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: 2016**

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) i) define the term dimension of a physical quantity

- the dimension of a physical quantity refers to the representation of the quantity in terms of the fundamental physical units such as mass (m), length (l), and time (t). for example, force has the dimension ml/t^2.

ii) the number of particles n crossing a unit area perpendicular to the x-axis in a unit time is given as $n = -d((n_2 - n_1) / (x_2 - x_1))$ where n_1 and n_2 are the number of particles per unit volume for the values of x_1 and x_2 respectively. what are the dimensions of diffusion constant d?

from the equation:

$d = n (x_2 - x_1) / (n_2 - n_1)$

dimensional analysis:

$[n] = l^{-3}$, $[x] = l$, $[t] = t$

thus, $[d] = l^2/t$

b) i) give two basic rules of dimensional analysis

- both sides of a physical equation must have the same dimensions.
- the fundamental quantities used to express the dimension of a physical quantity must remain consistent across different unit systems.

ii) the frequency f of a vibrating string depends upon the force applied f, the length l of the string, and the mass per unit length μ. using dimension show how f is related to f, l, and μ.

assuming $f = k\ f^a\ l^b\ \mu^c$

writing dimensions:

$[f] = t^{-1}$, $[f] = ml\ t^{-2}$, $[l] = l$, $[\mu] = m\ l^{-1}$

equating dimensions:

$t^{-1} = (ml\ t^{-2})^a\ (l)^b\ (m\ l^{-1})^c$

solving for a, b, and c gives:
$a = 1/2$, $b = -1$, $c = -1/2$

thus, $f = k\ (f^{1/2})\ (l^{-1})\ (\mu^{-1/2})$

c) i) what is meant by least count of a measurement?

- the least count of a measuring instrument is the smallest measurement that can be accurately measured using the instrument. for example, a vernier caliper with a least count of 0.01 mm can measure changes as small as 0.01 mm.

ii) the period of oscillation of a simple pendulum is given by $t = 2\pi \sqrt{(l/g)}$ where by 100 vibrations were taken to measure 200 seconds. if the least count for the time and length of a pendulum of 1m are 0.1 sec and 1mm respectively, calculate the maximum percentage error in the measurement of g.

fractional error in g:

$\delta g/g = 2(\delta t/t) + (\delta l/l)$

substituting given values:

$\delta g/g = 2(0.1/200) + (0.001/1)$
$\delta g/g = 0.001 + 0.001$
$\delta g/g = 0.002$

percentage error = $0.002 \times 100 = 0.2\%$

2. a) i) mention two characteristics of projectile motion

- the horizontal motion has a constant velocity as there is no acceleration acting horizontally.
- the vertical motion is affected by gravity, causing an acceleration of 9.81 m/s^2 downward.

ii) if the range of the projectile is 120m and its time of flight is 4sec, determine the angle of projection and its initial velocity of projection assuming that the acceleration due to gravity $g = 10m/s^2$.

using range formula:

$r = v^2 \sin(2\theta) / g$
$120 = v^2 \sin(2\theta) / 10$

also, using time of flight formula:

$t = 2v \sin \theta / g$
$4 = 2v \sin \theta / 10$

solving for v and θ:
$v \approx 17.68$ m/s
$\theta \approx 45°$

b) state the principles on which the rocket propulsion is based.

- newton's third law: every action has an equal and opposite reaction.
- conservation of momentum: as the rocket expels gases backward, it gains forward momentum.

c) an object of mass 2kg is attached to the hook of a spring balance which is suspended vertically near the roof of a lift. what is the reading on the spring balance when the lift is:

i) going down with an acceleration of $0.1m/s^2$

apparent weight = m(g - a)

= 2(10 - 0.1)
= 19.8 n

ii) ascending with uniform velocity of 0.15m/s
since there is no acceleration, apparent weight remains mg = 2 × 10 = 20 n

3. a) i) define the term inertia.

- inertia is the tendency of a body to resist changes in its state of motion or rest unless acted upon by an external force.

ii) why is newton's first law of motion called the law of inertia?

- newton's first law states that an object remains at rest or in uniform motion unless acted upon by an external force, which directly describes inertia.

b) a jet of water from a fire hose is capable of reaching a height of 20m. if the cross-sectional area of the hose outlet is $4.0\times10^{-4}m^2$, calculate the

i) minimum speed of water from the hose

using kinematic equation:

$v = \sqrt{(2gh)}$

substituting values:

$v = \sqrt{(2 \times 10 \times 20)}$
$v = \sqrt{400}$
v = 20 m/s

ii) mass of water leaving the hose each second

mass flow rate = ρav

where,
$\rho = 1000\ kg/m^3$,
$a = 4.0 \times 10^{-4}\ m^2$,
$v = 20\ m/s$

mass flow = $(1000 \times 4.0 \times 10^{-4} \times 20)$
$= 8\ kg/s$

iii) force on the hose due to the water jet

$f = mv / t$

$= (8 \times 20) / 1$
$= 160\ N$

c) a boy ties a string around a stone of mass 0.15kg and then whirls it in a horizontal circle at constant speed. if the period of rotation of the stone is 0.4 sec and the length between the stone and the boy's hand is 0.50m

i) calculate the tension in the string.

centripetal force = tension in string

$t = mv^2 / r$
since $v = 2\pi r / t$

substituting values:

$v = (2 \times 3.14 \times 0.5) / 0.4$
$v = 7.85 / 0.4$
$v = 1.96\ m/s$

$T = (0.15 \times 1.96^2) / 0.5$
$T = (0.15 \times 3.84) / 0.5$
$T = 0.576\ N$

ii) state one assumption taken to reach the answer in 3 c i.

- air resistance is neglected.

4. a) i) what do you understand by the following terms

damped oscillations
- damped oscillations occur when the amplitude of an oscillating system decreases over time due to resistive forces such as friction or air resistance.

undamped oscillations
- undamped oscillations occur when there is no loss of energy in the oscillating system, meaning the amplitude remains constant indefinitely.

ii) sketch the waveform diagrams to represent the terms in 4 a i

- for damped oscillations, the waveform gradually decreases in amplitude over time.
- for undamped oscillations, the waveform maintains a constant amplitude.

b) show that the total energy of a body executing simple harmonic motion is independent of time

total energy e in simple harmonic motion is given by:

e = kinetic energy + potential energy
$e = (1/2)\, m\, \omega^2\, a^2$

since mass m, angular frequency ω, and amplitude a are constants, total energy remains constant and is independent of time.

c) a mass of 0.5kg connected to a light spring of force constant 20n/m oscillates on a horizontal frictionless surface. if the amplitude of the motion is 3.0cm, calculate

i) maximum speed of the mass

maximum speed $v_{max} = \omega\, a$

where $\omega = \sqrt{(k/m)}$,
k = 20 n/m,
m = 0.5 kg,
a = 3.0 cm = 0.03 m

$\omega = \sqrt{(20/0.5)}$
$\omega = \sqrt{40}$
$\omega = 6.32$ rad/s

$v_{max} = 6.32 \times 0.03$
$v_{max} = 0.1896$ m/s

ii) kinetic energy of the system when the displacement is 2.0cm

kinetic energy is given by

$ke = (1/2)\ m\ (\omega^2)(a^2 - x^2)$

substituting values:

$ke = (1/2)\ (0.5)\ (6.32^2)\ (0.03^2 - 0.02^2)$
$ke = 0.25 \times 40 \times (0.0009 - 0.0004)$
$ke = 10 \times 0.0005$
$ke = 0.005\ j$

5. a) i) what is meant by moment of inertia of a body?

- moment of inertia is the measure of an object's resistance to changes in its rotational motion about a given axis. it depends on the mass distribution relative to the axis of rotation.

ii) list two factors on which the moment of inertia of a body depends

- mass of the body: greater mass results in a larger moment of inertia.
- distribution of mass relative to the axis of rotation: moment of inertia increases as mass moves farther from the axis.

b) a thin sheet of aluminium of mass 0.032kg has the length of 0.25m and width of 0.1m. find its moment of inertia on the plane about an axis parallel to

i) length and passing through its centre of mass m

moment of inertia i for a rectangular sheet rotating about its length is given by

$i = (1/12)\ m\ w^2$

substituting values:

$i = (1/12) \times 0.032 \times (0.1)^2$
$i = (1/12) \times 0.032 \times 0.01$
$i = 0.0000267\ kgm^2$

ii) width and passing through the centre of mass in its own plane

$i = (1/12)\ m\ l^2$

substituting values:

$i = (1/12) \times 0.032 \times (0.25)^2$
$i = (1/12) \times 0.032 \times 0.0625$
$i = 0.000167\ kgm^2$

c) i) define the term angular momentum

- angular momentum is the rotational equivalent of linear momentum, given by $l = i\omega$, where i is the moment of inertia and ω is the angular velocity.

ii) a thin circular ring of mass m and radius r is rotating about its axis with constant angular velocity ω. if two objects each of mass m are attached gently at the ring, what will be the angular velocity of the rotating wheel?

using conservation of angular momentum:

initial angular momentum = final angular momentum

$m_i \omega_i = m_f \omega_f$

for a thin circular ring, moment of inertia is:

$i_{initial} = m r^2$

when two masses m are added,

$i_{final} = (m + 2m) r^2$
$i_{final} = 3m r^2$

substituting into conservation equation:

$m r^2 \omega = 3m r^2 \omega_f$

solving for ω_f:
$\omega_f = \omega / 3$

6. a) i) mention one application of parking orbit

- used in geostationary satellites for telecommunications and weather monitoring.

ii) briefly explain how parking orbit of a satellite is achieved

- a satellite is launched into a transfer orbit where it gradually increases altitude using controlled thrust until reaching a stable geostationary orbit.

b) the earth satellite revolves in a circular orbit at a height of 300km above the earth's surface. find the

i) velocity of the satellite

orbital velocity is given by

$v = \sqrt{(g\ r)}$

where,
r = radius of earth + height of satellite = 6400 km + 300 km = 6700 km = 6.7×10^6 m
g = 9.81 m/s²

$v = \sqrt{(9.81 \times 6.7 \times 10^6)}$
$v = \sqrt{(6.57 \times 10^7)}$
$v = 8.11 \times 10^3$ m/s

ii) period of the satellite

$t = 2\pi\ r / v$

substituting values:

$t = (2 \times 3.14 \times 6.7 \times 10^6) / (8.11 \times 10^3)$
$t = (42 \times 10^6) / (8.11 \times 10^3)$
$t = 5181$ s ≈ 86.35 min
c) i) why are space rockets usually launched from west to east?

- launching rockets from west to east takes advantage of the earth's rotation, which provides an extra velocity boost, reducing the fuel required.

ii) a spaceship is launched into a circular orbit close to the earth's surface. what additional velocity has to be imparted to the spaceship in order to overcome the gravitational pull?

the required velocity is the escape velocity given by:

$v\_e = \sqrt{(2\ g\ r)}$

substituting values:

$v_e = \sqrt{(2 \times 9.81 \times 6.4 \times 10^6)}$
$v_e = \sqrt{(1.26 \times 10^8)}$
$v_e \approx 11.2$ km/s

7. a) i) briefly explain why a body with large reflectivity is a poor emitter

- a body with high reflectivity reflects most of the incident radiation rather than absorbing it. since good emitters are also good absorbers (as per kirchhoff's law of radiation), a reflective body emits very little radiation, making it a poor emitter.

ii) the earth without its atmosphere would be too cold to live

- the earth's atmosphere traps heat through the greenhouse effect, maintaining a habitable temperature. without it, most of the heat would escape into space, making the earth extremely cold and uninhabitable.

b) i) identify two factors on which the coefficient of thermal conductivity of a material depends

- temperature: in metals, thermal conductivity generally decreases with increasing temperature, while in gases and insulators, it increases.
- material structure: crystalline solids have higher thermal conductivity than amorphous materials due to better atomic arrangement.

ii) a brass boiler of base area $1.50\times10^{-2}m^2$ and thickness of 1.0cm boils water at the rate of 6.0kg/min when placed on a gas stove. estimate the temperature of the part of the flame in contact with the boiler.

using fourier's law:

$q = k\ a\ (t_{hot} - t_{cold}) / d$

where,
q = heat transfer rate (j/s),
k = 109 w/mk (thermal conductivity of brass),
$a = 1.50\times10^{-2}\ m^2$,
d = 0.01 m,
$t_{cold} = 100°c$,
mass flow rate = 6.0 kg/min = 0.1 kg/s,
specific heat of water = 4.186 kj/kgk

$q = m\ c\ \Delta t$
$= 0.1 \times 4186 \times (100 - 25)$
$= 31395$ j/s

substituting in fourier's law:

$31395 = 109 \times 1.50 \times 10^{-2} (t\_hot - 100) / 0.01$

solving for t_hot:

$t\_hot \approx 292.5°c$

c) i) briefly describe the working principle of a thermocouple

- a thermocouple works on the seebeck effect, where two dissimilar metals joined at two different junctions produce an emf proportional to the temperature difference. this emf can be measured to determine temperature.

ii) in a certain thermocouple thermometer the e.m.f. is given by $e = a\theta + \frac{1}{2} b\theta^2$ where θ is the temperature of hot junction. if $a = 10mv/°c^2$, $b = -1/20\ mv/°c^2$ and the cold junction is at 0°c, calculate the neutral temperature.

neutral temperature occurs when $de/d\theta = 0$

$d/d\theta (a\theta + \frac{1}{2} b\theta^2) = 0$

$a + b\theta = 0$

solving for θ:

$\theta = - a/b$

$\theta = - (10 \times 10^{-3}) / (-1/20 \times 10^{-3})$
$\theta = (10 \times 20)$
$\theta = 200°c$

8. a) i) what is meant by thermal radiation?

- thermal radiation is the transfer of heat energy through electromagnetic waves, typically infrared, emitted by all bodies due to their temperature.

ii) briefly explain why forced convection is necessary for excess temperature less than 20k?

- when the temperature difference is very low (less than 20k), natural convection is inefficient due to weak buoyant forces. forced convection, which involves external means like fans or pumps, enhances heat transfer.

b) i) why is the energy of thermal radiation less than that of visible light?

- energy of radiation is given by e = h f, where h is planck's constant and f is frequency. since thermal radiation (infrared) has a lower frequency than visible light, its energy is also lower.

ii) a body with a surface area of 5.0cm² and a temperature of 727°c radiates 300 joules of energy in one minute. calculate its emissivity.

using stefan-boltzmann law:

$q = e \sigma a t^4$

where,
q = 300 j,
$\sigma = 5.67 \times 10^{-8}$ w/m²k⁴,
a = 5.0 cm² = 5.0×10^{-4} m²,
t = 727 + 273 = 1000 k

$300 = e \times (5.67 \times 10^{-8}) \times (5.0 \times 10^{-4}) \times (1000)^4$

solving for e:

$e \approx 0.53$

c) i) state newton's law of cooling

- the rate of heat loss of a body is proportional to the difference in temperature between the body and its surroundings.

ii) a body cools from 70°c to 40°c in 5 minutes. if the temperature of the surroundings is 10°c, calculate the time it takes to cool from 50°c to 20°c.

using newton's law of cooling:

$t \propto \ln(\Delta t)$

$\ln((70-10)/(40-10)) = \ln((50-10)/(20-10)) \times (t_2 / 5)$

$\ln(60/30) = \ln(40/10) \times (t_2 / 5)$

$0.693 = 1.386 \times (t_2 / 5)$

solving for t_2:

t_2 = 2.5 minutes

9. a) i) define the term junction as applied in electrical networks

- a junction in an electrical network is a point where two or more circuit elements (such as resistors or wires) meet.

ii) what is the physical significance of kirchhoff's first law?

- kirchhoff's first law (current law) states that the sum of currents entering a junction is equal to the sum of currents leaving the junction, implying the conservation of charge.

b) i) why is kirchhoff's second law sometimes referred to as the voltage law?

- kirchhoff's second law (voltage law) states that the sum of voltage drops around a closed loop is equal to the sum of emf sources, which is based on the principle of conservation of energy.

ii) list down five points to be considered when applying kirchhoff's second law in formulating analytical problems or equations.

- choose a closed loop in the circuit.
- assign loop currents and their direction.
- apply voltage drops based on the resistor values and ohm's law.
- consider the sign convention: voltage drop across resistors is negative, emf source is positive in direction of the loop.
- write and solve simultaneous equations for multiple loops.

c) study the circuit diagram in figure 1 then answer the questions that follow.

i) how many loops are there in the circuit?

- the circuit consists of 2 loops.

ii) find the current flowing through 2Ω, 4Ω and 8Ω resistors

To solve question 9(c) ii, we will use Kirchhoff's Voltage Law (KVL) which states that the sum of all voltage drops in a closed loop is equal to the sum of all emf sources.

Given Circuit:
- Voltage sources: 12V and 9V
- Resistors: 2Ω, 4Ω, and 8Ω

Step 1: Define Current Flow
Let:
- I_1 be the current in the left loop (loop containing the 9V battery and 2Ω & 4Ω resistors).
- I_2 be the current in the right loop (loop containing the 12V battery and 4Ω & 8Ω resistors).

Since the 4Ω resistor is common in both loops, the net current through it will be $(I_1 - I_2)$.

Step 2: Apply Kirchhoff's Voltage Law (KVL)

Loop 1: Left Loop (Containing 9V, 2Ω, and 4Ω)
Applying Kirchhoff's Voltage Law:
$9V - (2\Omega \times I_1) - (4\Omega \times (I_1 - I_2)) = 0$
Expanding:
$9 - 2I_1 - 4I_1 + 4I_2 = 0$
$9 - 6I_1 + 4I_2 = 0$
Rearrange:
$6I_1 - 4I_2 = 9$ (Equation 1)

Loop 2: Right Loop (Containing 12V, 8Ω, and 4Ω)
Applying Kirchhoff's Voltage Law:

$12V - (8\Omega \times I_2) - (4\Omega \times (I_2 - I_1)) = 0$
Expanding:
$12 - 8I_2 - 4I_2 + 4I_1 = 0$
$12 - 12I_2 + 4I_1 = 0$

Rearrange:
$4I_1 - 12I_2 = -12$ (Equation 2)
Step 3: Solve the Simultaneous Equations
We have the system:

$6I_1 - 4I_2 = 9$
$4I_1 - 12I_2 = -12$
Multiply Equation 1 by 3 to match I_2 coefficients:
$18I_1 - 12I_2 = 27$
$4I_1 - 12I_2 = -12$

Subtract the second equation from the first:

$(18I_1 - 12I_2) - (4I_1 - 12I_2) = 27 - (-12)$
$18I_1 - 4I_1 = 27 + 12$
$14I_1 = 39$
$I_1 = 2.79$ A

Substitute $I_1 = 2.79$ A into Equation 1:

$6(2.79) - 4I_2 = 9$
$16.74 - 4I_2 = 9$
$-4I_2 = -7.74$
$I_2 = 1.94$ A

Step 4: Find the Current through Each Resistor

1. Current through 2Ω resistor = $I_1 = 2.79$ A
2. Current through 4Ω resistor = $I_1 - I_2 = 2.79 - 1.94 = 0.85$ A
3. Current through 8Ω resistor = $I_2 = 1.94$ A

10. a) i) what is meant by the following terms

phase of alternating e.m.f.
- the phase of an alternating e.m.f. refers to the position of the waveform relative to a reference point in time. it is usually measured in degrees or radians and determines the alignment of the waveform in an ac circuit.

root mean square (r.m.s.) value of alternating e.m.f.
- the root mean square (r.m.s.) value of an alternating e.m.f. is the equivalent direct current (dc) voltage that produces the same power dissipation in a resistive circuit. it is given by

$v_{rms} = v_{peak} / \sqrt{2}$

b) an a.c. circuit consisting of a pure resistance of 10Ω is connected across a 230V, 50Hz supply. calculate the

i) current flowing in the circuit

ohm's law states that:

$i = v / r$

where,
$v = 230$ v
$r = 10\Omega$

substituting values:

$i = 230 / 10$

i = 23 a

ii) power dissipated

power dissipated in a resistive circuit is given by:

$p = v_{rms} \times i$

substituting values:

$p = 230 \times 23$
$p = 5290$ w

c) a 25 μf capacitor, a 0.10h inductor and a 25Ω resistor are connected in series with an a.c. source whose e.m.f. is given by e = 310 sin 314t volt. determine the

i) frequency of the e.m.f.

the general form of an a.c. voltage is given by:

$e = e_{max} \sin(\omega t)$

where ω is the angular frequency, $\omega = 2\pi f$

from the given equation,

$\omega = 314$ rad/s

since,

$f = \omega / 2\pi$

substituting values:

$f = 314 / (2 \times 3.14)$
$f = 314 / 6.28$
$f = 50$ hz

ii) net reactance of the circuit

the net reactance x is given by:

$x = x_l - x_c$

where,
x_l = inductive reactance = $\omega l = 314 \times 0.10$
$x_l = 31.4\Omega$

x_c = capacitive reactance = $1 / (\omega c) = 1 / (314 \times 25 \times 10^{-6})$
$x_c = 1 / (0.00785)$
$x_c = 127.4\Omega$

thus,

$x = 31.4 - 127.4$
$x = -96\Omega$

the negative sign indicates that the circuit is more capacitive in nature.

11. a) i) what is the importance of doping as applied to semiconductors?

- doping increases the conductivity of semiconductors by introducing charge carriers (electrons or holes) into the material. this process enables the control of electronic properties, allowing semiconductors to function in electronic circuits such as diodes, transistors, and integrated circuits.

ii) distinguish between n-type and p-type semiconductors. give three points.

n-type semiconductor:
- formed by adding pentavalent impurities (e.g., phosphorus, arsenic).
- majority charge carriers are electrons.
- conductivity increases due to an increase in free electrons.

p-type semiconductor:
- formed by adding trivalent impurities (e.g., boron, gallium).
- majority charge carriers are holes.
- conductivity increases due to an increase in hole concentration.

b) i) why are transistors mostly used in common emitter arrangement?

- the common emitter arrangement provides high voltage and current gain, making it suitable for amplification applications. it also allows phase inversion, which is useful in signal processing circuits.

ii) when does a transistor amplifier work as an oscillator?

- a transistor amplifier works as an oscillator when positive feedback is applied to sustain oscillations. this requires a proper phase shift and loop gain greater than or equal to unity, as described by barkhausen's criterion.

c) i) explain the use of an op-amp as a summing amplifier.

- a summing amplifier is an operational amplifier (op-amp) circuit that adds multiple input signals and provides a single output. it is widely used in audio mixers, signal processing, and data acquisition systems.

ii) figure 2 is an operational amplifier circuit where $r_1 = 39k\omega$, $r_2 = 4.7k\omega$, $r_3 = 10k\omega$ and $r_4 = 2.7k\omega$.

calculate the output potential v_0 given that the input voltage $v_1 = 4.0v$, $v_2 = -2.5v$ and $v_3 = 1.5v$.

for an inverting summing amplifier, the output voltage is given by:

$$v_0 = - (r_f / r_1) v_1 - (r_f / r_2) v_2 - (r_f / r_3) v_3$$

where,
$r_f = r_4 = 2.7k\omega$
$r_1 = 39k\omega$, $r_2 = 4.7k\omega$, $r_3 = 10k\omega$
$v_1 = 4.0v$, $v_2 = -2.5v$, $v_3 = 1.5v$

substituting values:

$$v_0 = - (2.7 / 39) (4.0) - (2.7 / 4.7) (-2.5) - (2.7 / 10) (1.5)$$

$$v_0 = - (0.0692 \times 4.0) + (0.574 \times 2.5) - (0.27 \times 1.5)$$

$$v_0 = -0.2768 + 1.435 - 0.405$$

$$v_0 = 0.753 \text{ v}$$

12. a) name three electronic circuits in which multivibrators can be constructed.

- astable multivibrator
- monostable multivibrator
- bistable multivibrator

b) i) list down three types of multivibrators.

- astable multivibrator
- monostable multivibrator
- bistable multivibrator

ii) briefly explain the applications of multivibrators listed in 12(b) i.

- astable multivibrator: used in waveform generation and clock pulse circuits.
- monostable multivibrator: used in pulse width modulation and timers.
- bistable multivibrator: used as a flip-flop in digital circuits for data storage.

c) i) mention two characteristics of op-amps.

- high gain: op-amps have very high voltage gain, making them suitable for amplification.
- high input impedance: op-amps draw very little current, minimizing the effect on connected circuits.

ii) briefly explain why op-amps are sometimes called differential amplifiers.

- op-amps amplify the difference between two input signals, making them useful in signal conditioning and instrumentation applications.

13. a) discuss the mode of action of each of the following sensors.

i) thermistor (th)
- a thermistor is a temperature-sensitive resistor whose resistance changes with temperature. in an ntc (negative temperature coefficient) thermistor, resistance decreases as temperature increases, whereas in a ptc (positive temperature coefficient) thermistor, resistance increases with temperature.

ii) light dependent resistor (ldr)
- an ldr is a photosensitive resistor whose resistance decreases as light intensity increases. it is used in automatic lighting systems, cameras, and solar-powered devices.

b) give symbols, expressions, and truth tables for each of the following logic gates.

i) nand gate
- expression: $y = (a \cdot b)'$
- symbol: two-input nand gate
- truth table:

a	b	y
0	0	1
0	1	1
1	0	1
1	1	0

ii) exclusive nor (xnor) gate

- expression: y = (a ⊕ b)'
- symbol: two-input xnor gate
- truth table:

a	b	y
0	0	1
0	1	0
1	0	0
1	1	1

c) i) why is nand gate considered as a basic building block for a variety of logic circuits?

- nand gate is considered a universal gate because it can be used to implement all other basic logic gates (and, or, not) using only nand gates.

ii) produce a truth table for the gate shown in figure 3 hence show that it behaves as an and gate.

a	b	c	d	q
0	0	1	1	0
0	1	1	0	0
1	0	1	0	0
1	1	1	1	1

the output q is high only when both a and b are high, confirming that the circuit behaves as an and gate.

14. a) i) what is meant by aerial environment? give two examples.

- an aerial environment refers to the atmospheric layer that influences weather, climate, and aviation. examples include:
  - troposphere, where weather changes occur.
  - stratosphere, where the ozone layer is found.

ii) describe three ways at which the aerial environment is threatened.

- air pollution from industries and vehicles.
- deforestation leading to changes in atmospheric composition.
- ozone layer depletion due to cfc emissions.

b) i) briefly explain three major concepts on solar wind.

- solar wind is a stream of charged particles (mainly electrons and protons) released from the sun's corona.

- it interacts with earth's magnetic field, causing auroras.
- solar storms due to solar wind variations can disrupt satellite communications and power grids.

ii) how do soil environmental components influence plant growth? give four points.

- soil nutrients provide essential minerals for plant growth.
- soil texture affects water retention and root penetration.
- ph levels determine nutrient availability.
- microbial activity influences soil fertility.