Physics

Unit 11: Electromagnetic Waves

1. *Know about the spectrum of light including the complete spectrum and visible light.*
2. *Know about the eye, vision correction, and color vision*
3. *Know how to make ray diagrams for mirrors and lenses.*
4. *What type of images to the various mirrors and lenses make? (real or virtual) (upright or inverted) (enlarged or reduced)*
5. *Why does refraction happen?*
6. *A spy satellite is in orbit at a distance of* 1.0×10^5 *m above the ground. It carries a telescope that can resolve the two rails of a railroad track that are 1.4 m apart using light of wavelength 500 nm. What is the size of the mirror in the telescope?*
7. *WAUS has a frequency of 90.7 MHz. What is it's wavelength?*
8. *An electromagnetic wave has a magnetic field with peak value 0.500 T. What is the average intensity of the wave?*
9. *If the index of refraction is 12.5, what is the speed of light in the material?*
10. *A beam of light in a material of index of refraction of 1.5 hits a boundary with air (n = 1.00). If the angle of incidence is 25°, what is the angle of refraction?*
11. *A 2 cm object is placed 15 cm from a lens. The resulting image height has a magnitude of 0.5 cm and the image is inverted. What is the focal length of the lens?*
12. *What is the image distance if an object is placed 10 cm in front of a concave mirror with radius of curvature of 12 cm?*
13. *Light with a 700nm wavelength is shown through a double slit. If the m = 0 and m = 1 bright fringes are separated by 10°, what is the separation of the slits?*
14. *Light with a700nm wavelength is shown through a single slit onto a screen 3 m away. What is the width of the slit if the 2nd-order dark fringe is located 50 cm from the center of the central bright region?*
15. *A diffraction grating has 2000 lines/cm and has monochromatic light shown on it. If the 3rd-order maximum is at 20°, what is the wavelength of the light?*
16. *A portion of a soap bubble appears to have* λ *= 500.0 nm in a vacuum when viewed at normal incidence in white light. Determine the smallest, non-zero thickness for the soap film if its index of refraction is 2.0.*
17. *Unpolarized light with an average intensity of 1000 W/m² enters a polarizer with a vertical transmission axis.*
    a. *What is the intensity of the light after the polarizer?*
    b. *Then the light hits a second polarizer. The light that exits the second polarizer has an intensity of 300 W/m². What is the orientation angle of the second polarizer?*

4. *Mirrors*
Concave: $d_o > R$ image real, inverted, reduced, between C and F
$f < d_o < R$ image real, inverted, enlarged, beyond C
$d_o < f$ image virtual, upright, enlarged, behind mirror
Convex: image virtual, upright, reduced, behind mirror

Lenses
Converging: $d_o > 2f$ image real, inverted, reduced, between 2F and F
$f < d_o < 2f$ image real, inverted, enlarged, beyond 2F
$d_o < f$ image virtual, upright, enlarged, behind lens
Diverging: image virtual, upright, reduced, behind lens

5. ***Speed of light changes***

6. $\theta = 1.22\frac{\lambda}{D}$
$tan\,\theta = \frac{1.4\ m}{1\times10^5\ m}$
$\theta = 0.000014$
$\theta = 1.22\frac{\lambda}{D}$
$0.000014 = 1.22\frac{500\times10^{-9}\ m}{D}$
$D = \mathbf{0.044\ m}$

7. $f = 90.7\times10^6\ Hz, c = 3.00\times10^8\frac{m}{s}$
$c = f\lambda$
$3.00\times10^8\frac{m}{s} = (90.7\times10^6 Hz)\lambda$
$\boldsymbol{\lambda = 3.31\ m}$

8. $I_{ave} = \frac{cB_0^2}{2\mu_0}$
$I_{ave} = \frac{\left(3.00\times10^8\frac{m}{s}\right)(0.500\ T)^2}{2\left(4\pi\times10^{-7}\frac{T}{Nm}\right)}$
$I_{ave} = \mathbf{2.98\times10^{13}\ W/m^2}$

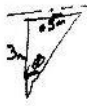
9. $n = 12.5$
$n = \frac{c}{v}$
$12.5 = \frac{3.00\times10^8\frac{m}{s}}{v}$
$\boldsymbol{v = 2.4\times10^7\frac{m}{s}}$

10. $n_1 = 1.5, \theta_1 = 25°, n_2 = 1.0, \theta_2 = ?$
$n_1\,sin\,\theta_1 = n_2\,sin\,\theta_2$
$1.5\,sin\,25° = 1.0\,sin\,\theta$
$0.6339 = sin\,\theta$
$\theta = sin^{-1}\,0.6339 = \mathbf{39.3°}$

11. $h_0 = 2\ cm, d_o = 15\ cm, h_i = -0.5\ cm, f = ?$
$\frac{h_i}{h_o} = -\frac{d_i}{d_o}$
$\frac{-0.5}{2} = \frac{-d_i}{15}$
$-2d_i = -7.5$
$d_i = 3.75\ cm$
$\frac{1}{f} = \frac{1}{d_i} + \frac{1}{d_o}$
$\frac{1}{f} = \frac{1}{15} + \frac{1}{3.75}$
$\boldsymbol{f = 3\ cm}$

12. $R = 12\ cm, f = 6\ cm, d_o = 10\ cm$
$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$
$\frac{1}{6} = \frac{1}{10} + \frac{1}{d_i}$
$\frac{1}{6} - \frac{1}{10} = \frac{1}{d_i}$
$\boldsymbol{d_i = 15\ cm}$

13. $sin\,\theta = \frac{m\lambda}{d}$
$sin\,10° = \frac{1(700\times10^{-9}\ m)}{d}$
$d = 4.03\ \mu m = \mathbf{4.03\times10^{-6} m}$

14. $sin\,\theta = \frac{m\lambda}{W}$

$tan\,\theta = \frac{0.5}{3}$
$\theta = 9.46°$
$sin\,9.46° = \frac{2(700\times10^{-9}\ m)}{W}$
$\boldsymbol{W = 8.52\times10^{-6}\ m}$

15. $sin\,\theta = \frac{m\lambda}{d}$
$d = \frac{1}{2000\frac{lines}{cm}} = 0.0005\ cm = 0.000005\ m$
$sin\,20° = \frac{3\lambda}{0.000005\ m}$
$\boldsymbol{\lambda = 5.7\times10^{-7}\ m}$

16. *Only ray 1 phase shifts so to get constructive interference,* $2t = \frac{\lambda_n}{2}$
$\lambda_n = \frac{\lambda}{n} = \frac{500\times10^{-9}\ m}{2.0} = 250\times10^{-9}\ m$
$2t = \frac{250\times10^{-9}\ m}{2}$
$t = \mathbf{6.25\times10^{-8}\ m}$

17. *a.* $\mathbf{500\frac{W}{m^2}}$ *(halved)*
b. $S = S_0\,cos^2\,\theta$
$300\frac{W}{m^2} = 500\frac{W}{m^2}cos^2\,\theta$
$0.6 = cos^2\,\theta$
$0.7746 = cos\,\theta$
$\theta = cos^{-1}\,0.7746 = \mathbf{39.2°}$