CHAPTER 1

INTRODUCTION

OBJECTIVES

- To provide an introduction to the basic quantities and idealizations of mechanics.
- To give a statement of Newton's laws of Motion and Gravitation.
- To review the principles for applying the SI system of units.
- To examine the standard procedures for performing numerical calculations.
- To present a general guide for problem solving.

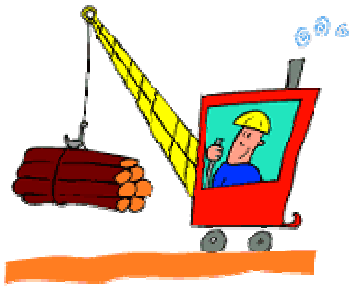
TOPIC OUTCOMES

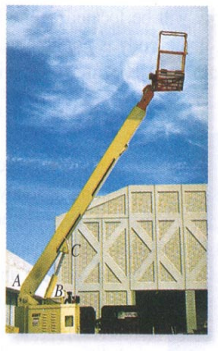
It is expected that students will be able to:

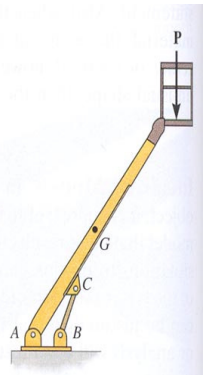
- **Recite** Newton's Laws and express how each of them relates to the different branches of mechanics.
- **Explain** the difference between the weight and mass of an object.
- **Explains** how the gravitational constant (g) relates to Newton's laws and to calculate the value of the gravitational constant.
- **Define** the fundamental quantities of mechanics and to write the correct units for each quantity in either the SI system of units.

WHAT IS MECHANICS

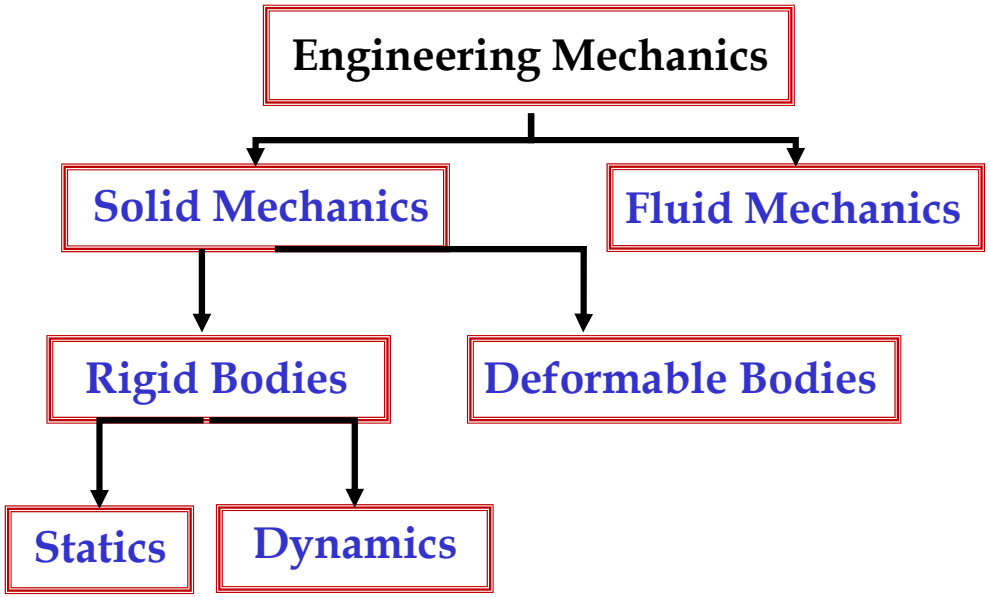
Mechanics - the physical science which describes or predicts the conditions of rest or motion of bodies under the action of forces.







CLASSIFICATION



GENERAL

- In Statics we will assume the bodies to be perfectly rigid, no deformation.
- This is never true in the real world, everything deforms a little when a load is applied.
- These deformations are small and will not significantly affect the conditions of equilibrium or motion → negligible.
- Rigid body - a body is considered rigid when the relative movement between its parts are negligible for the purpose at hand

MECHANICS OF RIGID BODIES

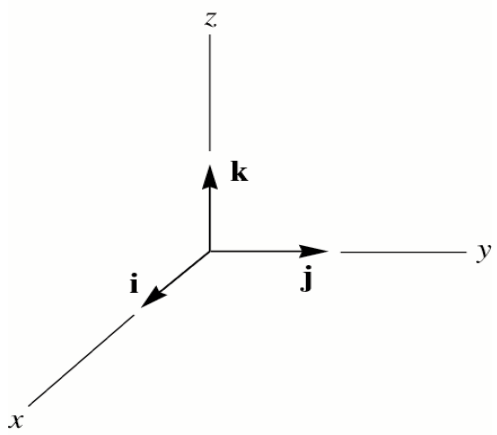
Subdivided into:

- **Statics: a study of resultant and equilibrium of bodies. Utilised to determine the exerted forces (external and internal) investigate a body to be in equilibrium or moving with a constant velocities.**

- **Dynamics: is concerned with the accelerated motion of bodies.**

FUNDAMENTAL CONCEPTS AND PRINCIPLES

- SPACE - the geometric region occupied by bodies whose positions are described by linear and angular measurements relative to a coordinate system.
- TIME - the measure of the succession of events
- MASS - the measure of the inertia of a body, which is its resistance to a change of motion. Sometimes called "quantity of matter"
- FORCE - the action of one body on another
- PARTICLE - A body of negligible dimension and it may be analyzed as a point mass



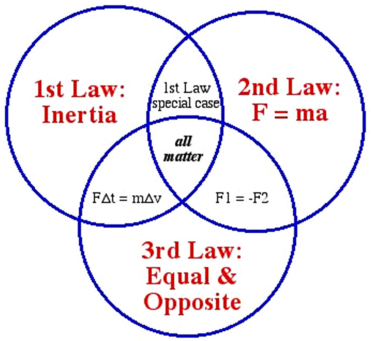
1. The parallelogram Law (for the addition of the forces)

- Any two forces acting on a particle may be replaced by a single force, called their resultant, obtained by drawing the diagonal of the parallelogram which has sides equal to the given forces.

2. The principle of Transmissibility

- The condition of equilibrium or motion of a rigid body will remain unchanged if a forced acting at a given point of the rigid body is replaced by a force of the same magnitude and same direction, but acting at a different point, provided that the two forces have the same line of action

3. Newton's three fundamental laws



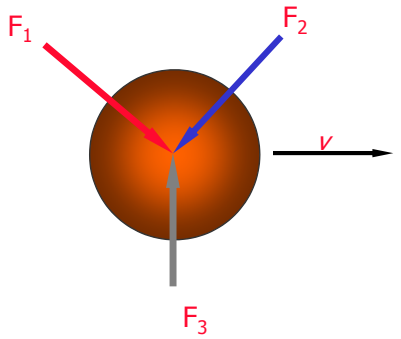
Newton's Laws

3. Newton's three fundamental laws

3.1 First law

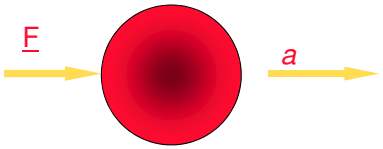
- If the resultant force acting on a particle is zero, the particle will remain at rest (if originally at rest) or will move with constant speed in a straight line (if originally in motion).

EQUILIBRIUM



3.2 Second Law

- If the resultant force acting on a particle is not zero, the particle will have an acceleration proportional to the magnitude of the resultant and in the direction of this resultant force.



Accelerated motion

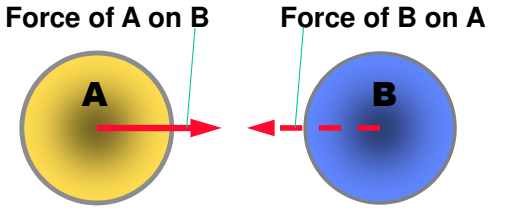
$$F = m a$$

Where:

F is resultant force
m is mass of the particle
a is acceleration of the particle

3.3 Third Law

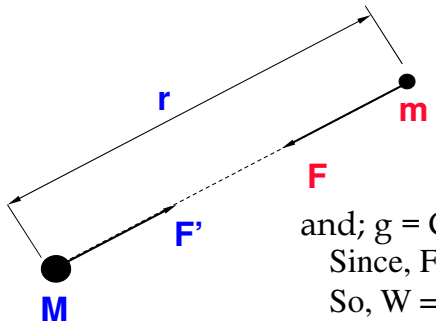
- The forces of action and reaction between bodies in contact have the same magnitude, same line of action and opposite sense.



Action force Reaction force

3.4 Newton's Law of gravitation

- Two particles of mass M and m mutually attracted with equal and opposite forces F and F′ of magnitude F given by the formula;



and; $g = GM/r^2$
Since, F = W
So, W = mg

$$F = G\frac{Mm}{r^2}$$

Where:

F = force of gravitation

G = universal constant of gravitation

M,m= mass of two particles

r = distance between two particles

- **Base units are units of length, mass and time**

	Length	Mass	Time
SI Units	Meter (m)	Kilogram (kg)	Second (s)
English Units	Foot (ft)	Slug (slug)	Second (s)

Force: Newton (N)

1 N = (1 kg)(1 m/s²) = 1 kg.m/s²

- **1 Newton is the force required to give a mass of 1 kg an acceleration of 1 m/ s². Weight is a force.**

The weight of 1 kg Mass is:

$W = mg$

$W = (1\ kg)(9.81\ m/s^2) = 9.81\ N$

- **Units of Area and Volume:**

Area = (Length)²

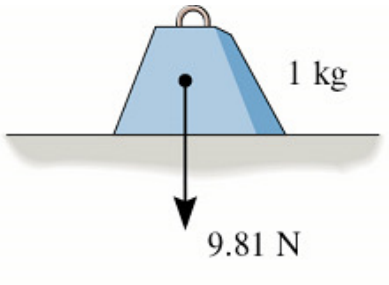
Volume = (Length)³

SI UNITS

- Modern version of metric system.
- Base units are length, time and mass, meter (m), second (s), and kilogram (kg).
- Acceleration of gravity:

$$g = 9.81 \ \frac{m}{s^2}$$

- Force is derived quantity measured in unit called a **Newton**



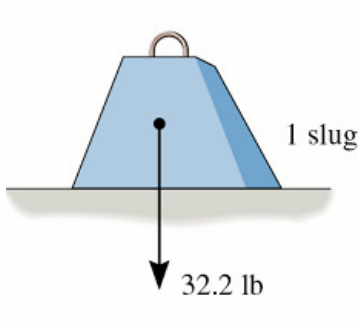
$$1\ N = 1\ \frac{kg \cdot m}{s^2}$$

U.S. CUSTOMARY UNITS

- Base units are length, time and force; feet (ft), second (s), and pound (lb)
- Acceleration of gravity:

$$g = 32.2 \ \frac{ft}{s^2}$$

- Mass is derived quantity measured in a unit called a **slug:**



$$1\ slug = 1\ \frac{lb_f \cdot s^2}{ft}$$

UNIT CONVERSIONS

Force: 1 lb_f = 32.174 $lb_m \cdot ft/s^2$ = 4.4482 N

Mass: 1 slug = 32.174 lb_m = 14.5938 kg

Length: 1 ft = 0.3048 m

SIGNIFICANT FIGURES

- Accuracy specified by number of significant figures.
- Defined as any digit including a zero (provided it is not used to specify the location of a decimal point).
- 5604 and 34.52 both have four significant figures

CALCULATIONS

- When performing calculations retain a greater number of digits than the problem data.
- Engineers usually round off **final answer** to **three (3) significant figures**. Intermediate calculations are usually done to four (4) significant figures.
- Answer can never have more significant figures than given data!

METHOD OF PROBLEM SOLVING

1. state the given data
2. state the results desired
3. draw necessary diagrams (free-body diagrams)
4. develop equations
5. solve the problem to obtain solution
6. check solution
7. CHECK UNITS!!

- review Trigonometry Law
- Law of Cosines
- Law of Sines
- Right triangle Trigonometry