MAGNETIZATION+DIPOLES

Class Activities: Magnetization (1)

Discussion

Magz toys

I also brought some strong magnets and Magz toys - the magz are dipoles, and I used them to engage in a class discussion of "how do you know this is NOT just electrostatics". They would come up with solutions ("you can't ground it, if it was electric you could") which I tried to counter ("it's coated in a thin plastic film") ("So scrape off the plastic"-> "Maybe it's an electret") ("If you cut it in half, you get two smaller magnets" -> "As I said, maybe it's an electret"...)

Group Activity

Polarization and Magnetization

Start of class, asked them to write down (on paper) everything they could remember about P (electric polarization). ~3 minutes for that. Then, got in groups of three (new groups, this time!) and went to *boards* (so we had 6 groups, each group got one "board section") and they had to write down what their group came up with. ~5 minutes for that. Then the "scribes" sat down, we picked the nicest handwriting to go first, and they read/explained what they had done. Other groups erased what they had that was duplicated, and we argued when groups had disagreements (e.g. if there is an epsilon_0 in the formula P = xi*E*epsilon0, if if there is a minus sign in rho_bound = -? del.P, etc.) until all groups had presented. In the end, we had reviewed much of Chapter 4, and the analogies to Ch 5 (magnetization) were on everyone's fingertips. Took a little long (~20 minutes) but was fun, seemed pretty worthwhile. Many old formulas and ideas got "dredged up", they hit almost everything except the integral formulas for potential.

Simulations

B field and magnets

Activities: Had several MIT sim/quicktimes, showing B field for falling superconducting ring onto a magnet (or vice versa, or with finite resistance) See http://web.mit.edu/8.02t/www/802TEAL3D/visualizations/faraday/index.htm and "Activity Resources" folder.

Demo

Floating Magnet above another magnet

"Magnet floating above another magnet" demo (which provoked some questions and discussion - what determines the height, how does it scale, what happens if you let TWO strong magnets "stick" and then try to float them...)

Class Activities: Magnetization (2)

Demo
Solenoid
Also brought in a solenoidal electromagnet and nails, to introduce ferromagnets.

Demo
Barkhausen Effect
(CU Demo # 5G20.10)
Hear the sound of magnetic domains aligning themselves.

Demo
Permalloy Bar and Tape
(CU Demo # 5G20.55)
A bar will attract wire when aligned with the earth's magnetic field, and not when it is not. The effect is possible due to the high permeability of the alloy.

Demo
Diamagnetism and paramagnetism
(CU Demo # 5G30.11)
See how diamagnetic and paramagnet align in different directions with B field.

Dipoles

Whiteboard/paper
Dipoles
I put up the FORMULA for the B field from an ideal magnetic dipole (from Griffiths), and asked them to sketch it, as well as sketching the field for a *real* current loop of finite radius, and think about the differences. Gave about 5 minutes for this, they did it on paper but talked to each other. It was a very useful exercise - we'd done this before for the electric dipole (same thing!) but they STILL struggled in a variety of ways. Some (most) "knew the answer" either from memory or their heuristics about fields around rings, but they were not good about seeing the connection to the formula. I poked some groups with questions like "on the x axis, at very small x, what is the direction of B for the two cases (ideal and real), and can you reconcile these"?)

5.30

The leading term in the vector potential multipole expansion involves $\oint d\vec{l}\,'$

What is the magnitude of this integral?

A) R

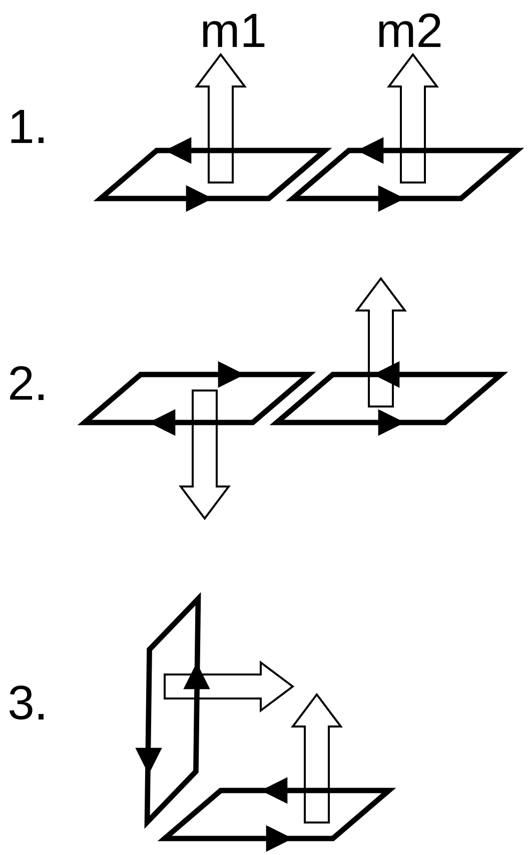
B) 2 π R

C) 0

D) Something entirely different/it depends!

MD12-5

Two magnetic dipoles **m**1 and **m**2 (equal in magnitude) are oriented in three different ways.



Which ways produce a dipole field at large distances?

A) None of these

B) All three

C) 1 only

D) 1 and 2 only

E) 1 and 3 only

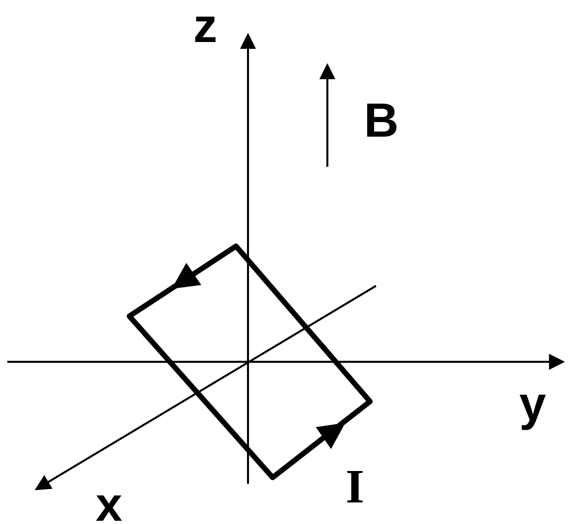
The force on a segment of wire L is $\vec{F} = I\,\vec{L} \times \vec{B}$

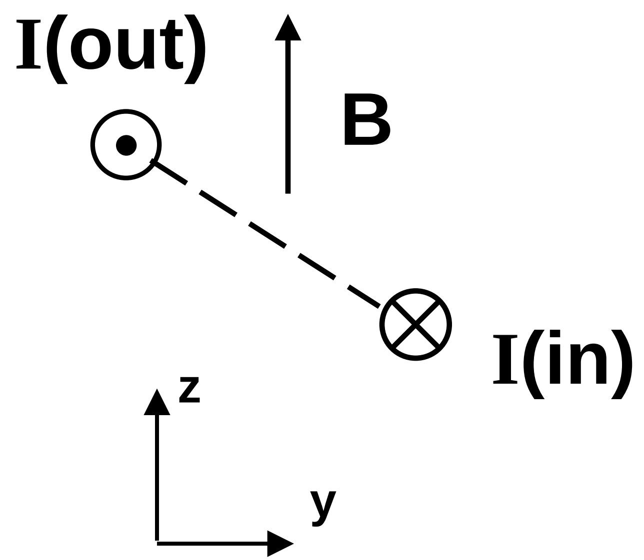
A current-carrying wire loop is in a constant magnetic field **B** = B **z_hat** as shown.

What is the direction of the torque on the loop?

A) Zero B) +x C) +y D) +z

E) None of these



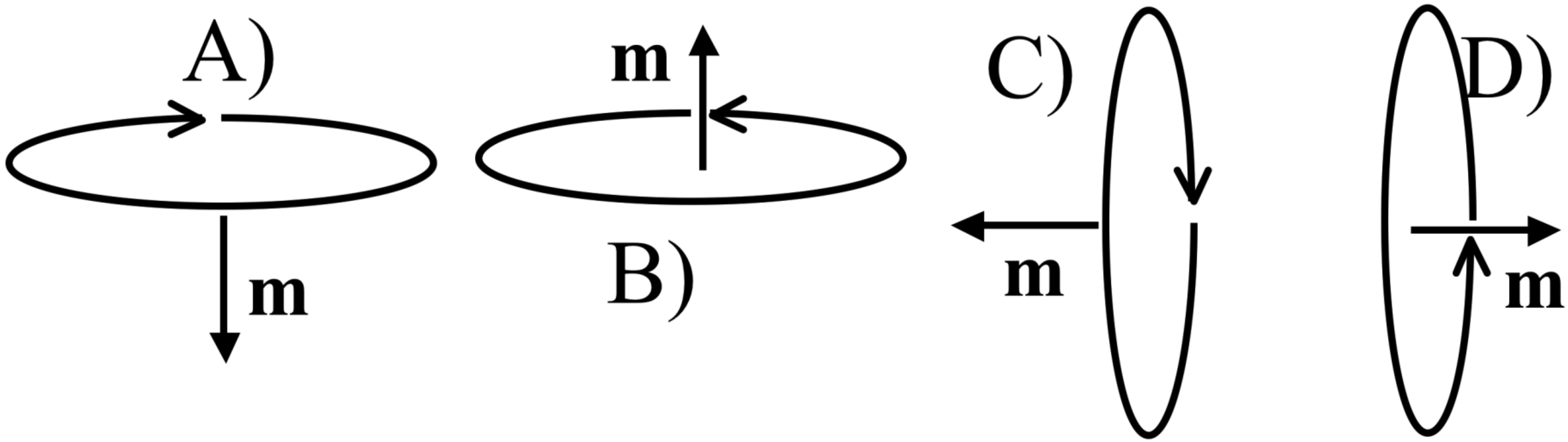


6.1

Griffiths argues that the torque *on* a magnetic dipole in a B field is:

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

How will a small current loop line up if the B field points uniformly up the page?



6.2

Griffiths argues that the force *on* a magnetic dipole in a B field is: $\vec{\mathbf{F}} = \vec{\nabla}(\vec{\mathbf{m}} \bullet \vec{\mathbf{B}})$

If the dipole **m** points in the z direction, what can you say about **B** if I tell you the force is in the x direction?

A) **B** simply points in the x direction
B) Bz must depend on x
C) Bz must depend on z
D) Bx must depend on x
E) Bx must depend on z

E-field around
electric dipole

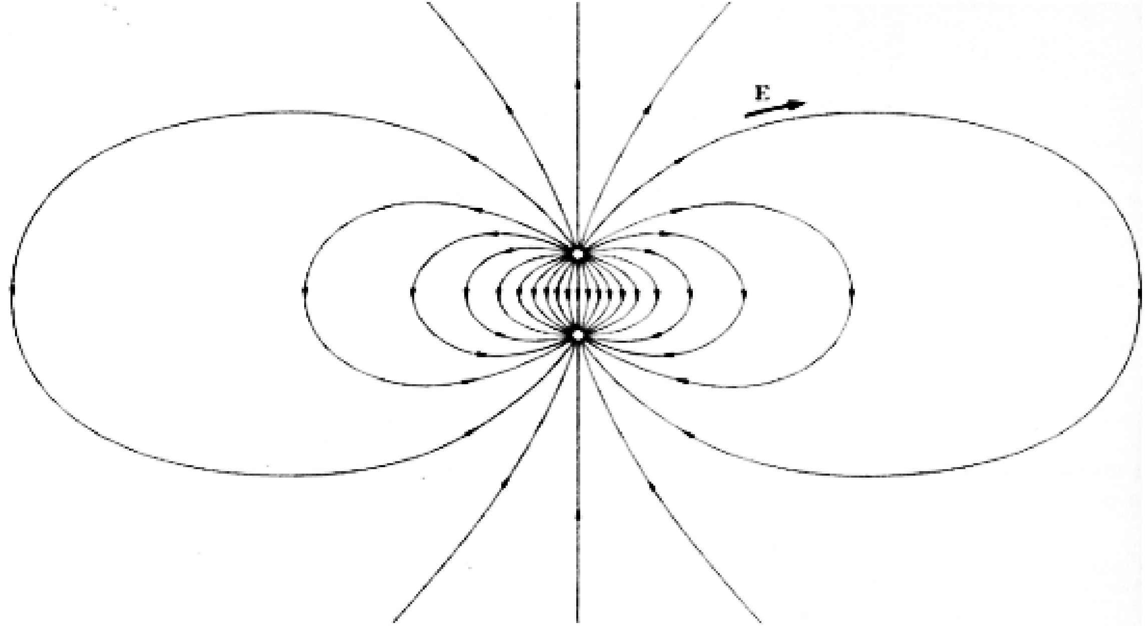
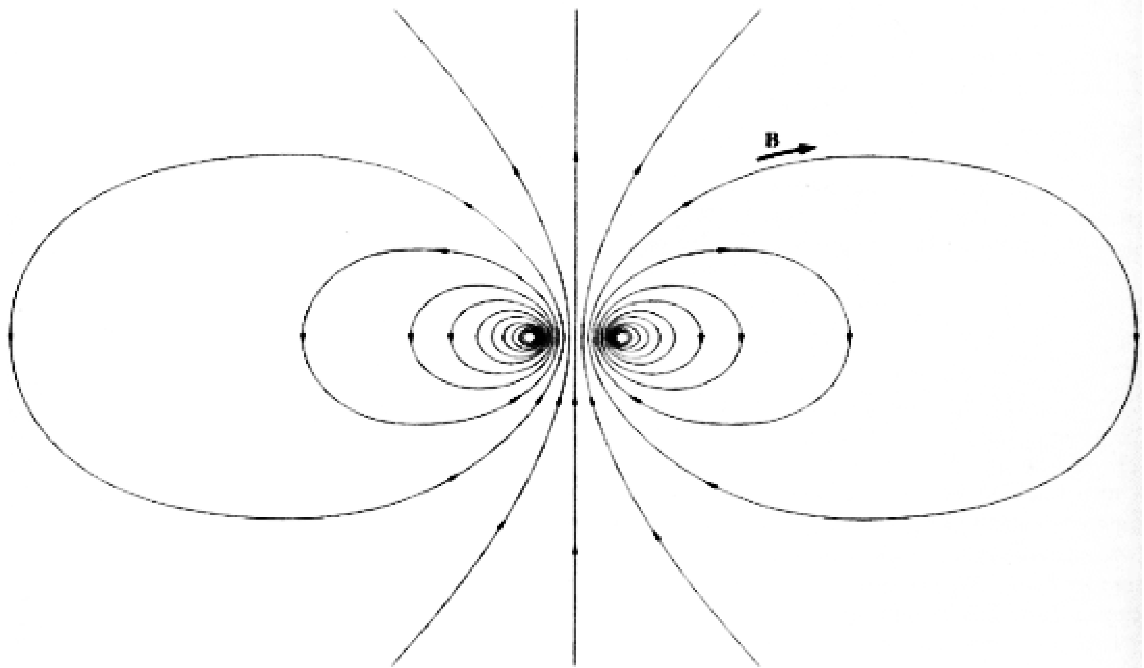


Fig. 10.8 (*a*) The electric field of a pair of equal and opposite charges. Far away it becomes the field of an electric dipole.

B-field around
magnetic dipole
(current loop)

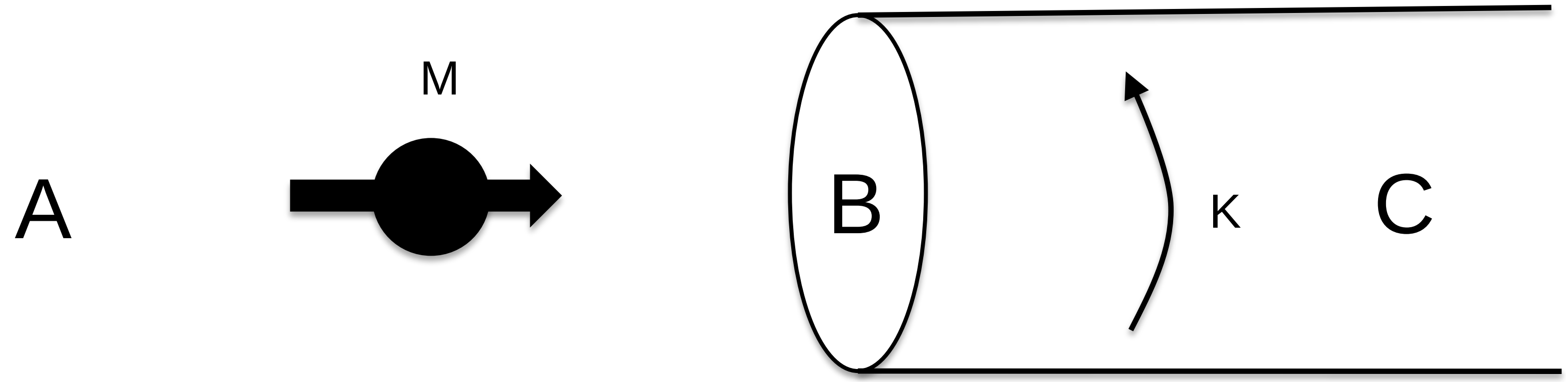


(*b*) The magnetic field of a current ring. Far away it becomes the field of a magnetic dipole.

From Purcell,
Electricity and Magnetism

6.2x

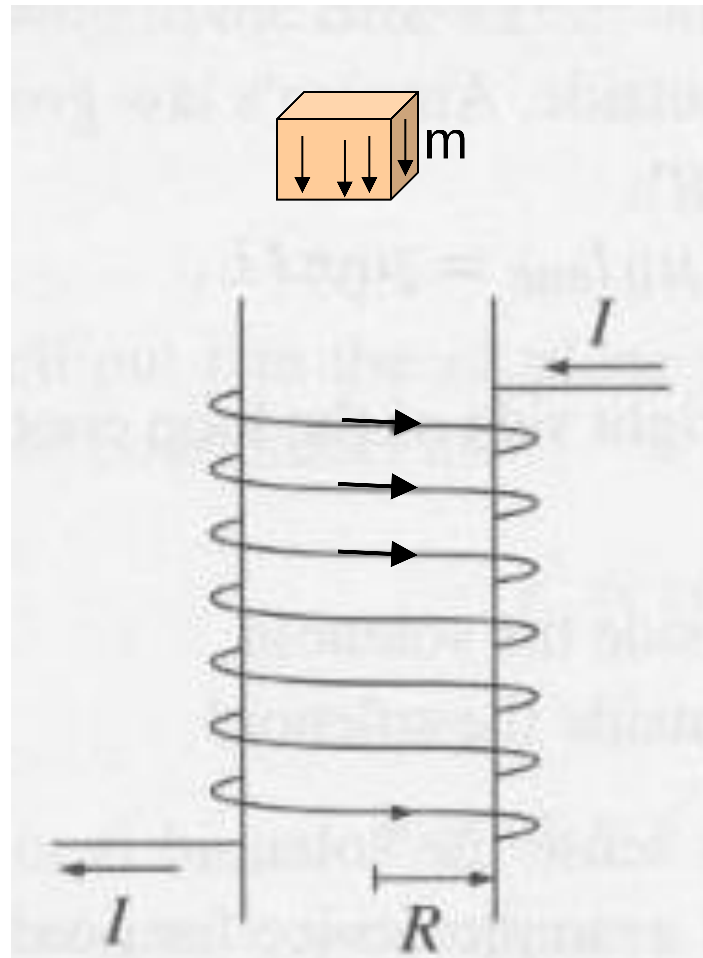
Suppose I place a small dipole M at various locations near the end of a large solenoid. At which point is the magnitude of the force on the dipole greatest?



D) Not enough information to answer

E) There is no net force on a dipole

6.7a A small chunk of material (the "tan cube") is placed above a solenoid. It magnetizes, weakly, as shown by small arrows inside. What kind of material must the cube be?



A) Dielectric
B) Conductor
C) Diamagnetic
D) Paramagnetic
E) Ferromagnetic

6.7 b

Predict the results of the following experiment: a paramagnetic bar and a diamagnetic bar are pushed inside of a solenoid.

a) The paramagnet is pushed out, the diamagnet is sucked in
b) The diamagnet is pushed out, the paramagnet is sucked in
c) Both are sucked in, but with different force
d) Both are pushed out, but with different force

Which type of magnetic material has the following properties:

1) The atoms of the material have an odd number of electrons
2) The induced atomic magnetic dipoles align in the same direction as an applied magnetic field
3) Thermal energy tends to randomize the induced dipoles

A. Ferromagnetic
B. Diamagnetic
C. Paramagnetic