

Aristotelian Physics

- Natural (vertical) Motion
 - Fire, above
 - Air, above
 - Water, above
 - Earth
- Violent (horizontal) Motion
 - Requires pushes or pulls
- Celestial Motion
 - Ether
 - Different Laws than on Earth

Scientific Method – Galileo

- Controlled Quantitative Experiments
- Idealisations
- Limit the scope of the inquiry
 - “Separate variables”

Kinematics – description of motion

- Speed – how fast
- Velocity – how fast and in what direction
- Acceleration – rate of change of the velocity

Dynamics – forces and motion

- Principle of Inertia: if no net force is acting on a body it is unaccelerated.
 - Different view than Aristotle’s
- Acceleration = net force / mass
 - Acceleration in the direction of the force
- Weight – the force due to gravity
 - Not the same as the mass

Universal Law of Gravitation

- Mass M exerts a force F on a mass m that is a distance r away:

$$F = G M m / r^2$$

Newtonian Worldview

- Universal natural laws
- Atomism
- Absolute space and time
- Objective observation
- Every physical system predictable

Work & Energy

Work \equiv force x distance

$\frac{1}{2}$ mass x speed² \equiv kinetic energy KinE

Net work = change KinE

Energy \equiv KinE + GravE + ThermE + ...

Energy can be transformed from one form to another

The total energy is conserved

Second Law of Thermodynamics

- Heat never spontaneously flows from the colder to the hotter
- No engine can be 100% efficient
- The disorder (entropy) never spontaneously decreases
 - Irreversible processes

Electricity and Magnetism

- Some objects have a property called “electric charge”
 - Two kinds of charge: (+)ve and (-)ve
 - Charges exert **electric forces** on other charges
 - Likes repel; Unlikes attract
- Moving charges exert **magnetic forces** on other moving charges
 - Magnets
 - Electric currents

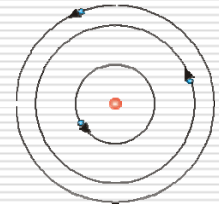
Planetary Model of Atom

Central Nucleus

- Most of the mass
- Positive charge

Electrons in Orbit

- Very small mass
- Negative charge



The electric force on the electrons by the nucleus keeps the electrons in orbit.

Oscillating Charges

- Radiate energy away in an wave of electric and magnetic fields
 - “light” “radio waves” “gamma rays” etc. etc.
- Frequency of the wave = frequency of the oscillating charge
 - The Planetary Model of the atom is wrong
 - ThermE – internal energy of vibration

Galilean Relativity

- Law of Physics the same for all observers, i.e. all “reference frames”
 - “Inertial Reference Frames”
- Only true for non-accelerating observers
 - Stationary or in uniform motion in a straight line wrt Absolute Space.

The Medium for Electromagnetic Waves

- "Ether"
 - Massless, homogenous everywhere
 - Stationary with respect to ("wrt") Absolute Space
 - $c = 1,079,253,000$ km/hr wrt ether
- Michelson-Morley Experiment
 - Measure the speed of the "ether wind" wrt Earth
 - Expect: $\sim 100,000$ km/hr
 - Result: consistent with zero

Einstein "explains" Michelson-Morley

- "... light is always propagated in empty space with a definite velocity c which is independent of the state of [relative] motion of the emitting body." (1905)
 - Ether "superfluous"
 - Probably unaware of the experiment
- Definition of "Inertial Reference Frame" is now circular

Time Dilation

- Follows from the constancy of the speed of light for all observers
- Moving clocks run slow
- Experimentally confirmed
- Mort and Velma same age
 - Velma goes to a distant star at high speed and returns to Earth
 - When re-united Velma is younger than Mort
 - This not tested with people