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P510/1

PHYSICS

2026

3 Hours

ST. JULIAN SCHOOLS RESOURCE MOCK (SJSRM)
UGANDA ADVANCED CERTIFICATE OF EDUCATION
PHYSICS (Competence-Based Assessment)
Paper 1
3 Hours

INSTRUCTIONS:

- Section A is **compulsory**
- Section B has **two parts**
- In Section B, answer **one item** from Part I and **one item** from Part II
- Answer a total of **4 items**.

SECTION A (COMPULSORY)

ITEM 1: MOTION AND FORCES

At a mechanical engineering workshop in MPoma satellite, Engineer Massy and his S.6 student Hilly are studying elastic behaviour of metals for designing a precision suspension system. Two wires, one made of steel and the other of bronze from which one must be chosen with lowest extension when a weight of 280 N is attached to the free end of the wires. The steel wire has length 0.55 m and cross-sectional area 1.2×10^{-6} m^2. It is connected to a bronze wire of length 0.42 m and cross-sectional area 2.2×10^{-6} m^2. Engineer Massy selected another wire to pair it with the chosen wire but he could not determine its young's modulus for their combination to work in the workshop.

Later, Hilly takes a small metal ball of mass 0.45 kg and attaches it to a light inextensible string of length 0.9 m such that he hits the bird in the compound in order to do so he whirls the ball in a horizontal circle of radius 50cm at a constant speed of 5.5 m/s. The bird is at a distance of 20m from him. If it flies 4.5s just after the released of the ball, he wounders if the ball hits the bird.

Finally, a technician at a satellite ground station worries about a communication satellite. The satellite orbits Earth at an altitude of 35,000 km. Hilly wonders, *"What is the orbital period of this satellite? Is it geostationary orbit?"* Mary a friend to Hilly could not explain why satellites in lower orbits move faster than those in higher orbits and also how it could aid in communication.

Support Material:

Young's modulus of steel = 2.0×10^{11} Pa
Young's modulus of bronze = 1.0×10^{11} Pa
acceleration due gravity $g = 9.8$ m/s^2

Earth radius = 6.4×10^{6} m
$G = 6.67 \times 10^{-11}$ N·m^2/kg^2,

mass of Earth = 6.0×10^{24} kg

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Tasks:

(a) Study the workshop situation closely and guide Hilly to overcome all her **worries**.

(b) Address Mary's worry .

ITEM 2: PARTICLES

At a certain school, the physics teacher Mr. Luli and his S.6 student Joan are investigating a cathode ray tube (CRT) in the laboratory. When they switch on the tube, a bright green glow appears on the fluorescent screen. Joan wonders, *"What are these cathode rays? Are they particles or waves?"* Mr. . Luli could not explain why the rays are deflected by a magnetic field but not by an electric field when the tube is set up incorrectly. Joan worries that their apparatus might be faulty.

To understand better, Mr. Luli asks Joan to calculate the specific charge (e/m) of the cathode ray particles using Thomson's method. Electrons accelerated through 750 V enter a magnetic field of 0.032 T and move in a circle of radius 6.0 cm. Joan wonders if her answer will match the known value of 1.76×10^{11} C/kg.

Mr. Luli then demonstrates the production of X-rays using a Coolidge tube. He explains that fast-moving electrons are stopped by a metal target, producing X-rays. Joan wonders, *"What determines the minimum wavelength of the X-rays produced? And why are X-rays dangerous to living tissue?"* Mr. Luli worries because Joan could not explain how X-rays are used in medical imaging while being harmful at the same time.

Mr. Luli then draws Bohr's atomic model on the whiteboard. He explains how electrons jump between energy levels by absorbing or emitting photons. Joan wonders, *"Why does hydrogen produce a line spectrum while hot solids produce a continuous spectrum?"* She could not explain why Bohr's model failed for helium or carbon atoms.

Finally, Mr. Luli asks Joan to calculate the ionisation energy of hydrogen using the Rydberg constant R = 1.097×10^7 m. Joan worries whether her answer in eV will be like the known value of 13.6 eV.

Matha a friend to Joan wondered whether the emitted electrons thermionically can be accelerated into a magnetic field to determine specific charge of electrons experimentally.

Support Material:
Electron charge e = 1.60×10^{-19} C
Electron mass m = 9.11×10^{-31} kg
Accelerating voltage = 750 V
Magnetic field B = 0.032 T
Radius r = 6.0 cm = 0.060 m
Planck's constant h = 6.63×10^{-34} J·s
Speed of light c = 3.0×10^8 m/s
1 eV = 1.60×10^{-19} J
Rydberg constant R = 1.097×10^7 m^{-1}
Known specific charge of electron = 1.76×10^{11} C/kg

Tasks:

(a) Dive into Joan's observations and assist her to resolve all her **puzzles**.

(b) Asses Matha's worry.

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SECTION B – ENERGY

PART I:

Answer one item only

ITEM 3:

In certain rural health centre, a doctor and his intern Peter are struggling with a damaged solar-powered vaccine refrigerator. The refrigerator uses a thermodynamic cycle to remove heat from the vaccine compartment (maintained at 5°C) and releases it to the outside air at 35°C. The compressor does 600 J of work per cycle, and the refrigerator absorbs 2,000 J of heat from the cold compartment each cycle. Peter wonders, *"How much heat is released to the room? And is this refrigerator working as efficiently as it should?"* He calculates the coefficient of performance but worries because the actual performance is lower than the ideal Carnot value.

A broken window allows humid outside air (relative humidity 80% at 35°C) to enter. The doctor explains that water vapour in the air condenses on the cold evaporator coils, forming ice. Peter could not explain why ice forms even when the air temperature is above freezing. He reminds him of latent heat of vaporisation and condensation.

To check the vaccine vials, Peter uses a compound microscope (objective focal length 0.6 cm, eyepiece focal length 2.5 cm, tube length 11 cm). He wonders, *"What is the magnification of this microscope? And why is the image inverted?"* Dr. Sembatya then asks him to use a small refracting telescope (objective focal length 70 cm, eyepiece focal length 7 cm) to spot a distant ambulance across the valley. Peter worries because he cannot remember whether the telescope produces an upright or inverted image in normal adjustment.

Later, Peter helps fix a solar panel that powers the refrigerator. The panel provides 280 W of power for 4.5 hours of sunlight per day. He calculates the energy produced and wonders, *"Is this enough to run the refrigerator if the compressor runs 30% of the time?"* The compressor consumes 200 W when running.

After Peter narrated how the day went on to the friend. This made him ask if there is any system which can be used to determine specific latent heat of vaporisation

Support Material:

saturation vapour pressure at 35°C = 5.62 kPa, at 0°C = 0.61 kPa

Latent heat of vaporisation = 2.26×10^6 J/kg

Tasks:

(a) Work through the health centre situation and assist Peter to address all his **concerns**.

(b) Answer the concern of Peter's friend

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ITEM 4:

At a secondary school in Mbale, physics teacher Mr. Mutonyi and his S.6 student Fiona are investigating heat conduction through different materials. They have a metal rod of length 65 cm and cross-sectional area 1.2 cm^2. One end is placed in boiling water at 100°C and the other end in melting ice at 0°C. The thermal conductivity of the metal is 170 W/(m·K). Fiona wonders, *"What is the rate of heat transfer through the rod? How much ice melts per minute?"* She could not explain why a copper rod of the same dimensions would transfer heat faster.

Mr. Mutonyi then asks Fiona to consider a heat engine operating between a hot reservoir at 500°C and a cold reservoir at 30°C. The engine absorbs 3,800 J of heat per cycle and does 1,400 J of work. Fiona wonders, *"What is the actual efficiency of this engine? How does it compare with the Carnot efficiency?"* She worries because the actual engine is much less efficient than the ideal.

Later, Fiona investigates the expansion of an ideal gas. A gas at 260 K occupies 0.035 m^3 at a pressure of 1.2×10^5 Pa. She heats it at constant pressure until its volume doubles. Fiona wonders, *"What is the final temperature? How much work is done by the gas?"* She could not explain why the internal energy increases during this process.

Finally, Bena a student also investigated stationary waves on a string. A string of length 1.2 m is fixed at both ends. It vibrates in its fourth harmonic with a frequency of 200 Hz. Fiona wonders, *"What is the speed of waves on the string? What is the fundamental frequency?"* She worries because she could not explain why the string vibrates with nodes and antinodes.

Support Material:

Specific latent heat fusion = 3.34×10^5 J/kg

Tasks:

(a) Examine the laboratory investigation and help Fiona clear all her **wonders**.

(b) Analyse Bena's investigation and describe the relation ship between frequency in the string and tension.

SECTION B – PART II: FIELDS AND CHARGES

Answer one item only

ITEM 5:

At a printing press in Kampala, an inkjet printer is used to produce high-quality documents. The printer forms images by ejecting tiny ink droplets that are electrically charged. These droplets pass between two parallel plates at a potential difference of 550 V, where an electric field deflects them into the correct positions on the paper. For the ink droplets to be properly directed to the paper, the force on each ink droplet should be more than 2.8×10^{-6} N. The charging system is powered by a DC supply of 160 V through a resistor R to control current. According to specifications, a current of

0.22A should flow through R for proper working of the charging system.

However, during use, the printer becomes hot and produces faint and poorly aligned prints. A technician has been invited to resolve the issues. On opening the printer, he discovers that the resistor was spoilt and needed replacement. The resistor was made of wire of certain resistivity, but the exact length of wire needed and the resistivity were not known. The technician wonders, *"How long should the wire be?"* He also worries about the deflecting system of the printer.

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Support Material:

Area of deflecting plates = 4.0×10^{-3} m²
Separation of plates = 0.8×10^{-4} m
Charge on one droplet = 3.5×10^{-13} C
Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
Resistivity of wire = 1.0×10^{-6} Ω·m
Diameter of wire = 0.08 mm
DC supply voltage = 160 V, required current = 0.22 A

Tasks:

(a) Analyse the printer situation and help the technician resolve all his **troubles**.

(b) Explain how the resistivity of the wire can be determined.

ITEM 6

In our community people listen to radios for many reasons among them are to promote emotional comfort, mental stimulation and to be informed of what is going on. John visited his parents with his child who was doing physics in s6. The parent complained to John of the challenge they had with radio set which often failed to tune in their favourable religious program the radio operated at a frequency of 0.755MHz John opened the radio and found its tuning circuit consisting of a capacitor and an inductor very weak. John decided to install a new strong variable capacitor and inductor. He purchased materials and made the two small capacitor each of plate separation 2mm and maximum area of overlap $0.005m^2$ filled with a material of dielectric constant 4. The two capacitors were found in series and connected with motor for tuning.

He made a pure inductor L from a 15cm air-cored solenoid of 100 turns and $0.012m^2$ cross sectional area John requested his child to perform the necessary calculation to establish whether the new circuit can tune in to desired channel.

John's parent also took the presence of their ground child and asked for the explanation of the structure and mode of operation radio charging device being used, because the grandparent had always wondered how the charge can be connected in the socket which was labelled to supply 240V charge a radio whose input required only 12V

Support Material

Permittivity of free space $\epsilon_0 = 8.85 \times 10^{-12}$ F/m
Dielectric strength of air = 3.0×10^6 V/m

Task

As a Physics student at Senior six level:

a) Analyze the scenario and help John to address the challenges.
b) Assess the concern of the grandparent about the structure of the device.

END

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