Fundamental of Dynamics

CONTENTS:-

INTRODUTION

CENTRE OF MASS

CONSERVATION OF MOMENTUM

MOMENTUM OF VARIABLE MASS SYSTEM

WORK AND KINETIC ENERGY THEROEM

CONSERVATIVE FORCE

NON- CONSERVATIVE FORCE

FORCE AS GRADIENT OF POTENTIAL ENERGY

LAW OF CONSERVATION OF ENERGY

BASIC OF FUNDAMENTALS OF DYNAMICS

Dynamics is the branch of physics developed in classical **mechanics** concerned with the study of forces and their effects on motion. Isaac Newton was the first to formulate the **fundamental** physical laws that govern **dynamics** in classical non-relativistic physics, especially his second law of motion.

Dynamics deals with the study of motion of objects taking into consideration the cause of their motion and also concerned with the forces which cause motion.

CENTRE OF MASS

The center of mass of a distribution of mass in space (sometimes referred to as the balance point) is the unique point where the weighted relative position of the distributed mass sums to zero. This is the point to which a force may be applied to cause a linear acceleration without an angular acceleration. Calculations in mechanics are often simplified when formulated with respect to the center of mass. It is a hypothetical point where the entire mass of an object may be assumed to be concentrated to visualize its motion. In other words, the center of mass is the particle equivalent of a given object for application of Newton's laws of motion.

CENTRE OF MASS

$$\mathbf{R} = \frac{1}{M}\sum_{i=1}^{n} m_i \mathbf{r}_i \,;$$

CONSERVATION OF MOMENTUM

The total external force **F** acting on a system is related to the total momentum **P** of the system by

$$\mathbf{F} = \frac{d\mathbf{P}}{dt}.$$

$M_1\mathbf{V_1}=M_2\mathbf{V}_2$

Impulse and a Restatement of the Momentum Relation

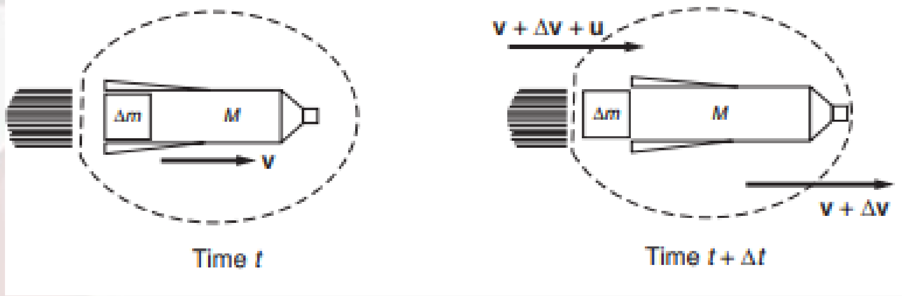
$$\int_0^t \mathbf{F}\, dt = \mathbf{P}(t) - \mathbf{P}(0).$$

Momentum of Variable Mass System:-

Most systems encountered in physics may consider having constant mass, but there are certain cases, where the mass is variable. The simplest familiar example is a raindrop. While the drop falls, moisture may condense on the surface or water may evaporate so that the mass change, in which the mass of the body changes during the motion, that is, m is a function of t, i.e. m (t).
Although there are many cases for which this particular model is applicable, one of obvious importance to us are rockets.
The rocket, at take-off, has a certain amount of fuel; as the rocket gradually uses the fuel, the rocket mass decreases. Obviously, the motion of rocket is equivalent to motion of a system of variable mass, the thrust being produced by ejecting a part of the mass of the system.

Momentum of Variable Mass System:-

- Motion of Rocket -
- Principle of rocket motion by focusing on momentum.



$$P(t) = (M + \Delta m)v$$
$$P(t + \Delta t) = M(v + \Delta v) + \Delta m(v + \Delta v + u)$$
$$\Delta P = M\Delta v + \Delta m(\Delta v + u).$$

The general equation for rocket motion becomes

$$F = M\frac{dv}{dt} - u\frac{dM}{dt}.$$

Work and Kinetic Energy Theorem

$$\frac{1}{2}mv_b^2 - \frac{1}{2}mv_a^2 = \int_{x_a}^{x_b} F(x)\, dx.$$

The quantity $\frac{1}{2}mv^2$ is called the *kinetic energy* K, and the left-hand side can be written $K_b - K_a$. The integral $\int_{x_a}^{x_b} F(x)\, dx$ is called the *work* W_{ba} by the force F on the particle as the particle moves from a to b. Our relation now takes the form

W ba = Kb - Ka.

The work–energy theorem for the translational motion of an extended

$$\int_{\mathbf{R}_a}^{\mathbf{R}_b} \mathbf{F} \cdot d\mathbf{R} = \frac{1}{2}MV_b^2 - \frac{1}{2}MV_a^2.$$

NON- CONSERVATIVE FORCE

In many physical processes non-conservative forces like friction are present

Often both conservative and non-conservative forces act on the same system.

We can write the total force **F** as

$$\mathbf{F} = \mathbf{F}^{c} + \mathbf{F}^{nc}$$

If we define the total mechanical energy by *E* = *K* + *U*, as before, then *E* is no longer constant but depends on the state of the system. We have

$$E_b - E_a = W_{ba}^{nc}.$$

Force as Gradient of Potential Energy

Suppose that we have a one-dimensional system, such as a mass on a spring, where the force is $F(x)$ and the potential energy is

$$U_b - U_a = -\int_{x_a}^{x_b} F(x)\, dx.$$

$$F(x) = -\frac{dU}{dx}.$$

i.e. potential energy is the negative integral of the force so it follows that force is the negative derivative of the potential energy .

Law of conservation of energy

The law of conservation of energy states that energy can neither be created nor destroyed - only converted from one form of energy to another. This means that a system always has the same amount of energy, unless it's added from the outside. This is particularly confusing in the case of non-conservative forces, where energy is converted from mechanical energy into thermal energy, but the overall energy does remain the same. The only way to use energy is to transform energy from one form to another.

$$U_T = U_i + W + Q$$

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