Physics 10164 - Exam 3C

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (25 pts) The intensity of sunlight received by a satellite just outside of the Earth's atmosphere is 1380 W/m^2.

a) What is the rms value of the Electric field of this radiation?
b) Assume the Earth's cross-sectional area is that of a circular disk with a radius equal to the radius of the Earth (on page 1 of formula sheet). How much solar energy is incident on the Earth in one day?
c) The amount of energy used by all of humanity on the Earth in one day is approximately 1.9 x 10^{18} Joules. How much time does it take for that much solar energy to shine on the entire Earth?

a) $1380 \frac{W}{m^2} = c * U_{TOT} \Rightarrow U_{TOT} = 4.6 \times 10^{-6}\ J/m^3$

$4.6 \times 10^{-6} = \epsilon_0 E_{rms}^2 \Rightarrow \boxed{E_{rms} = 721\ V/m}$

b) $P = I \times Area = (1380)\pi(6.38 \times 10^6)^2$

$= 1.76 \times 10^{17}$ Watts

$E = P * t = (1.76 \times 10^{17} \frac{J}{s})(1\ day)(\frac{86400 s}{day})$

$= \boxed{1.5 \times 10^{22}\ J}$

c) $1.9 \times 10^{18} = (1.76 \times 10^{17})\, t$

$\boxed{t = 11\ sec}$

2. (25 pts) A person has a near point of 24 cm and a far point of 48 cm. Glasses are used to correct this person's far point to a normal far point of infinity, and the glasses are 2.0 cm in front of the eye.

a) What must be the focal length of the lenses in order to correct the far point?
b) With these glasses, what is the new near point for the person?

a) For $p = \infty$, need $q = -46\,cm$

$$\Rightarrow \boxed{f = -46\ cm}$$

b) What value of p results in $q = -22\,cm$?

$$\frac{1}{p} + \frac{1}{-22} = \frac{1}{-46}$$

$$\Rightarrow \boxed{p = 42\ cm} \Rightarrow \boxed{44\ cm\ \text{from eye}}$$

3. (25 pts) Light of wavelength 632 nm is incident on a single slit of width 5.6×10^{-6} m. The resulting single-slit interference pattern illuminates a screen 7.5 meters away.

a) If the center of the central maximum is in the geometric center of a circular screen of radius 55 cm, how many complete maxima can fit on the screen, considering both the central maximum and the maxima on either side of the center?

b) If the slit width increases significantly, would your answer to part (a) increase, decrease or remain the same? Justify your answer mathematically or qualitatively.

a) Assume $y = 55$ cm, find what order # minimum is at that location.

assumes $a = 6.8 \times 10^{-5}$

$$\frac{ay}{L} = m\lambda \Rightarrow m = \frac{ay}{\lambda L} = 7.89$$

So 7th min is there, meaning 6 complete maxima are present on either side of the center.

Total # of maxima $= \boxed{13}$

b) If a increases, m also increases

so total $\boxed{\text{increases}}$

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a) For $a = 5.6 \times 10^{-6}$, $m = 0.65$, no complete maxima are visible.

4. (25 pts) Light is incident on a diffraction grating, resulting in several complete orders of the visible spectrum (400 - 700 nm) being visibly reflected. The red edge of the third order spectrum is reflected at an angle of 32.0° from the normal.

a) What is the angle of reflection for the blue edge of the third-order spectrum?
b) How many lines per cm does the grating have?
c) How many complete orders of the visible spectrum can be seen for this grating?

a) $d \sin\theta = m\lambda$

$d \sin 32° = (3)(700\ nm)$

$d = 3963\ nm$

$3963 \sin\theta = (3)(400)$

$\boxed{\theta = 17.6°}$

b) $d = 3963\ nm = 3.963 \times 10^{-4}\ cm$

$n = \frac{1}{d} = \boxed{2520\ lines/cm}$

c) For $\lambda = 700\ nm$, $\theta = 90°$, $m = ?$

$3963 \sin 90 = m(700)$

$m = 5.66$

$\boxed{\text{5 orders visible}}$