AL MUSTAQBAL UNIVERSITY

ENGINEERING TECHNICAL COLLEGE

DEPARTMENT OF BUILDING & CONSTRUCTION ENGINEERING TECHNOLOGIES

ENGINEERING PHYSICS

FIRST CLASS

LECTURE NO. 4

ASST. LECTURER

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FORCE AND MOTION

NEWTON'S LAWS OF MOTION

Sir Isaac Newton gave three fundamental laws. These laws are called Newton's laws of motion.

Newton’s First Law: It states that everybody continues in its state of rest or of uniform motion in a straight line until some external force is applied on it.

Newton’s Second law: The rate of change of momentum of a body is directly proportional to the applied force and the change takes place in the direction of force applied.

Or

Acceleration produced in a body is directly proportional to force applied.

$$F = ma$$

Units of force(**Newton**)

$N = kgm/s^2$

Newton’s Third law: To every action there is an equal and opposite reaction

or

action and reaction are equal and opposite.

Types of forces affecting Newton's laws of motion

1. **Tensile Stress (F_T):** The external force per unit area of the body that causes the body to stretch along the direction of applied force is called Tensile stress.
2. **Frictional force (F_f):** is the force generated by two surfaces that contact and slide against each other.
3. **Normal force (F_N):** is one type of ground reaction force

The coefficient of friction(u_k): is a measure of the amount of friction existing between two surfaces.

$$\mu_k = \frac{\text{frictional force}}{\text{normal force}} = \frac{F_f}{F_N}$$

Example1: Calculate the weight on the ground of an object of mass

(a)3.00 kg (b) 200 g

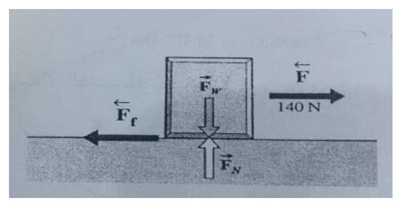
Solution:

(a) $F_w = (3.00kg)(9.81\ m/s^2) = 29.4\ N$

(b) $\frac{200}{1000} = 0.2kg$

$F_w = (0.200kg)(9.81m/s^2) = 1.96N$

Example2: A box with a mass of 60 kg requires a force of 140 N to pull it onto a horizontal floor at a constant speed. Calculate the coefficient of friction between the box and the floor.



Solution:

$a_y = 0$

$\sum F_y = ma_y$

$F_N - mg = (m)(0)$

$F_N = mg = (60)(9.81) = 588.6N$

$a_x = 0$

$140 - F_f = 0$

$F_f = 140N$

$$\mu_k = \frac{F_f}{F_N} = \frac{140}{588.6} = 0.238$$

Linear Momentum (p): The quantity of motion contained in the body is linear momentum. It is given by product of mass and the velocity of the body. It is a vector and its direction is the same as the direction of the velocity.

$$\mathbf{p} = \mathbf{mv}$$

Units of momentum: The SI unit is kg m/s

Dimension formula = $[M^1L^1T^{-1}]$.

Impulse (symbolized by J or Imp): is the change in momentum of an object. If the initial momentum of an object is p1, and a subsequent momentum is p2, the object has received an impulse J.

$$J = \Delta p$$

$$J = p_2 - p_1$$

$$J = mv_2 - mv_1$$

Newton's second law of motion states that the rate of change of momentum of an object is equal to the resultant force F acting on the object:

$$F = \frac{p_2 - p_1}{\Delta t}$$

$$J = F\Delta t$$

$$F\Delta t = mv_2 - mv_1$$

Example3: A mass of 2 kg moves at a speed of 6 m/s. determine the force is needed to stop the mass in a time $7 \times 10^{-4} s$

Solution:

$F\Delta t = mv_2 - mv_1$

$F(7 \times 10^{-4}) = 0 - (2 \times 6)$

$F = -1.7 \times 10^4 N$

Example4: A ball with a mass of 0.25 kg moving in the x+ direction and at a speed of 13 m/s is hit with a bat and its final speed is 19 m/s in the x- direction. If the racket acts on the ball for a period of 0.0105 S, calculate the average force F exerted by the racket on the ball

Solution:

$v_f = -19 m/s \qquad v_i = 13 m/s$

$F\Delta t = mv_f - mv_i$

$F(0.0105) = (0.25)(-19) - (0.25)(13)$

$F = -0.80N$

Angular Displacement (θ): The angle described by a body moving in a circle is called angular displacement.

SI unit of angular displacement is radian (**rad**).

$$\boldsymbol{\theta = \frac{l}{r}}$$

$l = Arc\ length$

$r = radius$

$1rev = 360° = 2\pi rad$ or $1rad = 57.3°$

Angular Velocity (ω): Angular velocity of a body moving in a circles the rate of change of angular displacement with time. It is denoted by ω (omega) If θ is the angular displacement in time t then

$$\omega = \frac{\theta}{t}$$

$$\omega_{av} = \frac{\theta_f - \theta_i}{t}$$

ω_{av} = Average angular velocity

θ_f = Final angular displacement

θ_i = Initial angular displacement

SI unit of angular velocity is **rad/s**.

Example5: Express each of the following in terms of other angle measures

(a) $28°$ (b) $\frac{1}{4} rev/s$ (c) $2.18 rad/s^2$

Solution: