Answers – Physics 2 Magnetism Assignment

1. a. Compass would point toward the south spot and away from the north.
   b. Sun's field would point directly upward from a north spot.
2. a. The red end of a compass needle is the north pole.
   b. The field generated by the compass needle aligns with the earth's field.
3. a. sketch
   b. 0.40 mT
   c. The fields point in the same direction along the midlines and so reinforce one another.
4. a. The field of the disk is pointing upward also.
   b. The heads side is the north pole.
5. a. 4.0×10^{-18} N, 2.4×10^{9} m/s^2 east
   b. 4.0×10^{-18} N, 4.4×10^{12} m/s^2 west
6. a. 5$\underline{0}$ μT, 26° from vertical
   b. 3.0×10^{-13} N, west
   c. 1.7×10^{-8} degrees (63 microarcseconds)
7. a. 7.9×10^{-10} N, north and up 26° from horizontal or south and down 26° from horizontal
   b. 220 C
   c. 2.8×10^{10} m/s – which is beyond the speed of light and impossible!
8. a. Because magnetic force is always perpendicular to velocity, there is never an acceleration component in the same or opposite direction of movement and therefore the speed does not change. The only change in velocity is a change in direction.
   b. No work can be done by the magnetic force because it is perpendicular to the movement and work is defined as a dot product, which is a product of parallel components. There are no parallel components of magnetic force and displacement.
9. a. 240 km/s clockwise
   b. 770 kHz
   c. 2.5 cm
   d. 27 μT
10. a. 160 kN/C
    b. 10.3 cm and 5.2 cm
    c. 35 u and 37 u
11. a. $m = \dfrac{qB^2r}{E}$
    b. $V = \dfrac{qB^2rd}{m}$
12. a. 0.036 N up
    b. 83 A
13. a. 3.7 mN, 60°
    b. 1.8 mN, 180°
    c. Net force would be zero for any shape. In a closed circuit for any length of current in one direction there must be an equivalent length/current in the opposite direction resulting in an equal and opposite force.
    d. If flexible the outward forces would tend to turn it into a circular loop.
    e. Presence of the battery doesn't matter because there is current through it just like the rest of the circuit, and total length of current would be the length of that side of the triangle.

14. a. 0.10 T
    b. diagram – current is clockwise
    c. Because the force would be out of the page on all sides of the rectangular coil the average field across the entire length of wire would be 0.0073 T, but the strength between the poles should be greatest. The actual strength between the poles is probably less than 0.10 T because there is more current near the poles than assumed if only the 1.0 cm side of the rectangle is analyzed.
15. a. 8.5×10^{-5} N, left
    b. If loop is at center of the magnet the net force would be zero (inward on all sides). If it moves in either direction away from center it experiences a force directed back toward the center. This force would be greatest when loop is directly on a pole.
    c. If the current is reversed then the force described above is always away from center and so it would be repelled.
    d. The loop's north pole is just to the right of the current shown in the diagram and the south pole is just to the left.
16. a. short sides: 28 mN each, long sides: 0 N – net force is zero because force on one short side is exactly opposite direction from the other short side.
    b. 2.0×10^{-3} Nm in a direction that would align magnetic dipole moment with external field
    c. short sides: 0 N, long sides: 65 mN each – net force still zero and torque is unchanged
17.
18. a. $B = \dfrac{2\tau\rho}{\pi R V r^2}$
    b. 23 T – not very practical! However this is assuming there is nothing inside the coil. In reality an electric motor would typically have an iron core inside the coil, which has the effect of reducing the required magnetic field.
19. a. 1.00×10^{-4} T, west
    b. 2.0 cm west of wire's center
    c. If the earth's field is horizontal then the two fields would cancel for a net field of zero. Otherwise there would be a net field that could be found by adding two vectors of equal magnitude with angle dependent on the inclination of earth's field.
    d. 5000 A
20. a. 1.9×10^{-17} N
    b. Electron moving same direction as conventional current (or opposite direction of electrons in the wire) would experience force away from the wire.
    c. 0.11 m
    d. sketch of path looks like "curlicue" – think curly fries!
21. a. 4.0 mT
    b. 0.5 mT, 4.5 mT or any value between these two
    c. 0.13 N repulsion
22. Proton is located at coordinates: (–96 m, +96 m) in the 2nd quadrant.
23. a. 6.0 mT, 3.0 mT
    b. 60 to 30 times greater as a result of any point inside the solenoid being relatively close to all of the current through the wire instead of being relatively close to only a small part of the current through the wire.
    c. The net field inside the solenoid is a superposition of fields of each coil. When the length

is shorter the coils are all closer to a point inside the solenoid and the field of each is greater due to the decrease in distance. Therefore the sum of all those fields of each coil is greater.

24. a. The majority of domains have a north pole facing same as that of the magnet.
    b. Not all domains have to face exactly the same way, but the majority must face at least somewhat in the same direction – the external field is the superposition of all fields, some of which may actually lessen the sum.
    c. The majority of electrons are "spinning" clockwise from this perspective facing the north pole of the magnet.
    d. Increasing temperature increases random and chaotic motion of the atoms and subatomic particles, which tends to randomize the organization. With less or no organization the net external field is weakened or eliminated.
25. a. Domains in the nail are now pointing mainly away from the head of the nail.
    b. By pointing away from the head the south pole of each domain is now closer to the head of the nail, which makes the head of the nail a "temporary" south pole that is attracted to the north pole of the bar magnet.
    c. The domains flip the opposite way and the head of the nail is a "temporary" north pole if it sticks to the south pole of the bar magnet.
26. If the rod is perpendicular to the external field the domains would tend to line up parallel to one another and perpendicular to the rod. But if that happens it is a little like having a bunch of bar magnets side by side north pole adjacent to north pole and south pole adjacent to south pole, which is unstable due to repulsion. If the rod aligns with the external field and the domains are now aligned parallel to the rod then the north pole of each domain is adjacent to a south pole of another domain – a little like having bar magnets linked to one another north to south, north to south by attraction. This is a stable situation.
27. If the rod is parallel to the external field, the induced fields in a diamagnetic material would tend to line up parallel to this but pointing opposite the external field. This would essentially turn the rod into compass needle pointing the wrong way. But if the rod spins around so do the induced fields. Therefore there is no way for the rod to stay aligned – instead it orients perpendicular to the external field as the only stable alternative.
28. a. The core increases the magnetic field by a factor of 33 times what would exist without it. Domains and electron dipoles are aligning with the field generated by the current in the wire. The net field produced by the electrons in the steel is added to the field coming from the current.
    b. Surprisingly, 34 mT out of the total 35 mT is actually coming from the steel bolt – not the current in the wire.
29. In the presence of an external field ferromagnetic or paramagnetic materials will create a secondary field – an induced field that will align with the external field. If the external field is coming from a north pole it will in essence create a south pole in the nearest part of the material and therefore an attraction occurs. This is a little like a positive object inducing a negative charge in the nearest part of a neutral object resulting in attraction. Reverse everything in both cases and it still is an attraction.
30. a. Induced current below the falling magnet is counterclockwise as viewed from above.
    b. Induced current above the falling magnet is clockwise as viewed from above.
    c. The current below the falling magnet creates a dipole with north pointing upward, which repels the north pole of the falling magnet. The current above the falling magnet creates a

dipole with north pointing downward, which attracts the south pole of the falling magnet. Both of these interactions result in upward force on the falling magnet.

31. a. Drop a ring onto a vertical bar magnet and it will induce current. Hold the ring beyond one end of the vertical bar magnet (as if you were going to drop it onto the bar) and then move it away horizontally – this will induce current.

    b. Lay the bar magnet flat on a table. Lay the ring flat on the same table. move the ring in any direction around the magnet should not produce current because there is no significant flux.
32. a. 5.4 mWb, 11 V clockwise

    b. 22 mWb, 0 V clockwise

    c. 5.4 mWb, 5.4 V counterclockwise

    d. 0, 5.4 V counterclockwise

    e. Graph of emf clockwise shows horizontal line at 11 V (0 to 1 ms), plateau at – 5.4 V (4 ms and beyond), and diagonal line connecting the two (1 ms to 4 ms).
33. a. 0, 1.6×10^{-6} Tm^2

    b. 16 μV each turn, 4.7 mV total

    c. 79 μs
34. a. 0.18 V clockwise

    b. 5.5 mA clockwise

    c. 0.16 mN

    d. 1.5 m/s^2, right; 5<u>0</u> m/s
35. a. 2.3×10^{-22} N upward in the antenna

    b. 0.00144 N/C upward.

    c. –0.43 mV
36. a. $I = \dfrac{\pi B r^2 \sqrt{2as}}{4\rho}$

    b. $F = \dfrac{\pi B^2 r^2 s \sqrt{2as}}{4\rho} + ma$

    c. As the loop exits the field the magnetic flux would decrease. This induces a current in a clockwise direction in the loop. Current moving upward on the left side of the loop experiences a magnetic force to the left, which would cause the loop's speed to decrease is it leaves the region of the field.
37. a. 0.38 $\text{Tm}^2\text{/s}$

    b. 16

    c. 17 mA

    d. $N_P/N_S = V_P/V_S = (I_P/I_S)^{-1}$

    e. The magnetic flux cannot possibly be *exactly* the same at all times. Resistance of the wires in the coils will cause heat to be generated and prevent the transformer from being 100% efficient.