UNITED REPUBLIC OF TANZANIA
MINISTRY OF DEFENCE AND NATIONAL SERVICE
MILITARY SCHOOLS ASSOCIATION
FORM SIX PRE-NATIONAL EXAMINATON

131/1 PHYSICS 1

TIME:3 Hours DATE: 27 FEBRUARY 2024

INSTRUCTIONS

1. This paper consist sections A and B with a total of **ten** questions.
2. Answer **all** questions in section A and choose **only (2)** questions from section B.
3. Cellular phones and any unauthorized materials are not allowed in the examination room.
4. Mathematical table and non-programmable calculator may be used.
5. Write your examination number on every page of your answer booklet.
6. The following constants may be used;
   - Acceleration due to gravity g = $9.8ms^{-2}$
   - Universal gravitation constants, G = $6.67 \times 10^{-11}Nm^2kg^{-2}$
   - Latent heat of vaporization = 106 JKg^{-1}
   - Pie,3.14
   - Universal molar gas constant, R = 8.314J/mol K
   - Boltzmann constant, k = $1.38 \times 10^{-23}JK^{-1}$
   - Thermal conductivity of brass = $109Wm^{-1}K^{-1}$

SECTON A (70 Marks)

Answer **all** questions in this section

1 (a) (i) What is dimensionless variable? Give out its example

(ii) The de Broglie wavelength associated with a moving electron depends on its momentum and the value of planks constant. Prove the equation, $h = \frac{\lambda}{p}$ is dimensionally correct.

(b) (i) Applying formula where it does not hold is a mistake or error? Explain by giving difference between the two key terms

(ii) Asha was doing simple pendulum experiment and noted that time period of oscillation is given by $T = 2\pi\sqrt{\frac{l}{g}}$. In finding the value of g, which quantity should be measured most accurately and why?

2 (a) (i) Explain how in a the horizontal range of a projectile is affected when its initial velocity is doubled for a given angle of projection, θ?

(ii) The velocity of maximum height of a projectile is half of its initial velocity of projection u_o. What is the horizontal range of the projectile?

(b) (i) What is the nature of the projectile motion?

(ii) An aero plane travelling horizontally at $78ms^{-1}$ at a height of 210m drops a bomb to hit a target. At what horizontal distance should the bomb be released to hit the target?

3 (a) Explain the following phenomena as applied in Newton`s law of motion

(i) If action and reaction are equal in magnitude and opposite in direction, why do not they always cancel each other and leave no net force for acceleration of a body?

(ii) Explain why the length of horse pipe when is lying in a curve on a smooth horizontal surface straightness on it, when a fact flowing stream of water passes through it.

(b) Rain falls vertically onto a plane roof, 1.5m square, which is inclined to the horizontal at an angle of 30℃. The rain drops strike the roof with a vertical velocity of $30ms^{-1}$, and a volume of $2.5 \times 10^{-2}m^3$ of water is collected from the roof in one minute. Assume that the conditions are steady and that the velocity of the raindrops after impact is zero, calculate:

(i) The vertical force exerted on the roof by the impact of the falling rain; and

(ii) The pressure normal to the roof due to the impact of the rain.

4 (a) (i) Explain with the help of relation, how the angle of banking depends on the mass of vehicle?

(iii) A car whose wheels are 1.5 apart laterally and whose center of gravity is 1.5m above the ground rounds a curve of radius 250m. Find the maximum speed at which the car travels without toppling.

(b) A bob of mass 0.1kg hung from the ceiling of a room by a string 2m long is set into oscillation. The speed of the bob at its mean position is $1ms^{-1}$. What is the trajectory of the bob if the string is cut when the bob is *(a)* at one of its extreme position *(b)* at its mean position?

5 (a) (i) Why water is preferred as a cooling agent in many automobile engines?

(ii) The peak of Mountain Kilimanjaro is closer to the sun than a boy on the level ground. During a hot day, a boy on the level ground surfer's hotness than the ice on the peak survive while is closer to the sun. How can you explain this?

(b) A brass boiler has a surface of $1.5m^2$ and thickness of 1cm. it boils water at the rate of 6 kilogram per minute when placed on a gas stove. What is the temperature of the part of flame in contact with boiler?

6 (a) (i) The tile floor feels colder than the wooden floor even though both floor materials are at the same temperature. Why?

(ii) Identify three limitations of the first law of thermodynamics.

(b) (i) Why water at the base of waterfall is slightly warmer than at the top?

(ii) What amount of heat must be supplied to 2×10^{-2}kg of nitrogen at room temperature rise its temperature by 45◦C at constant pressure? Molecular mass of N_2 IS 28g and R = 8.3Jmol^{-1}K^{-1}

7 (a) (i) What is the role of solar radiations in agriculture?

(ii) List four changes that take place at a location just before onset of an earthquake at The particular location

(b) (i) State the influence of oxygen and carbon dioxide to plant gases

(ii) Explain the effect of rainfall on the renewal of soil air

SECTION B (30 Marks)

Answer **only two (2)** questions from this section

8 (a) (i) Briefly explain why electrical appliances are connected in parallel at home?

(ii) A resistor R in series with capacitor C is connected to 50Hz, 240V supply. Find the value of C so that R absorbs 300W at 100V.

(b) For the circuit shown in the figure below, answer the questions that follow

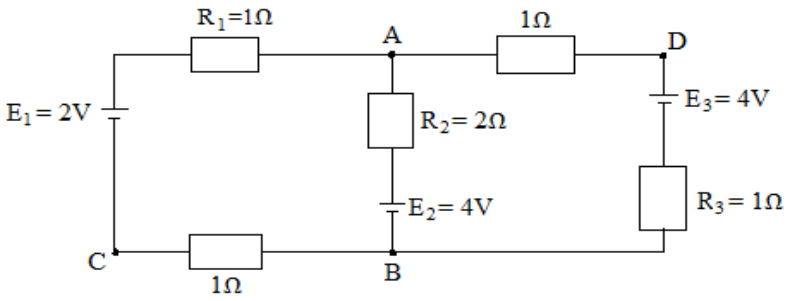

Figure 1

(i) Find the current through R_2.

(ii) Find the potential difference between point C and D

(c) (i) Why a bulbs in a house became dim when a high power heater is connected to the main supply

(ii) Why is Wheatstone bridge not suitable for measuring low resistances?

9 (a) How does the arrangement of energy level in a semiconductor differ from that of an insulator?

(b) Using a notion of energy bands, explain the following optical properties of solids.

(i) All metals are opaque to light of all wave lengths

(ii) Semi-conductors are transparent to infrared light although opaque to visible light.

(iii) Most insulators are transparent to visible light

(c) Figure 2 shows a LED circuit. The LED has a minimum drop of 1.5V and a maximum drop of 2.3V. If the supply voltage is 10V and $R_1 = 470k\,\Omega$. What is minimum and maximum value of current in a LED circuit?

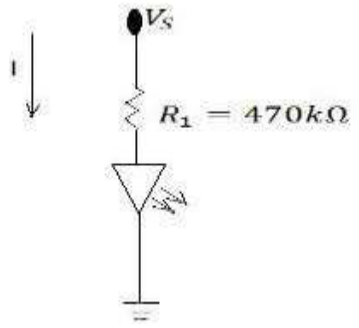

Figure 2

10 (a) (i) Outline two advantages of digital circuit over analogy circuits

(ii) Draw any combination of basic gates, showing logic circuits that implements the express $X = AB + BC$

(b) (i) How many NAND gates are required to make a NOT gate?

(ii) Construct the truth table from the logic gates shown in Figure 3

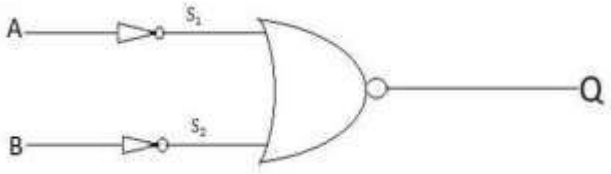

Figure 03

(c) (i) How can you implement a NOT gate using transistors?

(ii) Differentiate Amplitude Modulation from Frequency Modulation.

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PHYSICS - 01. YEAR: 2024.

(MARKING SCHEME).

SECTION A (70 Marks).

01. (a) (a) Dimensionless Variable: Is the physical quantity which have neither dimension nor fixed value Example angle, strain, and specific gravity. (02 marks).

(ii). Consider the dimension of: $l = [L]$, $h = [ML^2T^{-1}]$ and $\rho = [ML^{-1}T^{-1}]$ ------ (01 mark)

The equation in terms of dimension will be:

$$[L] = \frac{[ML^2T]}{[ML^{-1}T^{-1}]} \text{ ---(01 mark)}$$

$$[L] = [L] \text{ ---- (01 mark)}$$

∴ From above equation; The dimension in right hand side is the same as that of left hand side. So equation is dimensionally correct as proved.

(b). (i). It is a mistake and not error. since mistake is a wrong way of doing something while Error is the uncertainity occured during the measured. —(02 mark)

(ii). Given: $T = 2\pi\sqrt{\frac{l}{g}}$ or $T^2 = \frac{4\pi^2 l}{g}$ ---(01 mark)

By applying ln both sides.

$$\ln T^2 = \ln\left(\frac{4\pi^2 l}{g}\right) \text{ or } \ln g = \ln\left(\frac{4\pi^2 l}{T^2}\right) \text{ ---(01 mark}$$

$$\frac{\Delta l}{l} + \frac{2\Delta T}{T} = \frac{\Delta g}{g}$$ (Fraction error in term of g) ---(01 mark)

From the above expression since any error in T is doubled up. Therefore, time should be measured most accurately. ---- (01 mark)

Q2. (a). (i). When the initial velocity of a projectile is doubled for a given angle of projection, the horizontal range will increase because the projectile's initial horizontal speed and time of flight both increase. (02 marks)

(ii). If the velocity of projection is U_0 at the highest point body possess only; $U_0 \cos\theta$

Therefore; $U_0 \cos\theta = \frac{U_0}{2}$ (Given) ---(01 mark)

$$\theta = 60^\circ$$

Now; $R = \frac{U_0^2 \sin 2\theta}{g}$

$= \frac{U_0^2 \sin 60 \times 2}{g}$ ---- (01 mark)

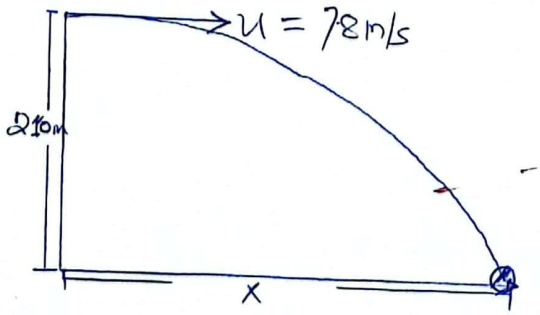
$$R = \frac{\sqrt{3}\, U_0^2}{2g} \text{ ---} \quad (01 \text{ mark})$$

∴ The horizontal range of the projectile is

$$R = \frac{\sqrt{3}\, U_0^2}{2g}$$

(b). (i). The nature of projectile motion is two dimensional motion as it involves horizontal and vertical motion of a body. ------ (02 marks)

(ii). Consider free Body diagram below:



---(01 1/2 mark)

Q2 (b). From $y = u\sin\theta\, t + \frac{1}{2}gt^2$ but $\theta = 0$

$$y = \frac{1}{2}gt^2 \quad \text{---} \quad (00\tfrac{1}{2}\text{ mark})$$

$$t = \sqrt{\frac{2y}{g}} = \sqrt{\frac{2\times 2\cdot 10}{9\cdot 8}}$$

$$t = 6\cdot 5\text{sec} \quad \text{---} \quad (01\text{ mark})$$

Also; from; $R = u \times t$

$$= 78 \times 6\cdot 5\text{ sec}$$

$$R = 507\text{m} \quad \text{---} \quad (01\text{ mark})$$

∴ Horizontal distance will be 507m.

Q3 (a) (i). Action and reaction which are equal in magnitude and opposite in direction do not cancel each other because they act on different bodies. ------ (02 marks)

(ii). The horse pipe is smooth horizontal because the stream of water is external force which is straight line, when acted on it changes the slope. ---- (02 marks)

(b). (i) from the equation; $F = V\, dm/dt$ But; $dm = \rho V$

So; $F = V\frac{\rho dv}{dt}$ --- (01 mark)

Where; $\frac{dv}{dt}$ is the rate of change of volume of water collected from the roof

$F = 30\text{m/s} \times 1000\,\text{kgm}^{-3} \times \frac{2\cdot 5\times 10^{-2}\text{m}^3}{60}$ (01 mark)

03 (b). (i). $F = 12.5\ N$ ---- (01 mark)

∴ The vertical force exerted on the roof 12.5 N

(ii). pressure normal to the roof, $P = \frac{F_N}{A}$

Since; the roof inclined at an angle, 30°

$F_N = F\cos\theta$ ---- (01 ½ mark)

$= 12.5 \times \cos 30$

$F_N = 10.83\ N$ ---- (01 ½ mark)

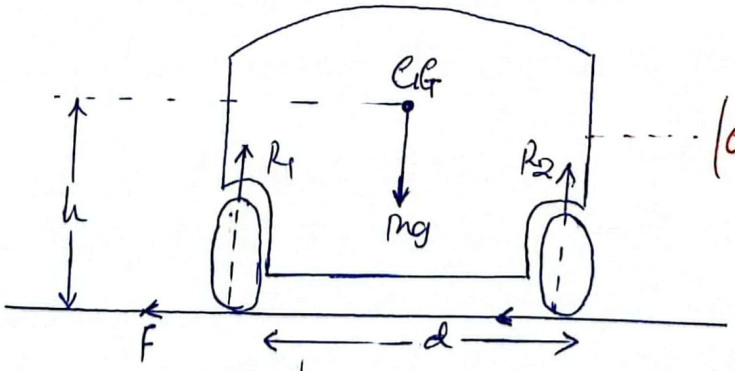
Then; pressure, $P = \frac{F_N}{A} = \frac{10.83\ N}{1.5 \times 1.5}$

$P = 4.81\ Nm^{-2}$ ---- (01 mark)

∴ The pressure normal to the roof will be $4.81\ Nm^{-2}$.

04. (a). (i). From the relation, $\tan\theta = \frac{v^2}{rg}$, since the relation does not contain mass of vehicle, so the angle does not depend on the mass of vehicle. --- (01 mark)

(ii). Consider free body diagram below:



(01 ½ mark)

Given: $d = 1.5m$, $h = 1.5m$

$R_1 + R_2 = mg$

$F = \frac{mv^2}{r}$ ---- (01 ½ mark)

04. (a). (ii). The frictional force f between tyres and the road provides the necessary centripetal force. At the instant of toppling, the left-hand wheel leaves contact with the ground so, that $R_1 = 0$ ... (01 mark)

Hence; $R_2 = mg$

Let; v_m be the maximum allowed speed.

Moment of frictional force about C.G = $f \times h$

But; $f = \frac{mv_m^2}{r}$; $C.G = \frac{mv_m^2}{r} \times h$ ... (01 mark)

Soi moment of R_2 about C.G = $R_2 \times \frac{d}{2}$

$= \frac{mgd}{2}$ ... (01 mark)

Hence; $\frac{mv_m^2}{r} \times h = \frac{mgd}{2}$

$v_m = \sqrt{\frac{gdr}{2h}} = \sqrt{\frac{9.8 \times 1.5 \times 250}{2 \times 1.5}}$

$v_m = 35 m s^{-1}$ ... (01 mark)

∴ The maximum speed for vehicle motion 35m/s.

(b). (a). When the bob is at the extreme position, its velocity is zero. Therefore; If the string is cut when the bob is at one of the extreme positions, the bob will fall vertically down under the action of gravity. ... (02 marks)

(b). When the bob is at mean position, its velocity is 1m/s along tangent to the circular path such as along horizontal direction. Therefore, if the string is cut when the bob is at mean position, the bob will behave as a projectile thrown horizontally with a velocity of 1m/s. Consequently, the bob will follow a parabolic path. ... (02 marks)

Q5. (a) (i). High specific heat capacity. Water relatively has high specific heat capacity compared to many other fluids. This means it can absorb and retain a significant amount of heat without a substantial increase in its own temperature. As a result, water is effective at absorbing heat generated by the engine and help maintain a stable operating temperature. ---- (03 marks)

(ii). Heat transfers from the sun to the earth by radiation and hence does not heat air particles around. The hotness of body feels due to amount of heat reflected back from the earth's surface and the ice at the peak is very far from the ground, hence ice does not get reflected heat and remains cold but the boy surfer's hotness. --- (03 marks)

(b). Given: Area, $A = 1.5m^2$, $L = 1mm$, K of brass $= 109 W m^{-1} K^{-1}$

Latent heat of vaporation $= 2.25 \times 10^6 J/kg$

$\theta_2 = 100°C$, $\theta_1 = ?$

from: $\frac{d\theta}{dt} = \frac{KA(\theta_1 - \theta_2)}{l}$ --- (01 mark) - for conduction

For vaporization; $\frac{\theta}{t} = \frac{mL_v}{t}$

$\frac{KA(\theta_1 - \theta_2)}{l} = L_v \frac{dm}{dt}$ ---- (01 mark)

$\frac{109 \times 1.5(\theta_1 - 100)}{0.01} = 225 \times 10^6 \times 6.$

$\theta_1 - 100 = 825.69°C$. --- (01 mark)

$\theta_1 = 825.69°C + 100°C = 925.69°C$

∴ The temperature will be: 925.69°C --- (01 mark)

06. (a).(i). It is because tile is a better heat conductor than wood. The heat transferred from your foot to the wood is not conducted away rapidly. So, the wood quickly heats up on its surface to the temperature of your foot. But the tile conducts the heat away rapidly and thus can take more heat from your foot, so its surface temperature drops. (02 marks)

(ii). Limitations of the first laws of thermodynamics.

(a). Does not indicates direction of heat transfer

(b). Does not tell anything about the conditions under which heat can be converted into work

(c). Does not tell why the whole heat energy can not be converted into mechanical work continously. (01 mark @).

(b).(i). The potential energy at the top gets converted into kinetic energy at the bottom. The kinetic energy partially converted into heat energy. when the water ~~heats~~ hits the ground. Consequently, there is slightly increase in the temperature of water. - - - - - (02 marks)

(ii). Heat added, $Q = n \times R \times \Delta T$

Where, n is the number of moles given by;

$$n = \frac{\text{mass of nitrogen (M)}}{\text{Molecular weight of nitrogen (M)}} \quad (01 \text{ mark})$$

$$\Delta Q = \frac{2 \times 10^{-2}\ kg}{28 \times 10^{-3}\ kg} \times 8.3\ J\,mol^{-1}\,K^{-1} \times 45^{\circ}C \text{ - - (01 mar}$$

$$= 266.8\ J.$$

∴ The ammount of heat that must be supplied is 266.8J. - - - - - - - (01 mark)

07. (a). (i). solar radiation produces energy for photosynthesis influencing plant growth and development in agriculture. - - - - - - - - (.01 mark)

(ii). Physical changes to occur are;

01. Changes of density of rocks.
02. Occurance of stresses
03. faults.
04. Waves.

(01/2 mark @)

(b). (i). positive influence of oxygen to plant growth.

- Used for respiration which enable plant to obtain energy for growth and metabolic activities.

Negative influences;

- It causes photorespiration which decrease plant yield and affect plant growth.
- It causes decline in process of photosynthesis

(03 marks)

positive influence of carbondioxide.

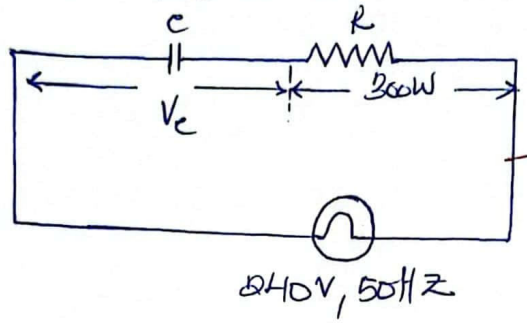
- Used as raw material for photosynthesis hence increase yield and plant growth.

(ii). When P and S waves are sent from one side of the earth to another, only P waves can be detected on other side, WHILE S-waves do not pass through the core provedes the evidence that the core consists of a liquid core.

(02 marks)

08 (a) (i). Electrical appliances are connected in parallel so as to reduce the resistance of these devices to the current flowing which reduce the power loses. - - - - - - (02 marks)

(ii). Consider the circuit below:



- - - (80½ mark)

$$E_V^2 = V_c^2 + V_R^2$$

$$V_c^2 = E_V^2 - V_R^2$$

$$V_c = \sqrt{(240)^2 - (100)^2} \quad - - - (01 \text{ mark})$$

$$V_c = 218.1742V \quad \text{But; } V_c = I_r X_c$$

Where; $I_r = \frac{P}{V_R} = \frac{300}{100}$ - - - (00½ mark)

$$I_r = 3$$

$$X_c = \frac{V_c}{I_r} = \frac{218.1742}{3}$$

$$X_c = \frac{218.1742}{3}$$

Again; $X_c = \frac{1}{2\pi fc} = \frac{218.1742}{3}$ - - - (01 mark)

$$c = \frac{3}{218.1742 \times 2 \times 3.14 \times 50}$$

$$c = 0.4384F \quad - - - (01 \text{ mark})$$

∴ The value of capacitance, c is 0.4384F.

08. (b). (i). At the junction A/B

$$I_1 = I_2 + I_3 \quad \text{---- (i).}$$

by applying KVL at the Loop ABEFA

$$(-I_1 \times 2) - 4 - (I_1 + 2) - I_1 = 0$$

$$-2I_2 - 2I_1 - 2 = 0 \quad \text{---- (01 mark)}$$

$$I_1 + I_2 = -1 \quad \text{---- (ii).}$$

Applying KVL at the loop ADEBCFA

$$-I_3 - 4 - I_3 - I_1 + 2 - I_1 = 0$$

$$-2I_3 - 2I_1 - 2 = 0 \quad \text{---- (01 mark)}$$

$$I_3 + I_1 = -1 \quad \text{---- (iii).}$$

From eqn (i) $I_3 = I_1 - I_2$ substituting into eqn (iii)

$$I_1 - I_2 + I_1 = -1$$

$$2I_1 + I_2 = -1 \quad \text{---- (iv).}$$

Solving eqn (ii) and (iv) we get

$I_1 = -2/3\ A$ and $I_2 = -1/3\ A$ ---- (01 mark)

∴ The current through R_2 is $1/3\ A$.

(ii). The p.d across C and D

Taking; $V_D - \frac{1}{3} + 2\left(\frac{1}{3}\right) - 4 - \frac{2}{3} = V_C$

$$V_D - 1 + \frac{2}{3} - 4 = V_C \quad \text{---- (01 mark)}$$

$$V_D - V_C = 5 - \frac{2}{3} = \frac{13}{3}\ V$$

$$V_{DC} = \frac{13}{3}\ V$$

∴ The potential difference between C and D is $\frac{13}{3}\ V$ ---- (01 mark)

08. (a) (i). The greater the length of potentiometer wire, the smaller the potential gradient along the wire. Hence the distance of the null position will be increased which will be measured more accurate. (02 marks)

(ii). For high sensitivity of the bridge, all resistance should have high value. This will reduce the value of the current through the galvanometer. (02 marks)

09. (a). The energy level in semi-conductor are such that the gap between the valency band and the conduction band is small and can be crossed by excited electrons. In contract to insulator which have large valency band no electron can cross. (02 marks).

(b). (i). In metals the forbidden gap overlaps the conduction and valence bands. Thus when light is shone on a metal, its electrons will absorb light and get excited to higher levels since they need very little energy to get excited. (02 marks)

(ii). In semiconductor, the forbidden gap is narrow. It requires much more energy to cross the gap. Infrared light has low radiation energy; thus insufficient to excite electrons to cross the valence band. On other hand, visible light has enough energy because such an excitation across the gap, thus visible light will be absorbed by semi-conductor but infrared will pass through it unabsorbed. (03 marks)

(iii). Insulator has very wide forbidden gaps and have no charge carriers (electrons and holes). Thus visible light will pass through an insulator without being absorbed and so, the insulator will look transparent. (02 marks)

Q1.(c). From: $V_S = V_R + V_D$ --- (0½ mark)

$$V_S = IR + V_D$$

$$I = \frac{V_S - V_D}{R} \quad \text{--- (01 mark)}$$

For minimum LED current, the values of V_D should be maximum

$$\text{So; } I_{min} = \frac{V_S - V_{max}}{R} \quad \text{--- (0½ mark)}$$

$$I_{min} = \frac{10 - 2.3}{470000} \quad \text{--- (01 mark)}$$

$$I_{min} = 16.4\mu A \quad \text{--- (01 mark)}$$

For maximum LED current, the value of V_D should be minimum

$$\text{So; } I_{max} = \frac{V_S - V_{min}}{R} \quad \text{--- (01 mark)}$$

$$I_{max} = \frac{10 - 1.5}{470000} = 18.1\mu A \quad \text{--- (01 mark)}$$

∴ The minimum and maximum current of LED circuit are 16.4μA and 18.1μA respectively.

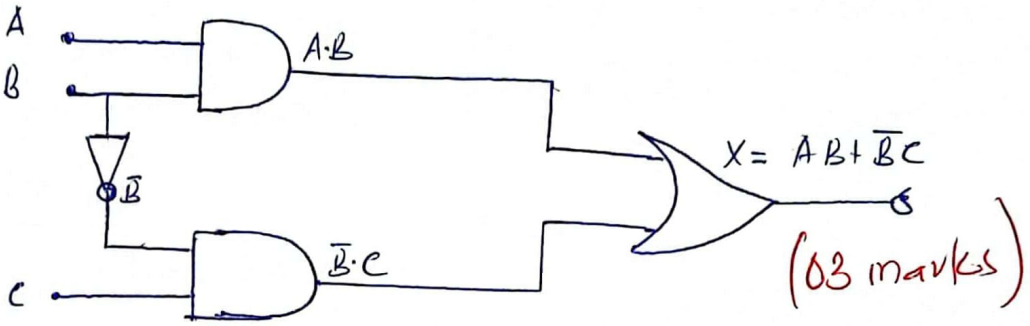
10 @ (i) 01. It's signal are easier to transmit and more accurate.

02. Its signal are transmitted at specific amplitudes and frequencies.

03. They are more immune to noise.

(01 mark @)

(ii). Logic circuit will be:



(03 marks)

(b) (i). A NOT gate can be made using only one NAND gate. By connecting the input of NAND gate together you can achieve the NOT function.

- - - - (02 marks)

(ii). Truth table:

Inputs				Outputs
A	B	S_1	S_2	Q
0	0	1	1	0
0	1	1	0	0
1	0	0	1	0
1	1	0	0	1

- - - - (04 marks)

10 (i).(a). To implement a NOT gate using transistor, you connect the input to the base of an NPN transistor, and the output to the collector of the same transistor. The emitter should be connected to the ground. When the input is low (0), the transistor will be in an ON state, and the output will be high (1). Conversely, when the input is high (1), the transistor will be in an OFF state, and the output will be low (0). This setup effectively creates a NOT gate. (02 marks)

(a). Amplitude modulation (A.M)

Is a modulation technique whereby the amplitude of the carrier signal is varied in accordance with the intensity of the information signal. - - - (01 mark)

while.

Is a technique whereby the frequency of carrier signal is changed accordance with the intensity of information. - - - - - (01 mark)