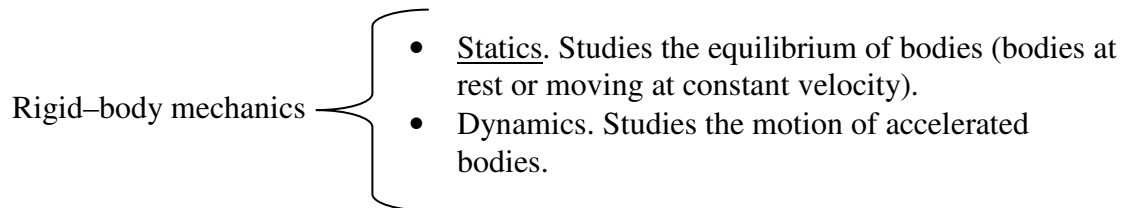
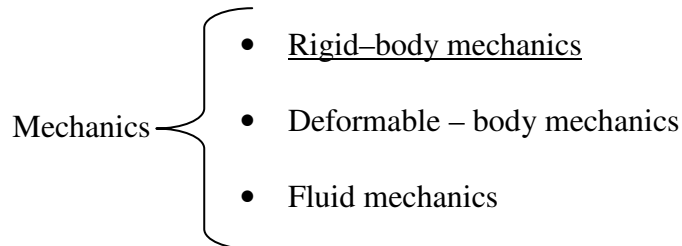


## GENERAL PRINCIPLES

### 1. MECHANICS

*Mechanics* is the branch of physics (classic) that studies the state of rest or motion of bodies subjected to the action of forces.



### 2. FUNDAMENTAL CONCEPS

*Basic Quantities* are quantities which cannot be defined via other quantities because there is nothing more fundamental than what is presently known.

The international system of units (SI) defines seven *basic quantities* and the specific unit for each of these basic quantities.

TABLE 1.1

Quantity	Unit	Description
Length	Meter (m)	Quantity required to locate the position of a point in space
Mass	Kilogram (kg)	Property of a physical object that quantifies the amount of matter
Time	Second (s)	Time is conceived as a succession of events
Electric current	Ampere (A)	Flow of electric charge
Temperature	Kelvin (k)	Measure of the average energy contained in the microscopic degrees of freedom of a system
Amount of substance	Mole (mol)	Number of particles in a given amount of matter
Luminous intensity	Candela (Cd)	Measure of the wavelength-weighted power emitted by a light source in a particular direction

Other major systems of units exist such as the cgs and U. S. customary systems. Many other quantities can be derived out of the combination of the basic quantities: speed, acceleration, force, power, energy.

*Idealizations.* The implementation of models for the analysis of systems is necessary due to the enormous complexity of real systems. Some basic idealization concepts are

**Particle.** A particle has mass but with a negligible size. Thus when a body is reduced to a particle the principles of mechanics are reduced to a simplified form since the geometry of the body is not relevant for the analysis of the problem.

**Rigid Body.** This idealization means that a body can be considered as a combination of a large number of particles, in which all the particles remain at a fixed distance from each other both before and after applying the load. Based on this assumption, the material properties of any body under analysis will not be considered.

**Concentrated Force.** A concentrated force represents the effect of a loading which is assumed to act at a point on a body.

*Newton's Laws of Motion.* The mechanics of a rigid-body is governed by the laws of motion introduced by Newton (1642–1727). These laws apply to the motion of a particle as measured from a non-accelerating frame of reference.

**First Law.** A particle originally at rest, or moving in a straight line with constant velocity will remain in this state provided the particle is not subjected to an unbalance force.

**Second Law.** A particle subjected to an unbalanced force  $\mathbf{F}$  experiences an acceleration  $\mathbf{a}$  that has the same direction as the force and a magnitude that is directly proportional to the force.

$$\vec{F} = m\vec{a} \quad (1.1)$$

**Third Law.** The mutual forces of action and reaction between two particles are equal, opposite and collinear.

*Newton's Law of Gravitational Attraction.*

$$F = G \frac{m_1 m_2}{r^2} \quad (1.2)$$

where

$F$  is the gravitational force between two bodies.

$G$  is the universal constant of gravitation,  $G = 66.73 \times 10^{-12} \text{ m}^3/(\text{kg s}^2)$ .

$m_1, m_2$  are the mass of each particle.

$r$  is the distance between the two particles.

**Weight.** According to Eq. 1.2, any two particles or bodies have a mutual force of attraction. For the case of a particle located at or near the surface of the earth the only gravitational force having any sizable magnitude is that between the earth and the particle. This force is called weight and is defined as

$$W = mg \quad (1.3)$$

$g$  is the acceleration due to gravity. Since  $g$  depends on  $r$  it can be seen that the weight of a body is not an absolute quantity.

### 3. UNITS OF MEASUREMENT

The fundamental units we will be dealing with in this course are basically three, kg for mass, second for time and m for length. These are SI units and have their equivalency in the cgs and U. S. customary systems.

#### Systems and Fundamental Units

$$\text{SI} \left\{ \begin{array}{l} \bullet \text{ kg} \rightarrow \text{mass} \\ \bullet \text{ m} \rightarrow \text{length} \\ \bullet \text{ s} \rightarrow \text{time} \end{array} \right. \quad \text{US} \left\{ \begin{array}{l} \bullet \text{ slug} \rightarrow \text{mass} \\ \bullet \text{ ft} \rightarrow \text{length} \\ \bullet \text{ s} \rightarrow \text{time} \end{array} \right.$$

Combination of these three fundamental units results in *derived* units. For example, the velocity of a moving object is defined as the distance traveled by that object in a given time; therefore the units for velocity are m/s. Similarly, the units for acceleration are  $\text{m/s}^2$ .

From Eq. 1.3, we know that the weight of an object, which is a force, is obtained by multiplying its mass times the acceleration of gravity; then the unit for force is  $\text{kg}\cdot\text{m/s}^2$ . This unit is named as Newton, thus

$$\left[ \frac{\text{kg} \cdot \text{m}}{\text{s}^2} \right] = [N]$$

#### Conversion Factors

The conversion factor for the units of length and mass between the U. S. and SI systems are:

$$\begin{aligned} 1 \text{ ft} &\rightarrow 0.3048 \text{ m} \\ 1 \text{ slug} &\rightarrow 14.5938 \text{ kg} \end{aligned}$$

The conversion factors of *derived* units can be obtained from these two conversion factors. For example, the conversion factor for force can be obtained as

$$1 \text{ lb} = 1 \frac{\text{slug} \cdot \text{ft}}{\text{s}^2} \times \frac{14.5938 \text{ kg}}{1 \text{ slug}} \times \frac{0.3048 \text{ m}}{1 \text{ ft}} = 4.4482 \text{ N}$$

Examples. Derive the units in SI for energy (work) and power. Express 100 mi/hr in m/s. Express 20 W in lb·ft/s.

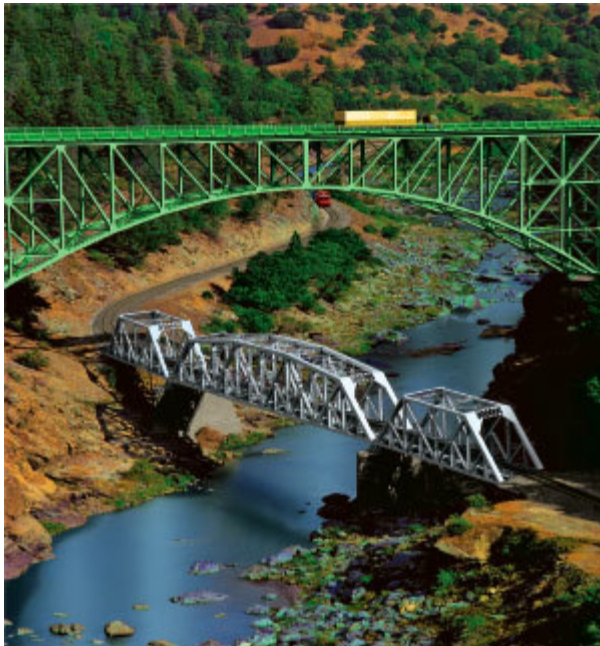
## 4. PREFIXES

Table 1.2

<i>Multiple</i>	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
<i>Submultiple</i>			
0.001	$10^{-3}$	milli	m
0.000 001	$10^{-6}$	micro	$\mu$
0.000 000 001	$10^{-9}$	nano	n

## 5. APPLICATIONS

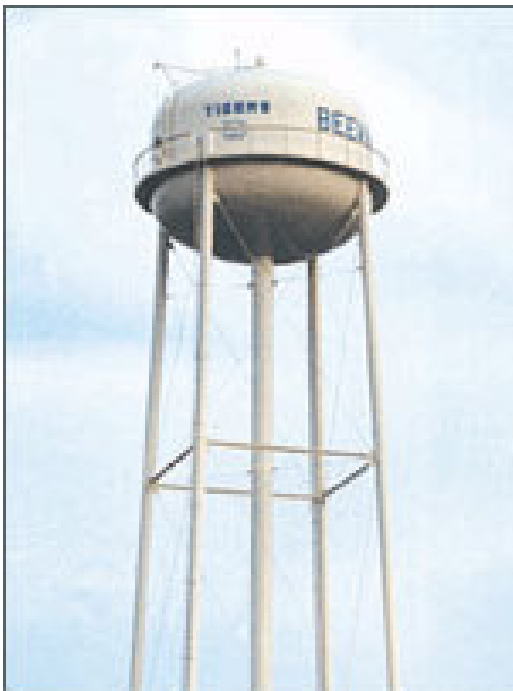
The forces that are going to be applied on virtually every element of every mechanical structure to be built must be determined prior to its construction. Next some typical examples of structures



The forces within the every member of these bridges must be determined to ensure a proper design.



The maximum capacity of a tower crane must be properly specified to determine the forces that every member will support.



When a pressure vessel is designed, it is important to be able to determine the center of gravity of its component parts, calculate its volume and surface area, and reduce three-dimensional distributed loadings to their resultants.