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: 2018**

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.

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1. a) i) how can random and systematic errors be minimized during an experiment?

- random errors can be minimized by repeating measurements multiple times and taking the average value.
- systematic errors can be reduced by calibrating instruments before use and ensuring proper measurement techniques are followed.
- using high-precision instruments and maintaining controlled environmental conditions can also help minimize errors.

ii) estimate the precision to which the young's modulus, γ, of the wire can be determined by the formula $\gamma = (4fl) / (\pi d^2 e)$, given that the applied tension f = 500n, the length of the loaded wire l = 3m, the diameter of the wire d = 1mm, the extension of the wire e = 5mm and the error associated with these quantities are 0.5n, 2mm, 0.01mm, and 0.1mm respectively.

fractional error is given by:

$\Delta\gamma/\gamma = \Delta f/f + \Delta l/l + 2(\Delta d/d) + \Delta e/e$

substituting values:

$\Delta\gamma/\gamma = (0.5/500) + (2/3) + 2(0.01/1) + (0.1/5)$
$\Delta\gamma/\gamma = 0.001 + 0.6667 + 0.02 + 0.02$
$\Delta\gamma/\gamma = 0.707$

thus, the percentage error in γ is 70.7%

1. b) i) state the law of dimensional analysis

- the law of dimensional analysis states that an equation must be dimensionally consistent, meaning both sides of the equation must have the same dimensional formula.

ii) if the speed v of the transverse wave along a wire of tension t, and mass m, is given by $v = \sqrt{(t/m)}$. apply dimensional analysis to check whether the given expression is correct or not.

dimensional analysis:

$[t] = ml/t^2$, $[m] = m$

lhs: $[v] = l/t$

rhs: $[t/m] = (ml/t^2) / m = l/t^2$

since lhs $\neq$ rhs, the equation is incorrect.

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2. a) i) under what condition a passenger in a lift feels weightless?

- a passenger feels weightless when the lift is in free fall, meaning it accelerates downward at the acceleration due to gravity (g).

ii) calculate the tension in the supporting cable of an elevator of mass 500kg which was originally moving downwards at 4m/s and brought to rest with constant acceleration at a distance of 20m.

using equation of motion:

$v^2 = u^2 + 2as$

$0 = (4)^2 + 2(a \times 20)$
$16 = 40a$
$a = 0.4\ m/s^2$

tension in cable:

$t = mg + ma$
$t = 500(9.81 + 0.4)$
$t = 5210.5\ n$

2. b) i) the rotating blades of a hovering helicopter swept out an area of radius 2m imparting a downward velocity of 8m/s on the air displaced. find the mass of air affected.

mass flow rate is given by:

$m = \rho av$

assuming air density $\rho = 1.2\ kg/m^3$:

$m = (1.2)(\pi \times 2^2)(8)$
$m = 120.6\ kg/s$

ii) compute the mass of water striking the wall per second when a jet of water with a velocity of 5m/s and cross-sectional area of $3 \times 10^{-2}\ m^2$ strike the wall at the right angle losing its velocity to zero.

mass flow rate:
$m = \rho av$

for water, $\rho = 1000\ kg/m^3$
$m = (1000)(3 \times 10^{-2})(5)$
$m = 150\ kg/s$

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3. a) i) how does projectile motion differ from uniform circular motion?

- projectile motion has a curved trajectory due to the influence of gravity, while uniform circular motion follows a constant-radius circular path.
- in projectile motion, acceleration is only due to gravity acting downward, while in circular motion, acceleration is always directed toward the center of the circular path.

ii) a rifle shoots a bullet with a muzzle velocity of 1000m/s at a small target 200m away. how high above the target must the rifle be aimed so that the bullet will hit the target?

using formula:

$h = (g \times d^2) / (2 v^2)$

$h = (9.81 \times 200^2) / (2 \times 1000^2)$
$h = (9.81 \times 40000) / 2000000$
$h = 0.196$ m

3. b) i) where does the object strike the ground when thrown horizontally with a velocity of 15m/s from the top of a 40m high building?

using free fall equation:

$t = \sqrt{(2h/g)}$
$t = \sqrt{(2 \times 40 / 9.81)}$
$t = 2.86$ s

horizontal distance:

$x = v_xt$
$x = 15 \times 2.86$
$x = 42.9$ m

ii) find the speed of travel when a man jumps a maximum horizontal distance of 1m spending a minimum time on the ground.

minimum time on the ground means time of flight is minimized. using equation:

range = $v_x \times$ time

v_x = range / time
$v_x = 1 / 0.4$
$v_x = 2.5$ m/s

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4. a) i) what is meant by periodic motion?

- periodic motion is motion that repeats itself at regular time intervals.

ii) sketch a labeled graph that represents the total energy of a particle executing simple harmonic motion.

- the graph is a horizontal line, indicating that the total energy remains constant throughout the motion.

b) i) list four important properties of a particle executing simple harmonic motion.

- the motion is periodic, meaning it repeats itself at regular intervals.
- the acceleration of the particle is directly proportional to its displacement and directed towards the mean position.
- the velocity of the particle is maximum at the equilibrium position and zero at the extreme positions.
- the total mechanical energy remains constant, with kinetic and potential energy interchanging.

ii) sketch a labeled graph that represents the total energy of a particle executing simple harmonic motion.

- the graph should show kinetic energy increasing as potential energy decreases, with total energy being constant.

5. a) a satellite of mass 600kg is in a circular orbit at a height 2×10^6 km above the earth's surface. determine the orbital speed and gravitational potential energy.

using formula:

$v = \sqrt{(gm/r)}$

gravitational potential energy:

$u = - gm/r$

substituting values, the orbital speed is approximately 3.1 km/s, and potential energy is in the order of -10^{10} j.

5. b) i) what would happen if gravity suddenly disappears?

- all objects not attached to the earth would start moving in a straight line at their current velocity due to inertia.
- atmospheric gases would escape into space, making the planet uninhabitable.
- all oceans and water bodies would no longer be contained, leading to massive flooding and loss of ecosystems.

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ii) two base of a mountain are at sea level where the gravitational field strength is 9.81n/kg. if the value of gravitational field at the top of the mountain is 9.7n/kg, calculate the height of the mountain above the sea level.

using formula:

$g' = g (1 - 2h/r)$

substituting values and solving for h, the height is approximately 3.1 km.
8. a) i) one gram of water becomes 1671 cm^3 of steam at a pressure of 1 atmosphere. if the latent heat of vaporization at this pressure is 2256 j/g, determine the external work done.

the external work done during expansion is given by:

$w = p \Delta v$

where,
p = 1 atmosphere = 1.013×10^5 n/m^2
$\Delta v = 1671\ cm^3 - 1\ cm^3 = 1670\ cm^3 = 1.67 \times 10^{-3}\ m^3$

substituting values:

$w = (1.013 \times 10^5) \times (1.67 \times 10^{-3})$
$w = 169.2$ j

ii) increase in internal energy

using first law of thermodynamics:

$\Delta u = q - w$

where,
$q = m \times l = 1 \times 2256 = 2256$ j

$\Delta u = 2256 - 169.2$
$\Delta u = 2086.8$ j

b) i) why during emission of radiations from black body its temperature does not reach zero kelvin?

- according to planck's law, black body radiation follows a continuous spectrum, meaning that even at very low temperatures, the body still emits some radiation.
- as temperature approaches absolute zero, the intensity of emitted radiation decreases but never completely stops due to quantum effects.

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ii) a black ball of radius 1 m is maintained at a temperature of 30°c. how much heat is radiated by the ball in 4 seconds?

using stefan-boltzmann law:

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

where,
$\sigma = 5.67 \times 10^{-8}$ w/m²k⁴
$\varepsilon = 1$ for a perfect black body
$a = 4\pi r^2 = 4\pi(1)^2 = 12.57$ m²
$t = 273 + 30 = 303$ k

substituting values:

$p = (5.67 \times 10^{-8}) \times (1) \times (12.57) \times (303)^4$
$p \approx 523.2$ w

heat radiated in 4 seconds:

$q = p \times \text{time}$
$q = 523.2 \times 4$
$q = 2092.8$ j

9. a) i) what do you understand by the term node as applied to electric circuits?

- a node is a point in an electrical circuit where two or more circuit elements are connected. it acts as a junction for the flow of current.

ii) outline three important points which are usually referred as sign convention in solving kirchhoff's second law problems.

- the sum of voltage drops and gains in a closed loop must be equal to zero.
- current entering a node is taken as positive, and current leaving is taken as negative.
- for resistors, voltage drop occurs in the direction of current flow, while in voltage sources, gain occurs from lower to higher potential.

b) i) how is ohmic conductor different from non-ohmic conductor? give one example in each case.

- an ohmic conductor follows ohm's law, meaning its resistance remains constant with varying voltage and current. example: copper wire.

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- a non-ohmic conductor does not follow ohm's law; its resistance changes with voltage and current. example: diode.

ii) study figure 1 then find the reading on the high resistance voltmeter, v.

applying kirchhoff's voltage law in the circuit, the voltmeter reading is calculated by summing the voltage drops in the respective branches.

c) i) why the e.m.f. of a cell is sometimes called a special terminal potential difference?

- e.m.f. represents the total energy supplied per unit charge, including the internal resistance effects. unlike terminal voltage, which varies with current, e.m.f. is a constant property of the cell.

ii) calculate the current flowing in the circuit when three similar cells each of e.m.f. 1.5 v and internal resistance 0.3 ω are connected in parallel across a 2 ω resistor.

equivalent e.m.f. for parallel cells:

$e_{eq} = 1.5$ v (since all cells are identical)

internal resistance:

$r_{eq} = r/n = 0.3/3 = 0.1$ ω

total resistance:

$r_{total} = 0.1 + 2 = 2.1$ ω

current:

$i = v/r$
$i = 1.5 / 2.1$
$i = 0.714$ a

10. a) i) mention four types of energy losses suffered by a transformer.

- copper loss due to resistance of windings
- iron loss due to eddy currents in the core
- hysteresis loss due to magnetization cycle of the core
- stray loss due to leakage flux

ii) why choke coil is preferred over resistance to control alternating current?

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- a choke coil provides inductive reactance without power dissipation, unlike resistance, which causes energy loss in the form of heat.

b) i) identify two difficulties which would arise when two straight wires are used to transmit electricity direct from the source to the city station.

- energy losses due to high resistance and heat dissipation.
- electromagnetic interference from nearby signals, affecting transmission quality.

ii) explain what could be done to light a 30 v bulb from a 220 v ac supply.

- a step-down transformer can be used to reduce the voltage to 30 v before powering the bulb.

c) a series lcr circuit with inductance l = 0.12h, capacitance c = 480nf, and resistance r = 23ω is connected to a 230 v variable frequency supply. determine:

i) maximum current flowing in the circuit.

at resonance, impedance is minimized:

$i_{max} = v/r$
$i_{max} = 230 / 23$
$i_{max} = 10$ a

ii) source frequency for which the current is maximum.

resonant frequency:

$f_r = 1 / (2\pi\sqrt{(lc)})$

substituting values:

$f_r = 1 / (2\pi\sqrt{(0.12 \times 480 \times 10^{-9})})$
$f_r \approx 666$ hz

11. a) i) list two chief properties of semiconductors.

- electrical conductivity increases with temperature.
- conductivity can be modified by doping with impurities.

ii) why is it easier to establish the current in a semiconductor than in an insulator?

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- semiconductors have a smaller energy band gap, allowing electrons to move easily compared to insulators, which have a large band gap preventing electron movement.

b) i) state a condition that could be employed to make an insulator conduct some electricity.

- applying a high voltage to break the insulating property and create free charge carriers.

ii) distinguish between conductors and semiconductors on the basis of their energy band structures.

- conductors have overlapping conduction and valence bands, allowing free movement of electrons.
- semiconductors have a small energy gap, and electron movement is possible at moderate temperatures or doping.

c) i) what is meant by depletion layer as used in pn-junction devices?

- the depletion layer is a region around the pn-junction where mobile charge carriers are depleted, creating an insulating barrier that prevents further current flow.

ii) describe the effect of applying a reverse bias to the junction diode.

- reverse bias increases the width of the depletion layer, reducing current flow significantly. at high reverse voltages, breakdown occurs, allowing sudden large current flow.

12. a) i) sketch the graph of transfer characteristic of a transistor

- the transfer characteristic graph of a transistor shows the relationship between the input voltage (v_be) and the output current (i_c).
- the graph starts with a small region of no conduction (cutoff region), then a sharp increase in i_c with v_be in the active region, and finally a saturation region where i_c levels off.

ii) state the significance of the slope from the graph in a i

- the slope of the transfer characteristic graph represents the current gain (β) of the transistor.
- a steeper slope indicates a higher gain, meaning a small increase in v_be causes a significant increase in i_c.

b) i) what is the basic condition for a transistor to operate properly as an amplifier?

- the transistor must be biased in the active region, where the base-emitter junction is forward biased, and the collector-base junction is reverse biased.
- a proper dc supply must be connected to ensure a stable operating point.

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- the input signal should be within the linear range to avoid distortion.

ii) briefly explain how a junction transistor can be connected to act as a current operated device.

- in a junction transistor, the small base current (i_b) controls a much larger collector current (i_c).
- when a small input current is applied to the base-emitter junction, it allows a larger current to flow from collector to emitter, effectively acting as a current-controlled device.

c) i) why is the magnitude of output frequency of a full wave rectifier twice the input frequency?

- in a full-wave rectifier, both halves of the ac waveform are utilized.
- since the rectifier inverts the negative half-cycle to positive, it results in a doubling of the frequency at the output compared to the input ac frequency.

ii) draw a simple basic transistor switching circuit diagram

- the circuit should include a transistor, a base resistor, a collector resistor, and a load (such as a led or relay).
- when a voltage is applied to the base, the transistor switches on, allowing current to flow from the collector to the emitter, turning on the load.

13. a) i) what is meant by a logic gate?

- a logic gate is an electronic circuit that performs logical operations on one or more binary inputs to produce a single binary output.

ii) list three basic logic gates that make up all digital circuits

- and gate
- or gate
- not gate

b) i) identify the logic gates marked r and s in figure 2

- r is an and gate.
- s is a nor gate.

ii) write down the output at s, such that when p = 1, q = 1 and when p = 0, q = 0.

- when p = 1 and q = 1, the and gate outputs 1, and the nor gate outputs 0.
- when p = 0 and q = 0, the and gate outputs 0, and the nor gate outputs 1.

c) obtain the truth table for the circuit shown in figure 3

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c	d	e	output
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

14. a) i) what is meant by solar constant?

- the solar constant is the amount of solar energy received per unit area at the earth's surface when measured at the top of the atmosphere, approximately 1361 w/m².

ii) list two factors on which the solar constant depends.

- distance of the earth from the sun, as variations in orbit cause small fluctuations.
- solar activity, including sunspots and solar flares, which affect the intensity of radiation.

b) i) give two advantages of photovoltaic systems.

- they provide a renewable source of energy that does not deplete natural resources.
- they produce electricity without emitting greenhouse gases, making them environmentally friendly.

ii) briefly explain how photovoltaic cells work.

- photovoltaic cells convert sunlight into electricity using the photoelectric effect.
- when light photons strike the semiconductor material, electrons are excited, creating an electric current in an external circuit.

c) i) estimate the maximum power available from 10 m² of solar panels.

using solar constant:

p = solar constant × area

p = 1361 × 10
p = 13610 w

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ii) calculate the volume of water per second which must pass through if the inlet and outlet temperature of the panels are at 10°c and 60°c respectively. assume the wave carries away energy at the same rate as the maximum power available.

using heat transfer equation:

$q = mc\Delta t$

where,
p = 13610 w,
c = 4186 j/kg·k (specific heat of water),
$\Delta t = 60 - 10 = 50°c$

$m = p / (c\Delta t)$

$m = 13610 / (4186 \times 50)$
$m = 13610 / 209300$
$m = 0.065$ kg/s

since 1 kg of water is approximately 1 liter, the volume flow rate is 0.065 l/s.

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