Chapter I
Patterns of Motion and Equilibrium
In a nutshell

• Inertia - objects don’t change motion (mass)
• mass vs. weight
• Net Force - forces add (with direction)
• Net Force and Equilibrium
• Friction
More shell

• Speed and Velocity (vector - scalar)
• Acceleration is a change in velocity (vector)
Greek Ideas

- Deductive Reasoning
- Start with the obvious
- What happens if I drop a bowling ball and a basketball?
Aristotle

- Obviously, the bowling ball will fall faster and hit the ground first

- Aristotle’s Laws of motion:
  - Natural motions
    - objects seek their place (fire, rock)
  - Violent motions
  - Heavenly motions were different
Example

- What happens when you stop pushing a cart?
- It stops

Aristotle: No force means no motion
According to Aristotle, why would a ball stop after you kick it?

1. There is a force slowing it down
2. That is what balls do
3. There is no force to keep it going
Enter Galileo

• Perhaps the first to challenge Aristotle’s assumption

• Does a heavier ball fall faster?

• What about a rock and a feather?

• What about a pebble and a pillow?
Galileo’s Experiments

• Changed: angle, mass, length
• Idealized - what happens as the track gets lower?
• track slows things down
Galileo’s Results

- Things speed up as the fall (roll)
  - distance goes as time squared
- Does not depend on mass
- No force means it keeps going
Why was Aristotle wrong?

- Ideas made sense (2000 years)
- No experiments
- Difficult to imagine no air resistance and no friction
Motion

• Position (think $x = \ldots$)

• Speed

• Velocity

• Acceleration

\[
speed = \frac{\text{distance}}{\text{time}}
\]

\[
velocity = \frac{\text{change in position}}{\text{time}}
\]

\[
acceleration = \frac{\text{change in velocity}}{\text{time}}
\]
Vector - Scalar

- Scalar - just one thing. Temperature, mass, volume
- Vector - also direction
  - velocity, acceleration, force
Change in position (has direction)

Position 1

Position 2

Velocity
Acceleration (change in velocity)

- Also has direction
- Velocity can change in magnitude
- or direction
- Acceleration is NOT velocity
\[ \Delta t = 1 \text{second} \quad \text{acceleration} = \frac{\Delta v}{\Delta t} \]

\[ a = \frac{0 \text{ m/s} - 10 \text{ m/s}}{1 \text{ sec}} = -10 \frac{\text{m}}{\text{sec}^2} \]

\[ a = \frac{-10 \text{ m/s} - 0 \text{ m/s}}{1 \text{ sec}} = -10 \frac{\text{m}}{\text{sec}^2} \]

\[ a = \frac{10 \text{ m/s} - 20 \text{ m/s}}{1 \text{ sec}} = -10 \frac{\text{m}}{\text{sec}^2} \]

\[ a = \frac{-20 \text{ m/s} - (-10) \text{ m/s}}{1 \text{ sec}} = -10 \frac{\text{m}}{\text{sec}^2} \]
Enter the Newton

- Force is an interaction BETWEEN two objects
- Forces change momentum
- Change is the key word
- Net Force

\[ \vec{F} = \frac{\Delta \vec{p}}{\Delta t} \]
Inertia
Weight, mass, inertia

- Mass = how much stuff (kg or slugs)
- Weight = gravitational force (Newtons or lbs)
- Inertia = resistance to change in motion (mass)
The net force on any object in equilibrium is

1. zero
2. 10 meters per second squared
3. equal to its weight
4. none of these
The tension in a rope that supports a 2-lb bag of sugar hanging at rest is

1. 9 N
2. 2 lbs.
3. Either 1 or 2
4. Neither 1 nor 2
The concept of inertia mostly involves

1. mass
2. weight
3. volume
4. density
The mass of 1 kg of iron on Earth

1. is less on the Moon
2. is the same on the Moon
3. is greater on the Moon
4. weighs the same everywhere
When we say that 1 kg weighs 9.8 N, we mean that

1. 1 kg is 1 N
2. it’s true at the Earth’s surface
3. it’s true everywhere
4. mass and weight are one and the same
The difference between speed and velocity involves

1. acceleration
2. amount
3. direction
4. all of these
When a ball increases in speed by the same amount each second, its acceleration

1. also increases each second
2. decreases each second
3. is constant
4. none of these
If a falling object gains 10 m/s each second it falls, its acceleration is

1. 10 m/s
2. 10 m/s per second
3. both of these
4. neither of these