ENGINEERING MECHANICS
BAA1113

Chapter 1: General Principle (Static)

by

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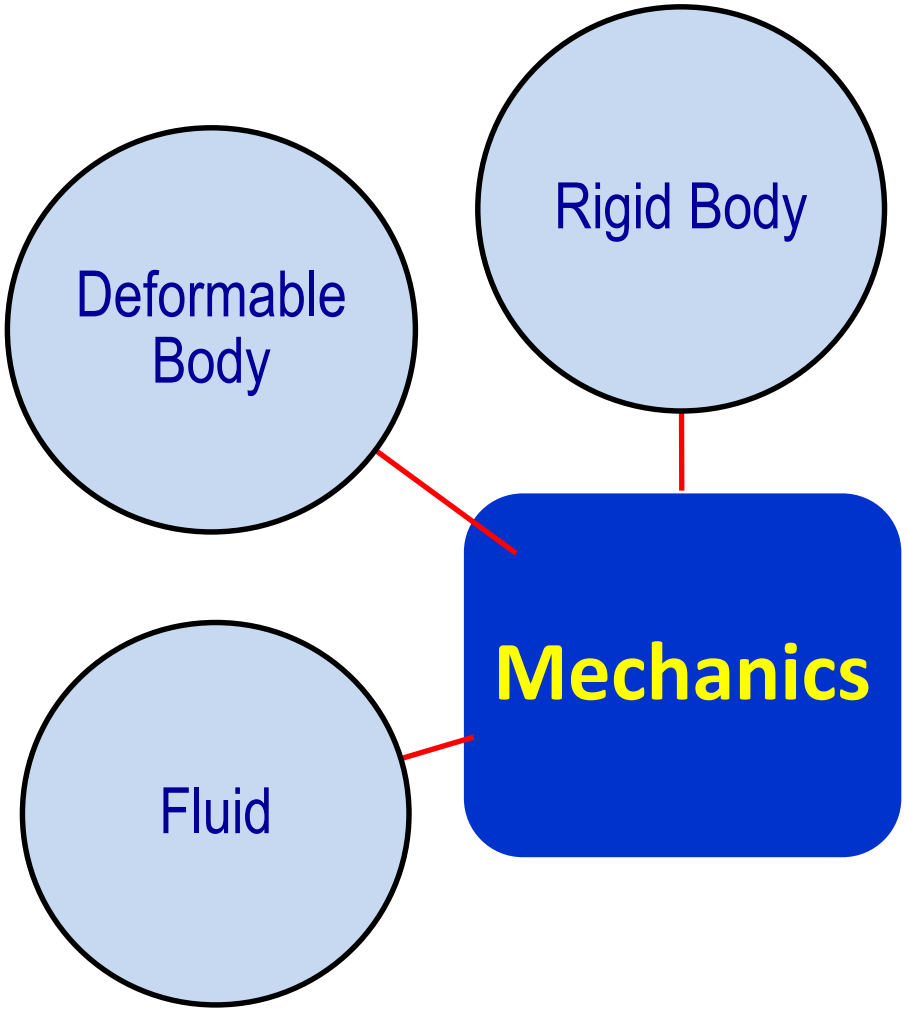
Chapter Description

- Aims
  - To introduce the fundamental concepts (basic quantities and idealizations) applied in mechanics
  - To describe the Newton's Laws in Motion and Gravitation
  - To review the application of SI units
- Expected Outcomes
  - Able to implement the fundamental concepts and Newton's principle which involved in the mechanics applications
- References
  - Russel C. Hibbeler. Engineering Mechanics: Statics & Dynamics, 13th Edition
  - ……..

Chapter Outline

1.1 Mechanics
1.2 Fundamental Concepts
1.3 Units of Measurement
1.4 The International System of Units
1.5 Numerical Calculation
1.6 Example Calculation

1.1 Mechanics



- Statics

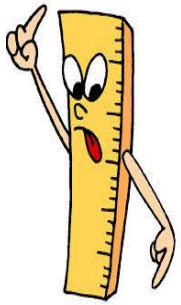
Equilibrium of bodies, at rest or move with a constant velocity

- Dynamics

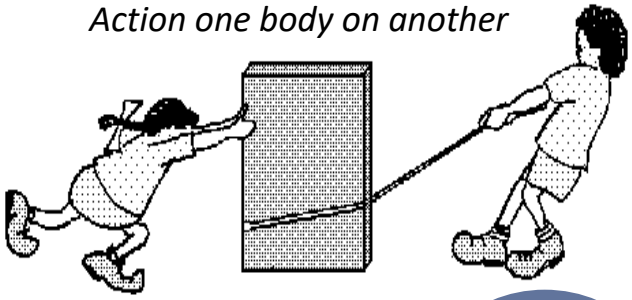
Accelerated motion of bodies

1.2 Fundamental Concepts (Basic Quantities)

Distances and geometric of properties



Action one body on another



Length

Force

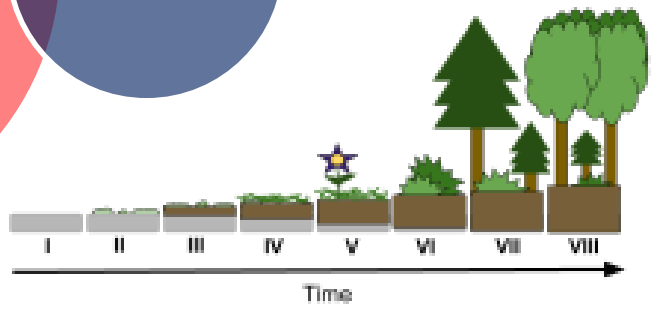
Basic Quantities

Time

Mass

mass → kg

Quantity of matter



Duration of travel

1.2 Fundamental Concepts (Idealizations)

Particle

- It has a mass but no size
- Geometry of the body will be negligible

Rigid Body

- Combination of large number of particles
- All particles stick from one another
- Suitable for analysis

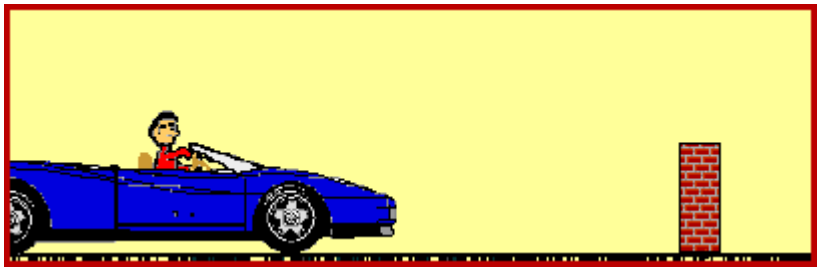
Concentrated Force

- Loading effect acting over the surface area of the body

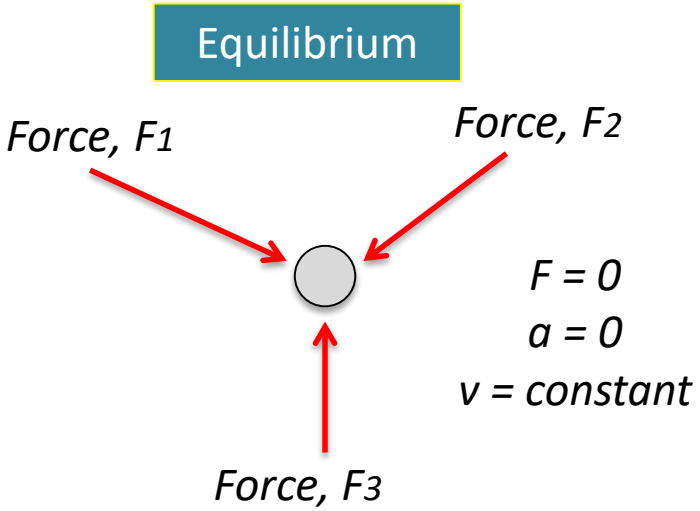
1.2 Fundamental Concepts (Newton's Law)

First Law

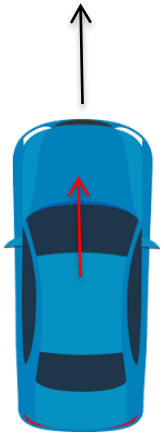
A particle is in the rest position (no motion) or moving in straight line with constant velocity or else in equilibrium.



Source: http://www.physicsclassroom.com

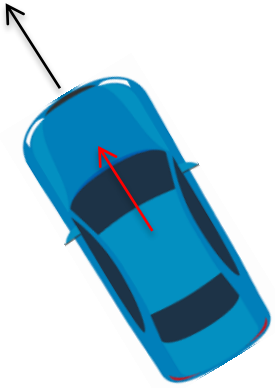


Why do passengers get thrown to the side when the car they are driving in goes around a corner?



Both car and driver in the same position

But when the car turn to the left, the driver try to maintain the same position (inertia)

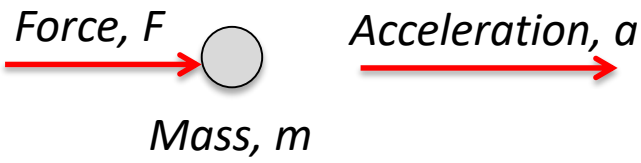


Then, the car and driver back into the same position

Second Law

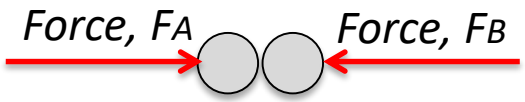
A particle is in the motion (unbalance force) which produce an acceleration in the same direction as the force and magnitude.

$$F = ma$$



Third Law

Action and reaction forces between two particles are equal, opposite, and collinear



Action = Reaction

$$F_{AB} = - F_{BA}$$

Newton's law of Gravitational Attraction

A particle attracts other particles in the universe using gravity force whether direct proportional to the masses of objects or inverse proportional to the square of the distance between their centers.

$$F = G\frac{m_1 m_2}{r^2}$$

F = force of gravitation between two particles
G = universal constant of gravitation $66.73 \times 10^{-12} m^3/(kg.s^2)$
m_1, m_2 = mass of each of the two particles
r = distance between the two particles

Weight

This force influenced only by gravitational force. Therefore:

Weight, $$W = G\frac{mM_e}{r^2}$$

m = mass of particle
M_e = mass of earth

Let say: $$g = G\frac{M_e}{r^2}$$

g = based on sea level and latitude of 45°
Standard rate: 9.81m/s²

Thus, $$W = mg$$

Difference?

$F = mg$ and $F = ma$

1. ‘g’ is the acceleration due to gravity
2. Weight of a body is not an absolute quantity
3. Magnitude is determined at sea level and at a latitude of 45° as standard location
4. F = ma maintained when 3 of 4 base units have been used and 4^{th} unit is derived from the equation.

1.3 Units of Measurement

- The International System (SI) system have been applied as a standard measurement unit.

Table 1: Basic Units

Name	Unit
Length	Meter (m)
Time	Second (s)
Mass	Kilogram (kg)
Force	Newton (N)

1.4 The International System of Units

- Purpose of Prefixes is to convert the very large/small quantity into proper unit

Table 2: Prefixes

Prefixes	Value	Standard form	Symbol
Tera	1 000 000 000 000	10^{12}	T
Giga	1 000 000 000	10^{9}	G
Mega	1 000 000	10^{6}	M
Kilo	1 000	10^{3}	k
deci	0.1	10^{-1}	d
centi	0.01	10^{-2}	c
milli	0.001	10^{-3}	m
micro	0.000 001	10^{-6}	μ
nano	0.000 000 001	10^{-9}	n
pico	0.000 000 000 001	10^{-12}	p

Source: http://spmphysics.onlinetuition.com.my

Example:

Large quantity

5,000,000 N → 5,000 kN @ 5 MN

prefix

unit

Small quantity

0.004 m → 4 mm

prefix

unit

Rules:

1) Multiple units must be separated by the dot
   Eg: $N = kg.m/s^2 = kg.m.s^{-2}$

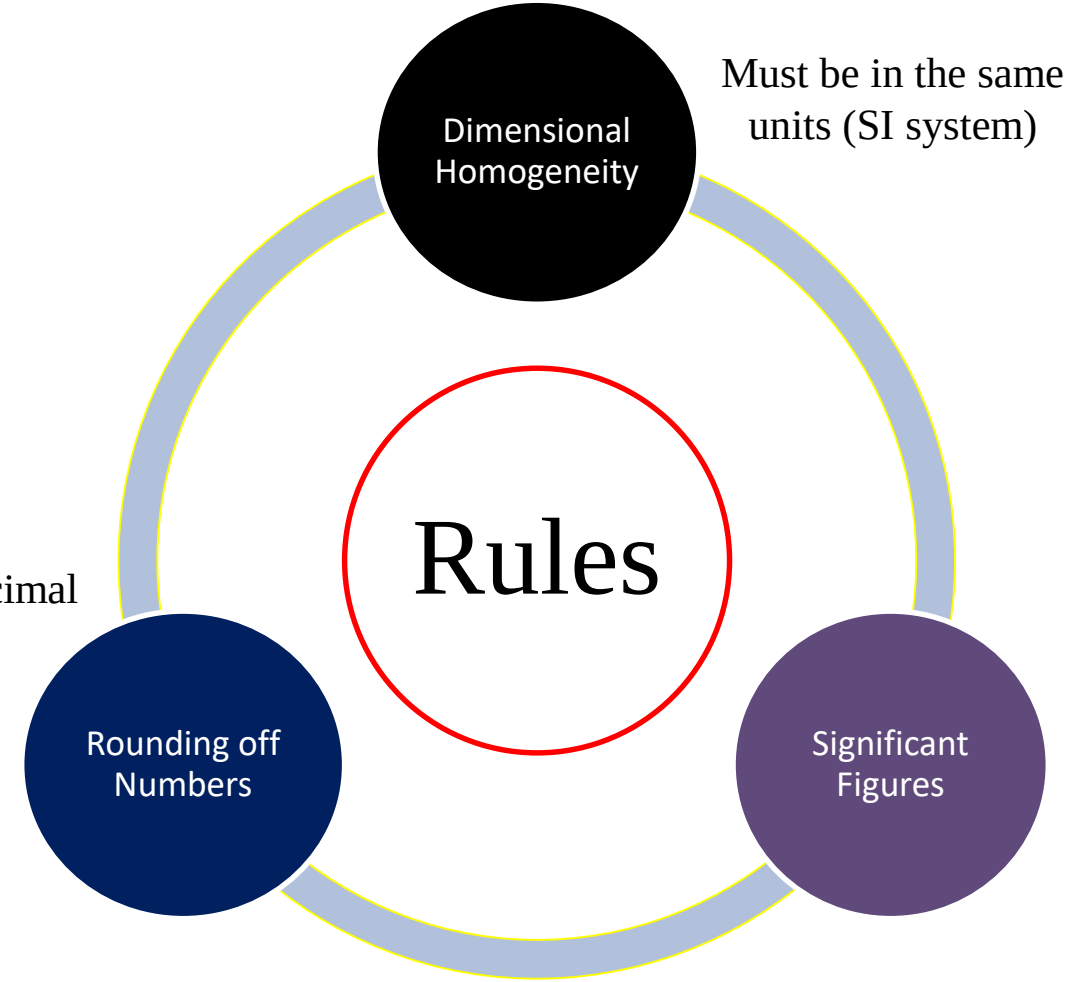
2) The exponential power of the unit represented for both unit and prefix
   Eg: $\mu N^2 = (\mu N)^2 = \mu N.\ \mu N$

3) Convert all prefixes into power of 10
   50kN x 60nm = 3000kNnm = 3mN.m

4) Symbols of prefixes are in lowercase letters, except
   Tera (T), Mega (M), and Giga (G)

5) With exception of base unit kilogram, avoid use of prefix in the denominator of composite units
   Eg: i) N/mm → kN/m
   ii) m/mg → Mm/kg

Numerical Calculations:



Must be in the same units (SI system)

Rounded into 3 decimal place

3 significant figures (sf) only.
Ex:
1) 26300 (5sf)
= 26.3 (10^3) → 3sf

2) 0.000662 (6sf)
= 0.662 (10^{-3}) → 3sf
= 662 (10^{-6}) → 3sf

Example Calculations:

Example 1

Solve the problems below and express in SI units with appropriate prefix:

(a) 40 mN x 6 GN (ans: 300 kN^2)

(b) 400 mm x $(0.6\ MN)^2$ (ans: 144 $Gm.N^2$)

(c) 55 $MN^3/900\ Gg$ (ans: 61 kN^3/kg)

Conclusion of The Chapter 1

- Conclusions
  - The fundamental concepts of mechanics including basic quantities and units were introduced and applied in the mechanics
  - The Newton’s law in Motion and Gravitations have been identified and implemented in the mechanics

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