

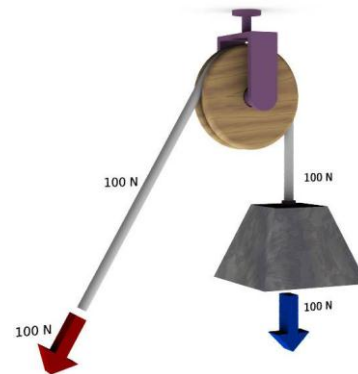
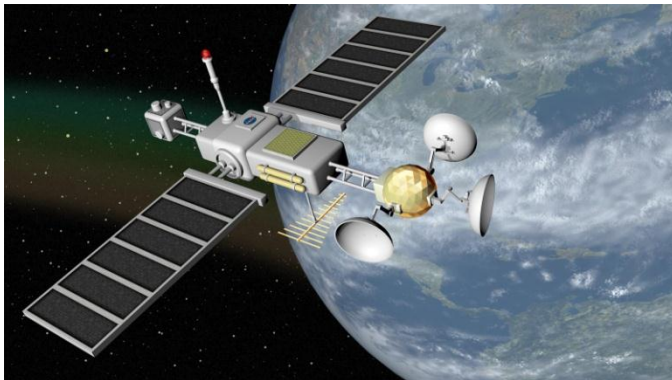


Lecture 1

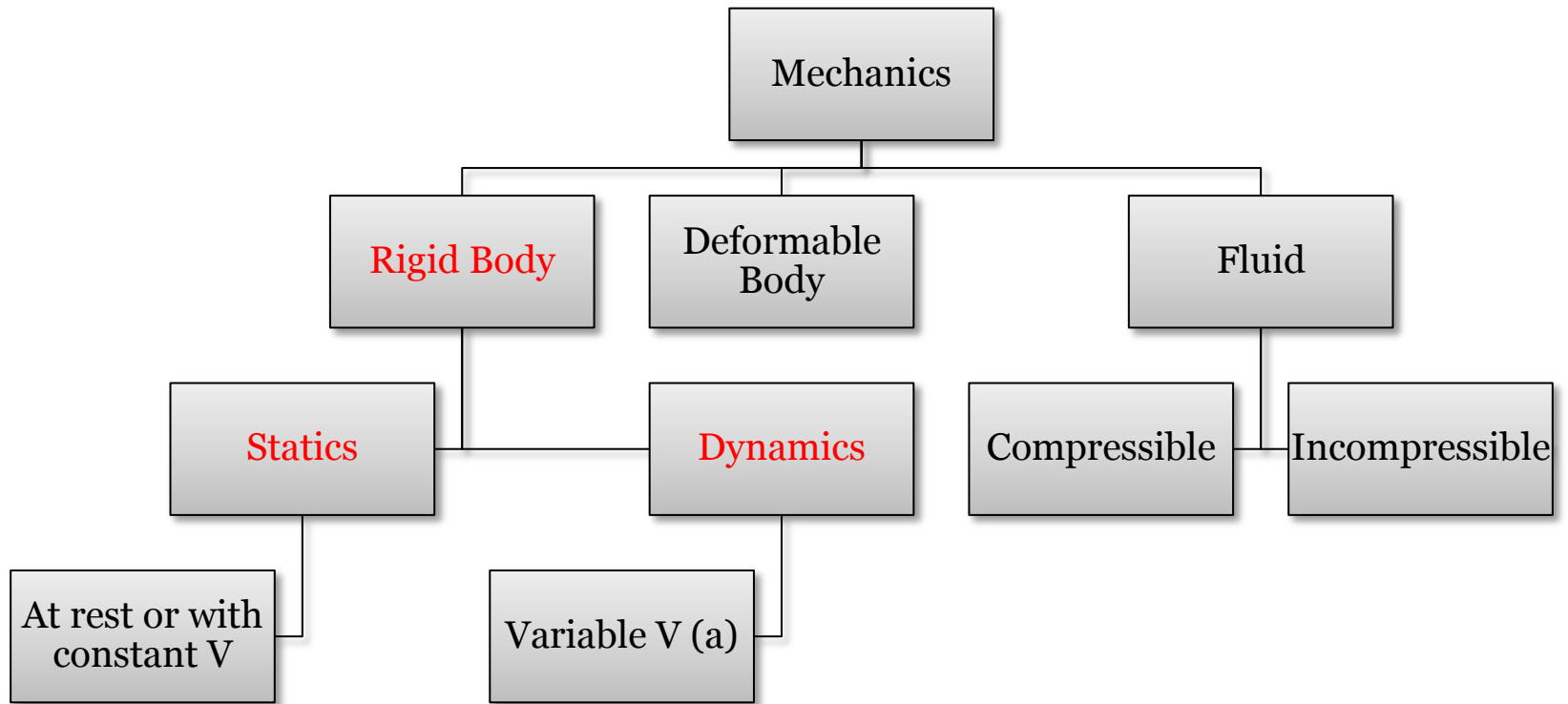
ECOR1101 Mechanics I

What is Mechanics?

- Study of the state of rest or motion of bodies when acted upon by forces
- Either the bodies or the forces can be large



Branches of Mechanics



Fundamental Units (Dimensions)

- Four fundamental physical quantities (dimensions)
 - **Length:** to locate a body in space and measure dimension of bodies (m, inch)
 - **Mass:** measure of a quantity of matter in a body (kg, lb)
 - **Time:** measure of succession of events (s)
 - **Force:** a “push” or “pull” exerted by one body on another (N, lbf)

Systems of Units

- We will work with two (2) systems of units in mechanics (statics and dynamics)
 - International System (SI – Système International d'Unités)
 - US Customary (imperial units)
- Both systems have 3 base units and 1 derived

Base and Derives Units

TABLE 1-1 Systems of Units

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

*Derived unit.

Conversion of Units

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

Dimensional Analysis

- Unit conversions are easily solved through the process of dimensional analysis
- Facts of dimensional analysis
 - Conversion factor is a statement of equal relations
 - Conversion factor in ratio form = 1
 - Units cancel out like variables

Dimensional Homogeneity

- The terms of all equations must be dimensionally homogeneous.
 - Dimension of LHS = Dimension of RHS
- Consider the kinematic equation:

$$v_f = v_i + at$$

$$\frac{m}{s} = \frac{m}{s} + \frac{m}{s^2} \cdot s$$

Models and Idealizations

- Models and idealizations are often used in mechanics to simplify problems
- **Particle:** has mass but negligible size. For example, the earth can be considered a particle with negligible size when viewed with respect to its orbit or other celestial bodies
- **Rigid body:** A rigid body can be considered as a collection of particles but all particles remain fixed with respect to one another under load
- **Concentrated force:** when the area of load application is small with respect to the size of the body

Newton's Laws of Motion

- Engineering mechanics is formulated on Newton's Laws of Motion
 - The laws were postulated based on experimental observation
 - The laws apply to the motion of a particle with reference to a non-accelerating reference frame

Newton's Laws of Motion

- **1st Law:** A particle at rest or in motion will continue in its state of rest or motion unless acted upon by an **unbalanced** system of forces

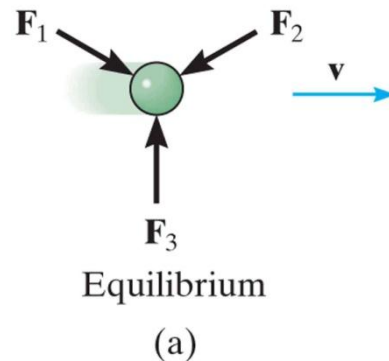


fig01_01a.jpg

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Newton's Laws of Motion

- **2nd Law:** A particle of **mass** (m) acted upon by an **unbalanced system of forces** (F) experiences an **acceleration** (a) in the same **direction as the force** and with a magnitude proportional to the force.

$$F = m \cdot a$$



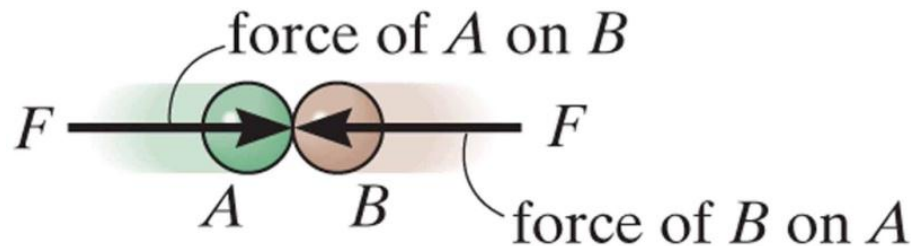
Accelerated motion

(b)

fig01_01b.jpg
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Newton's Laws of Motion

- **3rd Law:** For every action, there is an equal and opposite reaction.



Action – reaction

(c)

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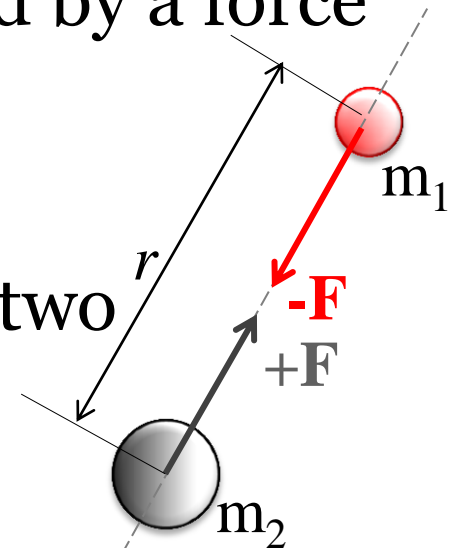
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Newton's Law of Gravitational Attraction

- States that two bodies are attracted by a force of gravity

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

- F = force of gravity between the two particles
- m_1, m_2 = mass of the particles
- r = distance between the two particles
- G = universal constant of gravitation, = $66.73 \times 10^{-12} \text{ m}^3/(\text{kg} \cdot \text{s}^2)$



Weight of a Body

- Consider an object of mass m on the surface of the earth
- The force exerted between the body and the earth, i.e. the body's weight (W) is given as:

$$W = mg = G \frac{M_e m}{r^2}$$

- $W = m \cdot g$ ($F = m \cdot a$)
- $g = GM_e / r^2$
- g = acceleration due to gravity



Accuracy of Numerical Calculations

- Depends on the
 - Accuracy of the given data
 - Accuracy of computations
- Results of computations cannot be more accurate than the least accurate of the given data
- Example: if the side of a square is 31 mm (2 significant figures) then area of the square 961 mm^2 has to be in **960 mm²** (2 significant figures)

Significant Figures

- The number of significant figures conveys the accuracy of a number.
 - 4903 has 4 significant figure without doubt
 - 23500 is less obvious. It could have:
 - 3 significant figure (235)
 - 4 significant figures (2350)
 - 5 significant figures (23500)

Significant Figures

- To ensure clarity engineering notation is used
 - e.g. 23.5×10^3 for 3 significant figures
 - 23.50×10^3 for 4 significant figures
- For numbers less than 1;
 - 0.00356 has 3 significant figures (zeros are not significant)
 - In engineering notation 3.56×10^{-3}

Rounding off Numbers

- Numbers are rounded off to ensure the accuracy of the results is same as given data or computations
- Generally;
 - number $\geq 5 \Rightarrow$ rounded up
 - number $< 5 \Rightarrow$ rounded down
- A special rule sometimes used
 - number $> 5 \Rightarrow$ rounded up
 - number $< 5 \Rightarrow$ rounded down
 - number = 5
 - \Rightarrow if preceding number is even, do not round up
 - \Rightarrow if preceding number is odd, round up

Rounding off Numbers

- If the number 3.14159
 - = 3.14 in 3 significant figures
 - = 3.142 in 4 significant figures
- For special case if the number is 0.1275 or 2.245 round to three significant figures
 - 0.1275 = 0.128 in 3 significant figures
 - 2.245 = 2.24

In Calculations

- Round off only final answer. (do not round off intermediate results)
- Calculations should be to **3 significant figures**.
- In mechanics, geometries (sizes and locations) and loads are reliably measured to 3 significant figures

Sample Problem

- If a car is traveling at 55.0 mi/h, determine its speed in:
 - Km/h
 - m/s
- Important Information
 - 1mi = 5280 ft
 - 1 ft = 0.3048 m
 - 1 m = 0.001 km
 - 1 hr = 60min
 - 1 min = 60 s
 - 1 hr = 60×60 = 3600 s

Sample Problem

- Solution

$$\frac{1 \text{ mi}}{5280 \text{ ft}} = \frac{5280 \text{ ft}}{1 \text{ mi}} = 1$$

$$\frac{1 \text{ ft}}{0.3048 \text{ m}} = \frac{0.3048 \text{ m}}{1 \text{ ft}} = 1$$

$$\frac{1 \text{ m}}{0.001 \text{ km}} = \frac{0.001 \text{ km}}{1 \text{ m}} = 1$$

$$55.0 \frac{\text{mi}}{\text{h}} = 55.0 \frac{\cancel{\text{mi}}}{\text{h}} \frac{\cancel{5280 \text{ ft}}}{\cancel{1 \text{ mi}}} \frac{\cancel{0.3048 \text{ m}}}{\cancel{1 \text{ ft}}} \frac{\cancel{0.001 \text{ km}}}{\cancel{1 \text{ m}}} = 88.51392 \frac{\text{km}}{\text{h}} = 88.5 \frac{\text{km}}{\text{h}}$$

$$55.0 \frac{\text{mi}}{\text{h}} = 55.0 \frac{\text{mi}}{\text{h}} \frac{5280 \text{ ft}}{1 \text{ mi}} \frac{0.3048 \text{ m}}{1 \text{ ft}} \frac{1 \text{ h}}{60 \text{ min}} \frac{1 \text{ min}}{60 \text{ s}} = 24.5872 \frac{\text{m}}{\text{s}} = 24.6 \frac{\text{m}}{\text{s}}$$