0. Introduction

2142111 Statics, 2011/2

Objectives Students must be able to

Course Objective

- Not specified

Chapter Objectives

- State the scope of Statics
- Define and identify scalar & vector as well as other type of quantities in mechanics
- State the Newton's laws and Newtonian law of gravitation
- Use appropriate significant figures and unit prefixes
- Describe the procedure of problem solving in Statics

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Mechanics #1

- A branch of physical science that deals with forces and their effects on bodies
- Deal with **force** and **motion**
- First analytical fundamental engineering course

Statics

Equilibrium of bodies under the action of forces

Dynamics

The motion of bodies

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Mechanics #2

Statics
Dynamics
Mechanics of Materials
Fluid Mechanics
Vibration
Fracture Mechanics
etc.

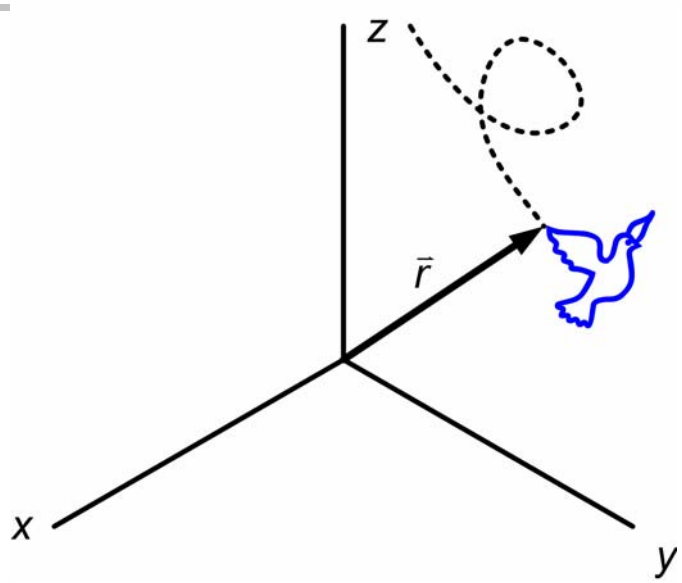
→ Mechanics →

Structures
Automotives
Robotics
Spacecrafts
MEMs
etc.

Basic Definitions

Body

- Particles
- Rigid Bodies
- Deformable Bodies



Quantity

- Space
- Time
- Force
- Mass

- Position
- Velocity
- Acceleration

Tensor Scalar vs. Vector vs. Others

- Scalar: Magnitude only
  - Exp: mass, length, etc.
- Vector: Magnitude + direction
  - Exp: force, position, etc.
- Others: Dyads, dyadics, triadics, tetradics, etc.
  - Exp: stress, strain, etc.

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Writing Convention

	Hand	Print
Scalar	F	F
Vector	$\vec{F}$ $\vec{F}$ $\underset{\sim}{F}$ $\underline{F}$	$\mathbf{F}$ $\vec{F}$ $\underline{F}$
Unit Vector	$\hat{i}$	$\mathbf{i}$ $\hat{i}$
Magnitude of Vector	F $\lvert\vec{F}\rvert$	F $\lvert\mathbf{F}\rvert$ $\lvert\vec{F}\rvert$

Manipulation

- Scalar: magnitude
- Vector: magnitude & direction, components
  - Scalar multiplication
  - Addition, subtraction
  - Dot product
  - Cross product
  - Mixed triple product

$$a\vec{A}$$

$$\vec{A}+\vec{B},\ \vec{A}-\vec{B}$$

$$\vec{A}\cdot\vec{B}$$

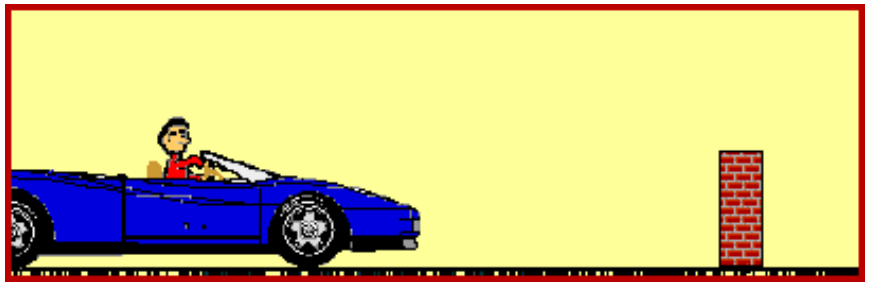
$$\vec{A}\times\vec{B}$$

$$\vec{A}\cdot(\vec{B}\times\vec{C})$$

Mathematical Meanings
vs
Physical Meanings

Newton's 1st Law

An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction **unless acted upon by an unbalanced force**.



$$\sum \vec{F} = \vec{0}$$

$$\sum \mathbf{F} = \mathbf{0}$$

Newton's 2nd Law

The acceleration of a particle is proportional to the vector sum of forces acting on it, and is in the direction of this vector sum.

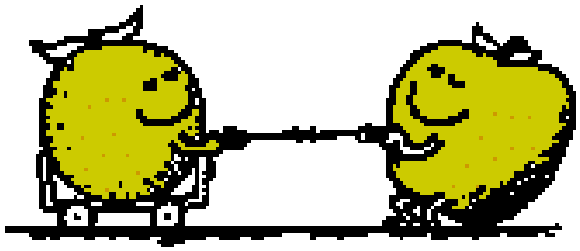
$$\sum \vec{F} = m\vec{a}$$

$$\sum \mathbf{F} = m\mathbf{a}$$

Newton's 3rd Law

For every action, there is an **equal** and **opposite** reaction.

Forces always occur in pairs – equal and opposite action-reaction force pairs.

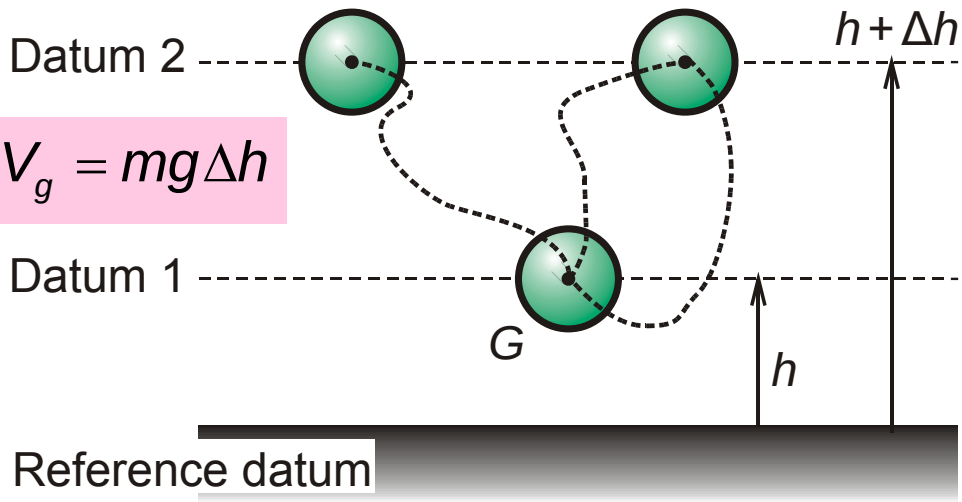


Law of Gravitation

$$F = \frac{Gm_1m_2}{r^2}$$

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

$$\Delta V_g = mg\Delta h$$



Earth attraction

$$\vec{W} = m\vec{g}$$

$$\mathbf{W} = m\mathbf{g}$$

Units

- **SI** Units [MLT]
  (International System of Units)
- **U.S. Customary** Units [FPS]
  (British System of Units)

Unit Prefix
See HW1

Quantity	Unit	Symbol	Dimensional Symbol
Length	meter	m	L
Time	second	s	T
Force	newton	N	F
Mass	kilogram	kg	M

Accuracy & Approximations

- The number of significant figures (s.f.) in an answer should be no greater than the significant figure numbers of the given data.

- Accuracy to **three significant figures** is considered satisfactory for most engineering results.
  - For instance, you may use 5 s.f. in the calculations and answer with 3 s.f.

$$1\ \text{kg}\cdot\text{m}^2/\text{s}^2 = 1\ \text{kg}\cdot\text{m}^2/\text{s}^2 \times \left(\frac{1\ \text{slug}}{14.594\ \text{kg}}\right) \times \left(\frac{1\ \text{ft}}{0.3048\ \text{m}}\right)^2$$

$$= 0.73756 = 0.738\ \text{slug}\cdot\text{ft}^2/\text{s}^2\ \#$$

Problem Solving Procedure

- Formulate problems from physical situations
  - Making appropriate assumptions
- Use graphics
  - The free body diagram or **FBD**
- Apply principles
  - State governing equations
- Substituting variables and calculate numerical values
  - Delay substitute numbers
  - Use appropriate significant figures
- Technical judgment and engineering sense
  - Try to predict the answers
  - Is the answer reasonable?

Concepts #1

- Statics is the first course for studying mechanics. The learning is based upon the physics which demands good thinking structures, understanding of physical meanings.
- The basic concepts of Statics involve ***space***, ***mass*** and ***force***. Only the ***particles*** and ***rigid bodies*** are analysed.
- Main quantity types in Statics are scalar and vector. A ***scalar*** is associated with the ***magnitude*** only while a ***vector*** possesses ***magnitude*** and ***direction***. Basic concepts of scalar and vector were studied in Mathematics but they acquire ***physical meanings*** here.
- Statics is based on the ***Newton's 1st law***, supplemented by the 3rd law and law of gravitation.

Concepts #2

- The ***SI units*** are used during study, but US units are also used in real life. The ***significant figure*** indicates the accuracy level of data while the ***prefix*** reduces confusion. Appropriate uses of the significant figure and prefix are necessary.
- Problem solving requires clear problem identification, formulation and solving processes, which must be connected together logically and chronologically. In the solving process, the main components are making assumptions, draw ***FBDs***, stating the ***governing equations***, ***substituting the data*** in FBD into the governing equations, ***solving*** for answers and presenting the solution with ***engineering sense***.

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