ELECTROMAGNETICS HAYT 8 EDITION

DRILL SOLUTION FROM CHAPTERS 1 TO 5

CHAPTER 1

D1.1. Given points $M(-1, 2, 1)$, $N(3, -3, 0)$, and $P(-2, -3, -4)$, find: (*a*) $\mathbf{R}_{MN}$; (*b*) $\mathbf{R}_{MN} + \mathbf{R}_{MP}$; (*c*) $|\mathbf{r}_M|$; (*d*) $\mathbf{a}_{MP}$; (*e*) $|2\mathbf{r}_P - 3\mathbf{r}_N|$.

(*a*) $\mathbf{R}_{MN} = (3-(-1))\mathbf{a}_x + (-3-2)\mathbf{a}_y + (0-1)\mathbf{a}_z = 4\mathbf{a}_x - 5\mathbf{a}_y - \mathbf{a}_z$

(*b*) $\mathbf{R}_{MN} + \mathbf{R}_{MP} = \mathbf{R}_{MN} + (-2-(-1))\mathbf{a}_x + (-3-2)\mathbf{a}_y + (-4-1)\mathbf{a}_z$

$= \mathbf{R}_{MN} - \mathbf{a}_x - 5\mathbf{a}_y - 5\mathbf{a}_z = 4\mathbf{a}_x - 5\mathbf{a}_y - \mathbf{a}_z - \mathbf{a}_x - 5\mathbf{a}_y - 5\mathbf{a}_z$

$= 3\mathbf{a}_x - 10\mathbf{a}_y - 6\mathbf{a}_z$

(*c*) $|\mathbf{r}_M| = \sqrt{(-1)^2 + 2^2 + 1^2} = \sqrt{6} = 2.45$

(*d*) $\mathbf{a}_{MP} = \dfrac{-\mathbf{a}_x - 5\mathbf{a}_y - 5\mathbf{a}_z}{\sqrt{(-1)^2 + (-5)^2 + (-5)^2}} = \dfrac{-\mathbf{a}_x - 5\mathbf{a}_y - 5\mathbf{a}_z}{\sqrt{51}} = -0.14\mathbf{a}_x - 0.7\mathbf{a}_y - 0.7\mathbf{a}_z$

(*e*) $2\mathbf{r}_P - 3\mathbf{r}_N = 2(-2\mathbf{a}_x - 3\mathbf{a}_y - 4\mathbf{a}_z) - 3(3\mathbf{a}_x - 3\mathbf{a}_y) = -4\mathbf{a}_x - 6\mathbf{a}_y - 8\mathbf{a}_z - 9\mathbf{a}_x + 9\mathbf{a}_y$

$= -13\mathbf{a}_x + 3\mathbf{a}_y - 8\mathbf{a}_z$

$|2\mathbf{r}_P - 3\mathbf{r}_N| = \sqrt{(-13)^2 + 3^2 + (-8)^2} = 11\sqrt{2} = 15.56$

D1.2. A vector field $\mathbf{S}$ is expressed in rectangular coordinates as $\mathbf{S} = \{125/[(x-1)^2 + (y-2)^2 + (z+1)^2]\}\{(x-1)\mathbf{a}_x + (y-2)\mathbf{a}_y + (z+1)\mathbf{a}_z\}$. (*a*) Evaluate $\mathbf{S}$ at $P(2, 4, 3)$. (*b*) Determine a unit vector that gives the direction of $\mathbf{S}$ at P. (*c*) Specify the surface $f(x, y, z)$ on which $|\mathbf{S}| = 1$.

(*a*) $\mathbf{S} = \dfrac{125}{(2-1)^2 + (4-2)^2 + (3+1)^2}\{(2-1)\mathbf{a}_x + (4-2)\mathbf{a}_y + (3+1)\mathbf{a}_z\}$

$= \dfrac{125}{1^2 + 2^2 + 4^2}(\mathbf{a}_x + 2\mathbf{a}_y + 4\mathbf{a}_z) = \dfrac{125}{21}(\mathbf{a}_x + 2\mathbf{a}_y + 4\mathbf{a}_z)$

$= 5.95\mathbf{a}_x + 11.9\mathbf{a}_y + 23.8\mathbf{a}_z$

(*b*) $\mathbf{a}_S = \dfrac{5.95\mathbf{a}_x + 11.9\mathbf{a}_y + 23.8\mathbf{a}_z}{\sqrt{5.95^2 + 11.9^2 + 23.8^2}} = \dfrac{5.95\mathbf{a}_x + 11.9\mathbf{a}_y + 23.8\mathbf{a}_z}{27.27}$

$= 0.218\mathbf{a}_x + 0.436\mathbf{a}_y + 0.873\mathbf{a}_z$

(*c*) $1 = |\mathbf{S}| =$

$$\sqrt{\left(\frac{125(x-1)}{(x-1)^2 + (y-2)^2 + (z+1)^2}\right)^2 + \left(\frac{125(y-2)}{(x-1)^2 + (y-2)^2 + (z+1)^2}\right)^2 + \left(\frac{125(z+1)}{(x-1)^2 + (y-2)^2 + (z+1)^2}\right)^2}$$

$$1 = \sqrt{\frac{125^2[(x-1)^2 + (y-2)^2 + (z+1)^2]}{[(x-1)^2 + (y-2)^2 + (z+1)^2]^2}} = \frac{125\sqrt{(x-1)^2 + (y-2)^2 + (z+1)^2}}{(x-1)^2 + (y-2)^2 + (z+1)^2}$$

Transposing,

$$\frac{(x-1)^2 + (y-2)^2 + (z+1)^2}{\sqrt{(x-1)^2 + (y-2)^2 + (z+1)^2}} = 125$$

Conjugating,

$$\frac{(x-1)^2 + (y-2)^2 + (z+1)^2}{\sqrt{(x-1)^2 + (y-2)^2 + (z+1)^2}} \cdot \frac{\sqrt{(x-1)^2 + (y-2)^2 + (z+1)^2}}{\sqrt{(x-1)^2 + (y-2)^2 + (z+1)^2}} = 125$$

$$\sqrt{(x-1)^2 + (y-2)^2 + (z+1)^2} = 125$$

D1.3. The three vertices of a triangle are located at $A(6, -1, 2)$, $B(-2, 3, -4)$, and $C(-3, 1, 5)$. Find: (*a*) $\mathbf{R}_{AB}$; (*b*) $\mathbf{R}_{AC}$; (*c*) the angle θ_{BAC} at vertex A; (*d*) the (vector) projection of $\mathbf{R}_{AB}$ on $\mathbf{R}_{AC}$.

(*a*) $\mathbf{R}_{AB} = (-2-6)\mathbf{a}_x + (3-(-1))\mathbf{a}_y + (-4-2)\mathbf{a}_z$

$= -8\mathbf{a}_x + 4\mathbf{a}_y - 6\mathbf{a}_z$

(*b*) $\mathbf{R}_{AC} = (-3-6)\mathbf{a}_x + (1-(-1))\mathbf{a}_y + (5-2)\mathbf{a}_z$

$= -9\mathbf{a}_x + 2\mathbf{a}_y + 3\mathbf{a}_z$

(*c*) Locating angle θ_{BAC},

$\mathbf{R}_{AB} \cdot \mathbf{R}_{AC} = (-8)(-9) + 4(2) + (-6)3 = 72 + 8 - 18 = 62$

Using dot product,

$\mathbf{R}_{AB} \cdot \mathbf{R}_{AC} = |\mathbf{R}_{AB}||\mathbf{R}_{AC}| \cos\theta_{BAC}$

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