# University of Science and Technology
# Faculty of Engineering
# first Year - Semester (1)
# physics (1)

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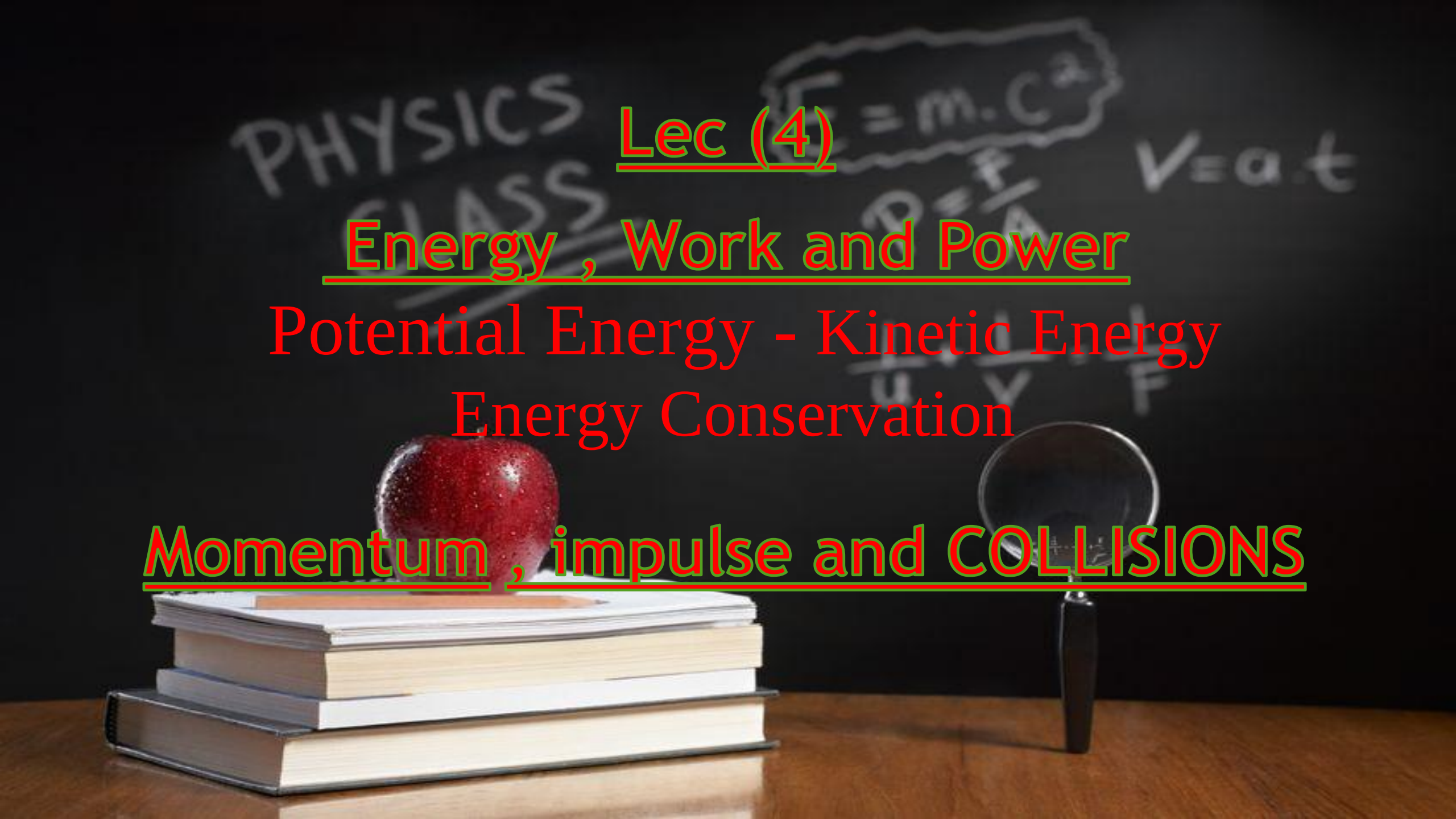



# Lec (4)

# Energy , Work and Power

## Potential Energy - Kinetic Energy

## Energy Conservation

# Momentum , impulse and COLLISIONS

# Energy , Work and Power

## Energy

- Energy: The ability of an object to do work
  - Units: Joules (J)
- Types of energy include:
  - Mechanical: Energy of movement and position
  - Chemical: Energy stored in chemical bonds of molecules

- Thermal: “Heat energy” stored in materials at a certain temperature
- Nuclear: Energy produced from the splitting of atoms
- Radiant Energy: Energy traveling the form of electromagnetic waves
- Electric Energy: Energy traveling as the flow of charged particles (i.e. electrons)

# Work

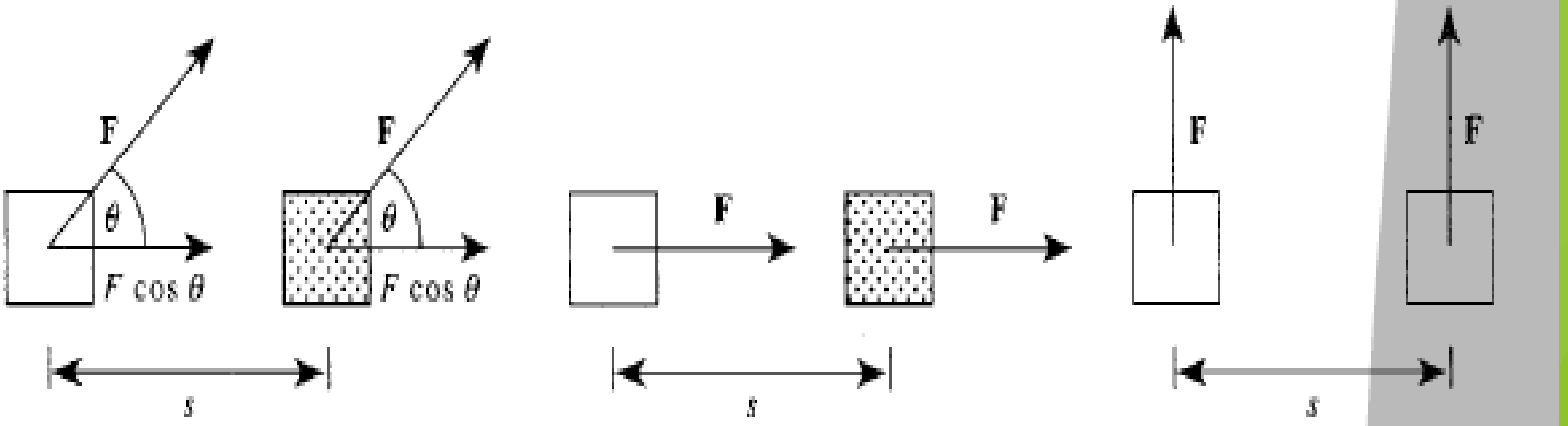
- Work is done when a task produces a change in energy
- Factors affecting work done:
  - The application of a force
  - The movement of the object by that force over a distance

$$\text{Work} = \text{Force} \times \text{Distance}$$

$$W = Fd$$

$$W = Fs \cos \theta$$

- Units: Joule (J)
  - 1 J = 1 N·m


F
θ
F cos θ
s
W = Fs cos θ
F
F
s
W = Fs cos 0 = Fs
F
F
s
W = Fs cos 90° = 0

## SOLVED PROBLEM (1) :

**A horizontal force of 420 N is used to push a crate for 5 m across a level warehouse floor. How much work is done?**

$$W = Fs = (420\ \text{N})(5\ \text{m}) = 2100\ \text{J} = 2.1\ \text{kJ}$$

## SOLVED PROBLEM (2) :

**The 420-N force of Prob is instead exerted on the crate at an angle of 35◦ above the horizontal. How much work is done now?**

$$W = Fs\cos\theta = (420\ \text{N})(5\ \text{m})(\cos 35^\circ) = 1920\ \text{J} = 1.92\ \text{kJ}$$

# Power

- How much work is performed over a period of time

$$\text{Power} = \text{Work} / \text{Time}$$

$$P = W/t$$

$$\text{Power} = (\text{force})(\text{velocity})$$

$$P = Fv$$

- Power can also be converted to units of horsepower (hp)
  - Note: 1 hp ≈ 750 W
- Units: Watts (W) where 1 W = 1 J/s

# Mechanical Energy

- Mechanical Energy: Energy of movement and position
  - There are two major types of mechanical energy:

# Potential Energy

- Gravitational Potential Energy: The potential due to elevated positions
  - P.E. = mass x gravity x height
    - P.E. = mgh
- weight = mass x gravity
  - P.E. = weight x height

# Kinetic Energy

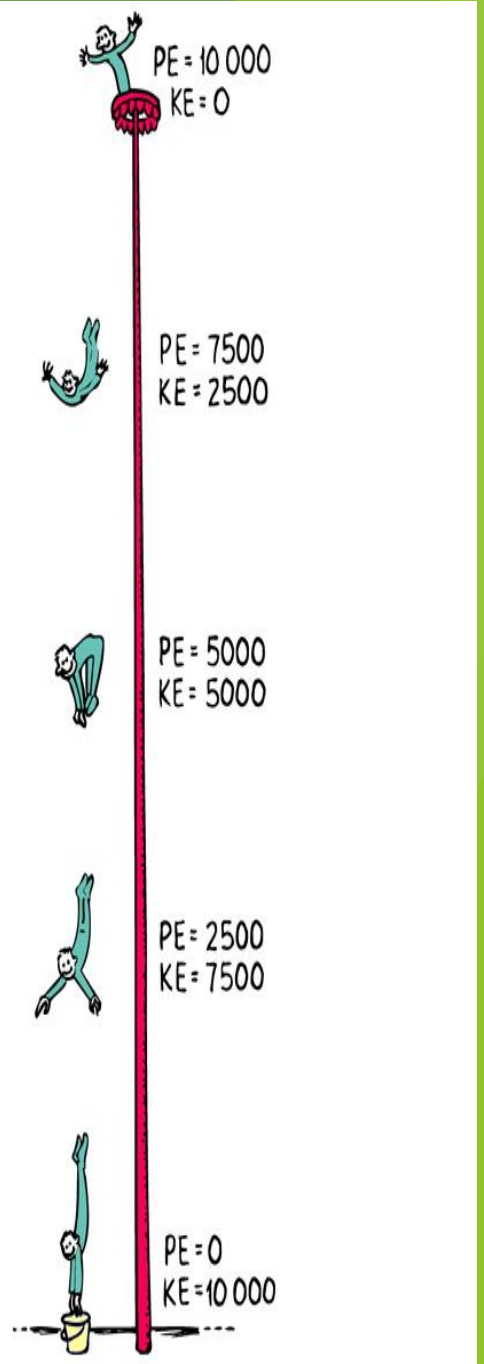
- Objects in motion are capable of doing work

$$KE = \tfrac{1}{2} \cdot mass \cdot velocity^2$$

$$KE = \tfrac{1}{2} m v^2$$

# Energy Conservation

- Law of Conservation of Energy: *Energy cannot be created or destroyed, only changed from one form to another.*



## SOLVED PROBLEM (3) :

**A 40-kg woman runs up a staircase 4 m high in 5 s. Find her minimum power output.**

$P_{min} = W/t = Fs/t = mgh/t = (40\ kg)(9.8\ m/s2)(4\ m)\ /5\ s = \underline{314}\ W$

## SOLVED PROBLEM (4) :

**A man uses a horizontal force of 200 N to push a crate up a ramp 8mlong that is 20◦ above the horizontal. (*a*) How much work does the man perform? (*b*) If the man takes 12 s to push the crate up the ramp, what is his power output in watts and in horsepower?**

(*a*) $W = Fs \cos\theta = (200\ N)(8\ m)(\cos 20^\circ) = \underline{1504}\ J$

(b) $P = W/t = 1504\ J\ /12\ s = \underline{125}\ W$ Since 1 hp = 746 W,

$P = 125\ W\ /746\ W/hp = \underline{0.17}\ hp$

## SOLVED PROBLEM (5) :

**Find the energy of a 1000-kg car whose velocity is 20 m/s.**

$$KE = 1/2mv^2 = 1/2\ (1000\ kg)(20\ m/s)^2 = 2 \times 10^5\ J$$

## SOLVED PROBLEM (6) :

**A 1.5-kg book is held 60 cm above a desk whose top is 70 cm above the floor. Find the potential energy of the book (*a*) with respect to the desk, and (*b*) with respect to the floor.**

(a) Here h = 60 cm = 0.6 m, so

PE = mgh = (1.5 kg)(9.8 m/s2)(0.6 m) = 8.8 J

(b) The book is h = 60 cm + 70 cm = 130 cm = 1.3 m above the floor, so its PE with respect to the floor is

PE = mgh = (1.5 kg)(9.8 m/s2)(1.3 m) = 19.1 J

# Momentum

**The linear momentum (usually called simply *momentum*) p of a body of mass *m* and velocity v is the product of *m* and v:**

$$\text{Momentum } p = mv$$

# IMPULSE

**A force F that acts on a body during time *t* provides the body with an *impulse* of F*t*:**

$$\text{Impulse} = Ft = (\text{force})(\text{time interval})$$

**The units of impulse are newton-seconds.**

**SOLVED PROBLEM (7) :**

**Find the momentum of a 50-kg boy running at 6 m/s.**

$$p = mv = (50\text{ kg})(6\text{ m/s}) = 300\text{ kg}\cdot\text{m/s}$$

## SOLVED PROBLEM (8) :

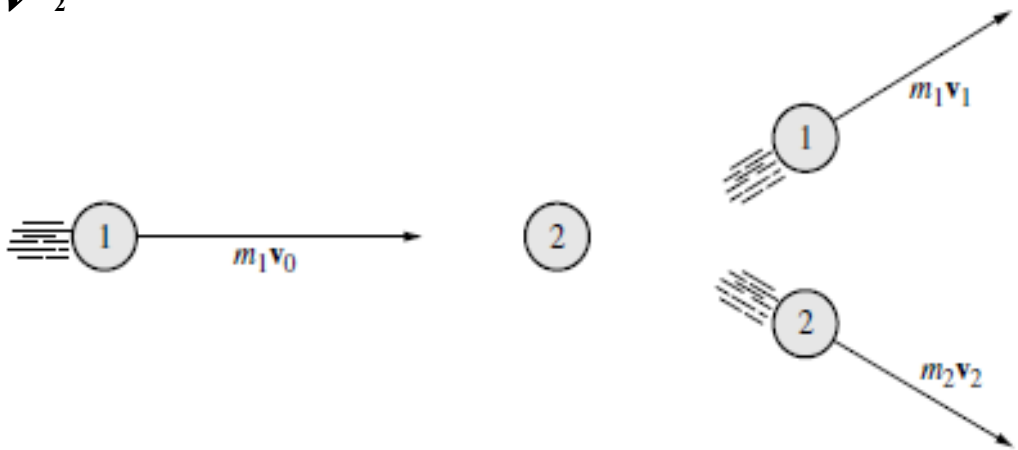
**A 46-g golf ball is struck by a club and flies off at 70 m/s. If the head of the club was in contact with the ball for 0.5 ms, what was the average force on the ball during the impact?**

**The ball started from rest, so $v_1 = 0$ and its momentum change is $m(v_2 - v_1) = mv_2$**
**$= (0.046\ \text{kg})(70\ \text{m/s}) = 3.22\ \text{kg·m/s}$**
**Since 1 ms = 1 millisecond = $10^{-3}$ s, here $t = 0.5\ \text{ms} = 5 \times 10^{-4}$ s and**
**$F = m(v_2 - v_1)/t = 3.22\ \text{kg·m/s} / 5 \times 10^{-4}\ \text{s} = 6.4 \times 10^3\ \text{N} = 6.4\ \text{kN}$**

# COLLISIONS

* *elastic* collision $\quad m_1v_1 + m_2v_2 = m_1\bar{v}_1 + m_2\bar{v}_2$

* inelastic collision $\quad m_1v_1 + m_2v_2 = (m_1 + m_2)v_3$



**Coefficient of restitution = $e = (\bar{v}_2 - \bar{v}_1) / (v_1 - v_2)$**

## SOLVED PROBLEM (9) :

**A 0.5-kg snowball moving at 20 m/s strikes and sticks to a 70-kg man standing on the frictionless surface of a frozen pond. What is the man's final velocity?**

**Let $v_1$ = snowball's velocity and $v_2$ = final velocity of man plus snowball.**

**Then Initial momentum of snowball = final momentum of man + snowball**

$$m_s v_1 = (m_m + m_s) v_2$$

$$v_2 = \left( \frac{m_s}{m_m + m_s} \right) (v_1) = \left( \frac{0.5 \text{ kg}}{70.5 \text{ kg}} \right) (20 \text{ m/s}) = 0.14 \text{ m/s}$$