Ch 1.
Review of classical physics

Mechanics

Kinetic energy of a particle of mass m moving with velocity v is given by

$K = (\frac{1}{2})mv^2$

$\mathbf{P} = m\,\mathbf{v}$ is the momentum

Then $K = P^2/2m$

$\mathbf{F} = d\mathbf{P}/dt$

Conservation laws are:

1. Energy = E = constant

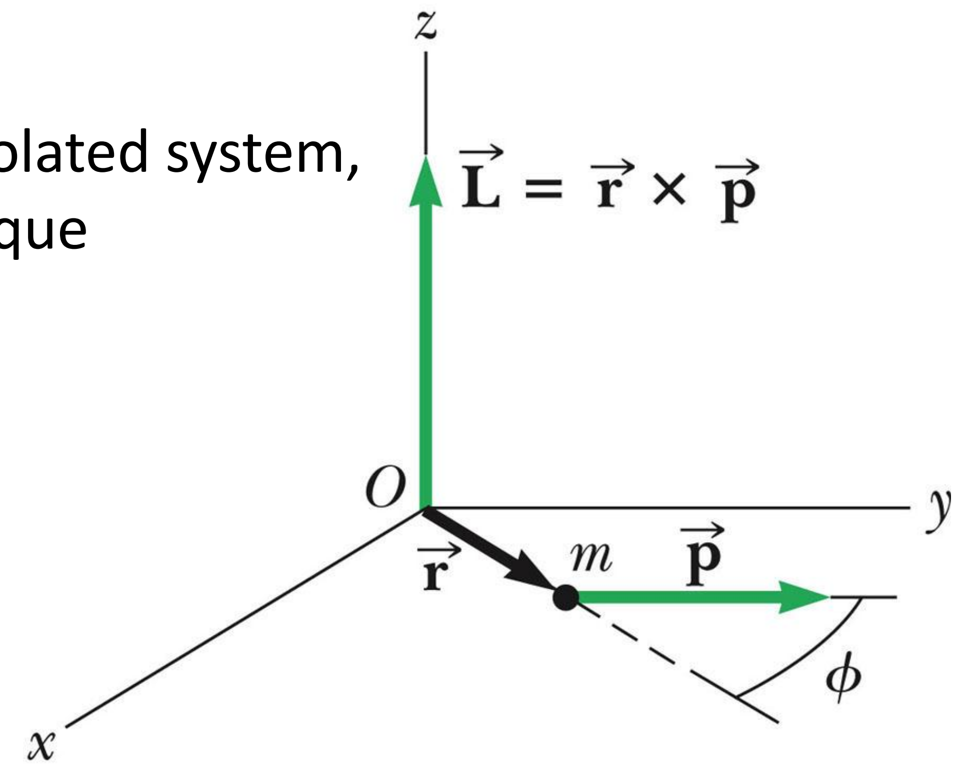
2. **P** is constant

3. **L** is constant

The angular momentum **L** about O is Shown in the figure for a mass m with a momentum **P**

L is conserved for an isolated system, means NO external torque

τ = d**L**/dt



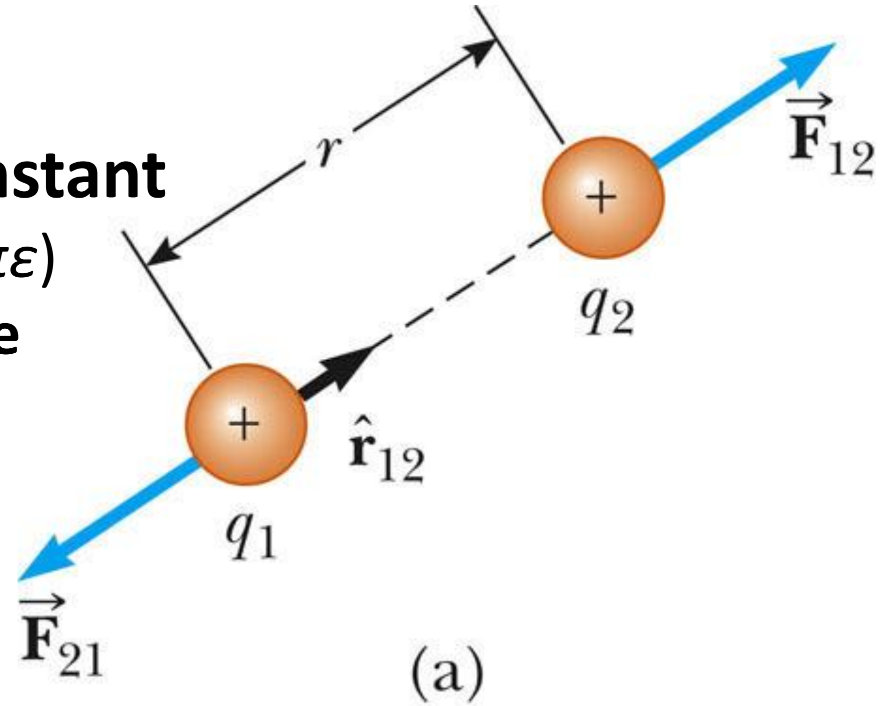
Potential energy U

- Is there a U for all forces?
- Only for conservative forces there are a U, which are given by
- **F = -** grad U = **-** i dU/dx – j dU/dy –k dU/dz

- The units of energy are
- Joule = kg m^2/s^2
- Ergs = gm cm^2/s^2

Electricity and Magnetism

$$\vec{\mathbf{F}}_{12} = k_e \frac{q_1 q_2}{r^2} \hat{\mathbf{r}}_{12}$$



k_e is called the **Coulomb constant**

k_e = 8.9876 x 10^9 N·m²/C² = 1/(4$\pi\varepsilon$)

ε is the **permittivity of free space**

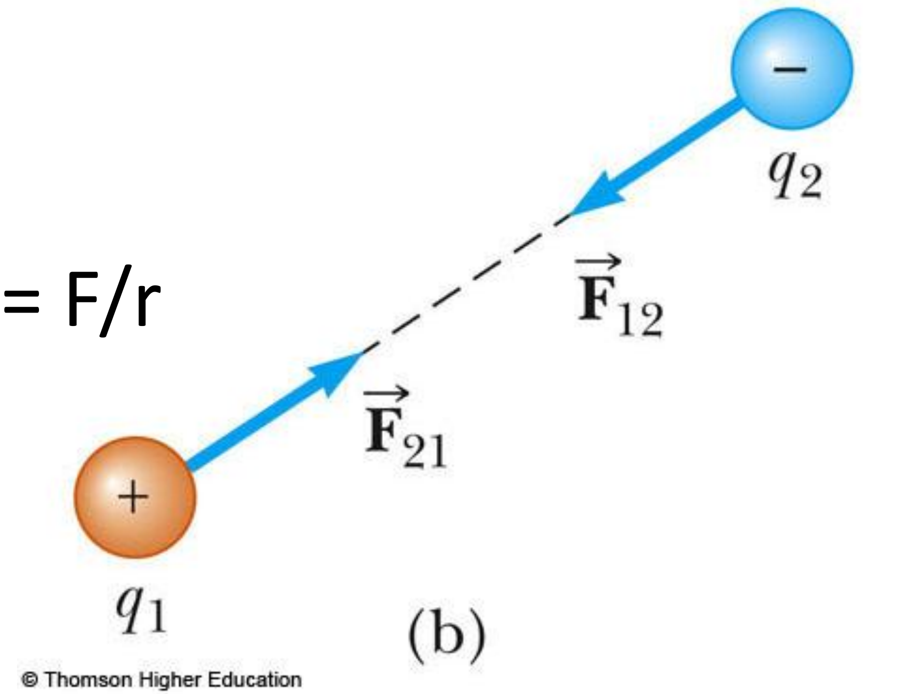
ε = 8.8542 x 10^{-12} C² / N·m²

In cgs system the Coulomb
The constant k is defined
to be = 1 = one

The Electric field E

$$\vec{\mathbf{E}} \equiv \frac{\vec{\mathbf{F}}}{q_o}$$

The potential energy U = F/r



Magnetic field **B**

$$\vec{\mathbf{F}}_B = q\vec{\mathbf{v}} \times \vec{\mathbf{B}}$$

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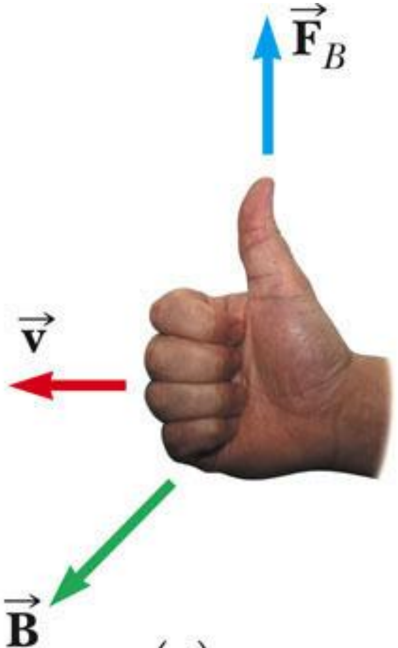
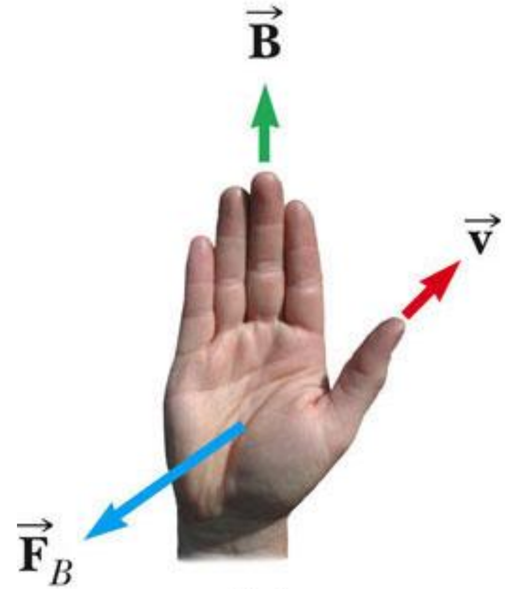


(a)

Another method to find the direction of the magnetic force Or the magnetic field.

In MKS system the units of B is
Tesla = Newton/(Coulomb.m/s)
= N/ Ampere.meter
where is m/s = (meter/sec)
and Ampere is = Coulomb/s
Another unit of B is gauss



(b)

Magnetic Moment

The product $I\vec{\mathbf{A}}$ is defined as the **magnetic dipole moment**, $\vec{\mu}$, of the loop, where I is the current and A is the area of the loop, so the units of $\vec{\mu}$ is Ampere. m^2

Torque in terms of magnetic moment:

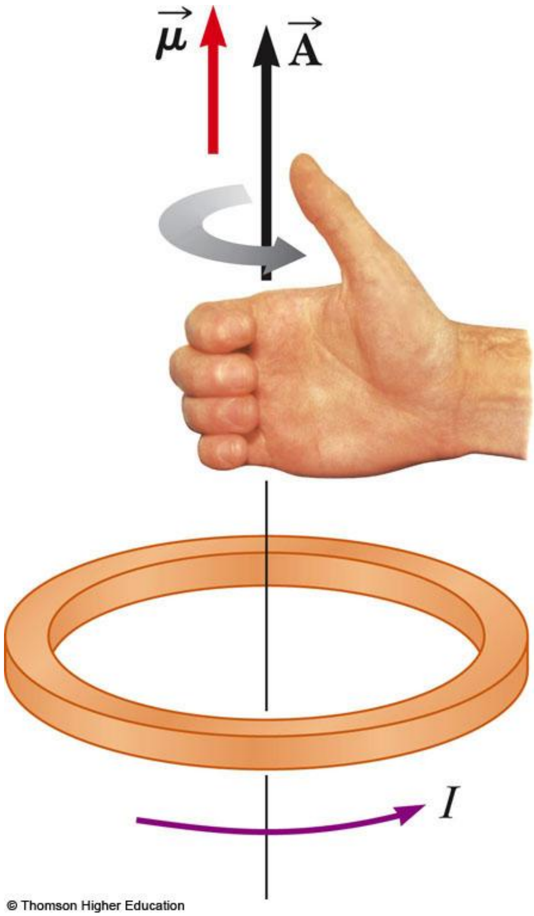
$$\vec{\tau} = \vec{\mu} \times \vec{\mathbf{B}}$$

Analogous to

$$\vec{\tau} = \vec{\mathbf{p}} \times \vec{\mathbf{E}}$$

for electric dipole

To find the direction of the magnetic moment



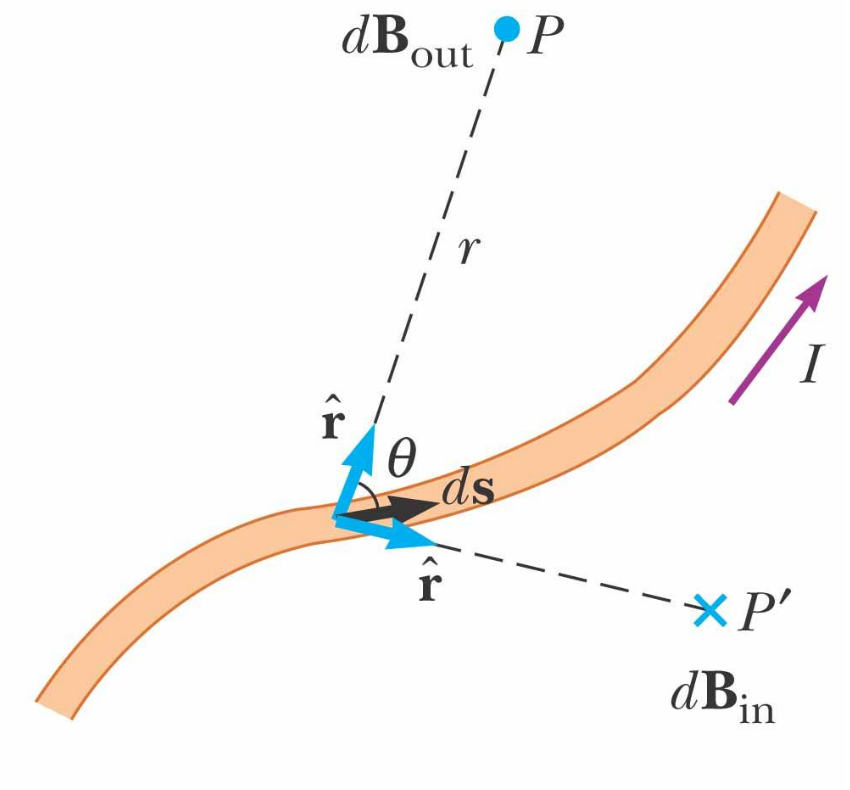
The potential energy is

$$U = -\vec{\mu} \cdot \vec{\mathbf{B}}$$

To find the magnetic field
Biot-Savart law can be used

$$d\vec{\mathbf{B}} = \frac{\mu_o}{4\pi}\frac{I\,d\vec{\mathbf{s}}\times\hat{\mathbf{r}}}{r^2}$$

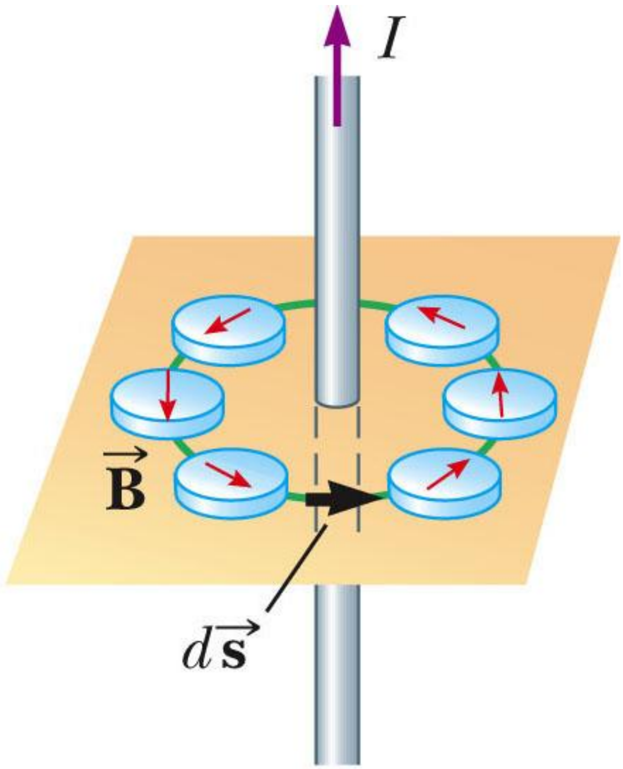
The constant μ_o is called the
permeability of free space
$\mu_o = 4\pi \times 10^{-7}$ T· m / A



Or Ampere's law can be
used if there is symmetry

$$\oint \vec{\mathbf{B}} \cdot d\vec{s} = \mu_o I$$

The integral around
closed loop as shown



(b)

Units and Dimensions

- Nearly all of the physical constants and variables will be using have both units and dimensions.
- The dimensions tell us something about the kind of constant or variable.

The fundamental dimensions

Length [L]

Mass [M]

Time [T]

Standardized systems of Units

1. SI – System International
   mks (meter- kg-sec)

Smaller than mks is the cgs (centi- gm –sec)

2. British System

Length in foot

Mass in Slug

Time in sec

In modern Physics Joule and meter are very large to be used, because the energies associated with atomic or nuclear processes may be 10^{-19} to 10^{-12} Joule, and typical sizes of atomic and nuclear systems range from 10^{-10} and 10^{-15} meter.

So a convenient units will be used as we will see for

Length :

micrometer = µm = 10^{-6} m

nanometer = nm = 10^{-9} m

femtometer = fm = 10^{-15} m = fermi

Atomic sizes are typically 0.1nm, and nuclear sizes are about 1 to 10 fm.

Energy

The electron – volt(eV) : is the energy gained or lost by a particle of charge equal in magnitude to that of the electron in moving through a potential difference of one volt.

1 eV = 1.602×10^{-19} J

keV = kilo electron-volt = 10^{+3} eV

MeV = mega electron-volt = 10^{+6} eV

GeV = giga electron –volt = 10^{+9} eV

For atomic, the eV will be used and the MeV for the nuclear size.

Electric charge of an electron is $e = 1.602 \times 10^{-19}$ C

Mass

$E = mc^2$ and from this

$m = E/c^2$ where E is the rest energy

For an electron E = 0.511 MeV

Then the unit of the mass for an electron is:

0.511MeV/c^2

Another unit is the unified atomic mass unit

Or just the atomic mass unit = u

So 1u = 1.66×10^{-27} kg

= 931.50 MeV/c^2

So the mass of an electron is m = 5.4858×10^{-4} u

The mass of proton is m = 1.007276 u

The mass of neutron is m = 1.008665 u

The rest energy(E) of any particle can be found by

Multiplying the mass of the particle in unit of atomic mass by the value of 1u = (931.5 MeV/c^2)

So the rest energy for a proton

(1.oo7276 u) x (931.5 MeV/c^2)/u = 938.3 MeV/c^2

For and an electron:

(5.4858×10^{-4} u) x (931.5 MeV/c^2)/u = 0.511 MeV/c^2

And for a neutron is = 946.6 MeV/c^2

Plank's Constant = h = 6.626×10^{-34} J.s

To convert the units of h into eV.s units

$h = (6.626 \times 10^{-34}\ J.s)/(1.6 \times 10^{-19}\ J/1eV)$

$= 4.136 \times 10^{-15}$ eV.s

What are the dimensions of h?

1. Energy x time

But $J = N.m = (kg.m/s^2)m = kg.m^2/s^2$

Then $J.s = kg.m^2/s = (kg.m/s)m$

= momentum x displacement

2. Momentum x displacement

3. Angular momentum = Momentum x displacement

Significant Figures (S.F)

- The number of S.F tells something about precision
- Examples:
- 0.0075 m has 2 significant figures

- 10.0 m has 3 significant figures

- 1500 m is ambiguous
  - Use 1.5×10^3 m for 2 significant figures

  - Use 1.50×10^3 m for 3 significant figures

  - Use 1.500×10^3 m for 4 significant figures

Operations with Significant Figures

Multiplying or Dividing

When multiplying or dividing, the number of S.F in the final answer is the same as the number of S.F in the quantity having the **lowest number** of S.F.

Example: 25.57 m x 2.45 m = 62.6 m^2

In case of Adding or Subtracting

When adding or subtracting, the number of decimal places in the result should equal the **smallest number of decimal** places in any term in the sum.

Example: 135 cm + 3.25 cm = 138 cm

Some Important values, which you need

$e^2/4\pi\varepsilon = (8.988 \times 10^9\ N.m^2/C^2\ )(1.602 \times 10^{-19}\ C\ )^2$

$= 2.307 \times 10^{-28}\ N.m^2 = 2.307 \times 10^{-28}\ J.m$

$= 2.307 \times 10^{-28}\ N.m^2\ )(1/1.602 \times 10^{-19}\ J/eV)(10^{9}\ nm/m)$

$= 1.440\ eV.nm$

Then the potential energy = U For two electrons with separation r = 1.00nm is

$U = (e^2/4\pi\varepsilon\ )(1/r) = (1.440\ eV.nm)(1/1.00nm) = 1.44\ eV$

Then the potential energy = U For nuclear sizes with r = 1fm

$U = (e^2/4\pi\varepsilon\ )(1/r) = (1.440\ eV.nm)(1/1.00fm) = 1.44\ eV$

$= 1.44\ MeV$ Because $1nm = 10^6\ fm$

$hc = (4.136 \times 10^{-15}\ eV.s)(3 \times 10^8\ m/s)(1nm/10^{-9}\ m)$

$= 1240\ eV.nm$ for atomic size

$= 1240\ MeV.fm$

Homework of chapter 1

- 3, 8, 13, 14
- due Thursday 27/1/2012