NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC NO: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

QUESTIONS AND THEIR RESPECTIVE ANSWERS i.e. QUE. 1-4;

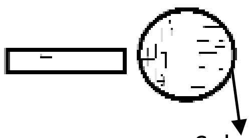
1. QUESTION ONE:

(**A**) Explain with the aid of a diagram how you can produce a negatively charged sphere by method of induction.

ANSWER: This process involves acquiring charges from a charged object without touching it. This process is called, '**ELECTROSTATIC INDUCTION'.** For example, if a negatively charged rod is brought close to an uncharged sphere that is insulated in such a way that there is no conducting path to the ground, there will be a redistribution of charges in the sphere caused by the repulsive forces between the electrons in the rod and the ones in the sphere.

The region of the sphere nearest the negatively charged rod will have excess positive charges because of the migration of the electrons from the area close to the rod which can equally be removed by connecting the sphere to earth. When the rubber rod is finally removed from the vicinity of the sphere, the induced positive charges would then be uniformly distributed over the surface of the ungrounded sphere. This is explained with the diagram below:

Fig 1.O; Redistribution of charges due to the repulsive force, **Fig 1.3;** Removal of Electrons



Sphere

Charged rod

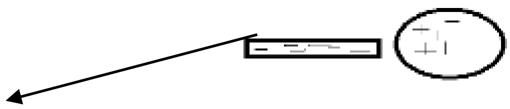


Fig 1.2: Application of Conducting Wire to Remove Electrons, **Fig 1.4;** Sphere becomes charged

(**B**) Each of two small spheres is charged positively, the combined charge being 5.0×10^{-5} C. If each sphere is repelled from the other by a force of 1.0N when the spheres are 2.0m apart, calculate the charge on each sphere.

ANSWER: Given two positive charges, the combined charge $[q_1+q_2]$ is = 5.0×10^{-5} C, Repulsive force [F] is = 1.0N, the distance between the spheres [r] is = 2.0m.

Since $\mathbf{q_1+q_2 = 5.0 \times 10^{-5}}$ **C** $\mathbf{q_2 = 5.0 \times 10^{-5} - q_1}$ {making q_2 subject of the formula}.

Remember that $\mathbf{K= 9.0 \times 10^9 N\ m^2/C^2}$. Therefore $\mathbf{F = Kq_1q_2 / r^2}$

Substituting our values, we have, $\mathbf{1.0 = (9 \times 10^9 \times q_1 [5.0 \times 10^{-5} - q_1]) / 2^2}$.

Cross multiplying, we have: $\mathbf{4.0 = 9 \times 10^9 [5.0 \times 10^{-5} - q_1]}$.

Also, we have; $\mathbf{4.0 = [4.5 \times 10^5 q_1] - [9 \times 10^9 q_1^2]}$.

NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC N0: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

Therefore, $9 \times 10^9 q_1^2 - 4.5 \times 10^5 q_1 + 4.0 = 0$. Solving the equation using completing the square method, divide all through by the coefficient of q_1^2 that is, 9×10^9

Therefore, we have: $([9 \times 10^9 q_1^2]/ [9 \times 10^9]) - ([4.5 \times 10^5 q_1]/ [9 \times 10^9]) + (4.0/ [9 \times 10^9]) = 0$.

Therefore, $q_1^2 - [5 \times 10^{-5} q_1] + [4.44 \times 10^{-10}] = 0$. We then have: $q_1^2 - 5 \times 10^{-5} q_1 = -4.44 \times 10^{-10}$---*

Therefore, the coefficient of $q_1 = -5 \times 10^{-5}$, half of the coefficient of $q_1 = [-5 \times 10^{-5}] / 2 = -2.5 \times 10^{-5}$,

Square of half of the coefficient = $[-2.5 \times 10^{-5}]^2 = 6.25 \times 10^{-10}$.

Add $[-2.5 \times 10^{-5}]^2 = 6.25 \times 10^{-10}$ to the both side of equation *,

We then have: $[q_1 - 2.5 \times 10^{-5}]^2 = -4.44 \times 10^{-10} + 6.25 \times 10^{-10}$,

By further expansion, we have: $[q_1 - 2.5 \times 10^{-5}]^2 = 1.81 \times 10^{-10}$.

Taking the square root of both sides and simplifying further,

We have $q_1 - 2.5 \times 10^{-5} = \pm 1.35 \times 10^{-5}$;

$q_1 = - 2.5 \times 10^{-5} \pm 1.35 \times 10^{-5}$, therefore it's; $q_1 = - 2.5 \times 10^{-5} + 1.35 \times 10^{-5}$ **or** $- 2.5 \times 10^{-5} - 1.35 \times 10^{-5}$,

$q_1 = 3.85 \times 10^{-5}$ **C or** 1.15×10^{-5} **C.** Since they are both positive charges.

Picking $q_1 = 3.85 \times 10^{-5}$ C,

Recall that $F = Kq_1q_2 / r^2$. Therefore, $q_2 = Fr^2/ kq_1$,

Substituting, $q_2 = [2^2 \times 1.0] / [9 \times 10^9 \times 3.85 \times 10^{-5}] = 1.15 \times 10^{-5}$ C.

Therefore, $q_1 = 3.35 \times 10^{-5}$ **C and** $q_2 = 1.15 \times 10^{-5}$ **C.**

Picking $q_1 = 1.15 \times 10^{-5}$ C,

Recall that $F = Kq_1q_2 / r^2$. Therefore, $q_2 = Fr^2/ kq_1$,

Substituting, $q_2 = [2^2 \times 1.0] / [9 \times 10^9 \times 1.15 \times 10^{-5}] = 3.87 \times 10^{-5}$ C.

Therefore, $q_1 = 1.15 \times 10^{-5}$ **C and** $q_2 = 3.87 \times 10^{-5}$ **C.**

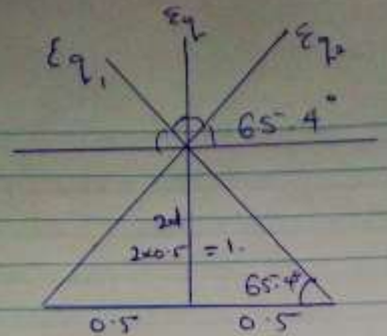
FINALLY, $q_1 = 3.85 \times 10^{-5}$ **C or** 1.15×10^{-5} **C and** $q_2 = 1.15 \times 10^{-5}$ **C or** 3.87×10^{-5} **C**

(**C**) Three charges were positioned as shown in the figure below. If Q1=Q2=8 micro coulomb and d= 0.5m, determine q if the electric field at p is zero.

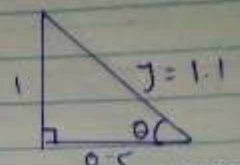
ANSWER: The answer to this question is seen in the image below:

NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC N$\underline{0}$: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY
ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

1c)



Consider the diagrams.



using pythagoras' theorem.

$H = \sqrt{1^2 + 0.5^2}$

$H = \sqrt{1.25} = 1.1$

$\tan\theta = 1/0.5$

$\theta = \tan^{-1} 2 = 63.43$

$E_p = E_{q_1} + E_{q_2} + E_q$

$E_{q_1} = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.1^2} = 59504$ N/C.

$E_q = \frac{kq}{r^2} = \frac{9\times10^9 \times q}{1^2} = 9\times10^9 q \, NC^{-1}$

$E_{q_2} = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.1^2} = 59504$ N/C.

∴ Vectors	Angle	x - component	y component.
$E_{q_1} = 59504$	63.4°	$-59504\cos 63.4 = 266043$	$59504\sin 63.4 = 53206$
$E_{q_2} = 59504$	63.4°	$59504\cos 63.4 = 26604$	$59504\sin 63.4 = 53206$
$E_q = 9\times10^9 q$	90	$9\times10^9 q \cos 90 = 0$	$9\times10^9 q \sin 90 = 9\times10^9 q$
		$E_x = 0$	$E_y = 106410 + 9\times10^9 q$

$E_p = \sqrt{0^2 + (106410 + 9\times10^9 q)^2} = \sqrt{E_x + E_y}$

$E_p = 106410 + 9\times10^9 q$

At $E_p = 0$,

$106410 + 9\times10^9 q = 0$

$\frac{9\times10^9 q}{9\times10^9} = \frac{-106410}{9\times10^9}$

$q = -1.182\times10^{-5}$ C. $= -\underline{12\mu C}$.

NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC N0: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

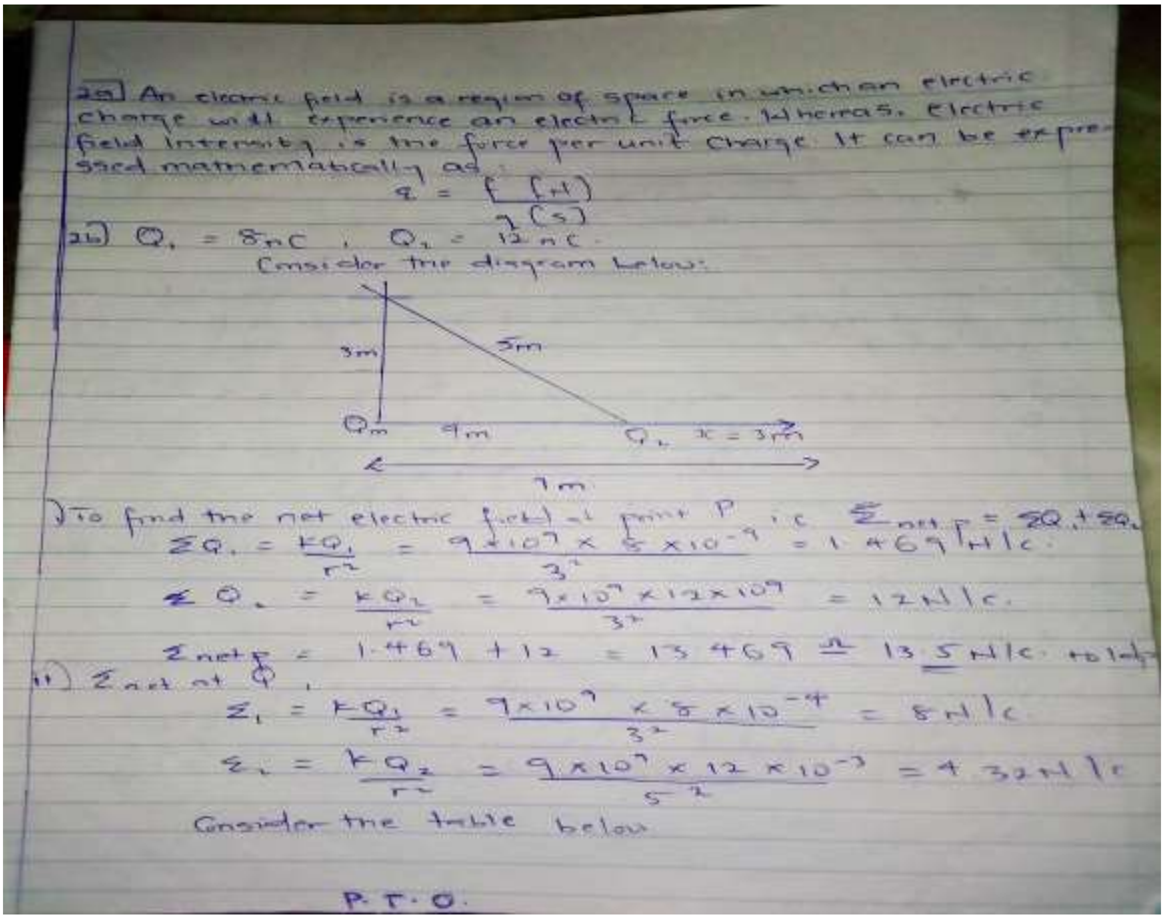
2. QUESTION TWO:

(**A**) Distinguish between the terms: electric field and electric field intensity. (b) A positive charge Q_1=8nC is at the origin, and a second positive charge Q_2=12nC is on the x-axis at x=4m.

Find:

(I) The net electric field at a point P on the x axis at x=7m.
(II) The electric field at a point Q on the y axis at y=3m due to the charges.

ANSWER: The answers to these questions are seen in the image below:


2a) An electric field is a region of space in which an electric charge will experience an electric force. Whereas, Electric field Intensity is the force per unit charge. It can be expressed mathematically as

$E = \frac{F (N)}{q (C)}$

2b) $Q_1 = 8nC$, $Q_2 = 12nC$.
Consider the diagram below:

i) To find the net electric field at point P i.e $E_{net}P = EQ_1 + EQ_2$

$EQ_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469 N/C$

$EQ_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12 N/C$

$E_{net}P = 1.469 + 12 = 13.469 \approx 13.5 N/C$ to 1dp

ii) E_{net} at Q,

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8 N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$

Consider the table below

P.T.O.

Vector	Degree	X component	Y component
$E_1 = 8 N/C$	90°	$8\cos 90 = 0$	$8 \sin 90 = 8$
$E_2 = 4.32 N/C$	36.9°	$-4.32\cos 36.9 = -3.45$	$4.32 \sin 36.9 = 2.59$
		$\Sigma E_x = -3.45$	$\Sigma E_y = 10.59$

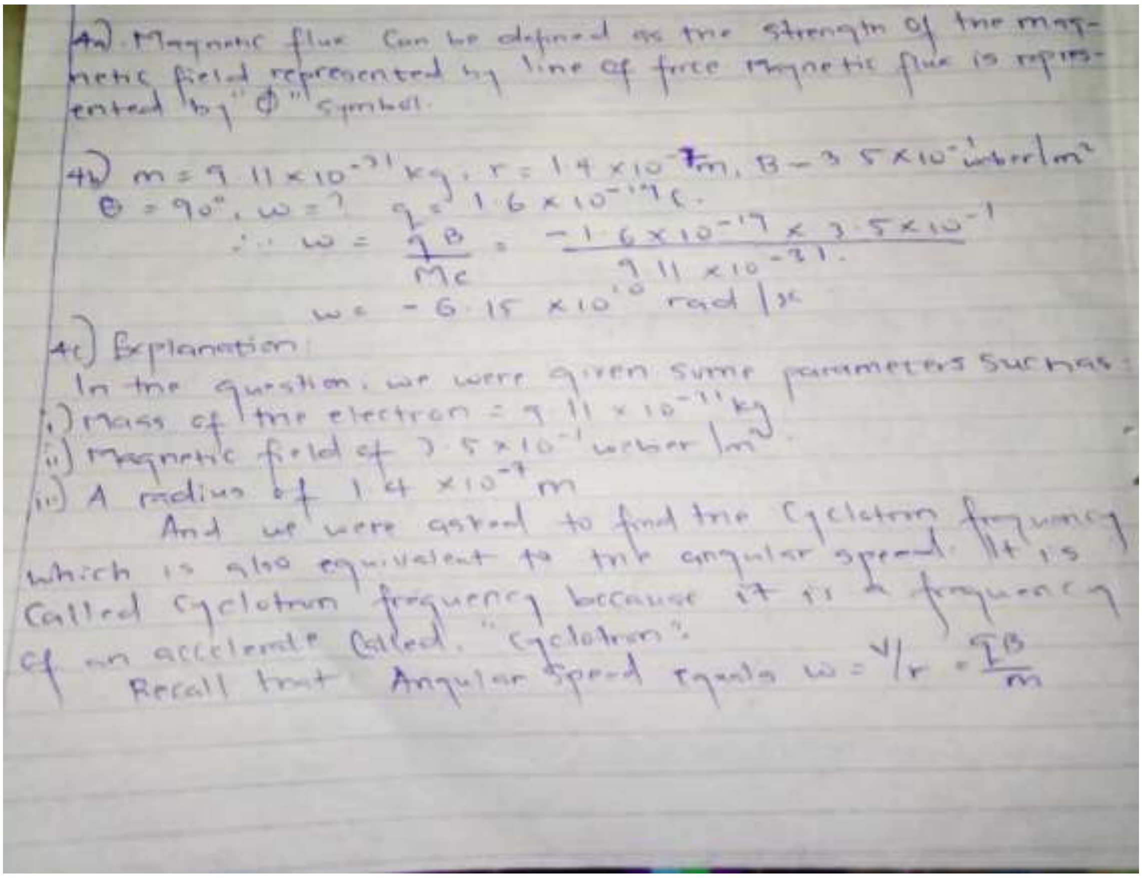
$\therefore E_{net}Q = \sqrt{(-3.45)^2 + (10.59)^2}$
$= 11.14 NC^{-1}$

NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC N0: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

4. QUESTION FOUR:

(a) What is Magnetic flux? (b) An electron with a rest mass of 9.11×10^{-31}kg moves in a circular orbit of radius 1.4×10^{-7}m in a uniform magnetic field of 3.5 x 10 -1 Weber/meter square, perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron. (c) Discuss your answer in 4b above

ANSWER: The answer to these questions are seen in the image below:


4a) Magnetic flux can be defined as the strength of the magnetic field represented by line of force. Magnetic flux is represented by "Φ" symbol.

4b) $m = 9.11 \times 10^{-31}$ kg, $r = 1.4 \times 10^{-7}$m, $B = 3.5 \times 10^{-1}$ weber/m^2
$\theta = 90°$, $\omega = ?$ $q = 1.6 \times 10^{-19}$C.
$\therefore \omega = \frac{qB}{Mc} = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$
$\omega = -6.15 \times 10^{10}$ rad/sc

4c) Explanation:
In the question, we were given some parameters such as:
i) Mass of the electron $= 9.11 \times 10^{-31}$ kg
ii) Magnetic field of 3.5×10^{-1} weber/m^2
iii) A radius of 1.4×10^{-7} m
And we were asked to find the cyclotron frequency which is also equivalent to the angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called "cyclotron".
Recall that Angular speed equals $\omega = V/r = \frac{qB}{m}$

5. QUESTION FIVE:

(a) State the Biot-Savart Law. (b) Using the Biot-Savart Law, show that the magnitude of the magnetic field of a straight current-carrying conductor is given as: $B = \mu_0 I / 2\pi r$

ANSWER: The answer to these questions are seen in the image below:

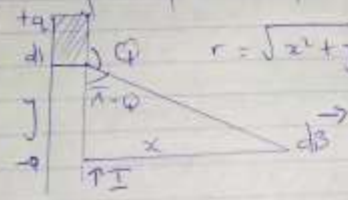
NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC N0: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

5a) Biot - Savart law states that the magnetic field is directly proportional to the product permeability of free space the current (H), the change in length, the radius and is also inversely proportional to the square of radius [r^2]. mathematically, it is expressed as:

$$dB = \frac{\mu \, I dr \times r}{4\pi r^2}$$

μ is a constant called permeability of free space.
$\mu = 4\pi \times 10^{-7}$ m/A
Unit force is weber/metre square.

5b) Magnetic field of a straight current carrying conductor



$r = \sqrt{x^2 + y^2}$ [From pythagoras' rule]

Applying Biot - savart law, we find the magnitude of the field $\vec{dB}$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dy \sin I}{r^2}$$

$\sin(\pi - \phi) = \sin\theta$

$$-B = \frac{\mu_0}{4\pi} \int_{-a}^{a} \frac{d\, I \sin(\pi - \phi)}{r^2}$$

From the diagram $r^2 = x^2 + y^2$

$$B = \frac{\mu_1 z}{4\pi} \int_{-a}^{a} \frac{d(\sin(\pi - \phi))}{x^2 + y^2} \quad \text{—(1)}$$

$$\sin(A - \phi) = \frac{x}{\sqrt{x^2 + y^2}} = \frac{x}{(x^2 + y^2)^{1/2}} \quad \text{—(2)}$$

NAME: OJO-ONI DANIEL OLUWASEGUN
MATRIC N0: 19/ENG09/016
DEPARTMENT: AERONAUTICAL AND ASTRONAUTICAL ENGINEERING
COURSE TITLE: ELECTRICITY, MAGNETISM AND MODERN PHYSICS
COURSE CODE: PHY 102, SESSION: 2019/20 COVID-19 HOLIDAY
ASSIGNMENT INSTRUCTION: ANSWER FOUR (4) QUESTIONS IN ALL - TWO FROM SECTION A AND TWO FROM SECTION B.

but $dL = dy$

$$B = \frac{\mu_o I}{4\pi}\int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}}\, dy$$

$$B = \frac{\mu_o I}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}}\, dy$$

$$B = \frac{\mu_o I}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}}\, dy \quad \cdots (3)$$

Using special integration,

$$\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2}\, y/(x^2+y^2)^{1/2}$$

Equation (iii) therefore becomes

$$B = \frac{\mu_o I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$$

$$B = \frac{\mu I}{4\pi x}\left(\frac{2a}{(x^2+a^2)^{1/2}}\right).$$

When the length 2a, the conductor is very great in comparison to the distance x from point P, we consider it infinitely long. This is when a is more logarithmic.

$$(x^2+a^2)^{1/2} \simeq a \text{ as } a \to \infty$$

$$\therefore B = \frac{\mu_o I}{2\pi x}$$

∴ There is an axial symmetry.