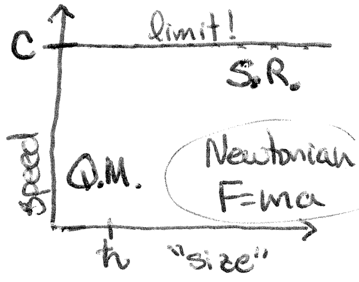
Introduction



PHY 231 ① Classical Mechanics $g=\frac{GM_\oplus}{R_\oplus^2}$, m_e, m_p, m_n

PHY 232 ② Electrodynamics e, ε_0, μ_0

- Optics c
- Special Relativity

"MODERN PHYSICS"

PHY 228 { Optics, Special Relativity, ③ Thermodynamics

③ Thermodynamics $R = kN_A$

PHY 361 ④ Quantum Mechanics $\hbar$

- Atomic & Molecular
- Nuclear & Particle
- Astro. & Cosmology

"MODERN PHYSICS"

Einstein 1905

- * Special Relativity.
- * Brownian Motion
- * Photoeletric Effect.

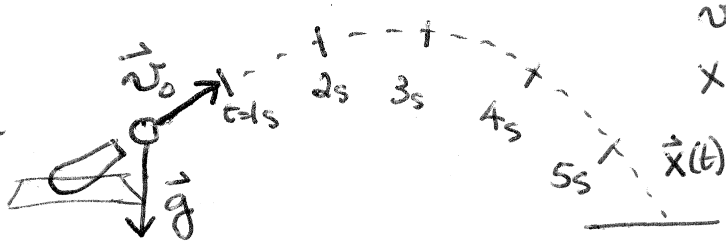
Planck ~1900

- * Black Body Radiation

Classical (Newtonian) Physics

NII: $\vec{F}_{net} = m\vec{a}$

example: $m\vec{g} = m\vec{a}$



$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$\vec{x}(t) = [v_{0x}t, v_{0y}t - \frac{1}{2}at^2$

NIII: $\vec{F}_1 = -\vec{F}_2$

impulse: $\int \vec{F} dt = \int m\, d\vec{v} = \Delta\vec{p}$ $\boxed{\vec{p} = m\vec{v}}$ (kinetic) momentum conserved by NIII

work: $\int \vec{F} \cdot d\vec{x} = \int m\, d\vec{v} \cdot \vec{v} = \Delta T$ $T = \frac{1}{2}mv^2$ kinetic energy.

conservative force: "stores kinetic energy" $\Delta U = -\int \vec{F} \cdot d\vec{x}$ potential energy $\boxed{E = T + U}$ total energy conserved by definition of conservative fo

Fundamental Forces & Potentials

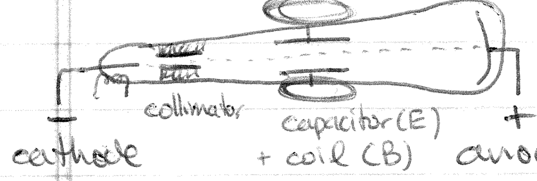
gravity: $\vec{F} = -\hat{r}\frac{GMm}{r^2} = m\vec{g}$ $U = mgh$ or $-\frac{GMm}{r}$

E&M: $\vec{F} = +\hat{r}\frac{k_e q' q}{r^2} + \dots = q(\vec{E} + \vec{v} \times \vec{B})$ $U = qEd = qV$ or $\frac{k_e q' q}{r}$

Nuclear: strong & weak forces & potentials.

- Newton's gravitational constant $\boxed{G = 6.67\times10^{-11}\ N\,m^2/kg^2}$
- speed of light in vacuum $\boxed{c \equiv 299792458\ m/s}$
  (Rømer, 1676)
- Avogadro's constant $\boxed{N_A = 6.02214179(30)\times10^{23}/mol}$
  (Loschmidt 1865, Perrin)
  - link between microscopic & macroscopic physics.
  - 1 mol of p or n has a mass of ≈ 1 g (atomic mass of $^{12}C \equiv 12\ g/mol$)
- mass of H atom $\boxed{M_H = 1.67\times10^{-27} kg}$ from N_A
  $= m_p + m_e$ - binding energy.
- magnitude of charge of an electron $\boxed{e = 1.602176487(40)\times10^{-19} C}$
  - from $F = N_A e$ coulometry (electrolysis). - oil drop experiment
    $= 96500C$.
- ratio of charge to mass $\boxed{e/m_e = 1.76\times10^{11}\ C/kg}$ electron
  - from bending beams in magnetic fields (CRT) $\boxed{e/M_p = 9.6\times10^{7}\ C/kg}$ proton
- mass of an electron $\boxed{m_e = 9.11\times10^{-31}\ kg}$ 2000 x smaller than proton.
  - from e, e/m_e
- Boltzman's constant $\boxed{k_B = 1.3806504(24)\times10^{-23}\ J/K}$
  note 1°C = 1°K 0K ↔ -273.15 room temp ≈ 300K.
- Planck's constant $\boxed{h = 6.626069\times10^{-34}\ J.s}$
  Josephson, van Klitzing constants. (superconductor, quantum Hall effect).

Thompson's Cathode Ray Tube



$$F_m = qvB = mv^2/R$$

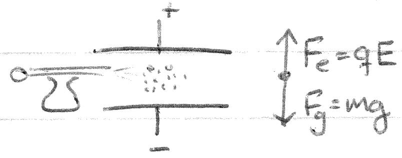
$$\boxed{\frac{q}{m} = \frac{v}{RB}}$$

$F_m = F_e$ (Wien Filter)

$$qvB = qE$$

$$\boxed{v = E/B}$$

Milliken & Fletcher Oil Drop Exp



$$m = V\rho = \tfrac{4}{3}\pi r^3 \cdot \rho$$

terminal velocity:

$$v = \frac{F}{6\pi r\eta} = \frac{2r^2\rho g}{9\eta}$$

viscocity $= \eta$.