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## CHAPTER 1

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

- a) a unit vector in the direction of  $-\mathbf{M} + 2\mathbf{N}$ .  
 $-\mathbf{M} + 2\mathbf{N} = 10\mathbf{a}_x - 4\mathbf{a}_y + 8\mathbf{a}_z + 16\mathbf{a}_x + 14\mathbf{a}_y - 16\mathbf{a}_z = (26, 10, 0)$   
Thus  
 $\mathbf{a} = \frac{(26, 10, 0)}{\sqrt{26^2 + 10^2}} = (0.92, 0.36, 0.11)$

- b) the magnitude of  $5\mathbf{a}_x + \mathbf{N} - 3\mathbf{M}$ .  
 $(5, 0, 0) + (8, 7, -2) - (-30, 12, -24) = (43, -5, 22)$  and  $\|(43, -5, 22)\| = 48.6$

- c)  $(\mathbf{M} \cdot \mathbf{N})/(\mathbf{M} \times \mathbf{N})$ .  
 $(-80, 4, -80) \cdot (8, 7, -2) = (-640, 28, -160) = (13, 4, 21.6)/(-2.11, -10)$   
 $= (-5853, 3138, -2902)$

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  $P = |\mathbf{AB}| + |\mathbf{BC}| + |\mathbf{CA}| = \sqrt{9+16+64} + \sqrt{25+25+1} + \sqrt{4+1+49} = 24.8$ .

- 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  $\mathbf{M}_{AB} = \frac{1}{2}(\mathbf{A} + \mathbf{B}) = \frac{1}{2}(-5\mathbf{a}_x + 7\mathbf{a}_y)$ . The vector from the origin to the midpoint of  $BC$  is  $\mathbf{M}_{BC} = \frac{1}{2}(\mathbf{B} + \mathbf{C}) = \frac{1}{2}(-3\mathbf{a}_x + 6\mathbf{a}_y - 5\mathbf{a}_z)$ . The vector from midpoint to midpoint is now  $\mathbf{M}_{BC} - \mathbf{M}_{AB} = \frac{1}{2}(-2\mathbf{a}_x - 6\mathbf{a}_y + 5\mathbf{a}_z)$ . The unit vector is therefore

$$\mathbf{a}_{BC-AB} = \frac{\mathbf{M}_{BC} - \mathbf{M}_{AB}}{|\mathbf{M}_{BC} - \mathbf{M}_{AB}|} = \frac{(-2\mathbf{a}_x - 6\mathbf{a}_y + 5\mathbf{a}_z)}{7.35} = -0.27\mathbf{a}_x - 0.81\mathbf{a}_y + 0.68\mathbf{a}_z$$

- where factors of  $1/2$  have cancelled.  
c) Show that the unit vector multiplied by scalar is equal to the vector from  $A$  to  $C$  and that the unit vector is therefore parallel to  $\mathbf{AC}$ . First we find  $\mathbf{AC} = 2\mathbf{a}_x + 8\mathbf{a}_y - 7\mathbf{a}_z$ , which we recognize as  $-7.35\mathbf{a}_{BC-AB}$ . The vectors are thus parallel (but oppositely-directed).

1.3. The vector from the origin to the point  $A$  is given as  $(6, -2, 4)$ , and the unit vector directed from the origin toward point  $B$  is  $(2, -2, 0)/3$ . If points  $A$  and  $B$  are ten units apart, find the coordinates of point  $B$ .

- With  $\mathbf{A} = (6, -2, 4)$  and  $\mathbf{B} = \frac{1}{3}(2i - 2j + 0k)$ , we use the fact that  $|\mathbf{B} - \mathbf{A}| = 10$ , or  
 $10 = \sqrt{(2-6)^2 + (-2+2)^2 + (0-4)^2} = 10$   
Expanding, obtain  
 $36 - 8i + \frac{1}{9}(4 + 4 + 0) = 100$   
or  $8i - 44 = 0$ . Thus  $i = \frac{55}{8} = 6.875$  (taking positive option) and so

$$\mathbf{B} = \frac{2}{3}(11.75\mathbf{a}_x - 2\mathbf{a}_y) = \frac{1}{3}(11.75\mathbf{a}_x - 2\mathbf{a}_y) = 3.92\mathbf{a}_x - 0.67\mathbf{a}_y$$

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