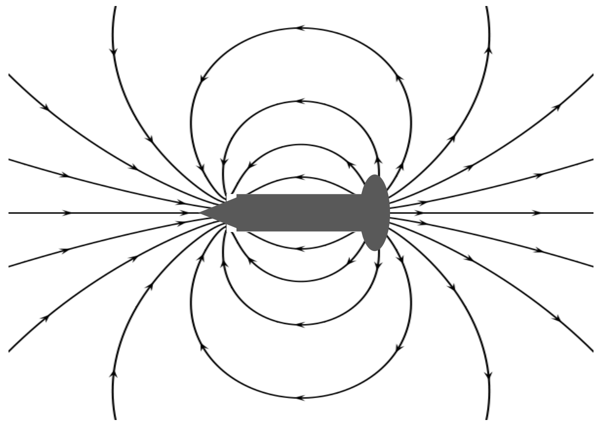
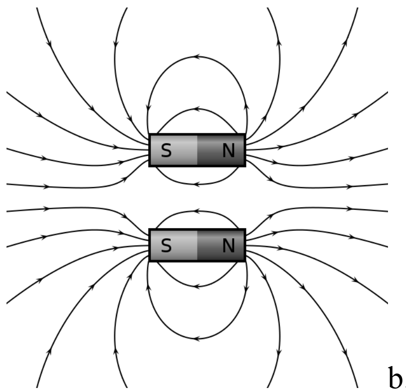
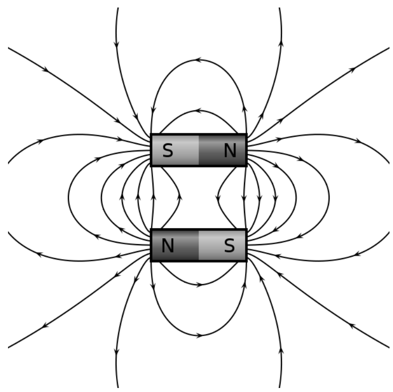
1. a. The head of the nail is the north pole of the magnet
   b. A compass would point toward the south pole of the magnetized nail, so it would point to the sharp end of the nail.
   c.



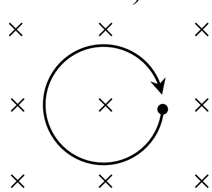
2. a.



   b.



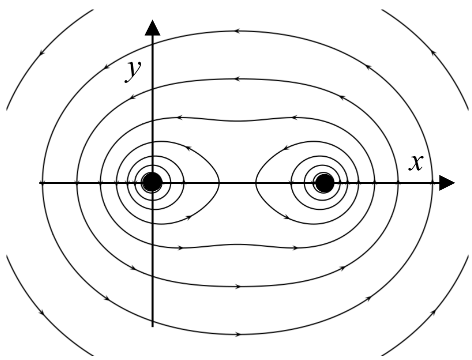
3. a. 1.25×10^{-10} N, north
   b. 2.50×10^{-10} N,down
   c. 1.25×10^{-10} N, down
   d. 0
4. $f = \frac{Bq}{2\pi m}$
5. a. b.
6. a. 1.69×10^{11} C/kg
   b. 9.5×10^{-31} kg
   (4.1% error)
   c.



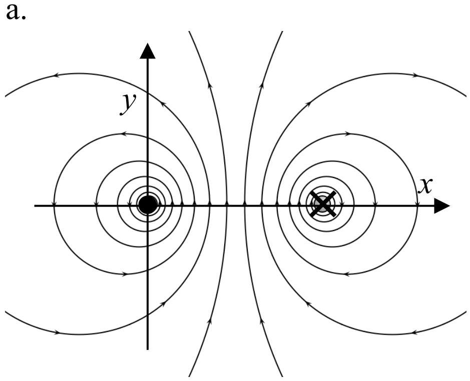
7. a. 3.8 m
   b. 160 m
8. 9.4 G, into the page

9. a. 25<u>0</u> km/s, right
   b. 1.67×10^{-27} kg (${}_1H^1$)
      3.36×10^{-27} kg (${}_1H^2$)
10. a. 6.6 mm
    b. Having a larger radius path would increase the sensitivity because it is "easier" to be more precise measuring the larger radius and also the *differences* in radii would be greater. In order to have a larger radius it would be necessary to create a larger vacuum chamber and a magnetic field broader in scope but lesser in magnitude.
11. a. 0
    b. $-2.25\,\hat{k}$ μN
    c. $-4.50\,\hat{k}$ μN
    d. $-3.90\,\hat{k}$ μN
    e. 0
12. a. 0.333 mN, west
    b. 0.714 mN, east
13. a. 0.42 A
    b.
    c. 0.35 N
14. I_1 net force = 0,
    net torque in $-\hat{j}$dir.
    I_2 net torque = 0,
    net force in $+\hat{\imath}$ dir. (depending on length)
    I_3 net torque = 0,
    net force in $-\hat{\imath}$ dir.
    I_4 net torque = 0,
    net force in $-\hat{k}$ dir.
15. a. −1<u>0</u> $\hat{j}$ μN
    b. 21 $\hat{j}$ μN
16. a. 0.0144 $\hat{\imath}$ Nm
    b. 0.0125 $\hat{\imath}$ Nm
17. w = 1 cm, h = 9 cm; w = 5 cm, h = 1.8 cm
    a. 0.16 N; 0.80 N
    b. 2(0.16N)(0.045m) = 2(0.80N)(0.009m) = 0.0144 $\hat{\imath}$ Nm
18. a. 11 rad/s^2
    b. 1.8 A
19. a. 5.57 $\hat{k}$ μT
    b. 2.34 $\hat{k}$ μT
    c. −1.39 $\hat{k}$ μT
    d. 0
20. 6.00 $\hat{k}$ μT, 3.00 $\hat{k}$ μT,
    −3.00 $\hat{k}$ μT
21. a. 1.36 mT into page
    b. The closer to one corner of the square, the stronger the magnetic field. Because of the inverse nature of field strength, getting really close to <u>two</u> of the four currents (that form the square) causes the field strength to "skyrocket".

22. a. 119
    b. 10.6 V
23. $\vec{B} = \frac{\mu_0 I}{4}\left(\frac{1}{a} - \frac{1}{b}\right)$, into page
24. $\vec{B} = \frac{\mu_0 I \cos^3\theta}{2R}$, up
25. a. 1.25 mT
    b. 2.50 mT
    c. 1.67 mT
26. a. -1.3×10^{-6} Tm
    b. 1.3×10^{-6} Tm
    c. -1.3×10^{-5} Tm
    d. -1.5×10^{-5} Tm
    e. 0
27. a.



    b. $\vec{B} = \frac{\mu_0 I}{2\pi} \cdot \frac{a-2x}{x(a-x)}\ \hat{j}$
    c. $-\frac{\mu_0 I}{2\pi a}\ \hat{\imath}$
28. a.



    b. $\vec{B} = \frac{\mu_0 I}{2\pi} \cdot \frac{a}{x(a-x)}\ \hat{j}$
    c. $\frac{\mu_0 I}{2\pi a}\ \hat{j}$
29. a. 17.7° Wof N
    b. 9.1° W of N
    c. r <1.6 cm W of wire

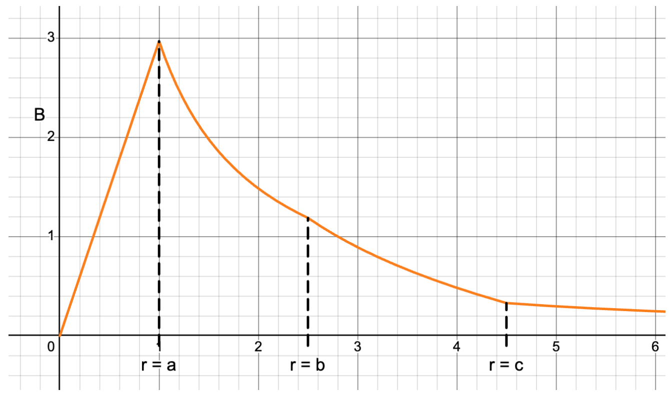
30. a. $B = \frac{\mu_0 I r}{\pi a^2}, r \leq a$

$B = \frac{\mu_0 I}{\pi r}, a \leq r \leq b$

$B = \frac{\mu_0 I}{2\pi r}\left(2 - \frac{r^2 - b^2}{c^2 - b^2}\right),$
$b \leq r \leq c$

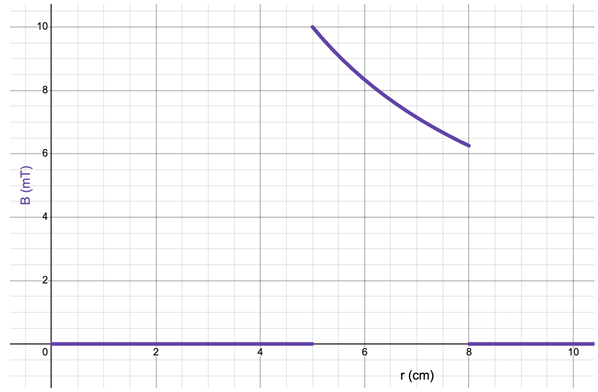
$B = \frac{\mu_0 I}{2\pi r},\ r \geq c$

b.



31. a. 1.00 G
    b. 0.500 G
    c. 2.33 G
32. a. $3.0 \times 10^{-5}\ \hat{k}$ T
    b. $1.1 \times 10^{14}\ \hat{\jmath}$ m/s^2
    c. 3.8 m
    d.
33. a. 4.00×10^{-3} N/m, down
    b. 294 A, opp. dir.
34. a. 1.4 mN/m, repulsion
    b. 2.9 mN
    c. The force calculated would be the mean amount of repulsion, however the amount of repulsion will vary with the current. When the current reverses direction, it reverses direction in *both* strands of wire. So, at all times, the currents are opposite and the force is *always* repulsion, but it increase and decreases 120 times per second (twice per cycle).
35. a. 2.08 mN
    b. 3.54 cm
    c. CCW
36. a. 10.4 mT
    b. 28.9 A
37. a. 434
    b. 58.2 m
    c. 2.61 mT
    d. Smaller diameter wire will allow for a greater number of turns to "fit" across the length of the tube. However, the decreased diameter and increased length of wire will increase the resistance of the wire and decrease the current. Greater diameter wire will result in fewer turns but greater current. So, the answer is not obvious! I calculate that the strongest field is created by using wire of diameter 1.02 mm.
38. $B = 0$, $r < R_1$ or $r > R_2$

$B = \frac{\mu_0 N I}{2\pi r}, R_1 < r < R_2$

39. a. 6.25 mT, 10.0 mT b. 

40. a. 0.88 mT
    b. 1000 times
    c. The electrons' orbits and spin properties will tend to be oriented in such away that the magnetic fields generated by the electrons align with the field generated by the current in the solenoid. The observed field is then the superposition of the field being generated by the current in the solenoid *plus* the fields being generated by all the electrons in the iron core.
    d. In principle the same thing should happen with the aluminum. However due to its intrinsic atomic structure and lattice structure there are other forces acting on the electrons that prevent as much alignment as happens with ferromagnetic materials like the iron. Also, the diamagnetic effect is said to occur in all materials and it would serve to diminish the "induced" magnetic field. Being classified as paramagnetic means that there should be a very weak "strengthening" effect so the net magnetic field should be ever so slightly greater than that produced by the "empty" solenoid.
41. a. b.
42. a. b.
43.
44. a. b. c.