced current is Lenz's law. It states that the direction of the induced current is such as to oppose the change producing it.

11(b)(iv). The induced e.m.f. can be increased by any two of the following:

Increase in the speed of rotation

Increase in the number of turns in the coil

Increase in the area of coil

Efficient core design

11(c). Energy = Pt

→ $E = 6\times5\times60$

$= 1800$ J

∴ Energy transformed = 1,800 J

12(a). Binding energy is the minimum amount of energy required to separate the nucleus of an atom.

12(b). Three evidences to support the claim that X-rays are electromagnetic waves are thus:

(i) They can travel through a vacuum.

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(ii) They can be polarized.

(iii) They are not affected by electric and magnetic fields.

(iv) They travel with the speed of light.

12(c). Peaceful uses of nuclear energy:

(i) It is used in generating electricity.

(ii) It is used in the treatment of tumour.

(iii) It is used to power submarines.

12(d)(i). Recall: $C = f\lambda$

$\rightarrow f = c/\lambda = 3.0\times10^{8}/4.5\times10^{-7}$

$= 0.6667\times10^{8-(-7)}$

$= 6.67\times10^{-1+15}$

$\therefore f = 6.67\times10^{14}$ Hz

12(d)(ii). Using $E = hf$

$= 6.67\times10^{-34}\times6.67\times10^{14}$

$= 44.4889\times10^{-34+14}$

$= 4.44889\times10^{1}\times10^{-20}$

$= 4.44889\times10^{-19}$

$\therefore$ Energy of incident light $= 4.45\times10^{-19}$ J

12(d)(iii). Energy of photoelectrons can be determined using: K.E = E − W

$= 4.45\times10^{-19} - 3.0\times10^{-19}$

$\therefore$ K.E $= 1.45\times10^{-19}$ J

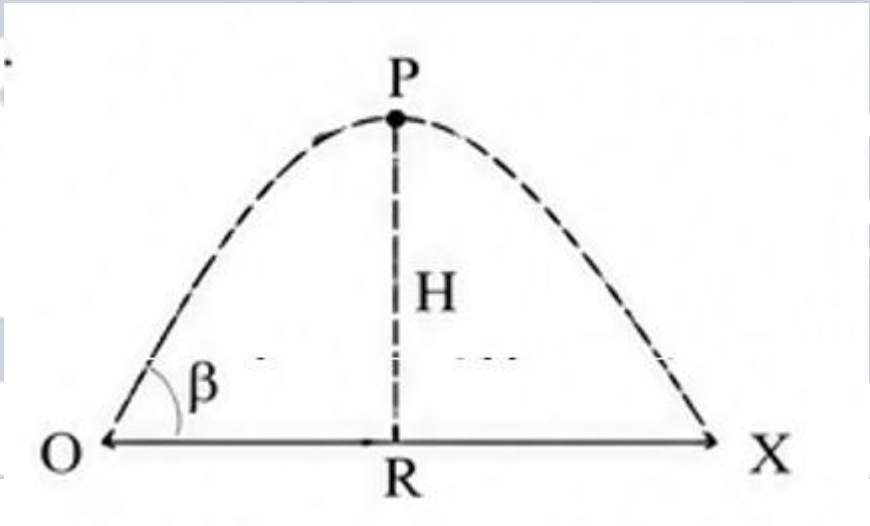
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# WASSCE JUNE 2019

# PHYSICS 2 THEORY QUESTIONS

**PART I**

1. A stone of mass 20 g is released from a catapult whose rubber is stretched through 5 cm. If the force constant of the rubber is 200 N $m^{-1}$, calculate the speed with which the stone leaves the catapult.




2. (a) **SEE DIAGRAM** — The diagram illustrates a projectile motion. Identify each of the physical quantities labelled P, β, H and R.
(b) Write an equation to show the relationship between P, β and R, where g is the acceleration due to gravity and R_max is maximum R.

3. State three observable phenomena in which waves behave like a particle.

4. List three magnetic elements that determine the earth's magnetic field at a point.

5. Explain each of the following terms as used in Electronics: (a) free electrons; (b) holes.

6. (a) State the principle of operation of fibre optics.

(b) State two applications of fibre optics in medicine.

7. Define diffusion.

b) State two factors that affect the rate of diffusion.

**PART II**

8. (a)(i) State Newton's Law of Universal Gravitation.

(ii) Define gravitational field.

(b)(i) Derive the equation relating the universal gravitational constant, G, and the acceleration of free fall, g, at the surface of the earth from Newton's Law of universal gravitation.

(ii) State two assumptions for which the relationship in 8(b)(i) holds.

(c) Calculate the force of attraction between a star of mass $2.00 \times 10^{30}$ kg and the earth assuming the star is located $1.50 \times 10^{8}$ au from the earth. [Mass of the earth = $5.98 \times 10^{24}$ kg; G = $6.67 \times 10^{-11}$ N m$^2$ kg$^{-2}$; au = 10 m$^{-1}$]

(d)(i) Define escape velocity.

(ii) State two differences between the acceleration of free fall (g) and the universal gravitational constant (G).

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9. (i) Explain latent heat.

(ii) State two factors that affect the rate of evaporation of a liquid.

(h) Explain each of the following observations:

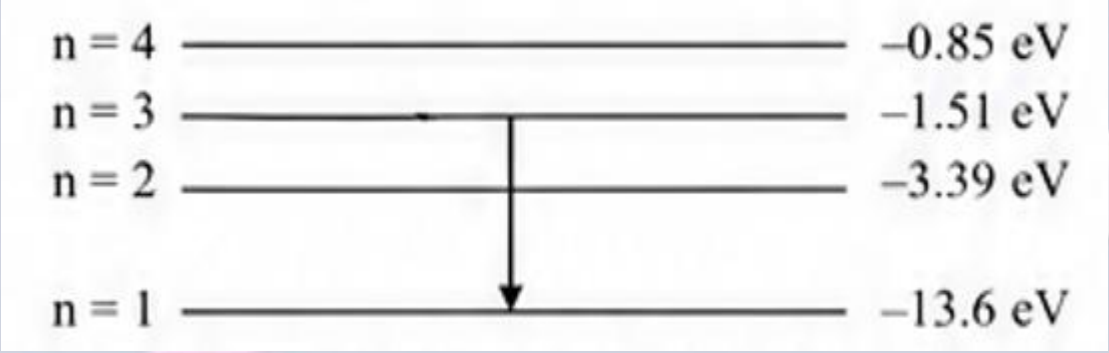
(i) On a dry day, water in a clay pot is cooler than water in a closed plastic container.

(ii) Food gets cooked faster in a pressure cooker than in an ordinary cooking pot.

(j) State two effects of heat on a substance.

(d) A 40 V electric heater is used to supply a current of 12 A for 1400 s to a body of mass 1.5 kg at the melting point of the body. The body melts, and its temperature rises through 60°C in an extra 72 s. Determine the: (i) latent heat of fusion of the body. (ii) specific heat capacity of the body.

10. (a)(i) Define atomic spectra.




(d) Differentiate between emission spectra and absorption spectra.

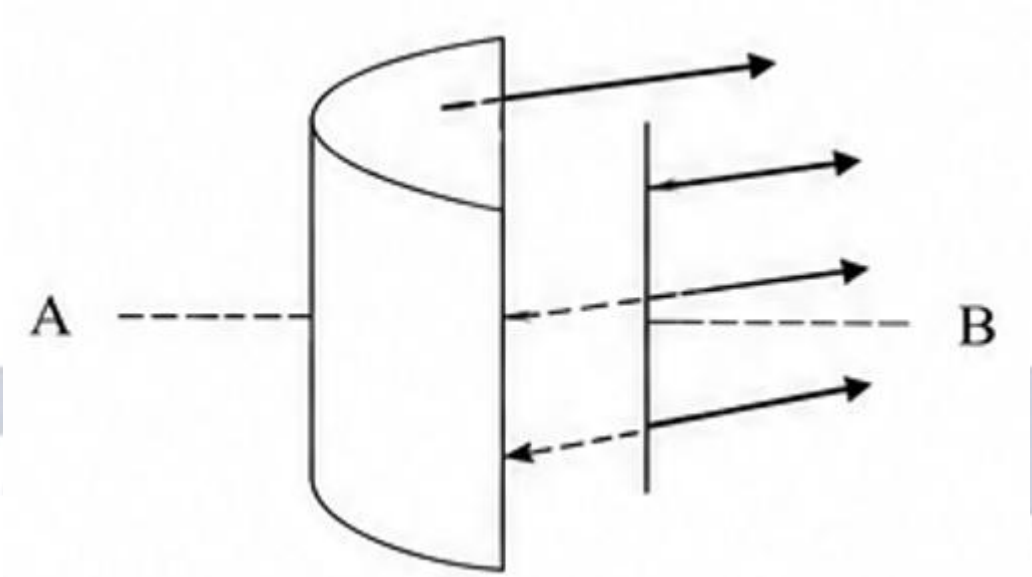
(b) **SEE DIAGRAM** — The diagram above illustrates an electron transition from energy level n = 3 to n = 1. Calculate the: (i) energy of the photon; (ii) frequency of the photon; (iii) wavelength.

[$h = 6.6 \times 10^{-34}$ J s; $c = 3.0 \times 10^{8}$ m $s^{-1}$; 1 eV = $1.6 \times 10^{-19}$ J].

11. (a)(i) Define force and state its S.I. unit.

(ii) List the two types of solid friction.

(b) A car traveling at a constant speed of 30 m $s^{-1}$ for 20 s was suddenly decelerated when the driver sighted a pot-hole. It took the driver 6 s to get to the pot-hole with a reduced speed of 18 m $s^{-1}$. He maintained the steady speed for another 10 s to cross the pot-hole. The brakes were then applied and the car came to rest 5 s later.




(i) Draw the velocity time graph for the journey. — SEE DIAGRAM

(ii) Calculate the deceleration during the last 5 s of the journey.

(iii) Calculate the total distance covered.

12. (a) **SEE DIAGRAM** — The diagram above illustrates a structure of a typical photoelectric cell. (i) Identify each of the parts labelled A and B. (ii) State one function each of A and B. (iii) Einstein's photoelectric equation can be written as $E = h\nu - W_o$. State what each of the terms E, hν and $W_o$ represents.

(b) A photon is incident on a metal whose work function is 1.32 eV. An electron is emitted from the surface with maximum kinetic energy of 1.97 eV. Calculate the frequency of the photon. [1 eV = $1.6 \times 10^{-19}$ J]

(c) Define half-life of a radioactive element. (ii) Sketch a graph of the relation N = $N_o$e^(−λt) and indicate the half-life. — SEE DIAGRAM

# ANSWERS TO WASSCE JUNE 2019

## PHYSICS 2 ESSAY

**PART I**

1. The speed with which the stone leaves the catapult is given by:

$\frac{1}{2}Ke^2 = \frac{1}{2}Mv^2$

$\Rightarrow \frac{1}{2} \times 200 \times (0.05)^2 = \frac{1}{2}(0.02) \times v^2$

$100(0.05)^2 = 0.01v^2$

$100 \times 0.0025 = 0.01v^2$

$0.25 = 0.01v^2$

$\Rightarrow v^2 = 0.25/0.01 = 25$

$\therefore v = \sqrt{25} = 5$ m/s

2. (a) Identification of the labelled physical quantities:

P = Initial speed or velocity of projection

β = Angle of projection

H = Maximum height attained

R = Horizontal range

(b) Equation indicating the relation between P, g and R_max:

$R_{max} = P^2/g$

3. Observable phenomena showing particle nature of waves:

Blackbody radiation

Compton effect

Photoelectric effect

Absorption of light/Absorption spectra

Thermionic emission

Atomic Emission

Interference

Polarization

Refraction

Diffraction

Reflection

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(Note: only three were required by the question; this list gives options to choose from.)

4. Magnetic elements that determine the Earth's magnetic field at a point:

Horizontal component of the earth's magnetic field

Angle of inclination/dip

Angle of declination/variation

5. Explanation of the following in respect of Electronics:

(a) Free electrons: These are the negative charge carriers in electronics which are detached from the atom.

(b) Holes are the positive charge carriers in an electronic project.

6. (a) The operational principle of fibre optics is based on total internal reflection of light.

(b) Applications of fibre optics in medicine:

Fibre optics is applied in imaging tools.

It can be used as a laser for surgery.

It can act as light guides.

It can be used as intravascular pressure transducers.

7. (a) Definition of Diffusion:

Diffusion is the process by which molecules of gases or liquids move randomly from a region of high concentration to that of lower concentration.

(b) Factors affecting the rate of diffusion of substances are these:

Mass of the substance

Temperature of the substance

State of the molecules (solid, liquid or gas)

Density of the substance

**PART II**

8. (a) Newton's law of universal gravitation states that there is a force of attraction between any two massive particles in the universe, and this force is directly proportional to the product of the masses and inversely proportional to the square of their distance apart.

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(b)(i) Consider two bodies whose masses are $M_1$ and $M_2$ separated by a distance R_m. The force of attraction between these bodies is given by:

$F = GM_1M_2/R^2$ ...(1)

Where G is the universal constant;

But F = mg, substituting in equation (1):

$mg = GM_1M_2/R^2$

Such that $g = GM_1M_2/mR^2$

$\Rightarrow g = GM/R^2$

(c) $F = GM_sM_e/R^2$ (Where M_s = Mass of star, M_e = Mass of Earth, R = Distance separating them, G = Universal constant)

$\Rightarrow F = (6.67\times10^{-11} \times 2.00\times10^{30} \times 5.98\times10^{24}) / (1.5\times10^{11})^2$

$\therefore F = 3.55 \times 10^{22}$ N

(d)(i) Escape velocity can be defined as the minimum speed or velocity required by a body to move away from the earth's gravitational influence.

(ii) Differences between G and g:

| **Universal Constant (G)** | **Acceleration of free fall (g)** |
|---|---|
| **It is constant everywhere.** | It varies from place to place. |
| **It is a scalar quantity.** | It is a vector quantity. |
| **Its unit is $Nm^2/kg^2$** | Its unit is $m/s^2$ |

9. (a)(i) Latent Heat refers to the quantity of heat absorbed or released when a substance changes its physical phase at constant temperature. For example, from solid to liquid at the melting point or from liquid to gas at the boiling point.

(ii) Factors affecting the rate of evaporation of a liquid:

Nature of the liquid

Wind or draught

Temperature of the liquid

Pressure of the air

Humidity or amount of water vapour

Exposed surface area of the liquid

(b)(i) Water in a clay pot is cooler than that in a closed plastic container because the clay pot has pores which allow evaporation to take place, but the plastic container does not have pores to

allow evaporation. Hence, in the process of evaporation, molecules take latent heat from the bulk of the water leaving the water cooler.

(ii) Food gets cooked faster in a pressure cooker than in an ordinary cooking pot because the ordinary cooking pot operates at normal atmospheric pressure, while the pressure cooker has an increased pressure which raises the boiling point of water within a short period.

(j) Effects of heat on a substance:

Change in temperature

Change in kinetic energy

Change in internal energy

Change in physical and chemical properties

Expansion

Change of state

(d)(i) In the 1st 1400 s, heat supplied by heater = latent heat of fusion of the body

$\Rightarrow IVt_1 = 672{,}000$

$= 6.72 \times 10^5$ J

(ii) Specific heat capacity of the body:

$IVt_2 = Mc\Delta\theta$

$\Rightarrow c = IVt_2/M\Delta\theta = (12\times40\times72)/(1.5\times60)$

$\Rightarrow c = 34{,}560/90.0 = 384$

$\therefore$ Specific heat capacity of the body = 384 J/kgK

10. (a)(i) Atomic spectra refers to the emission of light from a substance when its excited electrons move to a lower energy level.

(ii) Emission spectra is the pattern of light displayed when electrons jump from a higher energy level to a lower energy level, while absorption spectra is the displayed pattern of wavelengths absorbed by a gas.

(b)(i) From the energy levels shown: SEE DIAGRAM

$\Delta E = E_i - E_f$

$= -1.51 - (-13.6)$

$= 12.09$ eV

$= 12.09 \times 1.6\times10^{-19}$ J

$\therefore \Delta E = 1.934 \times 10^{-18}$ J

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(ii) Frequency of photon using $\Delta E = hf$

$\Rightarrow f = \Delta E/h = (1.934\times10^{-18})/(6.6\times10^{-34})$

$\Rightarrow f = 2.93 \times 10^{15}$ Hz

(iii) Wavelength of photon: Using $c = f\lambda$

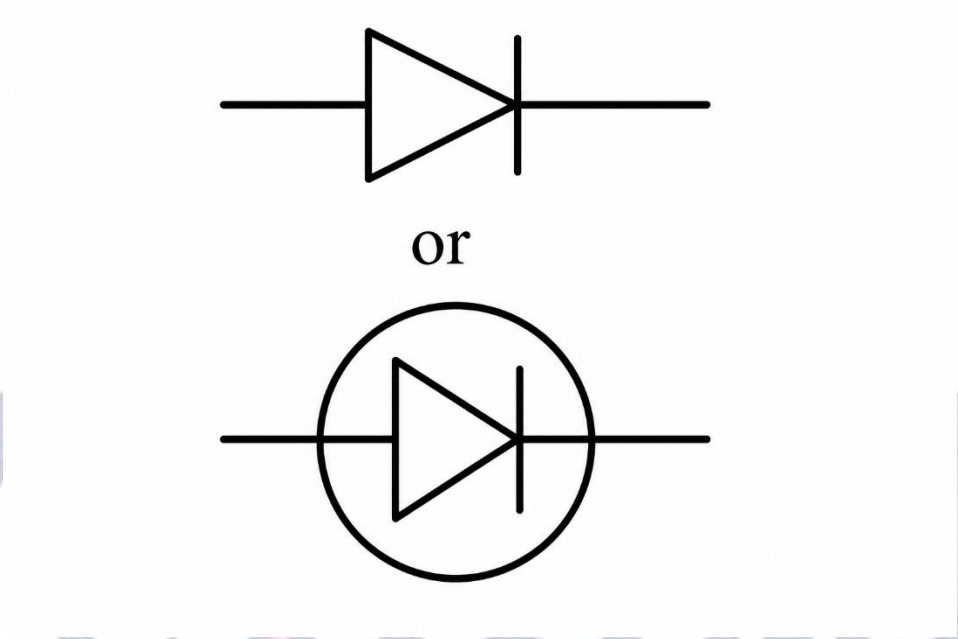
$\Rightarrow \lambda = c/f = (3.0\times10^{8})/(2.93\times10^{15})$

$\therefore$ Wavelength, $\lambda = 1.024 \times 10^{-7}$ m

(c)(i) Differences between soft X-rays and hard X-rays:

| **Soft X-rays** | **Hard X-rays** |
|---|---|
| **They possess less energy.** | They possess more energy. |
| **Soft X-rays have lower penetrating power.** | Hard X-rays have higher penetrating power. |
| **They have longer wavelengths.** | They possess shorter wavelengths. |

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(ii) Circuit symbol of p-n junction diode: SEE DIAGRAM

(iii) Reason for doping a semiconductor material:

To reduce the electrical resistivity of the semiconductor, which invariably will lead to an increase in electrical conductivity.

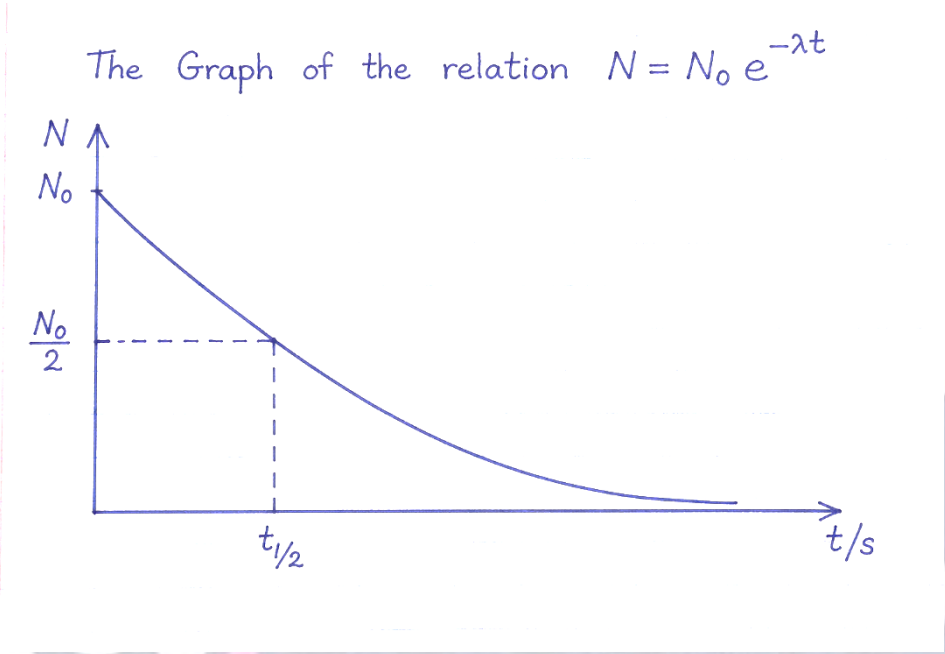
11. (a)(i) Force refers to an action that changes or alters the state of rest or of uniform motion of a body in a straight line. Its S.I. unit is Newton (N).

(ii) Types of solid friction:

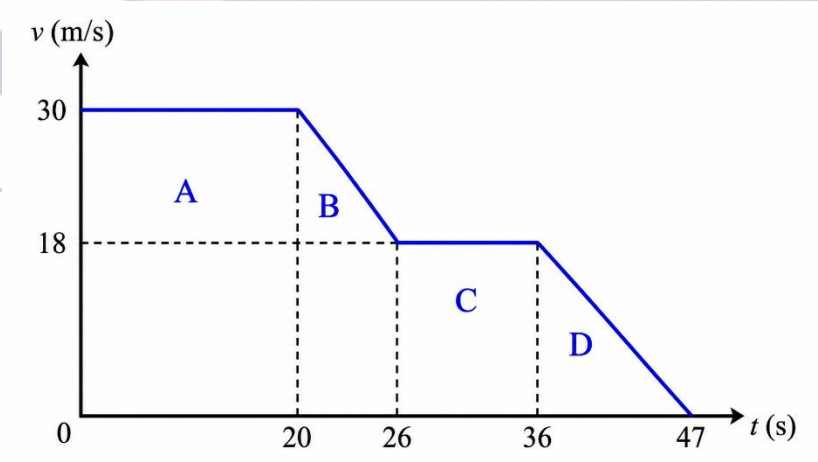
Static friction

Dynamic friction

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(b)(i) Velocity-time graph for the journey: SEE DIAGRAM




(ii) Final deceleration = (18−0)/(41−36) = 18/5 = 3.6 m/s²

(iii) Total distance covered from the sketch = Areas of A + B + C + D

= (30×20) + ½(30+18)×6 + (18×10) + ½(18)(5)

= 600 + 144 + 180 + 45

= 969

∴ Total Distance = 969 m

12. (a)(i) From the diagram: SEE DIAGRAM

A = Cathode

B = Anode

(ii) Functions:

A = Emits electrons.

B = Attracts/Absorbs electrons.

(iii) In the equation $E = hf - W_o$,

E represents Kinetic energy of photoelectrons

hf represents energy of incident photon

$W_o$ represents Work function of metal.

(b) From the equation, $E = hf - W_o$

$\Rightarrow hf = E + W_o$

$\Rightarrow f = (E + W_o)/h$

$= [(1.97+1.32) \times 1.6\times10^{-19}] / (6.6\times10^{-34})$

$= (5.264 \times 10^{-19}) / (6.6\times10^{-34})$

$= 0.797575 \times 10^{15}$

$\Rightarrow f = 7.97575 \times 10^{14}$

$\therefore$ Frequency $= 7.98 \times 10^{14}$ Hz

(c)(i) The half-life of a radioactive element is the time taken for one half of the radioactive element to decay. In other words, it is the time required for half the original nuclide of the element to decay.

(ii) The graph of the relation N = $N_o$e^(−λt)

hf represents energy of incident photon

$W_o$ represents Work function of metal.

(b) From the equation, $E = hf - W_o$

$\Rightarrow hf = E + W_o$

$\Rightarrow f = (E + W_o)/h$

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# WAEC PHYSICS PAPER 2 (SC 2020)

## Essay / Theory Questions

**Time Allowed:** 1½ hours | **Total Marks:** 60

---

**Instructions:**

*Answer **eight questions** in all. Answer five questions from **Part I** and three questions from **Part II**.*

## PART I

**[15 marks]**

*Answer any five questions from this part.*

*All questions carry equal marks.*

---

**Question 1**

An elastic material of 3m is to be stretched to produce an extension three times its original length. Calculate the force required to produce the extension if the force constant of the material is 982.3 N $m^{-1}$.

[3 marks]

---

**Question 2**

In a solar panel for heat supply, state the function of **each** of the following parts:

**(a)** metal flat plate;

**(b)** thermal insulator;

**(c)** tubes.

[3 marks]

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**Question 3**

In the design of an optical fibre, what type of material is most suitable for the design of the core?

**(a)** State **one** condition necessary to confine signals to the core of an optical fibre.

[3 marks]

**Question 4**

The velocity *v* of a wave in a stretched string depends on the tension, T, in the spring and the mass per unit length $\mu$ of the spring. Obtain an expression for *v* in terms of T and $\mu$, using the method of dimensions.

[3 marks]

**Question 5**

A satellite launched with velocity $V_c$ just escapes the earth's gravitational attraction. Given that the radius of the earth is R, show that:

$$V_E = \sqrt{20R}$$

[g = 10 m $s^{-2}$]

[3 marks]

**Question 6**

A bullet is fired from a gun at 30° to the horizontal. The bullet remains in flight for 25 s before touching the ground. Calculate the velocity of projection.

[g = 10 m $s^{-2}$]

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[3 marks]

---

**Question 7**

State **three** properties of lasers that make them preferable to ordinary light beam.

[3 marks]

---

**PART II**

*Answer three questions from this part. All questions carry equal marks.*

---

**Question 8**

**(a) (i)** Define a *torque*.

**(ii)** State **three** factors that determine a torque.

[5 marks]

**(b)**

**(i)** Define *free fall*.

**(ii)** A body is thrown vertically upwards from the top of a tower 40.0 m high with a velocity of 10.0 m $s^{-1}$. Calculate the time taken for the body to reach the ground.

[g = 10.0 m $s^{-2}$]

[5 marks]

---

**Question 9**

**(a)**

**(i)** Explain *resonance frequency* as applied in an RLC series circuit.

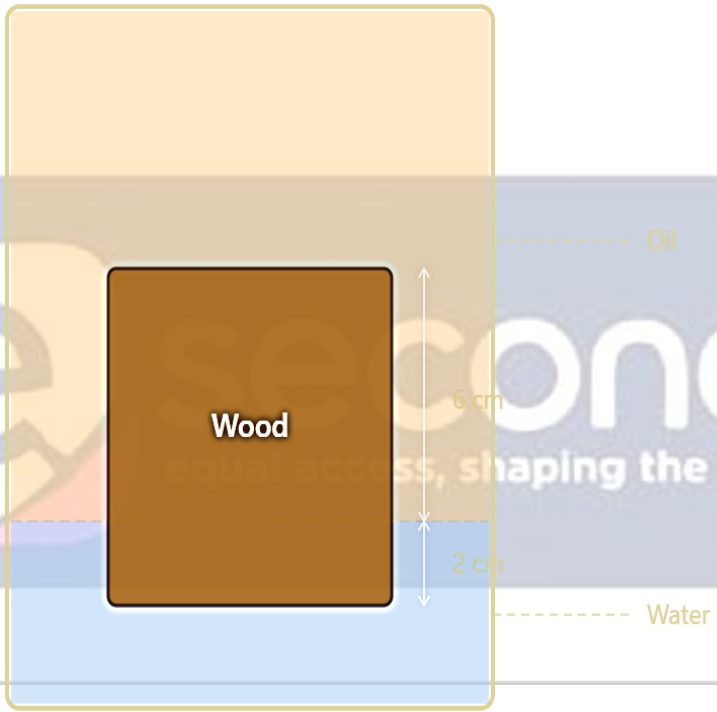
**(ii)** Sketch a diagram to illustrate the variation of frequency, f, with the resistance, R, the capacitive reactance, $X_c$, and the inductive reactance, X_L, in an RLC series circuit.

Describe the phase with which supply voltage leads or lags the current when:

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**(α)** $f = f_o$;

**(β)** $f < f_o$;




**(γ)** $f > f_o$;

where $f_o$ is the resonant frequency.

[7 marks]

**(b)**

**(i)** Define *mutual inductance*.

**(ii)** The coil of an electric generator has 500 turns and 8.0 cm diameter. If it rotates in a magnetic field of density 0.25 T, calculate the angular speed when its peak voltage is 480 V.

[π = 3.142]

[5 marks]

---

**Question 10**

A piece of wood floating in a container with oil and water is shown in the diagram below. The wood is 6 cm above the oil–water interface and 2 cm below it. *(The diagram above shows a block of wood floating in a container. The wood extends 6 cm into the oil layer and 2 cm into the water layer.*

Using the diagram, answer the questions that follow. [5 marks]

*(Questions relating to the diagram carry 5 marks)*

**(a)**

**(i)** Explain *resonance frequency* as applied in an RLC series circuit.

**(ii)** State **two** practical uses of eddy currents.

[3 marks]

**(d)**

**(i)** Define *critical angle* as used in optics.

**(ii)** State **two** conditions necessary for total internal reflection to occur.

**Question 11**

**(a)**

**(i)** Define *isotopes*.

**(ii)** Mention two uses of radioactive tracers in **each** of the following areas:

**(A)** medicine;

**(B)** industry;

**(C)** agriculture.

[5 marks]

**(b)** When light of frequency $5.4 \times 10^{14}$ Hz is incident on a metal surface, the maximum energy of the emitted electrons is $1.2 \times 10^{-19}$ J. Calculate the **minimum** frequency of radiation for which electrons can be emitted.

[$h = 6.6 \times 10^{-34}$ J s]

[3 marks]

**(c)** State **three** features common to electromagnetic waves.

[3 marks]

**(D)** State **two** effects of refraction.

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[2 marks]

**(E) (i)** Define *progressive waves*.

---

**Question 12**

A wave equation is given where *y* is in millimetres and *t* in seconds. Determine the:

**(α)** frequency of the wave;

**(β)** wavelength of the wave;

**(γ)** speed of the wave.

**(i)** Mention **four** components of the nuclear reactor.

**(ii)** State the function of **each** of the components stated in 12(d)(i).

[6 marks]

---

**Question 13**

Water is heated in a container until it starts boiling. The table below shows the readings taken once the water starts boiling.

| **Time/s** | **0** | **100** | **200** | **300** | **400** |
|---|---|---|---|---|---|
| Reading on balance/g | 203.22 | 201.62 | 199.79 | 198.26 | 196.50 |
| Mass of water evaporated/g | 0 | | | | |
| Energy supplied by heater/J | 0 | | | | |

**(i)** Fill in the mass of water evaporated.

**(ii)** Given that the heater supplies energy at the rate of 38 J/s, fill in the values of the energy supplied by the heater at 100 s, 200 s, 300 s, and 400 s.

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**(iii)** Plot a graph of energy supplied on the vertical axis and mass of water evaporated on the horizontal axis, starting both axes from the origin (0, 0).

**(iv)** Determine the slope of the graph.

**(v)** What does the value of the slope mean?

[12 marks]

**(b)**

**(i)** Explain what is meant by *saturated vapour pressure*.

**(ii)** State the factor that affects saturated vapour pressure.

[3 marks]

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# THE WEST AFRICAN EXAMINATIONS COUNCIL

## 2020 MARKING SCHEME

## PHYSICS 2

(Maximum Marks obtainable: 60)

PART I

Rubrics: Answer five questions from this part [15 marks]

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1. Calculation of the force needed to produce extension of material

F = ke (1)

= 982.3 × 3 × 3 (1)

= 8840.7 N (1)

[3 marks]

2. (a) Function of metal flat plate of solar panel

Receives and absorbs solar radiation to produce heat (1)

(b) Function of thermal insulator of solar panel

Minimises heat loss (1)

(c) Function of tubes of solar panel

Helps to circulate the heat (1)

[3 marks]

3. (a) Type of material most suitable for the design of the core of an optical fibre

Glass/plastics (1)

(b) Condition necessary to confine signal to the core of an optical fibre

The refractive index of the core must be greater than that of the cladding (2)

[3 marks]

4. Expression for v

$v \alpha T^a\mu^b$ OR

$v = kT^a\mu^b$, k is dimensionless (½)

$[v] = k[T]^a[\mu]^b$

$LT^{-1} = k(MLT^{-2})^a(ML^{-1})^b$ (1)

$LT^{-1} = kM^{a+b}L^{-a-b}T^{-2a}$

For T,

$-1 = -2a$

$a = ½$ (½)

For M,

$0 = a + b$

$b = -a$

$= -½$ (½)

$v = kT^a\mu^b$

OR

$v = k\sqrt{(T/\mu)}$ (½)

[3 marks]

5. To show that $V_e = \sqrt{(2gR)}$

KE = Gravitational Potential Energy

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$\frac{1}{2}mV_e^2 = GMm/R$ (1) OR P.E. = K.E.

$V_e^2 = 2GM/R$ (½) $mgR = \frac{1}{2}mv^2$ (1)

but $GM = gR^2$

$V_e^2 = 2gR^2/R = 2gR$ (½) $v^2 = 2gR$ (½)

$V_e = \sqrt{(2 \times 10 \times R)} = \sqrt{20R}$ (1) $v = \sqrt{2gR}$ (½)

$= \sqrt{20R}$ (1)

[3 marks]

6. Calculation of velocity of projection of fired bullet

Time of flight $T = 2u \sin\theta/g$ (1)

$25 = 2u \sin 30/10$ (1)

$u = 250\ ms^{-1}$ (1)

[3 marks]

7. Properties of laser beams that make them preferable to ordinary light beam

Any 3 × 1

Travels a very long distance without losing its intensity

Has a very narrow optical bandwidth

Can be emitted continuously

Gives more intense light/power

Is monochromatic

[3 marks]

PART II

Rubric: Answer any 3 questions from this part [45 marks]

8. (a) (i) Definition of a torque

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The turning effect of force about an axis/pivot

[2 marks]

(ii) Factors that determine a torque

Any 3 × 1

perpendicular distance of the force from the pivot

direction of the force

magnitude of the force

[3 marks]

(b) (i) Definition of free fall

The vertical motion of a body only under the influence of gravity/its own weight

[2 marks]

(ii) Calculation of the time taken by a body thrown vertically upward to reach the ground

$H = ut + \frac{1}{2}gt^2$ (1)

$-40 = 10t - \frac{1}{2} \times 10 \times t^2$ (1)

$(t + 2)(t - 4) = 0$

Time to fall to the ground, t = 4 s (1)

[3 marks]

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(c) Calculation of the mass of wood

Mass of wood = upthrust due to water displaced + upthrust due to oil displaced (2)

$= 1000 \times 2 \times 8 \times 8 \times 10^{-6} + 720 \times 6 \times 8 \times 8 \times 10^{-6}$ (1½)

= 0.404 kg (1½)

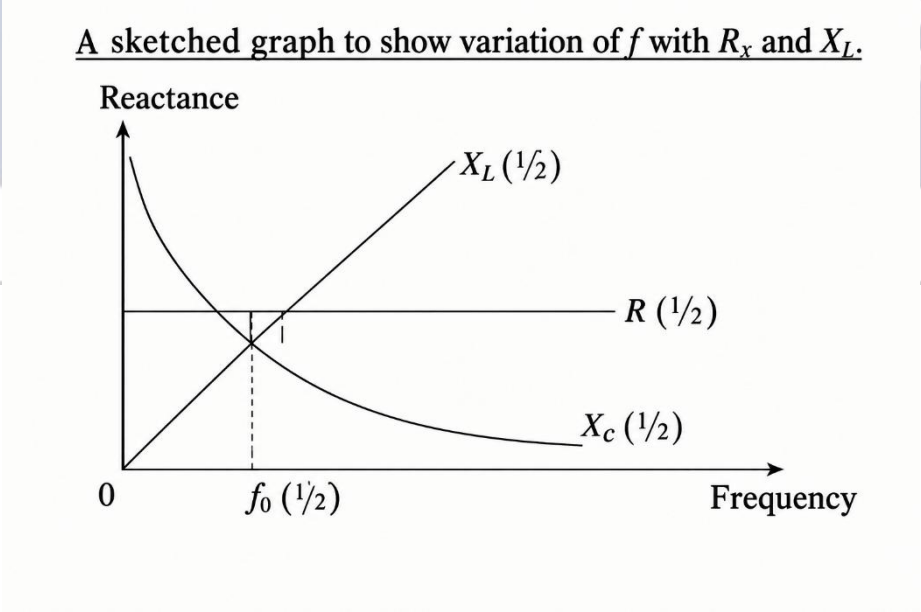
[3 marks]

9. (a) (i) Explanation of resonance frequency as applied to RLC series circuit

It is the frequency of oscillation of an RLC series circuit when the capacitive reactance is equal to the inductive reactance. (1) The impedance is equal to the resistance/the current is then maximum/the impedance is minimum. (1)

[2 marks]

(ii) A sketched graph to show variation of f with R, Xc and XL




(Graph showing Reactance on the y-axis vs Frequency on the x-axis: XL rises with frequency (½), R is constant/horizontal line (½), Xc falls with frequency (½), with $f_o$ marked at the intersection point (½))

[2 marks]

(iii) (α) Relationship between current and voltage when $f = f_o$

Current is in phase with the supply voltage. (1)

(β) Relationship between current and voltage when $f < f_o$

Current lags the supply voltage. (1)

(γ) Relationship between current and voltage when $f > f_o$

Current leads the supply voltage (1)

[3 marks]

(b) (i) Definition of mutual inductance

The ratio of the induced e.m.f in one coil/circuit to the time rate of change of current in the other coil

OR

The production of e.m.f in a circuit as a result of the change in the magnetic flux/magnetic circuit in an adjacent circuit linked to it

[2 marks]

(ii) Calculation of angular speed of the coil of an electric generator

$E = \omega BAN$ (1)

$480 = \omega \times 0.25 \times \pi \times (8.0\times10^{-2}/2)^2 \times 500$ (1)

$\omega = 763.8$ rad $s^{-1}$ (1)

[3 marks]

(c) (i) Explanation of eddy current

The current induced and flows within a metal block when there is a change in magnetic flux linking the block.

OR

Loops of electric current induced within a conductor by the changing magnetic flux/field in the conductor

OR

The localized electric current/loops of electric current

[2 marks]

(ii) Practical Uses of eddy current

Any 2 × ½

induction furnaces

induction coils

speedometers

induction motors

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[1 mark]

10. (a) (i) Definition of critical angle

The angle of incidence in the optically denser medium for which the angle of refraction in the less dense medium is 90°.

[2 marks]

(ii) Conditions necessary for total internal reflection to occur

Any 2 × 1

Light rays must travel from a dense medium to a less dense medium

Angle of incidence in the dense medium must be greater than the critical angle.

[2 marks]

(iii) Practical applications of total internal reflection

Any 3 × 1

Prism periscopes

Prism Binoculars

Fibre optics

Fish eye view

Transmission of radio signals

[2 marks]

(b) Effects of refraction

Any 2 × 1

straight objects placed in liquids appear bent (on the interface or boundary)

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mirages

dispersion of white light/formation of rainbow

apparent displacement of objects placed in liquids/apparent shadows of pools base

[2 marks]

(c) (i) Definition of progressive waves

A disturbance which travels through a medium that enables energy to be transferred from its source to another (without the particles of the medium transferred).

OR

Transfer of energy and momentum from the source of disturbances.

[2 marks]

(ii) (α) Calculation of frequency of wave

$y = 0.5 \sin(1000\pi t - 100\pi x/17)$

$= a \sin(2\pi ft - 2\pi x/\lambda)$

$2\pi f = 1000\pi$ (½)

$f = 500$ Hz (½)

(β) Calculation of wavelength of wave

$2\pi/\lambda = 100\pi/17$ (½)

$\lambda = 2 \times 17/100$

$= 0.34$ m (½)

11. (a) (i) **Table of values**

| Time/s | 0 | 100 | 200 | 300 | 400 |
|---|---|---|---|---|---|
| Reading on balance/g | 203.22 | 201.62 | 199.70 | 198.26 | 196.50 |
| Mass of water evaporated/g | 0 | 1.60 (½) | 2.43 (½) | 4.96 (½) | 6.72 (½) |
| Energy supplied/J | 0 | 3800 (½) | 7600 (½) | 11400 (½) | 15200 (½) |

[4 marks]

(γ) Calculation of speed of wave

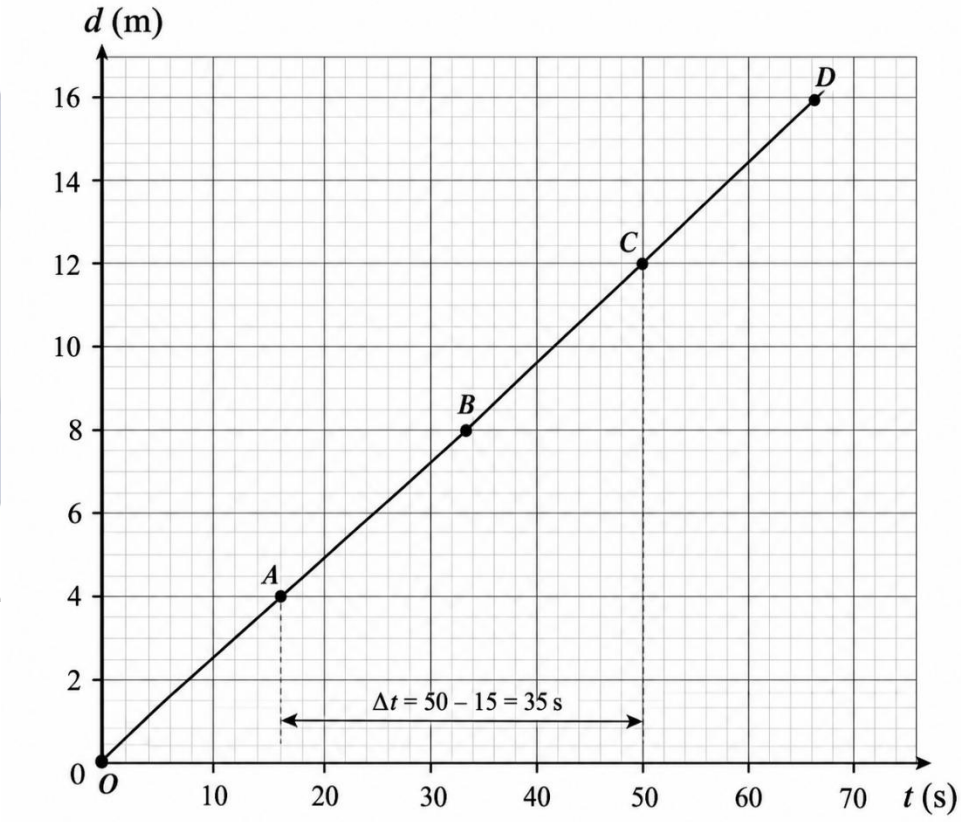
[4 marks]

v = fλ (½)

= 500 × 0.34 (½)

= 170 $ms^{-1}$ (½)

11. (a) (i) Table of values




| | |
|---|---|
| Axes correctly labelled | [1] |
| At least 4 points correctly shown | [2] |
| Line of best fit | [1] |

[4 marks]

(ii) Graph of Energy supplied/J vs Mass of water evaporated/g, plotted with line of best fit; from the graph: $\Delta Q = (14.0 – 2.0) \times 10^3$

$= 12.0 \times 10^3$; $\Delta m = 6.1 – 0.8 = 5.3$

Axes correctly labelled [1]

At least 4 points correctly shown ½ × 4 [2]

Line of best fit [1]

[8 marks]

(iv) Determination of slope of graph

Slope = $\Delta Q/\Delta M$ (1)

= $(14.0 - 2.0)\times10^3 / (6.1 - 0.8)$ (½)

= $2.26 \times 10^3$ J/g (½)

[2 marks]

(v) Meaning of the value of the slope of graph

$2.26 \times 10^3$ J of heat energy is needed (1) to evaporate 1 g of water at constant temperature (1)

[2 marks]

(b) (i) Explanation of saturated vapour pressure

At any given temperature, some energetic molecules of a liquid in a given system escape from the liquid surface as vapour and at the same time some return to the liquid. (½) Vapour pressure is built up above the liquid in the process. (½) When the rate of escape equals the rate of return, the vapour is said to be saturated (½) and the pressure it exerts is called saturated vapour pressure (½) at that temperature.

(ii) Factor that affects saturated vapour pressure

Temperature (1)

[3 marks]

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12. (a) (i) Definition of isotopes

Atoms of the same element that have the same number of protons but different number of neutron.

OR

Same atomic number but different mass number

[2 marks]

environmental pollution

(ii) Uses of Radioactive Tracers in Medicine

Any 2 × ½ [1 mark]

monitoring the function of the thyroid gland/other organs

detection of blood clots in the brain

diagnosis and treatment of disease

sterilization of medical equipment

(β) Uses of Tracers in Industry

Detection of:

Any 2 × ½ [1 mark]

leakages in underground pipes

wear and tear of moving parts of machinery

(γ) Uses of Tracers in agriculture

Any 2 × ½ [1 mark]

determination of plants absorption of mineral elements

study of the mechanism of photosynthesis

seed preservation

sterilization of insects

food preservation

(b) Calculation of minimum frequency of radiation

$E = h(f - f_o)$

OR

$f_o = f - E/h$

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$= 5.4 \times 10^{14} – (1.2 \times 10^{-19})/(6.6 \times 10^{-34})$ (1)

$= 3.6 \times 10^{14}$ Hz (1)

[3 marks]

(c) Features of electromagnetic waves

Any 3 × 1

Transverse waves

Travel with the speed of light in vacuum

Undergo refraction/reflection/diffraction/polarization/interference

Travel through vacuum

[3 marks]

(d) (i) Components of the nuclear reactor

Any 3 × ½ [1½ marks]

uranium fuel

graphite moderator

(boron) control rod

coolant

heat exchanger

shield

(ii) Functions of the components of the nuclear reactor

Any 3 × ½ [1½ marks]

uranium rods – serves as fuel

graphite moderator – controls neutron speed

(boron) control rod – control neutron population

coolant – reduces the excessive heat produced in the reaction

heat exchanger – converts the heat energy produced to other forms

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shield – to protect the operator and surrounding against extraneous radiation

shield – to protect the operator and surrounding against extraneous radiation

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# WEST AFRICAN SENIOR SCHOOL CERTIFICATE EXAMINATION (WASSCE)

## 2021 PHYSICS 2 ESSAY

## [60 marks] | 1½ hours

*Answer **eight** questions in all.*

*Five questions from Part I and three questions from Part II.*

**PART I**

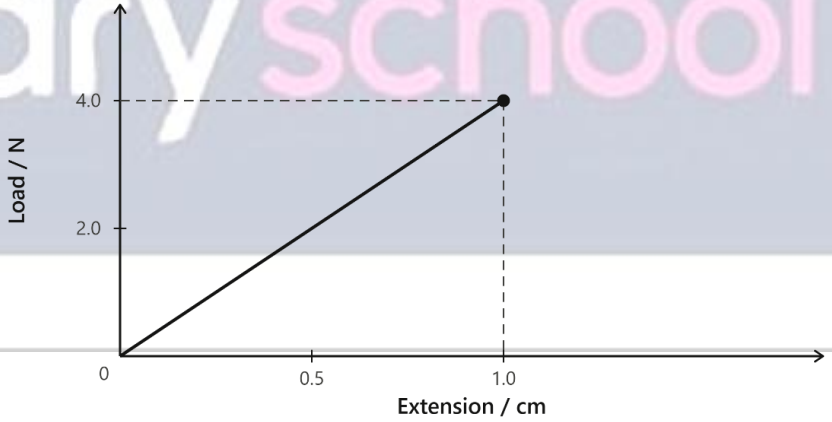
**[15 marks]**

*Answer any **five** questions from this part.*

*All questions carry **equal** marks.*

**Question 1**

The load-extension graph of an elastic material is illustrated below.




Use the graph to determine the work done in stretching the material.

**[3 marks]**

**Question 2**

**(a)** Name two artificial satellites.

**(b)** A geostationary satellite moves in an orbit of radius 6300 km.

Calculate the speed with which it moves in the orbit. [π = 22/7]

**[3 marks]**

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**Question 3**

A projectile is fired at an angle of 30° to the horizontal with a velocity of 40 $ms^{-1}$. Calculate the velocity attained after 1 s. [g = 10 $ms^{-2}$]

**[3 marks]**

**Question 4**




The circuit diagram below is a simple current rectifier circuit. Use it to answer the questions that follow.

**(a)** State the function of **each** of the parts labelled A and B.

**(b)** Sketch the output signal produced.

**[3 marks]**

**Question 5**

**(a)** Explain the *wave-particle duality* of light.

**[3 marks]**

**(b)** A particle of wavelength $4.2 \times 10^{-11}$ m travels with a momentum of $1.6 \times 10^{-23}$ kg $ms^{-1}$. Determine the value of Planck's constant, h.

**[3 marks]**

**Question 6**

State **three** observable phenomena where a particle behaves like a wave.

**[3 marks]**

**Question 7**

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**(a)** State the scientific principle underlying the operation of fibre optics.

**(b)** Explain **each** of the following terms as used in fibre optics:

**(i)** core;

**(ii)** cladding.

**[3 marks]**

---

**PART II**

**[45 marks]**

*Answer **three** questions from this part.*

*All questions carry **equal** marks.*

---

**Question 8**

**(a)**

**(i)** State Hooke's law.

**(ii)** A spring has a length of 0.20 m when a mass of 0.30 kg hangs on it, and a length of 0.75 m when a mass of 1.95 kg hangs on it. Calculate the:

- **(I)** force constant of the spring;
- **(II)** length of the spring when it is unloaded.

[$g = 10\ ms^{-2}$]

**[7 marks]**

**(b)**

**(i)** What is *diffusion*?

**(ii)** State **two** factors that affect the rate of diffusion of a substance.

**(iii)** State the exact relationship between the *rate of diffusion of a gas* and its *density*.

**[5 marks]**

**(c)** A satellite of mass, m, orbits the earth of mass, M with a velocity, v at a distance R from the centre of the earth. Derive the relationship between the period, T, of orbit and R.

**[3 marks]**

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**Question 9**

**(a)**

**(i)** Define *dew point*.

**(ii)** Explain why dew forms more quickly on the metal parts than on the rubber parts of a bicycle placed in the open overnight.

**[5 marks]**

**(b)**

**(i)** Explain the statement, *the specific heat capacity of copper is 400 J $kg^{-1}$ $K^{-1}$.*

**(ii)** Two metals, P and Q are supplied with the same quantity of heat. If the ratio of the specific heat capacity of P to Q is 7 : 1 and their masses are in the ratio 1 : 2 respectively, calculate the ratio of the temperature rise of P to Q.

**[4 marks]**

**(c)**

**(i)** Define *coefficient of thermal conductivity* of a material.

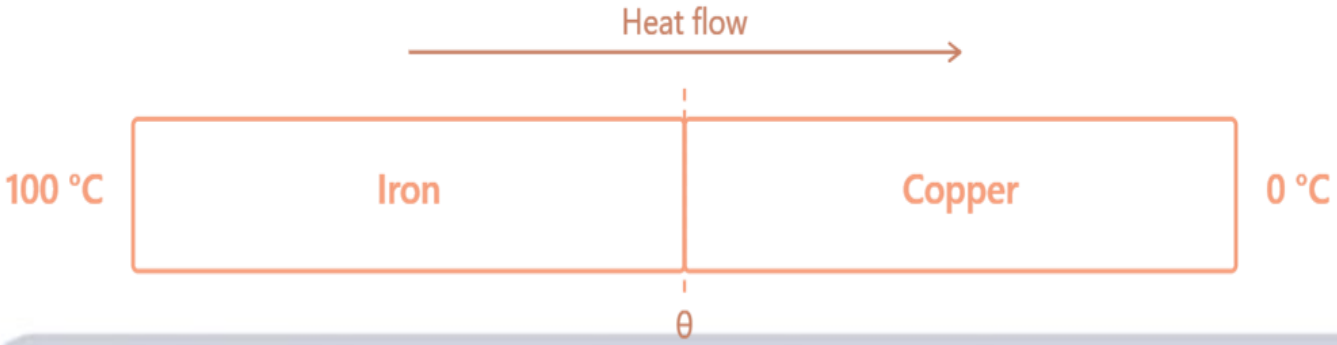
**(ii)** The diagram below illustrates a composite bar of iron and copper. The bar is insulated along its sides and has a diameter of 10 mm. The length and thermal conductivity of iron are 0.15 m and 40 $Wm^{-1}K^{-1}$ respectively, and those of copper are 0.05 m and 360 $Wm^{-1}K^{-1}$ respectively. If the free ends of the iron and copper are kept at 100 °C and 0 °C respectively, calculate the:

**(I)** temperature θ at the interface between the bars;

- **(II)** rate of heat flow along the bar.

**[6 marks]**

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**Question 10**

**(a)** Define **each** of the following terms as it relates to converging lenses:

**(i)** focal length;

**(ii)** optical centre.

**(ii)** Draw a ray diagram to illustrate how a converging lens is used to produce a **virtual** image of an object.

**(b)**

**(i)** Name the **primary** colours of light.

**(ii)** Match each primary colour to its corresponding complementary colour.

**[3 marks]**

**(c)** A ray passes symmetrically through a glass prism of angle 60° and refractive index of 1.5. Calculate the angle of:

**(i)** incidence;

**(ii)** minimum deviation.

**[6 marks]**

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**Question 11**

**(a)**

**(i)** What is meant by the *root-mean-square value* of an alternating current?

**(ii)** Define *impedance* of an alternating current circuit.

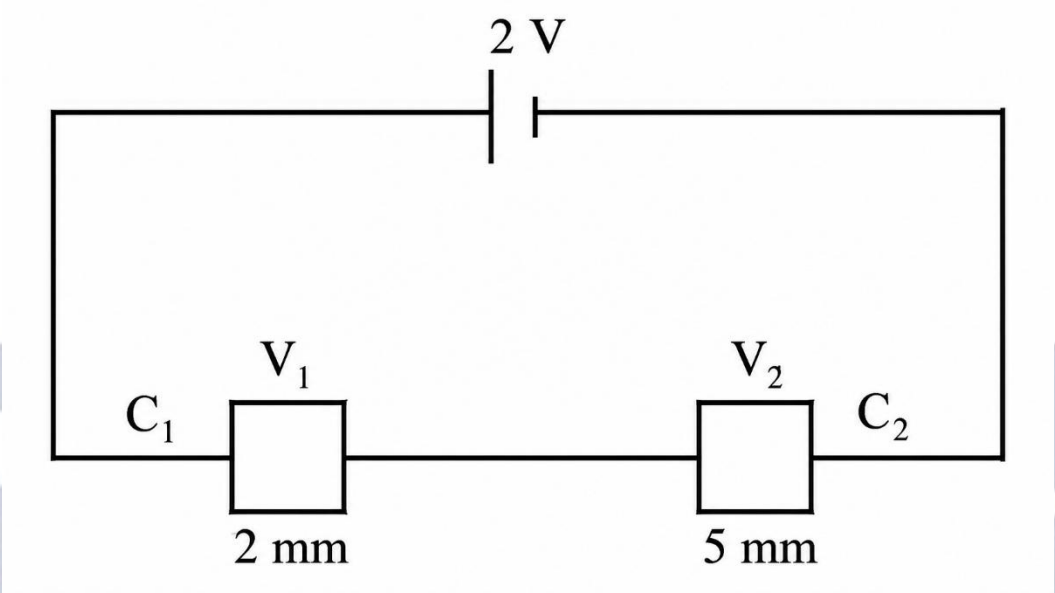
**[4 marks]**

**(b)** An electrical device rated 120 V, 60 W is operated on a 240 V, 50 Hz mains supply. The circuit has a capacitor connected in series with the electrical device and the supply. Calculate the capacitance of the capacitor.

[π = 3.142]

**[5 marks]**

The circuit diagram below illustrates two capacitors of capacitances $C_1$ and $C_2$ connected in series across a 2 V source.




**(c)**

**(i)** Define the *capacitance of a capacitor.*

**(I)** Obtain an expression for the total capacitance in terms of $C_2$.

**(II)** Calculate the potential difference across each capacitor.

**[6 marks]**

**Question 12**

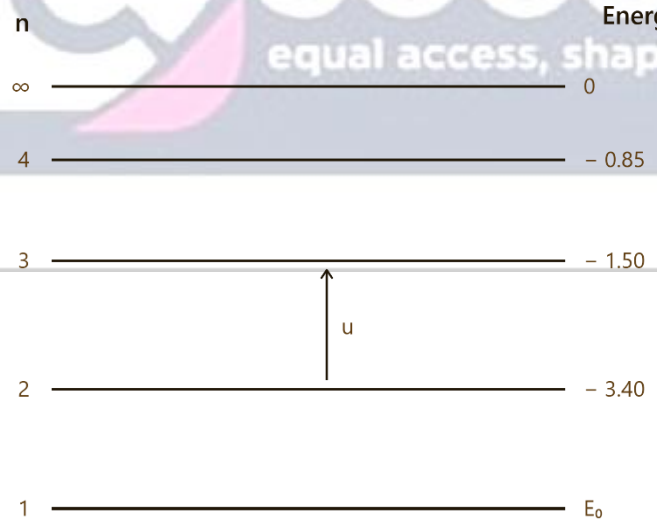
**(a)**

**(i)** State the principal factor that determines the relative stability of a radioactive nucleus.

**(ii)** Arrange the following radionuclides in **decreasing** order of stability. Justify your answer:

$^{2040}X$, $^{92}_{36}W$ and $^{95}_{42}Y$.

**[3 marks]**




**(b)**

**(i)** Explain the term *ionisation potential.*

**(ii)** The diagram below illustrates energy levels in the hydrogen atom. $E_0$ is the energy of the ground state.

**(I)** When an electron makes a transition from level n = 3 to level n = 1, it emits a photon of wavelength $1.02 \times 10^{-7}$ m. Calculate $E_0$.

**(II)** Calculate the ionization potential of the hydrogen atom.

**[6 marks]**

**(c)**

**(i)** Explain the statement, *the work function of sodium is 2.0 eV.*

**(ii)** Light of wavelength 160 nm is shone on the surface of a sodium metal of work function 2.0 eV. Determine whether photoelectrons will be emitted.

[h = $6.6 \times 10^{-34}$ Js, c = $3.0 \times 10^{8}$ $ms^{-1}$, 1 eV = $1.6 \times 10^{-19}$ J]

**[6 marks]**

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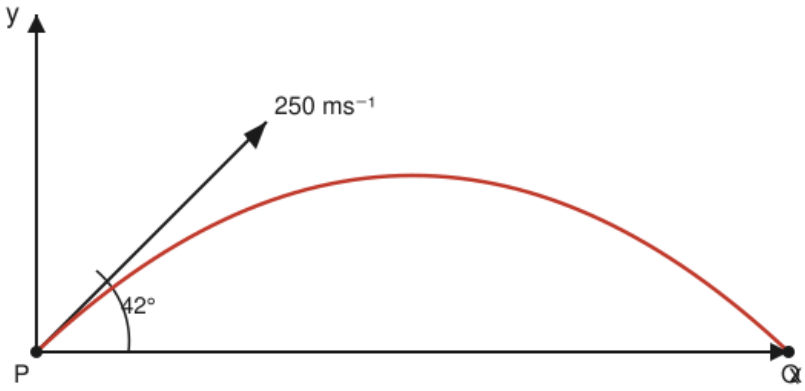
# WAEC PHYSICS

## PAPER 2 (ESSAY/THEORY) 2022

***Duration:*** *1½ hours · 60 marks · Answer eight questions in all: five from Part I and three from Part II*

**PART I — [15 marks] Answer any five questions. All questions carry equal marks.**

**1.** The force, $F$, acting on the wings of an aircraft moving through air of velocity, $v$, and density, $\rho$, is given by the equation $F = kv^x\rho^yA^z$, where $k$ is a dimensionless constant, and $A$ is the surface area of the wings of the aircraft. Use *dimensional analysis* to determine the values of $x$, $y$, and $z$. **[3 marks]**



Trajectory of a missile fired from P at 250 m s⁻¹, hitting Q after 40 s

**2.** (a) Define *strain energy*.

(b) Write an expression for the energy stored, $E$, in a stretched wire of original length, $l$, cross-sectional area, $A$, extension, $e$, and Young's modulus, $Y$, of the material of the wire. **[3 marks]**

**3.** (a) A projectile is fired at an angle, $\vartheta$, to the horizontal with velocity, $u$. Show that at any time, $t$, during the motion, the:

(i) horizontal component of the velocity is independent of $t$;

(ii) The vertical component of the velocity depends on $t$.

(b) State the assumption on which projectile motion is based. **[3 marks]**

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**4.** State **three** differences between *geostationary satellites* and *polar satellites*. **[3 marks]**

**5.** (a) Using the kinetic theory, explain the term *diffusion of fluid molecules*.

(b) Name one phenomenon that demonstrates that light behaves as a:

(i) wave;

(ii) particle. **[3 marks]**

**6.** (a) State one difference between an *intrinsic* and an *extrinsic* semiconductor.

(b) Draw a circuit diagram to illustrate full-wave smoothing rectification. **[3 marks]**

**7.** (a) What is *fibre optics*?

(b) State **two** reasons why optical fibres are preferred to copper cables in the telecommunications industry. **[3 marks]**

**8.** (a) (i) State the reason why simple harmonic motion is periodic.

(ii) State **two** factors that affect the period of oscillation of a simple pendulum.

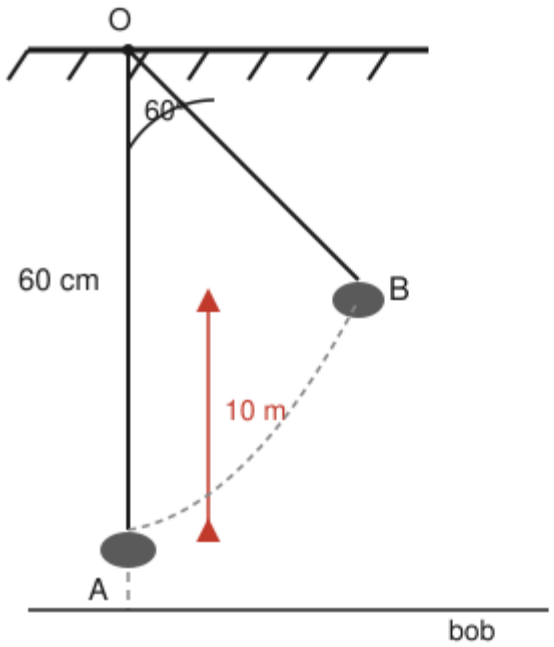
(iii) Sketch a graph of the total mechanical energy, *E*, against displacement, *y*, for the motion of a simple pendulum from one extreme position to the other. **[6 marks]**

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**PART II — [45 marks] — Answer three questions from this part. All questions carry equal marks.**

(b) The diagram below illustrates an oscillatory pendulum




ulum: string length 60 cm, swung through 60° from rest position A to B (rise ≈ 10 m

Calculate the work done in raising the pendulum to point B, if the mass of the bob is 50 g. [$g$ = 10 m s$^{-2}$] **[3 marks]**

(c) A spiral spring of spring constant, $k$, and natural length, $l$, has a scale pan of mass 0.04 kg hanging on its lower end while the upper end is firmly fixed to a support. When an object of mass 0.20 kg is placed on the scale pan, the length of the spring becomes 0.055 m, and when the object is replaced with another of mass 0.28 kg, the length becomes 0.065 m. Calculate the values of $k$ and $l$. [$g$ = 10 m s$^{-2}$] **[6 marks]**

---

**9.** *(parts (a) and (b) were not captured in your uploaded photos — the visible page begins partway through this question)*

(c) State **two** differences between *absolute zero temperature* and *ice point*. **[2 marks]**

(d) An uncalibrated liquid-in-glass thermometer was used in determining a celsius temperature. The readings are tabulated below.

| **Temperature/°C** | **−6** | **0** | **100** |
|---|---|---|---|
| **Length of column/cm** | $L$ | 2.0 | 15.0 |

Determine the value of $L$. **[3 marks]**

---

**10.** (a) (i) Why are *parabolic mirrors* suitable for use in headlamps of vehicles?

(ii) Draw a ray diagram to illustrate the answer in 10(a)(i).

(b) (i) State **two** applications of echoes.

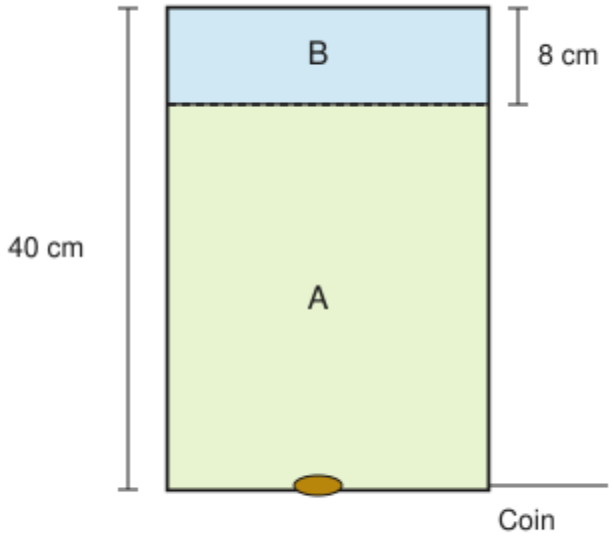
(ii) An observer standing at a point, P, on the same horizontal ground as the foot, H, of a tower shout and 1.20 s later he hears the echo. He then moved to another point, Q, 40 m from P, and shouts again but the echo was heard after 1.45 s. Calculate the:

I. distance between P and H;

II. speed of sound in air. **[6 marks]**

(c) (i) Define the term *absolute refractive index* of a medium.

(ii) A piece of coin falls accidentally into a tank containing two immiscible liquids A and B as illustrated in Fig. 10.0

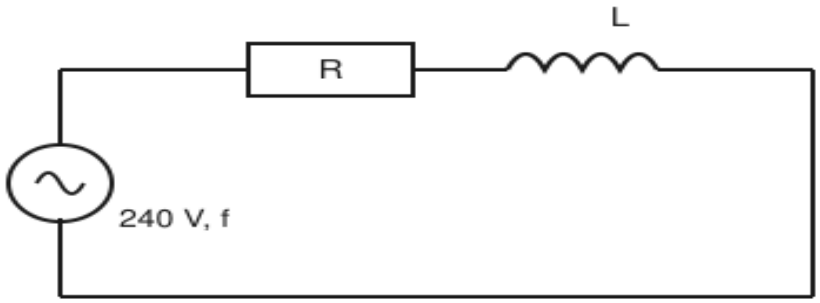



k of depth 40 cm containing liquid A, topped by 8 cm of liquid B; coin on t

Calculate the displacement of the coin when viewed vertically from above. [refractive index of A = 1.3, refractive index of B = 1.4] **[6 marks]**

---

**11.** *(parts (a) and (b) were not captured in your uploaded photos)*




l of inductance L and resistor of resistance R connected to a variable a.c. source, 24

(c) (i) Define *the electric potential at a point* in an electric field.

(ii) An uncharged body, A, was charged electrostatically by a test charge, B, using the method of induction and the method of contact. State **two** differences between the two methods. **[4 marks]**

---

**12.** (b) An important precaution during an electricity experiment is *to open the circuit when no reading is being taken*. Give **two** reasons for the stated precaution. **[2 marks]**

(c) is a circuit diagram in which a coil of inductance, *L*, and a resistor of resistance, *R*, are connected to a variable alternating source of frequency, *f*. The table shows the square of the impedance, $Z^2$, corresponding to each value of $f^2$.

| $f^2$/Hz$^2$ | 198.8 | 400.0 | 600.3 | 800.9 | 900.0 |
|---|---|---|---|---|---|
| $Z^2/\Omega^2$ | 249.6 | 400.0 | 552.3 | 702.3 | 800.9 |

(i) Write down the equation for *Z* in terms of $f^2$, $R^2$, and $L^2$.

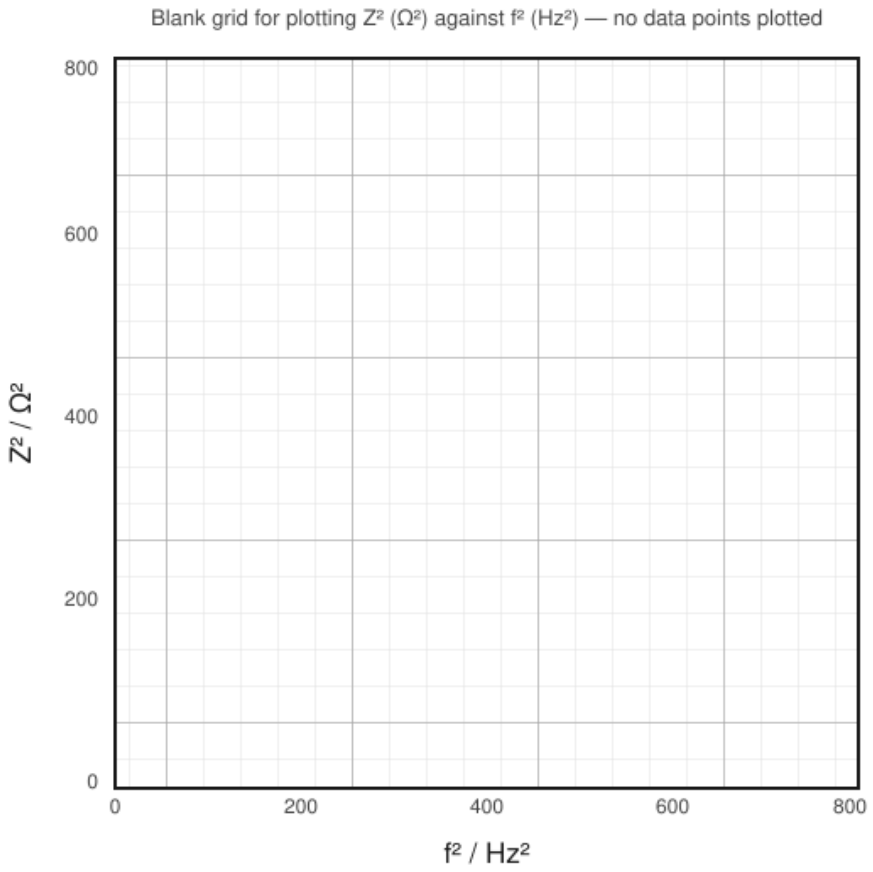
(ii) Plot a graph of $Z^2$ against $f^2$ and use it to determine the values of:

I. *L*;

II. *R*. [$\pi^2 = 10$] **[9 marks]**

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[mass of $^{235}_{92}U$ = 235.044 u, mass of $^{93}_{36}Kr$ = 91.898 u, mass of $^{141}_{56}Ba$ = 140.914 u, mass of neutron = 1.009 u, 1 u = $1.66 \times 10^{-27}$ kg, $c$ = $3.0 \times 10^{8}$ m $s^{-1}$]

(i) Write down the balanced nuclear reaction equation for the process.

(ii) State, with reason, whether Q is absorbed or released in the process.

(iii) Calculate the value of Q in joules. **[6 marks]**

**(d)** State **three** differences between *nuclear fusion* and *nuclear fission*. **[3 marks]**

**(c)** In a nuclear fission reaction, a nuclide $^{235}_{92}U$ is bombarded with a neutron to produce $^{93}_{36}Kr$ and $^{141}_{56}Ba$ with additional neutrons; the energy involved in the process is Q.

# WASSCE (SC) 2023

# PHYSICS 2 (ESSAY)

## PAPER 2 — ESSAY

***Answer eight questions in all: Five from Part I and three from Part II.***

***Time: 1½ hours | 60 marks***

**PART I**

*[15 marks] Answer any five questions from this part. All questions carry equal marks.*

Question 1

The force, *F*, acting on the wings of an aircraft moving through air of velocity, *v*, and density, *ρ*, is given by the equation $F = kv^x\rho^yA^z$, where *k* is a dimensionless constant and *A* is the surface area of the wings of the aircraft. Use dimensional analysis to determine the values of *x*, *y* and *z*.

[3 marks]

Question 2

(a) Define *strain energy*.

(b) Write an expression for the energy stored, *E*, in a stretched wire of original length, *l*, cross-sectional area, *A*, extension, *e*, and Young's modulus, *Y*, of the material of the wire.

[3 marks]

Question 3

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(a) A projectile is fired at an angle, $\vartheta$, to the horizontal with velocity, $u$. Show that at any time, $t$, during the motion, the:

(i) horizontal component of the velocity is independent of $t$;

(ii) vertical component of the velocity depends on $t$.

(b) State the assumption on which projectile motion is based.

[3 marks]

---

Question 4

State three differences between *geostationary satellites* and *polar satellites*.

[3 marks]

---

Question 5

(a) Using the kinetic theory, explain the term *diffusion of fluid molecules*.

(b) Name one phenomenon that demonstrates that light behaves as a:

(i) wave;

(ii) particle.

[3 marks — 1 mark for this part]

---

Question 6

(a) State one difference between an *intrinsic* and an *extrinsic* semiconductor.

(b) Draw a circuit diagram to illustrate full-wave smoothing rectification.

[3 marks]

---

Question 7

(a) What is *fibre optics*?

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(b) State two reasons why optical fibres are preferred to copper cables in the telecommunications industry.

[3 marks]

---

Question 8 *(a)*

(i) State the reason why simple harmonic motion is periodic.

(ii) State two factors that affect the period of oscillation of a simple pendulum.

(iii) Sketch a graph of the total mechanical energy, *E*, against displacement, *y*, for the motion of a simple pendulum from one extreme position to the other.

[6 marks]

---

**PART II**

[45 marks] Answer three questions from this part. All questions carry equal marks.

---

Question 9

(a) Define each of the following terms used with simple machines:

(i) pivot;

(ii) load;

(iii) efficiency.

[6 marks]

(b) A truck of mass $1.2 \times 10^3$ kg is pulled from rest by a constant horizontal force of 75.2 N on a levelled road. If the maximum speed attainable in the process is 60 km $h^{-1}$, calculate the:

(i) work done by the force;

(ii) distance travelled by the truck in reaching the maximum speed.

[4 marks]

---

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Question 10

(a) (i) Why are parabolic mirrors suitable for use in headlamps of vehicles?

(ii) Draw a ray diagram to illustrate the answer in 10(a)(i).

(b) (i) State two applications of echoes.

(ii) An observer standing at a point, P, on the same horizontal ground as the foot, H, of a tower shouts and 1.20 s later, he hears the echo. He then moved to another point, Q, 40 m from P, and shouts again but the echo was heard after 1.45 s. Calculate the:

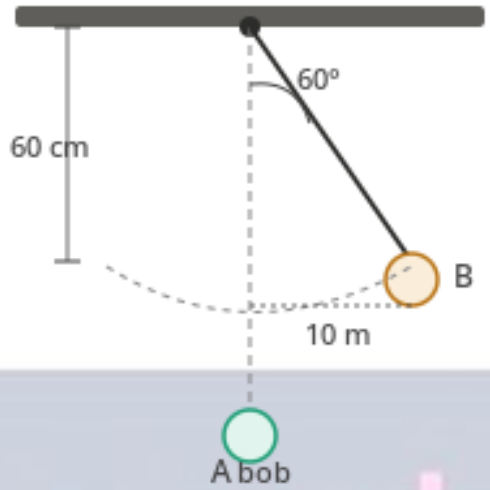
I. distance between P and H;

II. speed of sound in air.

(c) (i) Define the term *absolute refractive index* of a medium.

(ii) A piece of coin falls accidentally into a tank containing two immiscible liquids A and B as illustrated in Fig. 10.0.

The diagram below (Fig. 10.0) shows the tank with liquid B (8 cm deep) on top of liquid A (40 cm deep), with the coin at the bottom:




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Calculate the displacement of the coin when viewed vertically from above. [refractive index of A = 1.5, refractive index of B = 1.4]

[6 marks]

(c continued) (i) Define the *electric potential at a point in an electric field*.

(ii) An uncharged body, A, was charged electrostatically by a test charge, B, using the method of induction and the method of contact. State two differences between the two methods.

[4 marks]

---

Question 11

(b) An important precaution during an electricity experiment is to *open the circuit when no reading is being taken*. Give two reasons for the stated precaution.

[2 marks]

(c) Fig. 11.0 is a circuit diagram in which a coil of inductance, $L$, and a resistor of resistance, $R$, are connected to a variable alternating source of frequency, $f$.

---

The table shows the square of the impedance, $Z^2$, corresponding to each value of $f^2$:

| $f^2$ / $Hz^2$ | 198.8 | 400.0 | 600.3 | 800.9 | 900.0 |
|---|---|---|---|---|---|
| $Z^2$ / $\Omega^2$ | 249.6 | 400.0 | 552.3 | 702.3 | 800.9 |

(i) Write down the equation for $Z$ in terms of $f^2$, $R^2$ and $L^2$.

(ii) Plot a graph of $Z^2$ against $f^2$ and use it to determine the values of:

I. $L$;

II. $R$.

[$\pi^2 = 10$]

[9 marks]

---

Question 12

(a) State the function of each of the following parts of a modern x-ray tube:

(i) heater;

(ii) high tension source;

(iii) cooling fins.

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[3 marks]

(b) State one reason for each of the following design features of a modern x-ray tube:

(i) the glass envelope is highly evacuated;

(ii) the target is a metal of very high melting point;

(iii) the cooling fins are located outside the glass envelope.

[3 marks]

(c) In a nuclear fission reaction, a nuclide $^{235}_{92}U$ is bombarded with a neutron to produce $^{93}_{36}Kr$ and $^{141}_{56}Ba$ with additional neutrons; the energy involved in the process is Q.

[mass of $^{235}_{92}U$ = 235.044 u, mass of $^{93}_{36}Kr$ = 91.898 u, mass of $^{141}_{56}Ba$ = 140.914 u, mass of neutron = 1.009 u, 1 u = $1.66 \times 10^{-27}$ kg, c = $3.0 \times 10^{8}$ m $s^{-1}$]

(i) Write down the balanced nuclear reaction equation for the process.

(ii) State with reason whether Q is absorbed or released in the process.

(iii) Calculate the value of Q in joules.

[6 marks]

(d) State three differences between *nuclear fusion* and *nuclear fission*.

[3 marks]

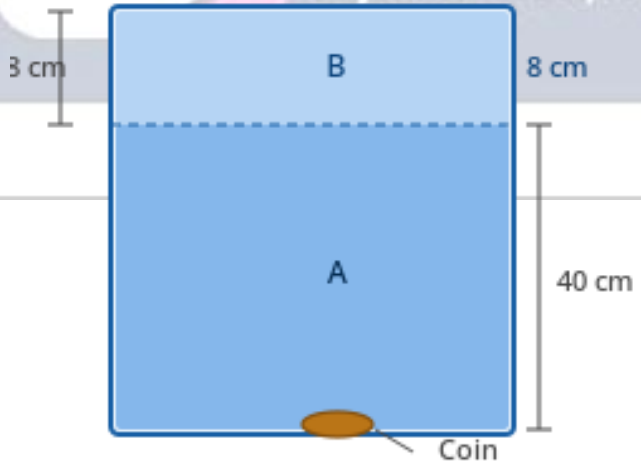



*Fig. 10.0*

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Question 13

(b) The diagram below illustrates an oscillatory pendulum.

Calculate the work done in raising the pendulum to point B, if the mass of the bob is 50 g.

[g = 10 m $s^{-2}$]

[3 marks]

(c) A spiral spring of spring constant, *k*, and natural length, has a scale pan of mass 0.04 kg hanging on its lower end while the upper end is firmly fixed to a support. When an object of mass 0.20 kg is placed on the scale pan, the length of the spring becomes 0.055 m and when the object is replaced with another object of mass 0.28 kg, the length of the spring becomes 0.065 m. Calculate the values of *k* and *l*.

[g = 10 m $s^{-2}$]

[6 marks]

(c) Temperature section:

State two differences between absolute zero temperature and the ice point.

[2 marks]

(d) An uncalibrated liquid-in-glass thermometer was used in determining a celsius temperature. The readings are tabulated below:

| | | | |
|---|---|---|---|
| Temperature / °C | −6 | 0 | 100 |
| Length of column / cm | *L* | 2.0 | 15.0 |

Determine the value of *L*.

[3 marks]

# WAEC PHYSICS

## PAPER 2 (ESSAY) 2024

**TIME: TOTAL: 60 MARKS**

*Answer eight questions in all: five questions from Part I and three questions from Part II.*

**PART I**

*Answer five questions from this part. All questions carry equal marks.*

**1. (a)** Derive the dimension of surface tension. *[2 marks]*

**(b)** Name the instrument used to measure the force of gravity at a place. *[1 mark]*

**2. (a)** State two uses of a polar satellite. *[2 marks]*

**(b)** What does the slope of a graph of tensile stress against tensile strain represent? *[1 mark]*

**(c)** Explain why evaporation leads to cooling.

**(d)** A kettle rated 2400 W contains water at 20°C. The kettle is switched on, and after two minutes, the water starts boiling. After another six minutes, 45% of the water in the kettle boils away.

**(i)** Determine the specific latent heat of vaporisation of the water.

**(ii)** State one assumption made in your calculation in 9(d)(i) above.

**3.** State the S.I. base units of the following physical quantities:

**a)** Stress;

**b)** Force constant;

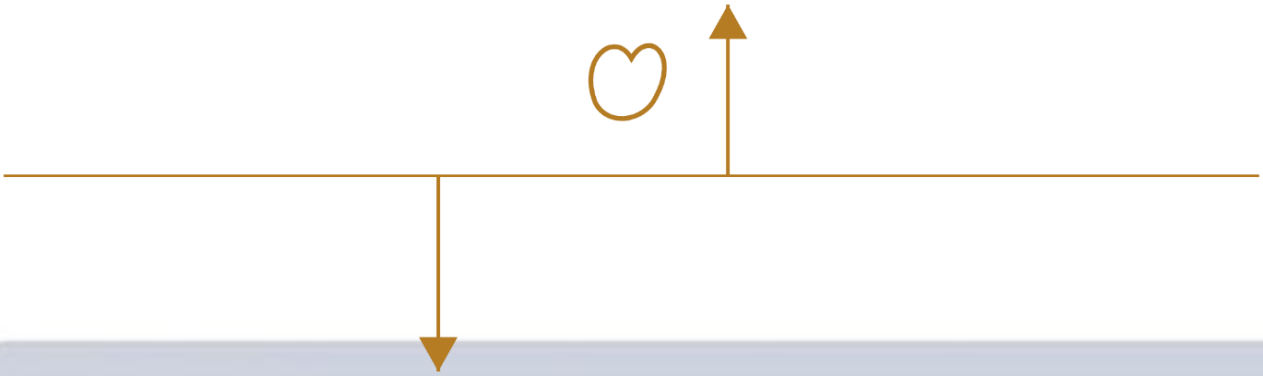
**c)** Planck's constant. *[3 marks]*

**4.** An object projected at an angle to a level ground has a time of flight of 4 s to move through still air. Calculate the maximum height attained by the object. [g = 10 $ms^{-2}$] *[3 marks]*

**5.** State three uses of ferromagnetic materials. *[3 marks]*

**6.** An electron of mass m and charge e moves through an electric field of potential difference $V_o$ with a speed v. Show that the de Broglie wavelength associated with the electron is given as

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Object (up), virtual image (loop), inverted image (down)

$$\lambda = \frac{h}{\sqrt{2meV_0}}$$

where ***h*** is Planck's constant.

**7.** The fractional change in length produced in an elastic material of spring constant 680 $Nm^{-1}$ when a force of 306 N is applied to stretch it is 1.5. Calculate the original length of the material.

**8.** Mention the main parts of an electrical transformer.

**9. (a)**

**(i)** What is a thermometric liquid?

**(ii)** State the reason for the following design features of a clinical thermometer:

I. Narrow bore;

II. Thin wall of the bulb.

**(b)** Distinguish between heat and temperature of an object in terms of energy of a particle.

**10. (a)** State the condition for a light ray incident on a concave mirror to reflect through the principal focus of the mirror.

**(b)** Explain spherical aberration as a defect of curved mirrors.

**(c)** The diagram below illustrates an image formed when an object is placed in front of a particular lens.

Redraw the diagram and indicate the center of curvature, C, principal focus, F, and the principal axis.

**(d)** What is meant by accommodation in connection to the human eye?

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**(e)** State quantitatively the:

**(i)** values of the near and far points of a normal human eye.

**(ii)** Use the answer in 10(e)(i) to determine the change in optical power of the normal human eye when reading a book and viewing the sky.

[lens-to-retina distance = 2.5 cm]

**1. (i)** State the condition for a charged particle to experience a force in a magnetic field.

**(ii)** State the expression for the magnetic force, F acting on a charged particle, Q in a magnetic field of flux density, B with a speed V.

**(iii)** Prove quantitatively that there is no magnetic force moving along in the direction of magnetic field.

**(b) (i)** Mention the main parts of an electrical transformer.

**(ii)** Explain how an alternating potential difference applied to the primary coil gives rise to an induced e.m.f. in the secondary coil of a transformer.

**(c)** A proton of mass $1.7 \times 10^{-27}$ kg enters a magnetic field of flux density 0.207 T normally and follows a quarter circle path before exiting with constant speed of $4.50 \times 10^{5}$ $ms^{-1}$.

**(i)** Explain why the speed of the proton remains constant.

**(ii)** Calculate the:

1. radius of circular path;
2. time taken by the proton to move through the magnetic field.

[$e = 1.6 \times 10^{-19}$ C, $\pi = 3.14$]

**12. (a)** Mention three facts about photoelectric effects.

**(b)** An entire magnetic radiation source of power $6 \times 10^{-3}$ W emits $1 \times 10^{16}$ photons per second. The most energetic photoelectron ejected from a metal surface is stopped by a potential difference of 2.2 V. Calculate the work function of the metal.

[mass of (photo) electron = $9.1 \times 10^{-31}$ kg, $1.6 \times 10^{-19}$ C]

---

**PART II**

*[45 marks]*

*Answer three questions from this part. All questions carry equal marks.*

**(Maximum marks obtainable: 50 marks) Rubrics: Candidates were required to answer any two questions.**

**8. (a)** State the effect of increasing temperature on the viscosity of a:

**(i)** liquid;

**(ii)** gas.

**(b)** *(continues from previous page, text not visible)* State two factors that determine the magnitude of a moment of a force about a point.

**(c)** A uniform stick AB of length, L and mass, m, is balanced horizontally on a knife edge 30.0 cm from A when an object of mass 400 g is suspended at A. When the knife edge is moved 5 cm further, the object has to be moved to a point 9.00 cm from A for the stick to balance.

**(i)** Represent the balance system with a suitable diagram.

**(ii)** Determine the:

I. mass, m of the stick;

II. length, L.

**(d)** Explain in terms of air molecules why the pressure at the top of a high mountain is less than that at sea level.

**(e)** Mercury of density $13.6 \times 10^3$ $kgm^{-3}$ is poured into a container of uniform cross-sectional area 40 $cm^2$ to a height of 20 cm. The total pressure exerted on the base of the container is $1.42 \times 10^5$ Pa. Calculate the:

**(i)** mass of mercury in the container;

**(ii)** pressure exerted at the surface of the mercury. [g = 10 $ms^{-2}$]

**13. (c)** State factors on which the activity of a radioactive sample depends.

**(d)** Cobalt-60 source has an activity of $2.0 \times 10^6$ Bq and a half-life of $1.8 \times 10^8$ s. Calculate the number of radioisotope nuclei in the source.

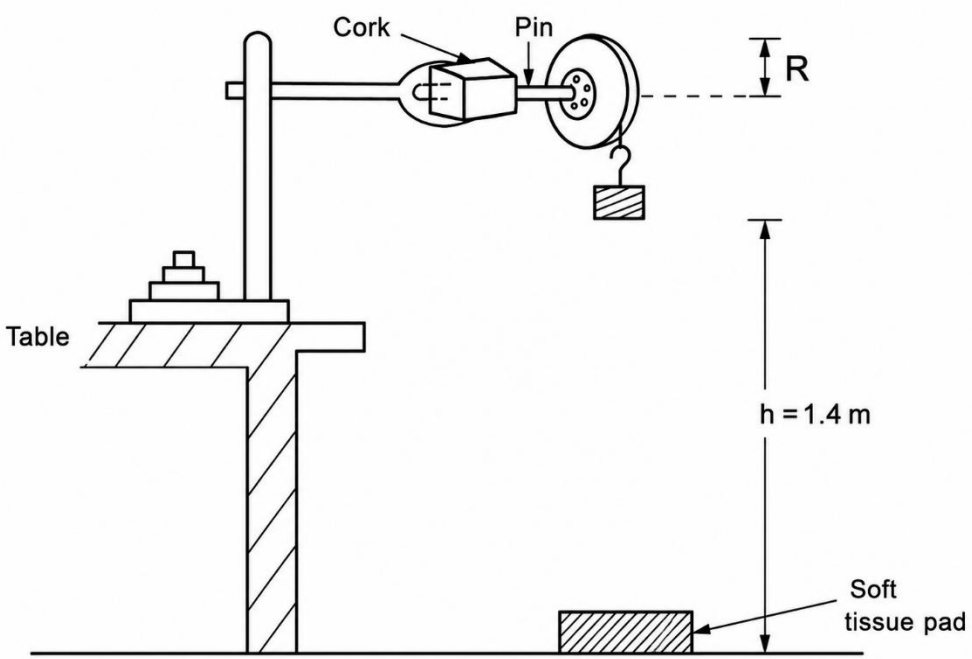
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# WASSCE (SC) 2015 PHYSICS 3 PRACTICALS

## MARKING SCHEME

**QUESTION 1 (a)**

(SEE DIAGRAM BELOW)




You are provided with a retort stand, boss head, clamp, stopwatch, slotted weights, hanger, grooved pulley, thread, measuring tape, and other necessary materials.

To determine the coefficient of static friction between two surfaces.

(i) Measure and record the radius R of the pulley.

(ii) Set up the apparatus as illustrated in the diagram above, such that the clamp is 1.5 m above the floor.

(iii) Tie one end of the thread to the pulley.

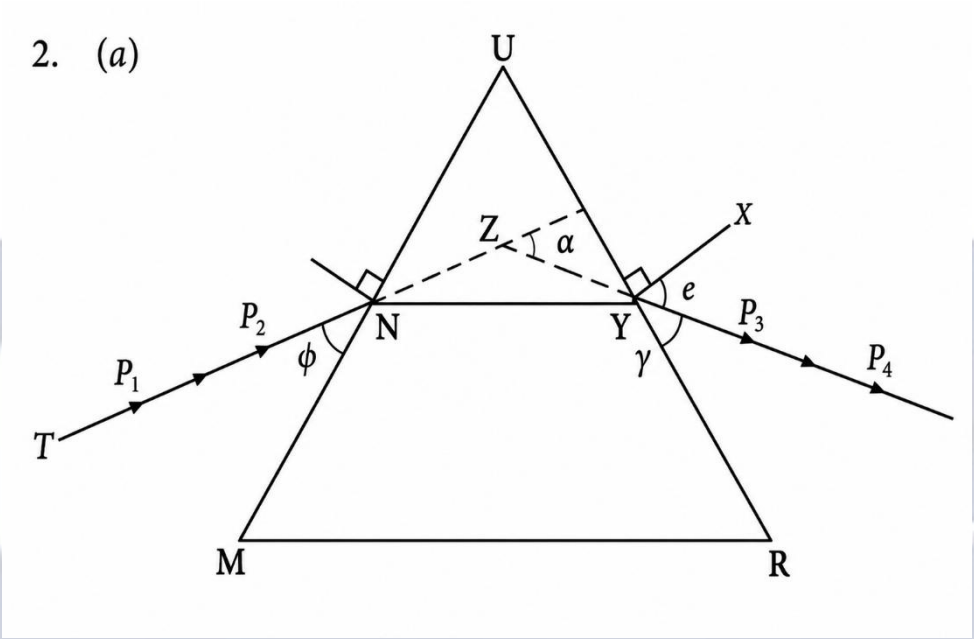
(iv) Tie the other end of the thread to the hanger.

(v) Slot a mass m = 50 g on the hanger.

(vi) Wind the thread around the groove of the pulley until the base of the hanger is at a height h = 1.4 m above the floor. Maintain this height h for every other value of m throughout the experiment.

(vii) Release the mass to unwind the thread.

(viii) Determine and record the time t taken by the mass m to reach the floor.




(ix) Evaluate $t^2$.

(x) Also evaluate $a = 2h/t^2$, $T = m/1000\ (10 - a)$ and $\alpha = a/R$.

(xi) Repeat the procedure for four other values of m = 70 g, 90 g, 110 g and 130 g.

(xii) Tabulate your readings.

(xiii) Plot a graph with α on the vertical axis and T on the horizontal axis.

(xiv) Determine the slope s, of the graph.

(xv) Evaluate I = R/s.

(xvi) State two precautions taken to obtain accurate results. [21 marks]

(b)

(i) Define centripetal force. [2 marks]

(ii) An object drops to the ground from a height of 2.0 m. Calculate the speed with which it strikes the ground. [g = 10 $ms^{-2}$] [2 marks]

---

QUESTION 2 (a)

(SEE DIAGRAM BELOW)

You are provided with a triangular glass prism, four optical pins and other necessary materials.

(i) Place the triangular glass prism on drawing paper and draw its outline UMR. Remove the prism.

(ii) Measure and record the value of the angle at U.

(iii) Draw a normal to the line UM at N. Also, draw another line TN to the normal such that $\phi = 60°$. Fix two pins at $P_1$ and $P_2$.

(iv) Replace the prism and fix two other pins at $P_3$ and $P_4$ such that the pins appear to be in a straight line with the images of the pins at $P_1$ and $P_2$ when viewed from the side UR. Remove the prism.

(v) Join points $P_3$ and $P_4$ producing the line to meet TN produced at Z. Draw the normal XY.

(vi) Measure and record the angle of emergence, e and that of deviation d.

(vii) Repeat the experiment with $\phi = 55°, 50°, 40°$ and $35°$.

(viii) In each case, measure and record the corresponding values of e and d.

(ix) Tabulate your readings.

(x) Plot a graph with d on the vertical axis and e on the horizontal axis starting both axes from the origin (0,0). Join your points with a smooth curve.

(xi) From your graph, obtain the minimum deviation $d_m$ and the corresponding angle of emergence $e_m$. Hence, calculate the refractive index n of the prism using the formula:

$n = \text{Sin}((d_m + U) / 2) / \text{Sin}(U / 2)$

(xii) State two precautions taken to obtain accurate results. Attach your traces to your answer booklet. [21 marks]

(b)

(i) State the conditions necessary for total internal reflection of light to occur. [2 marks]

(ii) The critical angle for a transparent substance is 39°. Calculate the refractive index of the substance. [2 marks]

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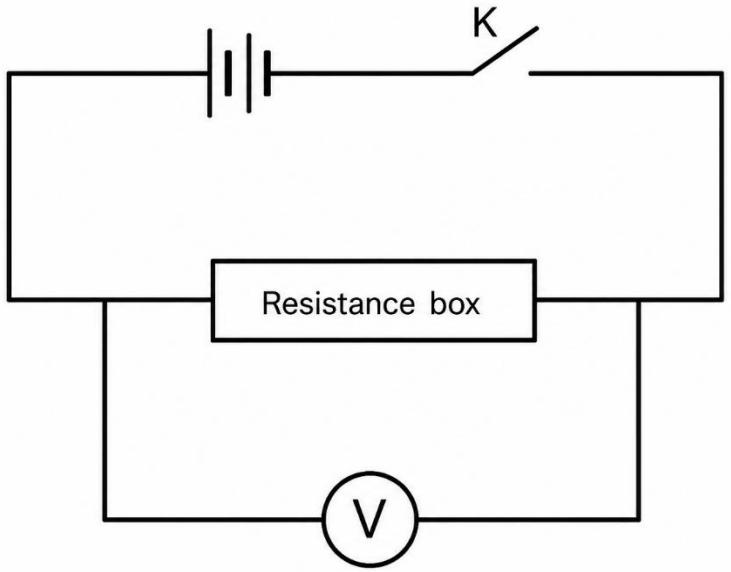
QUESTION 3 (a)

(SEE DIAGRAM BELOW)

You have been provided with a resistance box, a voltmeter, a key, a battery and other necessary materials.

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3. *(a)*




(i) Connect the circuit as shown in the diagram above.

(ii) With the key K closed, read and record the voltmeter reading $V_o$.

(iii) Set the resistance R in the resistance box equal to 1Ω.

(iv) Close the key, read and record the potential difference V on the voltmeter.

(v) Evaluate $R^{-1}$ and $V^{-1}$.

(vi) Repeat the procedure for five other values of R = 2Ω, 3Ω, 4Ω, 5Ω and 6Ω.

(vii) Tabulate your readings.

(viii) Plot a graph with $V^{-1}$ on the vertical axis and $R^{-1}$ on the horizontal axis.

(ix) Determine the slope, s, of the graph and the intercept, c, on the vertical axis.

(x) Evaluate $c^{-1}$.

(xi) State two precautions taken to obtain accurate results. [21 marks]

(b)

(i) Define potential difference between two points in an electric circuit. [2 marks]

(ii) Explain why the emf of a cell is greater than the p.d. across the cell when it is supplying current through an external resistance. [2 marks]

**QUESTION 1 — Mechanics (Circular Motion / Free Fall)**

Given: h = 1.4cm, R = 8.0cm

Results:

| S/N | M/g | t/s | $t^2/s^2$ | a = $2h/t^2$ | T = M/1000(10−a) | α = g/12 |
|---|---|---|---|---|---|---|
| **1** | 50.0 | 0.54 | 0.2916 | 9.6022 | 0.0199 | 0.8002 |
| **2** | 70.0 | 0.44 | 0.1936 | 14.4628 | −0.3124 | 1.2052 |
| **3** | 90.0 | 0.34 | 0.1156 | 24.2215 | −1.2799 | 2.0185 |
| **4** | 110.0 | 0.25 | 0.0625 | 44.8000 | −3.8280 | 3.7333 |
| **5** | 130.0 | 0.20 | 0.0400 | 70.0000 | −7.8900 | 5.8333 |

Graph of α against T.

Approximated Values of α and T:

| S/N | α | T |
|---|---|---|
| **1** | 0.800 | 0.020 |
| **2** | 1.205 | −0.312 |
| **3** | 2.019 | −1.280 |
| **4** | 3.733 | −3.828 |
| **5** | 5.833 | −7.800 |

(xiv) Slope

$S = \Delta\alpha/\Delta T = 4.3/6.0 = 0.7167$

(xv) $I = R/S = 8.0/0.7167 = 11.1623 \approx 11.162$

(xvi) Precautions:

I avoided parallax error in reading the metre rule, stopwatch and tape rule.

I observed the zero error on the metre rule, stopwatch and tape rule.

I ensured that the retort stand and pulley were firmly clamped.

(b)(i) Centripetal force is the force that acts towards the centre of an object moving in a circular path and makes the object move with a constant speed. It is given by:

$Cp = mv^2/r$

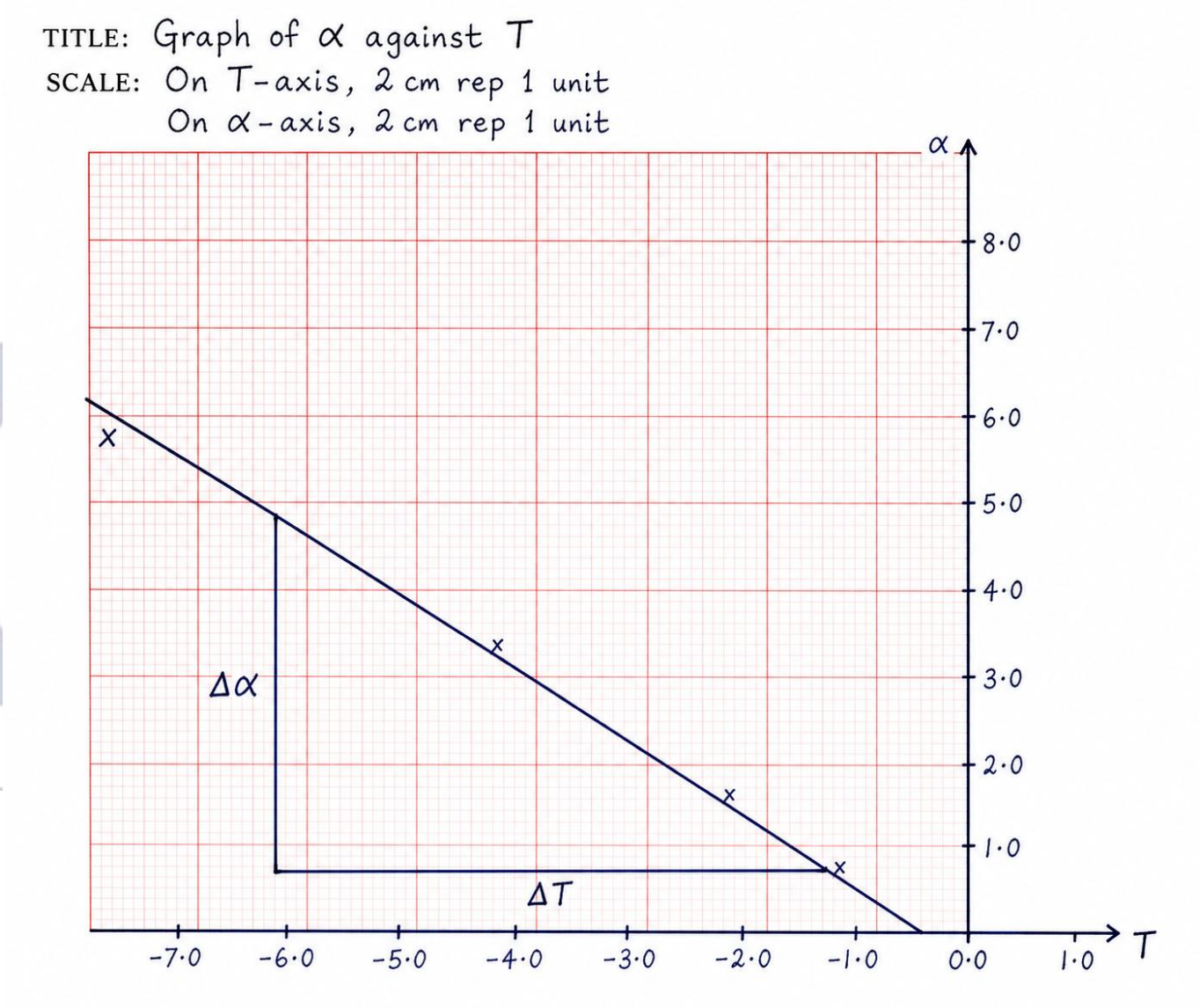
where: Cp = Centripetal force; v = speed or velocity of the object; r = radius of the object

(ii) h = 2.0m, g = 10 m/s², u = 0

Using: $V^2 = u^2 + 2gh$

$V^2 = 0^2 + 2\times10\times2 = 40$

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⇒ $V = \sqrt{40}$

Hence, $V = \sqrt{40} = 6.32$ m/s

*(Graph — see attached: "Graph of α against T", scale: T-axis 2cm rep 1 unit, α-axis 2cm rep 1 unit — straight line with ΔT and Δα marked for slope calculation.)*

**QUESTION 2 — Optics (Refraction / Prism)**

2(a) Results:

| S/N | θ/° | ϕ/° | d/° |
|---|---|---|---|
| **1** | 60.0 | 70.0 | 49.5 |
| **2** | 55.0 | 66.0 | 46.0 |
| **3** | 50.0 | 60.0 | 43.0 |
| **4** | 40.0 | 52.0 | 45.0 |
| **5** | 35.0 | 42.0 | 50.0 |

Graph of d against θ.

μ = sin[(dmin + A)/2] ÷ sin(A/2)

= sin[(43+60)/2] ÷ sin(60/2)

= sin(51.5) ÷ sin(30)

= 0.7861 ÷ 0.5000

= 1.5652

(xii) Precautions:

I avoided parallax errors when reading the protractor.

I ensured that the pins were upright by using sharp pencils.

(c) For total internal reflection to occur, the angle of incidence in the denser medium must be greater than the critical angle.

Light must be travelling from a denser medium to a less dense medium.

Second part (refractive index by critical angle method):

μ = 1/sinC = 1/sin39° = 1/0.6293 = 1.59

∴ The refractive index μ = 1.59

(Graph — see attached: "Graph of d against θ", scale: θ-axis 2cm rep 10 units, d-axis 2cm rep 10 units — curve showing minimum deviation region.)

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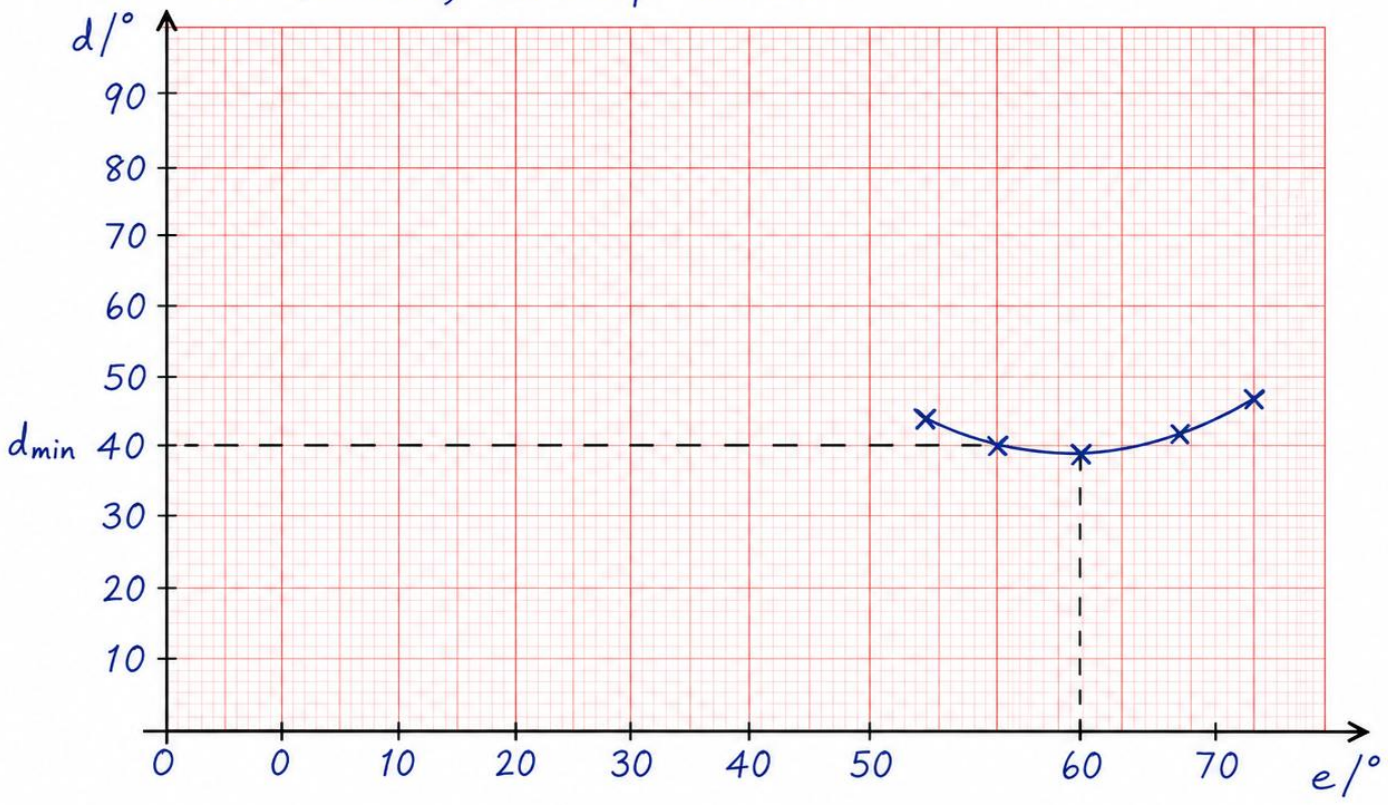
(ii) $\mu = \frac{1}{\sin C} = \frac{1}{\sin 39} = \frac{1}{0.6293}$ (16)

$\therefore$ The Refractive Index $\mu = 1.59$

TITLE: Graph of d against e.

SCALE: On d-axis, 2cm rep. 10 units

On e-axis, 2cm rep. 10 units



**QUESTION 3 — Electricity (Resistance / EMF)**

3(a) Results:

$V_o$ = 3.0V

| S/N | R/Ω | V/V | $V^{-1}/V^{-1}$ | $R^{-1}/\Omega^{-1}$ |
|---|---|---|---|---|
| **1** | 1.0 | 1.4 | 0.7143 | 1.0000 |
| **2** | 2.0 | 1.6 | 0.6250 | 0.5000 |
| **3** | 3.0 | 1.8 | 0.5556 | 0.3333 |
| **4** | 4.0 | 2.0 | 0.5000 | 0.2500 |
| **5** | 5.0 | 2.2 | 0.4545 | 0.2000 |
| **6** | 6.0 | 2.4 | 0.4167 | 0.1667 |

Approximated values of $V^{-1}$ and $R^{-1}$:

| S/N | $V^{-1}$ | $R^{-1}$ |
|---|---|---|
| **1** | 0.72 | 1.00 |
| **2** | 0.62 | 0.50 |
| **3** | 0.56 | 0.33 |
| **4** | 0.50 | 0.25 |
| **5** | 0.45 | 0.20 |
| **6** | 0.42 | 0.17 |

(ix) Slope of the graph

$S = \Delta V^{-1}/\Delta R^{-1} = (0.72-0.45)/(0.7-0.2) = 0.27/0.5 = 0.54$

Intercept on vertical axis:

$c^{-1} = 1/0.34 = 2.9412$

$\therefore c \approx 2.9$

Slope $S = \Delta V^{-1}/\Delta R^{-1} = 0.7-0.45 / 0.7-0.2 = 0.27/0.5 = 0.5$ (alternate slope reading shown)

Intercept on vertical axis, $c^{-1} = 1/0.34 = 2.9412$

$\Rightarrow c^{-1} = 2.9412$

Slope, $S \approx 0.54$

Intercept on horizontal axis, $c^{-1} = 1/0.34 = 2.9412$

$\Rightarrow c^{-1} = 2.9412$

(xi) Precautions:

I observed and corrected the zero error in reading the voltmeter.

I ensured tight connections of the wires.

I avoided parallax errors in reading the voltmeter.

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I opened the key when readings were not being taken, to prevent drainage of the batteries.

(b)(i) The potential difference between two points in an electric circuit is the work done in joules in moving a charge of one Coulomb from one point to another.

(ii) The electromotive force of a cell is greater than the potential difference of a cell's internal resistance. Mathematically, the electromotive force of a cell is given by:

$E = V + Ir$

where:

E = Electromotive force (Emf)

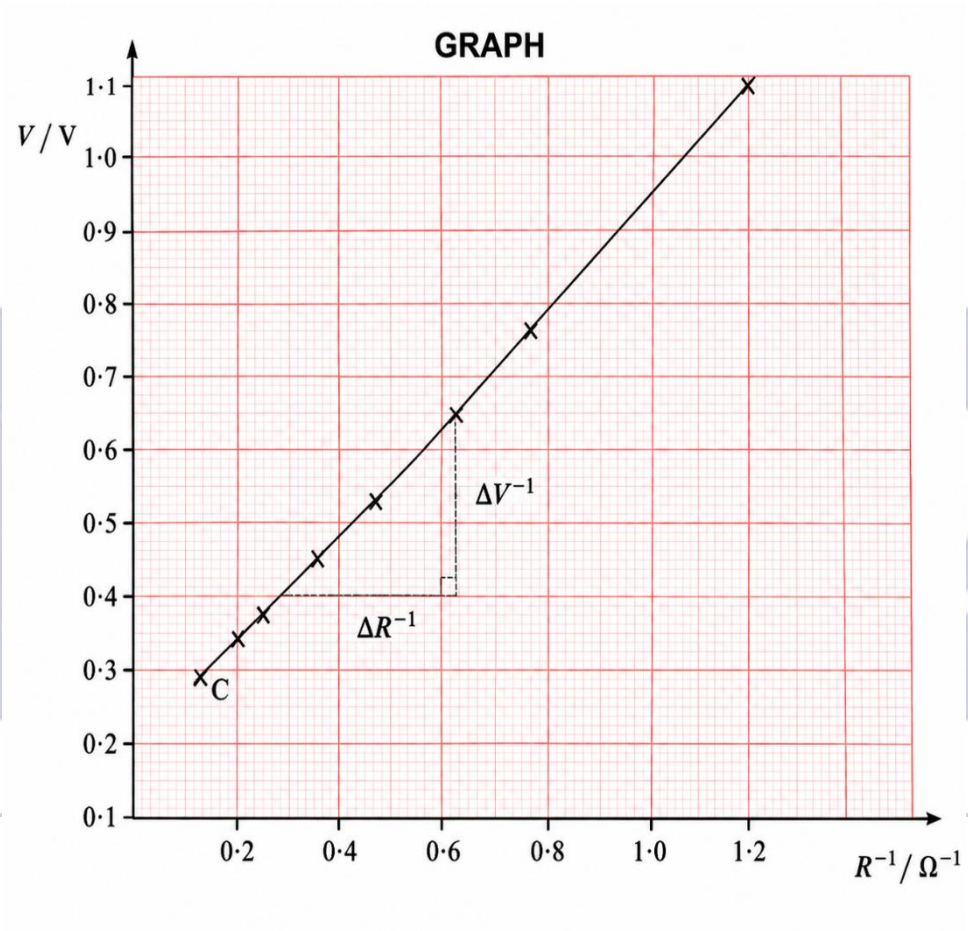
V = Potential difference

I = Current passing in the circuit

r = internal resistance of the cell

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(Graph — see attached: "Graph of $V^{-1}$ against $R^{-1}$", scale: $R^{-1}$-axis 2cm rep 0.1 units, $V^{-1}$-axis 2cm rep 0.2 units — straight line with negative slope, $\Delta R^{-1}$ and $\Delta V^{-1}$ marked.)

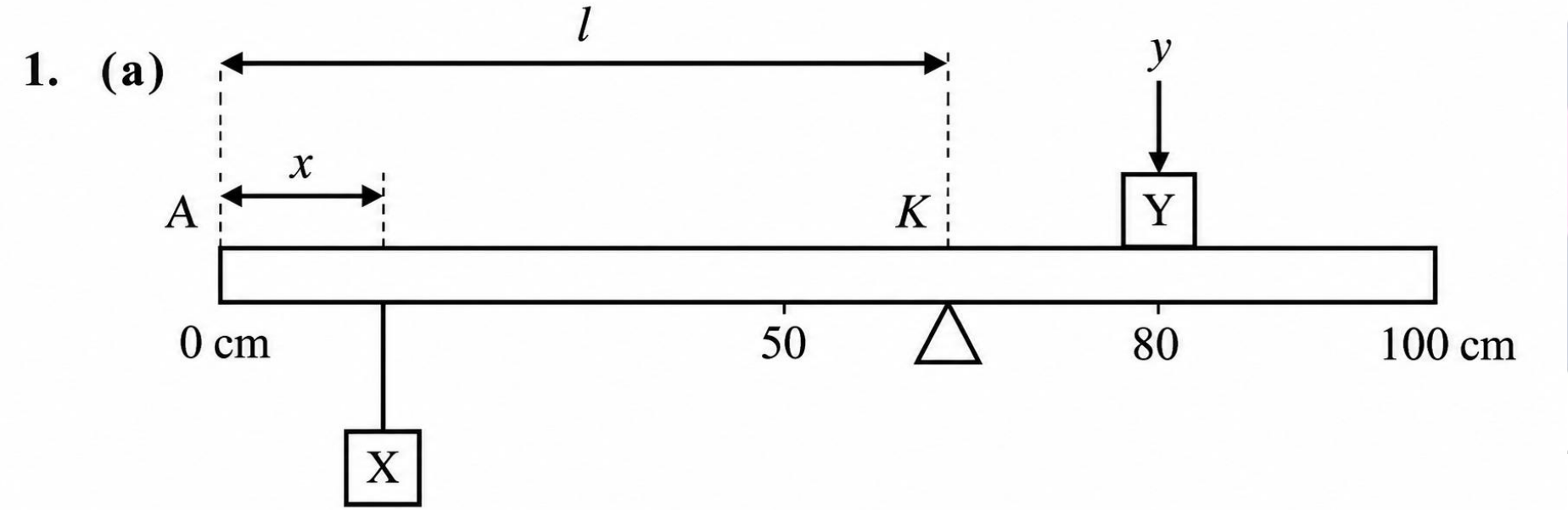

GRAPH
V / V
1·1
1·0
0·9
0·8
0·7
0·6
0·5
0·4
0·3
0·2
0·1
ΔV⁻¹
ΔR⁻¹
C
0·2
0·4
0·6
0·8
1·0
1·2
R⁻¹ / Ω⁻¹

## WASSCE 2016 PHYSICS 3 PRACTICAL —

## ALTERNATIVE A

## QUESTION PAPER — PAGE A

1.(a) [Diagram: a metre rule balanced on a knife edge, with mass N




hung at point Y (80 cm mark) and mass M at distance A from the 0 cm mark; a 100 cm scale shown]

You are provided with a uniform metre rule, a knife edge, some masses and other necessary materials.

(i) Determine and record the centre of gravity of the metre rule.

(ii) Fix the 100 g mass marked N at point Y, the 80 cm mark of the rule using a sellotape.

(iii) Suspend another 50 g mass marked M at X, distance A = 10 cm from the 0 cm mark of the rule.

(iv) Balance the arrangement horizontally on the knife edge as illustrated in the diagram above.

(v) Measure and record the distance B of the knife edge from the 0 cm mark of the rule.

(vi) Repeat the procedure for four other values of A = 15 cm, 20 cm, 25 cm and 30 cm.

(vii) Tabulate your readings.

(viii) Plot a graph with B on the vertical axis and A on the horizontal axis.

(ix) Determine the slope, s, of the graph.

(x) Also determine the intercept, c, on the vertical axis.

(xi) Evaluate: (α) $k_1 = [(1-2s)/s] \times 100$; (β) $k_2 = (2c/s) - 160$.

(xii) State two precautions taken to obtain accurate results.

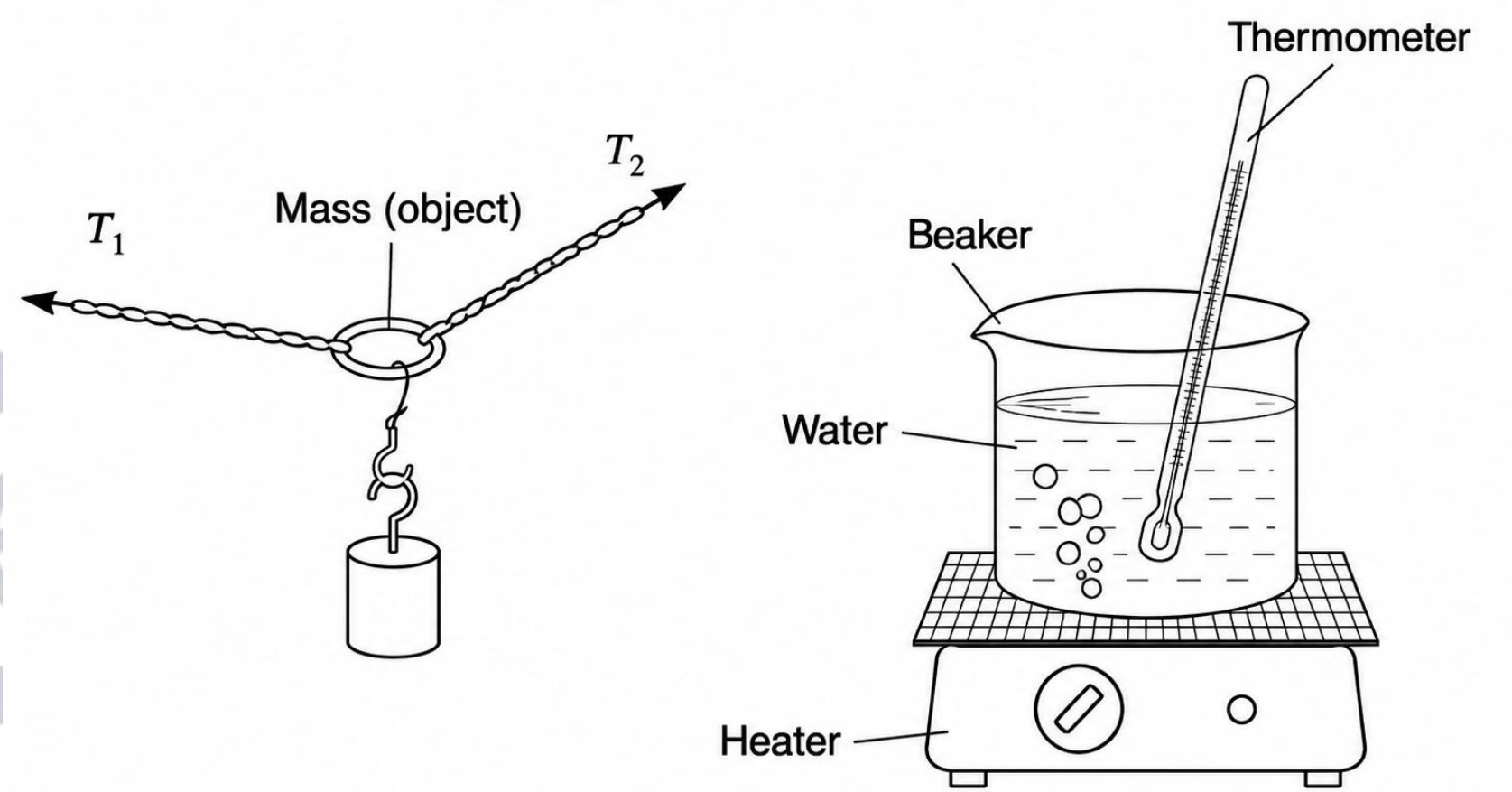
(b)(i) Define moment of a force about a point.

(ii) State two conditions under which a rigid body at rest remains in equilibrium when acted upon by non-parallel coplanar forces.

2.(a) [Diagram: apparatus — tong, mass (object), thermometer, beaker of water over a Bunsen burner]

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You are




provided with a beaker, a thermometer, a stirrer, a measuring cylinder, a Bunsen burner, a wire gauze, a 50 g mass, a pair of tongs, water, a tripod stand, and other necessary materials.

(i) Using the measuring cylinder, measure 150 $cm^3$ of water into the beaker. (ii) Record the volume v of the water in the beaker. (iii) Calculate the mass m of the water, given that $m = \rho v$ and $\rho = 1$ g $cm^{-3}$. (iv) Measure and record the initial temperature $\theta_o$ of the water in the beaker. (v) Hold the 50 g mass with the pair of tongs in the flame of the Bunsen burner for 2 minutes. (vi) Quickly transfer the 50 g mass to the water in the beaker. (vii) Stir gently and record the

highest temperature θ attained. (viii) Empty the content of the beaker and repeat the procedure above for other values of v = 200 $cm^3$, 250 $cm^3$, 300 $cm^3$ and 350 $cm^3$. (ix) Tabulate your readings. (xi) Plot a graph with m on the vertical axis and θ on the horizontal axis. Determine the slope, s, of the graph. Evaluate k = 50/s. (xiv) State two precautions taken to obtain accurate results.

(b)(i) Define heat capacity.

(ii) An electric kettle rated 1.2 kW is used to heat 800 g of water initially at a temperature of 20°C. Neglecting heat losses, calculate the time taken for the kettle to heat the water to its boiling point. [Take boiling point of water = 101°C, specific heat capacity of water = 4200 $Jkg^{-1}K^{-1}$]

**QUESTION PAPER — PAGE B**

3.(a) [Circuit diagram: cell E with key K, variable resistor, standard resistor 2Ω, ammeter A, voltmeter V]

You are provided with a variable d.c. power supply E, a 2Ω standard resistor, a key, an ammeter, a voltmeter, and other necessary materials.

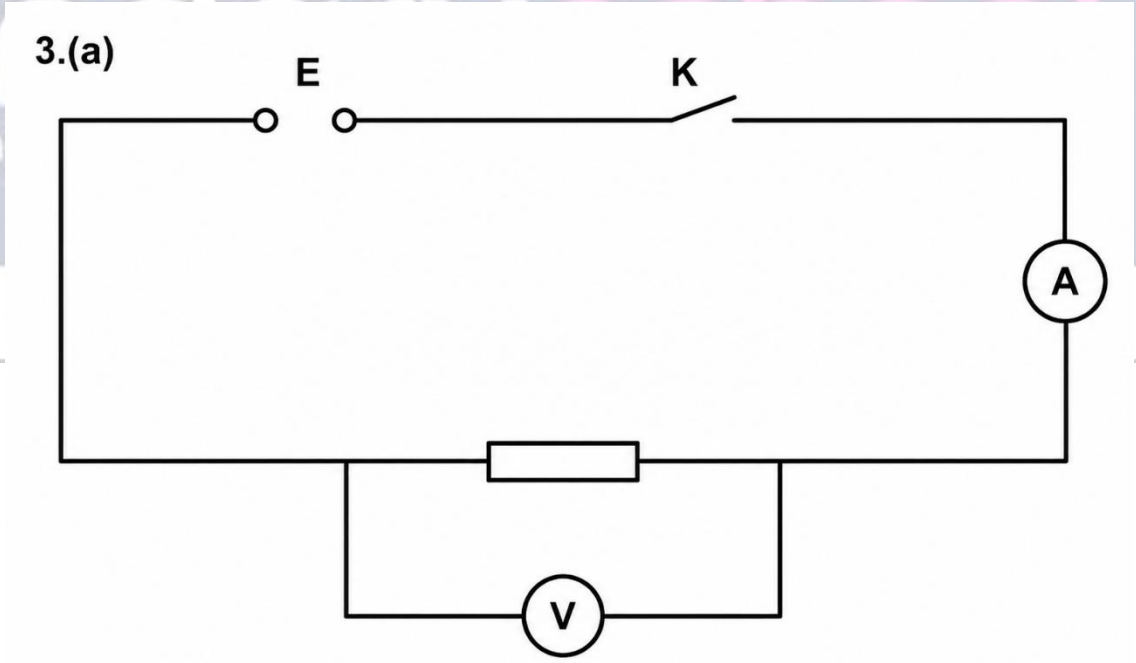
(i) Set up a circuit as shown in the diagram above with E = 1.5 V.

(ii) Close the key K.

(iii) Take and record the voltmeter reading V.

(iv) Take and record the corresponding ammeter reading I. (v) Evaluate $V^{-1}$ and $I^{-1}$.

(vi) Repeat the procedure for four other values of E = 3.0 V, 4.5 V, 6.0 V and 7.5 V.



(vii) Tabulate your readings.

(viii) Plot a graph with $V^{-1}$ on the vertical axis and $I^{-1}$ on the horizontal axis, starting both axes from the origin (0,0).

(ix) Determine the slope, s, of the graph.

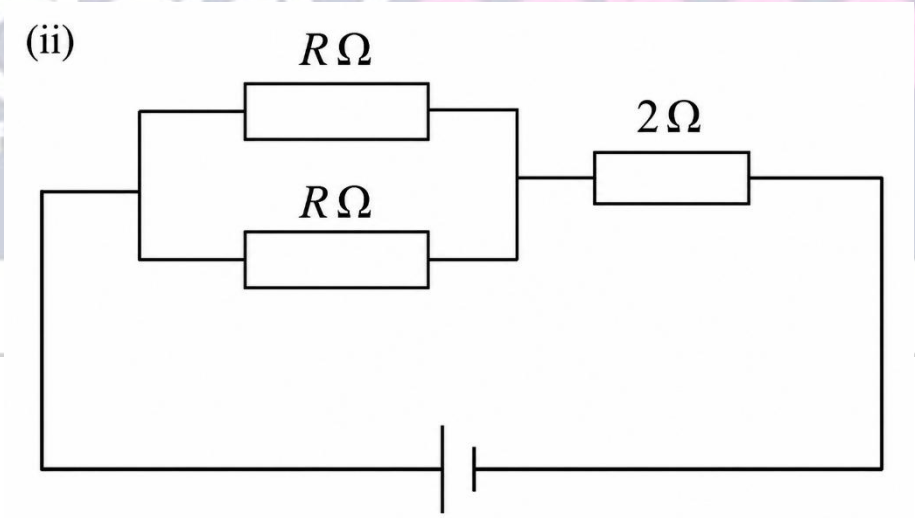
(x) Also determine the intercept, c, on the vertical axis.

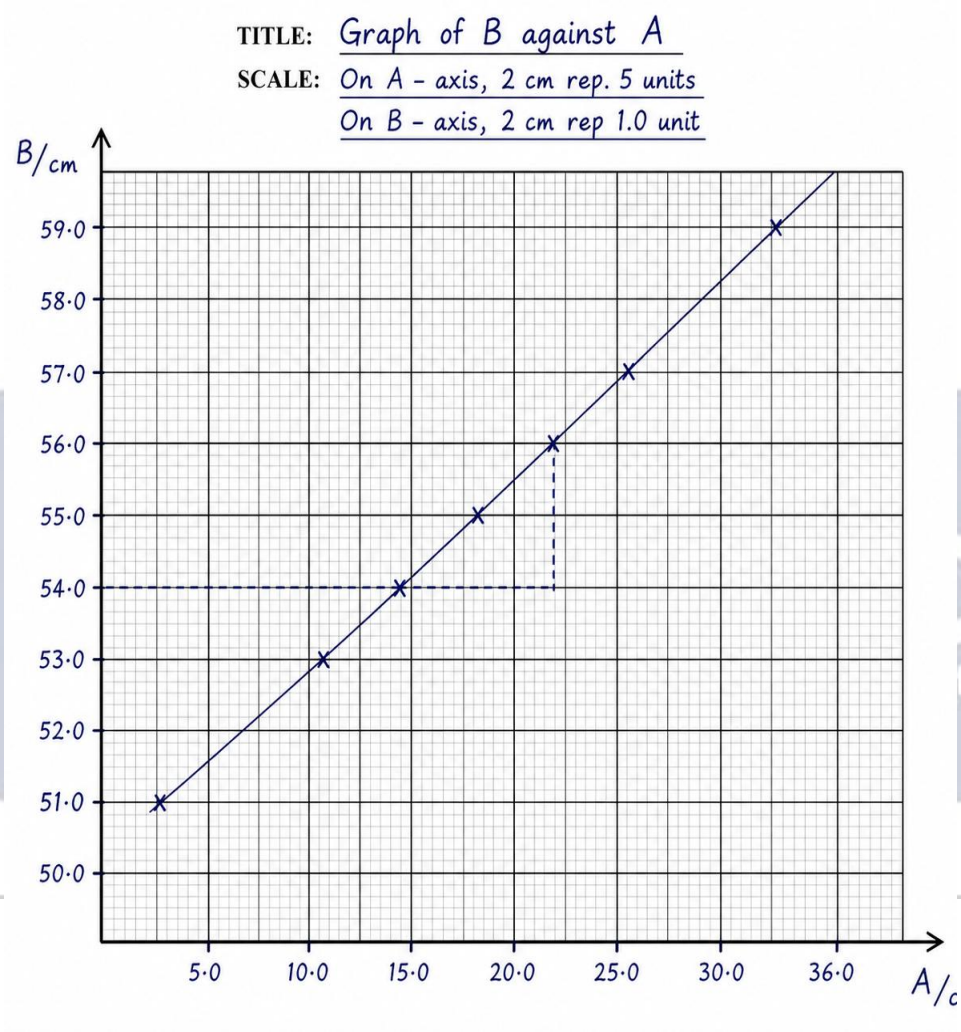
(ix) State two precautions taken to obtain accurate results.

(b)(i) State two methods by which an electric current can be produced.

(ii) [Circuit diagram: two RΩ resistors in parallel, in series with a 2Ω resistor]

Calculate the value of R in the circuit diagram shown above, given that the effective resistance of the circuit is 4.0Ω and the internal resistance of the cell is negligible.






## ANSWERS

**QUESTION 1**

1(a) Centre of gravity of the metre rule = 50.0 cm

Results:

S/N 1: A = 10.0 cm, B = 54.0 cm

S/N 2: A = 15.0 cm, B = 55.0 cm

S/N 3: A = 20.0 cm, B = 56.0 cm

S/N 4: A = 25.0 cm, B = 56.0 cm

S/N 5: A = 30.0 cm, B = 58.0 cm

Graph: Graph of B against A

(ix) Slope of the graph: $S = \Delta B/\Delta A = (57 - 54)/(25 - 10) = 3/15 = 1/5 = 0.2$

(x) Intercept c on the vertical axis (from the graph): $c = 52$

(xi) 1) $k_1 = [(1 - 2s)/s] \times 100 = [(1 - 0.4)/0.2] \times 100 = 0.6/0.2 \times 100 = 300$

2) $k_2 = (2c/s) - 160 = [2(52)/0.2] - 160 = 54/0.2 - 160 \rightarrow 270 - 160 = 110$

(Note: the "54" in this line doesn't match 2×52 = 104 — worth re-checking this step.)

(ix) Precautions:

I avoided parallax error in reading the metre rule scale.

I ensured the rule was well balanced/horizontal on the knife edge before taking readings.

(b)(i) Moment of a force about a point is the turning effect (or turning moment) produced by the force about that point; it is the product of the force and the perpendicular distance from the point to the line of action of the force.

(ii) Conditions for equilibrium under non-parallel coplanar forces:

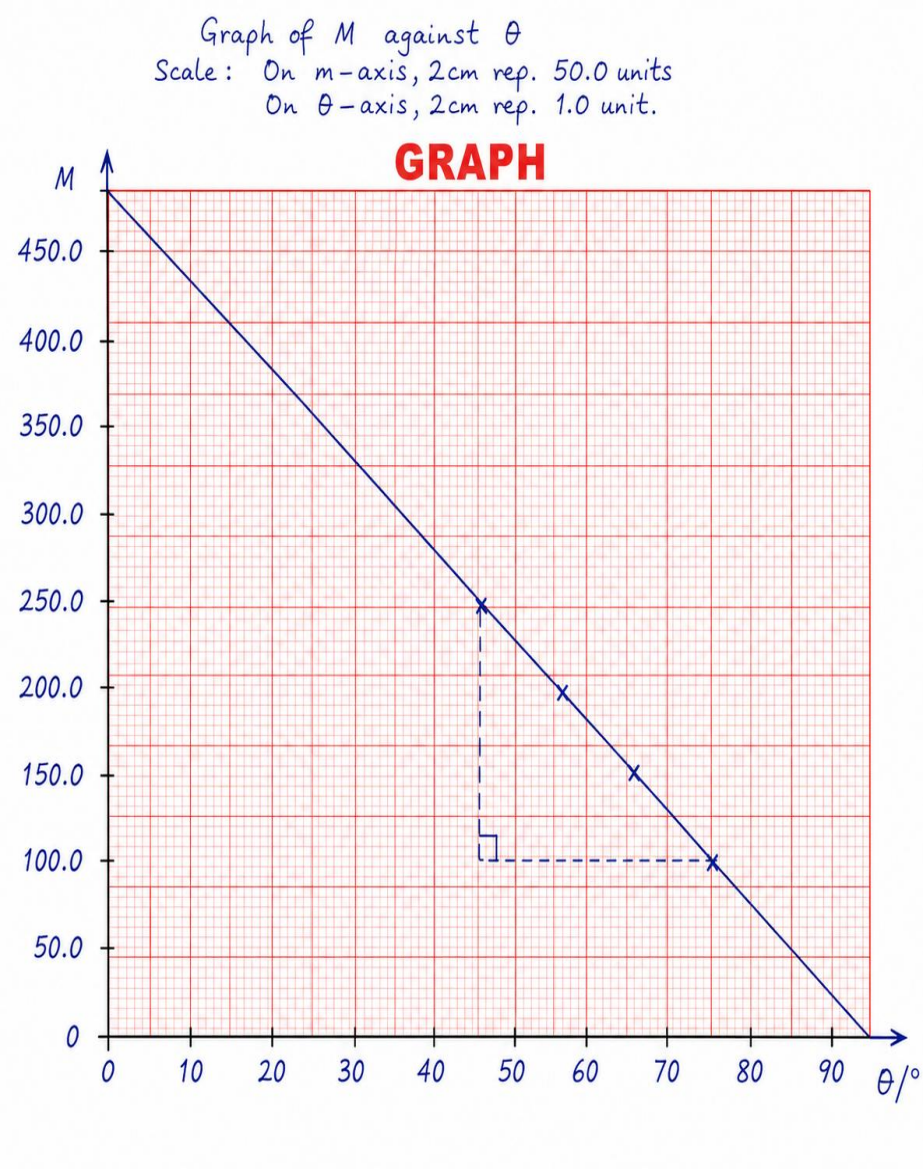
The resultant force acting on the body must be zero (sum of forces = 0).

The resultant moment (torque) about any point must be zero (sum of clockwise moments = sum of anticlockwise moments).

**QUESTION 2**

Graph: Graph of M against θ — Scale: M-axis, 2 cm rep. 50.0 units; θ-axis, 2 cm rep. 1.0 unit

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(xi) Slope of the graph: $S = \Delta M_i/\Delta\Theta_i = (40 - 20)/(8.0 - 4.0) = 20/4 = 5$

(x) Precautions:

I avoided parallax error in reading the thermometer.

I stirred the water gently to ensure uniform temperature.

I avoided splashing of water on the laboratory table and floor.

(b)(i) Boiling point of a liquid is the temperature at which the saturated vapour pressure of the liquid equals the external atmospheric pressure.

(ii) Impurities affect the boiling point of a liquid because their presence increases the boiling point of the liquid compared to the boiling point of a pure solvent.

**QUESTION 3**

Results:

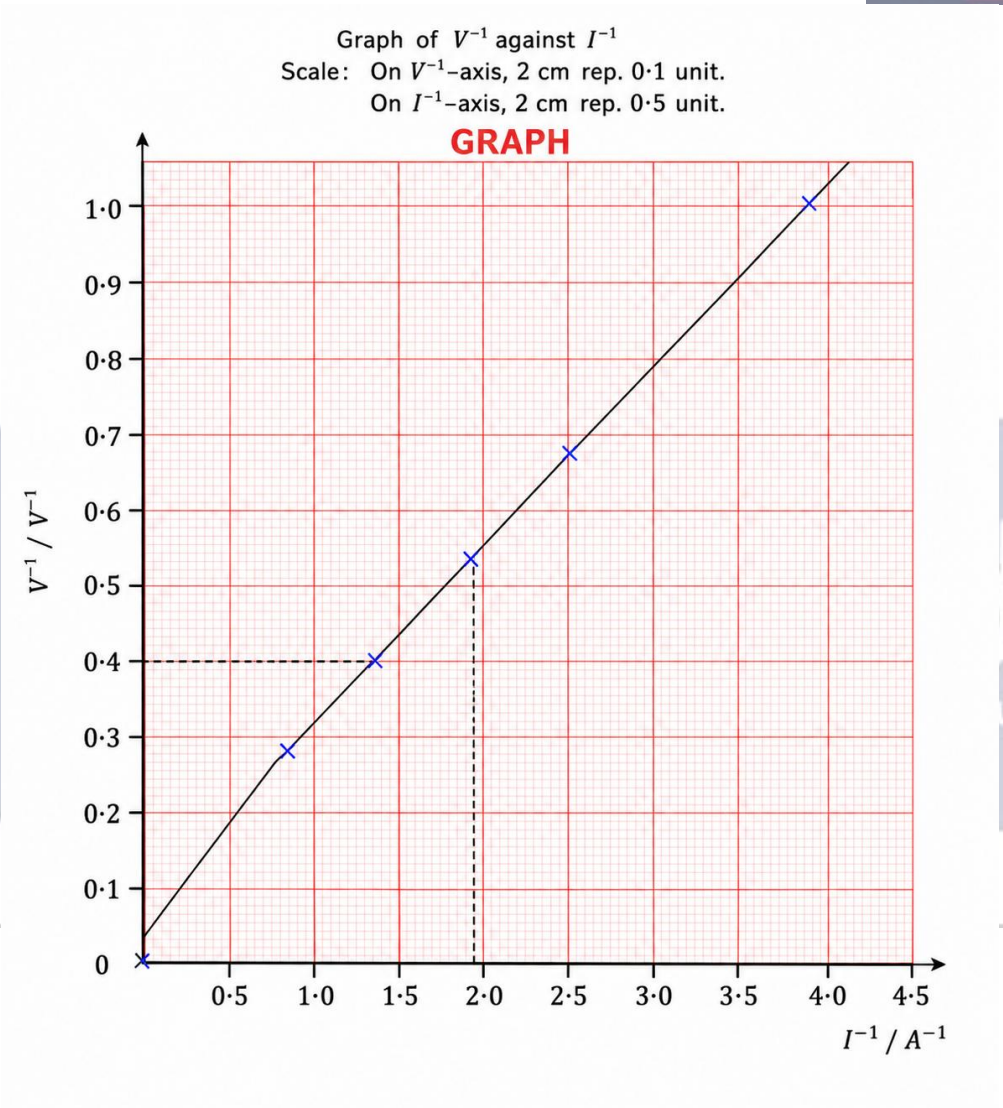
S/N 1: E = 1.5 V, V = 1.0 V, I = 0.3 A, $V^{-1} = 1.0000$, $I^{-1} = 3.3333$

S/N 2: E = 3.0 V, V = 1.5 V, I = 0.5 A, $V^{-1} = 0.6667$, $I^{-1} = 2.0000$

S/N 3: E = 4.5 V, V = 2.0 V, I = 0.7 A, $V^{-1} = 0.5000$, $I^{-1} = 1.4286$

S/N 4: E = 6.0 V, V = 2.5 V, I = 0.9 A, $V^{-1} = 0.4000$, $I^{-1} = 1.1111$

S/N 5: E = 7.5 V, V = 3.0 V, I = 1.10 A, $V^{-1} = 0.3333$, $I^{-1} = 0.9091$




Approximated values of $V^{-1}$ and $I^{-1}$ (from the graph):

S/N 1: $V^{-1}$ = 1.0, $I^{-1}$ = 3.3

S/N 2: $V^{-1}$ = 0.7, $I^{-1}$ = 2.0

S/N 3: $V^{-1}$ = 0.5, $I^{-1}$ = 1.4

S/N 4: $V^{-1}$ = 0.4, $I^{-1}$ = 1.1

S/N 5: $V^{-1}$ = 0.3, $I^{-1}$ = 0.9

Graph: Graph of $V^{-1}$ against $I^{-1}$ — Scale: $V^{-1}$-axis, 2 cm rep. 0.1 unit; $I^{-1}$-axis, 2 cm rep. 0.5 unit

Slope of the graph: $S = \Delta V^{-1}/\Delta I^{-1} = (0.7 - 0.4)/(2.0 - 1.1) = 0.3/0.9 = 0.33$

Intercept: C = 0.03

(ix) Precautions:

I ensured zero error on the ammeter and voltmeter was noted/corrected.

I avoided parallax error when reading the ammeter and voltmeter.

I ensured the key was removed/opened after each reading.

I ensured tight connections.

(b)(i) Methods of producing electric current:

By use of chemical cells

By use of generators

By use of solar cells

Through windmills

By tidal waves

By geothermal process

By nuclear power

By hydro-power

Through gas turbines

Through electrostatic generator (Van de Graaff generator)

Through thermionic (heat energy) emission, etc.

(ii) Calculation of R:

$1/R_e = 1/R_1 + 1/R_2$ (two RΩ resistors in parallel)

$1/R_e = 1/R + 1/R = 2/R$

$\Rightarrow 2R_e = R$, so $R_e = R/2$

$R_t = R/2 + 2$ (series with the 2Ω resistor)

Given $R_t = 4.0\Omega$: $R/2 = 4 - 2 = 2$

$\therefore R = 4\Omega$

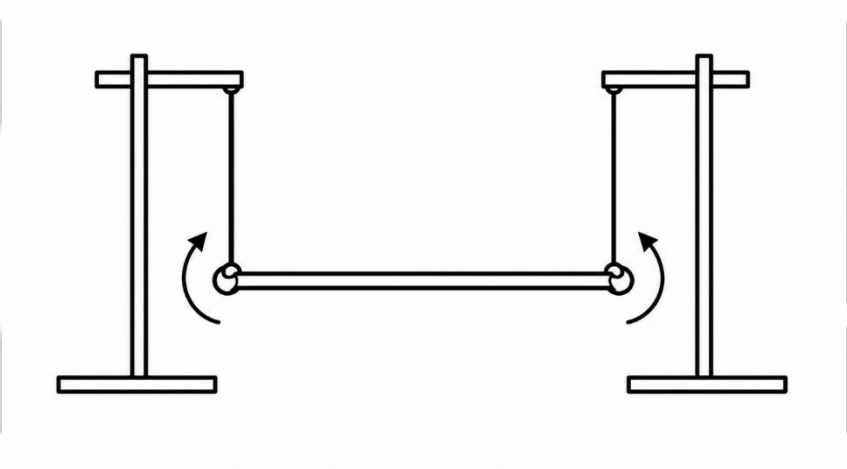
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# WASSCE JUNE 2017

# PHYSICS 3 PRACTICAL (ALTERNATIVE A)

**QUESTION 1**

1. (a) You are provided with two retort stands, two metre rules,



pieces of thread and other necessary apparatus.

(i) Set up the apparatus as illustrated above ensuring that the strings are permanently 10 cm from either end of the rule.

(ii) Measure and record the length L = 80 cm of the two strings.

(iii) Hold both ends of the rule and displace the rule slightly, then release so that it oscillates about a vertical axis through its centre.

(iv) Determine and record the time t for 10 complete oscillations.

(v) Determine the period T of oscillations.

(vi) Evaluate log T and log L.

(vii) Repeat the procedure for four other values of L = 70 cm, 60 cm, 50 cm and 40 cm.

(viii) Tabulate your readings.

(ix) Plot a graph with log T on the vertical axis and log L on the horizontal axis.

(x) Determine the slope, s and the intercept, c on the vertical axis of the graph.

(xi) State two precautions taken to ensure accurate results. [21 marks]

(b)

(i) Define simple harmonic motion. [2 marks]

(ii) Determine the value of L corresponding to t = 12 s from the graph in 1(a). [2 marks]

**QUESTION 1 — STUDENT ANSWERS**

**RESULTS TABLE — Question 1:**

| S/N | L/cm | $t_1$/s | $t_2$/s | t mean/s | T = t/n | Log T | Log L |
|---|---|---|---|---|---|---|---|
| **1** | 80.0 | 17.9 | 18.1 | 18.00 | 1.800 | 0.2553 | 1.9031 |
| **2** | 70.0 | 17.4 | 17.6 | 17.50 | 1.750 | 0.2430 | 1.8451 |
| **3** | 60.0 | 16.2 | 15.8 | 16.00 | 1.600 | 0.2041 | 1.7782 |
| **4** | 50.0 | 15.5 | 15.5 | 15.50 | 1.550 | 0.1903 | 1.6990 |
| **5** | 40.0 | 14.1 | 13.9 | 14.00 | 1.400 | 0.1461 | 1.6021 |

Graph: Graph of Log T against Log L

Slope, S = ΔLog T / ΔLog L

S = (0.24 − 0.15) / (1.85 − 1.60)

= 0.09 / 0.25

∴ Slope, S = 0.36

Intercept, C = 0.115

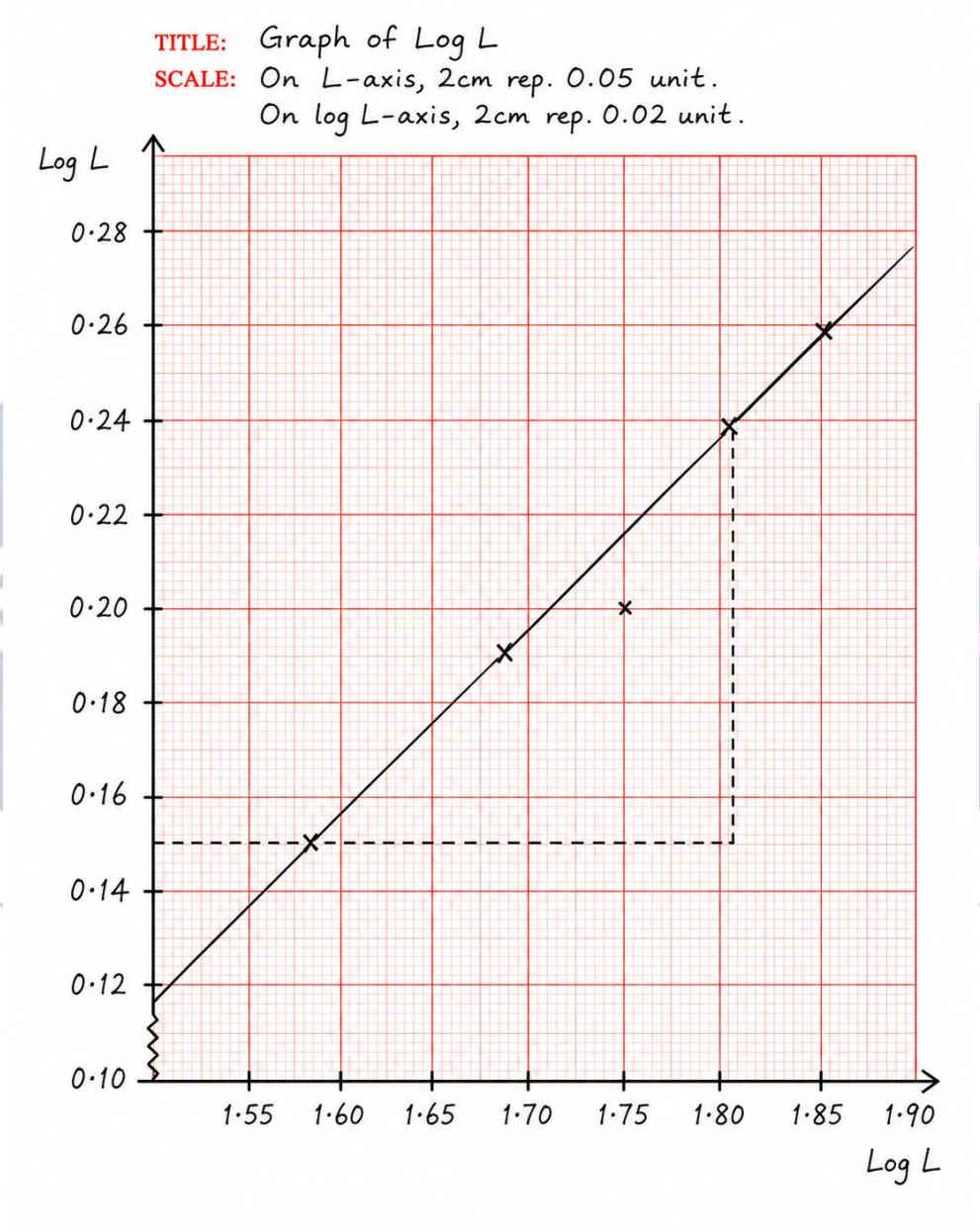
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**QUESTION 1 — GRAPH**

Title: Graph of Log T against Log L

Scale:

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TITLE: Graph of Log L
SCALE: On L-axis, 2cm rep. 0.05 unit.
On log L-axis, 2cm rep. 0.02 unit.
Log L
0·28
0·26
0·24
0·22
0·20
0·18
0·16
0·14
0·12
0·10
1·55
1·60
1·65
1·70
1·75
1·80
1·85
1·90
Log L

On Log L-axis: 2 cm rep. 0.05 unit

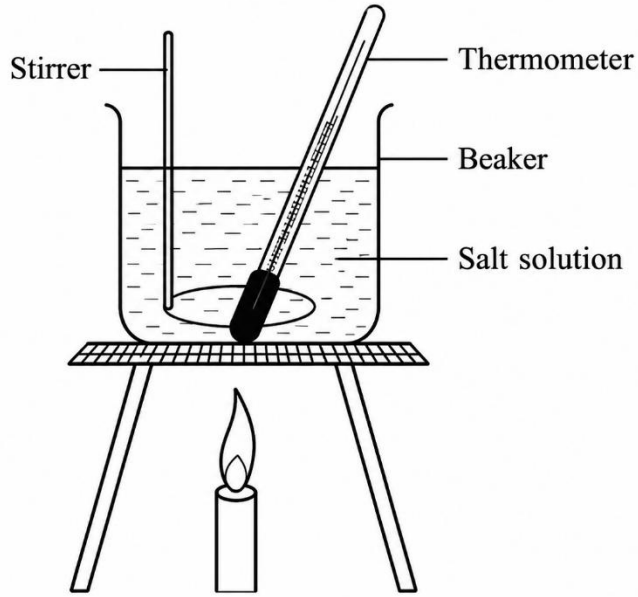
On Log T-axis: 2 cm rep. 0.02 unit

Plotted points: (1.60, 0.15), (1.70, 0.19), (1.78, 0.20), (1.85, 0.24), (1.90, 0.27)

Best fit straight line drawn through all points.

**QUESTION 2**

2. (a)




2. (a) You are provided with a beaker, a thermometer, a stirrer, stop watch/clock, measuring cylinder, table salt, water and other necessary materials.

(i) Measure 200 $cm^3$ of water into the beaker.

(ii) Heat the water until it boils steadily for about 2 minutes.

(iii) Read and record the boiling point $b_o$.

(iv) Add table salt of mass M = 10.0 g to the boiling water and stir continuously until another boiling point $b_1$ is attained.

(v) Read and record $b_1$.

(vi) Evaluate $\theta_i = (b_i - b_o)$.

(vii) Using the same mixture, repeat the procedure four more times by adding 10.0 g of salt each time to give the cumulative mass $M_i$ of salt as 20 g, 30 g, 40 g and 50 g.

(viii) In each case allow the mixture to boil steadily for at least 2 minutes then read and record the boiling point $b_i$.

(ix) Tabulate your readings.

(x) Plot a graph with $M_i$ on the vertical axis and $\theta_i$ on the horizontal axis.

(xi) Determine the slope, s, of the graph.

(xii) State two precautions taken to ensure accurate results. [21 marks]

(b)

(i) Define the boiling point of a liquid. [2 marks]

(ii) What effect do impurities have on the boiling point of a liquid? [2 marks]

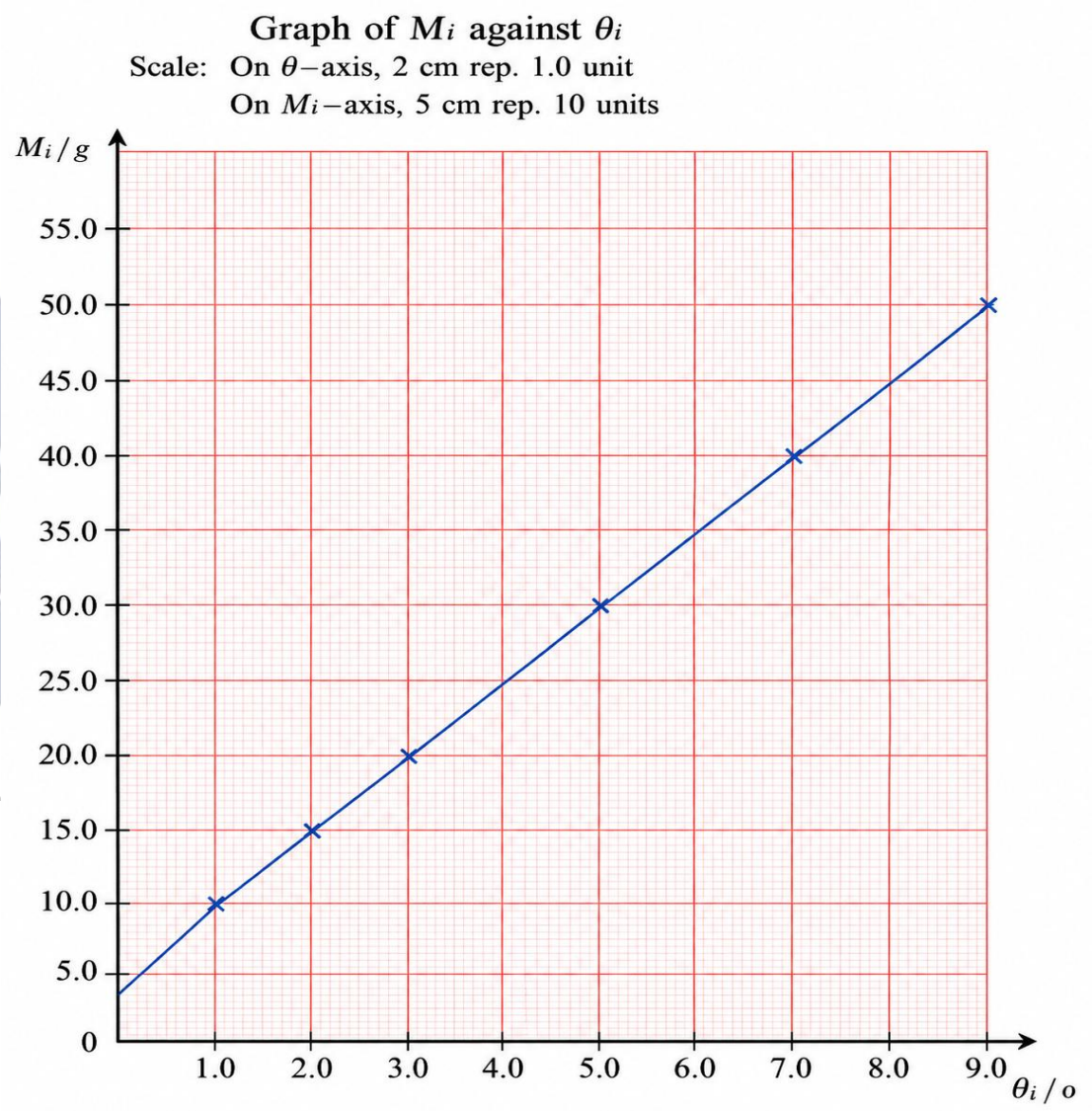
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**QUESTION 2 — STUDENT ANSWERS**

| **RESULTS TABLE — Question 2: $b_o$ = 102°C** **S/N** | **$M_i$/g** | **$b_i$/°C** | **$\theta_i = (b_i - b_o)$/°C** |
|---|---|---|---|
| **1** | 10.0 | 104.0 | 2.00 |
| **2** | 20.0 | 106.0 | 4.00 |
| **3** | 30.0 | 108.0 | 6.00 |
| **4** | 40.0 | 110.0 | 8.00 |
| **5** | 50.0 | 112.0 | 10.00 |

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Graph: Graph of $M_i$ against $\theta_i$  Title: Graph of $M_i$ against $\theta_i$



Scale: On $\theta_i$-axis: 2 cm rep. 1.0 unit

On $M_i$-axis: (scale not fully stated)

Plotted points: (2, 10), (4, 20), (6, 32), (8, 43), (10, 53)

Best fit straight line passes through origin.

Slope, S = ΔM / Δθ

= (300 − 150) / (8.0 − 5.0)

= 150 / 3

∴ Slope = 50

Evaluation of K = 50/50 = 1

Precautions:

I avoided parallax error when reading the thermometer.

I observed the zero error on the thermometer.

I stirred continuously to ensure even distribution of heat.

I ensured that the heated mass was gently dropped into the beaker.

(b)(i) Heat capacity of a body is the quantity of heat required to

raise the temperature of the body by one degree (K or °C).

(b)(ii) Pt = MCΔθ

→ 1200 × t = (800/1000) × 4200 × (101 − 20)

→ 1200t = 0.8 × 4200 × 81

→ t = (0.8 × 4200 × 81) / 1200

→ t = 272160 / 1200

∴ t = 226.8 seconds

(Time for the kettle to reach water's boiling point = 226.8 seconds)

**QUESTION 3**

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3. (a) You are provided with cells, a potentiometer, an ammeter, a voltmeter, a bulb, a key, a jockey and other necessary materials.

(i) Measure and record the e.m.f. E of the battery.

(ii) Set up a circuit as shown in the diagram above.

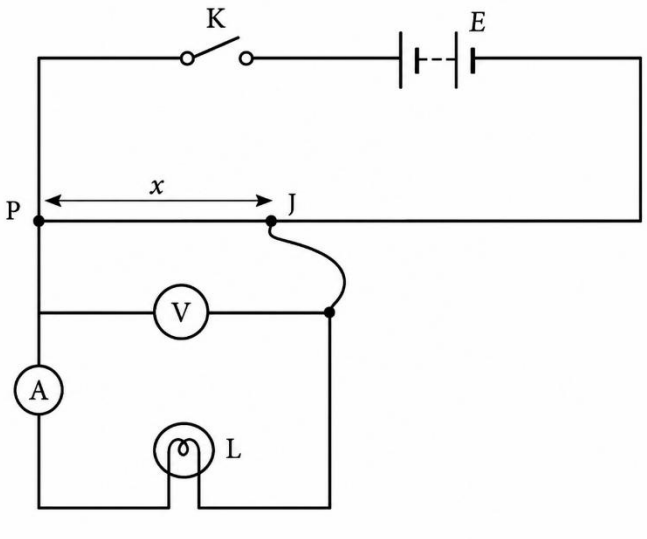
(iii) Close the key K and use the jockey to make a firm contact at J on the potentiometer wire such that PJ = x = 10 cm.

(iv) Take and record the voltmeter reading V and the corresponding ammeter reading I.

(v) Evaluate log V and log I.

(vi) Repeat the procedures for five other values of x = 20 cm, 30 cm, 40 cm, 50 cm and 60 cm.

3. (a) (vii)




Tabulate your readings.

(viii) Plot a graph with log I on the vertical axis and log V on the horizontal axis.

(ix) Determine the slope, s, of the graph.

(x) Determine the intercept, c, on the vertical axis.

(xi) State two precautions taken to ensure accurate results. [21 marks]

(b)

(i) How is the brightness of the bulb affected as x increases? Give a reason for your answer. [2 marks]

(ii) List two electrical devices whose actions do not obey Ohm's law. [2 marks]

---

**QUESTION 3 — STUDENT ANSWERS**

**RESULTS TABLE — Question 3:**

| S/N | X/cm | I/A | V/V | Log I | Log V |
|---|---|---|---|---|---|
| **1** | 10.0 | 0.06 | 0.25 | −1.22 | −0.60 |
| **2** | 20.0 | 0.22 | 0.35 | −0.66 | −0.46 |

| | | | | | |
|---|---|---|---|---|---|
| **3** | 30.0 | 0.18 | 0.50 | −0.75 | −0.30 |
| **4** | 40.0 | 0.24 | 0.65 | −0.62 | −0.19 |
| **5** | 50.0 | 0.27 | 0.80 | −0.57 | −0.10 |
| **6** | 60.0 | 0.27 | 0.80 | −0.57 | −0.09 |

Slope, S = ΔLog I / ΔLog V

= (−0.52 − (−1.0)) / (−0.5 − (−1.0))

= (−0.52 + 1.0) / (−0.5 + 1.0)

= 0.48 / 0.50

∴ Slope, S = 1.05

Intercept, C = −0.5 + 1.0 = 1.05

∴ Intercept, C = −0.34

Graph: Graph of Log I against Log V

Title: Graph of Log I against Log V

Scale:

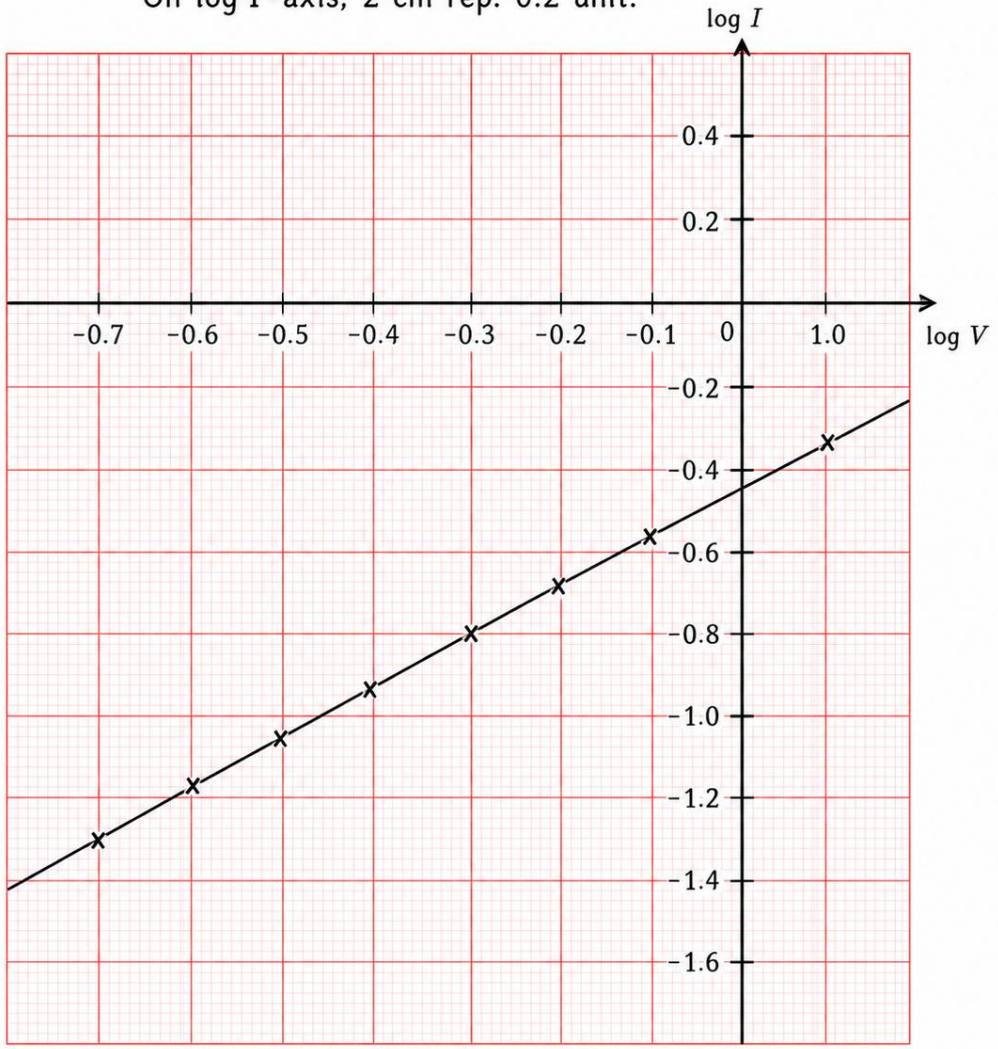
On Log V-axis: 2 cm rep. 1.0 unit

On Log I-axis: 2 cm rep. 0.2 unit

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Graph of log I against log V

SCALE: On log V-axis, 2 cm rep. 1.0 unit.
On log I-axis, 2 cm rep. 0.2 unit.

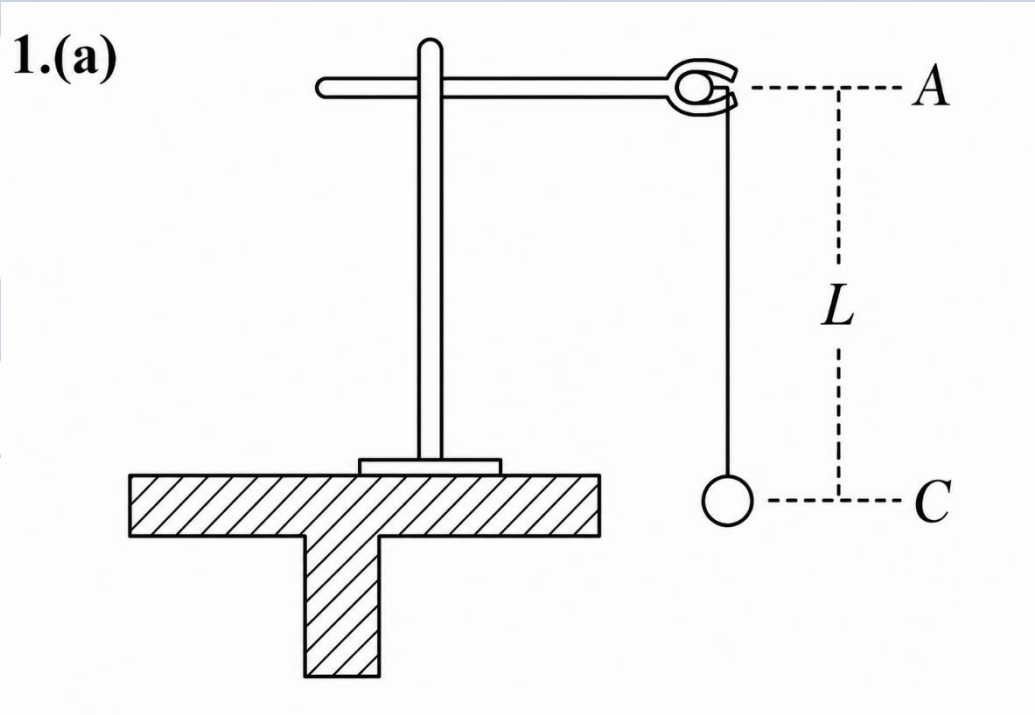


# WASSCE 2018 PHYSICS 3 (Alternative A)

## PRACTICAL QUESTIONS

**QUESTION PAPER**

1.(a) You are provided with a pendulum bob, a metre rule, a stopwatch, a retort stand with clamp, and other necessary apparatus.




(i) Suspend the pendulum bob from the clamp as illustrated in the diagram (see diagram: retort stand with clamp, string AC, bob at C).

(ii) Adjust the pendulum such that AC = L = 90 cm.

(iii) Displace the pendulum bob slightly such that it oscillates in a vertical plane.

(iv) Measure and record the time, t, for 20 complete oscillations. Evaluate the period, T.

(v) Repeat the procedure for four other values of L = 80 cm, 70 cm, 60 cm and 50 cm.

(vi) Tabulate your readings.

(vii) Plot a graph with T on the vertical axis and √L on the horizontal axis.

(viii) Determine the slope, s, of the graph.

(ix) Determine the intercept, c, on the horizontal axis.

(x) State two precautions taken to ensure accurate results.

(b) When the pendulum bob is set into simple harmonic motion:

(i) Determine from your graph the period, T, when L = 75 cm.

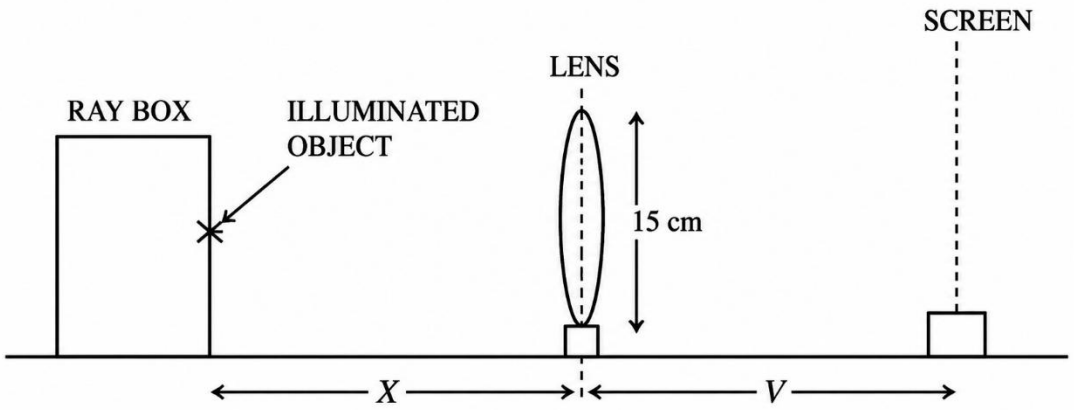
(ii) Sketch a diagram of the set-up and indicate on it the

positions of (α) maximum velocity (β) maximum acceleration of the bob.

---

2.(a) You are provided with a metre rule, a lens, a screen, a ray box with an illuminated object, and other necessary apparatus.

(i) Set up the apparatus as shown in the diagram above (see diagram: ray box — illuminated object — lens — screen, 15 cm marked between object and lens). Measure and record the diameter, $x_o$, of the illuminated object.




(ii) Place the object at a distance x = 25 cm from the lens. Adjust the lens/screen until a sharp image is obtained on the screen.

(iii) Measure and record the distance, d, of the image from the screen/lens.

(iv) Measure and record the diameter, y, of the image. Evaluate $p = y/x_o$ and $T = x + d$ (or similar combined distance term — this portion of the scan was too faint to confirm the exact formula).

(v) Repeat the procedure for x = 30 cm, 35 cm, 40 cm and 45 cm. In each case determine the corresponding values of d, y, p and T.

(vi) Tabulate your results.

(vii) Plot a graph of p (vertical axis) against T (horizontal axis).

(viii) Determine the slope, s, of the graph.

(ix) Determine the intercept, c, on the horizontal axis.

(x) State two precautions taken to ensure accurate results.

---

(b)(i) Explain the statement, "the focal length of a converging lens is 20 cm."

(ii) If the focal length of a converging lens is 20 cm and the distance between the object and the lens is x

cm, and the magnification of the lens is 5, calculate the value of x.

---

3.(a) You are provided with an ammeter, a resistor, a jockey, a key, a metre bridge wire AB, and other necessary apparatus.

(i) Connect a circuit as shown in the diagram above (see diagram: cell, key K, ammeter A, jockey J on wire AB).

(ii) Close the key and move the jockey to make contact with the wire AB at N such that AN = d = 25 cm.

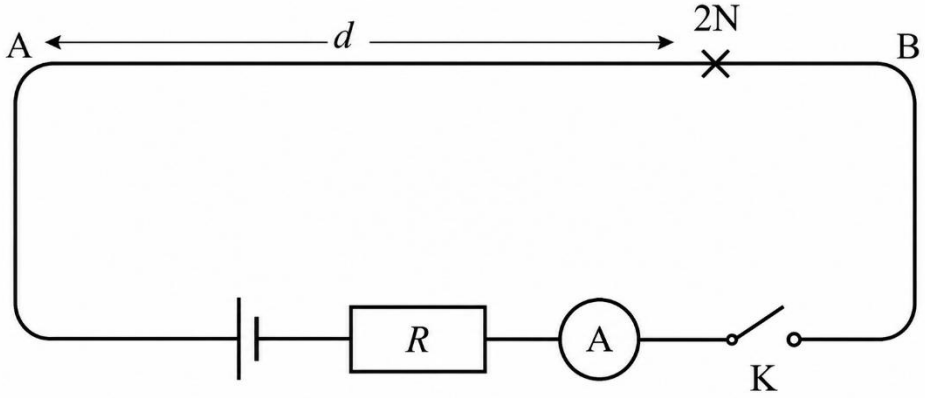
(iii) Read and record the ammeter reading, I. Evaluate $I^{-1}$.

(iv) Repeat the procedure for d = 35 cm, 50 cm, 65 cm and 80 cm. In each case determine the value of $I^{-1}$.

(v) Tabulate your results.

| S/N | x/cm | X/cm | y/cm | p/cm | T/cm |
|---|---|---|---|---|---|
| | | | | 1.50 | 73.50 |
| | | | | 0.85 | 74.00 |
| | | | | 0.65 | 77.00 |
| | | | | 0.40 | 78.00 |
| | | | | 0.20 | 78.50 |

3.(i)




(vi) Plot a graph of log $I^{-1}$ (vertical axis) against d (horizontal axis).

(vii) Determine the slope, s, of the graph.

(viii) Evaluate $10^{s}$.

(ix) State two precautions taken to obtain accurate results.

(x) State two factors which affect the resistance of a wire.

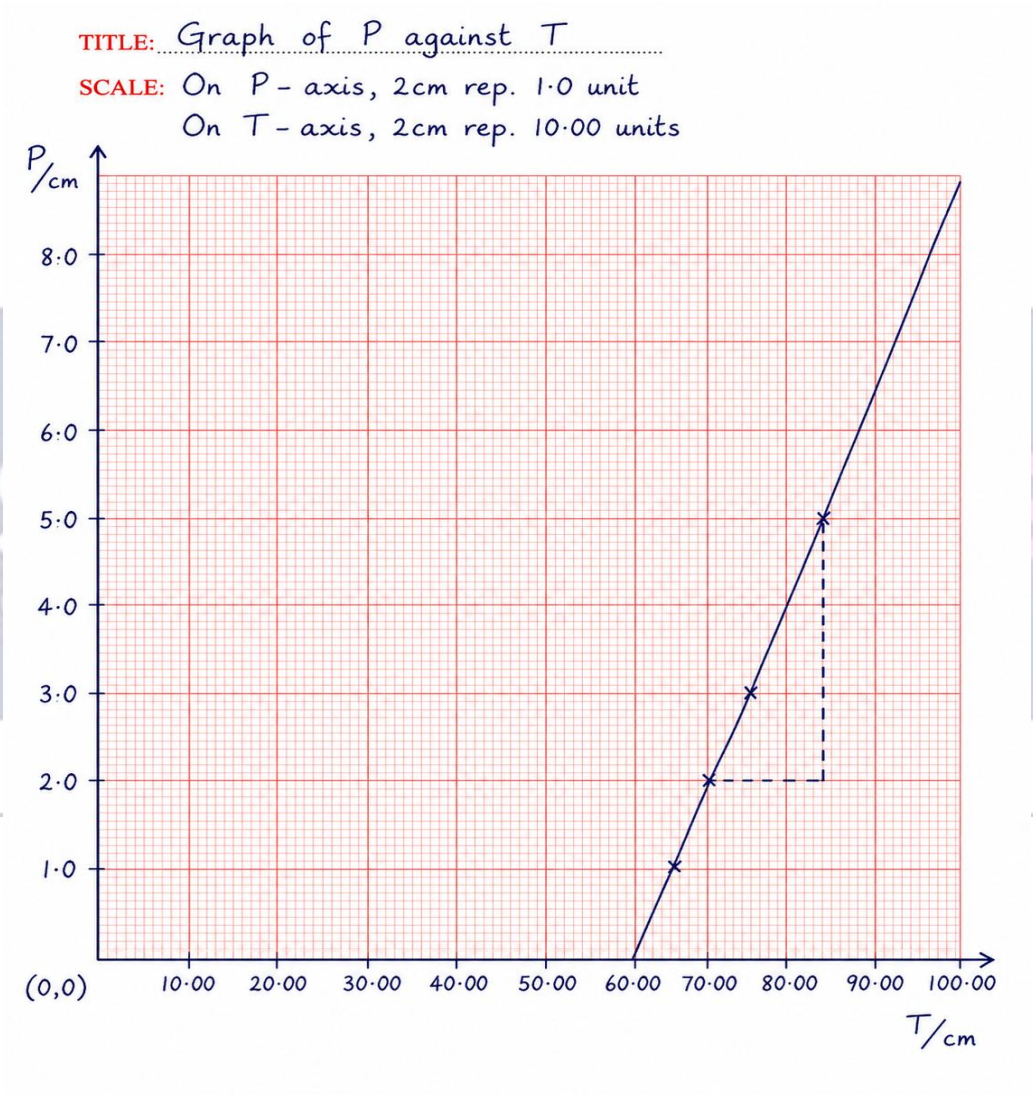
**QUESTION 2 (a) — Results & Calculations**

(i) Focal length of the lens = 20.0 cm

(ii) Diameter of the illuminated object, $x_o$ = 15 cm

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(viii) Graph of p against T —



(ix) Slope, S = ΔP/ΔT = (6.0 − 1.5)/(90.00 − 72.00) = 4.5/18

$\Longrightarrow$ S = 0.25

(x) Intercept on horizontal axis = 66.00 cm

(xi) K = C/2 = 66.00/2 = 33.00 cm

(xii) Precautions:

I avoided parallax error in reading the metre rule.

I ensured that sharp images were obtained before taking my readings.

I ensured/maintained a clear lens surface.

I ensured that the lens was kept upright throughout the experiment.

---

**QUESTION 2(B)**

(i) If the focal length of a converging lens is 20 cm, it means that the distance between the optical centre and the point at which parallel rays converge (the principal focus) is 20 cm.

(ii) Recall: 1/u + 1/v = 1/f (if u = x, at f = 20)

$\Longrightarrow$ 1/x + 1/v = 1/f

But m = v/x $\Longrightarrow$ 5 = v/x $\Longrightarrow$ v = 5x

Hence, 1/x + 1/5x = 1/20 (By L.C.M.)

5/5x + 1/5x = 1/20

6/5x = 1/20

$\Longrightarrow$ 5x = 6 × 20

5x = 120

∴ x = 120/5 = 24 cm

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**QUESTION 3, FACTORS & GRAPH**

(ii) Factors Affecting the Resistance of a Wire:

Cross Sectional Area of the Wire

Temperature of the Wire

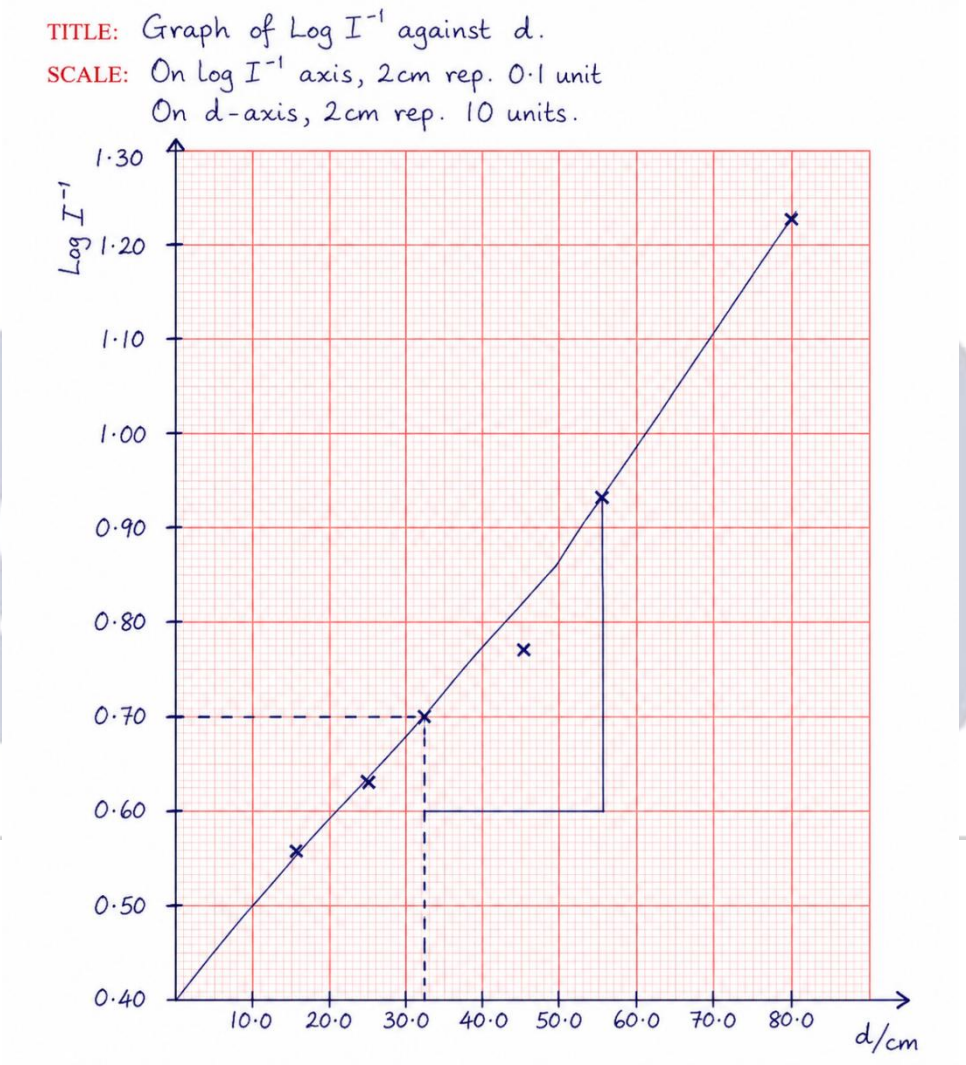
Thickness of the Wire

Resistivity of the Wire

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TITLE: Graph of Log $I^{-1}$ against d

SCALE: On log $I^{-1}$ axis, 2 cm rep. 0.1 unit. On d-axis, 2 cm rep. 10 units.




**CIRCUIT/RESISTORS QUESTION (SEPARATE QUESTION)**

(i) The 4Ω and 5Ω resistors have a combined resistance given by:

$R_{AB} = (4\times5)/(4+5) = 20/9$

Now, power dissipated at least is given by:

$P_{AB} = (V_{AB})^2/R_{AB} = (4^2 \times 9)/20 = 16\times9/20 = 7.2$ W

(ii) $P = 3.6 \times 1000$

$V = 240$

Recall $P = IV$

$\Longrightarrow I = P/V = (3.6 \times 1000)/240 = 15.0$ A

The circuit breaker will not open because the current drawn, $I \approx$ 15.0 A, is less than its rating of 20 A.

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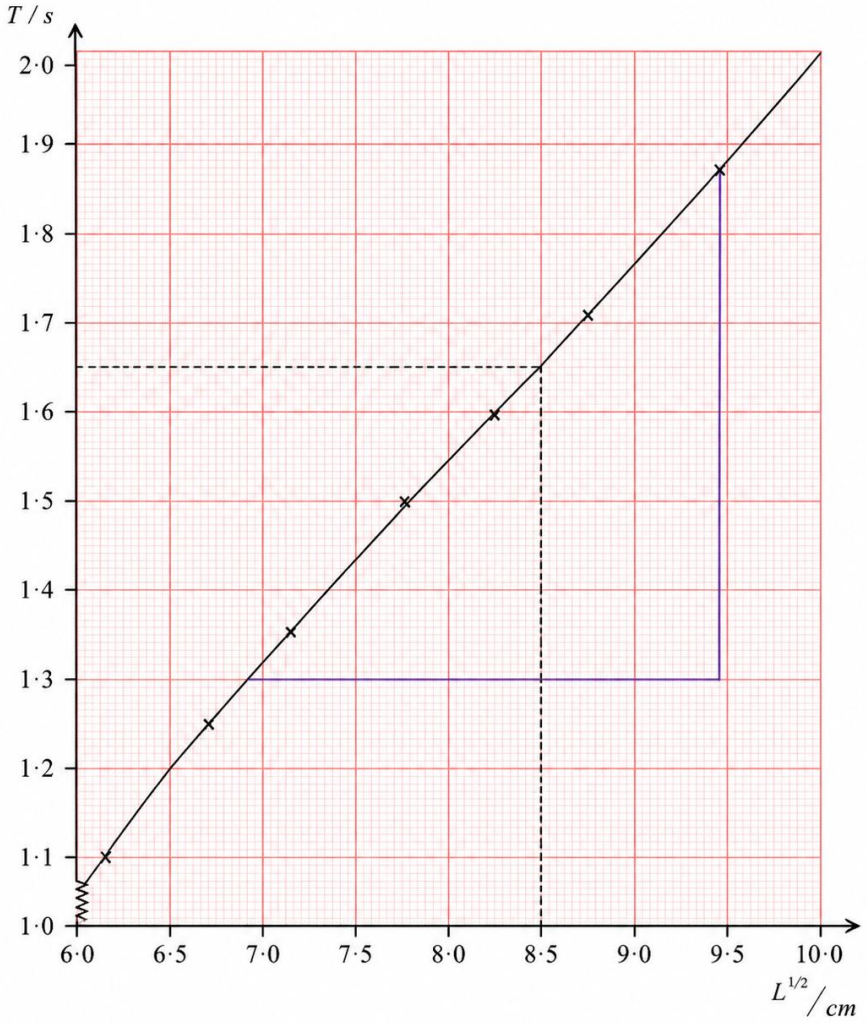
**GRAPH (QUESTION 1)**

TITLE: Graph of T against L^(1/2)

SCALE: On T-axis, 2 cm rep. 0.1 unit. On √L-axis, 2 cm rep. 0.5 unit.

TITLE: Graph of T against $L^{1/2}$

SCALE: On T – axis, 2 cm rep: 0.1 unit.
On $\sqrt{L}$ – axis, 2 cm rep: 0.5 unit.



**QUESTION 1, PRECAUTIONS & PART (B)**

(xi) Precautions taken for accuracy of results:

I took repeated readings (in timing) to minimize random error.

I observed and corrected the zero error on the stop watch.

I ensured that the bob did not touch the table.

I maintained small vertical oscillation.

(b)(i) When L = 75 cm

$\Longrightarrow \sqrt{L} = \sqrt{75} = 8.6603$

From the graph, when $\sqrt{L} = 8.66$, T = 1.66 s

(ii) Diagram of the pendulum showing three bob positions: "Maximum acceleration" (left extreme), "Maximum Velocity" (centre/lowest point), "Maximum acceleration" (right extreme) — see diagram below

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# WASSCE 2019 PHYSICS 3 (Alternative A)

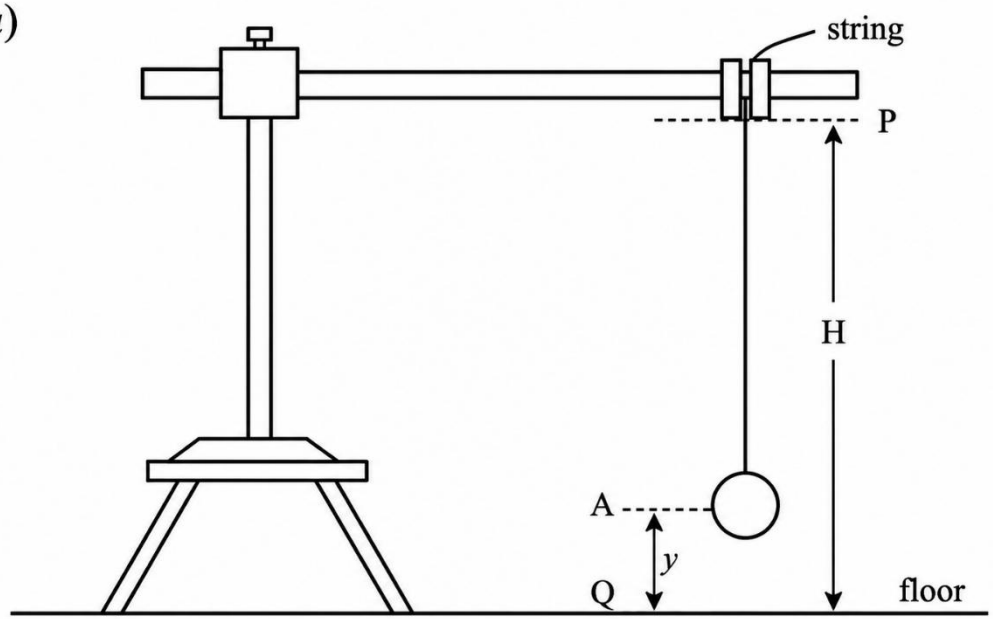
## PRACTICAL QUESTIONS

**QUESTION PAPER**

**QUESTION 1 SIMPLE PENDULUM**

(a) You are provided with a stopwatch, a meter rule, a piece of thread, a pendulum bob, a split cork, retort stand and clamp, and other necessary apparatus.

1. (*a*)



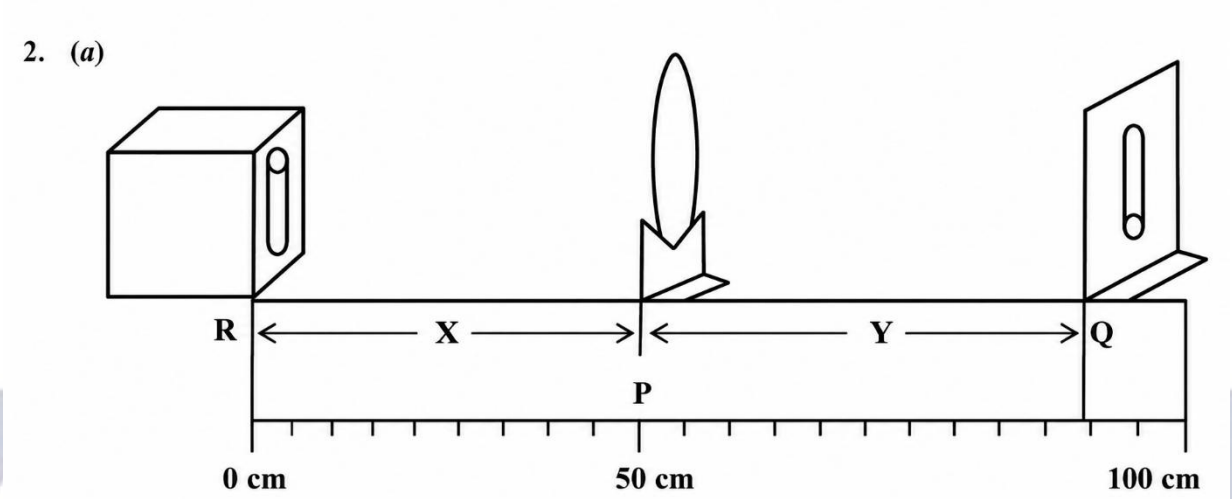

(i) Place the retort stand on a laboratory stool. Clamp the split cork.

(ii) Suspend the pendulum bob from the split cork such that the point of support P of the bob is at a height H = 100 cm above the floor Q. The bob should not touch the floor and H should be kept constant throughout the experiment.

(iii) Adjust the length of the thread such that the centre A of the bob is at a height y = AQ = 20 cm from the floor.

(iv) Displace the bob such that it oscillates in

2. (*a*)




a horizontal plane.

(v) Take the time t for 20 complete oscillations.

(vi) Determine the period T of oscillation and evaluate $T^2$.

(vii) Repeat the procedure for four other values of y = 30 cm, 40 cm, 50 cm and 60 cm. In each case, determine T and $T^2$.

(viii) Tabulate the results.

(ix) Plot a graph of $T^2$ on the vertical axis and y on the horizontal axis, starting both axes from the origin (0,0).

(x) Determine the slope, s, of the graph and the intercept c on the vertical axis.

(xi) If in this experiment SR = c, calculate R.

(xii) State two precautions taken to ensure accurate results. [21 marks]

(b)(i) The bob of a simple pendulum is displaced a small distance from the equilibrium position and then released to perform simple harmonic motion. Identify where its:

(α) kinetic energy is maximum;

(β) acceleration is maximum. [2 marks]

(ii) An object of weight 120 N vibrates with a period of 4.0 s when hung from a spring. Calculate the force per unit length of the spring. [g = 10 m $s^{-2}$, π = 3.142] [2 marks]

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**QUESTION 2 CONVERGING LENS**

(a) You are provided with a converging lens in its holder, a screen and holder, a ray box containing an illuminated object, a meter rule.

(i) Place the lens in its holder such that it is facing a distant object seen through a well-lit laboratory window. Move the screen to and fro until a sharp image of the distant object is formed on it. Measure the distance, $f_o$, between the screen and the lens.

(ii) Clamp the meter rule securely to the table.

(iii) Place the illuminated object pin at the end R of the meter rule. Place the lens at a position P such that X = RP = 20 cm.

(iv) Move the screen to a position Q to receive a sharp image of the object. Measure the distance Y = PQ.

(v) Evaluate Z = (X + Y).

(vi) Repeat the procedure for five other values of X = 25 cm, 30 cm, 35 cm, 40 cm and 45 cm. In each case, record X, Y and evaluate Z.

(vii) Tabulate the results.

(viii) Plot a graph with Z on the vertical axis and X on the horizontal axis. Draw a smooth curve through the points.

(ix) Determine from your graph the minimum value of $Z = Z_o$, and its corresponding distance $X = X_o$.

(x) Evaluate $W = ½(Z_o/4 + X_o/2)$.

(xi) State two precautions taken to ensure accurate results. [21 marks]

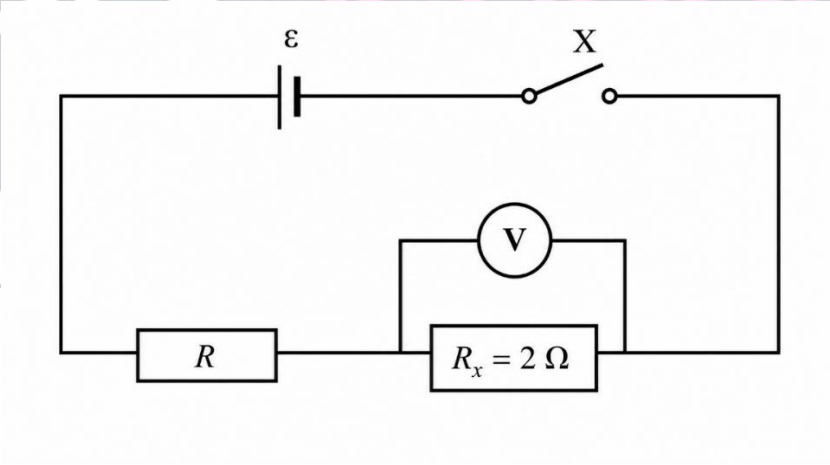
(b)(i) Draw a ray diagram to show how a convex lens camera forms an image of magnification less than one.

(ii) Name two pairs of features in the human eye and a lens camera that perform similar functions.

---

**QUESTION 3 RESISTANCE/CIRCUIT**

(a) You are provided with a battery of e.m.f. E, a key K, a voltmeter, a standard resistor $R_o = 2\Omega$, a resistance box R and some connecting wires.




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(i) Measure and record the e.m.f. E of the battery.

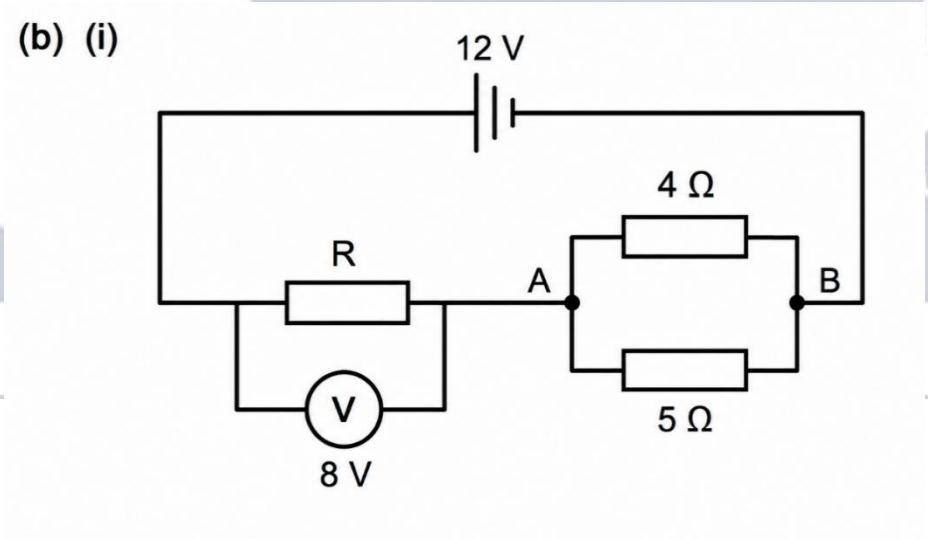
(ii) Set up a circuit as shown in the diagram above with the key open.

(iii) Set the resistance on the resistance box to R = 2.0 Ω.

(iv) Close the key, read and record the potential difference V on the voltmeter. Evaluate $V^{-1}$.

(v) Repeat the procedure for five other values of R = 5Ω, 10Ω, 12Ω, 15Ω [verify — a 6th value may be missing/cropped].

(b) (i)




(vi) In each case, record V and evaluate $V^{-1}$.

(vii) Tabulate the results.

(viii) Plot a graph with R on the vertical axis and $V^{-1}$ on the horizontal axis, starting both axes from the origin (0,0).

(ix) Determine the slope, s, of the graph and the intercept c on the vertical axis.

(x) Calculate α and β from the equations $s = R_o\alpha$ and $c = -(R_o + \beta)$.

(xi) State two precautions taken to obtain accurate results. [21 marks]

(b)(i) In the circuit diagram above [12 V supply, 4Ω and 5Ω resistors between points A and B, a rheostat R, voltmeter reading 8 V], calculate the power dissipated as heat in the section AB of the circuit. [4 marks]

(ii) An electric equipment of power rating 3.6 kW is to be connected to a 240 V line whose circuit breaker is rated 20 A. Justify whether or not the breaker would open when the equipment is switched on. [4 marks]

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# STUDENT'S ANSWERS

**QUESTION 1 — PENDULUM**

Results/Observations: H = 100.0 cm

| S/N | Y/cm | $t_1$/s | $t_2$/s | t_mean/s | T/s | $T^2/s^2$ |
|---|---|---|---|---|---|---|
| **1** | 20.0 | 35.40 | 36.40 | 35.90 | 1.7950 | 3.2220 |
| **2** | 30.0 | 33.20 | 33.30 | 33.25 | 1.6625 | 2.7639 |
| **3** | 40.0 | 31.10 | 31.00 | 31.05 | 1.5525 | 2.4103 |
| **4** | 50.0 | 28.00 | 28.10 | 28.05 | 1.4025 | 1.9670 |
| **5** | 60.0 | 25.30 | 25.10 | 25.20 | 1.2600 | 1.5876 |

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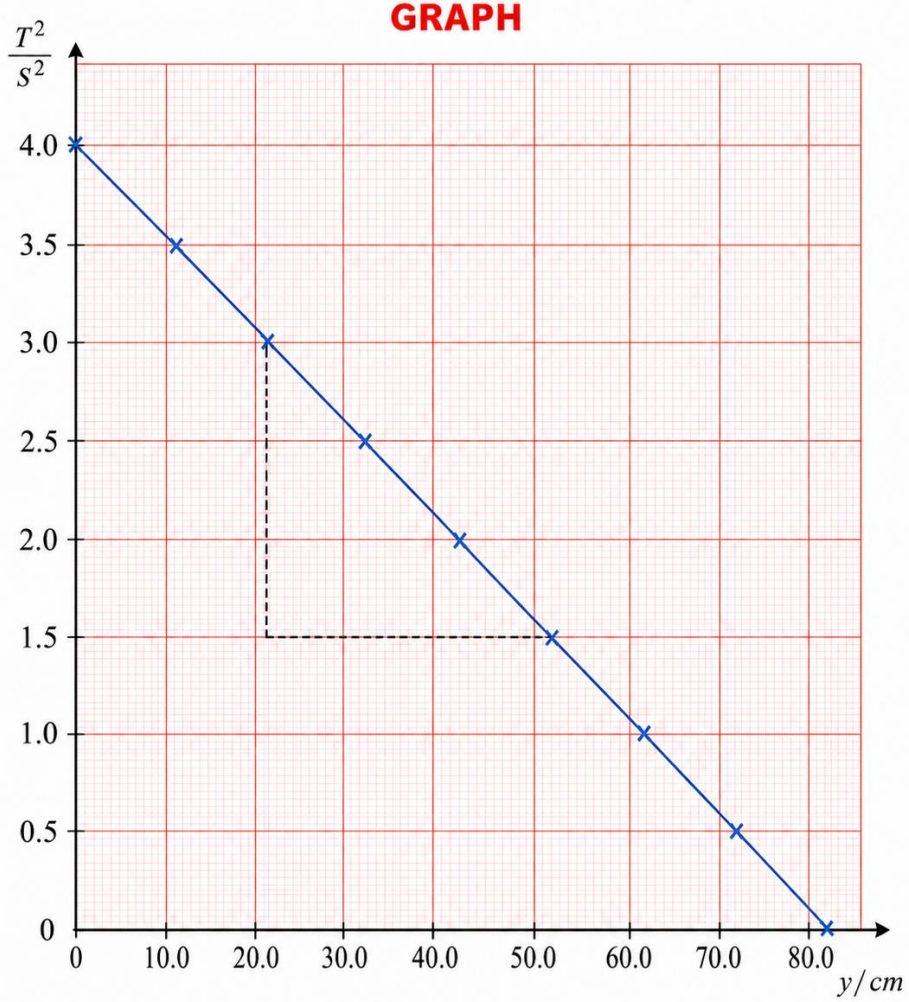
Graph: Graph of $T^2$ against y (Image 3) — Scale: on $T^2$-axis, 2 cm rep. 0.5 unit; on y-axis, 2 cm rep. 10 units.

**Graph of $T^2$ against $y$**

Scale: On $T^2$-axis, 2 cm rep. 0.5 unit

On $y$-axis, 2 cm rep. 10 units

**GRAPH**



(x) Slope of the graph:

$S = \Delta T^2/\Delta y = (3.20 - 1.75)/(55.0 - 20.0) = 1.45/35.0 = 0.0414$

Intercept, C = 4.0

(xi) SR = C

$R = C/S = 4.0/0.0414 = 96.6184$

$\therefore R = 96.62$

(xii) Precautions:

I avoided parallax error in reading the metre rule.

I avoided draught as the bob oscillated.

I observed and corrected zero error of the stopwatch.

I maintained firm suspension of the pendulum (clamping) to minimize random error.

(b)(ii) The period of a simple pendulum is given by $T = 2\pi\sqrt{(m/k)}$

$\Rightarrow T^2 = 4\pi^2 m/k$

Hence, $k = 4\pi^2 m/T^2$

$= 4\times(3.142)^2 \times 120/10 \div 4^2$

$= 4 \times 9.872164 \times 12 / 16$

$= 473.8638872 / 16$

$= 29.616492$

$\therefore$ The force per unit length = 29.62 N/m

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**QUESTION 2 — LENS**

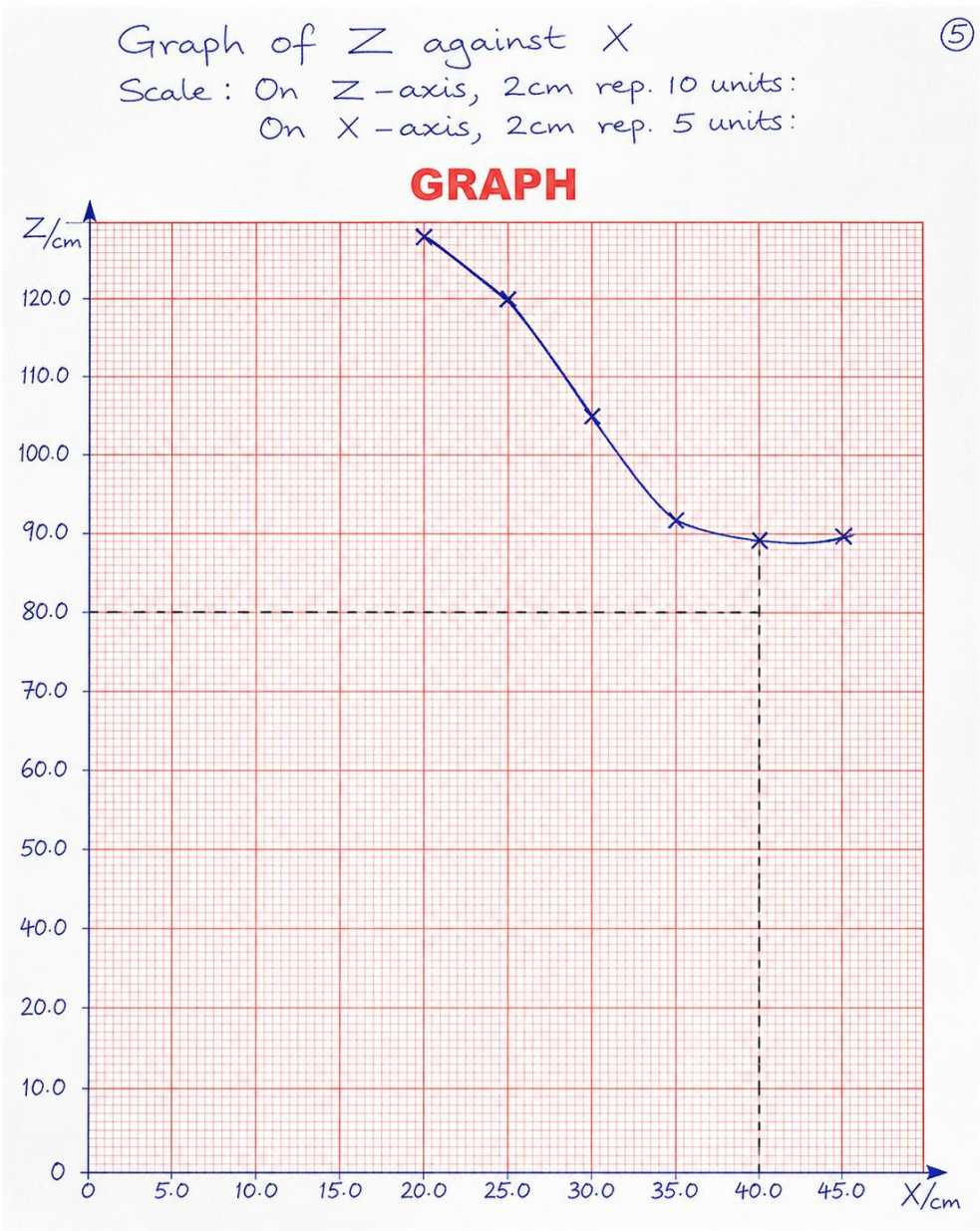
Results/Observations: $f_o = 20.0$ cm

| S/N | X/cm | Y/cm | Z = (X+Y)/cm |
|---|---|---|---|
| **1** | 20.0 | 98.00 | 118.00 |
| **2** | 25.0 | 85.00 | 110.00 |
| **3** | 30.0 | 64.00 | 94.00 |
| **4** | 35.0 | 48.20 | 83.20 |
| **5** | 40.0 | 40.80 | 80.80 |
| **6** | 45.0 | 36.00 | 81.00 |

Graph: Graph of Z against X (Image 2) — Scale: on Z-axis, 2 cm rep. 10.0 units; on X-axis, 2 cm rep. 5 units.

Graph of Z against X ⑤

Scale : On Z-axis, 2cm rep. 10 units:
On X-axis, 2cm rep. 5 units:



(ix) Minimum value of Z, $Z_o$ = 81.0; corresponding value of X, $X_o$ = 40.0

(x) $W = \frac{1}{2}(Z_o/4 + X_o/2)$

$= \frac{1}{2}(81.0/4 + 40.0/2)$

$= \frac{1}{2}(20.25 + 20.00)$

$= 0.5(40.25)$

$\therefore W = 20.13$

(xi) Precautions:

I avoided error due to parallax in reading the metre rule.

I ensured that sharp images were obtained.

I ensured that the lens was kept upright.

I maintained a neat surface of the lens throughout the experiment.

(b)(i) Ray diagram: Object placed beyond 2F → converging lens → real, diminished, inverted image formed between F' and 2F' (labelled "Image" on the diagram).

(ii) Similarity between Human Eye and Camera:

| Human Eye | Lens Camera |
|---|---|
| **Eye Lens** | Camera Lens |
| **Pupil** | Aperture |
| **Retina** | Screen/Film |
| **Iris** | Diaphragm |

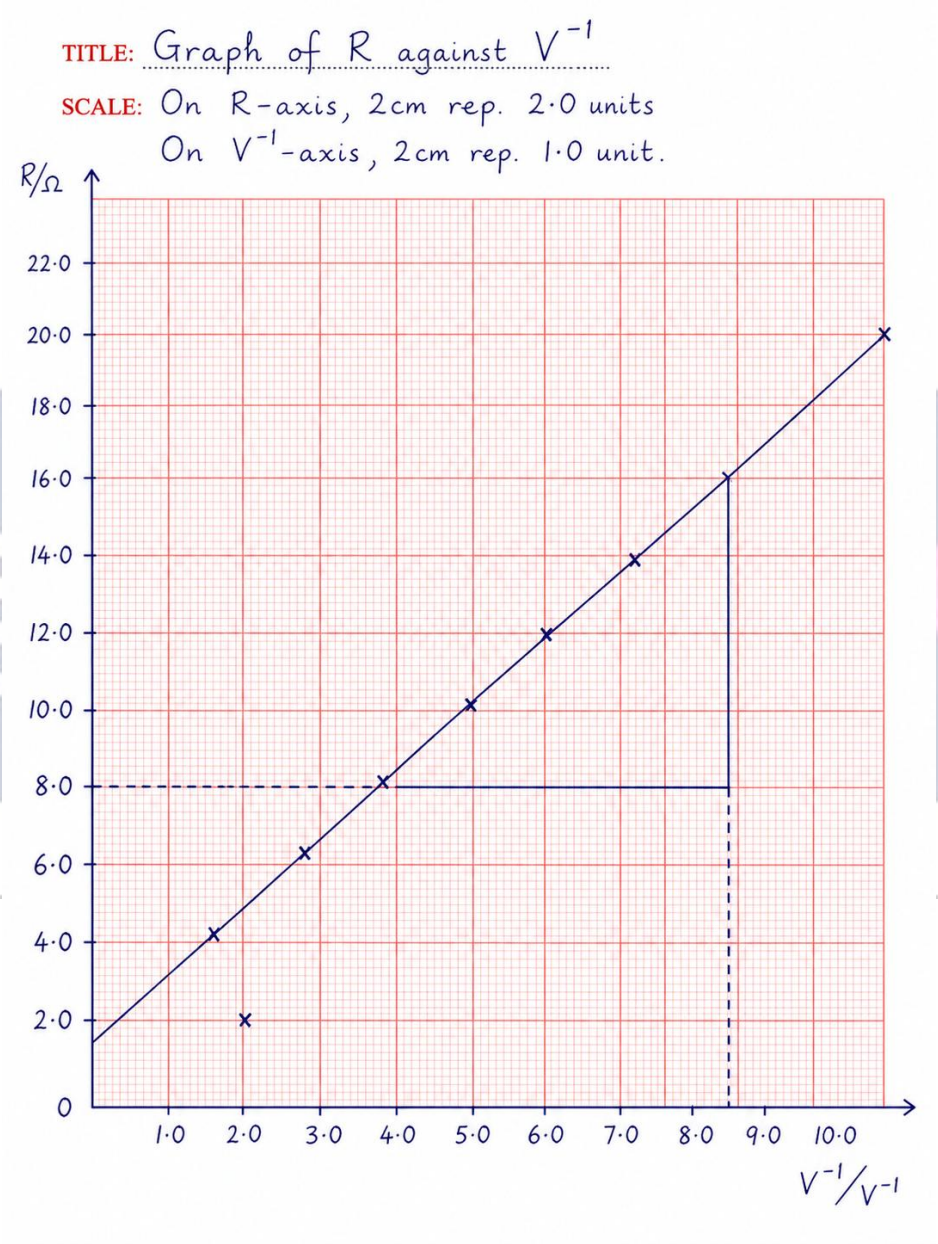
**QUESTION 3 — RESISTANCE**

Results/Observations: E = 3.0 V, $R_o$ = 2.0 Ω

| S/N | R/Ω | V/V | $V^{-1}/V^{-1}$ |
|---|---|---|---|
| **1** | 2.0 | 0.5 | 2.0000 |
| **2** | 5.0 | 0.4 | 2.5000 |
| **3** | 10.0 | 0.3 | 3.3333 |
| **4** | 12.0 | 0.2 | 5.0000 |
| **5** | 15.0 | 0.2 | 5.0000 [verify — duplicate V value with row 4, likely a misread digit] |
| **6** | — | 0.1 | 10.0000 |

Graph: Graph of R against $V^{-1}$ (Image 4) — Scale: on R-axis, 2 cm rep. 2.0 units; on $V^{-1}$-axis, 2 cm rep. 1.0 unit.

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TITLE: Graph of R against $V^{-1}$
SCALE: On R-axis, 2cm rep. 2·0 units
On $V^{-1}$-axis, 2cm rep. 1·0 unit.
R/Ω
22·0
20·0
18·0
16·0
14·0
12·0
10·0
8·0
6·0
4·0
2·0
0
1·0
2·0
3·0
4·0
5·0
6·0
7·0
8·0
9·0
10·0
$V^{-1}/V^{-1}$