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: 2017**

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) give the meaning of the following terms as used in error analysis

- absolute error is the difference between the measured value and the true value of a quantity. it is expressed as an actual numerical value without reference to the true value's magnitude.

- relative error is the absolute error divided by the true value of the quantity, expressed as a fraction or percentage. it gives a measure of how significant the error is compared to the correct value.

b) the force f acting on an object of mass m, traveling at velocity v in a circle of radius r is given by $f = m v^2 / r$. if the measurements are recorded as m = (3.5 ± 0.1) kg, v = (20 ± 1) m/s, r = (12.5 ± 0.5) m, find the maximum possible

i) fractional error

fractional error is given by

$\Delta f / f = (\Delta m / m) + 2(\Delta v / v) + (\Delta r / r)$

substituting values:

$\Delta f / f = (0.1 / 3.5) + 2(1 / 20) + (0.5 / 12.5)$
$\Delta f / f = 0.0286 + 0.1 + 0.04$
$\Delta f / f = 0.1686$

ii) percentage error in the measurement of force

percentage error = fractional error × 100

percentage error = 0.1686 × 100
percentage error = 16.86%

c) show how you will record the reading of force, f, in part b

- the calculated force value should be recorded as $f \pm \Delta f$, where Δf is obtained by multiplying the percentage error with the calculated force value.

2. a) i) define the term dimensions of a physical quantity

- the dimensions of a physical quantity represent how it is expressed in terms of fundamental physical quantities such as mass, length, and time.

ii) identify two uses of dimensional equations

- they help in checking the correctness of physical equations by ensuring dimensional consistency.
- they are used to derive formulas relating different physical quantities.

b) i) what is the basic requirement for a physical relation to be correct?

- the equation must be dimensionally consistent, meaning both sides of the equation must have the same dimensions.

ii) list two quantities whose dimension is ml^2t^{-2}

- work
- torque

c) i) the frequency f of vibration of a stretched string depends on the tension f, the length l and the mass per unit length μ of the string. derive the formula relating the three quantities by the method of dimensions

assuming f = k f^a l^b μ^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}) (μ^{-}1/2)

ii) use dimensional analysis to prove the correctness of the relation ρ = 3g / 4rg, where ρ = density of the earth, g = acceleration due to gravity, r = radius of the earth and g = gravitational constant

writing dimensions of each quantity:

$[\rho] = ml^{-3}$, $[g] = lt^{-2}$, $[r] = l$, $[g] = m^{-1}l^3t^{-2}$

lhs: ml^{-3}

rhs: $(lt^{-2}) / (m^{-1}l^3t^{-2})$

simplifying gives: ml^{-3}

since lhs = rhs, the relation is dimensionally correct.

3. a) i) why does the kinetic energy of an earth satellite change in the elliptical orbit?

- in an elliptical orbit, the distance between the satellite and earth changes, causing variations in gravitational potential energy.
- due to energy conservation, changes in potential energy result in changes in kinetic energy, making the satellite move faster when closer to earth and slower when farther away.

ii) give two factors which determine whether a planet has an atmosphere or not

- the planet's gravitational force, which determines its ability to retain gases.
- the temperature of the planet, as high temperatures cause gas molecules to move faster and escape into space.

b) i) draw a sketch showing how the gravitational force on the spacecraft varies during its journey

- the force is maximum at earth, decreases as the spacecraft moves away, and slightly increases when approaching the moon due to lunar gravity.

ii) calculate the distance from the centre of the earth where the resultant gravitational force becomes zero

using the equation for the point of zero gravitational force:

$r = d / (\sqrt{m\_e} / m\_m + 1)$

substituting given values and solving gives $r \approx 3.4 \times 10^5$ km

4. a) i) justify the statement that if no external torque acts on a body, its angular velocity will not be conserved

- according to the law of conservation of angular momentum, in the absence of external torque, the total angular momentum remains constant.
- since angular momentum $l = i\omega$, if the moment of inertia i changes, the angular velocity ω must change accordingly.

ii) a car is moving with a speed of 30 m/s on a circular track of radius 500m. if its speed is increasing at the rate of $2m/s^2$, find its resultant linear acceleration

resultant acceleration:

$a_r = \sqrt{(a_t^2 + a_c^2)}$

where,
$a_t = 2\ m/s^2$ (tangential acceleration)
$a_c = v^2 / r = (30)^2 / 500 = 1.8\ m/s^2$

$a_r = \sqrt{(2^2 + 1.8^2)}$
$a_r = \sqrt{(4 + 3.24)}$
$a_r = \sqrt{7.24}$
$a_r = 2.69\ m/s^2$

b) i) tension in the string

$t = m(v^2 / r) + mg$

substituting given values:

$t = (1 \times (v^2 / 0.6)) + (1 \times 9.81)$
$t = (1 \times (v^2 / 0.6)) + 9.81$

ii) period of motion

$t = 2\pi r / v$

substituting values:

$t = (2\pi \times 0.6) / v$

5. a) i) recoil velocity of the gun
using momentum conservation:
$m_g v_g = m_b v_b$
solving for v_g:
$v_g = (m_b v_b) / m_g$

substituting values:
$v_g = (0.01 \times 400) / 5$
$v_g = 0.8\ m/s$

ii) velocity acquired by the hunter during firing

momentum conservation:
$m_h v_h = m_g v_g$

solving for v_h:
$v_h = (m_g v_g) / m_h$

substituting values:
$v_h = (5 \times 0.8) / 75$
$v_h = 0.053$ m/s

b) i) at what horizontal distance from the target should the luggage be dropped?
using horizontal motion equation:
$x = v \times t$

finding t using free fall equation:
$t = \sqrt{(2h/g)}$

substituting values and solving gives:
$x = 500$ m

ii) find the velocity of the luggage as it hits the ground

using $v_f^2 = v_i^2 + 2gh$
solving for v_f gives:

$v_f \approx 31.3$ m/s

6. a) i) the equation of simple harmonic motion is given as $x = 6\sin 10\pi t + 8\cos 10\pi t$, where x is in centimeter and t in second. determine the amplitude.

the equation of shm is in the form

$x = a \sin \omega t + b \cos \omega t$

where,
$a = 6$ cm,
$b = 8$ cm

amplitude is given by

$a = \sqrt{(a^2 + b^2)}$

substituting values:

$a = \sqrt{(6^2 + 8^2)}$
$a = \sqrt{(36 + 64)}$

$a = \sqrt{100}$
$a = 10$ cm

ii) initial phase of motion

the initial phase φ is given by

$\tan \varphi = b / a$

substituting values:

$\tan \varphi = 8 / 6$
$\varphi = \tan^{-1}(4/3)$
$\varphi \approx 53.13°$

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

the total energy e in shm is given by

$e = 1/2\ m\ \omega^2\ a^2$

since mass m, angular frequency ω, and amplitude a are constants, the total energy remains constant and does not depend on time.

ii) find the periodic time of a cubical body of side 0.2m and mass 0.004kg floating in water then pressed and released such that it oscillates vertically.

the time period for vertical oscillation of a floating body is given by

$t = 2\pi \sqrt{(v/g\ a)}$

where,
v = submerged volume = $(0.2)^3 = 0.008\ m^3$
g = $9.81\ m/s^2$
a = cross-sectional area = $(0.2)^2 = 0.04\ m^2$

substituting values:

$t = 2\pi \sqrt{(0.008 / (9.81 \times 0.04))}$
$t = 2\pi \sqrt{(0.008 / 0.3924)}$
$t = 2\pi \sqrt{0.0204}$
$t \approx 0.9$ s

7. a) i) give a common example of adiabatic process.

- expansion of gas in a well-insulated container without heat exchange.

ii) what happens to the internal energy of a gas during adiabatic expansion?

- in adiabatic expansion, no heat is added or removed, so the internal energy decreases, resulting in a drop in temperature.

b) a mass of an ideal gas of volume 400cm³ at 288k expands adiabatically. if its temperature falls to 273k

i) find the new volume of the gas.

using the adiabatic relation:

$tv^{(\gamma-1)} = \text{constant}$

since the process is adiabatic,

$(v_2 / v_1) = (t_2 / t_1)^{(1/(\gamma-1))}$

assuming $\gamma = 1.4$ for air:

$(v_2 / 400) = (273 / 288)^{(1/(1.4-1))}$

$v_2 = 400 \times (273 / 288)^{2.5}$
$v_2 \approx 438.9\ cm^3$

ii) calculate the final volume of the gas if it is then compressed isothermally until the pressure returns to its original value.

using boyle's law ($p_1v_1 = p_2v_2$), since pressure returns to its original value:

$v_3 = v_1 = 400\ cm^3$

8. a) i) state the following according to heat exchange:

- prevost's theory: all bodies emit and absorb radiation at all temperatures, but a body in thermal equilibrium emits and absorbs energy at equal rates.
- wien's displacement law: the wavelength at which maximum radiation occurs is inversely proportional to the absolute temperature of the body.

b) i) briefly explain why steam pipes are wrapped with insulating materials.

- to minimize heat loss to the surroundings and maintain high temperature for efficient energy transfer.

ii) stainless steel cooking pans fitted with extra copper at the bottom are more preferred.

- copper has high thermal conductivity, which ensures uniform and quick heat distribution, improving cooking efficiency.

c) the value of the property x of a certain substance is given by:

$x\theta = x_0\ 0.50 + 2 \times 10^{-6}\theta^2$

where θ is the temperature in degrees celsius. what would be the celsius temperature defined by the property x which corresponds to a temperature of 50°c on this gas thermometer scale?

substituting $\theta = 50°c$:

$x_{50} = x_0\ (0.50 + 2 \times 10^{-6} \times 50^2)$
$x_{50} = x_0\ (0.50 + 2 \times 10^{-6} \times 2500)$
$x_{50} = x_0\ (0.50 + 0.005)$
$x_{50} = x_0\ (0.505)$

thus, the temperature on this scale is defined by $x_0\ (0.505)$.

9. a) i) what is the advantage of using a greater length of potentiometer wire?

- a longer wire provides higher sensitivity and greater accuracy in potential difference measurement.

ii) why is a wheatstone bridge not suitable for measuring very high resistance?

- at very high resistance, leakage currents and stray capacitances affect the accuracy, making measurements unreliable.

b) i) current flowing through the circuit.

using kirchhoff's voltage law and ohm's law,

v = ir, solving for i

substituting given resistor values and battery voltages, the current can be determined.

ii) potential difference v_ab

using ohm's law,

$v_{ab} = ir_{ab}$

where r_{ab} is the resistance between points a and b.

10. a) i) list two factors on which the resistivity of a material depends.

- temperature
- nature of the material

ii) a wire of resistivity ρ is stretched to double its length, what will be its new resistivity? give reason for your answer.

- resistivity remains constant because it is a material property and does not change with physical deformation.

b) i) why a high voltage supply should have high internal resistance?

- to limit excessive current flow and prevent damage to the supply or connected circuits.

ii) justify the statement that it is not possible to verify ohm's law by using a filament lamp.

- a filament lamp does not obey ohm's law because its resistance increases with temperature, causing a nonlinear current-voltage relationship.

c) a potential difference of 4v is connected to a uniform resistance wire of length 3.0m and cross-sectional area 9×10^{-9} m², when a current of 0.2a is flowing in the wire.

i) resistivity of a wire.

resistivity $\rho = (r\ a) / l$

where,
$r = v / i = (4 / 0.2) = 20\ \Omega$
$l = 3.0m$
$a = 9 \times 10^{-9}$ m²

substituting values:

$\rho = (20 \times 9 \times 10^{-9}) / 3$
$\rho = (180 \times 10^{-9}) / 3$
$\rho = 6 \times 10^{-8}\ \Omega m$

ii) conductivity of a wire.

conductivity $\sigma = 1 / \rho$

$\sigma = 1 / (6 \times 10^{-8})$
$\sigma = 1.67 \times 10^{7}$ s/m

11. a) i) briefly explain the function of the following

oscilloscope
- an oscilloscope is an electronic device used to visualize and measure electrical signals as a function of time. it displays waveforms and helps in analyzing signal properties like frequency, amplitude, and phase.

ii) op-amps
- an operational amplifier (op-amp) is a high-gain electronic voltage amplifier with differential inputs and a single-ended output. it is used in signal amplification, filtering, mathematical operations, and various analog computing applications.

b) study figure 2 then construct a truth table showing the output p, q, and r

analyzing figure 2, we see two and gates followed by an or gate.

truth table

x	y	z	p (AND)	q (AND)	r (OR)
0	0	0	0	0	0
0	0	1	0	0	0
0	1	0	0	0	0
0	1	1	0	1	1
1	0	0	0	0	0
1	0	1	1	0	1
1	1	0	1	0	1
1	1	1	1	1	1

c) i) list three basic elements of a communication system
- transmitter
- medium (channel)
- receiver

ii) explain the advantage of using optical fibre systems than coaxial cable system in telecommunication processes

- optical fibre transmits data at much higher speeds due to its higher bandwidth.
- it has lower signal attenuation, ensuring long-distance communication without signal loss.
- it is immune to electromagnetic interference, making it more reliable than coaxial cables.

12. a) i) define the term semiconductor
- a semiconductor is a material whose electrical conductivity lies between that of a conductor and an insulator, and it can be altered by doping or temperature changes.

ii) give three examples of semiconductor materials
- silicon
- germanium
- gallium arsenide

b) i) outline two factors on which electrical conductivity of a pure semiconductor depends
- temperature: as temperature increases, the conductivity of a semiconductor also increases.
- doping: adding impurities like phosphorus or boron increases the number of charge carriers, thereby increasing conductivity.

ii) how does the forbidden energy gap of an intrinsic semiconductor vary with increase in temperature?
- as temperature increases, the forbidden energy gap decreases because more electrons gain enough thermal energy to jump from the valence band to the conduction band, increasing conductivity.

c) i) calculate the peak voltage

given rms voltage = 3 v

peak voltage $v_{peak} = v_{rms} \times \sqrt{2}$
$= 3 \times 1.414$
$= 4.24$ v

ii) calculate the period

the period t is given by

$t = 1 / f$

where f = 50 hz

$t = 1 / 50$
$t = 0.02$ s

13. a) i) explain the meaning of the following terms

p-type semiconductor
- a p-type semiconductor is formed by doping a pure semiconductor with an element from group iii (such as boron), creating holes as the majority charge carriers.

n-type semiconductor
- an n-type semiconductor is formed by doping a pure semiconductor with an element from group v (such as phosphorus), introducing excess electrons as the majority charge carriers.

b) i) list three types of transistor configurations
- common emitter
- common base
- common collector

ii) why is the collector of a transistor made wider than emitter and base?
- the collector is wider to allow better heat dissipation and accommodate more current without overheating.
- a larger collector reduces the chance of saturation and ensures efficient electron flow from emitter to collector.

c) a change of 100 μa in the base current produces a change of 3 ma in the collector current. calculate

i) the current amplification factor, β

$\beta = i_c / i_b$

$= (3 \text{ ma}) / (100 \text{ μa})$
$= (3 \times 10^{-3}) / (100 \times 10^{-6})$
$= 30$

ii) the current gain, α

$\alpha = \beta / (\beta + 1)$

$= 30 / (30 + 1)$
$= 30 / 31$
$= 0.967$

14. a) i) state three sources of heat energy within the interior of the earth
- radioactive decay of elements such as uranium and thorium
- residual heat from the planet's formation
- gravitational compression and friction

ii) discuss two advantages of windbreaks to plant environment
- windbreaks reduce soil erosion by slowing down wind speed near the ground.
- they provide shelter for plants, reducing water loss due to excessive evaporation.

b) briefly explain the major causes of the following types of environmental pollution

i) water pollution
- industrial waste disposal into rivers and lakes introduces toxic chemicals.
- agricultural runoff containing fertilizers and pesticides contaminates water bodies.
- sewage and untreated waste contribute to microbial contamination.

ii) air pollution
- burning fossil fuels releases harmful gases like carbon monoxide and sulfur dioxide.
- industrial emissions introduce particulate matter and greenhouse gases.
- deforestation reduces the earth's ability to absorb carbon dioxide, worsening air pollution.