

ST JAMES LEGACY SECONDARY SCHOOL-KITAGOBWA
UGANDA ADVANCED CERTIFICATE OF EDUCATION (UACE)
END OF FIRST TERM EXAMINATIONS 2026
S.6 P510/1 PHYSICS (Paper 1)
Time Allowed: **3 HOURS**

STUDENT NAME:

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.....

PERSONAL NUMBER: **SIGNATURE:**

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO BY THE INVIGILATOR

INSTRUCTIONS TO CANDIDATES:

1. Do not write anything in this paper; any rough work should be written in the response booklet(s) provided and crossed out.
2. The time allowed for this paper is strictly **3 Hours** and no additional time shall be granted.
3. This paper consists of **four** sections; **A, B, C** and **D** with a total of **8 items**.
4. Section A (*Particles – AO4*) has 2 items; attempt **any ONE** item.
5. Section B (*Force and Motion – AO1*) has 2 items; attempt **any ONE** item.
6. Section C (*Energy and waves – AO2*) has 2 items; attempt **any ONE** item.
7. Section D (*Charges, capacitors, electrostatics and Fields – AO3*) has 2 items; attempt **any ONE** item.
8. **FOUR ITEMS** should be attempted in total (one per section). Any additional item(s) attempted will not be marked.
9. Begin each item on a fresh page and clearly indicate the item number in the response booklet.
10. Show all working clearly, include appropriate units, and present well-labelled diagrams where required.
11. Silent non-programmable calculators and mathematical/logarithmic tables may be used.

FOR SCORER'S USE ONLY

SECTION	A		B		C		D		TOTAL
ITEM	1	2	3	4	5	6	7	8	
SCORE									
INITIAL									

SECTION A: PARTICLES

AO4 — Investigate atomic, quantum, and nuclear phenomena | Attempt ANY ONE item from this section.

Item 1

(20 marks)

The Uganda Cancer Institute (UCI) at Mulago Hospital, Kampala, is a leading centre for the diagnosis and treatment of cancer using nuclear medicine. A medical physicist, Dr. Nakimera, supervises the preparation and administration of radioactive isotopes used in patient care. Iodine-131, which emits beta particles and destroys cancerous thyroid tissue, is among the most commonly used. A newly recruited radiographer, Tendo, observed that the count rate reading on the Geiger-Müller detector placed near a freshly prepared tracer sample had been dropping steadily over time. Puzzled as to whether the detector was faulty or the phenomenon was natural, Tendo recorded the corrected count rate every two hours under Dr. Nakimera's guidance. In an adjacent preparation room, a technician was reminding student interns that Uranium-238 — used as a sealed source for physics demonstrations — undergoes a chain of nuclear transformations beginning with alpha emission, releasing energy that can only be explained through the concept of nuclear binding energy.

Time (hours)	0	2	4	6	8
Count rate (min^{-1})	640	452	320	226	160

Support Material Provided:

- Mass of proton = 1.00728 u, mass of neutron = 1.00867 u, mass of ${}^4_2\text{He}$ nucleus = 4.00150 u – 1 u = 931.5 MeV/c²
- Atomic number of Uranium = 92

Tasks:

- (a) Using the data Tendo collected, determine the half-life and decay constant of the radioactive tracer, and present the result graphically in a way that Dr. Nakimera could use to verify the finding. **(05)**
- (b) Construct the nuclear equations for the decay chain described by the technician — one alpha decay followed by two successive beta-minus decays of Uranium-238 — and identify the symbol, proton number, and mass number of the final nuclide produced. **(05)**
- (c) Calculate the nuclear binding energy per nucleon of helium-4 using the data provided, and use the shape of the binding energy per nucleon curve to explain why both nuclear fission and nuclear fusion are viable sources of energy. **(06)**
- (d) Drawing from the work of Dr. Nakimera's department, discuss TWO applications of nuclear radiation in medicine or industry, identifying for each one associated risk and how it is managed in practice. **(04)**

OR

Item 2

(20 marks)

Physicists have set up a mobile laboratory in the Rwenzori Mountains to analyze debris from a fallen satellite. Inside the debris, they discovered a high-voltage particle injector and an unknown radioactive source. Preliminary tests show that the injector fires a beam of charge Q with mass m , which is accelerated by a potential difference V through an electric field E between plates of length d . To identify the leaking radiation, the team placed the source into a diffusion cloud chamber where uniform magnetic field of **1.2T** was applied. They observed particles, specifically α and β emitters following a circular path of radius **36.0 cm**.

To conclude the investigation, the team is performing a comparative analysis using carbon- 14 dating on organic material found at the crash site. This process involves measuring the mass defect and activity of radioactive isotopes. They are using a G-M tube to compare a **1.00 g** sample from the site against living material to determine the time elapsed since the satellite's impact, utilizing the known properties of beta decay and radioactive tracers.

- Mass of alpha particle = 4.0026 U with proton number 6
- **The sample of carbon from wood has mass = 1.00 g, count rate = 1000 counts per hour, background rate = 300 counts per hour and half life of carbon 14 = 5700 years.**

Tasks

- (a) Help the research team understand meaning of specific charge, describe an experiment to determine the specific charge of an electron and show that the angle θ of deflection for the charge Q is $\tan\theta = \frac{Ed}{2V}$ (09)
- (b) i) Explain how the diffusion cloud chamber observations can be used to ascertain whether the source is an α -particle or β -particle emitter. (02)
 ii) Use the lab data to find the energy in Mev with which the alpha particles were emitted (02)
- (c) i) write an equation for the decay of carbon- 14 and explain how carbon- 14 is used in carbon dating (04)
 ii) determine the age of the wood (03)

SECTION B: FORCE AND MOTION

AO1 — Evaluate how forces affect static and moving bodies | Attempt ANY ONE item from this section.

Item 3

(20 marks)

On the morning of 15 January 2026, a serious accident occurred on the Kampala–Jinja Highway near Namanve Industrial Park. A Toyota Premio saloon car of mass **1200 kg** was travelling at 30 m s^{-1} when the driver, Mr. Ssemanda, applied the brakes hard to avoid a stalled heavy goods vehicle, bringing the car to rest in 5.0 seconds on a dry, level road surface and leaving clear skid marks on the tarmac. Traffic investigator Constable Nabirye arrived at the scene to determine whether Mr. Ssemanda had exceeded the highway speed limit of 100 km h^{-1} . A group of Senior Six students from a nearby school happened to be on a field trip to the industrial park. Their Physics teacher, Mr. Opio, transformed the accident scene into a practical lesson, additionally challenging students to analyse the motion of a ball projected horizontally from the roof of a building overlooking the road, and to determine how engine power governs a car's performance both on the level highway and on the hilly terrain that is common on Ugandan roads.

Support Material Provided:

- Mass of car $m = 1\,200\text{ kg}$, initial speed $u = 30\text{ m s}^{-1}$, braking time $= 5.0\text{ s}$
- Building height $= 80\text{ m}$, horizontal projection speed $= 20\text{ m s}^{-1}$
- Engine power $= 60\text{ kW}$, gradient of incline: $\sin \theta = 0.05$ $g = 10\text{ m s}^{-2}$

Tasks:

- (a) Help Constable Nabirye reconstruct the accident by determining the deceleration of Mr. Ssemanda's car during braking, the length of skid marks she should have found on the road, and the average braking force exerted on the vehicle. **(06)**
- (b) Analyse the motion of the ball that Mr. Opio projected horizontally from the roof of the 80 m building, determining the time of flight, the horizontal distance from the building where it lands, and the magnitude and direction of its velocity at the moment of impact with the road. **(07)**
- (c) Determine the total resistive force acting on Mr. Ssemanda's car as it travels at a constant 30 m s^{-1} on the level highway, and recalculate the resistive force when the same car climbs the incline at the same speed with the same engine power. **(05)**
- (d) Using the impulse-momentum theorem, explain why modern vehicles are equipped with crumple zones and air bags, relating the physics principles to the protection they provided — or would have provided — to Mr. Ssemanda during the collision. **(02)**

OR

Item 4**(20 marks)**

At a construction site in Nakasero, Kampala, a worker named Godfrey was assigned to paint the outer wall of the third floor of a new office block. He placed a uniform Aluminium ladder of mass 25 kg and length 8.0 m against the smooth vertical concrete wall, with the base resting on the rough horizontal ground at an angle of 60° to the floor. Godfrey, whose mass is 75 kg , climbed to a point three-quarters of the way up the ladder and began working. The site engineer, Engineer Birungi, stopped to assess whether the ground friction was sufficient to prevent the ladder from sliding — a life-safety concern she had to resolve before allowing Godfrey to continue. The same construction company was also managing a satellite-linked ground monitoring project, in which a 500 kg satellite had been placed into a circular orbit 400 km above the Earth's surface to monitor landslides on the hills surrounding Kampala in real time. The junior engineer needed to compute the satellite's orbital speed, period, and gravitational potential energy to plan daily communication windows with the ground station.

Support Material Provided:

- $g = 10\text{ m s}^{-2}$, mass of Earth $M_E = 6.0 \times 10^{24}\text{ kg}$, radius of Earth $R_E = 6.4 \times 10^6\text{ m}$
- $G = 6.67 \times 10^{-11}\text{ N m}^2\text{ kg}^{-2}$, satellite mass $= 500\text{ kg}$, orbital altitude $= 400\text{ km}$

Tasks:

- (a) Draw a clearly labelled free-body diagram of Godfrey's ladder and analyses the equilibrium of forces acting on it to determine the reaction force exerted by the smooth wall and the minimum coefficient of static friction required at the base of the ladder to prevent it from slipping. **(08)**
- (b) Assist the junior engineer by calculating the orbital speed and orbital period (in minutes) of the satellite at its operating altitude of 400 km , and determine its gravitational potential energy in that orbit, taking the zero of gravitational potential energy at infinity. **(07)**

- (c) State Archimedes' principle and use it to explain why the large steel barges used to transport construction materials across Lake Victoria from Kampala Port are able to float, even though solid steel is denser than water. (03)
- (d) Define terminal velocity and explain, with reference to the forces acting on a body, the physical conditions under which an object falling through a viscous fluid reaches terminal velocity. (02)

SECTION C: ENERGY

AO2 — Investigate how energy is transferred and transformed | Attempt ANY ONE item from this section.

Item 5

(20 marks)

In a physics laboratory, a group of students is investigating the properties of transverse and longitudinal waves.

- **Part 1:** Monochromatic light is passed through a polarizing sheet to observe how the intensity of the light is affected by the orientation of the filter
- **Part 2:** A resonance tube is utilized to determine the local velocity of sound in air, employing a series of calibrated tuning forks
- **Part 3:** A uniform string of length 0.50m and mass 5.0g is stretched between two fixed bridges. A mechanical vibrator is used to induce standing waves in the string while it is held under a tension of 100N

Support Material Provided:

-velocity of sound in air = 330m/s

Tasks:

- (a) i) Distinguish between constructive interference and destructive interference (02)
 ii) Describe any one method of producing plane-polarized light and practical uses of polarized light (05)
- (b) Describe how you would determine the speed of sound in air using a resonance tube and many tuning forks. (04)
- (c) i) explain the formation of beats (03)
 ii) Derive the expression for beat frequency (03)
- d) calculate the frequency of the second harmonic for the stretched string (03)

OR

Item 6

(20 marks)

Fiber Link Uganda Limited recently won a license to lay fiber optic cables connecting Kampala to Gulu, Mbarara, and Fort Portal. Project engineer Dr. Ssali briefed his technical team that the cables work by trapping light inside a glass core of refractive index 1.52 through total internal reflection. To demonstrate the principle, he directed a laser ray in air onto a flat glass surface at an angle of incidence of 40° and challenged the team to calculate the refraction and critical angles and to explain, using a diagram, how data pulses travel thousands of kilometers without escaping through the sides of the fiber. In Tororo, the Tororo Cement factory's thermodynamics, Mr. Muwanga, was modelling the factory kiln's heat cycle using an ideal gas undergoing four steps: isothermal expansion at 500 K from 2.0 L to 6.0 L at initial pressure 3.0×10^5 Pa; constant-volume

cooling to 300 K; isothermal compression back to 2.0 L; and constant-volume heating back to 500 K. In the factory canteen, a kitchen assistant placed 50 g of ice at 0 °C into a copper calorimeter of mass 100 g already holding 200 g of water at 20 °C, and a physics intern was asked to predict the final temperature of the mixture.

Support Material Provided:

- Refractive index of glass $n = 1.52$
- Specific heat capacity: copper = $400 \text{ J kg}^{-1} \text{ K}^{-1}$, water = $4200 \text{ J kg}^{-1} \text{ K}^{-1}$
- Specific latent heat of fusion of ice = $3.36 \times 10^5 \text{ J kg}^{-1}$ – $\ln 3 = 1.099$

Tasks:

- (a) Support Dr. Ssali's team demonstration by calculating the angle of refraction and the critical angle for the glass used in the fibre, and drawing a labelled cross-sectional diagram of an optical fibre to explain how total internal reflection enables a light pulse to travel from Kampala to Gulu without escaping through the walls of the fibre. **(08)**
- (b) Assist Mr. Muwanga by sketching a fully labelled P-V diagram for the kiln's four-step thermodynamic cycle, calculating the work done by the gas during the isothermal expansion at 500 K, and applying the first law of thermodynamics to determine the heat exchanged during each constant-volume process, clearly indicating whether heat is absorbed or released in each case. **(08)**
- (c) Analyse the canteen calorimetry problem: show by calculation whether all 50 g of ice will melt when placed in the calorimeter, and determine the final equilibrium temperature of the mixture. **(04)**

SECTION D: CHARGES AND FIELDS

AO3 — Explore how electric and magnetic fields interact in systems ,electrostatics ,capacitors and charge distribution
 | Attempt ANY ONE item from this section.

Item 7

(20 marks)

Raymond, a newly recruited electrical engineering intern, was posted to the UETCL Namanve substation outside Kampala for his first field attachment. At the substation he observed a large step-down transformer that reduces the local grid supply from 240 V (rms) to 12 V (rms) for distribution to nearby residential estates. The primary coil has 2 000 turns and the secondary delivers a current of 1.5 A to the load. His supervisor, Engineer Mukalazi, explained the physical causes of energy loss in real-world transformers and demonstrated how the substation's design minimises them. Raymond also observed a technician testing a single-phase AC generator consisting of a rectangular coil of 50 turns and cross-sectional area 0.020 m^2 rotating at an angular velocity of $100\pi \text{ rad s}^{-1}$ in a uniform magnetic field of flux density 0.30 T and connected to an external load resistance of 40Ω . A straight conductor of effective length 0.50 m carrying a current of 4.0 A was simultaneously placed perpendicular to the same field. Later, Engineer Mukalazi showed Raymond a moving-coil galvanometer from the instrumentation cabinet and challenged him to explain its operating principle and how it is adapted for use as an ammeter and as a voltmeter.

Support Material Provided:

- Transformer: $V_p = 240 \text{ V (rms)}$, $V_s = 12 \text{ V (rms)}$, $N_p = 2\,000$ turns, $I_s = 1.5 \text{ A}$
- Generator: $N = 50$ turns, $A = 0.020 \text{ m}^2$, $\omega = 100\pi \text{ rad s}^{-1}$, $B = 0.30 \text{ T}$, $R = 40 \Omega$
- Conductor: length $l = 0.50 \text{ m}$, current $I = 4.0 \text{ A}$, $B = 0.30 \text{ T}$

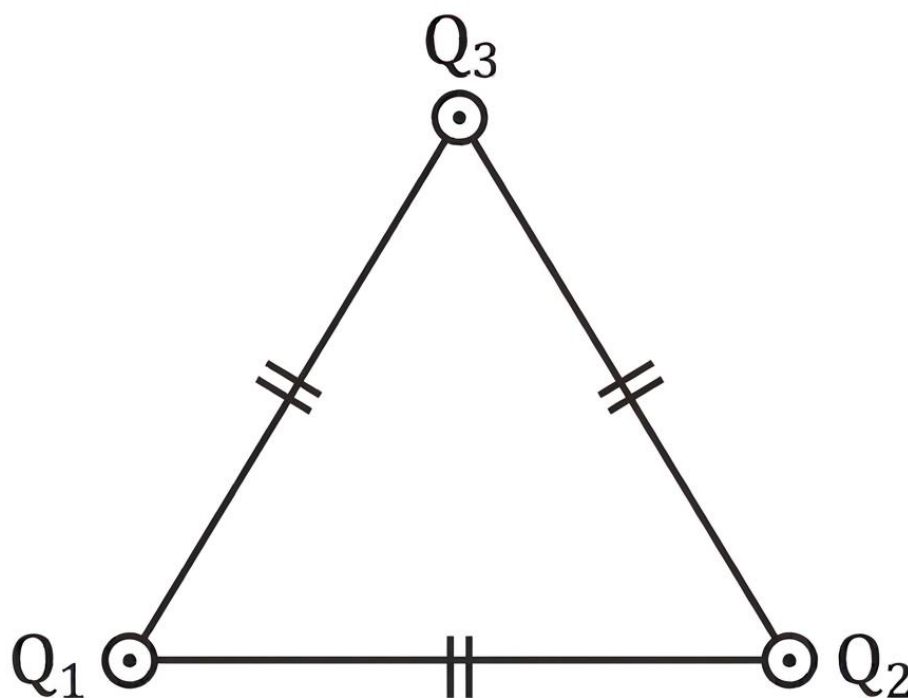
Tasks:

- (a) Assist Raymond in analysing the substation transformer by calculating the number of secondary turns and the primary current at 100% efficiency, and explain to him the TWO main causes of energy loss in the real transformer and how each is minimised in the substation's design. (08)
- (b) Analyse the AC generator being tested, deriving an expression for the instantaneous EMF and calculating the peak EMF, the rms EMF, and the rms current delivered to the $40\ \Omega$ external load. (06)
- (c) Calculate the magnetic force on the straight conductor placed in the field, and describe the operating principle of the moving-coil galvanometer, using labelled circuit diagrams to show how it is adapted to function as an ammeter and as a voltmeter. (06)

OR

Item 8**(20 marks)**

A physics student is investigating the behavior of electric fields and energy storage. They set up three-point charges $Q_1 = +2\mu C$, $Q_2 = -3\mu C$, and $Q_3 = +5\mu C$ at the vertices of an equilateral triangle in the vacuum. During the experiment, the student uses a parallel plate capacitor to study how different media affect its ability to store charge. A sheet of glass was placed between the plates of a capacitor to observe the change in capacitance, and after the readings were taken, the capacitor also needed to be fully discharged to ensure safety

**Support Material Provided:**

$$\frac{1}{4\pi\epsilon} = 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$$

Task

- a) Derive the expression for electric potential at a distance r , from a fixed charge (04)

- b) Show that the surface of a conductor is an equipotential surface (04)
- c) Determine the net force on charge Q_3 (05)
- d) i) Describe an experiment to show the effect of placing a sheet of glass between the plate of a capacitor on capacitance (05)
ii) explain briefly how a charged capacitor can be fully discharged

THE END