Department of Electrical Engineering
Assignment
Date: 14-04-2020

Course Details

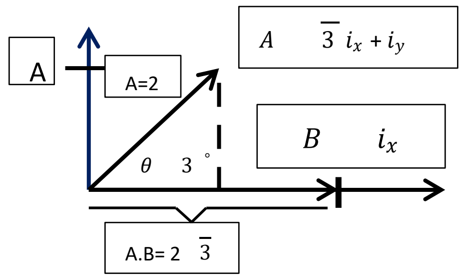
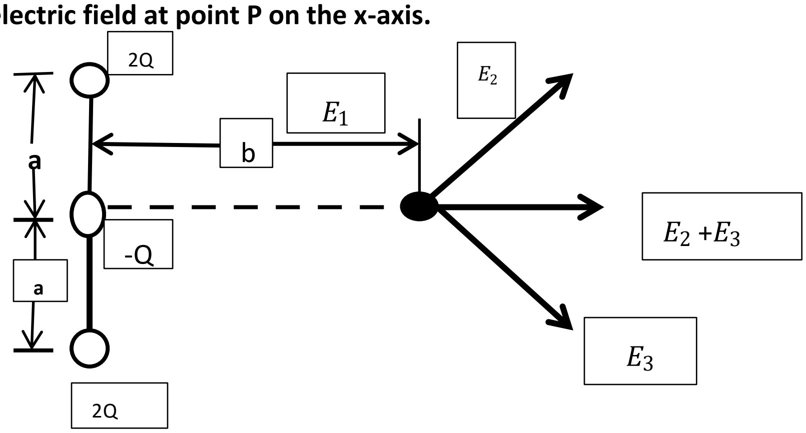
Course Title: **Electro Magnetic Field Theory** **Module:** ______

Instructor: Dr. Rafiq Mansoor **Total Marks:** **30**

Student Details

Name: **Saad Bin Tariq** **Student ID:** **5534**

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 10^{-8} electric field strength of 40 v/cm at a distance of 30cm in vacuum (in 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 $4.5 * 10^{-7}$ of 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**

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Course Titele:- ELECTRO MAGNETIC FIELD
DEPARTMENT:- BE (E)
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QNo# 1

Solve the following short Questions:-

Q(a) Transform the vector $B = yi(x+z)j$ located at points $(-2, 6, 3)$ into cylindrical coordinates:-

Sol:-

So $B = yi(x+z)j$

Point Given as $(-2, 6, 3)$

Now $B = yi(xj + zj)$

$B = yxi + ~~yi~~ yzij$

As

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

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

$\rho = \sqrt{40}$

$\boxed{\rho = 6.32}$

So $z = z$

$\boxed{z = 3}$

By knowing this that (5534) Pg#02

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

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

$\phi = \boxed{-71.56}$

So We Get:-

$\boxed{B = 6.32, -71.56, 3}$ ANS:-

Q(B) Convert the point (3,4,5) from ~~Car~~ Cartesian to Spherical coordinates.

Sol:- Points = P (3,4,5)

as $x = 3 \quad y = 4 \quad z = 5$

We know that in Spherical Coordinates System

r, θ, ϕ

So

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

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

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

$r = \sqrt{50}$

So ~~r =~~ $\boxed{r = 7.07}$

Now

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

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

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

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

Now

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

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

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

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

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

$\boxed{\phi = \tan^{-1} 45}$

$\boxed{r = 7.07, \quad \theta = 53.1^\circ \quad \phi = 45}$

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Q c) Find the Spherical Coordinates of A(2, 3, -1) Pg#04

Sol:-

r, θ, ϕ

As we know that:-

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

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

$r = \sqrt{14}$

$r = 3.74$

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

$\theta = \tan^{-1}(3/2)$

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

$\theta = 56.3^\circ$

Now:-

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

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

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

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

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

$\phi = 74.4$

5534 Pg # 05

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

Q D) Find the Cartesian Coordinates of B(4.25, 120)

Sol:- As we know that Point B(4, 25, 120) is given is in Spherical coordinates (r, θ, ϕ) So we required (x, y, z).

So:-
$x = r\sin\theta \cdot \cos\phi$
$x = 4\sin(25) \cdot \cos(120)$
$x = 4(0.42)(0.5)$
$x = -0.84$

Now:-
$y = r\sin\theta \cdot \sin\phi$
$y = 4\sin(25) \cdot \sin(120)$
$y = 4(0.42)(0.86)$
$y = 1.45$

Now:-
$z = r\cos\theta$
$z = 4\cos(25)$
$z = 4(0.90)$
$z = 3.625$

$(x, y, z) = (-0.84, 1.45, 3.625)$

QE)

Find the force betwen two charges when they are brought in contact and seperated by 4cm apart, charges are 2nC and -1nC in μN.

Sol:-

Given:-

$q_1 = 2nC$

$q_2 = -1nC$

Distance = 'd' = 4cm

Required DATA:-

$F = ?$

Sol:-

As we know that

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

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

$$F = \frac{2\times10^{-9} \times -1 \times 10^{-9}}{4(3.14)\times 8.85\times10^{-12}\times(4\times10^{-2})^2}$$

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

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

QNO:- F | 5534 | Pg # 07

Find the electric field intensity of two Charges -2C and -1C Seperated by a distance 1m in air.

DATA GIVEN:-

Charge1 = q_1 = -2C

Charge2 = q_2 = -1C

Distance = d = 1m

REQUIRED DATA:-

Electric Field Intensity = E = ?

Sol:- Formula for Electric field intensity is as given below.

$$E_1 = \frac{k q_1}{d^2}$$

Where $k = 9 \times 10^9$

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

$$\boxed{E_1 = -18 \times 10^9 \quad V/m}$$

Now For E_2

So

$$E_2 = \frac{k q_2}{d_2}$$

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

$E_2 = -9\times10^{9}$ Vm

Q9) Determine the charge that produce an electric field strength of 40 V/cm at a distance of 30 cm in vaccum (in 10^{-8}C)

DATA GIVEN:-

Electric field strength = E = 40 V/cm

Distance = d = 30 cm

DATA REQUIRED:-

Charge = Q = ?

Sol:- As we know the formula—

$$E = \frac{kQ}{d^2}$$

$$Ed^2 = kQ$$

$$\frac{Ed^2}{k} = Q \longrightarrow \text{eq 1}$$

Now we put values in eq ①

So

$$Q = \frac{Ed^2}{k}$$

$$Q = \frac{40\times(30)^2}{9\times10^{9}}$$

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

$$Q = 4 \cdot 10^{-6} C$$

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

QNO(H) A charge of $2 \times 10^{-7} C$ is acted upon by a force of 0.1N. Determine the distance to the other charge of $4.5 \times 10^{-7} C$ both the charges are in vaccum.

DATA GIVEN:-

Charge1 = $q_1 = 2 \times 10^{-7} C$

Charge 2 = $q_2 = 4.5 \times 10^{-7} C$

Force = F = 0.1N

Constant = K = 9×10^{9}

DATA REQUIRED:-

Distance = d = ?

SOL:-

As we know the Formula:-

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

So

$$d_2 = k \frac{q_1 q_2}{F}$$

Putting values in This Formula.

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Pg #10

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

$$d^2 = 8.1\times10^{-3}$$

$$\boxed{d_2 = 0.0081}$$

Taking underrooot on Both Sides: —

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

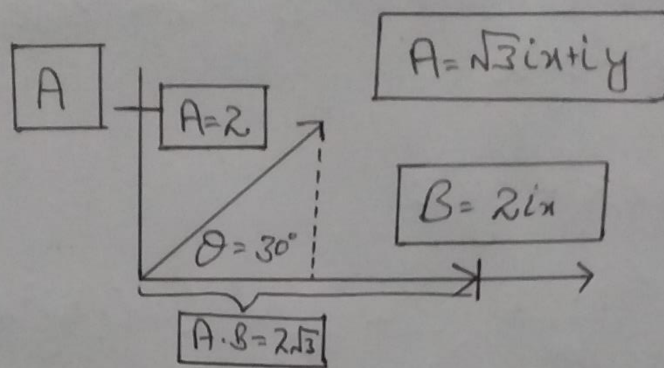
$$d = 0.09m$$

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

So $\boxed{d = 9\,cm}$ ANS:—

Q No# 2

Part (A) Find the angle betwen the vectors shown in figure



Sol:-

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

$|A| = 2$

$B = 2 i_x$

$|B| = 2$

Than ~~it will become~~

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

Now

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

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

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

$\theta_{AB} = 30°$

QNo 2

Part B

Find the gradient of each of the following functions where a & b are constant.

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

Sol:- $f = ax^2 + by^3z$

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

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

$$\nabla f = 2axi + 3bzy^2 j + by^3 k$$

Hence we get

$$\boxed{\nabla f = 2axi + 3bzy^2 j + by^3 k}$$

ii) $f = ar^2 si\phi + brz\cos 2\phi$

Sol:- Taking Gradient in spherical.-

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

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

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

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

Now: we have

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

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

Then:-

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

Taking Grdient In Cylindrical:-

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

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

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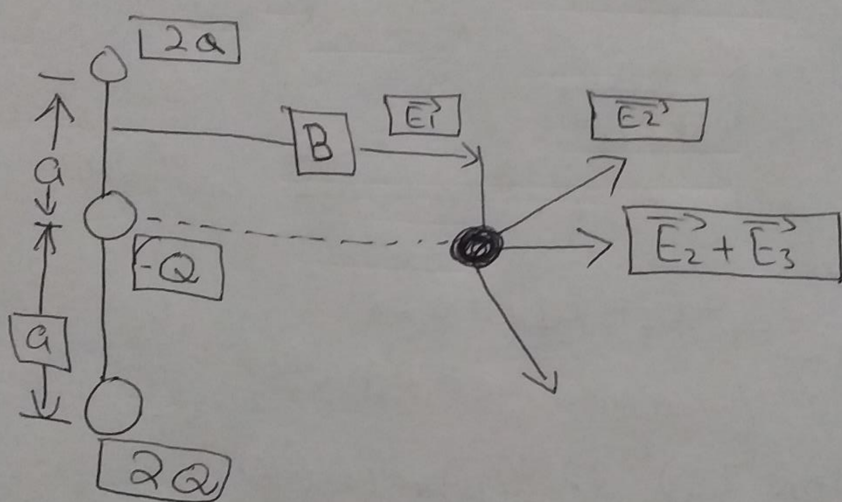
Hence we result that the first term will be zero (0)

So it become

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

QNo:-3 | 5534 | Pg#15

Three pointer charges are placed on the y-axis as shown. find the electric field at point P on the x-axis:-



Sol:- ~~Distan~~ Distance between charge 2Q ~~We~~ and point P is given as

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

Now taking Under Root

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

We can take charge 2Q making an angle (β) and ($-\beta$) along with x-axis

Magnitude of $|\vec{E_1}| = |\vec{E_2}| = \frac{Kq}{r^2}$

So

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

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

Hence we get $\vec{E_1}$ and $\vec{E_2}$ will be

$$\vec{E}_{1+2} = \vec{E_1} + \vec{E_2} = \vec{E}_{1x} + \vec{E}_{2x}$$

Y-componet get cancelled

So

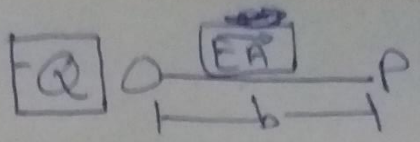
$$= \frac{k(2Q)}{b^2+a^2}(\cos(\beta) + \cos(-\beta)$$

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

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

So electric field at point P' is due to Charge $-Q$

When the charge is Negative Electric field at point P will be directed towords Charge $-Q$



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$$\vec{E_A} = \frac{-kQ}{b^2}$$

Here the net electric field at point P will be

$$\vec{E_{net}} = \vec{E_A} + (\vec{E_1} + \vec{E_2})$$

$$= \frac{-k(Q)}{b^2} + \frac{4kQ\cos(\beta)}{b^2 + a^2}$$

$$= \frac{-kQ(a^2+b^2) + 4kQb^2\cos\beta}{b^2(a^2+b^2)}$$

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

Here $K = 9\times10^9\ Nm^2/c^2$

$$\vec{E_{NET}} = \frac{9\times10^9 Q}{b^2(a^2+b^2)}\left[4b^2\cos\beta - (a^2+b^2)\right]$$

~~No~~ So

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