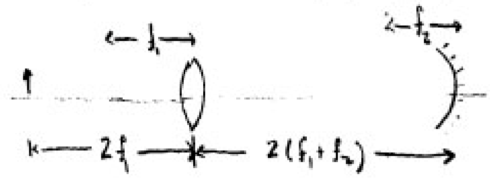
30a)



$$\frac{1}{o}+\frac{1}{i}=\frac{1}{f}$$

For first lens, this translates into

$$\frac{1}{2f_1}+\frac{1}{i}=\frac{1}{f_1} \Rightarrow \frac{1}{i}=\frac{2}{2f_1}-\frac{1}{2f_1}=\frac{1}{2f_1}$$

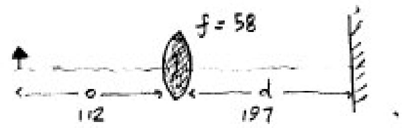
$$\Rightarrow \boxed{i = 2f_1}$$

This image becomes the object for the mirror. The distance from the mirror is $2(f_1+f_2)-2f_1 = 2f_2$

$$\frac{1}{2f_2}+\frac{1}{i}=\frac{1}{f_2} \Rightarrow \boxed{i = 2f_2}.$$

So an image forms at a distance $2f_1$ from the lens. This image is real and upright, but not where the eye is! Because this image is real, real light comes from it and forms an upside down image at the site of the original object

31)



$$\frac{1}{o}+\frac{1}{i}=\frac{1}{f} \Rightarrow \frac{1}{i}=\frac{1}{f}-\frac{1}{o}$$

$$\Rightarrow i = \frac{of}{o-f} \Rightarrow 120.3 \text{ cm}$$

which is 76.7 cm in front of the mirror

This real image (∴ real light comes from this image) sends light toward the lens which forms a real image at $\frac{1}{o}+\frac{1}{i}=\frac{1}{f} \Rightarrow i = 112$ cm

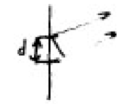
object distance is now 120.3

But also the original image reflects off the mirror and forms an image ... the object appears to be $197 + 76.7 = 273.7$ cm from the lens. Hence, the new image forms at 73.6 in front of the lens

Let's do it formally: 1^{st} image formed : $i = 120.3$ $m = -1.07$

2^{nd} image (formed by mirror) : $i = 76.7$ in back of mirror $m = 1$

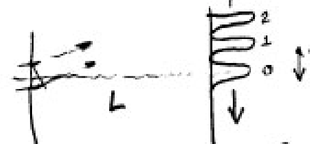
3^{rd} image (coming thru system ...

4) 

$d \sin\theta = m\lambda$. For small angle $d\theta_1 = m_1\lambda$

$d\theta_2 = (m_1+1)\lambda$

$$d(\theta_2 - \theta_1) = \lambda \Rightarrow d = \frac{\lambda}{\Delta\theta} = \frac{592\times10^{-9}}{1 \cdot 2\pi/360} \Rightarrow \boxed{33.9\,\mu m}$$

9) 

$$\left.\begin{aligned} d\sin\theta_{10} &= 19\lambda/2 \\ d\sin\theta_1 &= \lambda/2 \end{aligned}\right\} \text{ small } \theta \Rightarrow \begin{aligned} d\theta_{10} &= 19\lambda/2 \\ d\theta_1 &\ \ \lambda/2 \end{aligned}$$

So: 1) $\frac{d\,h_{10}}{L} = \lambda/2$

2) $\frac{d\,h_1}{L} = 19\lambda/2$

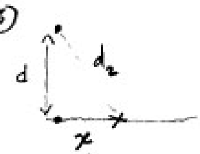
$$1) - 2) = \frac{\left(\frac{d}{L}\Delta h\right)2}{18} = \lambda$$

$$= \frac{(.15\times10^{-3})}{(50\times10^{-2})}\frac{(18\times10^{-3})\,2}{18} = \boxed{600\,nm}$$

14) We are, in essence, told that the path length difference to the central maximum has increased from 0 to 5λ. What is that path length difference ??

$$pld = 1.7t - 1.4t = 5\lambda$$

$$\text{Hence } t = \frac{5\lambda}{.3} = \boxed{8.0\,\mu}$$

23) 

$pld = d_2 - x = (d^2+x^2)^{1/2} - x = m\lambda$ where m are adjacent integers

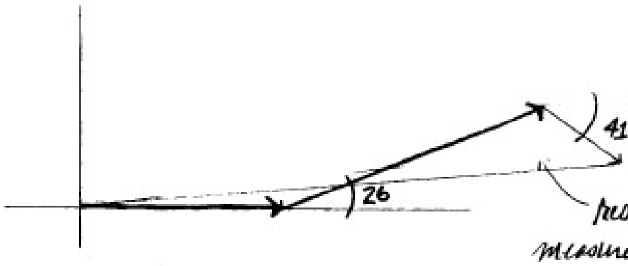
So $d^2 + \cancel{x^2} = m^2\lambda^2 + \cancel{x^2} + 2xm\lambda$

$$\Rightarrow x = \frac{d^2 - m^2\lambda^2}{2m\lambda}$$

a) I get
$$\left.\begin{aligned} m&=3 & x &= 1.14 \\ m&=2 & x &= 3.04 \\ m&=1 & x &= 7.67 \end{aligned}\right\}$$
the book doesn't agree. I think the book is wrong.

b) The intensity of the minima would not be zero, because the amplitude of the more distant source would be

24)



So, graphically, using a calibrated ruler (... what ruler isn't ??!...) and reasonably careful drawing technique, I get

$$\boxed{27 \sin(\omega t + 8^\circ)}$$

Doing it algebraically (... ugly work which I do not show.. + largely done by computer..), I get

$$\boxed{26.8 \sin(\omega t + 6.67^\circ)}$$

Ouch... my graphical technique is not great! -- but in some cases a 10%$^+$ error in phase angle, + my considerably smaller error in amplitude can be well tolerated.

29)

$n_1 = 1.2$ $\quad t = 460\ nm$

$n_2 = 1.33$

There is a 180° phase shift at both the front + back surfaces. They cancel each other out. So, the optical path length difference accounts for the interference

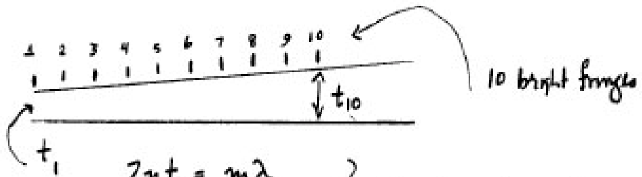
$$2tn_1 = m\lambda \Rightarrow \lambda = \frac{2tn_1}{m}$$ ... look for m's that give you visible λ's

for $m = 2$, $\lambda = 552\ nm$ (green)

The diver will see most intensely that light that is not reflected back

$$2tn_1 = (m + 1/2)\lambda \Rightarrow \lambda = 2tn_1$$

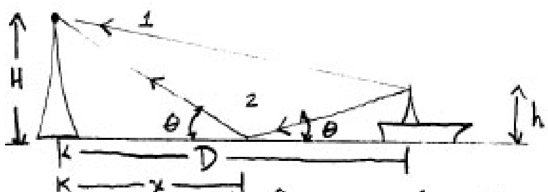
4)



$$2nt_1 = m\lambda$$
$$2nt_{10} = (m+9)\lambda$$
$$\Rightarrow 2n\Delta t = 9\lambda$$

$$\Delta t = \frac{9\lambda}{2n} = \frac{9\ 630}{2(1.5)} = 1890\text{ nm} = \boxed{1.89\ \mu m}$$

48)



H = 160
h = 23
λ = 3.43

Upon reflection from the surface of the water, there is a π phase shift introduced. What's the pld between 2 (the reflected wave), and 1 (the direct route), including an account of the phase shift upon reflection?

from similar Δ's, $\frac{h}{D-x} = \frac{H}{x} \Rightarrow HD - Hx = hx \Rightarrow (H+h)x = HD$

$$\boxed{x = \frac{HD}{H+h}}$$

$$pl_1 = \sqrt{D^2 + (H-h)^2}$$
$$pl_2 = \sqrt{(D-x)^2 + h^2} + \sqrt{x^2 + H^2}$$
$$pld = pl_2 - pl_1 = \sqrt{\left(D - \frac{HD}{H+h}\right)^2 + h^2} + \sqrt{\left(\frac{HD}{H+h}\right)^2 + H^2} - \sqrt{D^2 + (H-h)^2}$$

and we want pld = $m\lambda$ for a minimum (... remember the π shift due to reflection...)

Not pretty, but basically one equation in the unknown D.