Phys 112 2019

Lecture 16

Mon Warm Up 7

Tues: Discussion / quiz

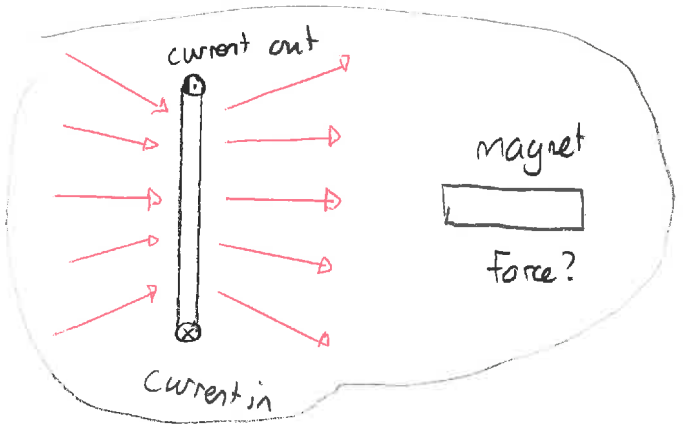
Supp 61, 62, 63, 64

Ch 24 Q 19, 24

Ch 24 Prob 23, 33

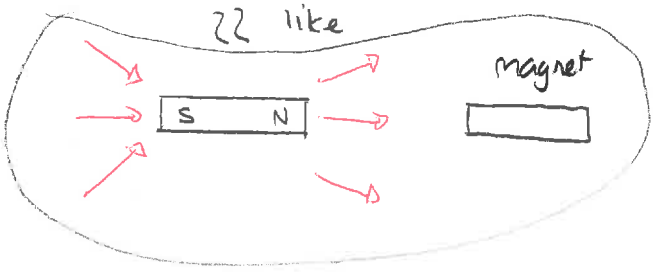
Fields / forces produced by loops

We know that a current loop produces a magnetic field that resembles that of a bar magnet. In terms of interactions with other magnets and currents, we can replace the loop with an effective magnet



Demo: PhET Faraday lab

- show coil field
- show bar magnet field



Quiz 1 60% - 90%

We see that the current exerts a force on the magnet. By Newton's third law the magnet must exert a force on the current. Thus the magnetic field (produced by the magnet) exerts a force on the moving charges in a current.

Magnetic forces on moving charges

In general we know that currents exert forces on magnets. Then Newton's third law implies that magnets exert forces on currents. This is an example of a more general phenomenon:

> A magnetic field can exert a force on a moving charge.

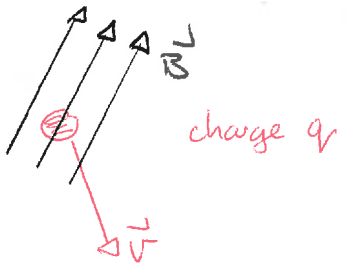
Demo: CRT tube and magnet

Observations show that

1) the charged particle must be moving relative to the magnetic field
2) the force is perpendicular to both the field and the particle velocity.
3) the magnitude of the force depends on:
   - magnitude of field B
   - velocity of particle v
   - charge of particle q.
   - relative orientation of field and velocity.

The rules for the force are:

> The magnitude of the force exerted by a magnetic field is
>
> $$F = |q| v B \sin\alpha$$
>
> where α is the angle between field $\vec{B}$ and velocity $\vec{v}$



Quiz 2 20% - 60%

The direction of the force is as follows

> The magnetic force is perpendicular to both $\vec{B}$ and $\vec{v}$
> The particular direction is determined by a right hand rule:
>
> thumb -> $\vec{v}$
> index -> $\vec{B}$
> middle -> $\vec{F}$

Quiz 3 60% - 90%

Demo: CRT particles - what charge do these have?

We can now see how units are related

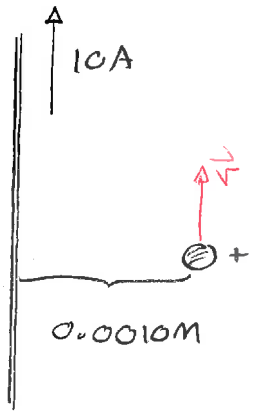
$$F = |q| v B$$

$$N = C\ m/s\ T \Rightarrow N = C/s\ mT \Rightarrow N = A\ mT$$

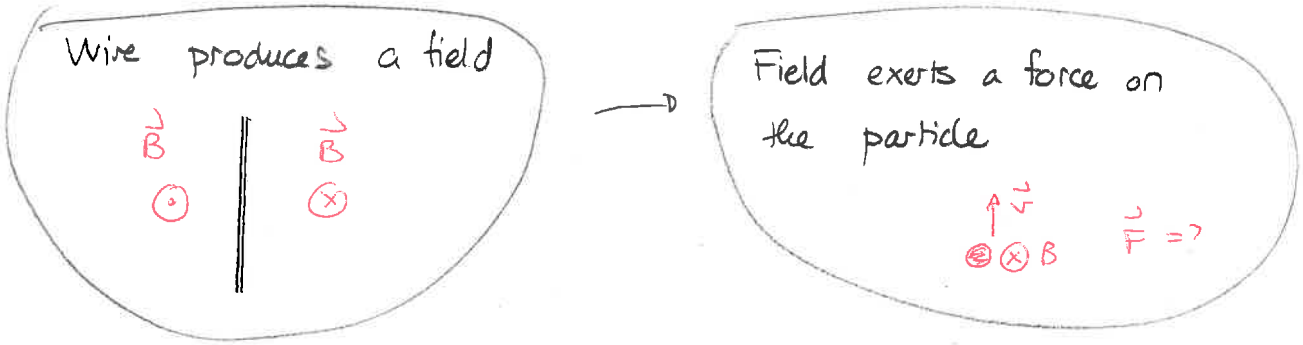
$$\Rightarrow T = \frac{N}{A \cdot m}$$

Quiz 4

Example: A 10 A current flows along a long straight wire, A particle with charge $+6.0\times10^{-9}$C moves as illustrated with speed 3.0×10^{6}m/s. Determine the force on the particle



Answer: Scheme



Step1: First determine field – the r.h. rule gives direction into page ⊗

– magnitude $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}\,Tm/A \times 10A}{2\pi \times 0.001m}$

$B = 2.0\times10^{-3}\,T$

Step2 Now force – r.h. rule $\vec{v}$, ⊗$\vec{B}$ ⇒ $\vec{F}$ towards wire

$F = |q|vB\sin\alpha = 6.0\times10^{-9}C \times 3.0\times10^{6}m/s \times 2.0\times10^{-3}T \sin 90°$

$= 36\times10^{-6}N$