

# 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  $\theta_{BAC}$  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  $\theta_{BAC}$ ,

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

Using dot product,

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

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