1

**(Dynamic)**

**Kinetics of a Particle: Force and Acceleration**

**Newton's Second Law of Motion**

Kinetics is a branch of dynamics that deals with the relationship between the change in motion of a body and the forces that cause this change. Newton's second law, which states that when an unbalanced force acts on a particle, the particle will accelerate in the direction of the force with a magnitude that is proportional to the force.

**F** = unbalanced force , a= the acceleration

m=the constant of proportionality=mass of the particle.

**m = F / a**

**Newton's Law of Gravitational Attraction**

Shortly after formulating three laws of motion, Newton postulated a law governing the mutual attraction between any two particles. In mathematical form this law can be expressed as

where

F = force of attraction between the two particles.

G = Universal constant of gravitation; G = 66.73(10-12) m3/ (kg · S2)

m1 , m2 = mass of each of the two particles

r = distance between the centers of the two particles.

In the SI system the mass of the body is specified in kilograms, and the weight is:



**The Equation of Motion**

When more than one force acts on a particle, the resultant force is determined by a vector summation of all the forces; i.e., FR = ∑F. For this more general case, the equation of motion may be written as:



**Equation of Motion for a System of Particles**

The equation of motion will now be extended to include a system of particles isolated within an enclosed region in space, as shown in Figure 1 a.

 Figure 1

The free-body and kinetic diagrams for the ith particle are shown in Figure b. Applying the equation of motion,



When the equation of motion is applied to each of the other particles of the system, similar equations will result. And, if all these equations are added together vectorially, we obtain



**Equations of Motion: Rectangular Coordinates**

When a particle moves relative to an inertial x, y, Z frame of reference, the forces acting on the particle, as well as its acceleration, can be expressed in terms of their i, j, k components, Fig. 13-5. Applying the equation of motion, we have:



For this equation to be satisfied, the respective i, j, k components on the left side must equal the corresponding components on the right side. Consequently, we may write the following three scalar equations:



In particular, if the particle is constrained to move only in the x-y plane, then the first two of these equations are used to specify the motion.

Example :

A smooth 2-kg collar C, shown i n Figure 2 a, i s attached t o a spring having a stiffness k = 3 N/m and an unstretched length of 0.75 m. If the collar is released from rest at A, determine its acceleration and the normal force of the rod on the collar at the instant y = 1m.

Solution :

Free-Body Diagram. The free-body diagram of the collar when it is located at the arbitrary position y is shown in Fig. 2 b.

Equations of Motion.

 Figure 2

From Eq. 2 it is seen that the acceleration depends on the magnitude and direction of the spring force. Solution for Nc and a is possible once Fs and θ are known.

The magnitude of the spring force is a function of the stretch s of the spring; i.e., F, = ks. Here the unstretched length is AB = 0.75 m, Fig. 2 a; therefore,

S = CB - AB = $\sqrt{y^{2}+0.75^{2}}-0.75$

 Since k = 3 N/m, then

