

MECHANICS, UNITS, NUMERICAL CALCULATIONS & GENERAL PROCEDURE FOR ANALYSIS

Today's Objectives:

Students will be able to:

- Explain mechanics / statics.
- Work with two types of units.
- Round the final answer appropriately.
- Apply problem-solving strategies.

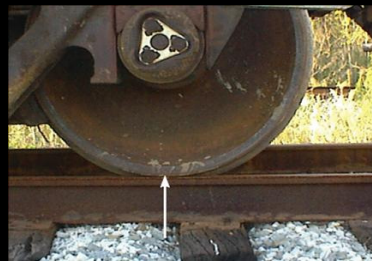
In-Class activities:

- What is Mechanics
- System of Units
- Numerical Calculations
- Concept Quiz
- Problem Solving Strategy

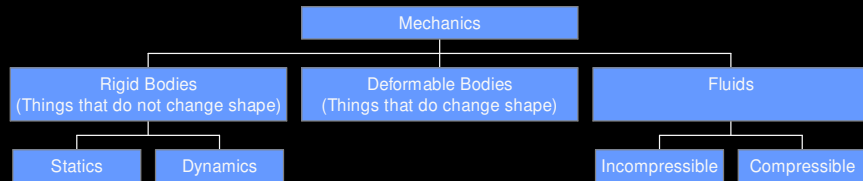


WHAT IS MECHANICS?

- Mechanics is a branch of the physical sciences that is concerned with the state of rest or motion of bodies that subjected to the action of forces
- Study of what happens to a **BODY** when **FORCES** are applied to it. In another way is the study of mechanical interaction between bodies.



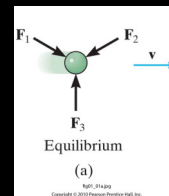
BRANCHES OF MECHANICS



Newton's Laws of motion

• First Law

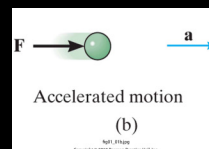
A particle originally at rest, or moving in a straight line with constant velocity, tend to remain in this state provided the particle is not subjected to an unbalanced force.



• Second Law

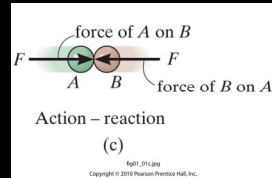
A particle acted up on by an unbalanced force **F** experiences an acceleration **a** that has the same direction as the force and magnitude that is directly proportional to the force.

$$F = m * a$$



- **Third Law**

the mutual forces of action and reaction between two particles are equal, opposite, and collinear.



- **Newton's Law of Gravitational Attraction**

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

where;

F= force of gravitation between the two particles

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

m_1, m_2 = mass of each of the two particles

r= distance between the two particles



UNITS OF MEASUREMENT

- Four fundamental physical quantities (or dimensions).
 - Length
 - Mass
 - Time
 - Force
- Newton's 2nd Law relates them: $F = m * a$
- We use this equation to develop systems of units.
- Units are arbitrary names we give to the physical quantities.



UNIT SYSTEMS

- Force, mass, time and acceleration are related by Newton's 2nd law. Three of these are assigned units (called base units) and the fourth unit is derived. Which is derived varies by the system of units.
- We will work with two unit systems in statics:
 - International System (SI)
 - U.S. Customary (USCS)

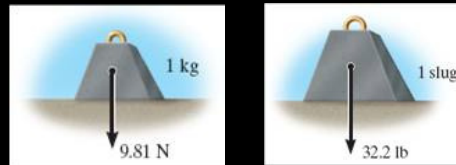


Table 1-1 in the textbook summarizes these unit systems.

TABLE 1-1 Systems of Units				
Name	Length	Time	Mass	Force
International System of Units	meter	second	kilogram	newton*
SI	m	s	kg	N $\left(\frac{\text{kg} \cdot \text{m}}{\text{s}^2}\right)$
U.S. Customary FPS	foot	second	slug*	pound
	ft	s	$\left(\frac{\text{lb} \cdot \text{s}^2}{\text{ft}}\right)$	lb

*Derived unit.



COMMON CONVERSION FACTORS

- Work problems in the units given unless otherwise instructed!

Quantity	Unit of Measurement (FPS)	Equals	Unit of Measurement (SI)
Force	lb		4.448 N
Mass	slug		14.59 kg
Length	ft		0.304 8 m

- Example: Convert a torque value of 47 in • lb into SI units.
 - Answer is 5.31026116 N • m?



THE INTERNATIONAL SYSTEM OF UNITS (Section 1.4)

- No plurals (e.g., $m = 5 \text{ kg}$, not kgs)
- Separate units with a • (e.g., meter second = $m \cdot s$)
- Most symbols are in lowercase.
 - Some exceptions are **N**, **Pa**, **M** and **G**.
- Exponential powers apply to units, e.g., $\text{cm} \cdot \text{cm} = \text{cm}^2$
- Compound prefixes should not be used.
- Table 1-3 in the textbook shows prefixes used in the SI system



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.)
- Use an appropriate number of significant figures (3 for answer, at least 4 for intermediate calculations).
- Be consistent when rounding off.
 - greater than 5, round up (3528 \rightarrow 3530)
 - smaller than 5, round down (0.03521 \rightarrow 0.0352)
 - equal to 5, see your textbook for an explanation.



PROBLEM SOLVING STRATEGY: IPE, A 3 Step Approach

1. **Interpret:** Read carefully and determine what is given and what is to be found/ delivered. Ask, if not clear. If necessary, make assumptions and indicate them.
2. **Plan:** Think about major steps (or a road map) that you will take to solve a given problem. Think of alternative/creative solutions and choose the best one.
3. **Execute:** Carry out your steps. Use appropriate diagrams and equations. Estimate your answers. Avoid simple calculation mistakes. Reflect on / revise your work.

