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Assignment:

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

4.9) The value of E at P(P=2, ϕ=40°, z=3) is given as $E = 100a_\rho - 200a_\phi + 300a_z$ V/m Determine the incremental work require to move a 20μC charge a distance of 6 um:

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

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

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

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

c) In the direction of a_z: Here, $dL = dz\, a_z = 6\times10^{-6}\, a_z$ & so $dW = -(20\times10^{-6})(300)(6\times10^{-6}) = -3.8\times10^{-8}J = 36nJ$

d) In the direction of E: Here $dL = 6\times10^{-6} a_E$

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

$- 0.535a_\phi + 0.802a_z$

Thus

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

$[0.267a_\rho - 0.802a_z](6\times10^{-6}) = -44.9J$

(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 now,

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

$- 0.557a_y + 0.743a_z](6\times10^{-6}) = -(20\times10^{-6})$

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

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

(4.2) let $E = 400a_x - 300a_y - 560a_z$

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) $a_x + 2_y + 2_z$: we write

$$dw = -qE \cdot dL = -4(400a_x - 300a_y + 500a_z)\frac{(a_x + a_y + a_z)}{\sqrt{3}}(10^{-3})$$

$$= -\frac{(4 \times 10^{-3})}{\sqrt{3}}(400 - 300 + 500) = -1.39\,J$$

(b) $-2a_x + 3a_y - a_z$: The computation is similar to that of part a but we change the direction:

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

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

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

4.3

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

2) $P(1,2,3)$ toward $Q(2,1,4)$ The vector along Thus direction will be $Q - P = (1,-1,1)$ from $dw = -qE\,dL = -(50 \times 10^{-6})\left[120a\rho \frac{(a_x - a_y - a_z)}{\sqrt{3}}\right](10^{-3})$

$= (50\times10^{-6})(120)[(a_p \cdot a_x) - (a_p \cdot a_y)] \frac{1}{\sqrt{3}} (2\times10^{-3})$

At P. Q = $\tan^{-1}(2/1) = 63.4°$. Thus $(a_p \cdot a_x) = \cos(63.4) = 0.447$ & $(a_p \cdot a_y) = \sin(63.4) = 0.894$ substituting these we obtained $dw = 3.1\ \mu J$

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 $(2,1,2)$

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

The change in x occurs when moving b/w B and P during which $y=1$ Thus

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

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(b) Straight line segment A (1,-1,2) to C (2,-1,2) to P (2,1,2) in this case the change in x occurs

$$\int_A^P G.dl = \int_A^C 2y\,dx = \int_1^2 2(-1)dx = -2$$

4.7

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

(a) Straight line: $y = x - 1$, $z = 1$ we obtain

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

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

we obtain

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