**PHY 101 GENERAL PHYSICS I**

**POSITION , VELOCITY AND ACCELERATION VECTORS**

**Position vector**

then

**Velocity vector**

**If the velocity of an object changes from to where**

**then**

**Acceleration vector**

**If the acceleration of an object changes from to where**

**then**

**Instantaneous velocity and acceleration**

**Recall that the average velocity and average acceleration of the object are given as**

**=**

**=**

**where x-displacement i.e the velocity of an object at any instant in time (i.e as the limit of ∆t→0) is called instantaneous velocity (m/s)**

**〖lim ∆t→0⁡〖∆v/∆t〗 where v=velocity i.e the acceleration of an object at any instant in time (i.e as the limit of ∆t→0) is called instantaneous velocity (m/s2)**

**Velocity and acceleration**

Velocity is defined as rate of change of displacement (m/s)

where x= displacement

from t1 to t2

Also, Acceleration is the rate of change of velocity or change in velocity over time taken (m/s2)

where v= velocity

evaluated from t1 to t2

In 3 coordinate system, If the displacement is given as

=

Calculations

Problem 1

The position of an object moving in a straight line is given by

n t=0 and t=4 s

(ii) the average velocity for the time interval t=2 s and t=4 s

*Solution*

At t=0 s, X1=3(0)-4(0)2+(0)3= 0 m

At t=4 s, X2=3(4)-4(4)2+43= 12 m

The displacement between t=0 and t=4 s =12-0 =12 m

(ii) at t=2 s, x1= 3(2)-4(2)2+(2)3 = - 2 m

Recall that at t = 4 s , x2= 12 m

**Problem 2**

A particle moves along the x-axis such that its instantaneous position x is given as -q where x is in meters and t is in seconds. If the numerical values of p and q are 2.0 and 1.0 respectively, calculate (i) the dimension of p and q (ii) apart from t=0. At what time is the particle at rest and determine the acceleration at that time

Solution

Given that -q

Both pt2 and qt3 must have the dimension of length L

L=Pt2, P=L/t2= LT-2

L=qt3 , q=L/t3 : q=LT-3

(ii) Given that -q V=0 when the particle is at rest

:

The acceleration,

Problem 3

The velocity of a particle moving along the x-axis varies with time according to the expression the average acceleration in the time interval t=o to t=20 s

Solution

= -10 (20) = -200 m/s2 (i.e deceleration or negative acceleration)

Tutorial #1

**Further examples/illustrations**

**Projectile**

A projectile is a body that is launched into the space. Which usually follows a curved or parabolic path? It is a motion under the influence of gravitational acceleration and air resistance. It has two types of motion. (i) constant horizontal motion (ii) a vertically downward motion. The path taken by the projectile is called trajectory.

Examples-Projectile motion

-Launching of a mechanically propelled missiles

Shooting of arrows, gun and rockets

-Throwing of discus and javelin

-taking off and landing of an aircraft

-Kicking the ball or throwing of a basket ball

Diagram

Y V=0

Uy=USinθ

U Hmax

Range x

Ux=U Cos θ

Time (t) reach the maximum height (t) and Time of flight (T)

At Hmax, , V=0

The time of flight=

**Range R**  can be defined as the horizontal distance from the point of projection to a point where the projectile hits the projection plane

=

Maximum height

S=Hmax, Hence,

Instantaneous velocity, V

θ

Using Pythagoras Theorem,

The angle of projection θ

**Problem 1**

A gun that is inclined at 30o to the horizontal fires a bullet with a speed of 500 m/s. Calculate the velocity of the bullet 5s after it is fired (g=9.8 m/s2) and the resultant speed of the bullet?

**Solution**

= 433 m/s

= 250 m/s

The velocity /vertical component after 5s,

= 201 m/s

The resultant speed of the bullet,

√(4332+2012)= 479.4 m/s at an angle of projection θ

**Problem 2**

An object is projected with a velocity of 30 m/s at an angle of 40o to the horizontal. Calculate (i) the time to get to the maximum height

(ii) the maximum height reached

(iii) the total distance covered (g=10 m/s2)

Solution

A= 30 m/s. θ=40o

1. The maximum height reached

TUTORIAL #2---- Questions 1-4

Further examples/illustrations

Circular motion

* This is the motion whose acceleration is directed radialy towards the centre of the circle and it is given in magnitude as
* Two types: (i) Uniform circular motion and (ii) Non-uniform circular motion
* Constant speed and acceleration is directed to the centre—Uniform circular motion e.g rotation of the blades of the helicopter, rotation of a satellite round the earth
* Non uniform circular motion: Speed is not constant and acceleration is not directed to the centre e.g a car or an athlete moving round a circle or a roundabout.
* From Newton’s 2nd law of motion, the net radial force (**centripetal force**) is

**Centrifugal force**  (tends to pull the object away from the centre)

**The force is always directed to the centre and acts perpendicular to the direction of the linear velocity (V)**

**Period** is the time taken for a particle to complete one revolution around a circular path of radius r is referred to as period (T) of the circular motion

Unit : Seconds (s)

The tangential component of acceleration

The linear acceleration is related to centripetal acceleration by

Since F = ma . (Newton, N)

The radial component of linear acceleration is the resultant of at amd ar .

Linear acceleration

tangential acceleration

Radial component of acceleration

S

θ

θ

r

V

Fc

Θ=ωt

The angular equations of motion are:

In the equations of motion, let S=θ, ω0 and ω =initial and angular speed u and v respectively, a=α )

-------------(i)

……………(ii)

………………(iii)

Equations (i) to (iii) are angular equations of motion

**Problem 1**

Suppose the moon is moving in a circular path of radius 3.8x105 km about the earth. If the period of revolution is 27.5 days, calculate the acceleration of the moon

**Solution**

R=3.8 x 108 m, T=27.5 days = 24 x 3600 =2.37 x 106 s

Problem 2

An earth satellite rotates in a circular orbit of radius 7,000 km (about 600 km above the earth’s surface) with an orbital speed of 27,000 km/h. calculate: (i) the period of the rotation (ii) the acceleration due to gravity at the orbit?

Solution

Given that r= 7 x 106 m v = 27,000 km/h=27000 x 1000/3600 m/s = 7500 m/s

1. == 8.04 m/s2

**Further examples/illustrations**