AE 104
STATICS

Prof. Dr. İbrahim GÖV.

CHAPTER 1
INTRODUCTION
To STATICS

1/1 What is Mechanics?

- *Mechanics* is the science which *describes* and predicts the conditions of *rest* or *motion* of *bodies under* the action of *forces*.
  - Categories of Mechanics:
    - Rigid bodies
      - *Statics*
      - Dynamics
    - Deformable bodies
    - Fluids

- *Mechanics* is used for solving problems in:
  - mechanical eng.
  - civil engineering
  - materials science
  - etc…
  - aerospace engineering
  - nuclear engineering
  - geological engineering

Mechanics

Rigid Bodies

Deformable Bodies

Fluids

Statics

Strength of Materials

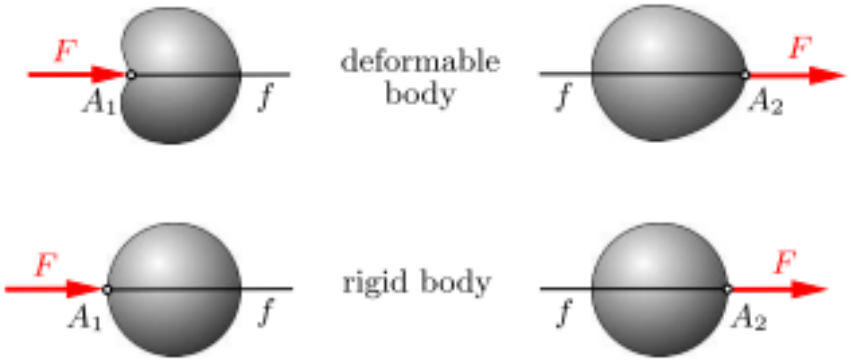
Compressible (Gases)

Dynamics

Incompressible (Hydraulics)

Kinetics

Kinematics



Rigid-body Mechanics

- Rigid-body mechanics is divided into two group: *statics* and *dynamics*.

➢ *Statics* deals with the *equilibrium* of bodies under the action of *forces*. Static means unchanging position in time.

➢ *Dynamics* deals with the *motion* of bodies.

What You Will Learn in Statics?

- How to *determine* the *resultant* of multiple *forces* and distributed forces.
- How to *determine* the *moment* of forces about points and axes.
- How to *draw* "*free body diagrams*" and identify all of the forces acting on a body.
- How to *use* "*equilibrium equations*" to determine unknown or unspecified forces and moments acting on (and within) bodies, including structures and machines.
- How to *identify* and quantify *friction forces*.
- How to *determine centroids*, centers of mass/gravity, and *moments of inertia* for shapes and objects.

And what will you do with these competencies???

- *Use* information about *forces* and *moments* to analyze and *design parts*, *assemblies*, *mechanisms*, and *structures* that are appropriate to their intended (and sometimes unintended) functions.

- *Use* information about *centroids*, centers of mass/gravity, and *moments of inertia* in support of the above.

Course Overview

- Basic principles
- Force systems
- Equilibrium
- Structural analysis and machines
- Centroids, distributed load systems
- Beams
- Friction
- Area and mass moments of inertia

1/2 The Basic Concepts

- Space - The geometric region where bodies position are represented by linear and angular measurements relative to a coordinate system.

- Time - Measure of succession of events.

- Mass - Measure of the inertia of the body (resistance to changes in translational motion). Also it is the quantity of matter in a body.

- Force - represents the action of one body on another. A force is characterized by its point of application, magnitude, and direction, i.e., a force is a vector quantity.

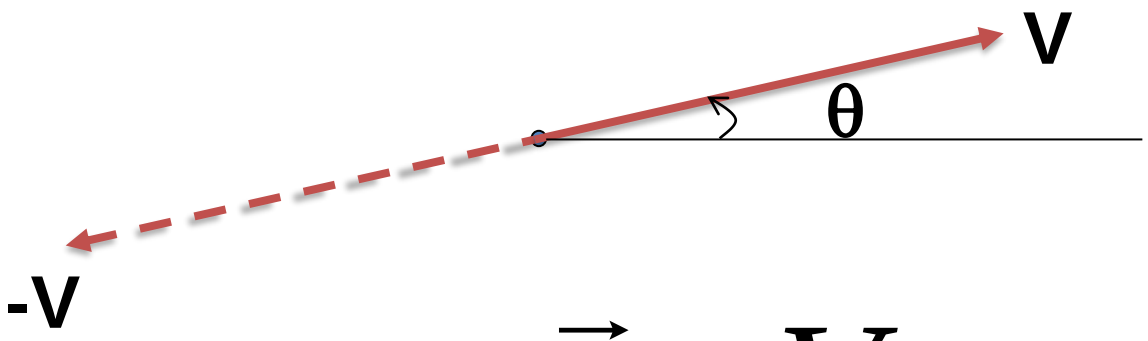
- Particle: A body of negligible dimension..

- Rigid Body: Deformation under forces is negligible. It can be considered as the relative movements between its parts are negligible under the action of force.

1/3 Scalars and Vectors

- *Mechanics deals* with the *two* kinds of *quantities*: *scalars* and *vectors*.
  - *Scalar*: is any positive or negative *physical quantity* that can be completely specified by its *magnitude*. Such as: time, volume, density…
  - *Vector*: is any *physical quantity* that requires both a *magnitude* and a *direction* for its complete description. Such as: velocity, acceleration, force, moment…

Vectors

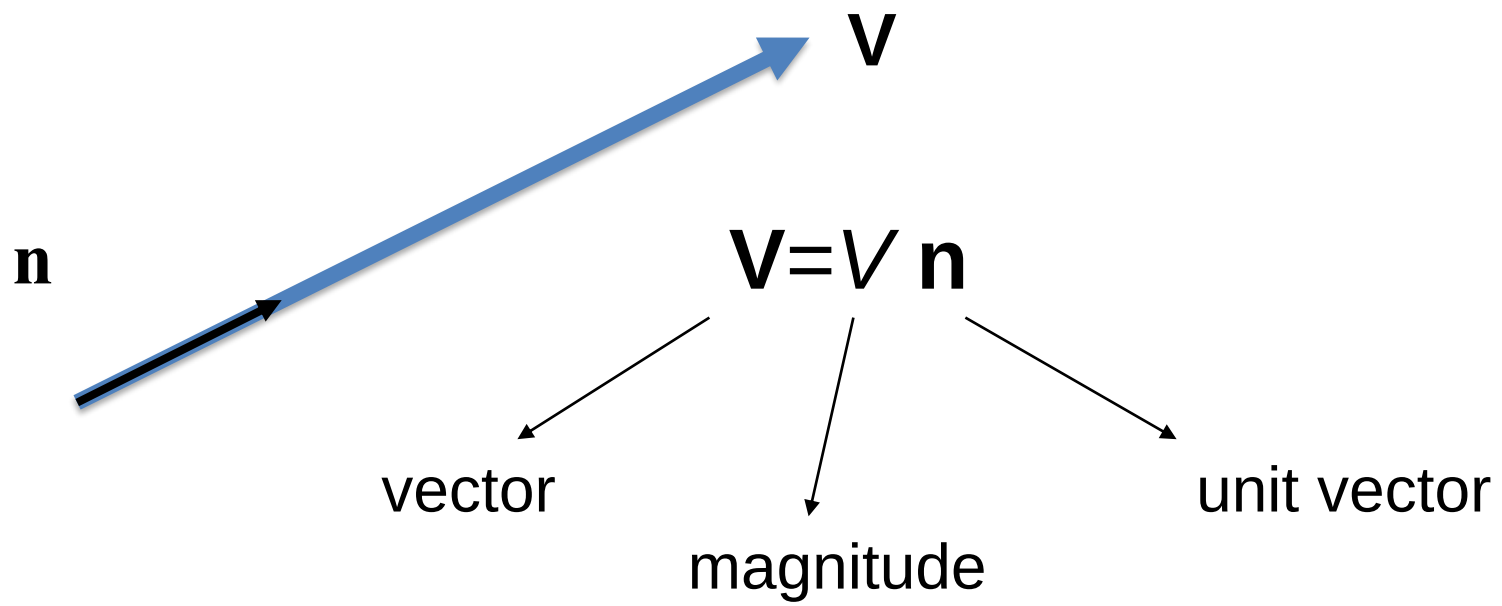


$$\vec{V} \text{ or } \mathbf{V}$$

Magnitude $\left|\mathbf{V}\right| = V$

Unit Vector

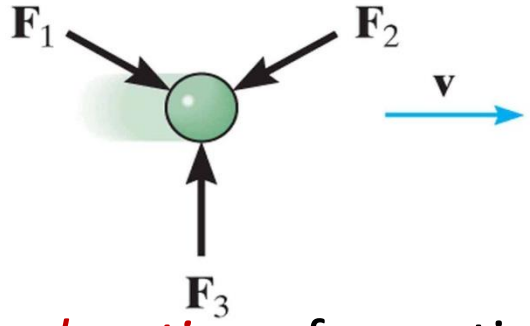
A vector **V** can be expressed mathematically as



n's magnitude is one and direction coincides with **V**'s direction

1/4 Newton's Laws

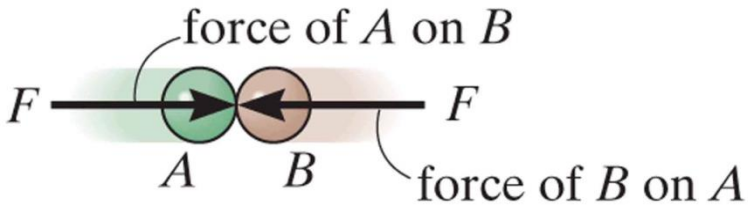
- First law: A particle remains at *rest* or continues to *move* in a straight line with *uniform velocity* if there is *no unbalanced force* acting on it.



- Second law: the *acceleration* of a particle is *proportional* to the resultant *force* acting on it and is in the *direction* of *this force*.

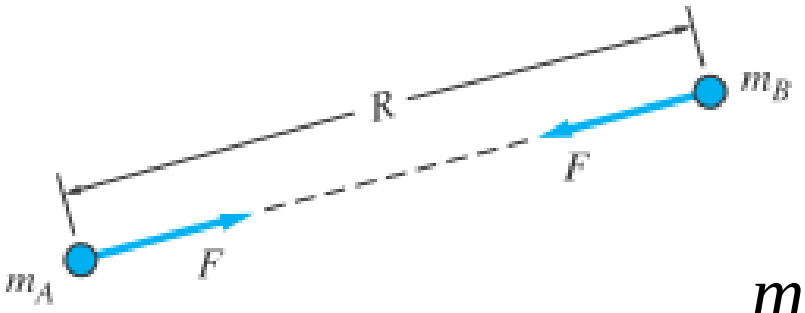
F = *m* x **a**

- Third law: The forces of *action* and *reaction* between *interacting bodies* are *equal* in magnitude, *opposite* in direction, and *collinear*.



1/5 Newton's Law of Gravitation

- The law of *gravitation* states that the *two particles* are *attracted* to each other by forces of magnitude F that *act* along the *line* connecting the particles.



$$F = G\frac{m_A m_B}{R^2}$$

m_A , m_B : masses of particles A and B respectively

R : distance between the particles

G: universal gravitational constant $\approx 66.74 \times 10^{-12}$ $m^3/(kg.s^2)$

F : force of attraction between two particles.

- The *gravitational attraction* of the *earth* on a *body* is known as the *weight* of the body.
- For a body of mass *m* near the surface of the earth, the weight of this body:

$$W = mg$$

W: weight (N)

m: mass (kg)

g: acceleration of the gravity ($\approx 9.81 m/s^2$)

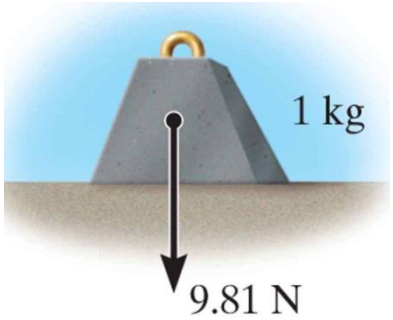
1/6 Units

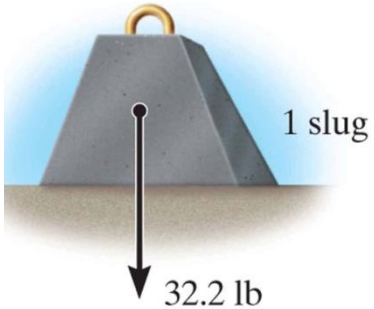
- *Mechanics* deals with *four* fundamental *quantities*: *length* (m), *mass* (kg), *force* (N), and *time* (sec).

- There are two *unit systems* which are commonly *used* in science and technology: *SI units* (The International System of Units) and *U.S. Customary units* (The U.S. Customary or British system of units).

The four fundamental quantities in the two unit system

Quantity	SI Units		US Units	
	Unit	Symbol	Unit	Symbol
Mass	kilogram	kg	slug	-
Length	meter	m	foot	ft
Time	second	s	second	sec
Force	newton	N	pound	lb





Unit conversion table

Quantity	SI Units	US Units
Force	1 N	0.2248 lb
Mass	1 kg	2.2 lbs
Length	1 m	3.2895 ft

Prefix

- When a *numerical quantity* is either *very large* or *very small*, the units used to define its size may be *modified* by using a *prefix*.

Quantity	Exponential form	Prefix	SI Symbol
1 000 000 000	10^{9}	Giga	G
1 000 000	10^{6}	Mega	M
1 000	10^{3}	Kilo	k
0.001	10^{-3}	Mili	m
0.000 001	10^{-6}	Micro	μ
0.000 000 001	10^{-9}	nano	n

Numerical Calculations

- *Dimensional Homogeneity*: the terms of any *equation* used to describe a *physical process* must be *dimensionally homogeneous*: that is, each term must be expresses in the *same units*. For example:

$W = mg$; m(kg) and g(m/s^2) => W(N)

m(lbs) and g(m/s^2) => is wrong

m(lbs) and g(ft/s^2) => W(lb)

or

5kN + 3N = 8kN or 8N ?

5kN (=5000N) + 3N = 5003N

1/7 Accuracy

- The accuracy of a solution depends on

  1) accuracy of the given data, and

  2) accuracy of the computations performed. The solution cannot be more accurate than the less accurate of these two.

- The use of hand calculators and computers generally makes the accuracy of the computations much greater than the accuracy of the data. Hence, the solution accuracy is usually limited by the data accuracy.

- Round:
  - ➢ greater than 5, round up (0.3528 → 0.353)
  - ➢ smaller than 5, round down (0.03521 → 0.0352)

1/8 Method of Problem Solution

- *Problem Statement*:
  Includes given data, specification of what is to be determined, and a figure showing all quantities involved.

- *Free-Body Diagrams*:
  Create separate diagrams for each of the bodies involved with a clear indication of all forces acting on each body.

- *Fundamental Principles*:
  The six fundamental principles are applied to express the conditions of rest or motion of each body. The rules of algebra are applied to solve the equations for the unknown quantities.

- *Solution Check*:
  - Test for errors in reasoning by verifying that the units of the computed results are correct,
  - test for errors in computation by substituting given data and computed results into previously unused equations based on the six principles,
  - **always** apply experience and physical intuition (feeling) to assess whether results seem "reasonable".

Tips for Success in Statics
(i.e., *what is expected!*)

- Do all assigned reading – before class.
- Solve extra problems
- Don’t spend more than 20 minutes/problem. Get help!
- Attend lecture regularly.
- Ask questions!!!

Text Book

Text Book:

Engineering Mechanics Vol-1;Statics
By J. L. Meriam and L. G. Kraige

Auxiliary Book:

Vector Mechanics for Engineers; Statics
By Ferdinand P. Beer and E. R. Johnston

Engineering Mechanics – Statics
By R.C. Hibbeler

Many books related with the Statics in the Library

Grading

1st midterm	:	30%
2nd midterm	:	30%
Final	:	40%
Total	:	100%

Exams

??.??.2018 ? First Examination

??.??.2018 ? Second Examination