Chapter 4 – 2D and 3D Motion

I. Definitions

II. Projectile motion

III. Uniform circular motion

IV. Non-uniform circular motion

V. Relative motion

I. Definitions

Position vector: extends from the origin of a coordinate system to the particle.

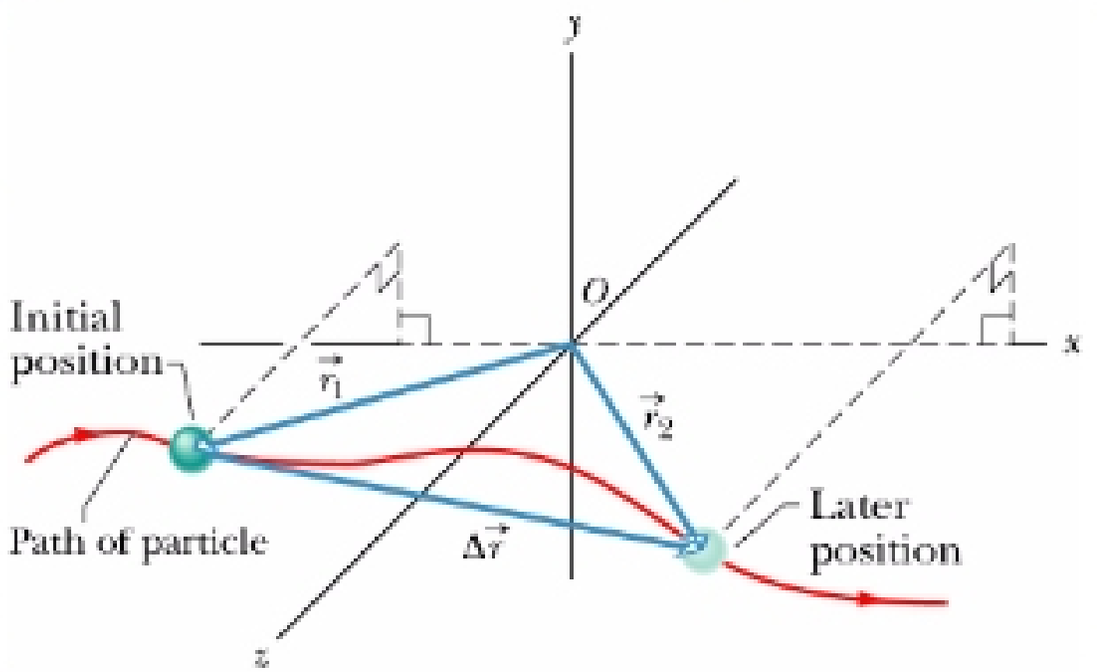
$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \qquad (4.1)$$

Displacement vector: represents a particle's position change during a certain time interval.

$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1 = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k} \qquad (4.2)$$

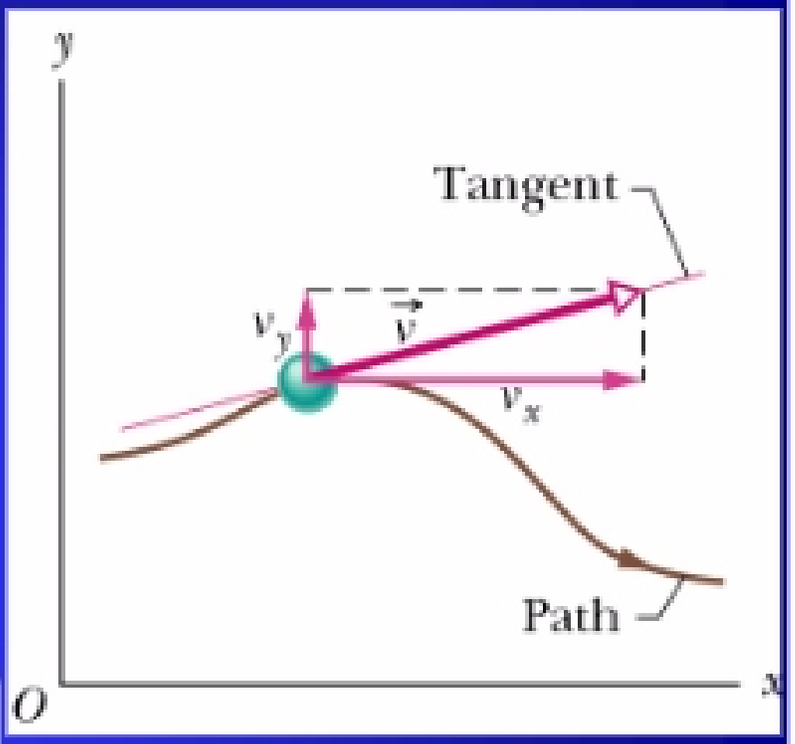
Average velocity:

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\Delta x}{\Delta t}\hat{i} + \frac{\Delta y}{\Delta t}\hat{j} + \frac{\Delta z}{\Delta t}\hat{k} \qquad (4.3)$$



Instantaneous velocity:

$$\vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k} = \frac{d\vec{r}}{dt} = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} + \frac{dz}{dt}\hat{k} \qquad (4.4)$$



-The direction of the instantaneous velocity of a particle is always tangent to the particle's path at the particle's position

Average acceleration:

$$\vec{a}_{avg} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \frac{\Delta\vec{v}}{\Delta t} \qquad (4.5)$$

Instantaneous acceleration:

$$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k} = \frac{d\vec{v}}{dt} = \frac{dv_x}{dt}\hat{i} + \frac{dv_y}{dt}\hat{j} + \frac{dv_z}{dt}\hat{k} \qquad (4.6)$$