



UCE 500/1 General science Paper 1 2014

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UCE 500/1 General Science Paper 1 2024 (physics)

Time 1hour 30 minutes

Marking guide

Compulsory section A

Item 1

An old man and his granddaughter were walking along a flat road on a hot day when they saw a sheet of water a short distance ahead, which disappeared as they moved closer to it.

The old man told his grand daughter that he has grown up seeing such and many other occurrences whose causes is unknown and no explanation can be given.

When the granddaughter asked her grandfather for example the many other occurrences, he could not remember.

Tasks

- (a) (i) State the name of the occurrence they saw.
 - (ii) what causes such occurrence?
- (b)(i) Define the cause of that occurrence
 - (ii) State the laws of the cause of that occurrence
 - (iii) Give an explanation of the occurrence
- (c) (i) List two other examples of other occurrences due to the same cause.
 - (ii) Explain any other occurrence due to the same cause.

Suggested answers

(a)

- (i) The occurrence they saw is called a **mirage**.
- (ii) A mirage is caused by the **refraction of light rays** when they pass through layers of air at different temperatures (temperature gradients).

(b)

(i) **Definition of the cause:** The cause is **refraction of light** — the bending of light rays as they travel from one medium to another with different optical densities (in this case, hot and cool air layers).

(ii) **Laws of refraction (Snell's Law):**

1. The incident ray, the refracted ray, and the normal all lie in the same plane.
2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for the same pair of media:

$$\frac{\sin i}{\sin r} = n$$

where n is the refractive index.

(iii) **Explanation of the occurrence:**

- On a hot day, the ground heats the air just above it, making it less dense than the cooler air above.
- Light rays from the sky bend (refract) as they pass through these layers of air.
- The bending makes the rays appear to come from the ground, creating the illusion of water or a shiny surface.
- As one approaches, the angle changes and the “water” disappears.

(c)

(i) **Two other examples of occurrences due to refraction:**

1. A stick appearing bent when partly immersed in water.
2. A fish appearing closer to the surface than it really is.

(ii) **Explanation of another occurrence (stick in water):**

- When light passes from water (denser medium) to air (less dense medium), it bends away from the normal.
- This bending makes the submerged part of the stick appear displaced, so the stick looks bent at the water's surface.

Item 2

Moses has a radio that uses dry cells. When his radio cannot produce good sound after using the cells for some time, he removes the cell and puts them under sunshine for some time. On fixing the cells back in the radio, it produces better sound for while but moses does not know why this happens.

One day, while he had put the dry cells under sunshine, his children removed one of th cells and dismantled it.

The children were surprised by the different parts they saw and were left wondering about the structure of the cell.

The children also wondered if there were er cells in the same category to which Moses's cell belonged as well as other categories of cells.

Task

(a)(i) Why would the radio produce a better sound whenever Moses fixed back the cells?

(ii) What is the general name given to the category to which Moses' cells belong.

(iii) Describe the structure of the cell and the functions of the different parts the children saw.

(b)(i) Give one example of other cells in the same category as that of Moses'.

(ii) Explain one defect of the cells Moses uses.

(iii) How is the defect overcome

(c)(i) Give one other category of cell besides that to which Moses's cells belong.

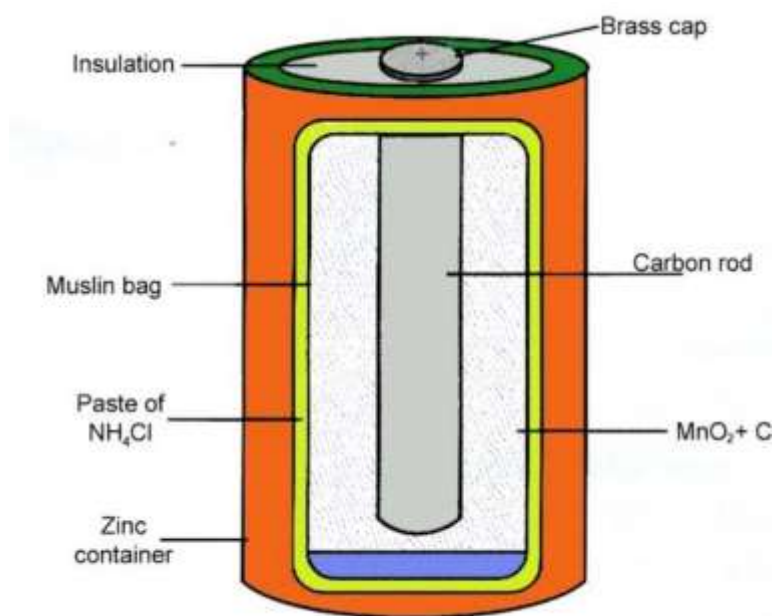
(ii) Sate the difference between the other category and that to which Moses' cell belongs.

Suggested answers

(a)

- (i) The radio produces better sound after the cells are put in sunshine because **heat temporarily increases the chemical activity inside the dry cell**, allowing it to deliver a slightly higher voltage/current for a short time.
- (ii) The general name of the category to which Moses' cells belong is **primary cells** (non-rechargeable cells).
- (iii) Structure of a dry cell and functions of its parts:

Parts of dry cell



- **Zinc container** → acts as the negative electrode (anode).
- **Carbon rod (central)** → positive electrode (cathode).
- **Electrolyte paste** (ammonium chloride and zinc chloride) → provides ions for the chemical reaction.
- **Manganese dioxide** → depolarizer, prevents hydrogen gas buildup.
- **Paper/pitch seal** → keeps the cell intact and prevents leakage.

(b)

- (i) Another example of a cell in the same category: **Leclanché cell** (the wet version of the dry cell).
- (ii) One defect of dry cells: **Polarization** — hydrogen gas forms on the carbon electrode, reducing efficiency.
- (iii) How the defect is overcome: By using a **depolarizer** (manganese dioxide) which reacts with hydrogen and prevents its accumulation.

(c)

- (i) Another category of cells besides primary cells: **Secondary cells** (rechargeable cells, e.g., lead-acid accumulator).
- (ii) Difference between primary and secondary cells:
 - **Primary cells:** Non-rechargeable, once chemicals are used up they are discarded (e.g., dry cell).
 - **Secondary cells:** Rechargeable, chemical reactions can be reversed by passing current through them (e.g., car battery).

Summary Table

Feature	Primary Cells (Dry Cell)	Secondary Cells (Accumulator)
Rechargeable?	No	Yes
Example	Dry cell, Leclanché cell	Lead-acid battery
Voltage per cell	~1.5 V	~2 V
Lifespan	Short, disposable	Long, reusable
Common uses	Radios, torches, clocks	Cars, UPS, solar systems

Item 3

Josep whose mass is 50kg, was driving on a flat road to his place of work and his car of mass 1870kg suddenly stopped because it had run out of fuel.

He requested the men who were nearby to help him push the car up to the fuel station that was 100m ahead.

As the men started pushing the car while Joseph was in the driver's seat holding the steering wheel to control the car, the car could not easily move yet Joseph had not applied the brakes. This puzzled the men.

When the men persisted with the pushing with increased force, the car eventually moved the pushed non-stop until it reached the petrol station in 4 minutes.

On reaching the fuel station, Joseph had to apply brakes for the car to stop.

As an appreciation, Joseph paid some money to the men, He thanked them for the force, energy, power they had used as well as the work done.

However, the men did not understand the terms Joseph used, how they related and why Joseph had to first apply brakes for the car to stop.

Task

(a)(i) Explain the men's puzzle

(ii) What is the meaning of the terms used when thanking the men?

(iii) State how the terms Joseph used are related.

(b)(i) Determine the work done by the men.

(ii) Explain why the car could only stop after Joseph's action

Suggested answers

(a)

(i) **Explanation of the men's puzzle:**

At first, the car resisted motion because of **inertia** and **frictional forces** (rolling resistance between tires and road, internal friction in the car's parts).

A greater force was needed to overcome these resistances and set the car in motion. Once moving, less force was required to keep it going.

(ii) Meaning of the terms Joseph used:

Force: A push or pull that changes the state of motion of an object.

Work: The product of force and displacement in the direction of the force.

$$W = F \cdot d$$

Energy: The capacity to do work. The men used muscular energy to push the car.

Power: The rate of doing work.

$$P = \frac{W}{t}$$

(iii) Relationship of the terms:

Force applied over a distance produces **work**.

Work is a measure of **energy transferred**.

Power is the **rate at which energy/work is done**.

(b)

(i) Work done by the men:

Mass of car = 1870 kg

Mass of Joseph = 50kg

Total mass pushed = 1870 + 50 = 1920kg

Distance = 100 m

Time = 4 minutes = 240 s

Work is given by:

$$W = F \cdot d$$

Here, the minimum force needed is equal to the weight of the car's mass resisted by friction. **Since exact friction is not given**, we assume the men overcame the resistive

force and moved the car uniformly. The work is simply the product of the total weight pushed and distance moved (idealized case when coefficient of friction = 1).

$$W = (1920 \times 9.8) \times 100$$

$$W = 18,816 \cdot 100 = 1,816,600 \text{ J}$$

So, the men did approximately **1.88×10^6 joules of work.**

(ii) Why the car could only stop after Joseph's action:

Once in motion, the car had **inertia** and **kinetic energy**.

It continued moving until an external force (brakes) provided enough friction to dissipate the kinetic energy.

Without brakes, the car would roll on until resistive forces (road friction, air resistance) gradually stopped it, but much farther ahead.

Summary Table

Term	Meaning	Relation
Force	Push/pull	Initiates motion
Work	Force $\times$ distance	Energy transferred
Energy	Capacity to do work	Source of work
Power	Work $\div$ time	Rate of energy use

Item 4

A mister had a flight to catch before 9.00am. She informed the head of her security that they had to set off at 7.00 a.m and instructed him to design a travel plan that she does not miss the flight.

The head of security instructed the driver using technical terms of motion that, when they set off the minister's home, the driver should uniformly accelerate the car and cover 10km in fifteen minutes. After that time, the driver should maintain the velocity attained by the car for the next two-third of the total distance they are supposed to cover and then retard uniformly up to the airport in half an hour.

He shared the plan with the minister and assured her that with that plan, they would take 1 ½ hours to reach the airport.

However, the driver did not understand the meaning of the technical terms of motion the head of security used as well as the distance they were supposed to cover by maintaining the velocity attained by the car.

The driver also wondered what the total distance was.

Task

(a)(i) Explain the meaning of the technical terms used by the head of security.

(ii) State how the technical used by the head of security related

(b) (i) Determine the distance they were to cover by maintaining the velocity attained by the car.

(ii) Find the total distance

Suggested answers

(a)

(i) **Meaning of the technical terms of motion:**

Uniform acceleration: The car's velocity increases at a constant rate.

Velocity attained: The speed reached at the end of the acceleration period.

Maintain velocity: Move at constant speed (no acceleration).

Uniform retardation: The car's velocity decreases at a constant rate until it stops.

(ii) **Relation of the terms:**

Acceleration increases velocity.

Constant velocity means no acceleration or retardation.

Retardation decreases velocity until the car stops.

Together, these describe the three stages of motion: speeding up, moving steadily, and slowing down.

(b)

Step 1: Distance during acceleration

Given: distance = 10 km = 10,000m , time = 15 min = 900 s.

Formula: $s = \frac{1}{2}at^2$.

Final velocity: $v = at$.

From $s = \frac{1}{2}at^2$:

$$10,000 = \frac{1}{2}a(900^2)$$

$$a = \frac{20,000}{810,000} \approx 0.0247 \text{ m/s}^2$$

Final velocity:

$$v = at = 0.0247 \times 900 \approx 22.2 \text{ m/s}$$

Step 2: Distance at constant velocity

Time taken during constant velocity = Total time – (time of acceleration + time of retardation)

$$= (1.5\text{h} - (15\text{min} + 30\text{min}))$$

$$= (90\text{min} - 45\text{min})$$

$$= (45 \times 60)\text{s}$$

$$= 2700\text{s}$$

Distance = velocity $\times$ time = $22.2 \times 2700 \approx 59940 \text{ m}$.

Distance $\approx$ **59,940 km**.

Step 3: Distance during retardation

- Time = 30 min = 1800 s.
- Distance $\approx$ **20 km**.

Step 4: Total distance

$$10 \text{ km} + 59.94 \text{ km} + 20 \text{ km} \approx 89.94 \text{ km}$$

So the **total distance $\approx$ 89.94 km**.

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