UGANDA NATIONAL EXAMINATIONS BOARD

Uganda Advanced Certificate of Education

P510/1 PHYSICS

SCORING GUIDE

FOR THE SAMPLE PAPER

SECTION A:

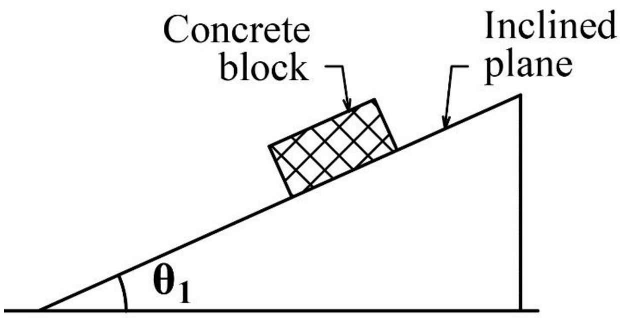
In items 1 to 6, to obtain the highest level of achievement, the candidate is expected to:

- ***Carry out analysis;*** *explains/ describes experiences or phenomena or observations using physics concepts on effect of force on the body/ material, coherently. i.e. why things happen the way they are; the* ***what****,* ***how*** *and* ***why****.*
  - *Gives advantages/ disadvantages, compares things, forms an opinion and supports it with force concept.*
  - *Uses at least ¾ of the* ***key words/points/terms in Force/motion*** *in the explanation/ description.*
  - *If data is provided:*
    - ***Substitutes*** *into the formula* ***correctly****.*
    - *Obtains the required value.*
    - *Uses the obtained value to make a decision/ give advice to address the challenge.*
    - ***Uses illustration*** *(where applicable).*
- *Proposes a complete or working solution(s) to the challenge(s) provided on the construct/ Justifies or supports the proposal/ examine the mode of operation of a device.*

Item 1

POSSIBLE RESPONSES:

(a) (i) A piece is out of the boards to act as a small inclined plane.

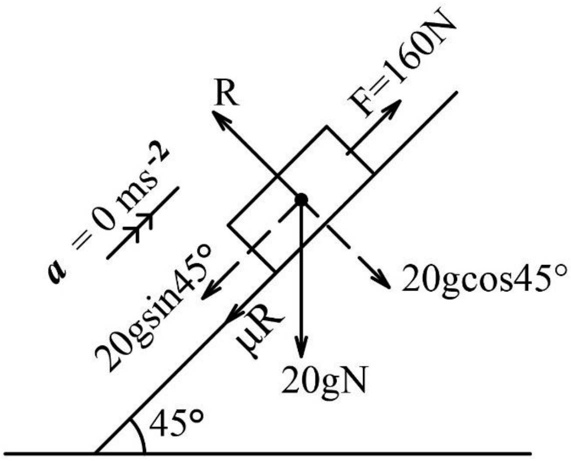


– A concrete block is placed on the surface of the piece of wood from one of the boards.

– The piece of wood is tilted until it the block slides down with uniform velocity. At that moment, the angle θ_1 the block makes with the horizontal is measured and noted. The value of $\tan\theta_1$ is determined.

– The experiment is repeated using the surface from the other board. The angle, θ_2, the block makes with the horizontal is measured and noted.

– The board with smaller value of $\tan\theta$ has small value of the coefficient of friction, and should therefore be used to make the inclined plane.



At constant velocity, $a = 0$.

$160 - (20g \sin 45 + \mu R) = 0$

But, $R = 20g \cos 45 = 20 \times 9.81 \cos 45 = 138.734N$

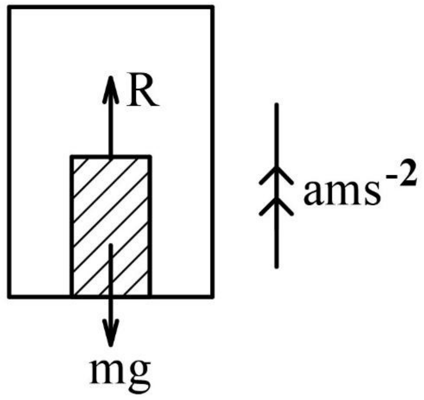
$20g \sin 45 + \mu \times 138.734 = 160$

$\mu = \frac{160 - 20 \times 9.81 \sin 40}{138.734}$

$\mu = 0.15$

Since the coefficient of friction is less than 0.2, the installed plane is efficient.

(ii) When in a lift, the apparent weight is the normal reaction from the lift.



At the start of the motion, the lift accelerates at a rate of a ms^{-2}.

From, $R - mg = ma$

$R = mg + ma$

The apparent weight, R, is greater than the actual weight, $W = mg$. Thus, Alex thus feels heavier.

When motion has progressed, the lift moves with uniform velocity. Hence, acceleration of the lift is zero.

$R - mg = 0$

$R = mg$

The apparent weight R is equal to the actual weight of Alex. Therefore, Alex feels normal weight.

Just as the lift comes to a stop, the lift decelerates at a rate a' ms^{-2}.

$R - mg = -ma'$

$R = mg - ma'$

The apparent weight, R is then less than the actual weight, thus Alex feels lighter.

(b) To solve the problem of too much smoke in the kitchen, a hollow metallic pipe is inserted through the roof of the kitchen to create a chimney. When wind blows over the chimney pipe, the increased air velocity reduces the pressure above the pipe.

The pressure inside the pipe is then greater than the pressure above the pipe.

The pressure difference creates a suction effect. The smoke is continuously drawn out of the kitchen.

ITEM 2

POSSIBLE RESPONSES:

(a) **Section P:**

The coil is connected to a 12 V (low voltage supply) and heated to produce electrons by

thermionic emission.

The electrons are accelerated by (a high p.d.) 2 kV towards the cylindrical anode. The energetic electrons constitute cathode rays. The speed, u, of electrons is obtained from: $\frac{1}{2}mv^2 = eV_a$

$$u = \sqrt{\frac{2(1.6\times10^{-19})(2\times10^3)}{9.11\times10^{-31}}} = 2.65 \times 10^7 \text{ms}^{-1}$$

Section Q:

The cathode rays that path through the anode enter into crossed fields which only allows particles of a certain speed to (pass through) proceed.

In this region:

$eE = Beu'$

$u' = \frac{E}{B} = \frac{7.2\times10^4}{3.0\times10^{-3}} = 2.4 \times 10^7 \text{ms}^{-1}$

Since $u' < u$ or (since $2.65 \times 10^7 > 2.4 \times 10^7 \text{ms}^{-1}$), the cathode rays will proceed through section Q.

Section R:

The cathode rays are further accelerated by a high p.d of 21 kV to the metal target.

When cathode rays strike the metal target, 99% of their energy is converted to the heat at the anode and 1% into x-rays.

Observations: The x-rays produced have energy of.

$E = \frac{1}{100}eV_a{}'$

$E = \frac{1}{100}(1.6 \times 10^{-19}) \times 21 \times 10^3 = 210\ eV$

Since the x-rays are directed on the metal plate of work function $100\ eV < 210\ eV$, photoelectric emission will take place.

The emitted electrons will lead to a net positive charge on the gold-leaf which makes it diverge.

(b) **Application of the effect:**

ALT 1: Solar energy utilization. The effect is applied in solar panels which absorb light/electromagnet radiation to produce photoelectric current. The photoelectric current charges the battery which is then used to produce electricity for use.

ALT 2: Photo electric sensors in alarm/automated door systems. Light beam is made incident on a photocell producing photocurrent. When an intruder interrupts the light electron flow is interrupted which triggers an alarm/open the door.

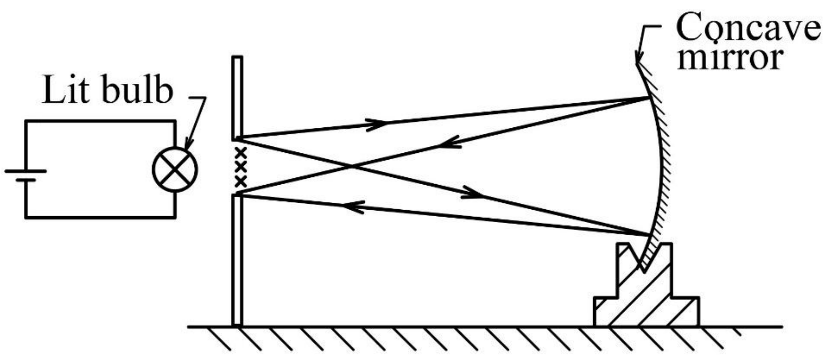
SECTION B

PART I

Item 3

POSSIBLE RESPONSES:

(a) Determination of the focus of a concave mirror.



Source of light is placed behind the hole of a screen with cross-wires.

A concave mirror is mounted in a holder and moved to and fro in front of the screen until a sharp image of the cross wires is adjacent to the cross wire.

The distance between the mirror and screen is measured and recorded as, r.

The focus, $\frac{r}{2}$.

Properties of the radiation:

The radiation is an electromagnetic wave with the following major properties.

- Can propagate in vacuum.
- Moves at the speed of light in air (3×10^8) m/s.
- Has a shorter wavelength (higher frequency).
- Formed a shorter wavelength electric and magnet fields.

Working process of the system (application process)

Electromagnetic wave from the sun is reflected by the concave mirror unto the focus where all the intensity will be concentrated

The energy is absorbed by the blackened bulb of the thermometer.

The thermometer converts thermal energy into electrical pulses which enables the digital thermometer to read the temperature.

If the temperature is high enough, it implies that the heat concentrated at that point can be used for cooking.

Maximum temperature:

Power received = (Solar constant/Energy Intensity) × Area

$$= 100\pi {r_A}^2$$

$$= 100\pi(0.1)^2$$

= 3.1416 W

By Stefan's law;

Power received = $A_b \delta T^4$

$$3.1416 = 4\pi(5 \times 10^{-3})^2(5.67 \times 10^{-8})T^4$$

$$T = 648.044 \text{ K}$$

$$T = 648.044 - 273 = 375.044\ °C$$

Quantity of heat received = Heat capacity × Temperature difference

$$= C(\theta_2 - \theta_1)$$

$$Q = 70(375.044 - 20)$$

$$Q = 24853.08\, J = 24.853\, kJ$$

Since, $Q > 20\ kJ$, the system is effective for cooking without using electricity or firewood.

(b) Improving efficiency of the solar system:

- Increase the diameter of the concave mirror.
- Using a parabolic mirror to increase the radiation intensity at the focus.
- Container for cooking should be made rough and blackened.
- Shielding the system from drought.
- Lagging parts of the cooking utensil leaving only the parts of exposed to radiation exposed.
- Silvering the inner walls of the container.

ITEM 4

POSSIBLE RESPONSES:

(a) The water waves are:

Progressive, since the wave energy is moved/transferred across the water surface at a constant speed.

Mechanical, since the waves are created by wind producing disturbance in the water.

Transverse, the particles of water vibrate up and down normal to the direction of energy transfer creating crests and troughs with constant amplitude of 1.5 m.

Safety check:

Amplitude, A= 1.5 m, y = 1.5 $\sin\frac{\pi}{3}(t-\frac{2x}{6})$

Wave height, h = (1.5 × 2) = 3.0 m

50% of boat length = $\left(\frac{50}{100}\times 8\right)$ = 4.0 m

Since, h = 3.0 m < 4 m, the boat is safe to buoy.

y = 1.5 $\sin\frac{\pi}{3}(t-\frac{2x}{6})$,

compare with $y=\sin A\sin(\omega t-\frac{2\pi x}{\lambda})$

$\omega=\frac{\pi}{3}=1.0472$ rad[-1]

λ = 18 m

$\omega=2\pi f, f=\frac{\omega}{2\pi}=\frac{\pi}{3(2\pi)}=0.1667$ Hz

Velocity of a wave:

$v = f\lambda = 0.1667 \times 18$

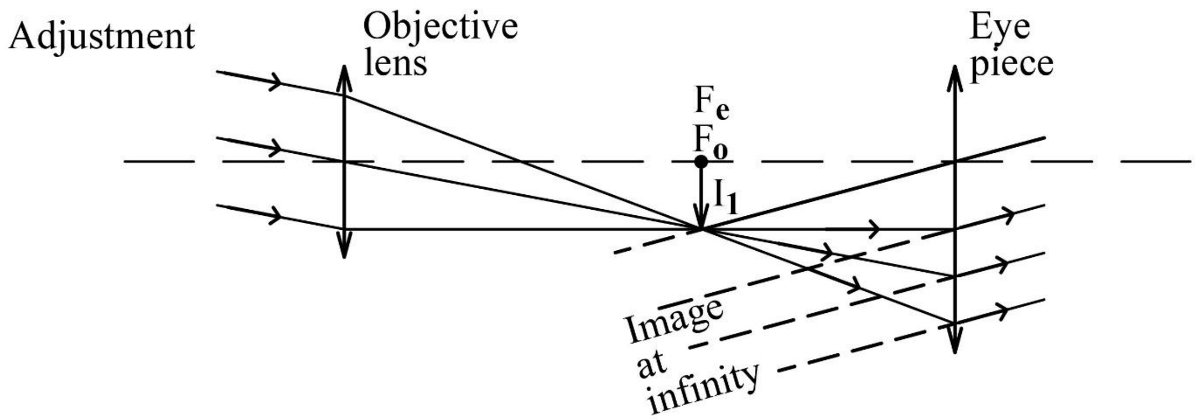
$v = 3.0\ ms^{-1}$

Maximum vertical acceleration of points on the wave:

$a_{max} = \omega^2 A = (\frac{\pi}{3})^2 \times 1.5 = 1.645\ ms^{-2}$

since wave height (h=3 m) is less than 50% of boat length = 4 m, velocity of the wave = 3.0 ms^{-1} is less than 6.0 ms^{-1}, and maximum acceleration of wave particle, 1.645 $ms^{-2} \leq 1.7\ ms^{-2}$, the boat is safe for navigation during windy conditions.

b) The crew members need an optical instrument that can clearly view distant objects like astronomical telescope in normal adjustment.



A telescope is pointed to a distant object/direction in the lake. The objective lens forms a real image, I, of distant object at the focal point, F_o, of the objective.

The image I, acts as the object for the eye piece.

The eyepiece lens is adjusted such that, I, is at the focal point, F_e, of the eye piece.

The final image formed by the eye piece is magnified, inverted, virtual and formed at infinity.

NB:

- All types of telescopes maybe used.
- The working of a prism binoculars.

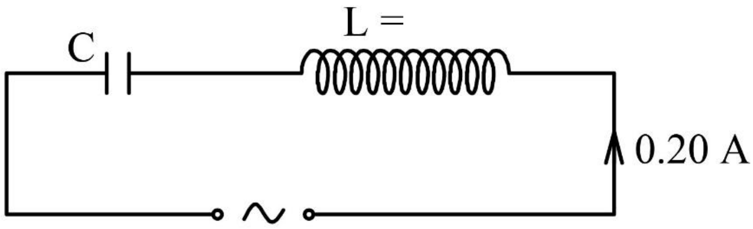
SECTION B
PART II

ITEM 5

POSSIBLE RESPONSES:

For the circuit to pick the radio signal, the circuit must be in electric resonance at the frequency of the radio signal.

At resonance, current flowing is maximum impedance of the circuit is minimum, and capacitive reactance is equal to inductive reactance.



$X_L = 2\pi f L$, $X_C = \frac{1}{2\pi f C}$, $2\pi f L = \frac{1}{2\pi f C}$, $f = \frac{1}{2\pi\sqrt{(LC)}}$

$L = \frac{1}{4\pi^2 f^2 C}$

A capacitance : $C_O = \frac{\varepsilon_O A}{d} = \frac{8.85\times10^{-12}\times1.5\times10^{-3}}{0.5\times10^{-3}} = 2.655\times10^{-11}$

For capacitors in parallel: C = $(10\times\ C_o) = 10\times2.655\times10^{-11}$

$C = 2.655\times10^{-10}F$

Inductance, $L = \frac{1}{4\pi^2\times(62\times10^6)^2\times2.655\times10^{-10}}$

$L = 2.48\times10^{-9}$ H

Magnetic flux density of the coil:

$B = \mu_o n I$

$1.0\times10^{-3} = 4.0\pi\times10^{-7}\times\frac{200}{l}\times0.2$

$l = 5.0\times10^{-2}$m

The capacitor discharges through the coil, producing current.

The current produces magnetic field in the inductor, storing energy in the magnetic field.

When the capacitor is completely discharged, magnetic field in the coil collapses inducing *e.m.f* that recharges the capacitor in the opposite direction.

This continuous exchange of energy produces continuous flow of charge in the circuit.

The *a.c* meter gives a reading, which is the *r.m.s* value of current in the circuit.

b) Heating of the solid iron in the coil is due to eddy currents induced in it, as magnetic flux changes.

This is applied in an induction furnace to melt metal.

A metal to be melted is inserted inside a solenoid carrying a high frequency current.

The high frequency a.c creates a very strong changing magnetic flux. A large amount of eddy currents produces heat that meets the metal.

ITEM 6

POSSIBLE RESPONSES:

(a) 1st test: $V_R = kl$

1st case: $10\, I_1 = 715\, k$............................ (i)

$E = I_1(r + R)$

$E = \frac{715}{10}k(r + 10 + 25)$ .... (ii)

2nd case: $10\, I_2 = 582\, k$ .... (iii)

$E = I_2(r + R)$

$E = \frac{582}{10}k(r + 10 + 33)$ .... (iv)

(iv) = (ii):

$71.5k(r + 35) = 58.2k(r + 43)$

$1.2285(r + 35) = r + 43$

$r = 0.011\, \Omega$

2nd case: $V_B = IR = 0.96 \times 50 = 48\, V$

$\frac{V_A}{V_B} = \frac{N_A}{N_B}$, $N_B = 4\, N_A$

$\frac{E}{48} = \frac{N_A}{4N_A}$

$E = 12\, V$

Since, $r < 1.0\, \Omega$, and the *e.m.f*, lies in the required range, then the battery is of good quality and customer's complaints were not valid.

Explanation of Heat: Moving electrons pass through the resistor with much energy. When they collide with an atom vibrating about its mean position, they give up some of their energy to the atom. This increases the amplitude of vibration of atoms due to collisions which generates heat in a realistic operation.

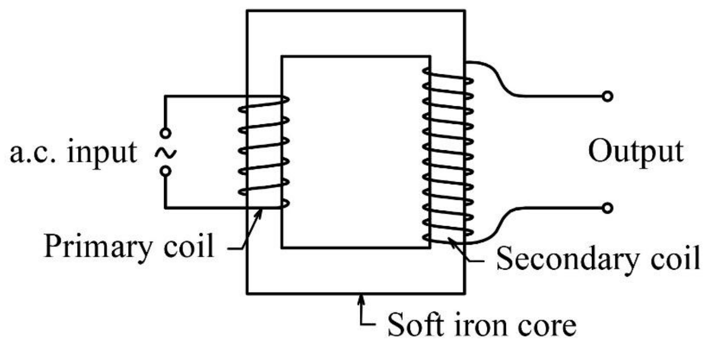
(b) The device which uses the set-up is a transformer.

It is applied in power stations to step-up voltages. This helps in generating high voltages into transformer lines.

Alternating current in the primary coil produces an alternating magnetic flux in the iron core which links up the secondary coil which produces induced e.m.f in the coil.

Since, the number of turns in the secondary coil is greater than those in the primary than those in primary coil, the voltage is stepped up in the secondary, since *e.m.f* is proportional to *N*.

Structure:



NB: The setup is also applied in an induction coil (ignition coil)