

# WELCOME

## **Physics 1 [Spring 2021-2022]**

**Department of Physics  
Faculty of Science & Technology (FST)  
American International University-Bangladesh**

# **COURSE: PHYSICS 1 (PHY 1101)**

## **SEMESTER: SPRING [2021-2022]**

**CREDIT: 3 CREDIT HOURS**

**MARKS DISTRIBUTION**

**ATTENDANCE AND PERFORMANCE: 10 (10%)**

**ASSESSMENTS (QUIZZES) : BEST TWO OUT OF THREE : 40 (40 %)**

**TWO MIDTERM ASSESSMENTS( COUNT ALL):  $25 + 25 = 50$  (50%)**

**TOTAL = 100 POINTS/MARKS**

# Outline up to Mid term

## **Reference Book: Fundamentals of Physics (10th Edition)**

**Written by Halliday, Resnick and Walker**

<b>Book chapter no</b>	<b>Chapter name</b>
<b>4</b>	<b>Motion in Two and Three Dimensions</b>
<b>5</b>	<b>Force and Motion-I</b>
<b>6</b>	<b>Force and Motion-II</b>
<b>7 and 8</b>	<b>Kinetic Energy and Work And Conservation of Energy</b>
<b>9</b>	<b>Center of Mass and Linear Momentum</b>
<b>10</b>	<b>Rotation</b>
<b>11</b>	<b>Rolling, Torque, and Angular Momentum</b>

# LESSON 1

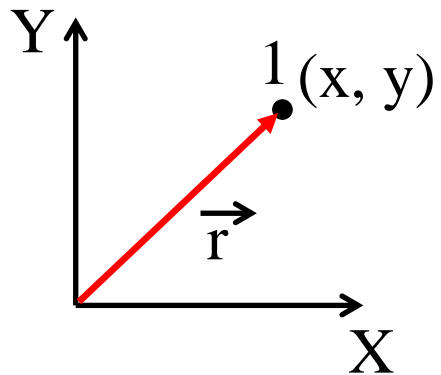
## BOOK CHAPTER 4

### Motion in Two and Three Dimensions

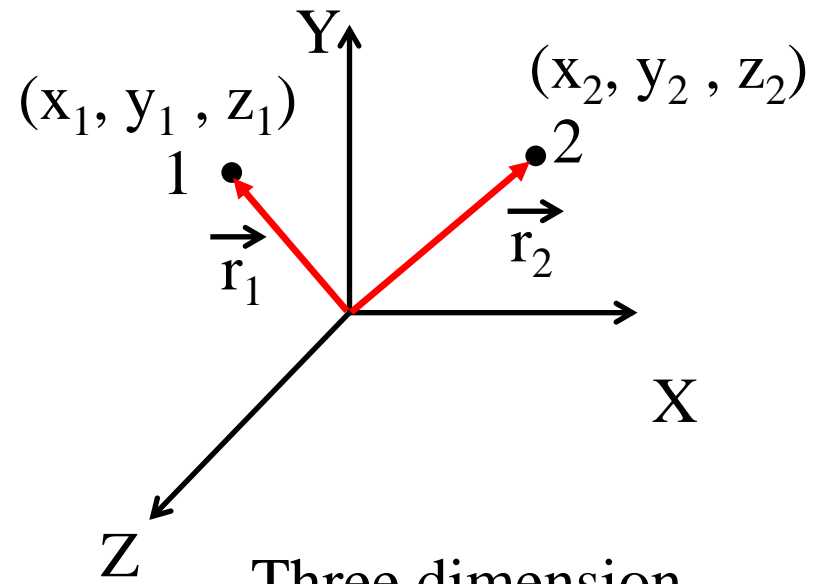
## Outline of Lesson 1

- Position and Displacement
  - Average Velocity and Instantaneous Velocity
  - Average Acceleration and Instantaneous Acceleration
-

# Position:



Two dimension

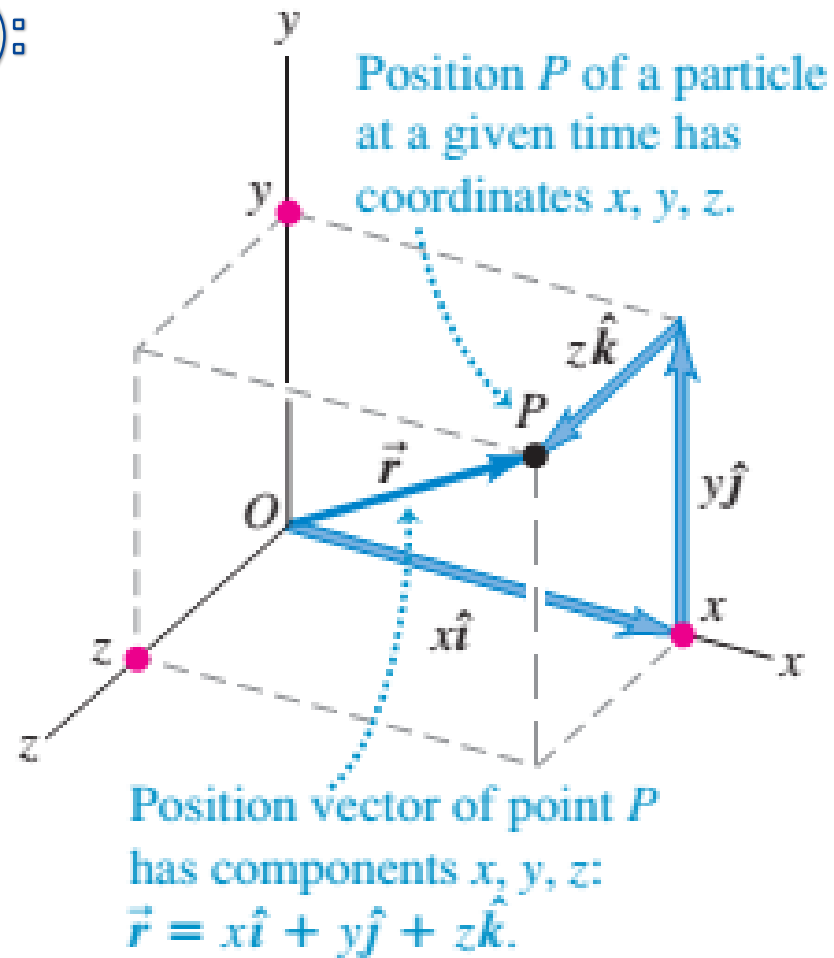


Three dimension

## Position Vector (three-dimension):

To describe the *motion* of a particle in space, we must first be able to describe the particle's *position*. Consider a particle that is at a point  $P$  at a certain instant. The **position vector**  $\vec{r}$  of the particle at this instant is a vector that goes from the origin of the coordinate system to the point  $P$  (as shown in the figure). The Cartesian coordinates  $x$ ,  $y$ , and  $z$  of point  $P$  are the  $x$ -,  $y$ -, and  $z$ -components of vector  $\vec{r}$ . Using the unit vectors we can write

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$$



## Position Vector and Displacement Vector:

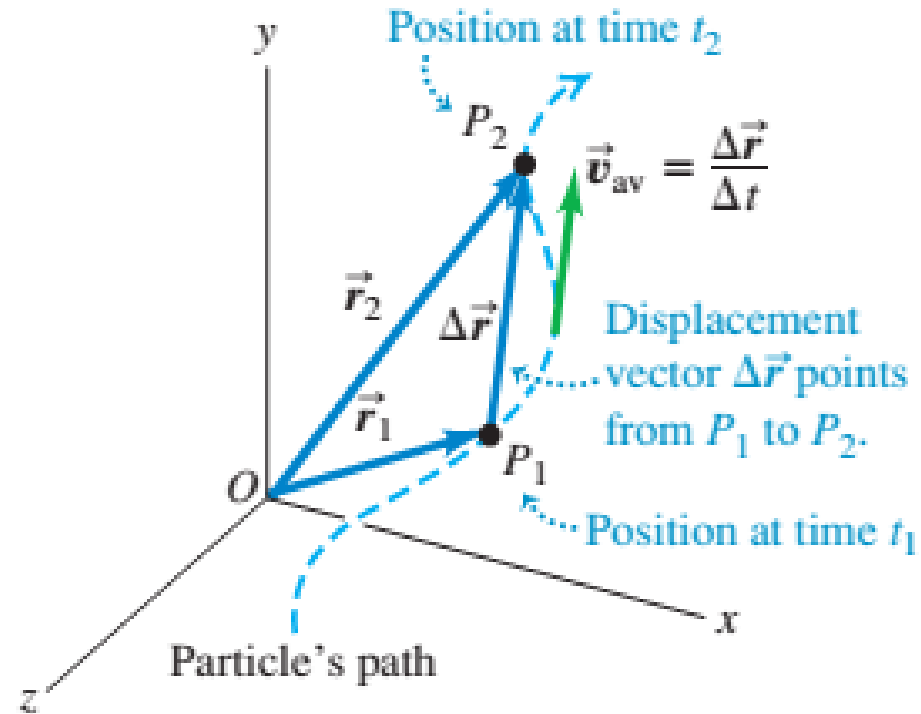
During a time interval  $\Delta t$  the particle moves from  $P_1$ , where its position vector is  $\vec{r}_1$  to  $P_2$ , where its position vector is  $\vec{r}_2$ . The change in position (the displacement) during this interval is

$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$$

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

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

$$\Delta\vec{r} = \Delta x\hat{i} + \Delta y\hat{j} + \Delta z\hat{k}$$



## Average Velocity and Instantaneous Velocity:

If a particle moves through a displacement  $\Delta\vec{r}$  in a time interval  $\Delta t$ , then its **average velocity**  $\vec{v}_{avg}$  is

$$\vec{v}_{avg} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta\vec{r}}{\Delta t}$$



**Instantaneous velocity (simply, velocity  $\vec{v}$ )** is the limit of the average velocity as the time interval approaches zero, and it equals the instantaneous rate of change of position with time. That is

$$\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$$

The *magnitude* of the vector  $\vec{v}$  at any instant is the *speed* of the particle at that instant. The *direction* of  $\vec{v}$  at any instant is the same as the direction in which the particle is moving at that instant.

**Note:** At every point along the path, the instantaneous velocity vector is tangent to the path at that point.

❑ Create a particle's position vector as a function of time and evaluate its (instantaneous) velocity vector.

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

We have the definition of velocity vector,

$$\vec{v} = \frac{d\vec{r}}{dt}$$

$$\vec{v} = \frac{d}{dt} (x\hat{i} + y\hat{j} + z\hat{k}) = \frac{dx}{dt}\hat{i} + \frac{dy}{dt}\hat{j} + \frac{dz}{dt}\hat{k} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k}$$

The **magnitude** of the instantaneous velocity vector  $\vec{v}$  —that is, the speed—is given in terms of the component  $v_x$ ,  $v_y$  and  $v_z$  by the Pythagorean relation:

$$|\vec{v}| = v = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

The adjacent Figure shows the situation when the particle moves in the  $xy$ -plane. In this case,  $z$  and  $v_z$  are zero. Then the speed (the magnitude of  $\vec{v}$ ) is

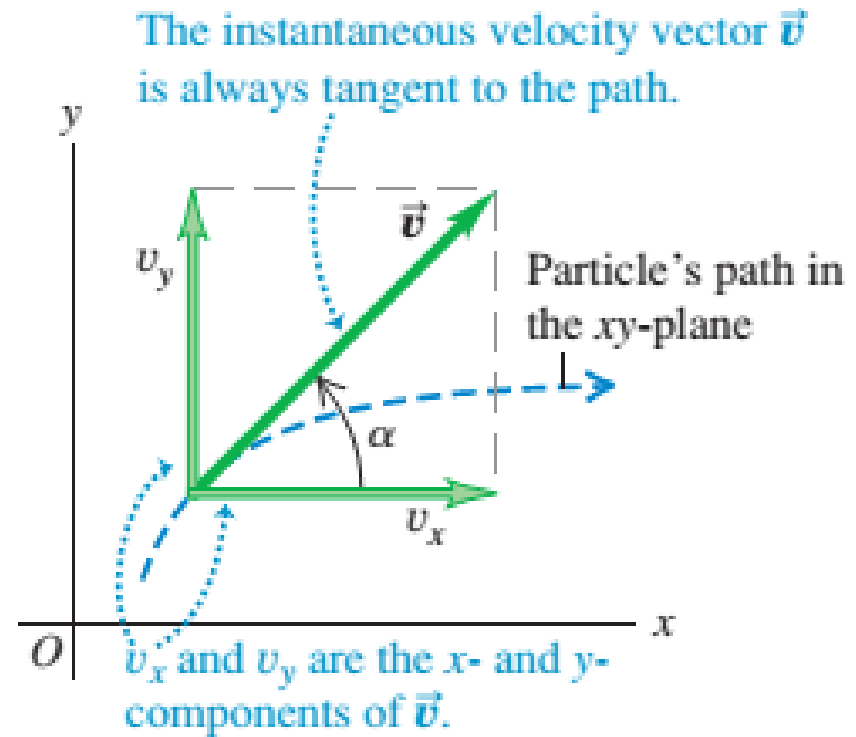
$$v = \sqrt{v_x^2 + v_y^2}$$

The **direction** of the instantaneous velocity is given by the angle  $\alpha$  (the Greek letter alpha) in the figure.

$$\tan \alpha = \frac{v_y}{v_x}$$

And

$$\alpha = \tan^{-1} \frac{v_y}{v_x}$$



If a body's (or particle's) velocity changes from  $\vec{v}_1$  to  $\vec{v}_2$  in time interval  $\Delta t$ , its average acceleration during  $\Delta t$  is

$$\vec{a}_{avg} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} = \frac{\Delta \vec{v}}{\Delta t}$$

If  $\Delta t$  approaches to zero about some instant, then in the limit  $\vec{a}_{avg}$  approaches the **instantaneous acceleration** (or **acceleration**) at that instant; that is,

$$\vec{a} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

□ Create a particle's velocity vector as a function of time and evaluate its (Instantaneous) acceleration vector.

$$\vec{v}(t) = v_x \hat{i} + v_y \hat{j} + v_z \hat{k}$$

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt} (v_x \hat{i} + v_y \hat{j} + v_z \hat{k}) = \frac{dv_x}{dt} \hat{i} + \frac{dv_y}{dt} \hat{j} + \frac{dv_z}{dt} \hat{k}$$

$$\vec{a} = a_x \hat{i} + a_y \hat{j} + a_z \hat{k}$$

### Problem 3 (Book chapter 4)

A positron undergoes a displacement  $\Delta\vec{r} = 2\hat{i} - 3\hat{j} + 6\hat{k}$ , ending with the position vector  $\vec{r} = 3\hat{j} - 4\hat{k}$ , in meters. What was the positron's initial position vector?

Answer:

We have 
$$\Delta\vec{r} = \vec{r} - \vec{r}_1$$

$$\vec{r}_1 = \vec{r} - \Delta\vec{r} = 3\hat{j} - 4\hat{k} - (2\hat{i} - 3\hat{j} + 6\hat{k}) = 3\hat{j} - 4\hat{k} - 2\hat{i} + 3\hat{j} - 6\hat{k}$$

$$\vec{r}_1 = -2\hat{i} + 6\hat{j} - 10\hat{k}$$

### Problem 13 (Book chapter 4)

A particle moves so that its position (in meters) as a function of time (in seconds) is  $\vec{r} = \hat{i} + 4t^2\hat{j} + t\hat{k}$ . Write expressions for (a) its velocity and (b) its acceleration as functions of time.

**Answer:**

We have 
$$\vec{v} = \frac{d\vec{r}}{dt}$$

$$\vec{v} = \frac{d}{dt}(\hat{i} + 4t^2\hat{j} + t\hat{k}) = 0 + 8t\hat{j} + \hat{k} = 8t\hat{j} + \hat{k}$$

Again, we have 
$$\vec{a} = \frac{d\vec{v}}{dt}$$

$$\vec{a} = \frac{d}{dt}(8t\hat{j} + \hat{k}) = 8\hat{j} + 0 = 8\text{ m/s}^2\hat{j}$$

Thank you