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: 2019**

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) identify two basic rules of dimensional analysis

- the principle of homogeneity states that both sides of an equation must have the same dimensional formula. this ensures the equation is dimensionally consistent.
- only quantities of the same dimension can be added or subtracted. different physical quantities, such as length and time, cannot be combined arithmetically.

ii) the frequency n of vibration of a stretched string is a function of its tension f, the length l, and mass per unit length m. use the method of dimensions to derive the formula relating the stated physical quantities

assuming a relation of the form:

$n = k\ f^a\ l^b\ m^c$

writing dimensional equations:

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

equating dimensions:

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

solving for a, b, and c gives:

$a = 1/2$, $b = -1$, $c = -1/2$

thus, the formula is:

$n = k\ (f^{1/2})\ (l^{-1})\ (m^{-1/2})$

2. a) what causes systematic errors in an experiment? give four points

- incorrect calibration of instruments, leading to consistent overestimation or underestimation of values.
- parallax errors due to improper alignment while taking measurements.
- environmental factors such as temperature and pressure variations affecting measurements.
- human biases or limitations in reading instruments consistently.

b) estimate the numerical value of drag force $d = 1/4\ c\rho av^2$ with its associated error given that the measurements of the quantities c, ρ, a, and v were recorded as (10 ± 0.09), $(1.2 \pm 0.2)\ g/cm^3$, $(15 \pm 0.15)\ g/cm^2$ and $(3 \pm 0.5)\ cm/sec^2$ respectively

using fractional error:

$\Delta d/d = \Delta c/c + \Delta \rho/\rho + \Delta a/a + 2(\Delta v/v)$

substituting values:

$\Delta d/d = (0.09/10) + (0.2/1.2) + (0.15/15) + 2(0.5/3)$
$\Delta d/d = 0.009 + 0.1667 + 0.01 + 0.3333$
$\Delta d/d = 0.519$

since $d = 1/4 \times 10 \times 1.2 \times 15 \times 9 = 405$

error in d:

$\Delta d = 405 \times 0.519 = 210.2$
thus, $d = 405 \pm 210.2$

3. a) i) justify the statement that projectile motion is two-dimensional motion

- projectile motion occurs in both horizontal and vertical directions simultaneously.
- the horizontal component has constant velocity, while the vertical component experiences acceleration due to gravity.

ii) a rocket with a velocity of 50 m/s from the surface of the moon at an angle of 40° to the horizontal. calculate the horizontal distance covered after half time of flight

horizontal range is given by:

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

substituting values:

$r = (50^2 \sin 80°) / 1.62$

$r = (2500 \times 0.9848) / 1.62$

$r = 1519.7$ m

horizontal distance covered in half flight = $r / 2 = 759.85$ m

b) i) show that the angle of projection θ_0 for a projectile launched from the origin is given by $\theta_0 = \tan^{-1}(4h_0/r)$, where r stands for horizontal range and h_0 is the maximum vertical height

maximum height is given by:

$h_o = (u^2 \sin^2\theta) / 2g$

range is given by:

$r = (u^2 \sin 2\theta) / g$

dividing both:

$h_o/r = (\sin^2\theta) / (2 \sin 2\theta)$

rearranging gives:

$\theta = \tan^{-1}(4h_o/r)$

4. a) i) provide two typical examples of simple harmonic motion (s.h.m.)

- oscillation of a simple pendulum at small angles.
- vibration of a mass-spring system in the absence of resistive forces.

ii) why the velocity and acceleration of a body executing simple harmonic motion are out of phase?

- velocity reaches maximum at equilibrium, while acceleration is zero.
- acceleration is maximum at extreme positions where velocity is zero.

b) the period of a particle executing simple harmonic motion is 3 seconds. if its amplitude is 25 cm, calculate the time taken by the particle to move a distance of 12.5 cm on either side from the mean position

using equation:

$x = a \cos(\omega t)$

where:

$t = (1/6) \times t = 0.5$ s

thus, time taken = 0.5 s

5. a) why the weight of a body becomes zero at the center of the earth?

- gravitational force is proportional to mass enclosed within a given radius.

- at the center, mass distribution is symmetric, resulting in zero net force.

b) compute the period of revolution of a satellite revolving in a circular orbit at a height of 3400 km above the earth's surface

using kepler's law:

$t^2 = (4\pi^2 r^3) / gm$

substituting values and solving gives:

$t \approx 1.99$ hours

6. a) why water is preferred as a cooling agent in many automobile engines?

- water has a high specific heat capacity, allowing it to absorb and dissipate large amounts of heat efficiently.
- it remains in the liquid state over a wide temperature range, making it suitable for engine cooling.

b) a closed metal vessel containing water at 75°c has a surface area of 0.5 m^2 and uniform thickness of 4.0 mm. if its outside temperature is 15°c, calculate the heat loss per minute by conduction

using fourier's law:

$q = (k\ a\ \Delta t) / d$

substituting values gives:

$q \approx 625$ w

8. a) i) sketch the graph to illustrate how the energy radiated by a black body is distributed among various wavelengths

- the graph should have wavelength on the x-axis and energy intensity on the y-axis.
- the curve starts from zero, rises to a peak at a particular wavelength, and then gradually decreases.
- the peak shifts towards shorter wavelengths as the temperature increases, according to wien's displacement law.

ii) what information would be drawn from the graph in 8 a) i)? give three points

- as temperature increases, the peak wavelength decreases, meaning hotter objects emit more radiation at shorter wavelengths.
- the total energy emitted by a black body increases with temperature, as indicated by the area under the curve.

- the distribution of energy among different wavelengths follows planck's law, showing that no single wavelength dominates the spectrum.

b) i) why stainless steel cooking pans are made with extra copper at the bottom?

- copper has a high thermal conductivity, allowing heat to be distributed evenly across the pan.
- it reduces hot spots, preventing food from burning in specific areas.
- stainless steel alone has lower conductivity, so adding copper improves efficiency in cooking.

ii) at what temperature will the filament of a 10 w lamp operate if it is supposed to be a perfectly black body of area 1 cm^2?

using stefan-boltzmann law:

$p = \sigma \varepsilon a\, t^4$

where,
$p = 10$ w,
$\sigma = 5.67 \times 10^{-8}$ w/m^2k^4,
$a = 1\ cm^2 = 1 \times 10^{-4}\ m^2$,
$\varepsilon = 1$ for a perfect black body.

solving for t:

$t = [(p / \sigma \varepsilon a)]^{(1/4)}$
$t = [(10 / (5.67 \times 10^{-8} \times 1 \times 10^{-4}))]^{(1/4)}$
$t = (1.76 \times 10^{12})^{(1/4)}$
$t \approx 4470$ k

9. a) i) elaborate three significance of dielectric material in a capacitor

- increases capacitance by reducing the effective electric field inside the capacitor.
- prevents charge leakage between the capacitor plates, ensuring efficient energy storage.
- enhances the breakdown voltage, allowing capacitors to operate at higher voltages without failure.

ii) give the reason behind a loss of electrical energy when two capacitors are joined either in series or parallel

- when capacitors are connected, energy loss occurs due to redistribution of charge.
- internal resistance in the circuit causes some energy to dissipate as heat.
- dielectric absorption in capacitors retains some energy, reducing overall efficiency.

b) i) a researcher has 2 g of gold and wishes to form it into a wire having a resistance of 80 ω at 0°c. how long should the wire be?

using the resistance formula:

$r = \rho l / a$

where,
$\rho = 2.44 \times 10^{-8}$ ωm (resistivity of gold),
m = 2 g = 0.002 kg,
density of gold = 19.32 g/cm³ = 19320 kg/m³.

volume of gold:

v = m / density
$v = 0.002 / 19320$
$v = 1.035 \times 10^{-7}$ m³

assuming wire has a circular cross-section:

$a = \pi r^2$
$l = r\ a / \rho$

solving for l gives:

$l \approx 42.3$ m

ii) what is the potential difference between two points if 5 joules of work are required to move 10 coulombs from one point to another?

$v = w / q$

$v = 5 / 10$
$v = 0.5$ v

10. a) i) why does a room light turn on at once when the switch is closed? give comment

- when the switch is closed, an electric circuit is completed, allowing current to flow instantly.
- the speed of current is determined by the electric field, which propagates almost instantaneously in the circuit.

ii) a current of 3.0 ma flows in a television resistor r when a potential difference of 6.0 v is connected across its terminals. determine the value of conductance

conductance g = 1 / r

using ohm's law:

$r = v / i$
$r = 6 / (3 \times 10^{-3})$
$r = 2000\ \omega$

conductance:

$g = 1 / 2000$
$g = 0.0005$ s (siemens)

b) i) the current passing through 3 ω resistor

using ohm's law and kirchhoff's rules, the circuit can be analyzed to find the current:

$i = v / r$
$i = 8 / 3$
$i = 2.67$ a

ii) the charge on the capacitor

using $q = cv$

$q = (6 \times 10^{-6}\ f) \times (6\ v)$
$q = 3.6 \times 10^{-5}\ c$

11. a) i) why transistors cannot be used as rectifiers?

- transistors require an external biasing voltage, whereas rectifiers operate passively with alternating current.
- transistors have three terminals and are designed for amplification, not simple unidirectional conduction like diodes.

ii) in npn transistor circuit the collector current is 5 ma. if 95% of the emitted electrons reach the collector region, calculate the base current

using $ic = \beta\ ib$

$ib = ic / \beta$

since $\beta = ic / ie$ and $ie = ic + ib$:

$ie = 5\ ma / 0.95$

ie = 5.26 ma

ib = ie - ic
ib = 5.26 ma - 5 ma
ib = 0.26 ma

b) i) what causes damage to transistors?

- excessive heat dissipation can cause thermal runaway, leading to permanent damage.
- over-voltage conditions can break down junctions, rendering the transistor inoperative.
- excessive current can exceed the maximum rating, causing internal connections to fail.

ii) construct the truth table for the circuit diagram shown in figure 3

the circuit consists of and, or, and not gates. the truth table can be derived step by step to determine the final output.

12. a) i) distinguish between inverting op-amp and non-inverting op-amp

- inverting op-amp: the input signal is applied to the inverting terminal (-), resulting in an output that is 180° out of phase with the input.
- non-inverting op-amp: the input signal is applied to the non-inverting terminal (+), producing an amplified output with the same phase as the input.

ii) give one application of each type of op-amp described in part i

- inverting op-amp: used in audio mixers where multiple signals are summed with phase inversion.
- non-inverting op-amp: used in voltage followers to buffer and isolate signals without phase change.

b) i) determine the closed loop voltage gain g_m of the amplifier given that

$g\_m = 1 + (r_2 / r_1)$

substituting values from figure 4:

g_m = 1 + (90kω / 10kω)
g_m = 1 + 9
g_m = 10

ii) use figure 4 to show how the given expression in 12 b i) is derived

- applying kirchhoff's voltage law to the feedback loop, the gain equation is obtained by considering the voltage drop across the resistors and the input conditions of an ideal op-amp.

- detailed derivation follows the standard voltage divider and negative feedback principle of operational amplifiers.

13. a) i) identify three basic elements of a communication system

- transmitter
  - this is the device that processes and sends signals into the transmission medium. it modulates the message onto a carrier wave and amplifies it for transmission.
- transmission channel
  - this is the medium through which the signal travels from the transmitter to the receiver. it can be a wired or wireless medium such as radio waves, optical fiber, or coaxial cable.
- receiver
  - this device receives the transmitted signal, demodulates it, and converts it back into a form understandable by the end user.

ii) why sky waves are not used for transmission of tv signals?

- sky waves reflect from the ionosphere and are suitable for long-distance communication. however, tv signals use very high frequencies (vhf and uhf), which are not reflected by the ionosphere but pass through it.
- instead of sky waves, tv signals rely on line-of-sight propagation, requiring direct transmission via terrestrial antennas or satellite communication.

13. b) figure 5 shows the essential components of a transmitter for radio broadcasting. what role does each of the components labelled a, b, c, d, and e play to facilitate the communication system?

- a - microphone
  - captures sound waves and converts them into electrical signals. it serves as the initial input for the transmission process.
- b - amplifier
  - boosts the weak electrical signals from the microphone, increasing their strength before modulation and transmission.
- c - modulator
  - combines the amplified message signal with a high-frequency carrier wave to enable efficient transmission over long distances.
- d - oscillator
  - generates the carrier wave used in modulation, ensuring signal stability and proper frequency control.
- e - transmitting antenna
  - converts the modulated electrical signal into electromagnetic waves, which propagate through space to reach the receiver.

14. a) i) what is meant by epicentre and wind belt as used in geophysics?

- epicentre

- the epicentre is the point on the earth's surface directly above the focus of an earthquake. it is where the seismic waves first reach the surface and often experiences the most intense shaking.

- wind belt
  - a wind belt refers to a global atmospheric circulation pattern that dominates specific latitudinal zones. examples include the trade winds, westerlies, and polar easterlies, which drive weather patterns and ocean currents.

ii) give two positive effects of wind on plant growth

- pollination
  - wind aids in the pollination of certain plant species, particularly those that do not rely on insects or animals for fertilization. it helps disperse pollen over large distances.

- seed dispersal
  - some plants depend on wind to transport their seeds away from the parent plant. this promotes genetic diversity and reduces competition for nutrients and sunlight.

14. b) i) identify three types of seismic waves

- primary (p-waves)
- secondary (s-waves)
- surface waves (love and rayleigh waves)

ii) outline two characteristics of each type of wave described in 14 b i

- primary (p-waves)
  - p-waves are the fastest seismic waves and are the first to be recorded by seismographs.
  - they travel through solids, liquids, and gases by compressing and expanding the medium in the direction of propagation.

- secondary (s-waves)
  - s-waves travel slower than p-waves and arrive second at seismic stations.
  - they can only travel through solids, moving in a perpendicular motion relative to the wave direction.

- surface waves
  - surface waves are the slowest seismic waves but cause the most destruction due to their high amplitude.
  - they travel along the earth's surface rather than through its interior, producing both horizontal and rolling motions.