Department of Electrical Engineering

Assignment

Date: 14-04-2020

Course Details

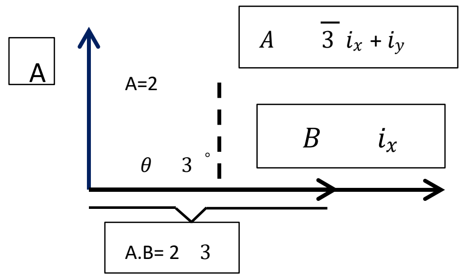
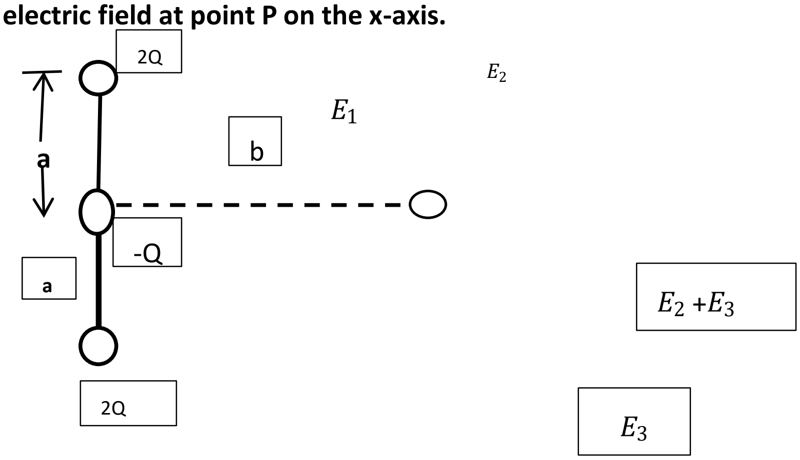
Course Title: **Electro Magnetic Field Theory** **Module:** ____________

Instructor: ____________ **Total Marks:** **30**

Student Details

Name: **Kiramat Ullah** **Student ID:** **13290**

Q1: Solve the following short Question	(a)	Transform the vector $B = yi\ (x + z)j$ located at point (-2,6,3) into cylindrical coordinates	Marks 2 CLO 1
	(b)	Convert the point (3,4,5) from Cartesian to spherical coordinates	Marks 2 CLO 1
	(c)	Find the spherical coordinates of A(2,3,-1)	Marks 2 CLO 1
	(d)	Find the Cartesian coordinates of B(4.25,120)	Marks 2 CLO 1
	(e)	Find the force between two charges when they are brought in contact and separated by 4cm apart, charges are 2nC and -1nC, in µN.	Marks 2 CLO 2
	(f)	Find the electric field intensity of two Charges -2C and -1C separated by a distance 1m in air	Marks 2 CLO 2
	(g)	Determine the charge that produce an electric field strength of 40 v/cm at a distance of 30cm in vacuum (in 10^{-8}c)	Marks 2 CLO 2
	(h)	A charge of $2 * 10^{-7}$ C is acted upon by a force of 0.1N. determine the distance to the other charge of $4.5 * 10^{-7}$C, both the charges are in vacuum	Marks 2 CLO 2
Q2:	**(a)**	**Find the angle between the vectors shown in figure.**	**Marks 4**

			**CLO 1**
	(b)	**Find the gradient of each of the following functions where a and b are constant** **(i)** $f = ax^2 + by^3z$ **(ii)** $f = ar^2 \sin\emptyset + brz\cos 2\emptyset$	**Marks 4** **CLO 1**
Q3:		**Three pointer charges are placed on the y-axis as shown. Find the electric field at point P on the x-axis.** 	**Marks 6** **CLO 2**

(1) ID 13290

STUDENT NAME#.

KIRAMATULLAH

ID NO # 13290

COURSE TITLE #

Electro Magnetic Field Theory

DEPARTMENT # BEE

TEACHER Name #

Dr. Rafia Mansoor

Kisamatullah (2) ID 13290

Q NO 1

Part (A)

Trans form The Vector $B = y\,i\,(x+z)\,j$ located at point $(-2, 6, 3)$ into cylindrical coordinates.

Solution:-

$$B = y\,i\,(x+z)\,j$$

Given points are $(-2, 6, 3)$

then, we know

$$B = y\,i\,(xj + zj)$$

$$B = y\,x\,ij + yz\,ij$$

$$\Rightarrow \rho = \sqrt{x^2+y^2}$$

$$\rho = \sqrt{(-2)^2+(6)^2}$$

$$\rho = \sqrt{40}$$

$$\boxed{\rho = 6.32}$$

As we know that

$$Z = z$$

so

$$\boxed{Z = 3}$$

As we know that

$$\phi = \tan^{-1}(y/x)$$

$$\phi = \tan^{-1}(6/-2)$$

$$\phi = \tan^{-1}(-3)$$

$$\boxed{\phi = -71.56}$$

So then,

$$B = (6.32\rho, -71.56\phi, 3z)$$ Ans

QNO 1

Part (B)

Convert the point (3, 4, 5) from cartesian to spherical coordinates.

Solution:-

At Point (3, 4, 5)

$x = 3$, $y = 4$, $z = 5$

When spherical coordinates System

r, θ, ϕ

$$r = \sqrt{x^2 + y^2 + z^2}$$

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$$r = \sqrt{3^2 + 4^2 + 5^2}$$

$$r = \sqrt{9 + 16 + 25}$$

$$r = \sqrt{50}$$

$$\boxed{r = 7.07}$$

As we know that

$$\theta = \tan^{-1}(y/x)$$

$$\theta = \tan^{-1}(4/3)$$

$$\theta = \tan^{-1}(1.33)$$

$$\boxed{\theta = 53.1^\circ}$$

As we know that,

$$\phi = \tan^{-1}\left(\frac{\sqrt{x^2 + y^2}}{z}\right)$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{3^2 + 4^2}}{5}\right)$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{9 + 16}}{5}\right)$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{25}}{5}\right)$$

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$$\phi = \tan^{-1}\left(\frac{5}{5}\right)$$

$$\phi = \tan^{-1}(1)$$

$$\boxed{\phi = 45}$$

$r = 7.07$, $\theta = 53.1^\circ$, $\phi = 45$ Ans

QNO 1

Part (C)

Find the spherical coordinates of A (2 , 3 , -1)

Solution:-

(r, θ, ϕ) These are find=?

As

$$r = \sqrt{x^2 + y^2 + z^2}$$

$$r = \sqrt{2^2 + 3^2 + (-1)^2}$$

$$r = \sqrt{14}$$

$$\boxed{r = 3.74}$$

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$$\theta = \tan^{-1}\left(\frac{y}{x}\right)$$

$$\theta = \tan^{-1}\left(\frac{3}{2}\right)$$

$$\theta = \tan^{-1}(1.5)$$

$$\boxed{\theta = 56.3^\circ}$$

As we know that,

$$\phi = \tan^{-1}\left(\frac{\sqrt{x^2+y^2}}{z}\right)$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{2^2+3^2}}{-1}\right)$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{4+9}}{-1}\right)$$

$$\phi = \tan^{-1}\left(\frac{\sqrt{13}}{-1}\right)$$

$$\phi = \tan^{-1}(-3.60)$$

$$\boxed{\phi = 74.4}$$

$r = 3.74$, $\theta = 56.3^\circ$, $\phi = 74.4$

Ans

———— x ————

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Q NO 1

Part (D)

Find the cartesian Coordinates of B(4, 25, 120)

Solution :-

The point of B = (4, 25, 120) is given in spherical (r, θ, ϕ) so we have to find the (x, y, z)

Now

$$x = r \sin\theta \cdot \cos\phi$$

$$x = 4 \sin(25) \cdot \cos(120)$$

$$x = 4(0.42)(-0.5)$$

$$\boxed{x = -0.84}$$

As we know that,

$$y = r \sin\theta \cdot \sin\phi$$

$$y = 4 \sin(25) \cdot \sin(120)$$

$$y = 4(0.42)(0.86)$$

$$\boxed{y = 1.45}$$

As we know,

$$Z = r\cos\theta$$

$$Z = 4\cos(25)$$

$$Z = 4(0.90)$$

$$Z = 3.62$$

$$(x, y, z) = (-0.84, 1.45, 3.62)$$

Ans

Question NO 1

Part (E)

Find the force between two charges ~~2C and~~ when they are brought contact and separated by 4cm apart charges are 2nc and -1nc, in μN.

Solution:-

Given data :-

$q_1 = 2nc$, $q_2 = -1nc$

$d = 4cm$

Required = F ?

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Where,

$$F = K \frac{q_1 q_2}{r^2}$$

As we know

$$K = \frac{1}{4\pi\varepsilon_0}$$

$$F = \frac{2\times10^{-9} \times -1\times10^{-9}}{4(3.14)\times 8.85\times10^{-12}\times(4\times10^{-2})^2}$$

$$F = -1.124\times10^{-5}$$

$$\boxed{F = -11.24\,\mu N}$$

Ans

QNO 1

Part (F)

Find the electric field Intensity of two charges -2C and -1c separated by a distance 1m in air

Solution:-

Given data:-

$q_1 = -2C$, $q_2 = -1C$

distance $d = 1\,m$ in air

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Required $E = ?$

Solution:-

$$E_1 = \frac{Kq_1}{d^2}$$

$\because k = 9 \times 10^9$

$$E_1 = \frac{9 \times 10^9 \times -2}{(1)^2}$$

$$E_1 = -18 \times 10^9 \ V/m$$

Now, when

$$E_2 = \frac{K q_2}{d^2}$$

$$E_2 = \frac{9 \times 10^9 \times (-1)}{(1)^2}$$

$$E_2 = -9 \times 10^9 \ V/m$$

As we know that,

$$E_T = E_1 + E_2$$

$$E_T = -18 \times 10^9 + (-9 \times 10^9)$$

$$E_T = -18 \times 10^9 - 9 \times 10^9$$

$$E_T = -27 \times 10^9 \ V/m$$

Ans//

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QNO 1

Part (G)

Determine the charge that produce an electic field strength of 40 V/cm at a distance of 30 cm in Vacuum (in 10^{-8} C).

Give data:-

$E = 40\ V/cm$, $d = 30cm$

Required

$Q = ?$

Solution:-

$\Rightarrow \quad E = \frac{KQ}{d^2}$

$\Rightarrow \quad Ed^2 = KQ$

$\Rightarrow \quad \frac{Ed^2}{K} = Q \longrightarrow$ eq ①

Now putting values in eq ①

$\Rightarrow \quad Q = \frac{Ed^2}{K}$

$\Rightarrow \quad Q = \frac{40 \times (30)^2}{9 \times 10^9}$

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$$\Rightarrow Q = \frac{40 \times 900}{9 \times 10^9}$$

$$\Rightarrow \boxed{Q = 4 \times 10^{-6}\ C}$$

OR

$$\Rightarrow \boxed{Q = 4\mu C}$$

Ans

Q No I

Part (H)

A charge of 2×10^{-7} is acted upon by a force of 0.1N. Determine the distance to the other charge of 4.5×10^{-7} C, both the charges are in vaccum

Given data:

$q_1 = 2\times10^{-7}\ C$. $F = 0.1\ N$

$q_2 = 4.5\times10^{-7}\ C$ $K = 9\times10^9$

Required $d = ?$

Solution:-

By using formula

then,

$$F = K\frac{q_1 q_2}{d^2}$$

$$d^2 = K\frac{q_1 q_2}{F}$$

Now putting the value

$$d^2 = 9\times10^9 \frac{(2\times10^{-7})(4.5\times10^{-7})}{0.1}$$

$d^2 = \sout{0.0081}$ 8.1×10^{-3}

As

$$\boxed{d^2 = 0.0081}$$

Taking under root on both sides

$$\sqrt{d^2} = \sqrt{0.0081}$$

$$d = 0.09\, m$$

$$\boxed{d = 9\times10^{-2}\, m}$$

OR

$$\boxed{d = 9\, cm}$$

Ans

X

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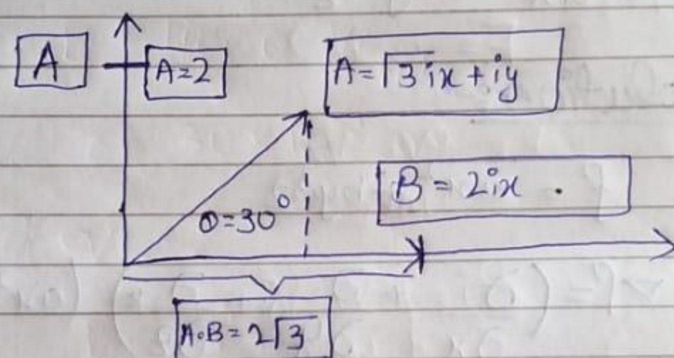
Question No 2

Part (a)

Answer:

Solution:-

$A = \sqrt{3}\, i_x + i_y$



$A = \sqrt{3}\, i_x + i_y$

$|A| = 2$

$B = 2 i_x$

$|B| = 2$

$A \cdot B = 2\sqrt{3}$

Now

$A \cdot B = |A||B| \cos\theta_{AB}$

$$\cos\theta_{AB} = \frac{A \cdot B}{|A||B|}$$

$$\theta_{AB} = \cos^{-1}\left(\frac{2\sqrt{3}}{|2||2|}\right)$$

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$\boxed{\theta_{AB} = 30^\circ}$ Ans

Question No 2

Part (B)

Answer

Find Gradient

(i) $f = ax^2 + by^3 z$

Solution:-

$$f = ax^2 + by^3 z$$

$$\nabla f = \left(\frac{\partial}{\partial x} i + \frac{\partial}{\partial y} j + \frac{\partial}{\partial z} k\right)(ax^2 + by^3 z)$$

$$\nabla f = \frac{\partial}{\partial x} ax^2 i + \frac{\partial}{\partial y} by^3 z j + \frac{\partial}{\partial z} by^3 z k$$

Now

$$\nabla f = 2ax i + 3bz y^2 j + by^3 k$$

so

we find

$$\boxed{\nabla f = 2ax i + 3bz y^2 j + by^3 k}$$

Ans

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ii) $f = ax^2 \sin\theta + brz\cos^2\theta$

Solution :-

=> Gradient the case of Spherical :-

$$\Rightarrow \nabla f = \frac{\partial f}{\partial r}\hat{r} + \frac{1}{r}\frac{\partial f}{\partial \phi}\hat{\theta} + \frac{1}{r\sin\theta}\frac{\partial f}{r\phi}\hat{\phi}$$

$$\Rightarrow \nabla f = \frac{\partial}{\partial r}(ar^2\sin\phi + brz\cos 2\phi)\hat{r}\ \frac{1}{r}$$

$$\Rightarrow \frac{\partial}{\partial\theta}(ar^2\sin\phi + brz\cos 2\phi)\hat{\theta} + \frac{1}{r\sin\theta}$$

$$\frac{a}{r\phi}(ar^2\sin\phi + brz\cos 2\phi)\hat{\phi}$$

as,

$$\Rightarrow \nabla f = (2ar\sin\phi + bz\cos 2\phi)\hat{r} + \frac{1}{r}(0)$$

$$+ \frac{1}{r\sin\theta}(ar^2\cos\phi - 2brz\sin\phi)\hat{\phi}$$

when,

$$\Rightarrow \nabla f = (2ar\sin\phi + bz\cos 2\phi)\hat{r} + \frac{1}{r\sin\theta}$$

$$(ar^2\cos\phi - brz\sin\phi)\hat{\phi}$$

=> Gradient case with Cylindrical :-

$$\nabla f = \frac{\partial f}{\partial\rho}\hat{\rho} + \frac{1}{\rho}\frac{\partial f}{\partial\phi}\hat{\phi} + \frac{\partial A_z}{\partial z}$$

$\Rightarrow \nabla f = 0\hat{\rho} + \frac{1}{\rho}(ar^2\cos\phi - 2brz\sin 2\phi)\hat{\phi} + (ar\cos 2\phi)\hat{z}$

$\Rightarrow$ so that the first term will zero (0).

Then,

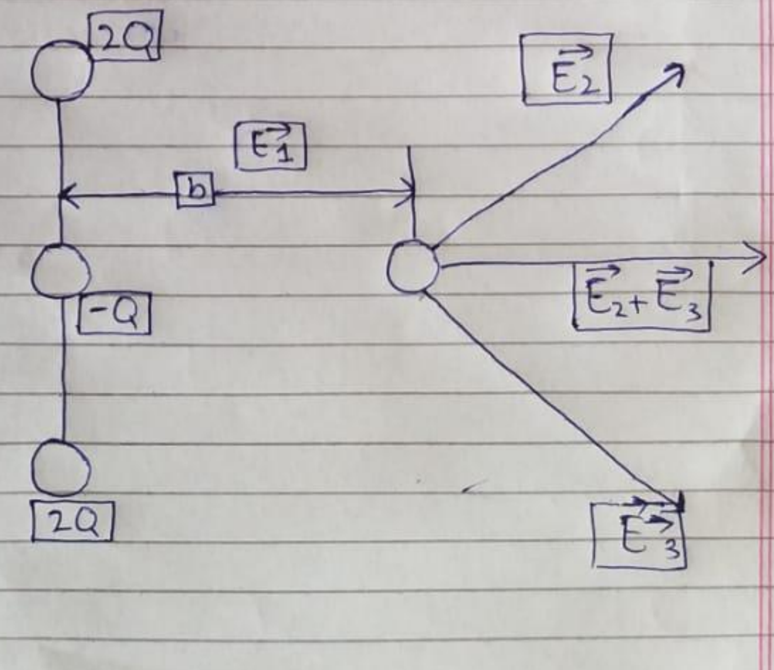
$$\nabla f = \frac{1}{\rho}(ar^2\cos\phi) - 2brz\sin 2\phi)\hat{\phi} + (br\cos\phi)\hat{z}$$

Ans

— x — x —

Question No 3

Answer



Solution:-

⇒ Therefore, Distance between charge 2Q and as point 'p' as

$$r^2 = b^2 + a^2$$

Then,

$$r = \sqrt{b^2 + a^2}$$

⇒ Therefore we assume the charge 2Q make the angle of (θ) and $(-\theta)$ with x-axis.

Where the magnitude of

$$|\vec{E}_1| = |\vec{E}_2| = \frac{KQ}{r^2} = \frac{KQ}{r^2}$$

$$= \frac{K(2Q)}{r^2}$$

$$= \frac{K(2Q)}{b^2 + a^2}$$

⇒ Therefore, the result of $\vec{E}_1$ and $\vec{E}_2$ is

$$\vec{E}_{1+2} = \vec{E}_1 + \vec{E}_2 = \vec{E}_{1x} + \vec{E}_{2x}$$

⇒ Component of y- will be canceled.

$$= \frac{K(2Q)}{b^2 + a^2}(\cos(\theta) + \cos(-\theta))$$

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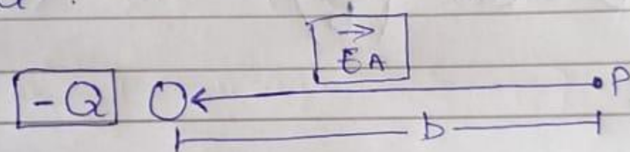
$$= \frac{K(2Q)}{b^2+a^2}\left(2\cos(\theta)\right)$$

$$\vec{E}_{1+2} = \frac{4KQ\cos\theta}{b^2+a^2} \rightarrow eq(1)$$

⇒ Therefore the electric field with poin 'P' due to charge 'Q'. The charge is negative and electric field with point will be directed towards charge "-Q".

So,



$$\Rightarrow \vec{E}_A = \frac{-K(Q)}{b^2}$$

Therefore electric field at point 'p' will be.

As,

$$\Rightarrow \vec{E}_{Net} = \vec{E}_A + \vec{E}_1 + \vec{E}_2$$

$$= \frac{-K(Q)}{b^2} + \frac{4KQ\cos\theta}{b^2+a^2}$$

$$= \frac{-KQ(a^2+b^2)+4KQb^2\cos\theta}{b^2(a^2+b^2)}$$

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$$= \frac{KQ}{b^2(a^2+b^2)}\left[4b^2\cos\theta - (a^2+b^2)\right]$$

= Therefor,

$$K = 9\times10^9 \frac{Nm^2}{C^2}$$

$$= \vec{E}_{Net} = 9\times10^9 Q\left[4b^2\cos\theta - (a^2+b^2)\right]$$

So,

$$\theta = \tan^{-1}\left(\frac{a}{b}\right)$$

Now,

$$\vec{E}_{Net} = \frac{9\times10^9 Q}{b^2(a^2+b^2)}\left[4b^2\cos\left[\tan^{-1}\left(\frac{a}{b}\right) - (a^2+b^2)\right]\right.$$