1) C

\[ E = \sum \frac{kq}{r^2} \ \text{rhat} = (8.99 \times 10^9) \left[ -\frac{3}{50^2} + 2(-1)/50^2 + 1(-1)/150^2 \right] = 1.8 \times 10^7 \ \text{N/C} \ (\text{negative is left}) \]

2) D

Dipole \( p = qd \) and torque \( = pE\sin(\theta) = qdE\sin(\theta) = 25 \times 9 \times 0.001 \times 3 \times 10^{-6} \times \sin(65) = 6.8 \times 10^{-17} \ \text{Nm} \)

3) B

By Gauss's law: surface integral \((EdA) = 4\pi kQ_{enc}\), only part of inner sphere is enclosed

\[ Q_{enc} = Q \times \frac{(4/3)\pi r^3}{((4/3)\pi a^3)} = Q r^3/a^3 \]

\[ E 4\pi r^2 = 4\pi k Q r^3/a^3 \]

4) C

By Gauss's law: surface integral \((EdA) = 4\pi kQ_{enc}\), full slab is enclosed.

\[ 2AE = (4\pi k) 2dA \rho \ : \ E = (4\pi k) \rho d \]

5) B

The potential energy of a charge in a potential difference is \( U = qV \). The potential energy will be converted to kinetic energy as the particle moves through the potential difference. They alpha particle has 2/3 as much charge as the lithium nucleus so to get the same change in kinetic energy you have to using 2/3 \( V \).

6) E

\[ C = \kappa \times \epsilon_0 \times A/d: \ 2.0 \times \epsilon_0 \times A/d \rightarrow \epsilon_0 \times A/3d. \ 6 \text{ times smaller: } 24 \ \text{microF} \rightarrow 4.0 \ \text{microF} \]

7) B

For the 6 Ohm resistor. \( V = IR = 3 \times 6 = 18 \ \text{Ohms} \)

In a parallel circuit this will be the voltage across any of the resistors.

\[ P = V^2/R = 18^2/3 = 0.11 \ \text{kV} \]

8) C
Magnetic field lines are circles. They do not start or end at any point so this statement is false. Note on answer A: The dipole fields and thus the field lines of electric and magnetic dipoles are very similar. As a result they have similar expressions for the field strength as a function of distance, similar expression for the dipole moment, similar behaviors in electric and magnetic fields respectively, and similar expressions for the potential energy in those fields. This was discussed extensively in lecture.

9) B

The expression for
\[ F = B I I_{\text{R}} \sin(\theta) = 1.5 \times 5.0 \times 0.10 \times \sin(90) = 0.75 \text{ N} \]

\( \theta = 90^{\circ} \) degrees since \( B \) and the 0.10 side of the loop are perpendicular

10) B

From lecture 15 \( B = \mu_0 I \frac{R^2}{2|x|} \)

11) B

\[ \frac{F}{\Delta L} = \frac{\mu_0 I I}{2 \pi R} : 4.3 \times 10^{-9} = 4 \pi \times 7 I I/(2 \pi I 0.076): I = 40 \text{ mA} \]

12) C

Using \( \text{EMF} = \frac{d(\text{Flux})}{dt} = \frac{d(NBA \cos(\theta))}{dt} \)

\( \cos(\theta) \) is going from \( \cos(55) \) to 0 in 0.33s

\[ NBA(\cos(\theta)-0)/t = 100 \times 0.35 \times 0.03 \times 0.05 \times \cos(55)/0.33 = 91 \text{ mV} \]

13) E

First find \( Q \) when the switch is changed: \( Q = C V = 8 \times 10^{-8} \times 6 = 48 \text{ microC} \)

Then as a function of time this LC circuit will oscillate: \( Q = Q_{\text{max}} \cos(\omega t) \)

\( \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{12 \times 3 \times 8 \times 6}} = 3227.5 \)

\( \cos(\omega t) = \cos(3227.5 \times 0.487 \times -3) = \cos(1.57) = 0 \)

\( Q = 0 \text{ C} \)

14) B

B has the same sin function dependence and is perpendicular to the propagation direction \( \text{ihat} \) and the Electric field direction \( \text{jhat} \). Therefore \( \text{khat} \)
15) E

Equation for the intensity of the reflected light. Text 31.7: \( I = I_0(n_1-n_2)^2/(n_1+n_2)^2 \)

A large different in \( n_1 \) and \( n_2 \) either way will result in a large amount of reflected light and a small amount of transmitted light

16) B

\( s' = s*n_2/n_1 = 1.83*(1/1.33) = 1.37 \text{m} \)

17) B

Snell’s law twice: \( \theta_2 = (n_1/n_2)*\sin(\theta_1) \): \( \theta_2 = 22.119 \), \( \theta_3 = 30 \)

18) D

Using \( d_i = fdo/(d_0-f) \)

\( d_{i1} = -10*20/(20+10) = -6.6667 \), then \( d_{02} = 26.6667 \)

\( d_{i2} = 20*26.6667(26.6667-20) = 80 \text{ cm positive means a real image!} \)

\( M = f/(f-d_0) \)

\( M_1 = -10/(-10-20) = 1/3 \)

\( M_2 = 20/(20-26.6667) = -3 \)

\( M_1*M_2 = -1 \), Same height but inverted.

19) E

First find the focal length using \( d_i = fdo/(d_0-f) \)

\( 40 = f(160)/(160-f) : 40(160-f) = f(160) ; 40*160 = 200f ; f = 32 \text{cm} \)

Only 40cm is outside the focal length and fill give a real image that can be formed on the screen.

Checking \( d_i = 32*40/(40-32) = 160 \text{cm where the screen is!} \)

20) B

The angular magnification is 10. Taking the orginal angle \( +\tan(\theta) = 1/25 \), \( \theta = +2.29 \)

Multiply by 10: \( +22.9 \). Full range 46 degrees
21) A

A is the configuration of a telescope where $M = \frac{f_o}{f_e}$

22) B

I goes as the electric field squared and we will be adding two electric fields $E \rightarrow 2E$ and $I \rightarrow 4I$

$I = 4I_0 \cos^2(\pi \delta/\lambda) = 4I_0 \cos^2(\pi \times 300/500) = 0.381I_0$

23) E

The second diffractive minimum is at $2\lambda/D$

Considering the interference between two light sources D apart the second maxima is at $2\lambda/D$

24) E

The central diffractive maxima is $+\lambda/D$ wide $D = a = 0.0016$

The maxima of the interference pattern are $+\lambda/d$, $d = 0.04$

Dividing them you get $+25$ fringes. However the $+25^{th}$ fringes are at the diffractive minima and is not seen. Also you have to add the central fringe. Therefore 49

25) E

Since the angular resolution due to diffraction is limited by $\Delta \theta = \lambda/D$ using a shorter wavelength will improve that resolution. A, B and C will not change the diffractive properties which are the limiting factors. D will make the resolution worse.