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**Department: BE(E)**

**Subject: Electromagnetic Field (EMF)**

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**Assignment:**

**Solve problem 4.1, 4.2, 4.3, 4.5, and 4.7 of course book.**

## 4.1:-

The value of $E$ at $P(\rho=2, \phi=40°, z=3)$ is given by $E = 100 a_\rho - 200 a_\phi + 300 a_z$ V/m. Determine the uncremental work require to move a 20 μc charge a distance of 6 μm:-

**(a):-**

In the direction of $a_\rho$:

The incremental work is given by $dw = -qE\,dL$, where in this case $dL = d\rho\, a_\rho = 6 \times 10^{-6}$

$$dw = -(20 \times 10^{-6} C)(100 V/m)(6 \times 10^{-6} m) = -12 \times 10^{-9} j = \boxed{-12 nJ}$$

**(b):-**

In the direction of $a_\phi$:-

In this case $dL = 2 d\phi\, a_\phi = 6 \times 10^{-6} a_\phi$

and so $dw = -(20 \times 10^{-6})(-200)(6 \times 10^{-6})$

$$= 2.4 \times 10^{-8} J$$

$$\boxed{= 24 nJ}$$

**(c):-**

In the direction of $a_z$:-

Here $dL = dz\, a_z = 6 \times 10^{-6} a_z$ & so

$$dw = -(20 \times 10^{-6})(300)(6 \times 10^{-6}) = -3.8 \times 10^{-8} J$$

$$\boxed{= 36 nJ}$$

(d):

In the direction of E:-

Here $dL = 6\times10^{-6} a_E$

where $a_E = \frac{100a_\rho - 200a_\phi + 300a_z}{[100^2 + 200^2 + 300^2]^{1/2}} = 0.267a_\rho$

$0.535a_\phi + 0.802\, a_z$

Thus:-

$dw = -(20\times10^{-6})(100a_\rho - 200a_\rho - 300a_z] \cdot$

$[0.267a_\rho - 0.802a_z] [6\times10^{-6}) *$

$= -6 \boxed{= -44.9 J}$

(e):-

In the direction of $G = 2a_x - 3a_y + 4a_z$:

In this case $dL = 6\times10^{-6} a_G$

Where

$$a_G = \frac{2a_x - 3a_y + 4a_z}{(2^2 + 3^2 + 4^2)^{1/2}}$$

$$= 0.371a_x - 0.557a_y + 0.743a_z$$

So

$dw = -[20\times10^{-6})[100a_\rho - 200a_\phi + 300a_z] \cdot$

$[0.371a_x - 0.557a_y + 0.743a_z] (6\times10^{-6})$

$= -(20\times10^{-6})$

$[37.1(a_\rho \cdot a_x) - 55.7(a_\rho \cdot a_y) - 74.2(a_\phi \cdot a_x)$

$+ 111.4(a_\phi \cdot a_y) + 222.9) [6\times10^{-6}]$

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4.2:-

Let

$E = 400a_x \cdot 300a_y - 560a_z$

in the neighborhood of point P(6,2,3) find the incremental work done in moving a 4-C charge a distance of 1mm in the direction specified by

(a):-

$a_x + 2y + 2z$ :

$dw = -q_i E\, dL = -4(400a_x - 300a_y + 500a_z]$

$\left[ \frac{(a_x + a_y + a_z)}{\sqrt{3}} (10^{-3}) \right.$

$= -\frac{(4 \times 10^{-3})}{\sqrt{3}} (400 - 300 - 500)$

$= \boxed{-1.39\,J}$

(b) $-2a_x + 3a_y - a_z$ :

The computation is similar to that of part a but we change the direction

$dw = -q_i E \cdot dL = -4(400a_x - 300a_y - 500a_z)$

$= \frac{(-2a_x + 3a_y - a_z)}{\sqrt{14}} (10^{-3})$

$= -\frac{(4 \times 10^{-3})}{\sqrt{14}} (-800 - 900 - 500) = \boxed{2.35\,J}$

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4.3

If $E = 120\, z\rho$ V/m. Find the incremental amount of work done is moving a 50uM charge a distance of 2mm from:

P(1, 2, 3) toward Q(2, 1, 4) The vector along this direction will be Q-P = (1, -1, 1) from $dw = -q\,E\,dl = -(50\times10^{-6})\left[120\,a_\rho \frac{(a_x - a_y + a_z)}{\sqrt{3}}\right](2\times10^{-3})$

$= (50\times10^{-6})(120)[a_\rho - 2x] - (a_\rho - a_y)]\frac{1}{\sqrt{3}}(2\times10^{-3})$

At P.Q = $\tan^{-1}(2/1) = 63.4°$ Thus $(a_\rho \cdot a_x) = \cos(63.4) = 0.447$ & $(a_\rho \cdot a_y) = \sin(63.4) = 0.894$ substituting these we obtained

$\boxed{dw = 3.1\,uJ}$

4.5:-

Compute the value of $\int_A^P G\cdot dl$ for $G = 2y\,a_x$ with A (1, -1, 2) & P(2, 1, 2). using the path.

(a) Straight line segment A (1, -1, 2) to (2, 1, 2) $\int_A^P G\cdot dl \cdot \int_A^P 2y\,dx$

The change in x occurs when moving between b and P during which y = 1

Thus

$$\int_A^P G\cdot dL = \int_A^P 2y\,dx = \int_1^2 2(1)dx = 2$$

(b)

Straight line segments A(1, -1, 2) to C(2, -1, 2) to P(2, 1, 2) in this case the ~~change~~ change in x occurs.

$$\int_A^P G\cdot dL = \int_A^P 2y\,dx = \int_1^2 2(-1)dx = -2$$

[4.7]:-

Repeat problem 4.6 for $G = 3xy^2 a_x + 2z a_y$ Now think are different in that the path does matter

(a) Straight line:

$y = x-1$, $z = 1$ we get

$$\int G\cdot dL = \int_2^4 3x\,y^2 dx + \int_1^3 3x(x-1)^2 dx + \int_1^3 (2)(1)\,dy = 90$$

(b) Parabolic by $= x^2 + 2 \rightarrow 2 = 1$ we get

$$\int G\,dL = \int_2^4 3xy^2 dx + \int_1^3 2x\,dy = \int_2^4 \frac{1x(x^2+2)^2}{12} dx + \int_1^3 2(1)\,dy = 80 + 2 = 82.$$