Forces and Newton’s Laws

Force

- Any push or pull on an object caused by physical contact or force field
- The cause of an acceleration or change in an object’s motion
- A vector quantity
- SI unit: Newton (N)
- 1 N accelerates 1kg at 1 m/s²
- 1 N = .225 lb
Types of Forces

• Contact Forces
  
  • At a Distance (Field) Forces

Weight

• Force of gravity on a mass
• Always directed downward
• \( F_g = mg \)
• Units
  – Newtons (N)
  – pounds(lbs)
• Conversions
  – 2.2 lbs in 1kg (on earth)
  – 4.45 N in 1 lb
Newton’s First Law

• Law states:
  – An object at rest will stay at rest, an object in motion will stay in motion, unless acted on by an outside force.

• Known as the Law of Inertia
  – Inertia is the ability of an object to maintains its current state of motion
  – Inertia is caused by the mass of an object. The more mass, the more inertia.

Net Force

• Definition
  – the “sum” of all forces acting on an object.

• Result
  – an acceleration in the direction of the force.
  – If zero, the object is at rest or moving with a constant velocity.
Net Force

- Accelerating up: $F_{net} = F_E - F_g$
- Constant speed: $F_{net} = F_E = F_g$
- Accelerating down: $F_{net} = F_E - F_g$

Atwood’s Machine

- Draw all of the forces acting the diagram below.
- What is the net force on each block?
Newton’s Second Law

- Law states:
  - any net force applied to an object will cause the object to accelerate in the direction of the force.
  - \( F_{net} = ma \)
- When an object has a constant speed or no speed at all, the net force on the object is zero.

Net Force Problem

- You pull a box along a table with a force of 20 N. Assuming the table has a frictional force of 8 N which opposes the direction of the box’s motion, and the box is 9 kg, what is the acceleration of the box? What is the box’s speed after 2 m?

\[
\begin{align*}
  F_{net} &= F_A - F_f \\
  F_{net} &= 20 N - 8 N = 12 N \\
  F_{net} &= 12 N \\
  m &= 9 kg \\
  F_{net} &= (9)(9) = 12 N \\
  A &= 1.33 \text{ m/s}^2
\end{align*}
\]
Newton’s Third Law

• Law States
  – For every action, there is an equal and opposite reaction.
    • When you push on a wall, do you exert a force? If you do, does the wall move? Why not?
    • Due to gravity, the Earth pulls on you. Using Newton’s 3rd Law, do you exert a force on the Earth? In which direction? What is the magnitude?