# Section 6.7 - Operations $\bar{w}$ vectors in $R^3$

**Unit vectors** - As in 2-D, we define the 3-D unit vectors along the axes. The unit vector along the x-axis is $\vec{i} = [1,0,0]$, along the y-axis is $\vec{j} = [0,1,0]$, and along the z-axis is $\vec{k} = [0,0,1]$. Again, unit vectors have length one.

"Algebraic or Position"
**Magnitude of a Cartesian Vector** -

- Similar to 2-D,

if $\vec{u} = [a,b,c]$, $|\vec{u}| = \sqrt{a^2+b^2+c^2}$

ex: Find the magnitude of $\vec{v} = [-2,0,1]$

$$|\vec{v}| = \sqrt{(-2)^2+(0)^2+(1)^2}$$
$$= \sqrt{4+1}$$
$$= \sqrt{5}$$

Scalar Multiplication in 3-D

For any vector $\vec{u} = [u_1, u_2, u_3]$ and any Scalar $k \in \mathbb{R}$, $k\vec{u} = [ku_1, ku_2, ku_3]$

ex: Find b and c such that $[-2,b,7]$ & $[c,6,21]$ are collinear.

Let k represent the scalar. Then
$[c,6,21] = k[-2,b,7]$.
$[c,6,21] = [-2k, bk, 7k]$
$\therefore c = -2k$ ; $6 = bk$ ; $21 = 7k$
$\boxed{3 = k}$
$\therefore c = -2(3)$ ; $6 = b(3)$
$c = -6$ ; $\therefore 2 = b$

Vector Addition and Subtraction
If $\vec{u} = [u_1, u_2, u_3]$ and $\vec{v} = [v_1, v_2, v_3]$,
$\vec{u} + \vec{v} = [u_1+v_1, u_2+v_2, u_3+v_3]$
and
$\vec{u} - \vec{v} = [u_1-v_1, u_2-v_2, u_3-v_3]$

Vector Between Two Points
The vector $\overrightarrow{P_1P_2}$ from $P_1(x_1,y_1,z_1)$ to point $P_2(x_2,y_2,z_2)$ is $\overrightarrow{P_1P_2} = [x_2-x_1, y_2-y_1, z_2-z_1]$

Magnitude of a Vector Between Two Points
- The magnitude of the vector $\overrightarrow{P_1P_2}$ between the points $P_1(x_1,y_1,z_1)$ & $P_2 = (x_2,y_2,z_2)$ is
$$|\overrightarrow{P_1P_2}| = \sqrt{(x_2-x_1)^2+(y_2-y_1)^2+(z_2-z_1)^2}$$

ex: a) Given $A(3,6,-1)$ and $B(-1,0,5)$ express $\overrightarrow{AB}$ as an ordered triple.
b) Determine the magnitude of $\overrightarrow{AB}$
c) Determine a unit vector, $\vec{u}$, in the direction of $\overrightarrow{AB}$

a) $\overrightarrow{AB} = [-1-3, 0-6, 5-(-1)]$
$= [-4, -6, 6]$

b) $|\overrightarrow{AB}| = \sqrt{(-4)^2+(-6)^2+(6)^2}$
$= \sqrt{16+36+36}$
$= \sqrt{88}$
$= 2\sqrt{22}$

c) Let $\vec{u}$ represent the unit vector in the direction of $\overrightarrow{AB}$.
Then $\vec{u} = \frac{1}{|\overrightarrow{AB}|}\overrightarrow{AB} = \frac{1}{2\sqrt{22}}[-4,-6,6]$
$= \left[\frac{-2}{\phantom{x}}, \frac{-3}{\phantom{x}}, \frac{3}{\phantom{x}}\right]$

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