Physics of Astronomy winter week 6 - Electromagnetism

Zita due Mon 23 Feb

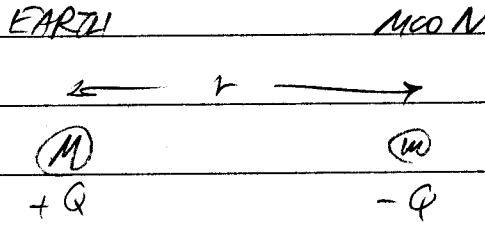
Giancoli Physics: Ch 21 #69 (572); Ch 22 Ex 4 (582), #2 (587) AND Q

Ch 27, Q8, #53 (707); Ch 28: Q5, #55 (727); Ch 29 (Ex 1), Q10 29, #7 (738-51)

Ch 21

69. Suppose that electrical attraction, rather than gravity, were responsible for holding the Moon in orbit around the Earth. If equal and opposite charges Q were placed on the Earth and the Moon, what should be the value of Q to maintain the present orbit? Use these data: mass of Earth = 5.97×10^{24} kg, mass of Moon = 7.35×10^{22} kg, radius of orbit = 3.84×10^{8} m. Treat the Earth and Moon as point particles.

M r



To make $F_G = F_E$

we need $\frac{GmM}{r^2} = \frac{kQ^2}{r^2}$ $\quad k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$

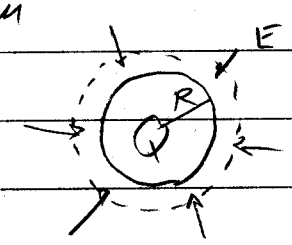
(notice that r^2 cancels!)

$Q^2 =$ _____

Ch 22

2. (I) The Earth possesses an electric field of (average) magnitude 150 N/C near its surface. The field points radially inward. Calculate the net electric flux outward through a spherical surface surrounding, and just beyond, the Earth's surface.

$R = 6.4 \times 10^6$ m



Electric flux $\Phi_E = \int E \cdot dA$

$\Phi_E = E \cdot 4\pi R^2 =$ _____

How much charge is on Earth? $\Phi_E = Q/\epsilon_0$

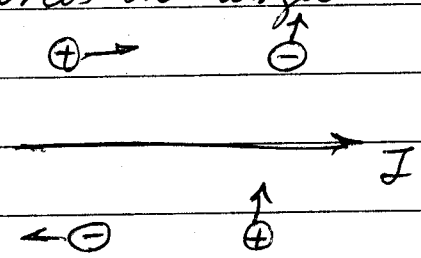
$Q =$ _____ $\quad \epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$

LORENTZ FORCE

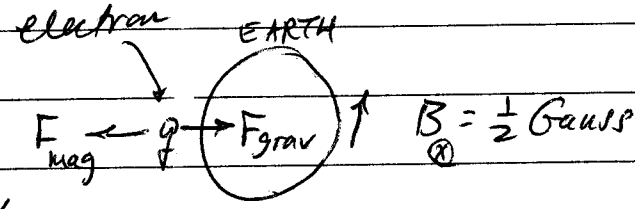
Ch 27 Q8 / 703 Find the direction of the force on these charged particles moving near a current-carrying wire : $\vec{F} = q\vec{v} \times \vec{B}$ where $\oint \vec{B} \cdot d\vec{l} = \mu_0 I$

First draw the magnetic field B due to current I:

Then find forces on charges - draw them



Ch 27 53. Near the equator, the Earth's magnetic field points almost horizontally to the north and has magnitude $B = 0.50 \times 10^{-4}$ T. What should be the magnitude and direction for the velocity of an electron if its weight is to be exactly balanced by the magnetic force?



First, how must the electron move (v) to experience the F_{grav} drawn?

Then, $\Sigma \vec{F} = 0$ if $F_{mag} = F_{grav}$ $\quad m_e = 9.11 \times 10^{-31}$ kg

$qvB = mg$ $\quad |q_e| = 1.6 \times 10^{-19}$ C

Solve for v = _____

Practice these in class:

Q 27

14. (I) Find the direction of the force on a negative charge for each diagram shown in Fig. 27–40, where **v** is the velocity of the charge and **B** is the direction of the magnetic field. (⊗ means the vector points inward. ⊙ means it points outward, toward the viewer.)

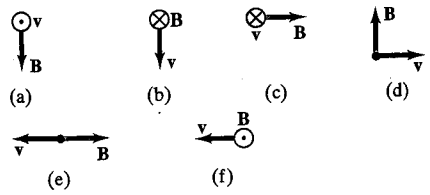


FIGURE 27–40 Problem 14.

15. (I) Determine the direction of **B** for each case in Fig. 27–41, where **F** represents the force on a positively charged particle moving with velocity **v**.

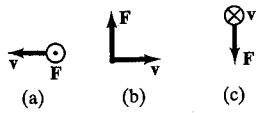


FIGURE 27–41 Problem 15.

Q28 Q5: Two current-carrying wires suspended in Earth's gravity:

$\longrightarrow I_1$ floats

$\downarrow g$

$\longrightarrow I_2$ is held up by external means

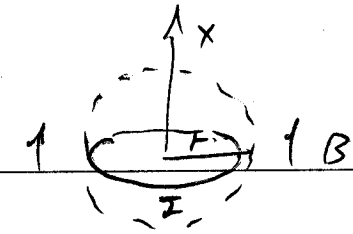
(a) Draw the magnetic field due to I_2 (call it B_2)

(b) Find the effect of B_2 on I_1, using $\bar{F} = I\bar{l} \times \bar{B}$

(c) Compare (Force on I_1 due to B_2) to gravitational force.

(d) Can I_1 be held in stable equilibrium due to B_2? EXPLAIN:

Ch26 55. Near the Earth's poles the magnetic field is about 1 G (1×10^{-4} T). Imagine a simple model in which the Earth's field is produced by a single current loop around the equator. What current would this loop carry?



(a) Use Ampere's law & right-hand rule to find the DIRECTION of I that will cause observed B. DRAW I (arrows)

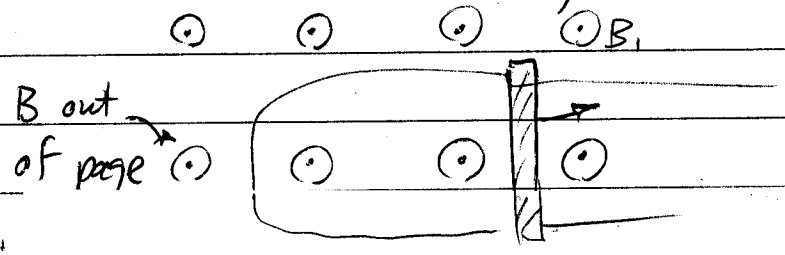
(b) Find magnitude of current loop using ~~$\oint \vec{B} \cdot d\vec{l} = \mu_0 I$~~

$R_\oplus = 6.4 \times 10^6$ m

$x = R_\oplus$ at N pole

Bon axis due to loop of current x $\dfrac{\mu_0 I R^2}{2\pi (R^2+x^2)^{3/2}} =$

Ch29 Q10 / 751 Use Lenz's Law to find the direction of the Emf in the moving rod in fig 29-9 (p. 739)



Ch 29

7. (II) What is the direction of the induced current in the circular loop due to the current shown in each part of Fig. 29–30? Explain.

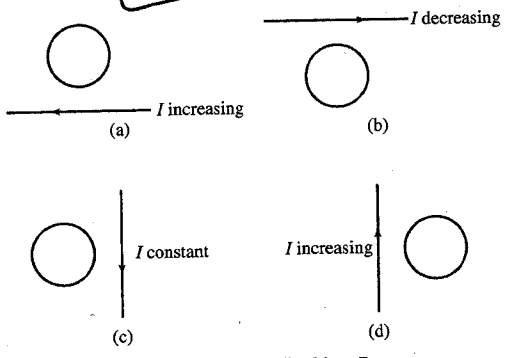


FIGURE 29–30 Problem 7.