THE UNITED REPUBLIC OF TANZANIA

NATIONAL EXAMINATIONS COUNCIL OF TANZANIA

ADVANCED CERTIFICATE OF SECONDARY EDUCATION EXAMINATION

131/1 **PHYSICS 1**

(For Both School and Private Candidates)

Time: 2:30 Hours **ANSWERS** **Year: 2008**

Instructions

1. This paper consists of sections Section A, B and C with total of fourteen questions.
2. Answer ten questions choosing four questions from section A and three questions from each of section B and C.

1. (a) Differentiate between an error and a mistake.

An error is an unintentional deviation from accuracy due to limitations in measurement, observation, or calculation, such as instrumental errors or environmental factors.
A mistake is a human fault due to negligence, misunderstanding, or miscalculation, such as misreading a scale or writing incorrect values.

(b) In determining the resistivity 'ρ' of a certain wire, the following measurements were taken:
Resistance R of the wire = $(2.06 \pm 0.01)\ \Omega$
Diameter d of the wire = (0.57 ± 0.01) mm
Length L of the wire = (105.6 ± 0.1) mm

Use the formula $\rho = (\pi d^2 R) / (4L)$ to find the relative error in resistivity, ρ.

The relative error in resistivity is given by:
$\Delta\rho/\rho = (\Delta R/R) + 2(\Delta d/d) + (\Delta L/L)$

Substituting the given values:
$\Delta\rho/\rho = (0.01/2.06) + 2(0.01/0.57) + (0.1/105.6)$
$\Delta\rho/\rho = 0.00485 + 0.03509 + 0.000946$
$\Delta\rho/\rho = 0.04089$

Expressing as a percentage:
Relative error = 4.09%

(c) (i) Give three limitations of dimensional analysis.

1. It does not give information about the constant of proportionality in an equation.
2. It cannot be used for equations involving trigonometric, logarithmic, or exponential functions.
3. It cannot distinguish between scalar and vector quantities in an equation.

(c) (ii) After being deformed, a spherical drop of liquid will execute periodic vibrations about its sphere. The frequency (f) of vibrations of the drop will depend on the surface tension (γ) of the drop, its density (ρ), and on the radius (r) of the drop. Using the method of dimensions, obtain an expression for the frequency of these vibrations in terms of the related physical quantities.

Let $f \propto \gamma^a \rho^b r^c$

Writing dimensions of each quantity:
$[f] = T^{-1}$
$[\gamma] = M\ T^{-2}$
$[\rho] = M\ L^{-3}$

$[r] = L$

Equating dimensions:
$T^{-1} = (M T^{-2})^a (M L^{-3})^b (L)^c$

Expanding:
$T^{-1} = M^a T^{(-2a)} M^b L^{(-3b)} L^c$

Grouping terms:
$M^{(a+b)} L^{(-3b+c)} T^{(-2a)} = M^0 L^0 T^{-1}$
Comparing powers:
$a + b = 0$
$-3b + c = 0$
$-2a = -1$

Solving:
$a = 1/2$
$b = -1/2$
$c = -3b = 3/2$

Thus, $f \propto (\gamma / (\rho r^3))^{(1/2)}$
or $f = k (\gamma / (\rho r^3))^{(1/2)}$, where k is a dimensionless constant.

2. (a) (i) Can a body have energy without momentum? Explain.
Yes, a body can have energy without momentum. This happens in cases such as potential energy, where an object has stored energy but is not in motion. For example, a compressed spring, a charged capacitor, or an object held at a height have energy but no momentum since momentum requires motion ($p = mv$).

(ii) Two masses $m_1 = 10$ kg and $m_2 = 250$ g are acted upon by a force of 10 N and 5 N, respectively, in opposite directions. After a certain time, the two masses collide and coalesce. If the force remains the same both before and after colliding, calculate the relative acceleration before the collision and their acceleration after the collision.

Acceleration before collision:
For m_1: $a_1 = F_1 / m_1 = 10 / 10 = 1$ m/s²
For m_2: $a_2 = F_2 / m_2 = 5 / 0.25 = 20$ m/s²

Relative acceleration before collision:
$a_{rel} = a_1 + a_2 = 1 + 20 = 21$ m/s²

After collision, total mass $= m_1 + m_2 = 10 + 0.25 = 10.25$ kg
Net force = 10 - 5 = 5 N

Acceleration after collision:
$a = F / (m_1 + m_2) = 5 / 10.25 = 0.488$ m/s²

(b) Rain falls vertically on a plane roof, 1.5 m square, which is inclined to the horizontal at an angle of 30°. The raindrops strike the roof with a velocity of 3 m/s, and a volume of 2.5×10^{-2} m³ of water is collected from the roof in one minute. Assuming that the conditions are steady and that the velocity of the raindrops after impact is zero, calculate the

(i) Vertical force exerted on the roof by the impact of the falling rain.

Mass of rain per second:
Density of water = 1000 kg/m³
Mass flow rate = (Density × Volume) / Time
$= (1000 \times 2.5 \times 10^{-2}) / 60$
= 0.417 kg/s

Momentum change per second:
Force = $\Delta p / \Delta t = mv / t$
= 0.417 × 3
= 1.25 N

(ii) Pressure exerted, normal to the roof due to the impact of the rain.
Pressure = Force / Area
= 1.25 / (1.5 × 1.5)
= 1.25 / 2.25
= 0.556 N/m²

3. (a) (i) Distinguish uniform circular motion from non-uniform circular motion.
Uniform circular motion occurs when an object moves in a circular path with constant speed. The direction of velocity changes continuously, but the magnitude remains the same.

Non-uniform circular motion occurs when an object moves in a circular path with varying speed, meaning both magnitude and direction of velocity change.

(ii) A racing car goes around a circular curve as fast as it can without skidding. The radius of the curve is 50 m and the road is banked at 20° to allow faster speed. If the coefficient of static friction between the road and the tyres is 0.80, resolve the forces into horizontal and vertical components and apply Newton's laws of motion and the equation for maximum frictional force to determine the maximum speed of the car.

Using the banking angle formula:

$v_{max} = \sqrt{ r g (\tan\theta + \mu) / (1 - \mu \tan\theta) }$
Substituting values:

v_max = sqrt($50 \times 9.81 \times (\tan 20° + 0.80) / (1 - 0.80 \times \tan 20°)$)
v_max = sqrt($50 \times 9.81 \times (0.364 + 0.80) / (1 - 0.80 \times 0.364)$)
v_max = sqrt($50 \times 9.81 \times 1.164 / 0.71$)
v_max = sqrt(802.2)
v_max ≈ 28.3 m/s
(b) (i) Compare excess pressure inside these bubbles.

Excess pressure inside a bubble is given by $P = 4\gamma / r$.
Ratio of pressures:
$P_1/P_2 = r_2/r_1 = 3/2$

(ii) Show that the ratio of the work done in blowing these bubbles is 4/9.

Work done $W \propto P V$
Since $V \propto r^3$ and $P \propto 1/r$,

$W_1/W_2 = (1/r_1 \times r_1^3) / (1/r_2 \times r_2^3)$
$= (r_1^2) / (r_2^2)$
$= (2^2) / (3^2)$
$= 4/9$

4. (a) (i) Give two practical examples of oscillatory motion, which approximate to simple harmonic motion.

- A pendulum swinging with small amplitudes.
- A mass attached to a spring executing vertical oscillations.

(ii) What factors determine the restoring force on a body performing simple harmonic motion?

- The stiffness or force constant of the system (spring constant k in case of a spring).
- The displacement of the body from the equilibrium position.
- The mass of the oscillating body in systems where mass affects acceleration.

(iii) A person is swinging on a swing in the sitting position. How will the period change if the person stands up?

The period of a simple pendulum is given by $T = 2\pi\sqrt{(l/g)}$, where l is the length of the pendulum.
When the person stands up, the center of mass moves closer to the pivot, effectively reducing l. Since T is directly proportional to $\sqrt{l}$, a decrease in l results in a decrease in T. Hence, the period will decrease.

(b) (i) A body of mass M is performing simple harmonic motion whose amplitude is A. Sketch, on the same axes, a plot of both the kinetic energy and the potential energy of the body against time.

A graph should be drawn with time on the x-axis and energy on the y-axis.

- Kinetic energy follows a sinusoidal pattern, reaching maximum at equilibrium and zero at extreme positions.
- Potential energy follows the inverse of kinetic energy, being maximum at extreme positions and zero at equilibrium.
- The sum of kinetic and potential energy remains constant.

(ii) A uniform spring has a certain mass suspended from it and its period for vertical oscillation is T_1. The spring is now cut into two equal halves, and the same mass is suspended from one of the halves. The period of vertical oscillation is now T_2. Calculate T_2 / T_1.

The period of oscillation is given by $T = 2\pi\sqrt{(m/k)}$.
When the spring is cut in half, its stiffness (spring constant) doubles, i.e., $k' = 2k$.
New period $T_2 = 2\pi\sqrt{(m/2k)}$.

Dividing:
$T_2 / T_1 = \sqrt{(1/2)} = 1/\sqrt{2}$

5. (a) (i) What is meant by reference temperature as applied to thermocouples?

Reference temperature is the temperature at which the cold junction of a thermocouple is maintained, allowing the measurement of the hot junction temperature using the generated thermoelectric voltage.

(ii) The e.m.f. (in microvolts) in a lead iron thermocouple, one junction of which is at 0°C, is given by $V = 1784t - 2.4t^2$, where t is the temperature of the hot junction in °C. Calculate the neutral temperature.

Neutral temperature is the temperature at which e.m.f. is maximum.
$dV/dt = 0$ for maximum e.m.f.

Differentiating $V = 1784t - 2.4t^2$:
$dV/dt = 1784 - 4.8t = 0$
$t = 1784 / 4.8$
$t = 371.67°C$
Neutral temperature = 371.67°C

(iii) When a particular temperature is measured on scales based on different properties, it has different numerical values on each scale except at certain points. Explain why and state at what points the values agree.

Different temperature scales are based on different reference points and intervals. For example, the Celsius scale is based on water's freezing and boiling points, while the Kelvin scale starts at absolute zero. Since their definitions vary, the numerical values of the same temperature differ.

Values agree at absolute zero (0 K = -273.15°C) and at the triple point of water (0.01°C = 273.16 K).

(b) A brass boiler has a base area of $0.15\ m^2$ and thickness of 1 cm. It boils water at the rate of 6 kg/min when placed on a gas stove. What is the temperature of the part of the flame in contact with the boiler?

Using Fourier's law of heat conduction:

$Q = (k\ A\ \Delta T) / d$

Where:
Q = heat transfer per second = (mass × specific heat × ΔT) / time
k = thermal conductivity of brass = 109 W/mK
$A = 0.15\ m^2$
d = 0.01 m
ΔT = temperature difference

Given data:
Mass = 6 kg/min = 0.1 kg/s
Specific heat of water = 4200 J/kgK
Latent heat of vaporization = 2.26×10^6 J/kg

Heat required per second:
$Q = 0.1 \times 2.26 \times 10^6$
$Q = 2.26 \times 10^5$ W

Using Fourier's law:

$2.26 \times 10^5 = (109 \times 0.15 \times \Delta T) / 0.01$

$\Delta T = (2.26 \times 10^5 \times 0.01) / (109 \times 0.15)$
$\Delta T \approx 138.78°C$

If boiling occurs at 100°C, the flame temperature = 100 + 138.78 = 238.78°C

6. (a) (i) Distinguish between forced and natural convection and state the laws governing these processes.

Forced convection occurs when an external force (such as a fan or pump) moves the fluid, enhancing heat transfer.
Natural convection occurs due to density differences caused by temperature variations, leading to buoyancy-driven fluid movement.

Laws:

- Newton's law of cooling states that the rate of heat loss is proportional to the temperature difference.
- The continuity equation and Navier-Stokes equations describe fluid flow in convection.

(ii) A piece of copper of mass 50 g is heated to 100°C and then transferred to a well-insulated copper calorimeter of mass 25 g containing 100 g of water at 10°C. Neglecting heat loss, calculate the final steady temperature of water after it has been well stirred.

Heat lost by copper = Heat gained by water and calorimeter.
Let final temperature = T.

$m_1c_1(T_1 - T) = (m_2c_2 + m_3c_3)(T - T_2)$
Copper: $m_1 = 50$ g, $c_1 = 0.39$ J/gK, $T_1 = 100°C$
Calorimeter: $m_2 = 25$ g, $c_2 = 0.39$ J/gK
Water: $m_3 = 100$ g, $c_3 = 4.18$ J/gK, $T_2 = 10°C$

$(50 \times 0.39 \times (100 - T)) = (25 \times 0.39 + 100 \times 4.18) \times (T - 10)$

Solving for T:
$T \approx 12.3°C$

(b) A blackened sphere of radius 2 cm is contained within a hollow evacuated enclosure maintained at 27°C. Assuming that the sphere behaves like a blackbody, calculate the rate at which the sphere loses heat when its temperature is 227°C.

Using Stefan-Boltzmann's law:
$P = \sigma A (T_1^4 - T_2^4)$

Where:
$\sigma = 5.67 \times 10^{-8}$ W/m²K⁴
$A = 4\pi r^2 = 4\pi(0.02)^2$
$T_1 = 227 + 273 = 500$ K
$T_2 = 27 + 273 = 300$ K

$P = 5.67 \times 10^{-8} \times 4\pi(0.02)^2 \times (500^4 - 300^4)$
Solving:
$P \approx 0.924$ W

7. (a) (i) What is a stationary wave?
A stationary wave is a wave formed by the superposition of two identical waves traveling in opposite directions, resulting in a wave pattern with nodes (zero displacement) and antinodes (maximum displacement).

(ii) In one set of axes draw graphs showing critically damped, overdamped, and underdamped oscillations.

- Critically damped: No oscillation, returning to equilibrium in the shortest time.

- Overdamped: Slow return to equilibrium without oscillation.
- Underdamped: Oscillates with decreasing amplitude.

(b) Plane sound waves of frequency 100 Hz fall normally on a smooth wall. At what distances from the wall will the air particles have maximum and minimum amplitude of vibration? Give reasons for your answer.

For plane sound waves of frequency 100 Hz incident normally on a smooth wall, the wall acts as a rigid boundary, reflecting the waves to form a standing wave. In a standing wave, nodes (minimum amplitude) occur where destructive interference is complete, and antinodes (maximum amplitude) occur where constructive interference is maximum.
Wavelength calculation: Speed of sound in air ≈ 343 m/s (at 20°C). Wavelength $\lambda = v/f = 343/100 = 3.43$ m.

Nodes (minimum amplitude): At the wall ($x = 0$), the air particles cannot vibrate due to the rigid boundary, forming a node. Additional nodes occur at intervals of $\lambda/2 = 1.715$ m from the wall, i.e., at $x = 0$, 1.715 m, 3.43 m, etc.

Antinodes (maximum amplitude): These occur midway between nodes, at $\lambda/4 = 0.8575$ m from the wall, and at intervals of $\lambda/2$ thereafter, i.e., at $x = 0.8575$ m, 2.5725 m, 4.2875 m, etc.

Reason: The standing wave results from interference between incident and reflected waves. Nodes form at the wall and every half-wavelength due to zero displacement, while antinodes form at quarter-wavelength intervals where displacement is maximized.

(c) A stationary wave is given by $y = 5 \sin(\pi x/3) \cos(40\pi t)$. Find the component waves.

The stationary wave is
$y = 5 \sin(\pi x/3) \cos(40\pi t)$

A standing wave is formed by two traveling waves of equal amplitude moving in opposite directions. The general form is
$y = A \sin(kx) \cos(\omega t)$

where:
$k = \pi/3$ (wave number),
$\omega = 40\pi$ (angular frequency),
Amplitude = 5.

The component traveling waves are:
$y_1 = (5/2) \sin(kx - \omega t) = (5/2) \sin(\pi x/3 - 40\pi t)$ (right-moving),
$y_2 = (5/2) \sin(kx + \omega t) = (5/2) \sin(\pi x/3 + 40\pi t)$ (left-moving).

8. (a) (i) What is a potentiometer?

A potentiometer is a device used to measure potential difference accurately and to compare the electromotive forces of different cells without drawing current from them.

(ii) A student sets up a potentiometer and finds that no matter where along the potentiometer wire contact is made, the galvanometer deflection is always in the same direction and it is impossible to obtain a zero current reading. Give reasons for this phenomenon.

This occurs due to one of the following reasons:

- The emf of the driving cell is less than the emf of the test cell, making it impossible to balance the circuit.
- The potentiometer wire or connections have high resistance, preventing proper functioning.
- The circuit is not properly connected, leading to a continuous unidirectional current.

(b) (i) Define resistivity.

Resistivity is the intrinsic property of a material that determines how strongly it opposes the flow of electric current. It is given by $\rho = R A / L$, where R is resistance, A is cross-sectional area, and L is length. Its unit is ohm-meter (Ωm).

(ii) Define temperature coefficient of resistance.

The temperature coefficient of resistance is the fractional change in resistance per degree change in temperature. It is given by $\alpha = (R_2 - R_1) / (R_1 \Delta T)$, where R_1 and R_2 are resistances at different temperatures and ΔT is the temperature difference.

(c) Calculate the steady temperature attained by a copper wire carrying a current of 5A, using the following data:
Temperature of the surrounding air = 10°C,
Diameter of wire = 1 mm,
Emissivity of surface of wire = 9.22 W/m^2K^4,
Resistivity of copper = 1.8×10^{-8} Ωm,
Temperature coefficient of resistance of copper = 0.0043 K^{-1}.

Power dissipated as heat:

$P = I^2 R$
$R = \rho L / A, A = \pi d^2/4$

Substituting values:

$R = (1.8 \times 10^{-8} \times L) / (\pi \times (0.001)^2 / 4)$

$R = (1.8 \times 10^{-8} \times 4) / (\pi \times 10^{-6})$
$R = 7.2 \times 10^{-8} / \pi \times 10^{-6}$
$R = 2.29 \times 10^{-2}\ \Omega/m$

$P = 5^2 \times 2.29 \times 10^{-2}$
$P = 0.572$ W/m

Heat radiated:

$P = \varepsilon \sigma A (T^4 - T_0^4)$
$P = (9.22 \times 5.67 \times 10^{-8} \times \pi \times 0.001 \times L) (T^4 - 10^4)$

Equating heat dissipated and radiated:

$0.572 = (9.22 \times 5.67 \times 10^{-8} \times \pi \times 0.001) (T^4 - 10^4)$
Solving for T:

$T \approx 31.5°C$

9. (a) (i) What is a magnetic field?

A magnetic field is a region around a magnet or current-carrying conductor in which magnetic forces are experienced. It is represented by field lines indicating the direction and strength of the field.

(ii) State four factors upon which the magnetic induction, B, at any point of the magnetic field depends.

1. Current flowing through the conductor.
2. Distance from the conductor.
3. Permeability of the medium.
4. Shape and orientation of the conductor.

(b) Derive an expression for the flux density B at the center of a circular coil of radius r and N turns placed in air carrying a current I.

Using Biot-Savart law:
$dB = (\mu_0 I\ dl \sin\theta) / (4\pi r^2)$

For a full circular loop, integrating:
$B = (\mu_0 N I) / (2r)$

(c) (i) The diameter of a 20-turn circular coil is 8.0 cm and it has a current of 3.0 A.
$B = (\mu_0 N I) / (2r)$

$\mu_0 = 4\pi \times 10^{-7}$ H/m
r = 8.0 cm / 2 = 0.04 m
N = 20
I = 3.0 A

$B = (4\pi \times 10^{-7} \times 20 \times 3) / (2 \times 0.04)$
$B = (7.54 \times 10^{-5}) / 0.08$
$B = 9.42 \times 10^{-4}$ T

(ii) If the coil is suspended in a uniform magnetic field of 1 Weber/m², such that its plane is parallel to the direction of the field, calculate the moment of the couple acting on it.

Torque $\tau = N B A I$
$A = \pi r^2 = \pi (0.04)^2$
$A = 5.03 \times 10^{-3}$ m²

$\tau = 20 \times 1 \times (5.03 \times 10^{-3}) \times 3$
$\tau = 0.3018$ N·m

10. (a) (i) Distinguish between zero bias and contact potential as applied to a P-N junction diode.
Zero bias refers to a condition where no external voltage is applied across the P-N junction.
Contact potential is the built-in potential difference due to the diffusion of charge carriers across the junction, creating a depletion layer.

(ii) A close examination of current-voltage characteristics of a diode shows that current varies exponentially with applied voltage V_a according to the equation

$I = I_0 \exp(eV_a / kT)$

where I_0 is the saturation current.
Calculate the resistance of the diode at the temperature T = 25°C (298 K) if the ammeter reading is 10^{-5} A.

Differentiating the equation:

$dI/dV = (I_0 e / kT) \exp(eV_a / kT)$
Resistance $R = 1 / (dI/dV)$
Substituting known values:
$R = (kT) / (I_0 e \exp(eV_a / kT))$

After solving,
R ≈ 2.5 kΩ

(b) (i) Describe basic logic gates.
Basic logic gates include AND, OR, NOT, NAND, NOR, XOR, and XNOR. They perform binary operations where input values (0 and 1) yield specific outputs based on logical rules.

(ii) A driver must wear a seatbelt when driving (D) unless reversing (R). Convert this conditional statement into a logic gate system.

Logic equation:
Seatbelt (S) = D AND NOT(R)

(c) Study the common emitter circuit in figure 2 and answer the questions which follow.
(i) What is the function of R_1, 1.5 V, and 10 V supply?

R_1 acts as a base resistor limiting base current.
1.5 V provides base-emitter bias.
10 V is the collector supply voltage.

(ii) Explain the role played by capacitor C_1.
C_1 blocks DC and allows AC signals to pass, ensuring signal amplification without distortion.

(iii) Given that $I_B = 1.0$ mA and $I_\beta = 0.02$ mA, calculate the voltage amplification of the circuit if V_i = 10 mV and input resistance is 2Ω.

Voltage gain $Av = \beta (R_C / R_{in})$

Substituting values:
$Av = (20 \times 5000) / 2$
$Av = 50000$
Output voltage = $Av \times V_i = 50000 \times 0.01$
$V_{out} = 500$ V

11. (a) (i) Define time constant as applied in capacitors.

Time constant (τ) is the time required for the charge or voltage across a capacitor in an RC circuit to change by approximately 63 percent of its initial value when charging or discharging. It is given by $\tau = RC$, where R is resistance and C is capacitance.

(ii) Define dielectric constant.

Dielectric constant (εr) is the ratio of the permittivity of a material (ε) to the permittivity of free space (ε_0). It represents the ability of a dielectric material to store electrical energy. It is given by $\varepsilon r = \varepsilon / \varepsilon_0$.

(b) (i) State the relationship between the capacitance of a capacitor and the distance between plates.

Capacitance (C) is inversely proportional to the distance (d) between the plates.
$C = (\varepsilon_0 \varepsilon r A) / d$

(ii) State the relationship between the capacitance of a capacitor and the area between plates.
Capacitance (C) is directly proportional to the plate area (A).
$C = (\varepsilon_0 \varepsilon r A) / d$

(c) In a vibrating reed experiment, two parallel plate capacitors with area 0.4 m^2 are separated by 3 mm of a dielectric. The battery of 200 V charges and discharges the capacitor at a frequency of 60 Hz and a current of 40 μA is produced.

(i) Calculate the value of dielectric constant εr.
The capacitive reactance is given by:

$I = V C \omega$
where $\omega = 2\pi f$

Rearranging for C:
$C = I / (V \omega)$

Substituting values:

$C = (40 \times 10^{-6}) / (200 \times 2\pi \times 60)$
$C = (40 \times 10^{-6}) / (200 \times 377)$
$C = 5.31 \times 10^{-12}$ F

Using $C = (\varepsilon_0 \varepsilon r A) / d$

$\varepsilon r = (C d) / (\varepsilon_0 A)$
$\varepsilon_0 = 8.85 \times 10^{-12}$ F/m

$\varepsilon r = (5.31 \times 10^{-12} \times 3 \times 10^{-3}) / (8.85 \times 10^{-12} \times 0.4)$
$\varepsilon r = 4.5$

(ii) What will be the new capacitance if half of the dielectric is withdrawn from the plates?
The system now consists of two capacitors in parallel, one with dielectric and one with air.

$C_1 = (\varepsilon_0 \varepsilon r A/2) / d$
$C_2 = (\varepsilon_0 A/2) / d$

Total capacitance:
$C\_new = C_1 + C_2$

$C\_new = (\varepsilon_0 A / d) [(\varepsilon r / 2) + (1 / 2)]$
$C\_new = C (\varepsilon r + 1) / 2$
$C\_new = (5.31 \times 10^{-12} \times (4.5 + 1)) / 2$
$C\_new = 1.33 \times 10^{-12}$ F

12. (a) (i) What is thermionic emission?
Thermionic emission is the process by which electrons are emitted from the surface of a heated metal due to increased kinetic energy overcoming the metal's work function.

(ii) Explain the action of the deflecting system in a cathode ray oscilloscope (CRO).

The deflecting system consists of horizontal and vertical plates that control the movement of the electron beam. When a voltage is applied to the plates, the electric field causes the beam to deflect in the respective direction, producing a visual representation of electrical signals on the screen.

(b) An electron beam passes through a parallel plate capacitor with a velocity of 10^7 m/s. The length of each plate is 10 cm while the distance between the plates is 5 cm. Calculate the deflection angle of the beam if the electric intensity between the plates is 20 V/cm.

Electric force:

$F = eE$
where E = 20 V/cm = 2000 V/m, $e = 1.6 \times 10^{-19}$ C

$F = 1.6 \times 10^{-19} \times 2000$
$F = 3.2 \times 10^{-16}$ N

Acceleration:
a = F / m, where $m = 9.11 \times 10^{-31}$ kg
$a = (3.2 \times 10^{-16}) / (9.11 \times 10^{-31})$
$a = 3.51 \times 10^{14}$ m/s²

Time taken in plates:

$t = l / v$
$t = (0.1) / (10^7)$
$t = 10^{-8}$ s

Vertical displacement:

$y = 1/2\ a\ t^2$
$y = (1/2) \times (3.51 \times 10^{14}) \times (10^{-8})^2$
$y = 1.75 \times 10^{-2}$ m

Deflection angle:

$\theta = \tan^{-1}(y / x)$, where x = 0.1 m
$\theta = \tan^{-1}(1.75 \times 10^{-2} / 0.1)$
$\theta = 9.93°$

(c) An oil drop of diameter 10^{-5} cm carrying two electronic charges remains suspended between charged parallel plates capacitor 10 mm apart. If the density of oil is 1.8 g/cm³, calculate the potential difference between the two plates.

Weight of drop:
$W = mg$
Volume of drop:
$V = (4/3)\ \pi\ r^3$
$V = (4/3)\ \pi\ (5 \times 10^{-8})^3$
$V = 5.24 \times 10^{-22}\ m^3$

Mass:
$m = \rho V$
$m = (1.8 \times 10^3) \times (5.24 \times 10^{-22})$
$m = 9.43 \times 10^{-19}$ kg

Weight:
$W = mg = (9.43 \times 10^{-19}) \times (9.81)$
$W = 9.25 \times 10^{-18}$ N

Electric force:
$F = qE = qV/d$
$V = Wd / q$
$q = 2e = 2 \times (1.6 \times 10^{-19}) = 3.2 \times 10^{-19}$ C
$V = (9.25 \times 10^{-18} \times 10^{-2}) / (3.2 \times 10^{-19})$
$V = 2.89$ V
13. (a) (i) What is meant by an electric field?

An electric field is the region around a charged object where an electric force is experienced by other charges. It is represented by field lines and has units of V/m.

(ii) What is meant by a magnetic field?
A magnetic field is the space around a moving charge or magnet where magnetic forces can be detected. It is represented by field lines and measured in Tesla.

(b) Define electric potential.
Electric potential at a point is the work done per unit charge in bringing a small positive test charge from infinity to that point. It is measured in volts (V).

(c) (i) What is an electric line of force?
An electric line of force is an imaginary line representing the direction of the electric field, where the tangent at any point gives the field direction.

(ii) In figure 3 below, $q_1 = -5 \times 10^{-6}$ C and $q_2 = 2 \times 10^{-6}$ C. Calculate the work done in moving a third charge $q_3 = 3 \times 10^{-6}$ C from B to A along the diagonal of the rectangle.

Using potential difference:

$W = q_3 \Delta V$
$\Delta V = V_A - V_B$
After calculating:
$W = 2.7 \times 10^{-2}$ J

14. (a) (i) Define earthquake.

An earthquake is a sudden shaking of the Earth's surface due to seismic waves caused by tectonic activity.

(ii) Define atmosphere.

The atmosphere is the layer of gases surrounding the Earth, essential for life.

(b) Distinguish between body waves and surface waves.

Body waves travel through the Earth's interior, while surface waves move along the Earth's surface, causing more damage.

(c) Define epicenter and focus.
The focus is the underground origin of an earthquake.
The epicenter is the point on the surface directly above the focus.