

## CHAPTER 1

1.1. Given the vectors  $\mathbf{M} = -10\mathbf{a}_x + 4\mathbf{a}_y - 8\mathbf{a}_z$  and  $\mathbf{N} = 8\mathbf{a}_x + 7\mathbf{a}_y - 2\mathbf{a}_z$ , find:

a) a unit vector in the direction of  $-\mathbf{M} + 2\mathbf{N}$ .

$$-\mathbf{M} + 2\mathbf{N} = 10\mathbf{a}_x - 4\mathbf{a}_y + 8\mathbf{a}_z + 16\mathbf{a}_x + 14\mathbf{a}_y - 4\mathbf{a}_z = (26, 10, 4)$$

Thus

$$\mathbf{a} = \frac{(26, 10, 4)}{|(26, 10, 4)|} = \underline{\underline{\{0.92, 0.36, 0.14\}}}$$

b) the magnitude of  $3\mathbf{a}_x + \mathbf{N} - 3\mathbf{M}$ :

$$\{5, 0, 0\} + \{8, 7, -2\} - \{-30, 12, -24\} = \{43, -5, 22\}, \text{ and } |(43, -5, 22)| = \underline{\underline{48.6}}$$

c)  $|\mathbf{M}||2\mathbf{N}|(\mathbf{M} + \mathbf{N})$ :

$$|(-10, 4, -8)||16, 14, -4||(-2, 11, -10)| = (13.4)(21.6)(-2, 11, -10) \\ = \underline{\underline{\{-380.5, 3193, -2902\}}}$$

1.2. The three vertices of a triangle are located at  $A(-1, 2, 5)$ ,  $B(-4, -2, -3)$ , and  $C(1, 3, -2)$ .

a) Find the length of the perimeter of the triangle: Begin with  $\mathbf{AB} = (-3, -4, -8)$ ,  $\mathbf{BC} = (5, 5, 1)$ , and  $\mathbf{CA} = (-2, -1, 7)$ . Then the perimeter will be  $\ell = |\mathbf{AB}| + |\mathbf{BC}| + |\mathbf{CA}| = \sqrt{9+16+64} + \sqrt{25+25+1} + \sqrt{4+1+49} = \underline{\underline{23.9}}$ .

b) Find a unit vector that is directed from the midpoint of the side  $AB$  to the midpoint of side  $BC$ : The vector from the origin to the midpoint of  $AB$  is  $\mathbf{M}_{AB} = \frac{1}{2}(\mathbf{A} + \mathbf{B}) = \frac{1}{2}(-5\mathbf{a}_x + 2\mathbf{a}_y)$ . The vector from the origin to the midpoint of  $BC$  is  $\mathbf{M}_{BC} = \frac{1}{2}(\mathbf{B} + \mathbf{C}) = \frac{1}{2}(-3\mathbf{a}_x + \mathbf{a}_y - 5\mathbf{a}_z)$ . The vector from midpoint to midpoint is now  $\mathbf{M}_{AB} - \mathbf{M}_{BC} = \frac{1}{2}(-2\mathbf{a}_x - \mathbf{a}_y + 7\mathbf{a}_z)$ . The unit vector is therefore

$$\mathbf{a}_{MAB} = \frac{\mathbf{M}_{AB} - \mathbf{M}_{BC}}{|\mathbf{M}_{AB} - \mathbf{M}_{BC}|} = \frac{\{-2\mathbf{a}_x - \mathbf{a}_y + 7\mathbf{a}_z\}}{7.35} = \underline{\underline{-0.27\mathbf{a}_x - 0.14\mathbf{a}_y + 0.95\mathbf{a}_z}}$$

where factors of  $1/2$  have cancelled.

c) Show that this unit vector multiplied by a scalar is equal to the vector from  $A$  to  $C$  and that the unit vector is therefore parallel to  $AC$ . First we find  $\mathbf{AC} = 2\mathbf{a}_x + \mathbf{a}_y - 7\mathbf{a}_z$ , which we recognize as  $-7.35\mathbf{a}_{MAB}$ . The vectors are thus parallel (but oppositely-directed).

1.3. The vector from the origin to the point  $A$  is given as  $(5, -2, -4)$ , and the unit vector directed from the origin toward point  $B$  is  $(2, -2, 1)/3$ . If points  $A$  and  $B$  are ten units apart, find the coordinates of point  $B$ .

With  $\mathbf{A} = (5, -2, -4)$  and  $\mathbf{B} = \frac{1}{3}B(2, -2, 1)$ , we use the fact that  $|\mathbf{B} - \mathbf{A}| = 10$ , or  $|(5 - \frac{2}{3}B)\mathbf{a}_x - (2 - \frac{2}{3}B)\mathbf{a}_y - (4 + \frac{1}{3}B)\mathbf{a}_z| = 10$

Expanding, obtain

$$36 - 8B + \frac{4}{9}B^2 + 4 - \frac{4}{9}B + \frac{4}{9}B^2 + 16 + \frac{8}{9}B + \frac{1}{9}B^2 = 100$$

or  $B^2 - 8B - 44 = 0$ . Thus  $B = \frac{8 \pm \sqrt{64+176}}{2} = 11.75$  (taking positive option) and so

$$\mathbf{B} = \frac{2}{3}(11.75)\mathbf{a}_x - \frac{2}{3}(11.75)\mathbf{a}_y + \frac{1}{3}(11.75)\mathbf{a}_z = \underline{\underline{7.83\mathbf{a}_x - 7.83\mathbf{a}_y + 3.92\mathbf{a}_z}}$$

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