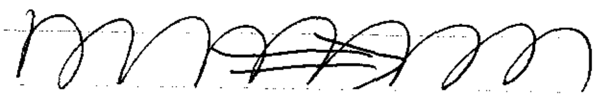
Phy ~~1~~32 – HW XI–XII solutions

1)



$n \Rightarrow$ turns/m

$B = \mu_0 n I$

a) Flux per turn is then $B \cdot A$

Total # of turns is $n \cdot l$ & total flux is scaled by this, so

$$\Phi = B \cdot A \cdot nl = \mu_0 n^2 I A l$$

$V = -L\frac{dI}{dt}$ and $V = -\frac{d\Phi}{dt}$, so, since $\Phi \propto I$,

$$LI = \Phi, \text{ or } \boxed{L = \frac{\Phi}{I} = \mu_0 n^2 A l}$$

turns per length! not total turns

b) $n = 10^4\ m^{-1}$

$d = .05m \Rightarrow r = .025m \Rightarrow A = \pi r^2 = .00196\ m^2$

$l = .5m$

so $L = \mu_0 n^2 A l = 4\pi\times10^{-7} \cdot (10^4)^2 \cdot (.00196) \cdot (.5) = .123\ H$

If $\frac{dI}{dt} \approx \frac{\Delta I}{\Delta t} = \frac{10A}{.001sec} = 10^4\ A/sec$

$$V = -L\frac{dI}{dt} \boxed{= -1230V!}$$

2) $L = 5\times10^{-3}H$ $V = 5V \Rightarrow \frac{dI}{dt} = \frac{V}{L} = \frac{5V}{5\times10^{-3}H} = 10^3\ A/sec$

so $I = \frac{dI}{dt} \cdot t = 10^3 A/s \cdot t = 1A$

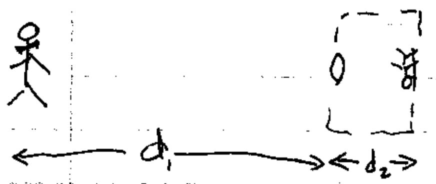
so $\boxed{t = 10^{-3} sec}$

3(b)) $\omega = 3\times10^{12}\,s^{-1}$ We know $v_{wave} = \frac{\omega}{k} = c = 3\times10^{8}\,m/s$

So $k = \frac{\omega}{c}$ and $k = \frac{2\pi}{\lambda}$, so

$$\lambda = \frac{2\pi}{k} = \frac{2\pi c}{\omega} = \frac{2\pi\cdot 3\times10^{8}\,m/s}{3\times10^{12}\,m/s} = \boxed{6.28\times10^{-4}\,m}$$

4) $f = 50\,mm$ $d_2 = 51\,mm$



$$\frac{1}{f} = \frac{1}{d_1} + \frac{1}{d_2} \Rightarrow \frac{1}{f} - \frac{1}{d_2} = \frac{1}{d_1}$$

$$d_1 = \left(\frac{1}{f} - \frac{1}{d_2}\right)^{-1} = \left(\frac{1}{50} - \frac{1}{51}\right)^{-1} mm = 2550\,mm$$

$$\boxed{d = 2.55\,m}$$

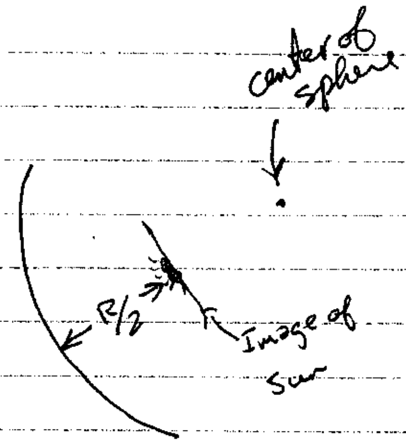
5(b)) $d_1 = 4\,m$. We want $M = \frac{2\,cm}{2\,m} = 10^{-2} = \frac{d_2}{d_1}$, so

$$d_2 = 10^{-2} d_1 = 4\,cm$$

What is f? $\frac{1}{f} = \frac{1}{d_1} + \frac{1}{d_2} \Rightarrow f = \left(\frac{1}{d_1} + \frac{1}{d_2}\right) = \left(\frac{1}{.04} + \frac{1}{4}\right)^{-1} m$

$$= .0396\,m = \boxed{39.6\,mm = f}$$

6)



We found $f = \frac{R}{2}$

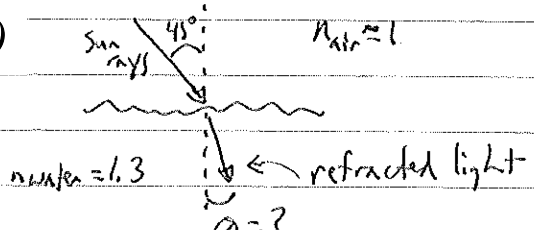
So $d_1 \simeq \infty$ (sun is far away!)

So $\frac{1}{d_1} + \frac{1}{d_2} \simeq \frac{1}{d_2} = \frac{1}{f}$

So $\boxed{d_2 = f = \frac{R}{2}} = \frac{d}{4} = 2.5\,cm$

Session XII, 3

7)



Use Snell's law to find angle of refraction $n_{air} \sin\theta_{air} = n_{water} \sin\theta_w$

So $\sin\theta_w = \frac{n_a}{n_w} \sin\theta_a$

$= \frac{1}{1.3} \frac{\sqrt{2}}{2}$

$\boxed{\theta_w \approx 33°}$

8) for diffraction grating $d \sin\theta_n = n\lambda$

Want to find est. of d - spacing b/t recording pits on CD

We are given that for $\lambda = 500\,nm$ $n=1$ spot is at $10°$

$d = \frac{n\lambda}{\sin\theta_n} = \frac{(1)\,500\,nm}{\sin(10°)} = \underline{2.88 \times 10^{-6}\,m}$

9) Apply diffraction eqn. $d \sin\theta_n = n\lambda$

Solve for λ $\lambda = \frac{d \sin\theta_n}{n} = \frac{(0.15\,nm)\sin(10°)}{1}$

$= 2.6 \times 10^{-11}\,m$

$2 \sim 2.5 \times 10^{4}$ times smaller than light wavelengths!

10.

a. As we saw in Guidebook entry XII.17, for telescope we have d_1 fixed and very large. This means

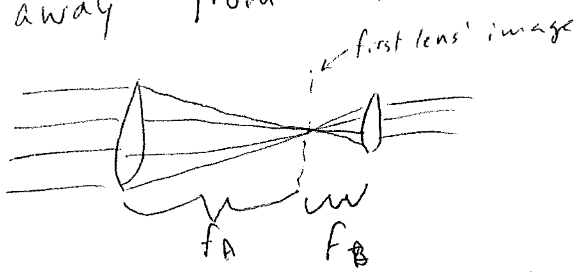
$$\frac{1}{f} = \frac{1}{d_1} + \frac{1}{d_2} \approx \frac{1}{\infty} + \frac{1}{d_2} \approx \frac{1}{d_2} \Rightarrow f \approx d_2.$$

Thus, for highest magnification, we want f big.

$M = \frac{d_2}{d_1} \approx \frac{f}{d_1}$ is biggest when f is big.

We want biggest f for our first lens, so want $\boxed{\text{1cm focal length lens}}$ for eyepiece.

b. With infinitely far away object, incoming rays are parallel, and thus are focused at focal length. To get these rays to come <u>out</u> paralled through eye piece, we need the second lens to be <u>its</u> focal length away from the first focal point.



total separation $= f_1 + f_2 = 20cm + 1cm = \boxed{21cm}$

c. We still want 2nd lens its focal length away from first lens' image. Since we've ~~...~~ brought the ~~image~~ object closer to the first lens, its image is now farther from the lens. Since nothing changes about the second lens, we know it must be two cm ~~inches~~ farther, that is, $d_2 = f_A + 2cm$. Using this, we can solve for d_1.

$$\frac{1}{f_A} = \frac{1}{d_1} + \frac{1}{d_2} = \frac{1}{d_1} + \frac{1}{f_A + 2cm} \Rightarrow \frac{1}{d_1} = \frac{1}{f_A} - \frac{1}{f_A + 2cm}$$

$$d_1 = \frac{1}{\frac{1}{20cm} - \frac{1}{22cm}} = \boxed{220cm}$$