Newton's Laws

Learning Objectives

★ Describing motion

★ Newton's 3 laws of motion

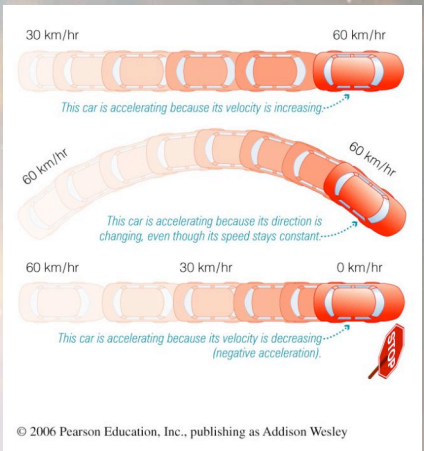
★ Conservation laws

Motion

★Physical Concepts

- Speed
- Velocity
  - Involves speed & direction
- Acceleration
  - a = Δv/Δt

    (Δ means "change in")



Motion

★Physical Concepts

- Acceleration of gravity
  - Galileo dropping balls of differing masses
- Prevailing view (Aristotle)
  - Heavier falls faster
- Correct view?

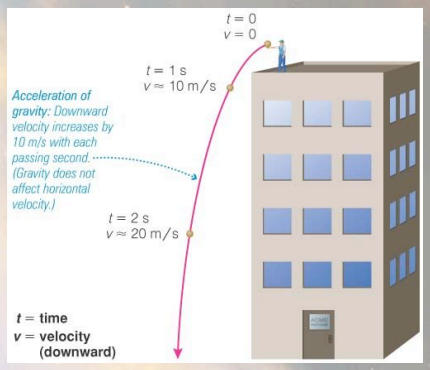
to illustrate

Motion

★Physical Concepts

- Acceleration of gravity
  - g = 9.8 m/s per sec
- momentum: p = m x v
- force F = Δp/Δt = ma
  - a = F/m or F = ma
- Mass differs from weight
  - Text illustration of elevator
  - Free fall
  - Astronauts not "weightless" but in free fall

(differ from text here)



Scientist as a Person

★ Isaac Newton (1643-1727)

- Brilliant, independent thinker
- Studied motion, gravity
- Developed calculus
- Major advances in study of light
- Built first reflecting telescope
- Personally:
  - Developed his ideas in his 20s
  - Extremely focused, tireless worker
  - Personality; did not want to publish
  - Christian (influenced his studies)

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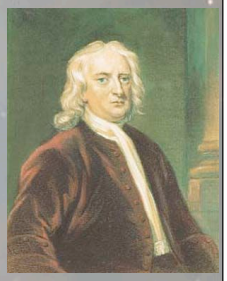
Motion



★ Isaac Newton (1643-1727)

- Apple & moon - gravity operated in heaven as well as Earth!

★ Laws of motion ("Principia" 1687)

(universal laws)

1) An object moves at constant velocity if there is no net force acting on it. $\Delta p = 0$

(illustrations)

1) $F = m\,a$

2) For any force, there is always an equal and opposite reaction force: $F_{2 \text{ on } 1} = -F_{1 \text{ on } 2}$

Conservation Laws

Newton's laws a manifestation of underlying laws

★ Conservation of Momentum

- For a single object, in the absence of forces, momentum is constant.
- When 2 objects interact, momentum can be transferred from one object to the other, but total momentum before = total momentum after

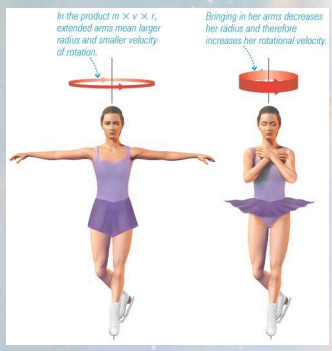
★ Conservation of Angular Momentum

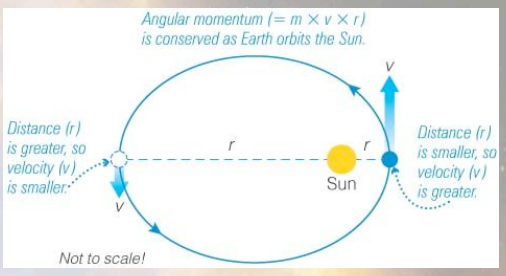
★ Conservation of Energy: Energy can be transferred from one object to another or transformed from one type to another, but the total amount of energy is always conserved.

Motion

★Conservation of Angular Momentum

- angular momentum = m x v x r
  - Illustration - skater (or chair)
  - Kepler's 2nd Law (or contracting gas cloud)





Many important applications in astronomy

Motion & Energy

★ Conservation of Energy: Energy can be transferred from one object to another or transformed from one type to another, but the total amount of energy is always conserved.

★ Kinetic Energy - Energy of motion

- Thermal Energy
  - Average kinetic energy → temperature (K) (Fig 4.9)
  - Thermal energy depends on temperature and density (illus - Fig 4.11)

★ Radiative Energy - Carried by light

★ Potential Energy - Stored energy

- Stored energy
  - Gravitational potential energy
  - Mass-energy: $E = mc^2$