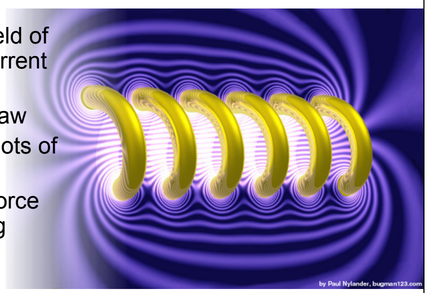
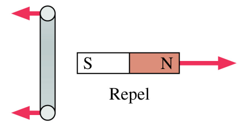
PHY132H1F Introduction to Physics II
Class 19 – **Outline:**

- Magnetic field of a long straight wire
- Magnetic field of a loop of current (dipole)
- Ampère's Law
- Solenoids (lots of loops)
- Magnetic Force on a Moving Charge.



Ch. 33 reading quiz..

What is the current direction in the loop?



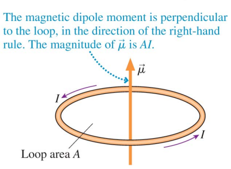
A. Out of the page at the top of the loop, into the page at the bottom.
B. Out of the page at the bottom of the loop, into the page at the top.

Magnetic Dipoles

The **magnetic dipole moment** of a current loop enclosing an area A is defined as

$\vec{\mu}$ = (AI, from the south pole to the north pole)

FIGURE 33.20 The magnetic dipole moment of a circular current loop.



The SI units of the magnetic dipole moment are A m². (Amp) The on-axis B-field of a magnetic dipole, at a distance z from the center, is:

$$\vec{B}_{\text{dipole}} = \frac{\mu_0}{4\pi}\frac{2\vec{\mu}}{z^3} \quad \text{(on the axis of a magnetic dipole)}$$

Evaluating line integrals

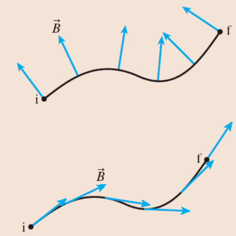
TACTICS BOX 33.3 **Evaluating line integrals**

1. If $\vec{B}$ is everywhere perpendicular to a line, the line integral of $\vec{B}$ is

$$\int_i^f \vec{B} \cdot d\vec{s} = 0$$

2. If $\vec{B}$ is everywhere tangent to a line of length l *and* has the same magnitude B at every point, then

$$\int_i^f \vec{B} \cdot d\vec{s} = Bl$$

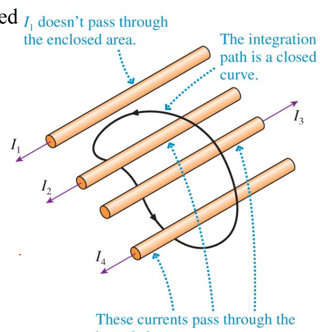


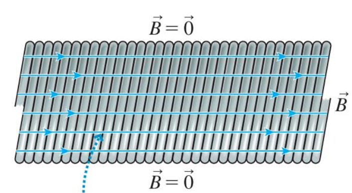
Exercises 23–24

Ampère's law

Whenever total current I_{through} passes through an area bounded by a *closed curve,* the line integral of the magnetic field around the curve is given by Ampère's law:

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{through}}$$





The magnetic field is uniform inside this section of an ideal, infinitely long solenoid.
The magnetic field outside the solenoid is zero.

The strength of the uniform magnetic field inside a solenoid is

$$B_{\text{solenoid}} = \frac{\mu_0 NI}{l} = \mu_0 nI$$

where $n = N/l$ is the number of turns per unit length.

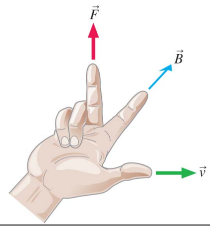
The Magnetic Force on a Moving Charge

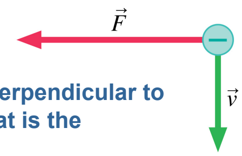
The magnetic force on a charge q as it moves through a magnetic field $\boldsymbol{B}$ with velocity $\boldsymbol{v}$ is

$$\vec{F}_{\text{on } q} = q\vec{v} \times \vec{B} = (qvB\sin\alpha, \text{ direction of right-hand rule})$$

where α is the angle between $\boldsymbol{v}$ and $\boldsymbol{B}$.

Right Hand Rule for Forces:

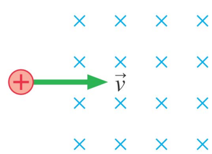




An electron moves perpendicular to a magnetic field. What is the direction of $\vec{B}$?

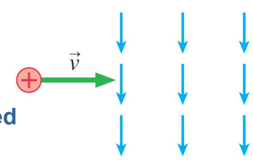
A. Left
B. Into the page
C. Out of the page
D. Up
E. Down

What is the *initial* direction of deflection for the charged particle entering the magnetic field shown?



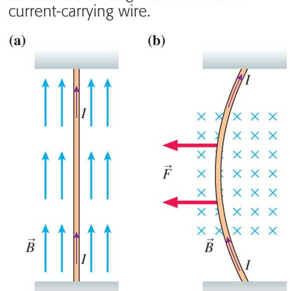
A. Left
B. Into the page
C. Out of the page
D. Up
E. Down

What is the *initial* direction of deflection for the charged particle entering the magnetic field shown?



A. Left
B. Into the page
C. Out of the page
D. Up
E. Down

FIGURE 33.43 Magnetic force on a current-carrying wire.



(a) There's no force on a current parallel to a magnetic field.

(b) A current perpendicular to the field experiences a force in the direction of the right-hand rule.

Magnetic Forces on Current-Carrying Wires

Consider a segment of wire of length l carrying current I in the direction of the vector $\boldsymbol{l}$. The wire exists in a constant magnetic field $\boldsymbol{B}$. The magnetic force on the wire is

$$F_{\text{wire}} = Il \times B = (IlB\sin\alpha, \text{ direction of right-hand rule})$$

where α is the angle between the direction of the current and the magnetic field.