Department of Electrical Engineering

Course Title: Electromagnetic Field

Module: 4th semester

Student Detail

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QNO1:- The value of E at ...

ⓔ $G = 2a_x - 3a_y + 4a_z$.

Solution:-

ⓐ in the direction of a_ρ = The incremental work is given by $dW = -qE \cdot dL$, where in this case $dL = d\rho a_\rho = 6\times10^{-6} a_\rho$. Thus.

$$dW = -(20\times10^{-6}C)(100V/m)(6\times10^{-6}m)$$
$$= -12\times10^{-9}J$$
$$= \boxed{-12\,nJ.}$$

ⓑ in the direction of a_ϕ = In this case $dL = 2d\phi a_\phi = 6\times10^{-6}$ and so,

$$dW = -(20\times10^{-6})(-200)(6\times10^{-6})$$
$$= 2.4\times10^{-8}J$$
$$= \boxed{24\,nJ}$$

ⓒ in the direction of a_z = Here, $dL = dz\,a_z = 6\times10^{-6}a_z$.

$$dW = -(20\times10^{-6})(300)(6\times10^{-6})$$
$$= -3.6\times10^{-8}J$$
$$= \boxed{-36\,nJ}$$

ⓓ In the direction of E.

$$a_E = \frac{100a_\rho - 200a_\phi + 300a_z}{[100^2+200^2+300^2]^{1/2}}$$
$$= 0.267a_\rho - 0.535a_\phi + 0.802a_z.$$

Thus

$$dW = -(20\times10^{-6})\left[100a_\rho - 200a_\phi + 300a_z\right]\cdot\left[0.267a_\rho - 535a_\phi + 0.802a_z\right] \times 6\times10^{-6}$$

$$= \boxed{-44.9\,nJ}$$

(e) In the direction of $G = 2a_x - 3a_y + 4a_z$.

$$a_G = \frac{2a_x - 3a_y + 4a_z}{\left[2^2+3^2+4^2\right]^{1/2}}$$

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

So Now

$$dW = -(20\times10^{-6})\left[100a_\rho - 200a_\phi + 300a_z\right]\cdot\left[0.371a_x - 0.557a_y + 0.743a_z\right] (6\times10^{-6}).$$

$$= -(20\times10^{-6})\left[37.1(a_\rho\cdot a_x) - 55(a_\rho\cdot a_y) - 74.2(a_\phi\cdot a_x) + 111.4(a_\phi\cdot a_y) + 222.9\right](6\times10^{-6}).$$

where at P, $(a_\rho\cdot a_x) = (a_\phi\cdot a_y) = \cos(40^\circ) = 0.766$

$$(a_\rho\cdot a_y) = \sin(40^\circ) = 0.643$$

$$(a_\phi\cdot a_x) = -\sin(40^\circ) = -0.643$$

Now substituting these results in.

$$dW = -(20\times10^{-6})\left[28.4 - 35.8 + 47.7 + 85.3 + 222.9\right](6\times10^{-6})$$

$$= \boxed{-41.8\,nJ}$$

(2)

QNo2 let $E = 10[\sin\pi/6)a_x + 5\sin\pi/6\, a_y + 10\cos(\pi/6)a_z]$.

Solution

ⓐ $E_p = -10[\sin(\pi/6)a_x + 5\sin(\pi/6)a_y + 10\cos(\pi/6)a_z]$

$= -[5a_x + 25a_y + 50\sqrt{3}a_z]$.

ⓑ $dW_x = -qE \cdot dLa_x$

$= -2\times10^{-9}(-5)(10^{-3}) = 10^{-11}J$.

$= \boxed{10\,pJ}$

ⓒ of a_y?

$dW_y = -qE \cdot dLa_y$

$= -2\times10^{-9}(-25)(-10^{-3}) = 5\bar{0}^{11}J$

$= \boxed{50PJ.}$

ⓓ of a_z

$dW_z = -qE \cdot dLa_z$.

$= -2\times10^{-9}(-50\sqrt{3})(10^{-3})$

$= \boxed{100\sqrt{3}\,pJ}$

ⓔ of $(a_x + a_y + a_z)$?

$dW_{xyz} = -qE \cdot dL \dfrac{(a_x + a_y + a_z)}{\sqrt{3}}$

$= \dfrac{10 + 50 + 100\sqrt{3}}{\sqrt{3}}$

$= \boxed{135\,pJ}$

3.

QNO3

Solution:-

(a) P(1,2,3) toward Q(2,14)

The vector along this direction will be Q-P=(1,-1,1) from which $a_{PQ} = [a_x - a_y + a_z]/\sqrt{3}$

$$dW = -qE \cdot dL$$
$$= -(50 \times 10^{-6})\left[120\, a_p \cdot \frac{(a_x - a_y + a_z)}{\sqrt{3}}\right](2 \times 10^{-3})$$
$$= -(50 \times 10^{-6})(120)\left[(a_x \cdot a_p) - (a_p \cdot a_y)\right]\frac{1}{\sqrt{3}}(2 \times 10^{-3})$$

At P, $\phi = \tan^{-1}(2/1) = 63.4°$, Thus $(a_p \cdot a_x) = \cos(63.4°)$
$= 0.447$

$(a_p \cdot a_y) = \sin(63.4°) = 0.894$

Substituting these, we obtain

$dW = 3.1 \mu J$.

(b) Q=(2,1,4) toward P(1,2,3) A little thought is in order here: Note that the field has only a radical component and does not depend on ϕ or z. And P and Q are at the same radius $(\sqrt{5})$ from z axis. Thus the answer is $dW = 3.1 \mu J$ as in part a. this is also found by going through the procedure as in part a, but with the direction (Roles of P & Q) reversed.

(4).

QNO4 Compute the value $\int_A^P G \cdot dL$.

Solution :-

(a) Straight line segments A(1,-1,2) to B(1,1,2) to P(2,1,2): In general we would have.

$$\int_A^P G \cdot dL = \int_A^P 2y\,dx.$$

The change in x occurs when moving b/w B & P, during which y = 1.

$$\int_A^P G \cdot dL = \int_B^P 2y\,dx$$

$$\int_1^2 2(1)\,dx.$$

$$= \underline{\underline{2}}$$

(b) Straight line segment A(1,-1,2) to C(2,-1,2) to P(2,1,2): In this case change in x occurs when moving from A to C during which y = -1

$$= \int_A^P G \cdot dL = \int_C^P 2y\,dx$$

$$= \int_1^2 2(-1)\,dx$$

$$= \underline{\underline{-2}}$$

QNO 5 let $G = 3xy^3 a_x + 2z a_y$. find.

Solution:-

let $G = 3xy^3 a_x + 2z a_y$.

(a) straight line $y = x-1$, $z = 1$

$= \int G \cdot dL = \int_2^4 3xy^2 + \int_1^3 2z\,dy$

$= \int_2^4 3x(x-1)^2 dx + \int_1^3 2(1) dy$

$= \boxed{90}$.

(b) Parabola $6y = x^2 + 2$, $z = 1$

$= \int G \cdot Ld = \int_2^4 3xy^2 + \int_1^3 2z\,dy$.

$= \int_2^4 \frac{1}{12} x(x^2+2)^2 + \int_1^3 2(1)\,dy$

$= \boxed{82}$

(c).