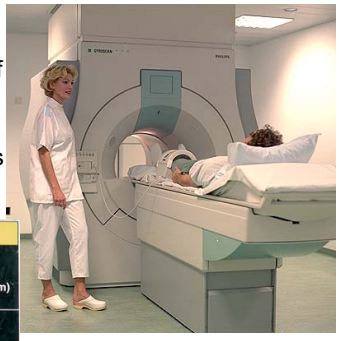
PHY132H1F Introduction to Physics II
Class 18 – **Outline:**

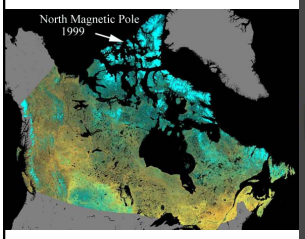
- Magnetism
- Magnetic Field of an Electric Current
- Magnetic Dipoles

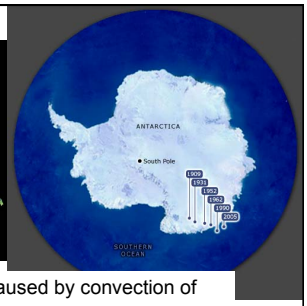


Quick Ch. 33 reading quiz..

What is the S.I. unit of Magnetic Field?

A. Gauss
B. Volts / meter
C. Amp^2 / m
D. Tesla
E. Henry





The Earth's Magnetic field is caused by convection of liquid iron in the outer core.

The strength of the magnetic field due to the Earth is 30 to 60 micro-Tesla at the Earth's surface, depending on where you are.

The N-pole of a permanent magnet free to rotate about a vertical axis will tend to point North: this is a "compass".

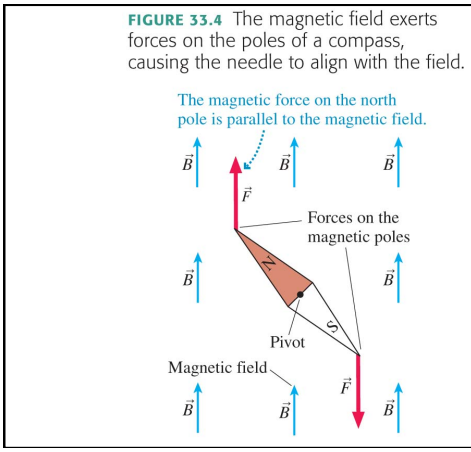
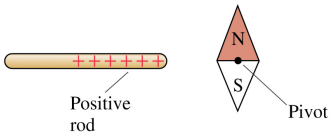


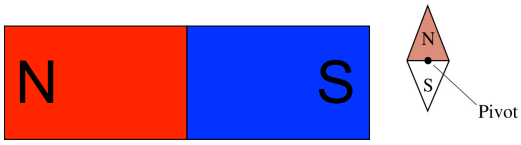
FIGURE 33.4 The magnetic field exerts forces on the poles of a compass, causing the needle to align with the field.



In-class discussion question

Does the compass needle rotate clockwise (cw), counterclockwise (ccw) or not at all?

A. Clockwise
B. Counterclockwise
C. Not at all



In class discussion question

Does the compass needle rotate clockwise (cw), counterclockwise (ccw) or not at all?

A. Clockwise
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C. Not at all

"Perpendicular to the page" notation:

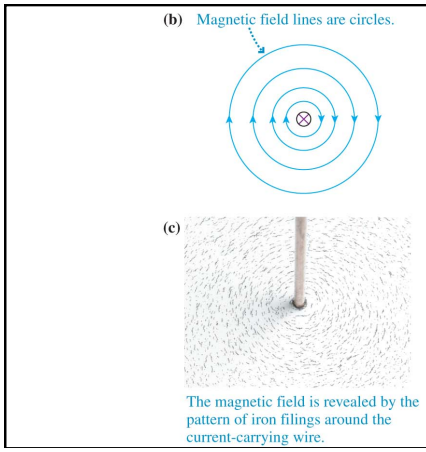
(a)

Vectors into page

Current into page

Vectors out of page

Current out of page



The magnetic field is revealed by the pattern of iron filings around the current-carrying wire.

Right-hand rule for fields

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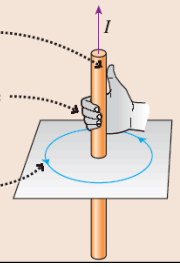
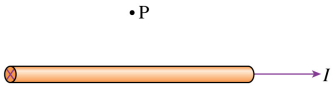
1. Point your *right* thumb in the direction of the current.
2. Curl your fingers around the wire to indicate a circle.
3. Your fingers point in the direction of the magnetic field lines around the wire.





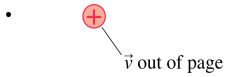
In class discussion question

The magnetic field at the position P points

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

In class discussion question

The positive charge is moving straight out of the page. What is the direction of the magnetic field at the position of the dot?



A. Left
B. Right
C. Down
D. Up

The Source of the Magnetic Field: Moving Charges

The magnetic field of a charged particle q moving with velocity $\boldsymbol{v}$ is given by the **Biot-Savart law**:

$$\vec{B}_{\text{point charge}} = \left(\frac{\mu_0}{4\pi} \frac{qv \sin\theta}{r^2}, \text{direction given by the right-hand rule} \right)$$

where r is the distance from the charge and θ is the angle between $\boldsymbol{v}$ and $\boldsymbol{r}$.

The Biot-Savart law can be written in terms of the cross product as

$$\vec{B}_{\text{point charge}} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2} \qquad \text{(magnetic field of a point charge)}$$

The Magnetic Field of a Current

The magnetic field of a long, straight wire carrying current I, at a distance d from the wire is

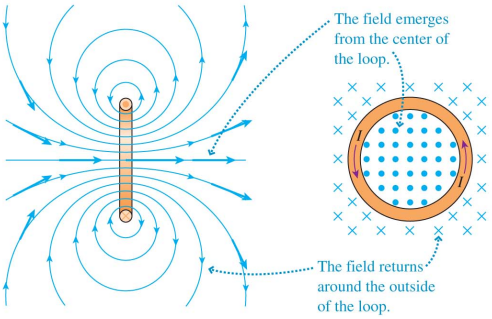
$$\vec{B}_{\text{wire}} = \left(\frac{\mu_0}{2\pi} \frac{I}{d}, \text{ tangent to a circle around the wire in the right-hand direction} \right)$$

The magnetic field at the center of a coil of N turns and radius R, carrying a current I is

$$B_{\text{coil center}} = \frac{\mu_0}{2} \frac{NI}{R}$$

FIGURE 33.18 The magnetic field of a current loop.

(a) Cross section through the current loop **(b)** The current loop seen from the right



Finding the magnetic field direction of a current loop

TACTICS BOX 33.2 **Finding the magnetic field direction of a current loop** MP

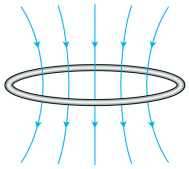
Use either of the following methods to find the magnetic field direction:

1. Point your right thumb in the direction of the current at any point on the loop and let your fingers curl through the center of the loop. Your fingers are then pointing in the direction in which $\vec{B}$ leaves the loop.
2. Curl the fingers of your right hand around the loop in the direction of the current. Your thumb is then pointing in the direction in which $\vec{B}$ leaves the loop.

Exercises 18–20

In class discussion question

What is the current direction in this loop? And which side of the loop is the north pole?



A. Current counterclockwise, north pole on bottom
B. Current clockwise; north pole on bottom
C. Current counterclockwise, north pole on top
D. Current clockwise; north pole on top

Before Next Class:

- There is no problem set due tonight. Problem Set 8 is due in one week.
- Friday's practical is all about magnets and magnetism. Yes, you will be playing with magnets!
- Please finish reading Chapter 33 this weekend, but you may skip sections 33.9 and 33.10

See you Monday!