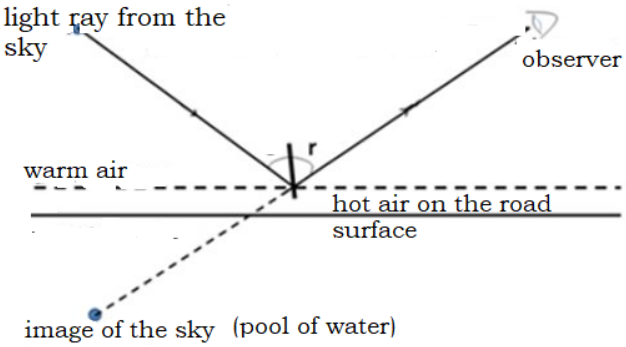
EXPECTED SEMINAR RESPONSES FOR O-LEVEL PHYSICS SEMINAR SLATED FOR 21ST JUNE 2025 AT ST JOSEPH OF NAZARETH HIGH SCHOOL KAVULE-KATENDE-MPIGI IN CONJUCTION WITH SEPTA

ITEM 1

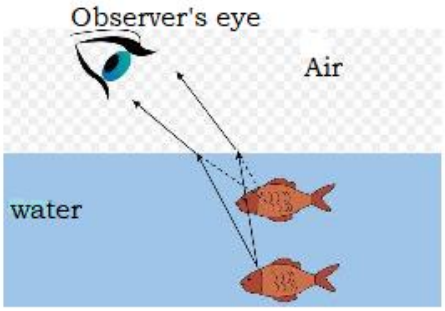
a) A magical pool of water was a mirage.



On a hot day, light from the sky is gradually and progressively refracted away from the normal as it passes through layers of warm but less dense air near hot road surface.

The refractive index of warm air is slightly smaller than that of cool air. So, when light from a cool layer of air meets a boundary of warm layer air at angle greater than the critical angle, it suffers total internal reflection, thus the observer on the road surface sees the image of the sky as the magical pool of water.

A fish appears closer and larger in water due to refraction of light at the water's surface.



- As light rays from the fish travel from water into the air, they are refracted at the boundary between air and water due to difference in the refractive indices of the two media. This bending of light rays makes the fish's image appear at a shallower depth since light that reaches the observer's eye appear as if its travelling in a straight line.
- The fish's image appears bigger than its actual size because a large water surface is not completely flat but consists of countless ripples whose convex surface on air acts as a convex lens of long focal length
- In consequence, the fish is within the focal length of the lens hence it appears magnified(bigger) to the observer viewing it from above.

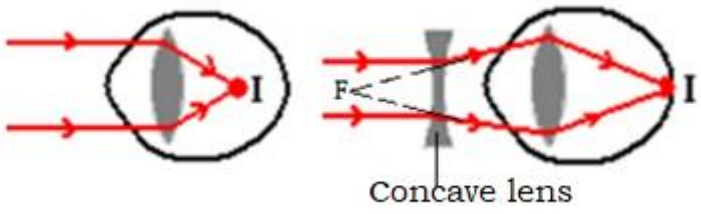
b) $$V = f\lambda$$
$$V = 180\ x\ 0.01$$
$$V = 1.8\ ms^{-1}$$
But $1.8\ ms^{-1} = 6.48\ kmh^{-1}$ after conversion which less than $7.2\ kmh^{-1}$ therefore, fishing activities would continue on the lake.

c) Properties of electromagnetic waves used by the radar;
- They can be refracted
- Polarized
- Diffracted
- .
- Interference
- Refraction

Applications
- Radio broadcasting
- Satellite communication
- Remote control.

Item 2

a) The student preferred such a sitting arrangement because, he was short sighted. With such an eye defect, the student can see near objects clearly, but the images of the distant objects are formed in front of the retina, resulting into blurred images as a result of too long eye ball or too short focal length.



The defect can be corrected by wearing spectacles containing diverging lens which increase the divergence of light rays before the enter the eye and then bring then to focus on the retina.

b) The sound waves were able to reach them from crying patient in the next room due to diffraction. Sound waves have a longer wavelength, therefore they easily spread around corners and gaps of the room there by extending to different positions through compressions and rarefactions.

c) Given that $f = 10cm = 0.1m$
Using
$$Power\ of\ the\ lens = \frac{1}{f}$$
$$power\ of\ the\ lens = \frac{1}{0.1}$$
$$power\ of\ the\ lens = 10\ D$$
Hence the student's vision was restored according to the directions of the medical personnel.

Item 3

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

$$f = \frac{3.0\ x\ 10^{\ 8}}{532x10^{-9}}$$

$$f = 5.6391\ x10^{14}\text{Hz}$$

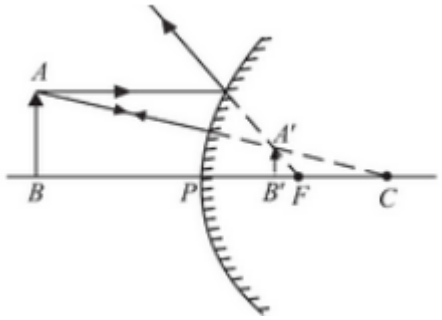
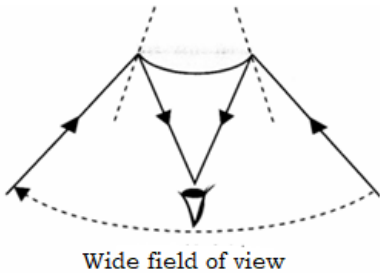
Hence the laser lights were not dangerous since $5.6391x10^{14}$ Hz is less than $7.5\ x\ 10^{14}Hz$

b) Laser light from lasers is highly monochromatic and coherent, meaning they consist of single wavelength and color which allows it to maintain focus and narrowness over long distances with minimal scattering. This allows laser light to maintain it's intensity and clarity over greater distances compared to light from normal bulbs.

c) The appearance of customers changed due to absorption and reflection of disco lights after falling on their costumes i.e
In presence of red lights, the white T-shirts and hats appeared red since red light was reflected and
In presence of blue lights, the White T-shirt appeared blue in presence of blue lights since, blue light is part of white light and therefore it was reflected, hats appeared dark, since blue light was absorbed by yellow hats and none was reflected.

Item 4

a) Driving mirror on her father's car was a convex mirror. It forms erect or upright images and has the ability to give a wide field of view which makes it suitable to be used as a driving mirror.

	
Formation of image by a convex mirror	Wide field of view

b) A scale ray diagram. On graph

c) The girl can use a plane mirror instead of the curved mirror since the plane mirror always forms images which are always erect/upright, virtual, equidistant, and same size as the object irrespective of the position of the object which is not the case with the curved mirrors that some-times form inverted/upright or diminished/magnified images which may confuse the observer depending on the position of the object from the mirror.

d) (i)At night radio signals are clearer than day time due to the behaviour of the ionosphere.
During the day, the sun's radiation ionizes the atmosphere creating the layer of free electrons that absorbs radio waves and little is reflected back and picked by the antenna.
During the night, the atmosphere is less ionized. This reduces the absorption of radio waves. Therefore, all the radio waves are reflected back

and picked by the radio antenna hence clear reception.

(ii) From $\lambda = \frac{V}{f}$

$$\lambda = \frac{3.0x10^8}{93.3x10^6} = 3.2m$$

Item 5

(a) Assume Z is ${}^{p}_{q}Z$,then from the equation of reaction,

$235 + p = 144 + 90 + 2$

$p = (144 + 90 + 2) - 235$

$p = 1$

Also $92 + q = 56 + 36 + 0$

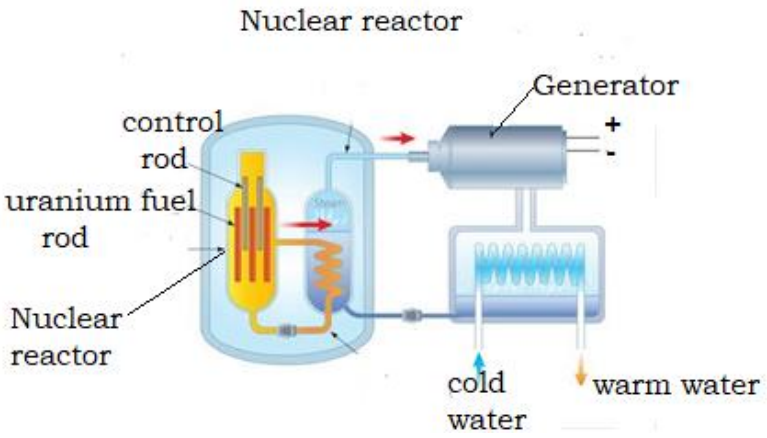
$q = (56 + 36 + 0) - 92$

$q = 0$

Hence Z is ${}^{1}_{0}Z$ which is a neutron.

${}^{139}_{56}Z$ is an isotope of X since they have the same atomic number but different mass number.

(b) The cheap electricity is nuclear power generated in a nuclear reactor at a power plant by a controlled nuclear fission reaction as follows;



- Uranium fuel (raw material) is prepared in form of pellets that are arranged in a fuel assembly(ies) which form a nuclear core
- When neutrons collide with uranium, nuclear fission takes place with release of more neutron and heat energy.
- The heat energy generated is transferred to a coolant like water or gas that circulates and transfers it to the steam generator upon being heated hence producing steam.
- The steam produced drives the turbines that are connected to the generator there by making them to spin.
- The connected generators to the spinning turbines covert their mechanical energy to electrical energy which is transmitted to the power grid and distributed to homes and industries for consumption.

(c) Dangers associated with radioactive substances

- Cause cancer
- Cause mutation
- Affect soil fertility through pollution
- Can cause sterility

Safety measures include;

- Avoid unnecessary exposure
- Wearing protective gears when at work
- Using tongs to handle radioactive substances
- Storing them in lead containers
- Proper waste management e.g by properly disposing wastes.

Item 6

(a) Count rate for uranium alone $= (6600 - 200) = 6400$ counts per hour

Half-life =2days

$$6400 \xrightarrow{2} 3200 \xrightarrow{2} 1600 \xrightarrow{2} 800 \xrightarrow{2} 400 \xrightarrow{2} 200 \xrightarrow{2} 100$$

$Time = 6 \times 2$

$= 12\ days$

(b) Natural resources

- Cosmic rays (radiation that reaches the Earth from space)
- Rocks and soil (some rocks are radioactive and give off radioactive radon gas)
- Living things (plants absorb radioactive materials from the soil and these pass up the food chain)

Artificial sources include

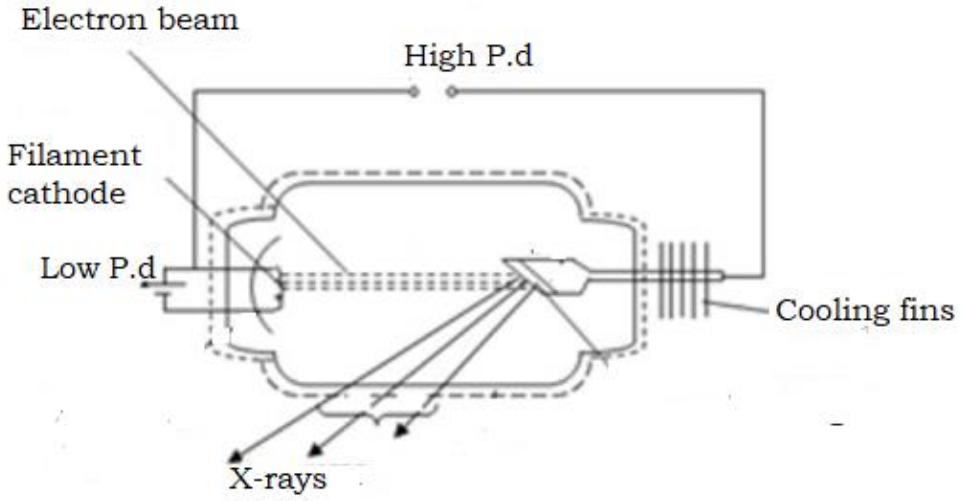
- Radioactive waste from nuclear power stations
- Medical X-rays
- Nuclear missiles (bombs when exploded release radiations into the environment)

(c) Environmental effects of uranium mining;

- Contamination of soil
- Local thermal pollution from waste affects marine life (water pollution)
- Creates radioactive wastes which remain radioactive and dangerous to human radioactive and dangerous to human health for thousands of years
- Dust pollution. Mining operations generate dust may contain radioactive particles impacting air quality
- Uranium mining releases radon gas which can travel long distances in air
- Long-term waste storage. Waste is radioactive and safe disposal is very difficult and expensive
- Disrupts ecosystem e.g underground mining disturbs large areas of land, leading to habitat loss for plants and animals
- Uranium mining and milling contribute to greenhouse gas emissions.

Item 7

(a) The electromagnetic waves used are X-rays
They can be produced in an X-ray tube
Illustration



How they are produced.

- The filament cathode is heated to emit electrons thermionically emission by the low voltage supply.
- A high pd is applied across the anode to accelerate the electrons towards the anode.
- When Cathode rays strike the metal target, about 99% of their kinetic energy is converted into heat energy and 1% is converted into X-rays.

(b) Protective measures include;

- Wearing protective gears like lead aprons on sensitive parts of the patient's body.
- Reducing exposure time

(c) On graph

Item 8

a) The home fan could only operate and allow to be turned on by the relay switch only when there is bright light and high temperatures.

b) Logic gates can be applied into

- Digital watches
- Calculators
- Computers
- Digital multimeters.

c) (i) The electrician

A	B	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

(ii) The son

A	B	C	D	E (OUT-PUT)
0	0	0	0	1
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	0	1
1	1	0	0	1
1	1	1	1	0

ITEM 9

(a) Some places having day time while others having night time was due to earth's rotation on its axis for about 24 hours.

- As the Earth rotates, parts of the Earth face the sun receive direct sunlight there by getting illuminated hence day time.
- Parts of the Earth that face away from the sun are not illuminated by sunlight therefore they are in a shadow hence experiencing night time.

Various parts having different weather seasons was due to the Earth's axial tilt of 23.5 degrees to its orbital plane and its revolution around the sun.

- As it revolves around the sun throughout the year plus areas being at different latitudes (distances from the equator),
- The areas close to the sun experience hot days, longer daytime that night time there by experiencing dry season or summer.
- The areas on the opposite side experience cold seasons, shorter days than nights hence experiencing wet or winter seasons. When the sun is over head(equinox). The length of days is equal to night hence spring.

(b) From;

$$Avearge\ speed = \frac{Distance\ travelled}{time}$$

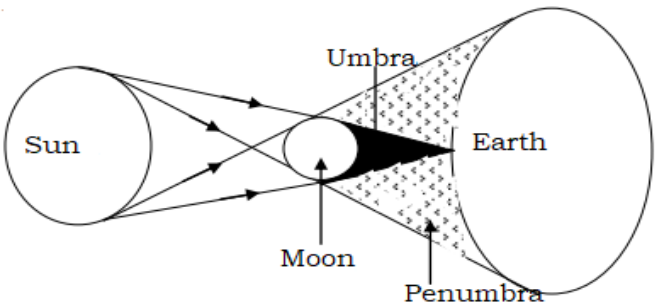
$$= \frac{2\pi r}{t}$$

$$= \frac{2 \times \pi \times 149{,}600{,}000}{365 \times 24}$$

$$= 107{,}301.8861 kmh^{-1}$$

ITEM 10

a) This particular type of eclipse is solar eclipse. It occurs during the day when the moon is between the sun and the earth, and the moon close to the earth. Total solar eclipse occurs when the light rays from the sun are blocked by the moon and umbra shadow of the moon reaches the earth.



b) The ***colours*** of stars depend on their surface temperature. The hotter the star the more blue it is and the colder the star, the more red it is.

Intermediate colours white and yellow have moderate temperature.

Brightness of stars depends on the following

- Distance from the earth. Stars closer to the earth are brighter than those that are far from earth
- Surface temperature. Hotter stars are brighter than colder stars.
- Size of the star. Bigger stars with a larger surface area from which light is emitted tend to be brighter than smaller stars of smaller surface area
- Age of the star. Young stars are blue and brighter than in red giant phase because young stars have high rates of nuclear fusion.

Stars appear to twinkle

When light from the stars enter the atmosphere, it is continuously refracted by regions with different temperatures and optical densities. When light rays are refracted towards the observer, a star is seen and when the rays are refracted away from the observer, the star disappears. This explains why stars appear to twinkle.

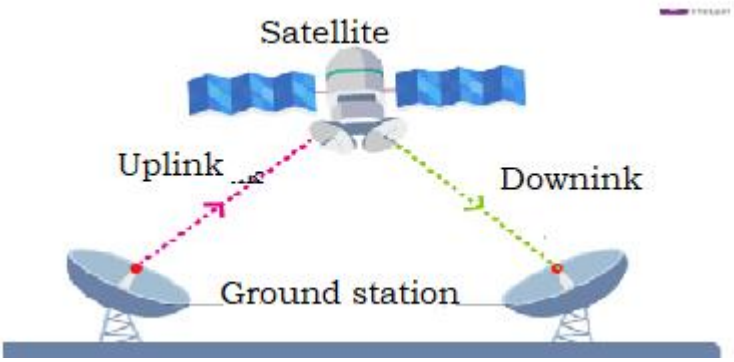
c) The energy released during nuclear fusion is the major source of energy of stars.

- This energy is produced at the centre of the star where the pressure is very high.
- Hydrogen atoms fuse together to form helium in a nuclear fusion process releasing a huge amount of energy in the form of light and heat.

It is advisable to wear solar glasses in or to prevent radiations from the sun to damage the eyes. Solar eclipse can cause solar blindness or retinal burns known as solar retinopathy.

d) People around the world were able to view eclipse by use of communication satellites.

- TV stations or providers transmit their programs in form of microwaves. Ground stations transmit signals to communication satellites using radio waves.
- The signals picked by the geostationary satellite in space (uplink) are weak due to the distance travelled.
- The geostationary satellite in space then amplifies (boosts) the signals and the signals are then retransmitted and received by the satellite dishes installed at subscribers' homes.
- These Signals can carry various types of data, including voice, video and can be viewed worldwide as television broadcast.



Item 11

(a) The GPS was able to locate the signals like;

- After the rider turning on GPS on his smart phone, the smart phone got connected to at least four satellites which normally orbit the earth in the middle Earth orbit
- The satellites are equipped with multiple atomic clocks
- The satellites continuously transmit radio signals containing their location and current time.
- The receiver (smart phone) calculates the time taken for the signals to arrive
- The receiver then calculates its position by combining the distances from the satellites
- This eventually gives the exact location of the person on Earth.

Time taken by signals to reach the receiver;

$$From\ Time = \frac{distance}{average\ speed}$$

$$= \frac{35786 \times 1000}{3 \times 10^8}$$

$$= 0.119s$$

(b) Working of communication satellites;

- When you speak into your smart phone, the voice is converted into digital signals by the phones microphone and software.
- The phone sends signals as radio waves to the nearest cell tower.
- From the cell tower, the signal is sent to your mobile network provider (earth station) equipped with large satellite dishes which uplink the signal to a satellite in the geostationary orbit
- The satellite transponder receives the signals, amplifies and re-transmits them via the downlink to the earth station at the receiver's end.
- The earth station connects to the receiver's smartphone that that receives the digital signals.

- The phone finally converts the data back to sound, making the friend to hear the voice.

(c) Uses of satellites;

- Navigation satellites are used to determine the ground position of an object e.g ships or any object in space e.g aircraft. They are vital to military forces.
- Weather satellites are used to
  - Monitor weather and climate of the earth
  - Predict weather conditions such as rainfall and temperature.
  - Monitor how weather conditions, storms, hurricanes and cyclones develop and change overtime.
- Astronomical satellites are used to;
  - Take pictures of planets in the solar system
  - Make star maps and galaxies
  - Understanding origin of the universe e.g the observe the cosmic microwave background radiation.
  - Research satellites provide land survey and data.
  - Communication satellites can also be used for radio and Tv broadcasting and for internet applications.
- International space station (ISS) the largest manmade satellite has the following uses;
  - Testing new space technologies
  - Supporting future missions to the moon and mars
  - Scientific research in space medicine, material science and astrophysics.
  - Serves as a base for international cooperation in space.
  - It's a home for international crews of astronauts.

(d) The variation of water levels are Ocean tides are brought due to the moon's gravitational pull being more than the Sun's gravitational pull. When the moon is directly above a given point of the Earth, it causes the water level in the ocean to bulge(increase) leading to a high tide. At the same time, a second high tide occurs on the opposite side of the Earth due to the outward motion of water.

Ocean tides are important in;

- Generating tidal power
- Tourism.

(e) The energy released during nuclear fusion is what makes the stars to shine. This energy is produced at the centre of the star where the pressure is very high. Hydrogen atoms fuse together to form helium (nuclear fusion). The nuclear fusion process releases a huge amount of energy in the form of light and heat which makes the star to shine brightly as observed in the night sky.

Item 12

(a) The wooden pole did not break because it was in equilibrium. That is;
The sum of clockwise moments about a given fixed point is equal to the sum of ant-clockwise moments about the same fixed point.
The sum of forces in one direction is equal to the sum of force in the other direction.

(b)
At equilibrium,

$Sum\ of\ forces\ in\ one\ direction = sum\ of\ forces\ in\ other\ direction$

$$T_A + T_B = 500 + 50$$

$$T_A + T_B = 550N \ldots\ldots\ldots\ldots (i)$$

Also, taking moments about B

$$Sum\ of\ clockwise\ moments = sum\ of\ ant - clockwise\ moments$$

$$(T_A \times 2) = (50 \times 1) + (500 \times 1.5)$$

$$2T_A = 800$$

$$T_A = 400N \ldots\ldots\ldots\ldots (ii)$$

Substituting (ii) in (i)

$$T_A + T_B = 550N \ldots\ldots\ldots\ldots (i)$$

$$400N + T_B = 550N \ldots\ldots\ldots\ldots (i)$$

$$T_B = 150N$$

(c) $heat\ energy\ supplied = heat\ energy\ gained\ by\ the\ meat$

$$(P \times t) = mc\Delta\theta$$

$$750 \times t = 16500 \times 120$$

$$t = \frac{1{,}980{,}000}{750}$$

$$t = 2{,}640\ s$$

Time in minutes;

$t = \frac{2640}{60}$

$t = 44\ minutes$

$Total\ time = (44 + 10)$

$\boldsymbol{Total\ time} = 52\ \boldsymbol{minutes}$

The hunters did not deliver the meat in time.

ITEM 13

(a) $Pressure\ difference = \mathrm{P}_{bottom} - \mathrm{P}_{top}$

$$\rho_{air} h_{air} g = \left(\frac{76}{100} \times 13600 \times 10\right) - \left(\frac{72.12}{100} \times 13600 \times 10\right)$$

$$1.2 \times h_{air} \times 10 = (0.76 \times 13600 \times 10) - (0.7212 \times 13600 \times 10)$$

$$12h_{air} = 103360 - 98083.2$$

$$12h_{air} = 5276.8$$

$$\boldsymbol{h_{air} = 439.73333m}$$

There, the height of the mountain from the bottom is $\boldsymbol{439.73333m}$ and since it is far beyond 430m, the will nose bleed. This is because at the top of the mountain, the atmospheric pressure is much less than the blood pressure in the body of the tourist, The difference causes nose bleeding.

(b) $$heat\ suplied = heat\ gained\ by\ the\ water$$

$$heat\ supplied = mc\Delta\theta$$

$$294000 = 1 \times 4200 \times (\theta_2 - 26)$$

$$\frac{294000}{4200} = (\theta_2 - 26)$$

$$70 = (\theta_2 - 26)$$

$$\boldsymbol{\theta_2 = 96^0 c}$$

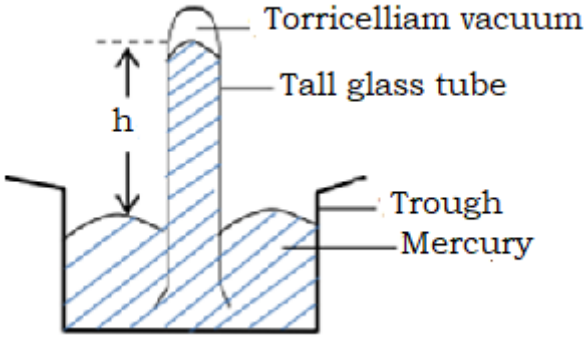
This implies that the water will boil quickly at the top of the mountain but at a lower temperature below $\boldsymbol{100^0 c}$. This is because atmospheric at the top of a mountain (high) altitude is lower than the atmospheric the atmospheric pressure at sea level (low altitude), this reduces the saturated vapour pressure above the liquid and since a liquid-boils when its saturated vapour pressure is equal to atmospheric pressure, reduction in the SVP lowers the boiling point of water.

(c) The instruments to design is a mercury barometer. And this designing involves the following steps.

- Filling a 1m long thick-walled tube**:** A 1 m long thick-walled tube is filled with mercury.
- Inverting the filled tube: The above filled is inverted several time with finger over the open end. This is done in order for the large air

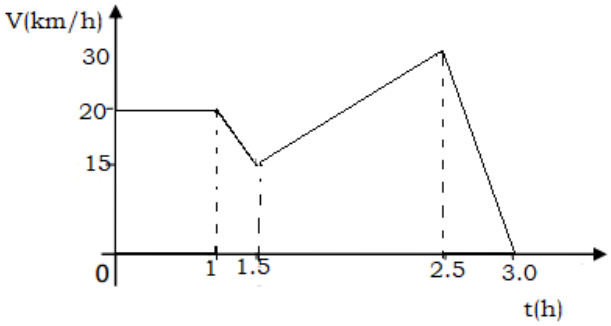
bubble to run up and down collecting any air small air bubble in mercury.

- Refilling the tube: After inverting several times, the tube is refilled with mercury.
- Inverting the filled tube into a trough: With a finger on the open end, the filled tube is inverted into a bowl of mercury. When the finger is removed, the mercury column falls until it is equal to atmospheric pressure.



Item 14

(a) A sketch of a velocity-time graph showing the motion of the driver



Total distance co

$= 20 \times 1 + \frac{1}{2} \times 0.5(20 + 15) + \frac{1}{2} \times 1(15 + 30) + \frac{1}{2} \times 0.5 \times 30$

$= 58.75km$

Total fuel consumed $= 58.75 \times \frac{1}{4}$

$= 14.6875\ litres$

Conclusion: The driver was cheated by petrol station attendant since the fuel consumed is less than the fuels tank capacity.

(b) The stability of the by-passing vehicle can be improved by having luggage loaded in the boot(base) of the car to lower its Centre of gravity.

(c) A moving car tyre in contact with the road experiences a frictional force that generates the heat energy. The heat energy generated increases the temperature of the tyre and the gas(air) inside which in turn increases the kinetic energy of the air molecules.
As the kinetic energy of the molecules increases, their rate of collision with themselves and the inner walls of the tyre increases giving rise to a greater internal gas pressure. When this air pressure is greater than the external pressure, the tyre bursts. Therefore, the fact that the tyre was already hot, a further continuation of the journey would make it burst.

Item 15

(a) The driver needs to use water as a coolant since its locally available and it has a high specific heat capacity of $4200Jkg^{-1}K^{-1}$. This implies that a small amount of water can be absorb large quantities of heat dissipated by the engine.

(b) Assume no heat losses,

Total heat energy produced by the engine = heat energy gained by water.

$p \times t = mc\Delta\theta$

$10000 \times (1.05 \times 60) = m \times 4200 \times 30$

$630000 = 126000m$

$m = 5kg$

But mass $m = \rho \times v$

$5 \times 1000 = 1 \times v$

$v = 5000cm^3$ which is equivalent to 5litres.

Therefore, the man would have added 5litres of water.

(c) From the principle of conservation of linear momentum.

$$m_l u_l + m_s u_s = m_l v_l + m_s v_s$$

$$3500 \times u_l + 1500 \times 0 = 3500 \times 20 + 1500 \times 15$$

$$3500u_l = 92500$$

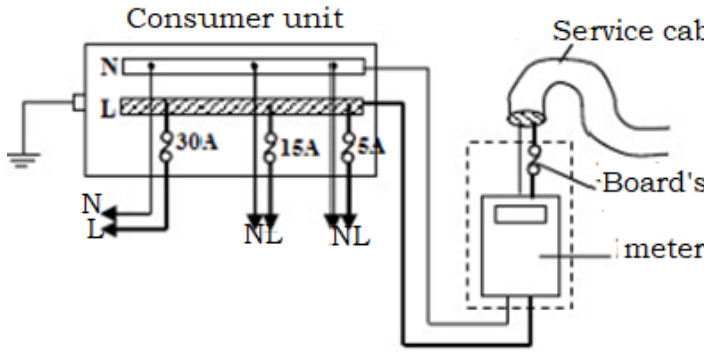
$$u_l = 26.429ms^{-1}$$

Given that the speed limit is $60kmh^{-1} = \frac{60\times1000}{1\times60\times60} = 16.666ms^{-1}$. Since the initial speed of the lorry is greater than the speed limit, then he was over speeding.

The collision was elastic collision since they moved separately after collision.

ITEM 16

a) Illustration for domestic house wiring.



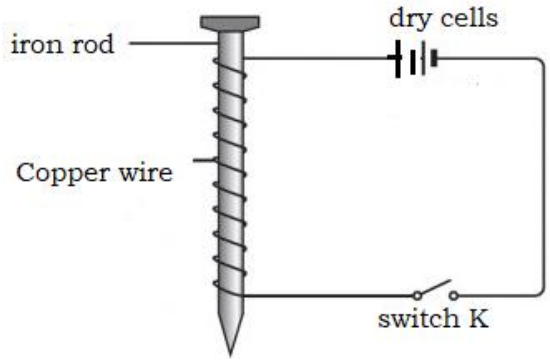
Power enters the house through the supply cable from the electric pole from which two insulated wires, the live and neutral wire come from, which are distributed by color i.e , the live wire is red/brown, neutral wire is blue/black and earth wire is yellow/green / yellow with green strips.

The earth wire, is green earthed, and its at zero potential while the live wire is at a potential of 240V.

The circuit board consists of the following;

- Switches: These are connected to the live wire so as to control the flow of current in the house(circuit)
- Fuses: These are connected to the live wire with a rating of slightly above the value of current required by the device since it melts when the current exceeds the required value.
- Sockets: These are power points usually put on the walls of the house and they have 3 holes leading to the live wire L, neutral wire N, and earth wire E.
- Plugs: These are points which connect or tap power from the socket to the appliances by fitting in the 3 holes of the socket.

b) An electromagnet is suitable for lifting of scrap metals since it can be easily magnetised and demagnetised.



- The copper wire (insulated) is wound around the iron rod connected in series with the fresh pair of dry cells.
- Switch K, is closed to allow flow of direct current through, the iron rod, for about 5 minutes.
- After, the device can be tested by bringing some soft pins near its ends, and it is found out to attract the soft pins meaning that it has been magnetised since the direct current aligns all the magnetic dipoles of such a material to face in one particular direction.
- Therefore, whenever the switch would be closed, the crane containing the electromagnet can be used to lift the scrap, and during the offloading, the switch is opened so that the electromagnet loses its magnetism. Hence making suitable for such industrial purposes.

c) Dry cells can be arranged in parallel connection so as to supply little at time to the electromagnet.

Consider two cells of emf, E_1, $and\ E_2$, with internal resistances, r_1 and r_2 respectively.

When connected in parallel,

$$E = E_1 = E_2 = 1.5V$$

And effective internal resistance $r = \frac{0.1\ x0.1}{0.1+0.1}$ =0.05 ohms

Using ohm's law:

$$V = I(R + r)$$

$$1.5 = I\ (2 + 0.05)$$

$hence\ I = 0.73$A

But for series connection;

$$E = E_1 + E_2 = 1.5 + 1.5 = 3.0\,V$$

Effective internal resistance, $r = r_1 + r_2 = 0.1 + 0.1 = 0.2\,ohms$

$$V = I\,(R + r)$$

$$3 = I\,(2 + 0.2)$$

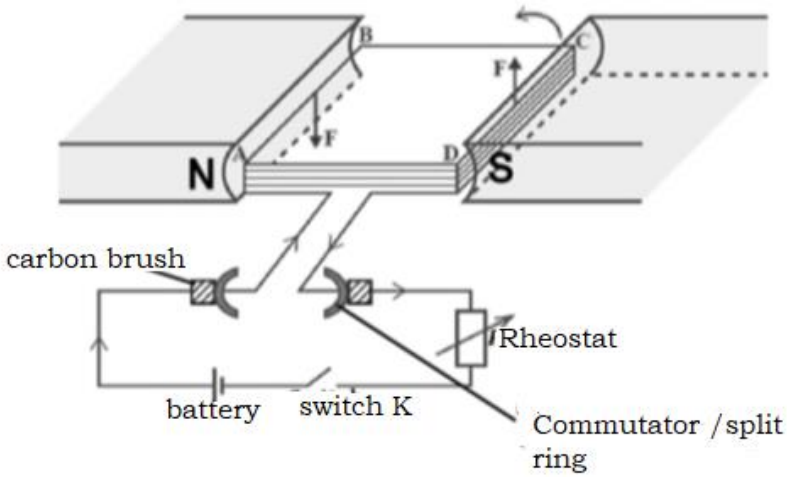
$$I = 1.36\,A$$

Hence the dry cells should be connected in parallel so as to supply less current at time which increases its life span since less current implies slow rate of chemical reactions in the dry cell.

Item 17

a) The electromagnetic device was an electric motor that would convert the electrical energy into kinetic energy for providing the rotational energy of the plastic rods.

How it operates



Mode of Operation

- When the switch is closed, current flows into the rectangular coil ABCD.
- Side CD experiences an upward force and side AB experiences a downward force according to Fleming's left-hand rule.

- The two forces form a couple which causes the coil to rotate in the anticlockwise direction.
- When the coil rotates until it reaches the vertical position, the carbon brushes lose contact with the commutators and current is cut off.
- However, the coil continues to rotate and passes over the vertical position due to the momentum gained.
- The two commutators interchange contacts with carbon brushes.
- This reverses the direction of current in the coil and the forces experienced by the sides of the coil.
- The coil continues to rotate as long as the current is rotating.

b) The labels on the fan mean that 75 joules of electrical energy per second are needed to run the electric fan when connected to 240V supply.

c) The phenomenon was lightning and it was caused by buildup and sudden release of electrical charge within a thunder-storm cloud.
Lightning is an electric discharge that occurs when two electrically charged regions collide with each other forming sparks with release of energy.

How it occurs

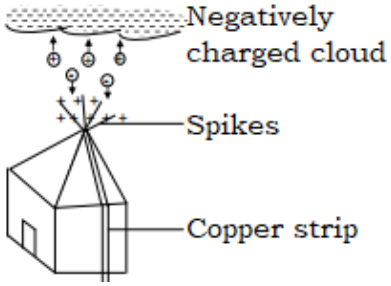
- Within the clouds, ice crystals and water droplets collide with each other there by getting charged by friction with the upper cloud being positively charged and the lower cloud negatively charged
- The negatively charged cloud at the bottom induces an opposite charge (positive) on the ground which concentrates on pointed bodies like tress or tall buildings
- Once the cloud becomes highly charged, negative charges rush down towards the earth there by attracting positive charges on the ground hence pulling them upwards.
- When these two charges meet, a strong electric current is generated (discharge) which is depicted as a bright flash of light called lightning.
- During the discharge, the thermal energy generated (due to rapid expansion of air) is converted to partly sound energy depicted as thunder. so thunder and lightning wasn't a punishment from gods as previously adopted.

Their property can be protected by installing of a lightning conductor since;

- When a negatively charged cloud passes over the spikes of the lightning conductor, it induces positive charges at the spikes of the conductor.
- At the spikes, there is high charge density due to the high concentration of charges.
- This high charge density causes ionization of air molecules around forming positive and negative ions.
- The positive charges on the spikes repel away the positive ions and attracts the negative ions which come neutralize the positives on spikes.

- The repelled positive ions also move upwards to the cloud and neutralize some of the negatives on the clouds.
- The remaining excess charges(electrons) are conducted away by the copper plate to the ground hence reducing the effect of lightning.

Illustration



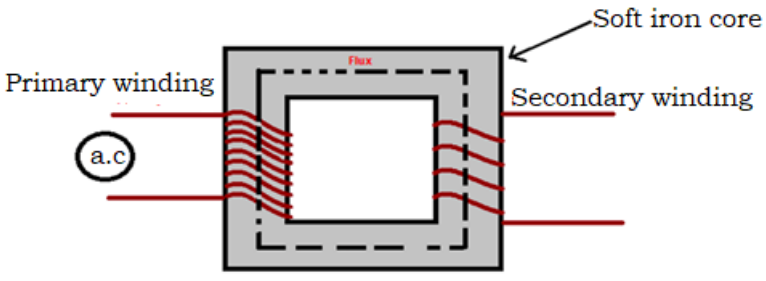
(d) People should;

- Seek shelter by going indoors.
- Avoid being under tall objects like trees and power lines and flag poles.
- Where necessary unplug electronics when it's raining.
- Wearing rubber foot wears.

ITEM 18

(a) The device required is a step-down transformer. It will be used to step down the high 240V voltage to the smaller voltage consumed by the radio.
A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. Transformers are vital in adjusting voltage levels, making them essential for safe and efficient electricity distribution across different applications.
A step-down transformer is a device that reduces the voltage of an alternating current (AC) power supply. It achieves this by having more turns of wire in the primary coil (the input side) than in the secondary coil (the output side). This configuration causes the output voltage to be lower than the input voltage.

Labelled diagram of a step-down transformer.



Operation of a step-down transformer

- AC Input: An alternating current (AC) voltage is applied to the primary winding of the transformer.
- Magnetic Field: The AC current in the primary winding creates a fluctuating magnetic field within the iron core.
- Induced Voltage: The changing magnetic field in the core induces an electromotive force (EMF) or voltage in the secondary winding.

- Turn Ratio: The ratio of the number of turns in the primary winding (Np) to the number of turns in the secondary winding (Ns) determines the voltage transformation.
- Voltage Reduction: In a step-down transformer, Ns is less than Np, resulting in a lower voltage in the secondary coil compared to the primary coil.
- Output: The induced voltage in the secondary winding is then available as the output voltage, which is lower than the input voltage.

Key Concepts:

- **Electromagnetic Induction:** The process by which a changing magnetic field induces a voltage in a conductor, as described by Faraday's law.
- **Mutual Induction:** The phenomenon where a changing magnetic field in one coil induces a voltage in a nearby coil.
- **Iron Core:** The iron core enhances the magnetic flux linkage between the primary and secondary windings, improving the efficiency of the transformer.

In essence, a step-down transformer utilizes electromagnetic induction and the turn ratio to efficiently reduce AC voltage to a lower, usable level.

(b) Since the maximum coil should be of 80 turns, then we shall have the primary coil with 80 turns, and therefore look for the possible number of turns in the secondary coil as per with the required voltage.

Given:$N_P = 80, V_P = 240V, N_S =, ? V_S =?.$

Looking $for\ V_S =?\ \ , from\ \ P = IV, V_S = \frac{360W}{3A} = 120V$

, from Transformer equation $\frac{V_P}{N_P} = \frac{V_S}{N_S}\ \ N_S = \frac{120X80}{240}\ , N_S =\ 40\ turns$

Hence the specifications of the transformer will include 80 turns in the primary coil and 40 turns in the secondary coil so as to be able to supply the radio with appropriate rating of 3A,360W.

(c) To establish this, we shall calculate the energy required by the devices and compare with the reading of the electric meter on assumption that there is no any other consumption/energy loss.

Device	Consumption details	No. of units
Radio	From energy =power×time $=\frac{360W}{1000}$x$\frac{45}{60}$hrs×14days = 3.78 KwHr	3.78 units
Bulb	$\frac{7W}{1000} \times 5 \times 14DAYS \times\ 3bulbs = 1.47\ KwHr$	1.47 units
Total number of units to be consumed		5.25 units

Therefore, since the metre reads $\mathbf{5.65}\ \boldsymbol{KwHr}$**,** then the electrical energy will be sufficient to run the appliances for that stipulated period.

(d) (i)***Detailed precautions while using electric energy***.

1. Water and Electricity:

- Never: use appliances near water. This includes sinks, baths, showers, and swimming pools.
- Don't: touch electrical appliances with wet hands or bare feet.
- Always: unplug appliances before cleaning, especially if they've been near water.
- Consider: installing Ground Fault Circuit Interrupters (GFCIs) in areas where water is present, like bathrooms and kitchens.

2. Cords and Plugs:

- Inspect: cords regularly for damage, and replace any that are frayed, cracked, or brittle.
- Avoid: overloading outlets by plugging in too many appliances at once.
- Don't: run cords under rugs or in high-traffic areas.
- Unplug: appliances when not in use to prevent accidental shocks and fires.
- Always: pull on the plug when unplugging, not the cord, to prevent damage.
- Make sure: the plug is properly inserted into the outlet and not loose.

3. **Appliance Safety:**

- Never: leave heating appliances like hair straighteners or toasters unattended.
- Follow: manufacturer's instructions carefully when using any appliance.
- Don't: use appliances with damaged cords or plugs.
- Keep: appliances out of reach of children.
- If: you suspect an appliance is malfunctioning, have it inspected by a qualified service person.

4. **General Safety:**

- Always: switch off an appliance before unplugging it.
- Wear: rubber-soled shoes when using appliances on concrete floors or outdoors.
- Be aware: of your surroundings and keep a safe distance from power lines.
- If: you see a downed power line, stay away and contact the utility company.
- Seek: immediate medical attention if you experience an electric shock, even if it seems minor.

d(ii)

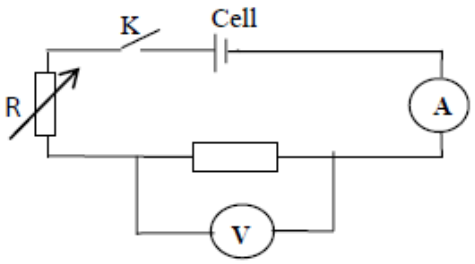
- Switch to energy saving devices like energy saving bulbs
- Boil the quantity of water you only need
- Switch off bulbs in rooms you are not using
- Keep rooms closed and curtains on cold days to avoid loss of heat and keep them open for proper aeration during dry seasons.

- Switch off bulbs during day
- Limit use of 'vampire devices.

ITEM 19

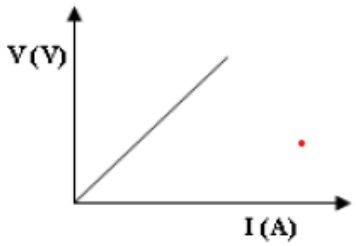
(a) The law to be proved is called Ohms law and it states that that the current through an ohmic conductor is directly proportional to the P.d across it provided the physical conditions remain constant.

The set up below may be used to prove the law



Procedure:

- The ammeter, rheostat, one of the resistors and a switch are connected in serries with the battery shown above. The voltmeter is connected in parallel with the resistor so as to read the p.d drop across the resistor. This is because the resistor has a very high resistance as compared to the ammeter connected in serries.
- Starting with the maximum rheostat adjustment Switch, K is closed, and a current, I flows through the circuit.
- The ammeter reading and the corresponding voltmeter reading are read and recorded.
- The rheostat is adjusted to obtain several values of V and I recorded in a suitable table.
- A graph of V against I is plotted and this gives a straight line through the origin as showed below:



This verifies ohms law.

(b) There are two ways of arranging such resistors i.e Serries and parallel arrangement as detailed below.

For serries:

From Ohms law : $V = IR, Where\ R = (R_1 + R_2),\ I = \frac{9}{3+4} = 1.288A$

For parallel

from Ohms law : $V = IR,\ where\ R = \left(\frac{R_1R_2}{R_1+R_2}\right), R = \frac{3x4}{3+7} = 1.2\Omega, I = \frac{9}{1.2} = 7.5A$

Hence , from the calculations above , it is evident that the parallel connection will allow more current to flow than the serries arrangement hence the parallel combination is highly recommended.

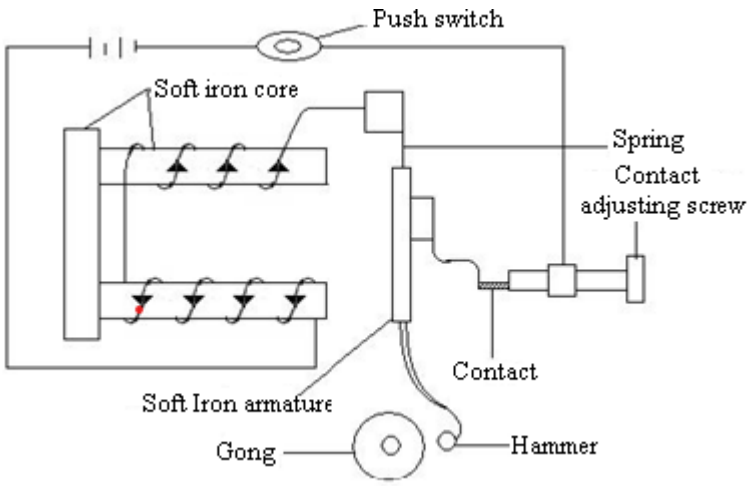
(c) The ammeter was measuring d.c current which is unidirectional. Therefore, it deflected in different direction because the terminals (negative & positive) were altered. I therefore advise learners to always change the terminals of the ammeter or voltmeter whenever they experience such.

(d) A current-carrying wire has moving electric charge (current) which generates a magnetic field around the wire. This magnetic field exerts a force on the compass needle, causing it to align with the magnetic field lines, which are circular and centered on the wire.

The compass needle, which is essentially a small magnet placed near the wire, will deflect when placed near a current-carrying wire due to the interaction between the magnetic field produced by the current and the magnetic field of the compass needle.

(e) The device is an electric bell

Structure and operation of an electric bell



It consists of a hammer, a gong, soft iron armature, contact adjusting screw, a push switch, steel spring and an electromagnet made of two coils wound in opposite directions on the iron core.

Operation

- When the switch is pressed, current flows through the electromagnet which becomes magnetized.
- It attracts the soft iron armature and hence breaking the contacts.
- This causes the hammer to strike the gong and sound is heard.
- As the armature moves, the current is broken causing the electromagnet to lose its magnetism. The spring pulls the armature again to its original position and contact is made again.
- The process is repeated on and on hence a continuous sound will be heard.

END