Engineering Mechanics
Brief Introduction and Overview

Dr. Yiheng Wang

Dr. Djedoui . Dr. Khechai

Engineering Mechanics
Brief Introduction and Overview

- Statics
- Dynamics
- Mechanics of Materials (Deformable Solids)

Prerequisites: Calculus I, University Physics I

Objectives :

- To provide a brief overview of engineering mechanics.
- To introduce the basic sub-disciplines of mechanics.
- To explain the scopes and relations of three common engineering mechanics courses: statics, dynamics and mechanics of materials.

Question 1: What is Mechanics?

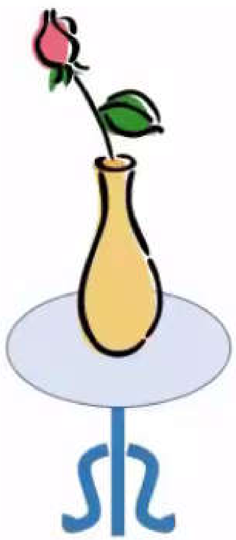
What is *Mechanics*?

1. A branch of **Physics**.

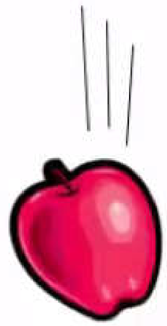
2. **Engineering mechanics** has a focus on the **applications**.

3. Calculates, describes and predicts the effects of **forces** on a **system**.

Question 2: What are some examples of what force can do?

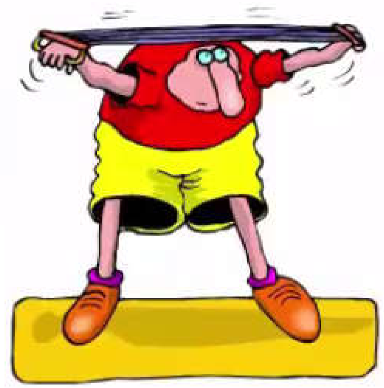


Keep an object **STATIC**



A gravitational Force

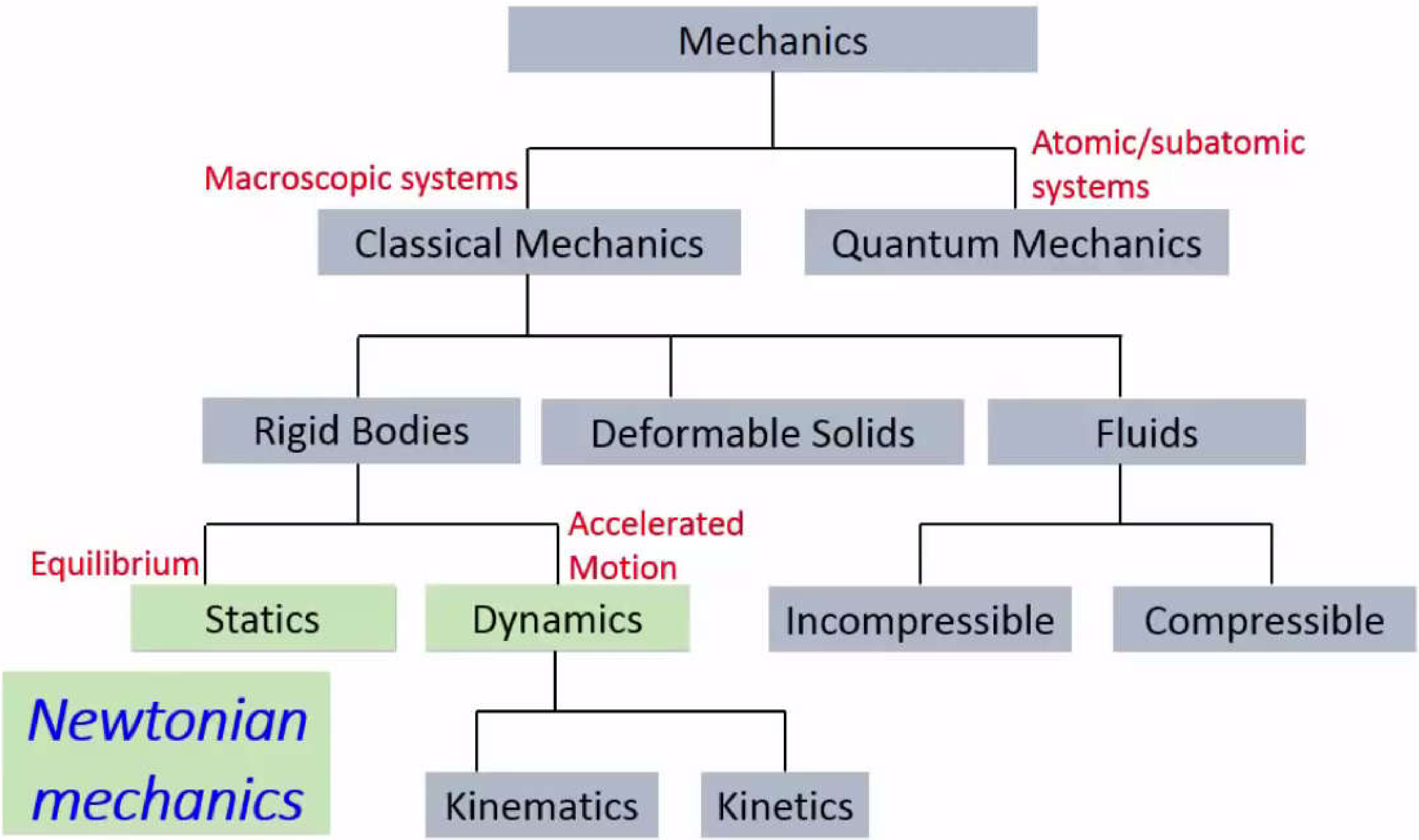
Make things **MOVE**



Force can **DEFORM** an object

Make things **ROTATE**

Engineering Mechanics: Statics



Newton's second law

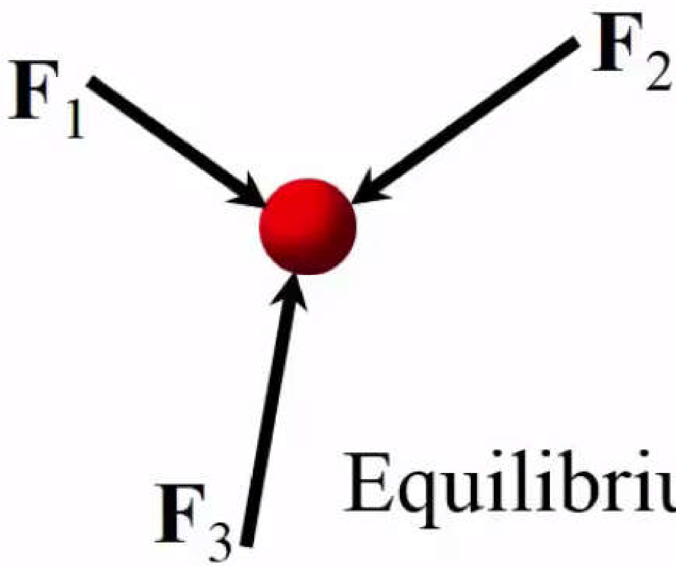
$$\mathbf{F} = m\mathbf{a}$$

Accelerated motion

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

The acceleration of the movement of an object is ***proportional to the resultant force***, and is also in the ***same direction*** of the resultant force.

Newton’s first law



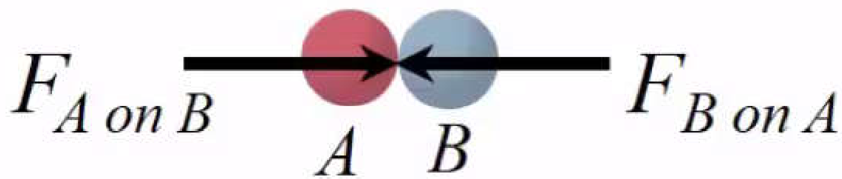
Equilibrium

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

$$\mathbf{a} = \frac{\mathbf{F}_R}{m} = \mathbf{0}$$

An object will remain its original state of motion (***rest*** or moving at ***constant velocity*** in a straight line) if there is no unbalanced force acting on it.

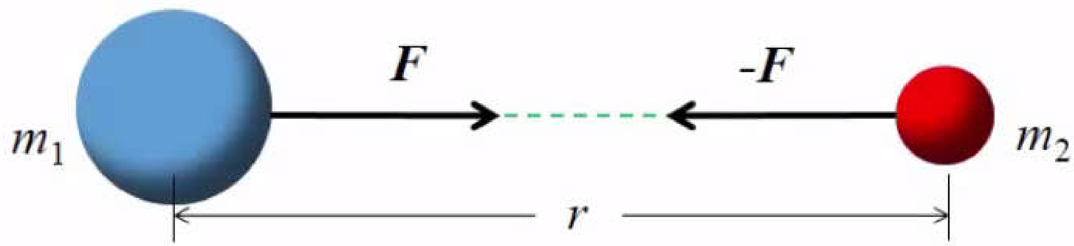
Newton's third law



Action and reaction

The forces of action and reaction between two objects are of the ***equal***, ***collinear*** and ***opposite***.

Newton's law of gravitation

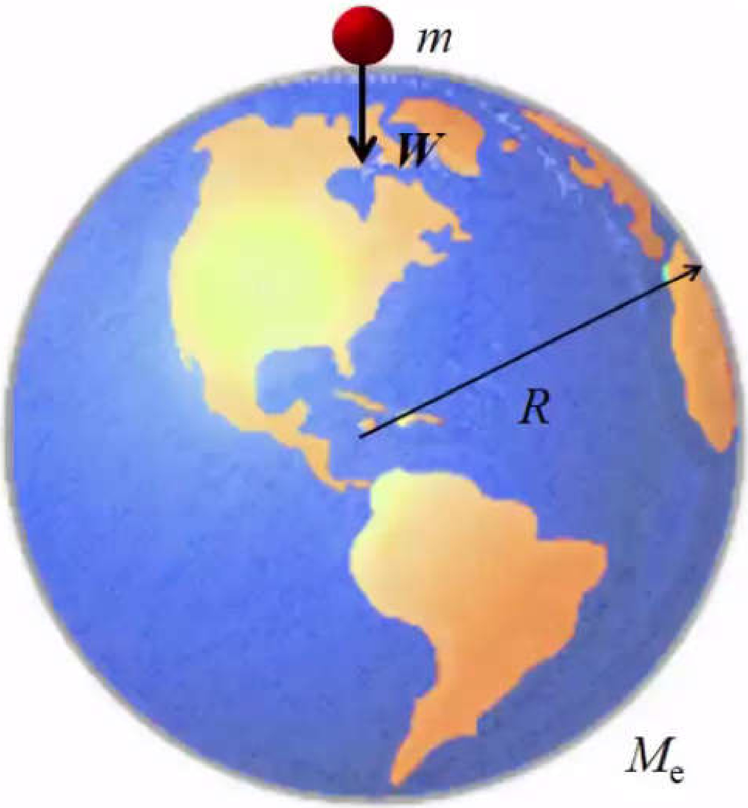


$$F = G\frac{m_1 m_2}{r^2}$$

G: universal constant of gravitation, 66.73×10^{-12} $m^3/(kg\cdot s^2)$

The gravitational attraction forces between any two objects are equal and opposite.

Newton's law of gravitation



$$W = G\frac{mM_e}{R^2}$$

R: radius of the earth

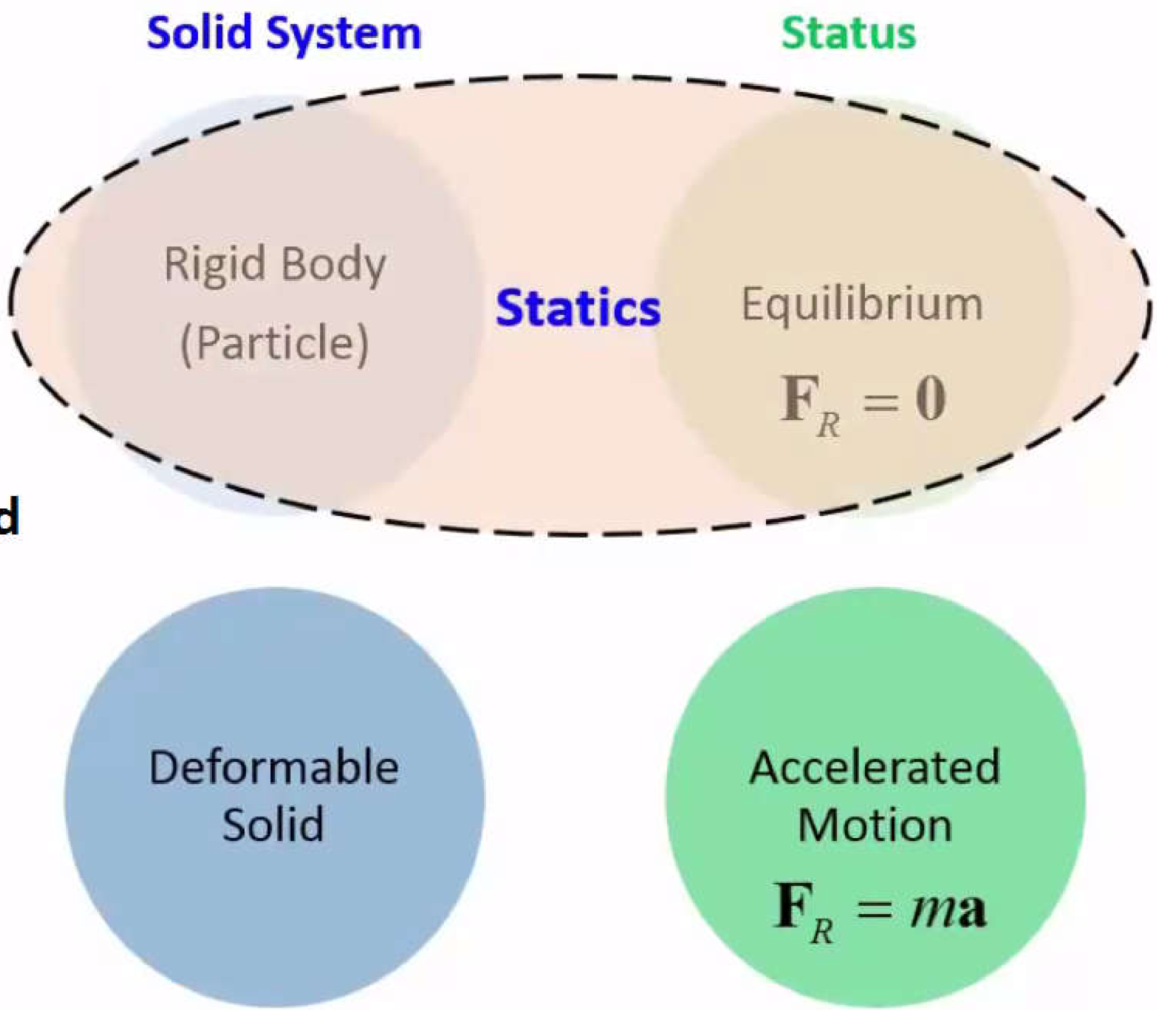
M_e: mass of the earth

Let $g = G\frac{M_e}{R^2}$

$$\therefore W = mg$$

g: constant of gravitation of the earth, 9.81 m/s^2 or 32.2 ft/s^2.

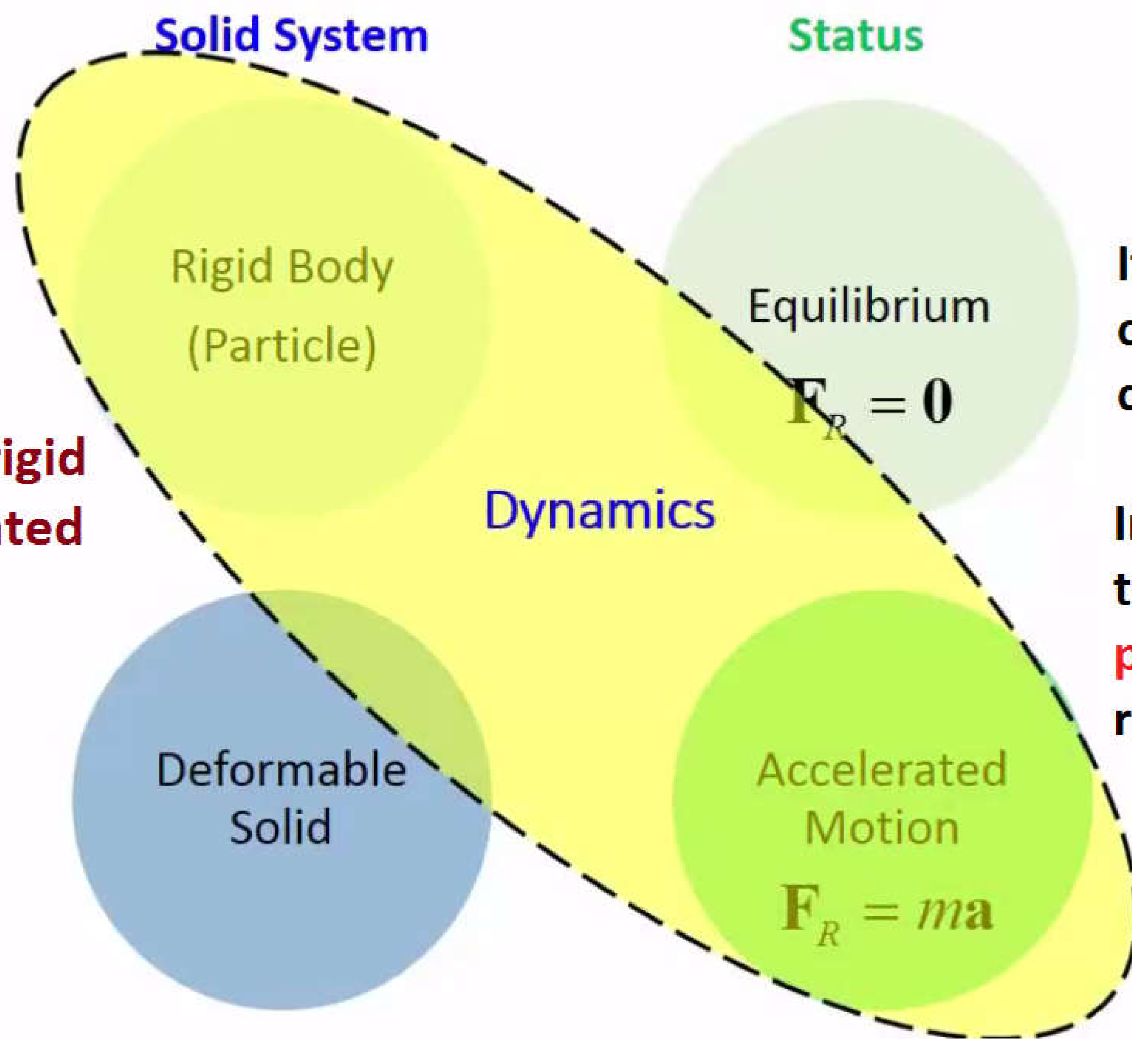
Solid System	Status
Rigid Body (Particle)	Equilibrium $\mathbf{F}_R = \mathbf{0}$
Deformable Solid	Accelerated Motion $\mathbf{F}_R = m\mathbf{a}$



Statics studies rigid body Equilibrium

It is the easiest class of the three.

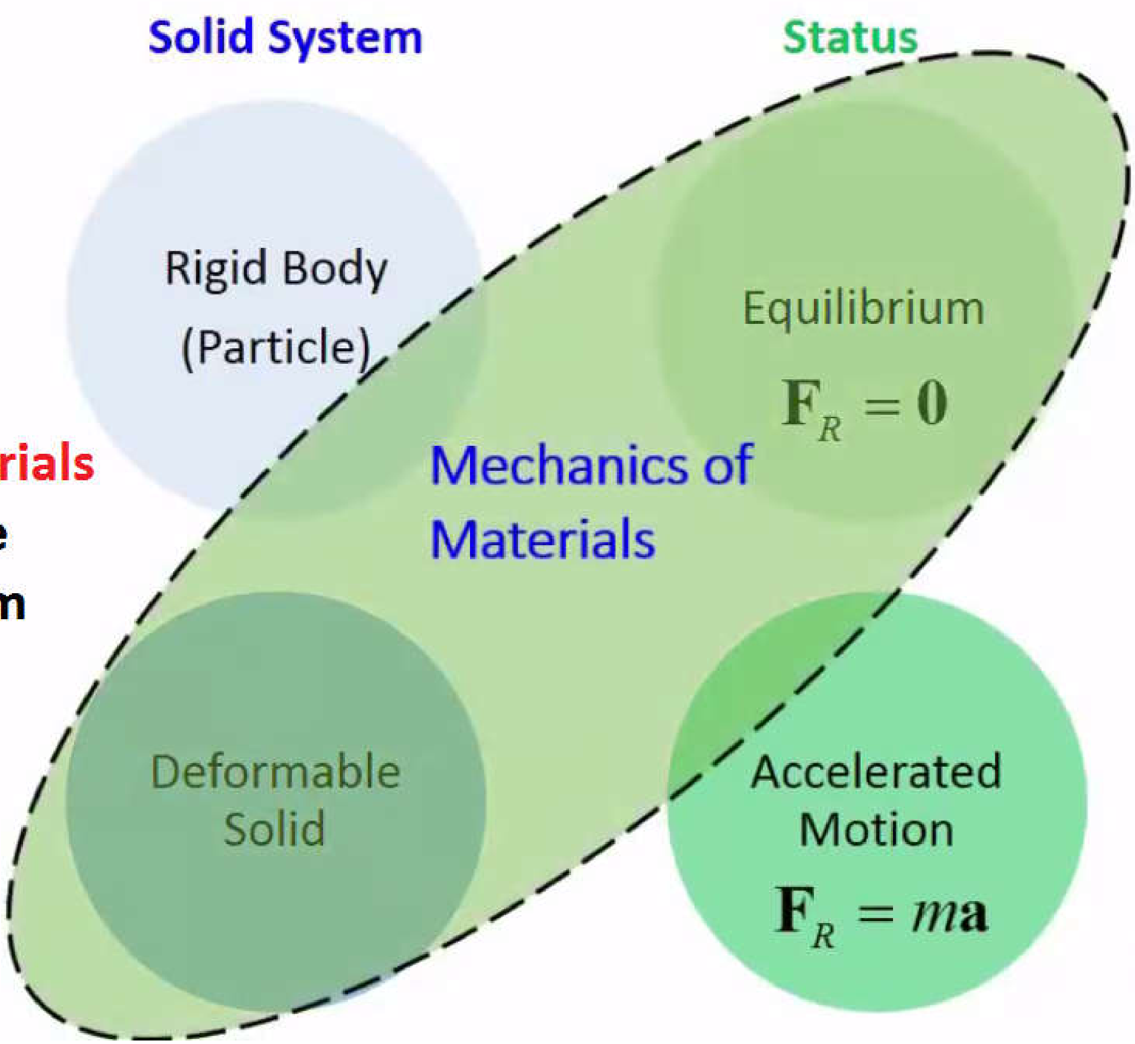
At the same time, it is the most important since it builds the theoretical foundation for the other two courses



Dynamics studies rigid body with accelerated motion

It could be translation or rotation or a combination of both.

In dynamics, we learn to understand and predict the motions of rigid bodies



Mechanics of materials studies deformable solids in equilibrium

We want to know how forces cause stress, deformation and even failure in the system.

It is important in many fields such as construction or design.

Fundamental Concepts:

Basic quantities and idealization

Objectives :

- To introduce the basic quantities of mechanics.
- To introduce the concept of idealization commonly used in mechanics.

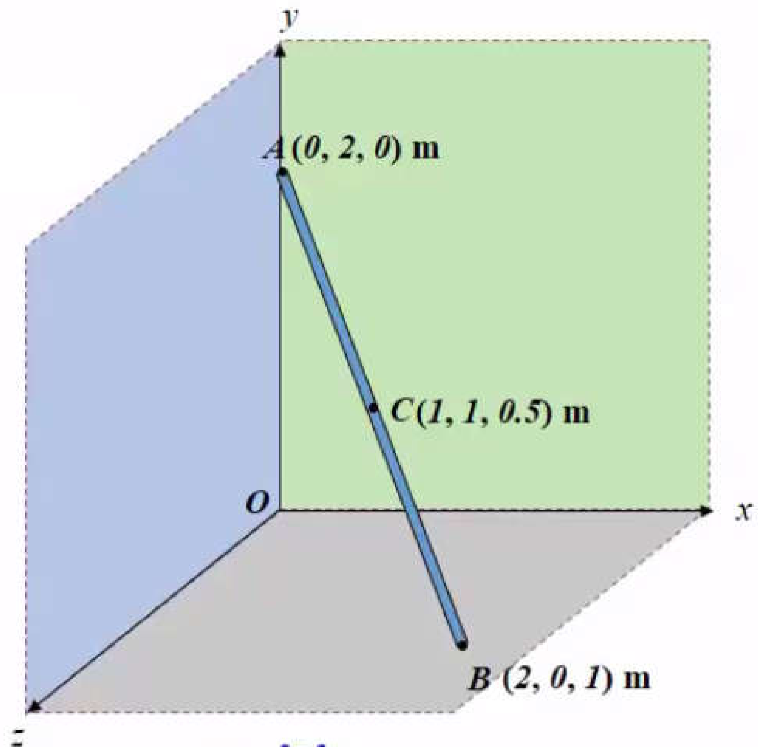
Basic quantities

length time mass force

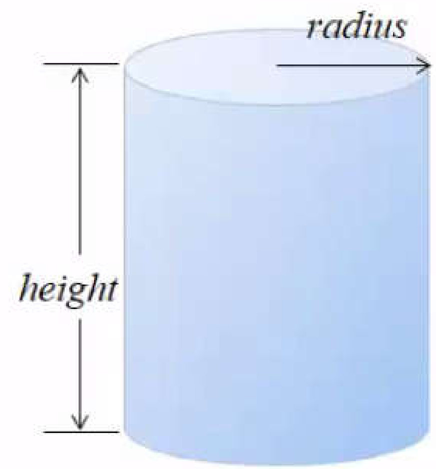
Question 1: In your own words, explain what *length*, *time*, *mass* and *force* are respectively.

Length

can be used to describe the position is space, the size of a physical system, and the geometric properties of a body.



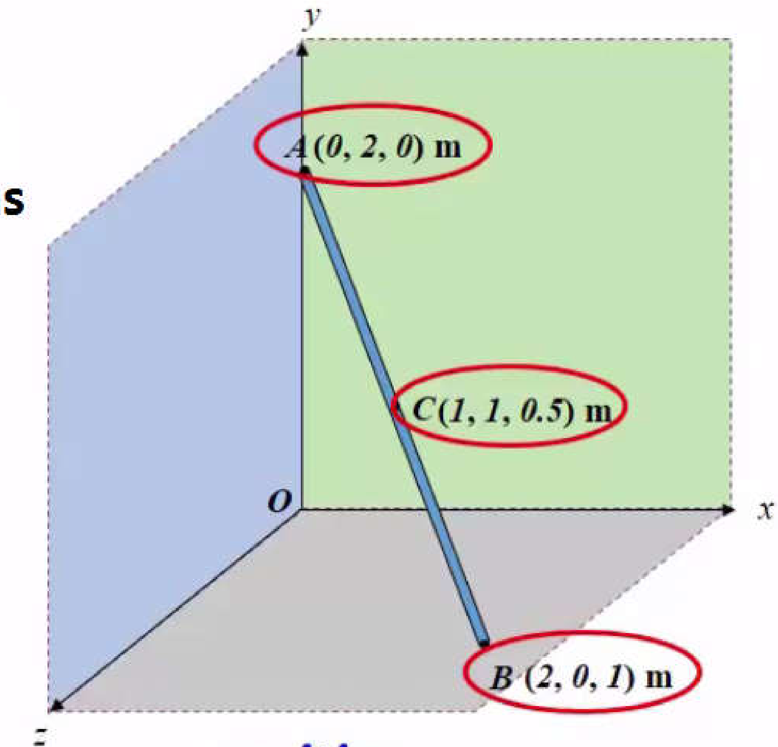
position



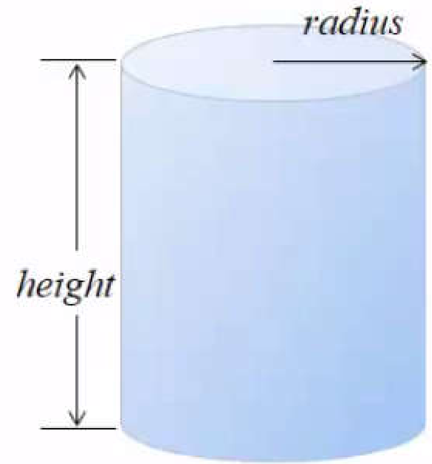
size, geometric properties

Length

Coordintes are the 3 lengths measured from the origin along *x*, *y* and *z* direction respectively in an established rectangular coordinate system.



position



size,
geometric properties

Unit: [m] or [ft]

Time

describes the succession of events.

Example: Speed describes the position of an object with respect to time.

Time is a very important concept in the subject of Dynamics, but in Statics, we mainly deal with objects that are motionless.

statics : time-independent
dynamics: time-dependent

Unit: [s]

Question 2: A person who weighs 143 pounds is about 65 kilograms, correct? Is *weight* the same as *mass*?

Mass

is a measure of quantity of matters.

Mass is a physical property that characterizes the extent of force and object experiences in a gravitational field.

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

Mass characterizes also the resistance of an object to changes in its state of motion.

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

Mass is NOT the same as weight since weight is a force

Unit: [kg] or [slug]

Force

The concept of force characterizes the action and reaction between two bodies.

They could be CONTACT between the two bodies.

There could be NO CONTACT.

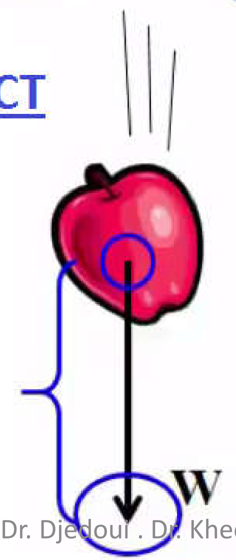
Force is a vector and it is fully described by:

magnitude
direction
point of application

Unit: [N] or [lb]

CONTACT

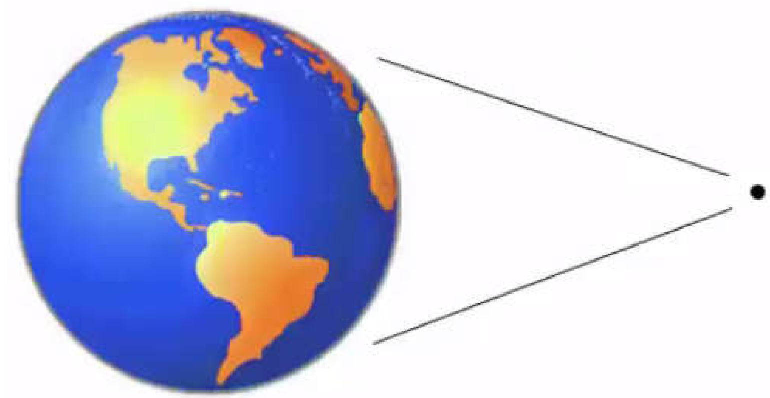
NO CONTACT



Idealizations

means to use scientific models to represent phenomena, so that they can be simplidied to an extent.

particle



An object can be modeled as a particle when it's geometry and dimension are negligible for the interest of the study

A particle is considered to only occupy a single point in space with NO shape or size and it has NO properties except its MASS.

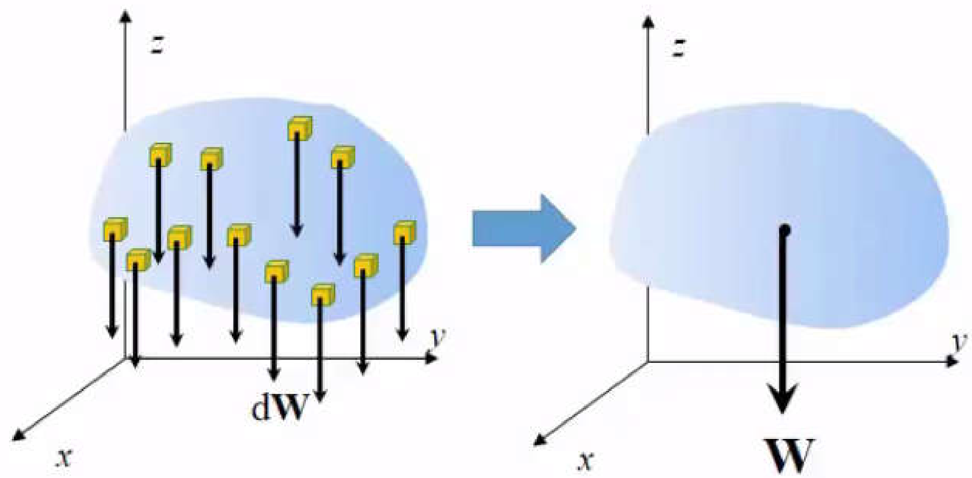
rigid body

not only has mass but also has dimensions and geometry.

In other words, it has size and shape that need to be taken into consideration in our analysis.

Unlike real world objects a rigid body does NOT have any other material properties such as ELASTICITY, therefore it will not deform.

concentrated force



assumes that a force only acts on a point, although in realty, forces are applied to an AREA or a VOLUME.

Example:

The weight of an object is distributed throughout its body, but in our analysis, we often use a concentrated force that is placed at the CENTER of GRAVITY in the object to replace the distributed gravitational force.