Engineering Mechanics: Statics in SI Units, 12e

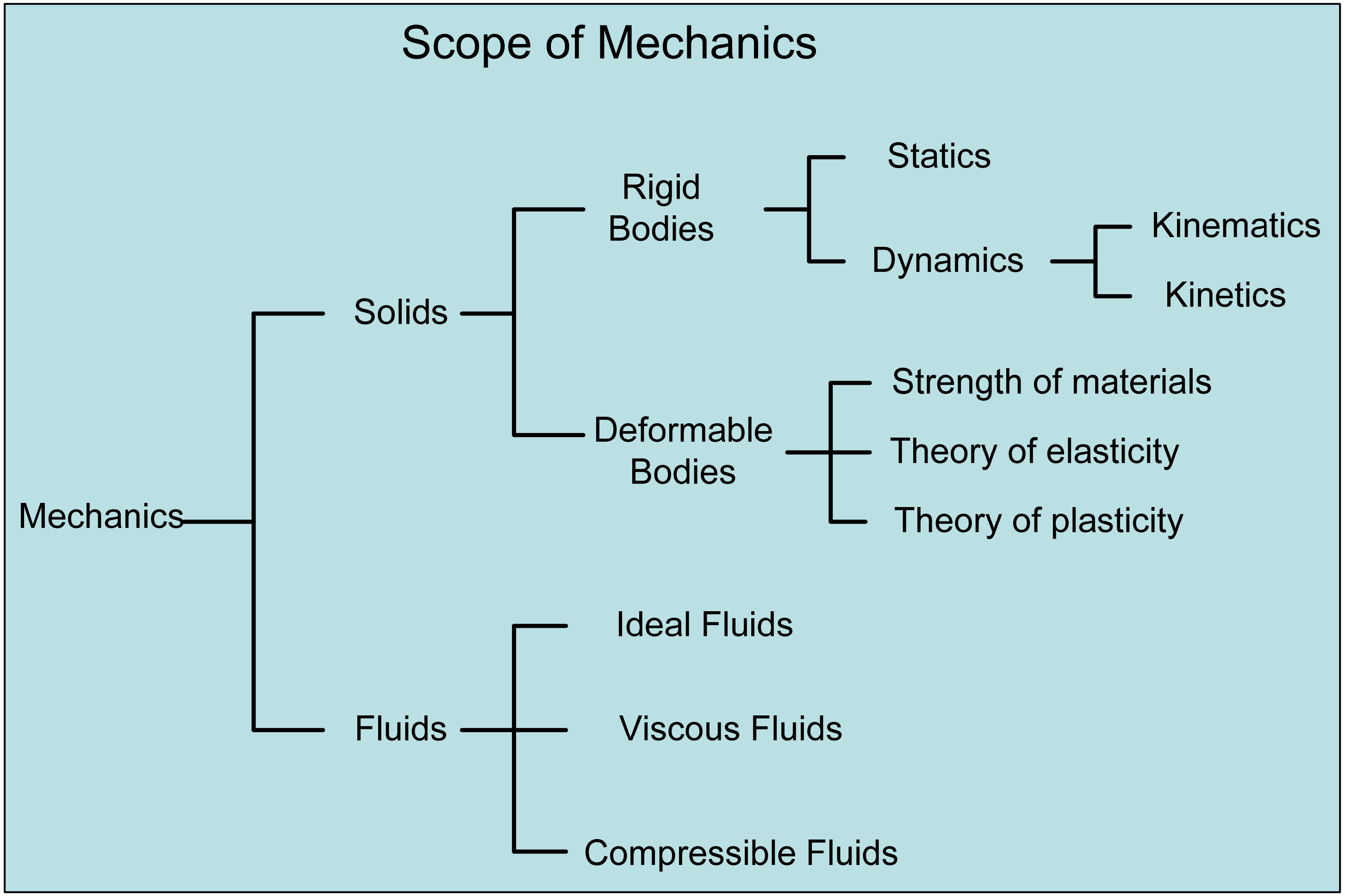
1

General Principles

1.1 Mechanics

- 力學：描述及預測物體在受力時靜止或運動狀態的科學

力學的範疇


Scope of Mechanics
Mechanics
Solids
Fluids
Rigid Bodies
Deformable Bodies
Statics
Dynamics
Kinematics
Kinetics
Strength of materials
Theory of elasticity
Theory of plasticity
Ideal Fluids
Viscous Fluids
Compressible Fluids

1.2 Fundamentals Concepts

Basic Quantities

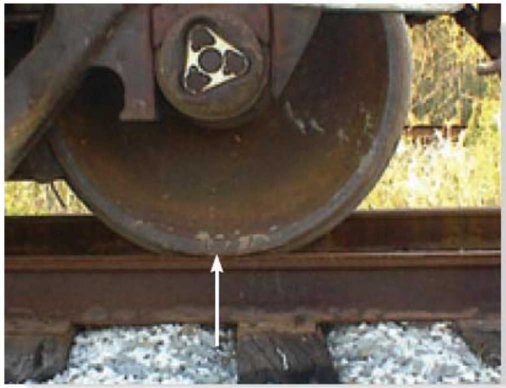
- Length
  - locate the position of a point in space
- Mass
  - measure of a quantity of matter
- Time
  - succession of events
- Force
  - a “push” or “pull” exerted by one body on another

1.2 Fundamentals Concepts

Idealizations

- Particles
  - has a mass and size can be neglected

- Rigid Body
  - a combination of a large number of particles



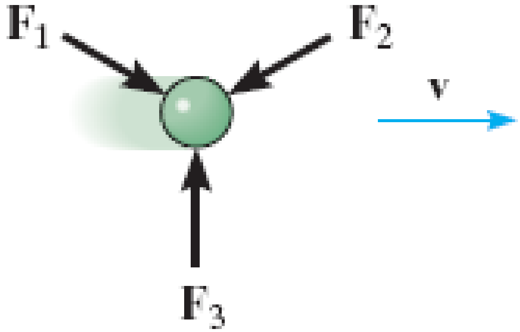
- Concentrated Force
  - the effect of a loading

1.2 Fundamentals Concepts

Newton's Three Laws of Motion

- **First Law**

  "A particle originally at rest, or moving in a straight line with constant velocity, will remain in this state provided that the particle is not subjected to an unbalanced force"



Equilibrium

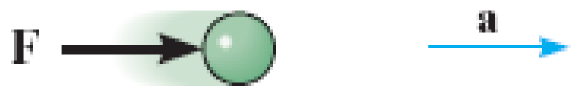
1.2 Fundamentals Concepts

Newton's Three Laws of Motion

- **Second Law**

  "A particle acted upon by an *unbalanced force* **F** experiences an acceleration **a** that has the same direction as the force and a magnitude that is directly proportional to the force"

$$F = ma$$



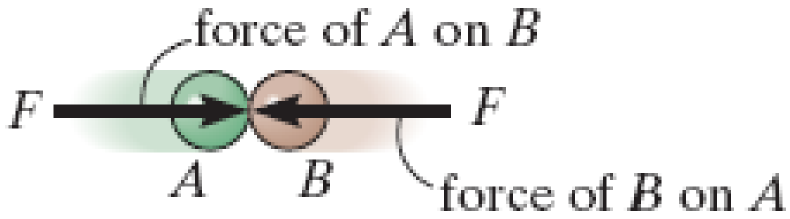
Accelerated motion

1.2 Fundamentals Concepts

Newton's Three Laws of Motion

- **Third Law**

  "The mutual forces of action and reaction between two particles are equal and, opposite and collinear"



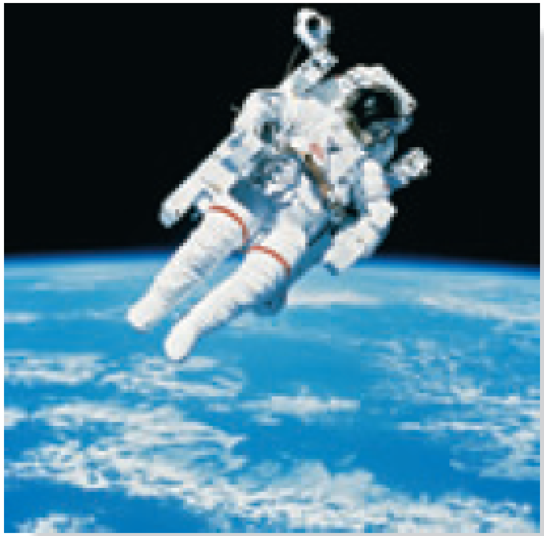
Action – reaction

1.2 Fundamentals Concepts

Newton's Law of Gravitational Attraction

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

F = force of gravitation between two particles
G = universal constant of gravitation
m_1,m_2 = mass of each of the two particles
r = distance between the two particles



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

Letting $g = GM_e / r^2$ yields $W = mg$

1.3 Units of Measurement

SI Units

- Stands for Système International d'Unités
- SI system specifies length in meters (m), time in seconds (s) and mass in kilograms (kg)
- Force unit, Newton (N), is derived from F = ma

1.3 Units of Measurement

TABLE 1–1 Systems of Units

Name	Length	Time	Mass	Force
International System of Units SI	meter m	second s	kilogram kg	newton* N $\left(\frac{kg \cdot m}{s^2}\right)$

1.4 The International System of Units

Prefixes

- For a very large or small numerical quantity, units can be modified by using a prefix

- Each represent a multiple or sub-multiple of a unit

  eg.: 4,000,000 N = 4000 kN (kilo-newton)

  = 4 MN (mega- newton)

  0.005m = 5 mm (milli-meter)

- Bad use: kμs ($\rightarrow$ ms)

1.4 The International System of Units

TABLE 1–2 Prefixes			
	Exponential Form	Prefix	SI Symbol
Multiple			
1 000 000 000	10^9	giga	G
1 000 000	10^6	mega	M
1 000	10^3	kilo	k
Submultiple			
0.001	10^{-3}	milli	m
0.000 001	10^{-6}	micro	μ
0.000 000 001	10^{-9}	nano	n

Prefix

Item	Power of 10
a(tto)	-18
f(emto)	-15
p(ico)	-12
n(ano)	-9
μ(micro)	-6
m(ili)	-3
k(ilo)	3
M(ega)	6
G(iga)	9
T(era)	12
P(eta)	15
E(xa)	18

RULES FOR USING SI SYMBOLS (Section 1.4)

- No Plurals (e.g., m = 5 kg not kgs)
- Separate Units with a • (e.g., meter-second = m • s)
- Most symbols are in lowercase (some exception are **N**, **Pa, M** and **G)**
- Exponential powers apply to units , e.g., cm^2 = cm • cm

NUMERICAL CALCULATIONS (Section 1.5)

- Must have dimensional “homogeneity.” Dimensions have to be the same on both sides of the equal sign, (e.g. distance = speed $\times$ time.)

$$L = L/T \times T$$

- Use an appropriate number of significant figures (3, 4 for answer, at least 4 for intermediate calculations). Why?

END OF LECTURE