ECOR1101: Mechanics I

Section C

Ch 1 : General Principles

Winter 2012

Carleton UNIVERSITY
Canada's Capital University

These slides include content copyrighted by Prentice Hall Inc. as part of the Engineering Mechanics text by R. C. Hibbeler, and its associated resources.

Mechanics

- Mechanics: Study of the state of
  - Rest (statics) or
  - Motion (dynamics)

  of bodies (subjected to forces)
- Bodies: Rigid or Deformable
- Force: Action between bodies
  - in direct contact
  - Remote actions

Engineering Mechanics

- This Course deals with "Newtonian" Mechanics.
  - Deals with typical Engineering problems encountered in practice
- No interest in
  - Very large speeds (e.g. close to the speed of light)
  - very small masses (sub atomic particles)
  - Motion of celestial objects

Statics & Dynamics

- Statics
  - Deals with bodies that are in equilibrium
    - At Rest
    - Moving with constant velocity
- Dynamics
  - Deals with the motion of bodies
  - Kinetics: Deals with causes of motion
  - Kinematics: Deals with motion without any regard to its causes (Relationship between position, velocity & acceleration are determined by Kinematics)

Basic Quantities

- Length: Position, size, (m, ft)
- Time: motion, speed, (s)
- Mass: Amount of matter, weight, (kg, slug) *[OR]*
- Force: push/pull between bodies, (N, lb) *[But, not both]*
- Temperature, Electric current (No interest in this course)
- Statics is time independent. Time, "t" matters only in Dynamics

Derived Quantities

- Derived from the basic Quantities
  - Pressure (Force per Unit Area)
  - Velocity (Time Rate of change of Displacement)
  - Acceleration (Time Rate of change of Velocity)

Models

- Particle: Size = 0, mass > 0.
  - A relative concept. Earth may be considered a point compared to the Universe
- Rigid body: The "shape" of the body does not change under applied forces (No Deformation)
- Concentrated Force: The Force is applied on a point (In reality, the area on which the force is applied is very small)

7

Newton's Laws of Motion

- First Law:
  - A particle originally at rest or moving with constant speed along a straight line will remain in the same state unless subjected to an unbalanced force.
- Forms the basis of "Statics"

8

Newton's Laws of Motion

- Second Law:
  - The acceleration due to an unbalanced force on a particle is proportional to the force, and inversely proportional to the mass.
  - $F \propto m.a$
- Forms the basis of "Kinetics" (Dynamics)

9

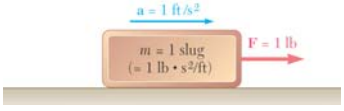
International System of Units (SI Units)

- Mass (kg), Length (m), Time (s) are the basic quantities
- Force is a derived quantity
- The unit of Force is defined from Newton's second law as
  - 1 Newton = 1 kg * 1 m/s^2

10

US Customary (or English) Units

- Force (lb), Length (ft), Time (s) are the basic quantities
- Mass is a derived quantity
- The unit of mass is defined from Newton's second law as
  - 1 lb = 1 slug * 1 ft/s2



11

Newton's Laws of Motion

- Third Law:
  - Every action has an equal and opposite reaction
- Important in determining force systems

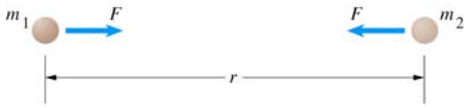
12

Newton's Laws (contd…)

- Second Law
  - F = m.a
  - F = 0 => First law is a special case of the Second Law
- Motion of Earth around the Sun ?
  - not along a straight line
    - Need unbalanced force(s) to control the motion
  - Where does the Force come from ?

13

Newtonian Gravitation



The gravitational forces between two particles are equal in magnitude and directed along the line between them.

$$F = G\frac{m_1 m_2}{r^2}$$ G = 66.73 x 10^{-12} $m^3/(kg\ s^2)$

14

Weight of an Object

- Weight is the force due to the gravitational attraction between the earth and the particle of a given mass

$$F = G\frac{M_{Earth}.m}{r^2}$$

$$F = \left[G\frac{M_{earth}}{r^2}\right]m = g\ m$$

$$w = mg$$

15

Acceleration due to Gravity

Mass of Earth, M_{Earth} = 5.974 x 10^{24} kg

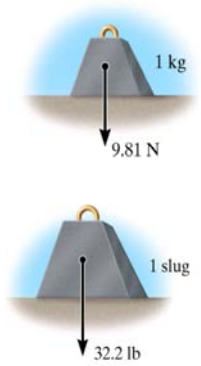
(Average) Radius = 6376 km

G = 66.73 x 10^{-12} $m^3/(kg\ s^2)$

$$g = \left[G\frac{M_{earth}}{r^2}\right]$$

$$= 9.807$$

$$= 9.81 \quad m/s^2$$



Numerical calculations

- Accuracy
- Precision: Significant digits
  - We'll use three significant figures to report final answer
  - But, use four significant digits in intermediate calculations
  - Covered in detail in your First Chemistry tutorial class
- Round-off
- Check homogeneity of dimensions

17