Main theme of Phys 1140: Light

(visible, IR, UV, radio, microwaves, X-rays, γ-rays)

= *electromagnetic waves*

Begin course with electricity + magnetism

Optics: ① rays (geometrical) → mirrors, lenses

→ interference, diffraction

② waves

③ quanta (photons) → photoelectric effect, thermal emission, atomic transitions

→ wave-particle duality

↳ also applies to matter (de Broglie waves)

atomic and nuclear structure

Interaction of light and matter → emission absorption, scattering

Electric charge q

Key takeaways:

1) scalar quantity (positive or negative)

2) quantized (comes in integer multiples of fundamental charge e)

3) conserved (total charge does not change over time)

Nearly all elementary particles carry electric charge.

proton $q_p = e$

electron $q_e = -e$

neutron $q_n = 0$

$1e = 1.602 \times 10^{-19}$ C (coulombs)

[Every known object is composed of these 3 objects, so its charge is a multiple of e. Explains quantization.]

[Not so simple.
First of all, n is not
really neutral]

Neutrons and protons consist of
3 charged up and down quarks. [see chart]

$n =$ (u, d, d)

$q_u = \frac{2}{3}e$

$q_d = -\frac{1}{3}e$

$p =$ (u, u, d)

[fundamental charge not e, but $\frac{1}{3}e$]

Fractional charges have never
been experimentally isolated. $\Rightarrow$ "quark confinement"

Some elementary particles are truly neutral

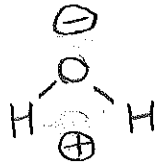
neutrino ν
Higgs boson h
photon γ
⋮

Electric charge usually neutralized

(1) in atoms (Z protons, Z electrons, N neutrons)

(except ions)

(2) in molecules

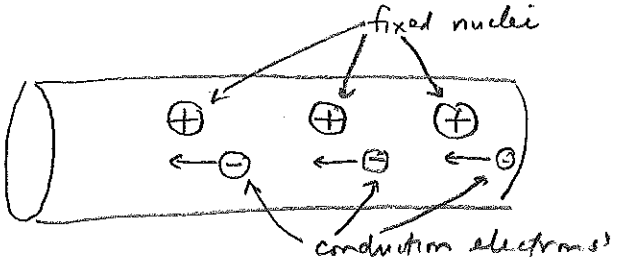


charge separation in polar molecules ("dipole")

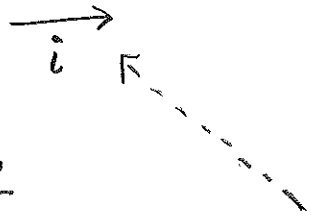
(3) in bulk matter

[when not neutralized, you know it! static electricity]

Electric current i = flow of charge

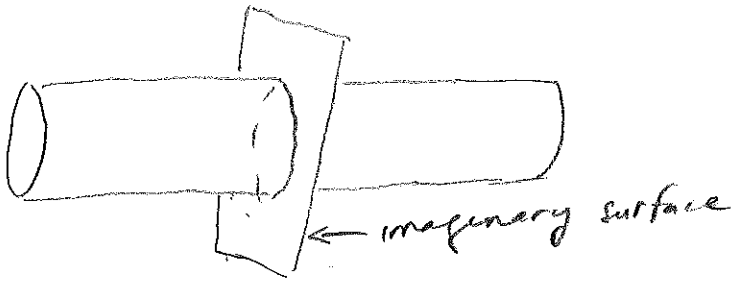


[charge flows, but neutrality is maintained]



Key take-aways

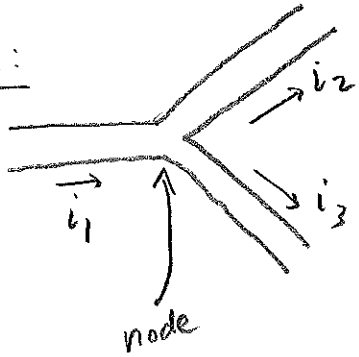
1) direction of current = direction that positive charge would flow
2) amount of current = charge per unit time through a surface
3) Kirchoff's current law (KCL), or node rule



$i = \frac{\Delta q}{\Delta t}$ in units of $\frac{\text{Coulombs}}{\text{sec}} \equiv$ amperes (amps)

[place an ammeter in the circuit]

KCL:



$i_1 = i_2 + i_3$ (node rule)

Follows from conservation of electric charge