

WELCOME

Physics 1 [Spring 2020-2021]

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

COURSE: PHYSICS 1 (PHY 1101)
SEMESTER: SPRING [2020-2021]

CREDIT: 3 CREDIT HOURS

MARKS DISTRIBUTION

ATTENDANCE AND PERFORMANCE: 10 (10%)

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

MIDTERM ASSESSMENT: 50 (50%)

TOTAL = 100 POINTS/MARKS

Outline up to Mid term

Reference Book: Fundamentals of Physics (10th Edition)

Written by Halliday, Resnick and Walker

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

Lecture 1

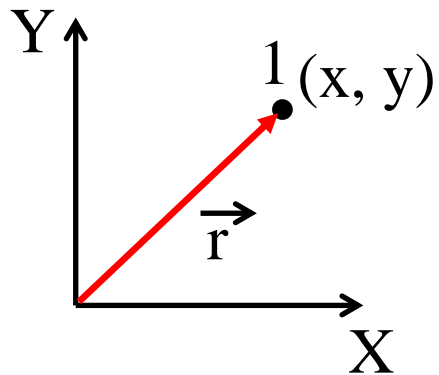
BOOK CHAPTER 4

Motion in Two and Three Dimensions

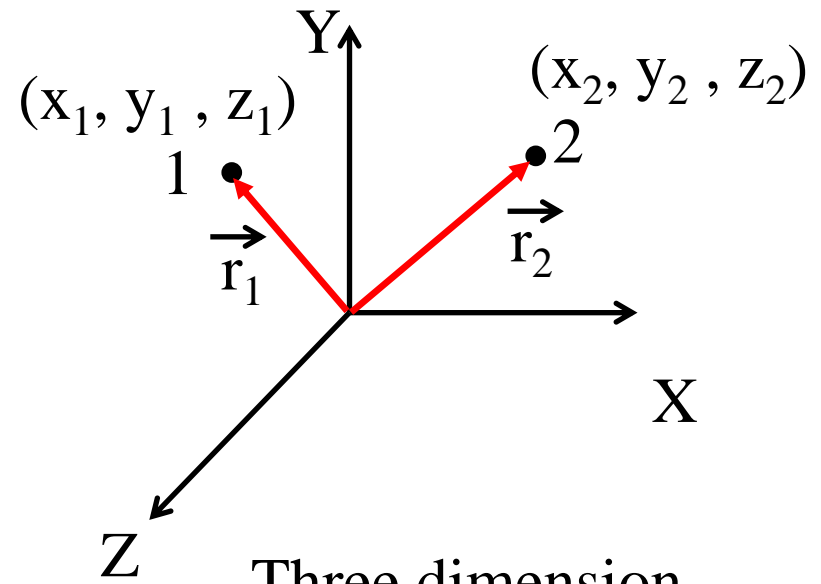
Outline of Lesson 1

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

Position:



Two dimension

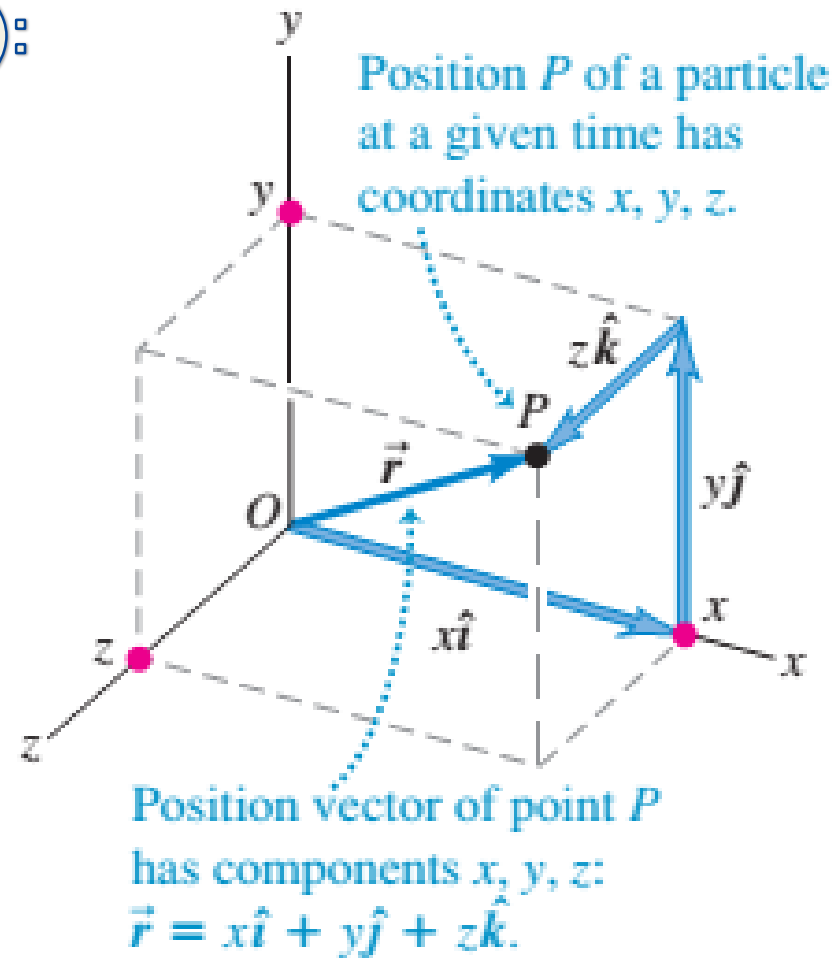


Three dimension

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 Δt 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

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

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

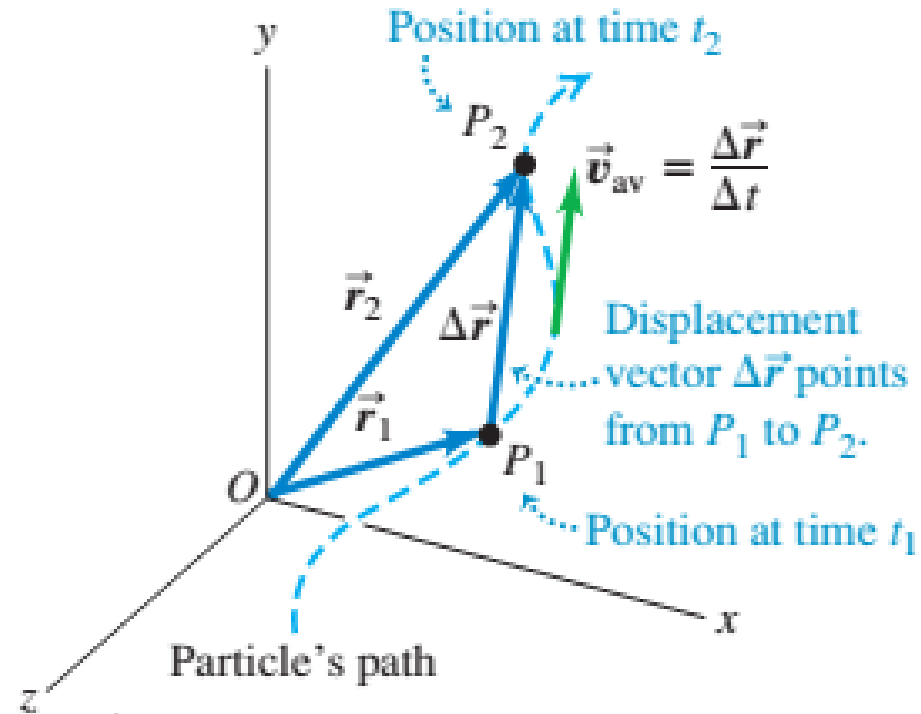
$$\Delta\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$$

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

Average Velocity and Instantaneous Velocity:

If a particle moves through a displacement $\Delta\vec{r}$ in a time interval Δt , 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

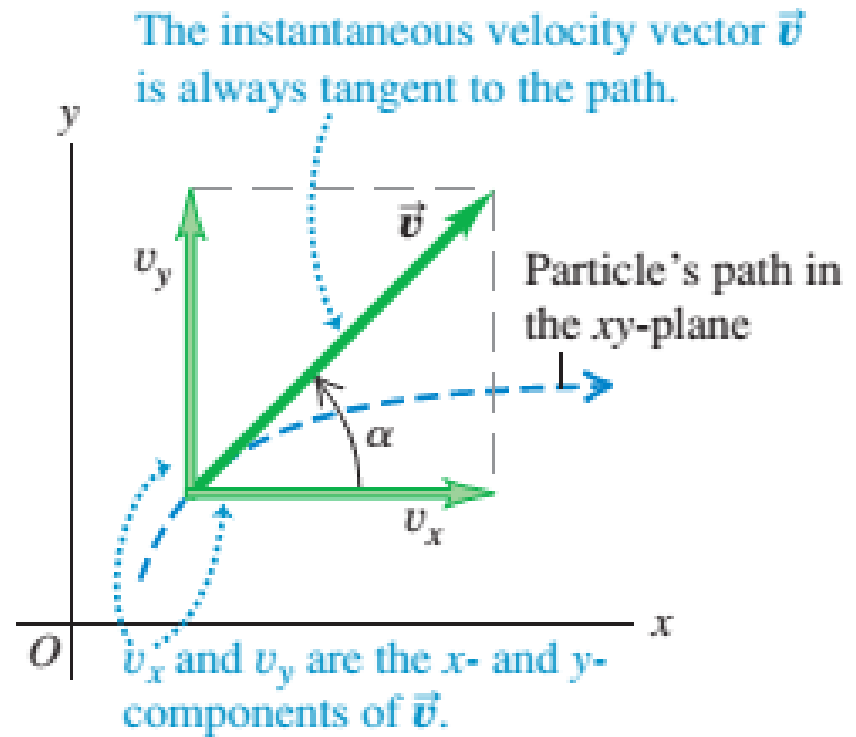
$$v = \sqrt{v_x^2 + v_y^2}$$

The **direction** of the instantaneous velocity is given by the angle α (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 Δt , its average acceleration during Δt is

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

If Δt 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.

Type equation here.

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