

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}_{MEV} ; (b) $\mathbf{R}_{MEV} + \mathbf{R}_{MP}$; (c) $|\mathbf{r}_{MP}|$; (d) \mathbf{a}_{MP} ; (e) $|2\mathbf{r}_P - 3\mathbf{r}_N|$.

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

$$(b) \mathbf{R}_{MEV} + \mathbf{R}_{MP} = \mathbf{R}_{MEV} + (-2 - (-1))\mathbf{a}_x + (-3 - 2)\mathbf{a}_y + (-4 - 1)\mathbf{a}_z \\ = \mathbf{R}_{MEV} - \mathbf{a}_x - 5\mathbf{a}_y - 5\mathbf{a}_z = 4\mathbf{a}_x - 5\mathbf{a}_y - \mathbf{a}_z - \mathbf{a}_x - 5\mathbf{a}_y - 5\mathbf{a}_z \\ = 3\mathbf{a}_x - 10\mathbf{a}_y - 6\mathbf{a}_z$$

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

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

$$(e) 2\mathbf{r}_P - 3\mathbf{r}_N = 2(-2\mathbf{a}_x - 3\mathbf{a}_y - 4\mathbf{a}_z) - 3(3\mathbf{a}_x - 3\mathbf{a}_y) = -4\mathbf{a}_x - 6\mathbf{a}_y - 8\mathbf{a}_z - 9\mathbf{a}_x + 9\mathbf{a}_y \\ = -13\mathbf{a}_x + 3\mathbf{a}_y - 8\mathbf{a}_z$$

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

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 $|\mathbf{S}| = 1$.

$$(a) \mathbf{S} = \frac{125}{(2-1)^2 + (4-2)^2 + (3+1)^2} \{ (2-1)\mathbf{a}_x + (4-2)\mathbf{a}_y + (3+1)\mathbf{a}_z \} \\ = \frac{125}{1^2 + 2^2 + 4^2} (\mathbf{a}_x + 2\mathbf{a}_y + 4\mathbf{a}_z) = \frac{125}{21} (\mathbf{a}_x + 2\mathbf{a}_y + 4\mathbf{a}_z) \\ = 5.95\mathbf{a}_x + 11.9\mathbf{a}_y + 23.8\mathbf{a}_z$$

$$(b) \mathbf{a}_S = \frac{5.95\mathbf{a}_x + 11.9\mathbf{a}_y + 23.8\mathbf{a}_z}{\sqrt{5.95^2 + 11.9^2 + 23.8^2}} = \frac{5.95\mathbf{a}_x + 11.9\mathbf{a}_y + 23.8\mathbf{a}_z}{27.27} \\ = 0.218\mathbf{a}_x + 0.436\mathbf{a}_y + 0.873\mathbf{a}_z$$

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

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

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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