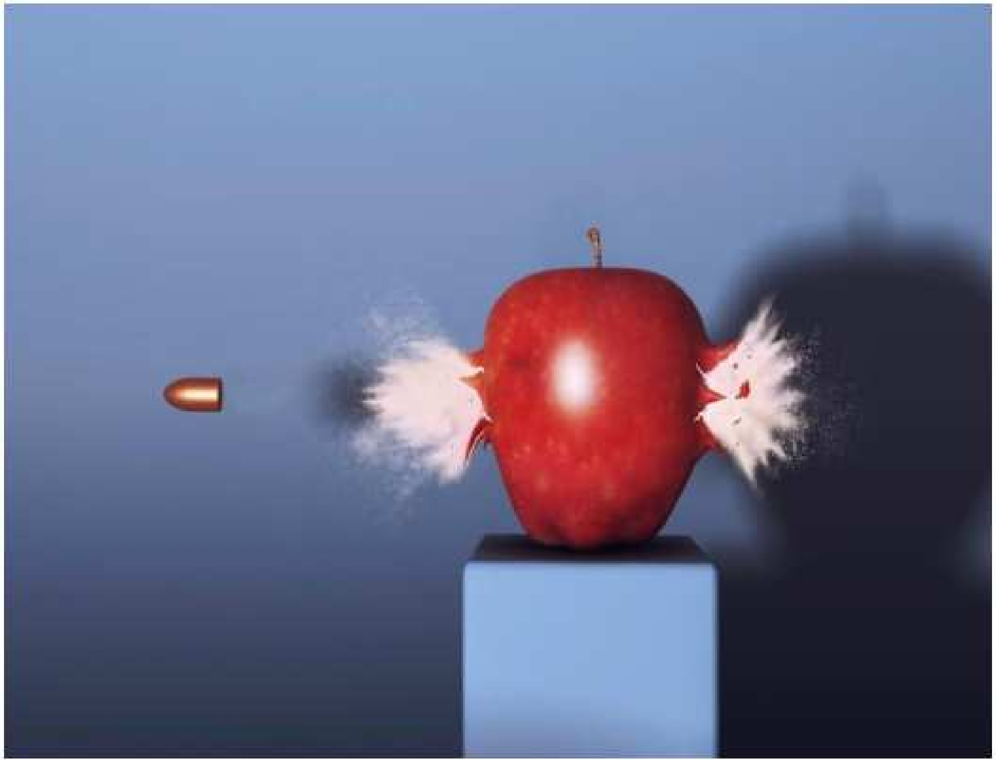
KINEMATICS

The velocity of this bullet in mid-flight describes the direction of motion and the magnitude of the motion of the caliber bullet.



KINEMATICS

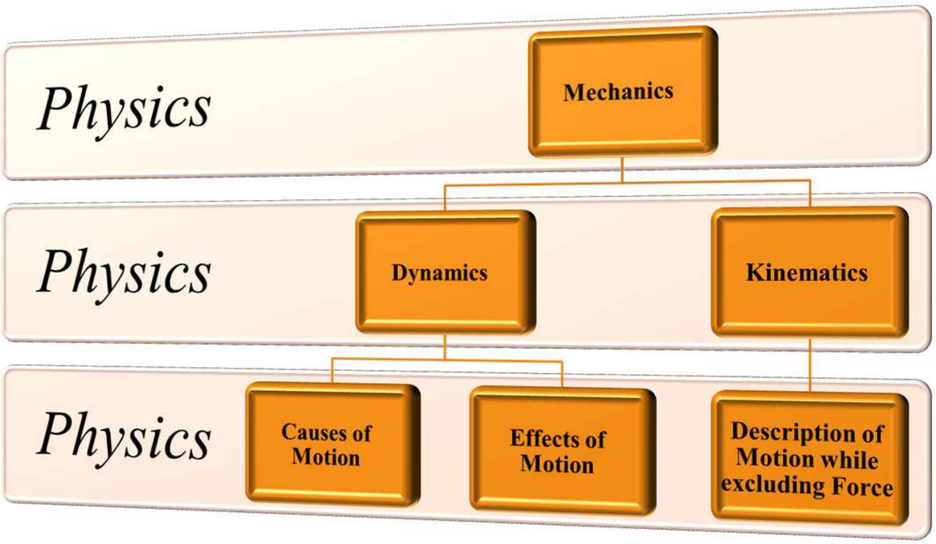
Recall:

Physics is the study of matter in relation to energy.

A branch of physics that deals with the relationship between force, matter and motion is called **Mechanics**.

Motion of a body can be one-dimensional or two dimensional.

Certain quantities such as displacement, velocities and acceleration and used to describe motion. They are **vector** quantities.



KINEMATICS:
Motion along a straight line

Imagine Ose moves from point P_1 to point P_2 along x-axis over a period of time.

Ose's displacement is characterized by the change in his position Δx:

$\Delta x = x_2 - x_1$

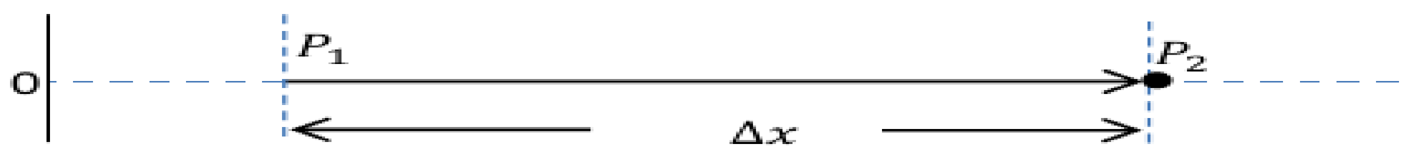
Ose's change in time is explained as Δt:

$\Delta t = t_2 - t_1$

To find Ose's average velocity:

$$average\ velocity = \frac{change\ in\ displacement}{change\ in\ time} = \frac{\Delta_x}{\Delta_t}$$

$$V = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$



KINEMATICS:
Motion along a straight line

#TuesdayTrivia

1) Deduce Ose's average velocity, if his initial and final positions are x_1= 15m and $x_2 = 250m$ respectively, while he travels at a time interval of t_2 = 6.7s and t_1 = 2.3s.

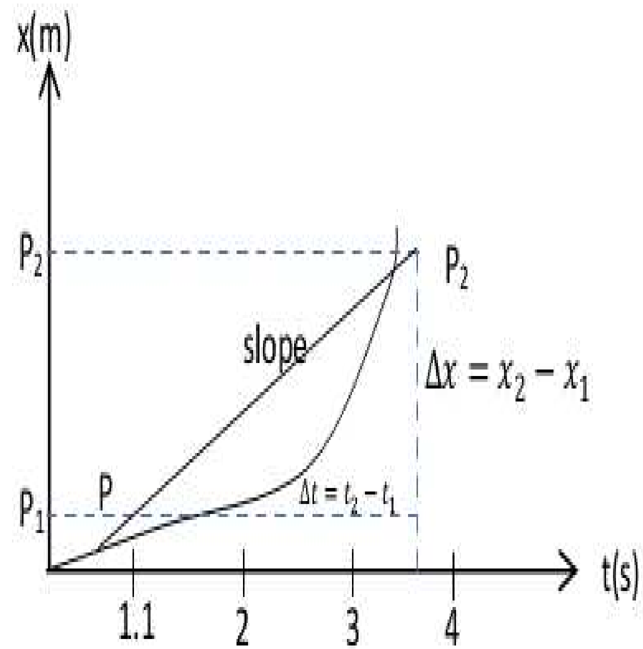
Answer = 53.41 m/s

Displacement-Time Graph:

Ose's motion can be represented with DTG

Ose's velocity is represented with the slope

Slope = V = $\frac{\Delta x}{\Delta t}$



KINEMATICS:
Instantaneous Velocity

Limitation: the average velocity does not provide us with how fast the moving particle is at specific times during motion.

To know the instant time during time motion, we need the **instantaneous velocity.**

It is the defined as the limit of the average velocity as the time interval approaches zero.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

$$v = \frac{dx}{dt}$$

The limit is a derivative of x with respect to t.

KINEMATICS:
Instantaneous Velocity

Class Example:

1) The variation of motion of Ehi along x-axis with respect to time is described by the equation $x = 20m + (5.0m/s^2)t^2$.

A) Find Ehi's displacement between $t_1 = 1.0s$ and $t_2 = 2.0s$

B) Find the average velocity during the same interval.

C) Find the instantaneous velocity at time $t_1 = 1.0s$

Answer: a) Δx = 15m b) v = 15m/s   c) v = 10m/s

KINEMATICS: Average Acceleration

Acceleration = Change in velocity *divided by* time.

Average acceleration is also defined as change in velocity per unit change in time.

Average acceleration is also a vector quantity. Unit is expressed as: m/s^2

$$a = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

KINEMATICS:
Instantaneous Acceleration

Same principle as instantaneous velocity!

Instantaneous acceleration is the limit of the average acceleration as the time interval approaches zero.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t}$$

$$a = \frac{dv}{dt}$$

KINEMATICS:
Instantaneous Acceleration

Class Example

2) Suppose the velocity of a car travelling along x axis at time interval t is given by the equation

v $= 30m + (0.50m/s^2)t^2$

A) Find the velocity of the car in the time interval between $t_1 = 1.0s$ and $t_2 = 3.0s$

B) Find the average acceleration in this time interval.

C) Find the instantaneous acceleration at time $t_1 = 1.0s$.

Answer: a) 4m/s b) 2m/s^2 c) 1m/s^2

Equations of Motion

For a body moving with constant acceleration, the velocity changes at the same rate throughout the motion:

$\boldsymbol{a = \frac{v-u}{t}}$ *equ. x*

Making velocity subject of formulae:

$\boldsymbol{v = u + at}$ *equ. 1*

$\boldsymbol{x = x_0 + ut + \frac{1}{2}at^2}$ *equ. 2*

$\boldsymbol{v^2 = u^2 + 2a(x - x_0)}$ *equ. 3*

$\boldsymbol{(x - x_0) = (\frac{v+u}{2})t}$ *equ. 4*

Equations of Motion

Class Example

3) Esosa is moving with a constant acceleration that covers the distance between two points 70.0m apart in 7.0s. Her speed as she passes the second point is 15.0m/s.

A) What is her first speed at the first point?

B) What is her acceleration?

Answer: a) 5m/s   b) 1.43m/s^2

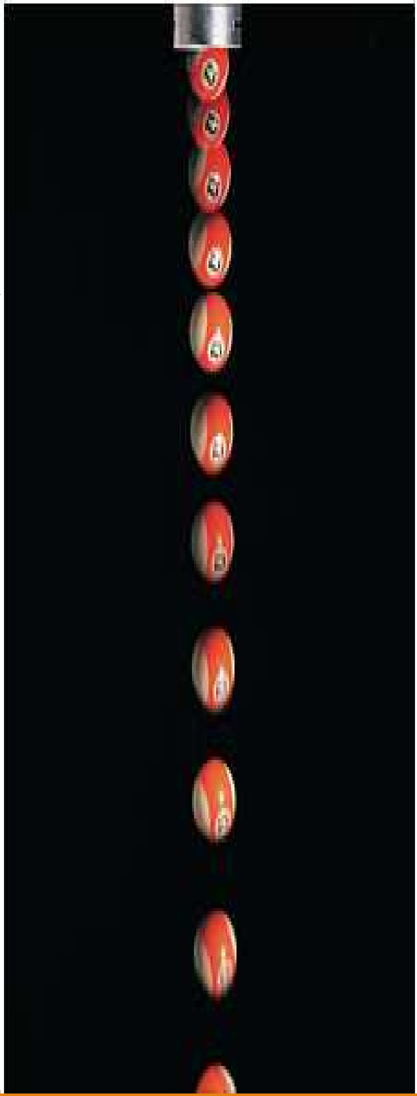
Motion under Gravity

Aristotle said heavy bodies fall faster than light bodies, but he was wrong!

Galileo Galilee argued that a body should fall with a downward acceleration that is constant and independent of its weight, and he was correct!

The constant acceleration of a freely falling body is called the **acceleration due to gravity** or the **acceleration of free fall**.

On earth, g = $9.8 m/s^2$ On moon g = $1.6 m/s^2$, near the sun g = $270 m/s^2$



Motion under Gravity

Replace a for g and x for h in the equations below:

$\boldsymbol{v = u + at}$ *equ. 1*

$\boldsymbol{x = x_0 + ut + \frac{1}{2}at^2}$ *equ. 2*

$\boldsymbol{v^2 = u^2 + 2a(x - x_0)}$ *equ. 3*

$\boldsymbol{(x - x_0) = (\frac{v+u}{2})t}$ *equ. 4*

Equations for motion under gravity:

$\boldsymbol{v = u + gt}$ *equ. 1a*

$\boldsymbol{h = h_0 + ut + \frac{1}{2}gt^2}$ *equ. 2a*

$\boldsymbol{v^2 = u^2 + 2g(h - h_0)}$ *equ. 3a*

$\boldsymbol{(h - h_0) = (\frac{v+u}{2})t}$ *equ. 4a*

Motion under Gravity

Class Example

4) A stone is dropped from rest and falls freely. Compute its position and velocity after 1.0s, 2.0s, and 3.0 s.

Finding Velocity and Position by Integration

When acceleration is not constant, it varies with time.

Hence $\Delta v = a_{av}\Delta t$

By integration, velocity becomes:

$$v = u + \int_{t_1}^{t_2} a_x dt$$

By integration, position becomes:

$$x = x_0 + \int_{t_1}^{t_2} v_x dt$$

Finding Velocity and Position by Integration

Class Example

5) Jovita is driving along a straight highway in her Mercedez benz. At time t = 0, when Jovita is moving at 10 m/s in the positive x direction, she passes a sign post at x = 50 m. Her acceleration is a function of time: $a_x = 2 - 0.10t$

a. Find her velocity and position as functions of time?

b. When is her velocity greatest?

c. What is the maximum velocity?

d. Where is the car when it reaches the maximum velocity?

Motion in Two or Three Dimension

Vector $\vec{r}$ can be described by the Cartesian coordinates x, y, and z.

Where $\vec{r} = xi + yj + zk$

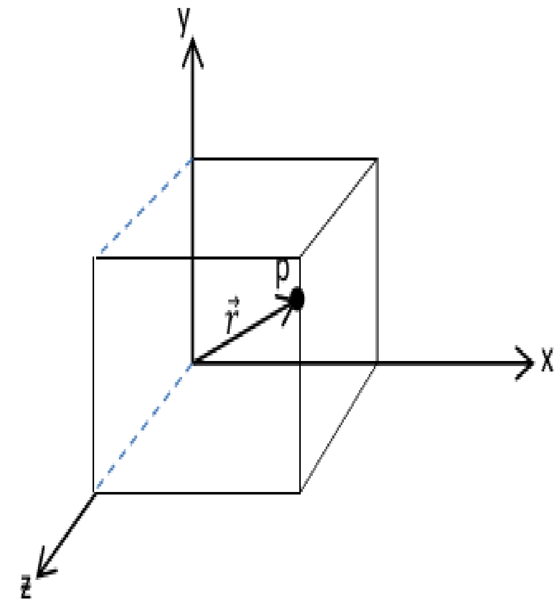
Assume another particle is in the rectangular space at position P_2, we have another vector $\vec{r}$

Where $\vec{r_2} = x_2 i + y_2 j + z_2 k$

The displacement between both position is given as $\Delta\vec{r}$

Where $\Delta\vec{r} = \vec{r_2} - \vec{r_1}$

Give me the answer: $(x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k}$



Motion in Two or Three Dimension

$\Delta\vec{r}$ is called total displacement or change in position.

Due to a change in position, there is a time interval between t_2 and t_1

Total change in time is given as $\Delta t = t_2 - t_1$

To find the average velocity v_{av}

$$v_{av} = \frac{\Delta\vec{r}}{\Delta t} = \frac{\overrightarrow{r_2} - \overrightarrow{r_1}}{t_2 - t_1}$$

The instantaneous velocity for this motion is expressed as: $v = \lim_{\Delta t \to 0} \frac{\Delta\vec{r}}{\Delta t} = \frac{dr}{dt}$

Motion in Two or Three Dimension

To find the average acceleration a_{av}

$$a_{av} = \frac{change\ in\ velocity}{change\ in\ time}$$

$$a_{av} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta\vec{v}}{\Delta t}$$

The instantaneous acceleration for this motion is expressed as: $a = \lim_{\Delta t \to 0} \frac{\Delta\vec{v}}{\Delta t} = \frac{dv}{dt}$

Motion in Two or Three Dimension

Class Example

6) The position of a certain computer program is given as:

$\vec{r} = (4.0cm + 2.5t^2)i + 5.0tj$

A) Find the magnitude and direction of the program's average velocity between t = 0 and t = 2.0 s.

B) Find the magnitude and direction of the instantaneous velocity at t = 0, t = 1.0s, and t=2.0 s.

Work Problems!

1) The position of an object as a function of time is given as $x = 4 + 5t^2\ meters$.

At time t = 3s. What will be the objects (a) position (b) velocity (c) acceleration?

2) An object moves such that its displacement varies with time as $x = 3.0 + 0.2t^4 meters$.

Find (a) its instantaneous velocity at time t = 3 s (b) Its average velocity between the time interval 2.0s and 3.0s.

3) The position of an object moving along positive x-axis is given by $x = 6t - 4t^2 + \ t^3$

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QUESTION TIME????????????????

About Lecturer:

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