13.1-2 Newton's Laws

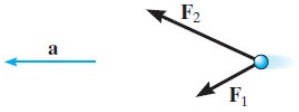
First Law: if $\sum \vec{F}_i = 0$ then $\vec{a} = 0$

Second Law: $\sum \vec{F}_i = m\vec{a}$

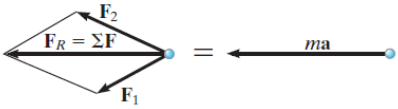
Third Law: for two particles (i and j) $\vec{F}_{ij} = -\vec{F}_{ji}$

13.1-2 Newton's Laws

free body diagram



kinetic diagram

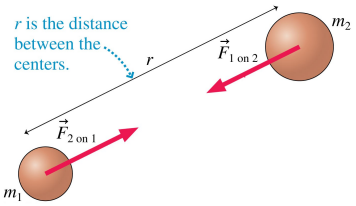


13.1-2 Force of Gravity

Newton's Universal Gravity Law:

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

$$G = 6.67 \times 10^{-11}\ \frac{\text{m}^3}{\text{kg} \cdot \text{s}^2}$$



13.1-2 Force of Gravity

Newton's Universal Gravity Law:

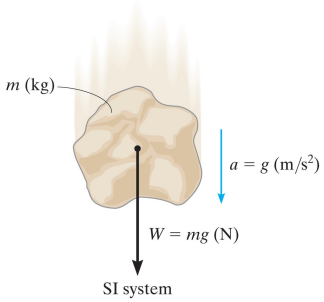
$$F = G\frac{m_1 m_2}{r^2}$$

This is often written as

$$F = W = m\left(\frac{GM}{r^2}\right) = mg$$

$$\boxed{W = mg} \qquad g = 9.81\ \frac{\text{m}}{\text{s}^2} = 9.81\ \frac{\text{N}}{\text{kg}}$$

on Earth's surface

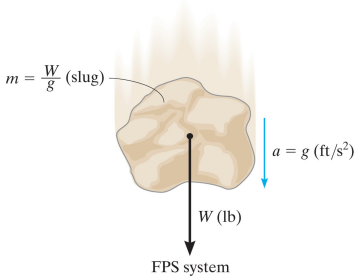


13.1-2 Force of Gravity

In the Foot-Pound-Second (FPS) unit system, we usually define mass with

$$m = \frac{W}{g}$$

$$W = mg \qquad g = 32.2\ \frac{\text{ft}}{\text{s}^2}$$



13.3 Systems of Particles

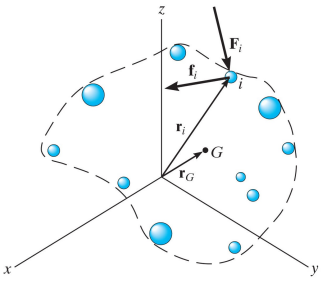
For a particle: $\sum \vec{F}_i = m\vec{a}$

For a system of particles:

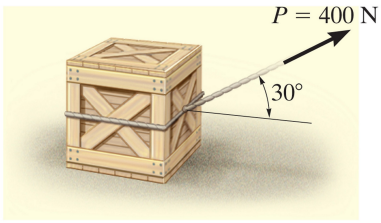
forces *external* to system

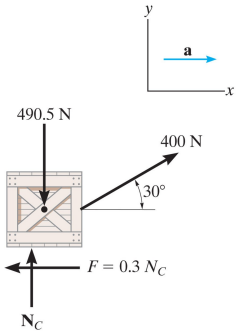
$$\sum \vec{F}_i = m\vec{a}_G$$

acceleration of the system's center of mass



13.1-4 Free Body Diagrams



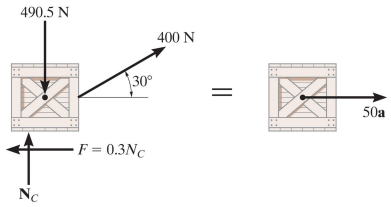


13.1-4 Free Body Diagrams

- Select the **coordinate system** (rectangular, *n*-*t*, cylindrical, etc) and sketch it.
- Identify the body you wish to analyze.
  - **Outline the body**. Imagine it is to be cut free from its environment.
- **Show all external forces** acting on the isolated body.
  - (a) all forces that cross the boundary of the cut (contact points)
  - (b) gravity.
- **Identify and label each external force**.
  Use letters to represent unknown magnitudes and angles.
- The **direction and sign (+/–) of the particle's acceleration a should be established**. If unknown, assume its components are in the same direction as the positive coordinate axes. Sketch the acceleration on the coordinate system.

13.4 Equations of Motion

Use the FBD with $\sum \vec{F}_i = m\vec{a}$ to obtain the equations of motion.



Knowing the acceleration and initial conditions (position and velocity), the particle's future motion can be completely determined.