ACEITEKA JOINT MOCK EXAMINATIONS 2024

Uganda certificate of education

PHYSICS

Paper 1

Theory

Time: 2 hours 30 minutes

INSTRUCTIONS TO CANDIDATES:

- *This paper consists of two sections; A and B. It has **seven** examinations items.*

- *Section A has **three** compulsory items.*

- *Section B has **two** parts I and II. Answer **one** item from **each** part.*

- *Answer **five** items in all.*

- *Any additional item(s) answered will not be scored.*

- *All answers **must** be written in the booklet provided*

SECTION A

Answer all the items from this section

1. With the intention of producing electricity by 2030, the Ugandan government is preparing to construct its first nuclear power station. The goal of this large-scale initiative is to meet the nation's increasing energy needs in a sustainable manner while lowering its dependency on fossil fuels. However, due to worries about the safety of nuclear power, there has been a lot of public criticism. Many people are unaware of the various benefits of nuclear energy and are concerned about the possibility of explosions if energy production is not controlled, the impact of background radiation on human health, and the long-term risks posed by radioactive waste with long half-lives.

   Task: A well-known local radio station has invited you as physics student to address the public's worries and provide an explanation of the science behind nuclear energy production in a nuclear reactor in a controlled way.

2. The science club at a Secondary School has initiated a national science literacy campaign. As part of this effort, they are hosting a series of outreaches aimed at primary school students to foster a better understanding of astrophysics and its relevance to everyday life. The focus of their discussions will include energy production in stars, the importance of the Sun's energy, the variation in stars' colours, the life cycles of stars, and the importance of space exploration.

   Task: As a student of physics, you have been requested by the school science club to deliver in one of the outreaches to primary school students. Your task is to educate them on

   (a) How the sun produces energy needed for live to survive?
   (b) the variation in colour and brightness of stars in the Milky way in terms of their size and distance from the earth
   (c) the different stages in the life cycle of a star
   (d) the purpose of the international station and its role in space exploration.

3. A new company has just been built next to your home, and while they have hired security guards, the security cameras they intended to purchase are currently out of stock. At the moment, they were looking for a basic tool that would enable them to view over the wall and what is outside when they are inside the perimeter fence. In addition, the company has been advised to install a laser rather than a regular lightbulb for nighttime security.

Hint;

- Available is a mirror and a glass prism.
- the laser chosen for the security system has a wavelength of $532 \times 10^{-9}m$.
- Speed of light in a vacuum is $3 \times 10^8 ms^{-1}$
- Frequency of laser suitable for security system should be less than $6 \times 10^{14} Hz$.

Task: As a physics student:

(a) Choose between a mirror and a glass prism for the design of the simple instrument. Explain your choice with reasons and use a diagram to illustrate the design and operation of the simple instrument.

(b) Explain to the company how light from the regular light bulb is different from a laser and advise on whether the laser they purchased is suitable for their needs.

↑ Based on the frequency calculate

SECTION B
PART I

Answer one item from this part

4. An ambulance is transporting critical medicine from the city Centre to an upcountry district. The medicine must be kept refrigerated, and the mini refrigerator in the ambulance is chargeable. However, the ambulance runs out of fuel, and the driver stops a passing pickup truck for help. The pickup truck driver offers to give some fuel, but when checking the battery, the ambulance driver realizes it is draining quickly. The refrigerator indicates it has only 3 hours of operational time left. The remaining distance to the destination is 150 km.

The only method they can use to get fuel from the pickup is through a pipe.

The amount of thermal energy required to maintain the refrigerator's internal temperature should be higher that than 450000J

Task: As a learner of physics, you have been requested to;

(a) Explain using diagram how the driver can get fuel using a pipe from the pick-up truck to his tank.

(b) Advise the driver on the minimum average speed the driver needs to maintain to ensure the medicine remains properly refrigerated upon arrival.

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(c) Establish whether there is enough energy to maintain the refrigerator's internal temperature if the refrigerator's power rating is 50 W.

5. Two cars collided at a junction: one car was traveling northward and the other southward. The driver of the southbound car claims that the northbound driver was over speeding. The traffic police are not sure of who is at fault. A witness stated that the cars travelled together after the collision. One of the drivers was not wearing a seatbelt. To identify a vehicle which was over speeding or braking heavily before the crash, the risen tyre temperatures can provide physical evidence. The police used an uncalibrated thermometer to measure the temperature of the tyres as follows:

Length of the mercury thread when in contact with the tyre: 40cm

Length of the mercury thread at the ice point: 10cm

Length of the mercury thread at the steam point: 80cm

Additional Information:

- Mass of the car travelling northward: 2000kg
- Mass of the car travelling southwards: 1800kg
- Velocity of the car travelling southwards before the collision: 70km/hr.
- Common velocity of the two cars after the collision: 35km/hr.
- Speed limit on this road: 70km/hr.

Task: As a learner of physics,

(a) Guide the police on whether the pickup was over speeding.

(b) Advise the driver who was not putting on the seat belt on how it can safeguard his live

(c) Assist the police to get the correct tyre temperature.

PART II
Answer **one** item from this part

6. A building has been struck by lightning, causing damage to its electrical system, including a fuse, a copper wire used as an earth connection, and a small transformer that was functioning as a voltage regulator. The building's owner has decided to replace only the transformer for now and plans to address the fuse and earth connection later. However, he is uncertain if the newly purchased transformer will perform adequately. The previous transformer had a power

output of over 80W. The building owner has also refused to install a lightning conductor.

Hint:

- The new transformer is designed to work on a 240V, 60W supply. Primary coil has 300 turns and secondary coil has 200 turns and its efficiency is 80%

Task; As a student of physics, you been requested to explain to the owner of the building
conductor.

(a) How installing a lightening conductor will protect his building

(b) Whether the newly bought transformer is suitable for the building's needs ← Transformer

(c) the dangers associated with delaying the replacement of the fuse and the re-establishment of a proper earth connection. ← advantages of earth wire

7. A business person has started a large-scale business and wants to understand his daily power usage. He also needs guidance on choosing a generator, saving power, and ensuring his workers are knowledgeable about wiring and maintenance. He has the following electrical instruments.

12 security bulbs (5W each) operating for 12 hours a day

A 65W refrigerator operating for 24 hours a day

A 3000W juice making machine operating for 5 hours a day

Tasks: As a student of physics, you have been requested to;

(a) assist him to know his daily power usage from the listed electrical instruments

(b) choose a suitable generator for his business needs and explain the operation of the chosen generator with a labelled diagram.

(c) Describe to his workers the insulator colour codes used in domestic wiring.

(d) Provide suggestions on how he can save energy.

THE END

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ACEITEKA MOCK EXAMINATIONS 2024, UCE PHYSICS P535/1, SCORING GUIDE

Item	Expected response	Points
1.	**Operation of a nuclear reactor.** -The reactor core is loaded with fuel rods containing pellets of uranium (U-235). These rods are assembled into fuel assemblies. -Control rods made of neutron-absorbing materials such as boron or cadmium are placed among the fuel rods to manage the rate of the fission reaction. -A neutron source initiates the nuclear fission process by bombarding the fuel rods with neutrons. -When a U-235 nucleus absorbs a neutron, it becomes unstable and splits into two smaller nuclei (fission fragments), releasing a large amount of energy in the form of <u>heat</u> and additional neutrons. ✓ -This heat is used to produce steam, which drives turbines connected to generators to produce electricity.	05pts
	How energy is produced in a control way. -In a nuclear reactor the energy production is controlled so that the heat energy is released over a longer period of time. This prevents explosion.	01pt
	Background radiations -Background radiation is low-level ionising radiation that is produced all the time. We are exposed to it from various sources like the sun, soil, and even certain foods. - Nuclear power plants contribute very little to this background radiation. ✓	02pts
	Radioactive waste with long half-lives. -Radioactive waste products with long half life produce in a nuclear reactor present a serious problem for a long period of time. ✓ -They are therefore sealed (closed) in containers which are then buried deep underground.	02pts
	Benefits of nuclear energy. -Low carbon emissions ✓ -High energy density ✓ **Any two points** -Reduces dependence on fossil fuels ✓ -Reliability (not weather dependent). ✓	02pts

Handwritten annotations (right margin):
- uranium put into the reactor
- it then splits into two neutrons.
- These neutrons bombard more uranium to cause a chain reaction.
- Heat will be produced.
- it will then produce steam wic turns the turbines connected to generators to produce electricity.
- Seal in thick containers made of Lead.
- Burrying them.

		1. 16pts		12 pts
		2. 16pts		Tot=~~16pts~~
		3. 14pts		
		4. 13pts		
		5. 11pts		
		6. 12pts		
		7. 16pts		

Item	Expected response	Points
2.	**(a) How the sun produce energy** The Sun produces energy through a process called <u>nuclear fusion.</u> In its core, hydrogen atoms are fused together under extreme pressure and temperature to form <u>helium atoms.</u> This fusion process releases a large amount of energy in the form of light and heat, which travels through space and reaches Earth. This energy is important for life on our planet	$^1H + ^1H \rightarrow ^2H + e^+ + \nu_e$ $^2H + ^1H \rightarrow ^3He + \gamma$ $^3He + ^3He \rightarrow ^4He + ^1H + ^1H$ 03pts
	(b) The variation in colour and brightness of stars in the milky way in terms of their size and distance from earth -Colour: The colour of a star <u>indicates its temperature.</u> Hotter stars appear <u>blue or white</u>, while cooler stars appear red or orange. Medium-temperature stars, like our Sun, <u>appear yellow.</u> -Brightness: A star's brightness, or how bright it appears to us, is influenced by its <u>size and distance from Earth.</u> Larger stars can produce more light and appear brighter if they are closer to us. Conversely, smaller stars or those further away appear dimmer.	05 pts 03pts 04pts
	(c) The different stages in the life cycle of a star -Nebula: Stars begin as clouds of gas and dust called nebulas. Protostar: Gravity pulls the gas and dust together, forming a protostar.✓ -Main sequence: The star enters the main sequence phase, where it spends most of its life fusing hydrogen into helium, like our Sun. -Red giant/supergiant: When the hydrogen runs out, the star expands into a red giant (for medium-sized stars) or supergiant (for massive stars). -White dwarf: After shedding its outer layers, a medium-sized star's core remains as a white dwarf.✓ -Neutron star or black hole: A massive star can explode in a supernova, leaving behind a dense neutron star or collapsing into a black hole. ✓	05pts
	(d) The purpose of the international space station (ISS) and its role in space exploration -Scientific research: Conducting experiments in microgravity that are not possible on Earth, leading to advances in science and technology. ✓	

(margin notes, left side:)

① The process is Nuclear fusion

②. Hydrogen combines to form helium.

③. Helium produces too much heat & light
④ which travels towards
⑤ the earth.

✓ Size
✓ Distance from earth.

Item	Expected response	Points
2.	-International cooperation: Serving as a symbol of international collaboration, with contributions from space agencies like NASA, ESA, Roscosmos, JAXA, and CSA. ✓ Any two points	02pts
	-Space exploration: Testing new technologies and conducting research that will help in future space missions to the Moon, Mars, and beyond. ✓	
	Education and inspiration: Providing educational opportunities and inspiring the next generation of scientists and engineers. ✓	= 17 pts. Tot=~~16~~pts

→ mirrors can give blurred images due to reflection & refraction.
→ prisms have total internal reflection.

Item	Expected response	Points
3.	(a) Choose between a mirror and a glass prism for the design of the simple instrument. Explain your choice with reasons and use a diagram to illustrate the design and operation of the simple instrument.	
	The use of prisms is preferred to plane mirror in a periscope because; is no energy loss in prisms.	
	~~There is~~ Any one point	01pt
	-Prisms produce clear image ✓ (No multiple images).	
	-Prisms do not tarnish and deteriorate as mirror. ✓	
	Operation of a prism periscope.	

	Correct diagram with any two correctly labelled parts	02pts

Light from a distant object meets the surface RS at 45° so light is totally internally reflected downwards. The reflected light is incident to the surface MN where it is totally internally reflected to give the emergent light to the observer. ✓

(b) Suitability of the laser

Given;

Using $v = \lambda f$, ✓

$$f = \frac{v}{\lambda}$$

$$= \frac{3 \times 10^8}{532 \times 10^{-9}} \quad ✓$$

$$= 5.64 \times 10^{14} Hz \quad ✓$$

Advise: Since the frequency $5.64 \times 10^{14} Hz$ of the laser is less than $6 \times 10^{14} Hz$, it is suitable for the security system based on the given criteria. ✓

| | 03pts |
| | 04pts |

Item	Expected response	Points
3.	Differences between light from a regular light bulb and a laser **Light from a regular light bulb** -Nature: Emits light in all directions. ✓ -Wavelength: Consists of a wide range of wavelengths (broad spectrum). ✓ -Coherence: Light waves are not coherent; they are out of phase. -Divergence: Light spreads out ~~quickly~~ equally. ✓ **While for Laser Light** -Nature: Emits light in a specific direction. ✓ Any two differences -Wavelength: Consists of a single wavelength (monochromatic). -Coherence: Light waves are coherent; they are in phase. ✓ -Divergence: Light spreads out very little, maintaining a narrow beam. ✓	04pts Tot=14pts
4.	**(a) how the driver can get fuel using a pipe from the pick-up truck to his tank.** Pickup fuel tank ✓ Pipe ✓ Ambulance fuel Correct diagram with any two correctly labelled parts -Insert one end of the pipe into the pickup truck's fuel tank. ✓ -Ensure the other end of the pipe is lower than the pickup truck's fuel tank to create a siphoning effect. ✓ -Suck on the lower end of the pipe to start the flow of fuel until fuel starts to flow out. ✓ -Quickly insert the lower end of the pipe into the ambulance's fuel tank to allow the fuel to continue flowing. ✓ **(b) Minimum speed,** $$\text{Speed} = \frac{\text{distance}}{\text{time}} ✓$$ $$= \frac{150}{3} ✓ = \frac{150000}{3 \times 3600} = 41.67ms^{-1}.$$ $$= 50kmh^{-1} ✓$$ **Advice:** -The driver needs to maintain a minimum average speed of ✓ $50kmh^{-1}$ to ensure the medicine remains properly refrigerated upon arrival.	02pts 04pts 04pts

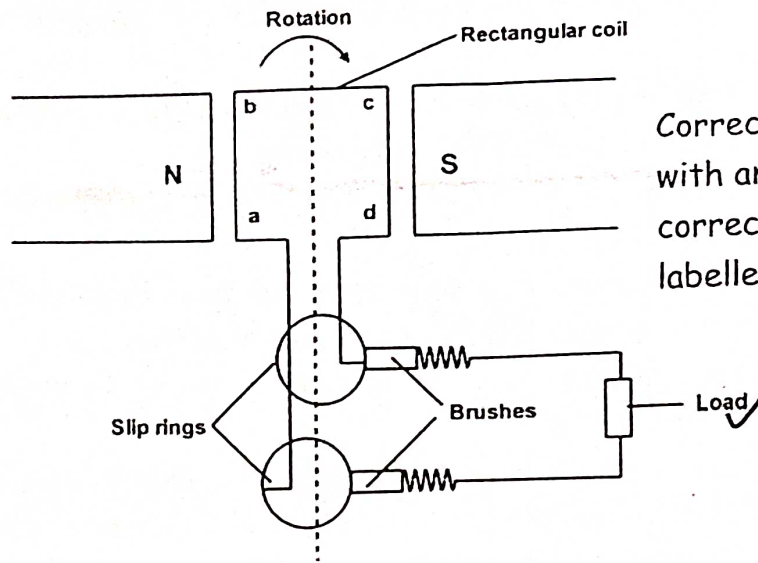| Item	Expected response	Points
4.	(c) Establishing whether there is enough energy to maintain the refrigerator's internal temperature if the refrigerator's power rating is 50 W. Total energy required=Power×Time ✓ ✓ $= 50 \times 3 \times 3600 = 540,000J$ **Advise:** -Given that the amount of thermal energy required to maintain the refrigerator's internal temperature should be higher than 450,000 J, and the total energy required is 540,000 J, there is enough energy to maintain the refrigerator's internal temperature. ✓	03pts Tot=13pts
5.	(a) **Guiding the police on whether the pickup was speeding.** Using the law of conservation of momentum, we can determine the velocity of the car traveling northward before the collision. $m_1u_1 + m_2u_2 = (m_1 + m_2)v,$ ✓ $(2000 \times u_1) - (1800 \times 19.44) = (2000 + 1800) \times 9.72$ ✓ $(2000 \times u_1) - 34992 = 36936$ $(2000 \times u_1) = 36936 + 34992$ ✓ $(2000 \times u_1) = 71928$ $u_1 = \dfrac{71928}{2000}$ $u_1 = 35.964ms^{-1}$ $= 129.47kmh^{-1}$ ✓ Adise: The pick up was travelling at $129.47kmh^{-1}$ which is beyond $70kmh^{-1}$ hence the pickup was speeding. ✓ (b) **Advise the driver who was not putting on the seat belt on the how it can safeguard his live** -When a car is moving, both the car and its occupants are traveling at the same speed. ✓ -Due to inertia, if the car suddenly stops (e.g., due to a collision), the bodies of the occupants will tend to continue moving forward at the same speed. ✓ -Upon a sudden stop, the seat belt applies a force to the occupants' bodies, decelerating them gradually and safely, preventing them from continuing to move forward and hitting the interior parts of the vehicle or being thrown out of the car. This prevents injuries or death. ✓	04pts 03pts

Item	Expected response	Points
5.	(c) Assisting the police to get the correct tyre temperature. $$\theta = \frac{L_\theta - L_0}{L_{100} - L_0} \times 100^0C \checkmark$$ $$= \frac{40 - 10}{80 - 10} \times 100^0C \checkmark$$ $$= \frac{30}{70} \times 100^0C \checkmark$$ $$= 42.86^0C \checkmark$$ -The correct tyre temperature is approximately 42.86^0C ✓	04pts ~~~~~~~~ Tot=11pts
6.	(a) How installing a lightening will protect his building -During a thunderstorm, the sharp points ~~near the ground~~ on top of the building becomes highly charged.✓ -The lightning rod, being a pointed conductor, has high concentration of positive charge around it. ✓ -This ionizes the air around the lightning rod, making it more conductive and creating an easy path for the ~~lightning~~ Charges (electron) to ~~follow~~ flow. ✓ -In case of a spark jump (lightning strike), it is safely conductor to the ground through the copper plate. ✓ -Without a lightning conductor, a lightning strike could directly hit the building, causing fire or significant damage to the structure.✓	05pts
	(b) Whether the newly bought transformer is suitable for the building's needs Efficiency = 80% = 0.80 Input Power = 60W Efficiency = $\frac{\text{Output Power}}{\text{Input Power}} \times 100\%$ ✓ Output Power = Efficiency × Input Power Output Power = 0.80 × 60W = 48W ✓✓ **OR** $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ ✓ $\frac{V_s}{240} = \frac{300}{200}$ ✓ $V_s = 360V$ ✓ Since, $V_s > V_p$ and $P \propto V$ ✓ -Advise: The newly bought transformer has an output power of 48W, which is less than the required 80W. Therefore, the new transformer is not suitable for the building's needs as it will not provide adequate power for the electrical system ✓	04pts

Item	Expected response	Points
6.	(c) The dangers associated with delaying the replacement of the fuse and the re-establishment of a proper earth connection. -Under normal operating conditions, the electrical current flowing through the circuit is within the safe limits. -The fuse element is designed to carry this current without overheating or melting. ✓ -If the current exceeds the safe limit due to a fault such as a short circuit or overload, the fuse element heats up. ✓ -The excessive current causes the fuse element to reach its melting point and melt ✓ -When the fuse element melts, it breaks the electrical circuit, interrupting the flow of current. This stops the excessive current from continuing to flow, preventing potential damage or hazards.	03pts Tot=12pts
7.	(a) **Total power** Total Energy $(kWh) = (5W \times 12 \times 12\ hours) + (65W \times 24\ hours) + (3000W \times 5\ hours)$ ✓ $= 720\ Wh + 1560\ Wh + 15000\ Wh$ ✓ $= 17280\ Wh$ ✓ $= 17.28\ kWh$ ✓ (b) choosing a suitable generator for his business needs and explaining the operation of the chosen generator with a labelled diagram. **Advantages of alternating current (a.c.) over direct current (d.c.).** - A.c. can be produced in large quantities unlike d.c. ✓ - A.c. can be stepped up or stepped down, allowing us to use the required amount, this is not possible with d.c. ✓ - Power losses due to a.c. can easily be minimised (i.e. by stepping up voltage). ✓ - A.c. is cheaper to generate compared to d.c. considering what is needed to produce them. ✓ Any two points	03pts 02pts

(Handwritten margin notes, item 6): — Electric shocks — Damage to the appliances.

(Handwritten margin notes, item 7): They should give reasons.

7.

Operation of an A.C generator

Correct diagram with any 1 correctly labelled part

01pt

-The simplest alternating current (A.C) generator consists of a rectangular coil between the poles of a C-shaped magnet. The ends of the coil are joined to two slip rings on the axle and against which carbon brushes press ✓

-When the coil is rotated it cuts the field lines and a voltage is induced in it. As the coil moves through the vertical position with ab uppermost, ab and cd are moving along the lines and no cutting occurs. The induced voltage is zero. ✓

-During the first quarter rotation, the p.d. increases to a maximum when the coil is horizontal. Sides ab and dc are then cutting the lines at the greatest rate. ✓

-In the second quarter rotation the p.d. decreases again and is zero when the coil is vertical with dc uppermost. After this, the direction of the p.d. reverses because, during the next half rotation, the motion of ab is directed upwards and dc downwards.

-An alternating voltage is generated which acts first in one direction and then the other; it causes alternating current (A.C) to flow in a circuit connected to the brushes. ✓

05pts

(c) Colour codes
-Live (Hot) Wire: Brown (or Red) ✓
-Neutral Wire: Blue (or Black) ✓
-Earth (Ground) Wire: Green/Yellow stripes ✓

03pts

(d) Energy saving tips
-Use energy-efficient devices and practices. ✓
-Maintain equipment regularly. ✓
-Control the usage of high-energy appliances. ✓

Any two points

02pts

........................The end....................

Tot=16pts