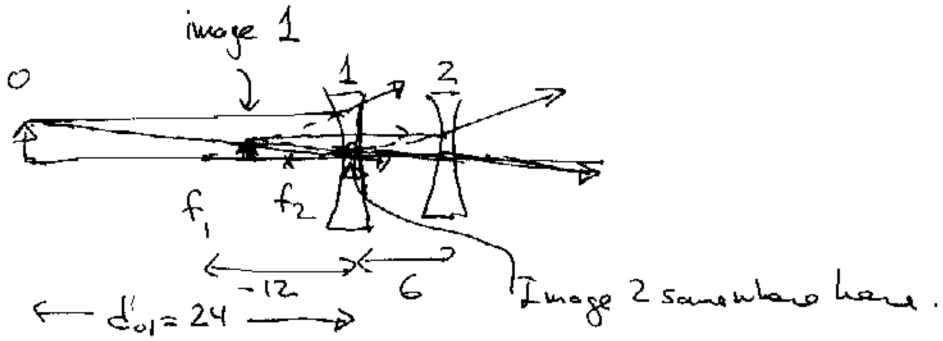
Physics 116
W 2007
O.E.V.

Solutions to extra problems

$\boxed{27\text{-}21}$



The sequence is Lens 1 makes an image, this image is the object for lens 2.

a) $\frac{1}{d_{i1}} = \frac{1}{f_1} - \frac{1}{d_{o1}} = -\frac{1}{12} - \frac{1}{24} = -\frac{1}{8} \Rightarrow d_{i1} = -8$ cm $\leftarrow$ image 1

image is virtual, on same side of lens as object.

$\frac{1}{d_{i2}} = \frac{1}{f_2} - \frac{1}{d_{o2}} = -\frac{1}{12} - \frac{1}{(8+6)} = -\frac{1}{6.47} \Rightarrow d_{i2} = -6.47$ cm in front of lens 2

So final image is $\simeq -6.5$ cm in front of lens 2, or -0.5 cm in front of lens 1.

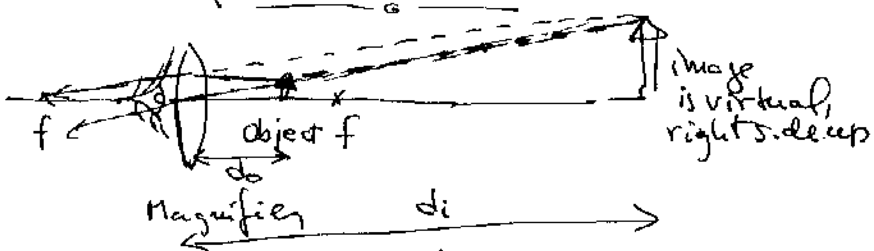
b) $M = M_1 \times M_2 = \left(-\frac{d_{i1}}{d_o}\right)\left(-\frac{d_{i2}}{d_{o2}}\right) = \left(-\frac{-8}{24}\right)\left(-\frac{-6.5}{14}\right) = +0.15$

———o———

$\boxed{27\text{-}27}$ Lenses need to make an image at 135 cm – So $\frac{1}{d_i} = \frac{1}{f} - \frac{1}{d_o}$ and since $d_o = \infty$ and f has to be negative to make an image in front of the lenses, $f = -135$ cm

———o———

$\boxed{27\text{-}49}$



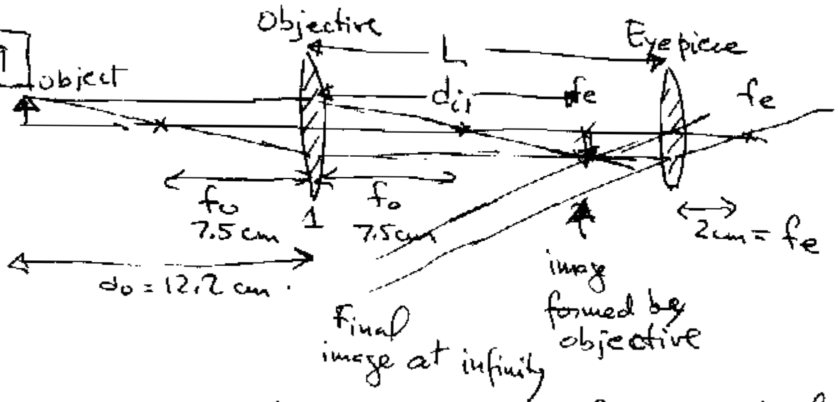
(a) $\frac{1}{d_o} = \frac{1}{f} - \frac{1}{d_i} = \frac{1}{+8.65} - \frac{1}{-25.6} = 0.1547 \Rightarrow d_o = +6.47$ cm

(b) Angular magnification for this specific case is

$$\frac{\frac{h_o}{d_o} \leftarrow \beta}{\frac{h_o}{25.6} \leftarrow \alpha} = 3.96$$

———o———

27-59



a) Assume image of object is formed at focal point of eyepiece.

$$\frac{1}{d_{i1}} = \frac{1}{f_o} - \frac{1}{d_o} \Rightarrow \frac{1}{7.5} - \frac{1}{12.2} = 0.514 \Rightarrow d_{i1} = 19.5\text{ cm}.$$

So $L = d_{i1} + f_e = 19.5\text{ cm} + 2\text{ cm} = 21.5\text{ cm}$

b) $$M = M_{\text{objective}} \times M_{\text{eyepiece}} = \underbrace{\left(-\frac{d_{i1}}{d_o}\right)}_{\text{linear magnification of objective}} \times \underbrace{\left(\frac{25}{f_e}\right)}_{\text{angular magnification of eyepiece}} = -\frac{19.5}{12.2} \times \frac{25}{2} = \underline{\underline{-20}}$$

This is the magnification with object at 12.2 cm in front of lens.

<u>NOTE</u>: In section 27-4 of text the magnification of the compound microscope is given as $M_{\text{objective}} = -\frac{d_{i1}}{d_{o1}} \approx \frac{d_i}{f_{\text{objective}}}$.

This is true if object is essentially at focal point of objective, which is not the case here. If $M_{obj} \approx \frac{d_i}{f_o}$, then

$$M_{\text{total}} = \left(-\frac{d_i}{f_o}\right)\left(\frac{25}{f_e}\right) \simeq -32$$, the answer in text.

27-65 (a) $L = f_o + f_e = 30 + 5 = 35$ cm.

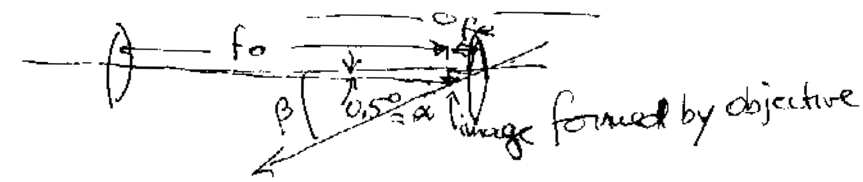
(b) Image formed by objective will be at a distance

$$\frac{1}{d_i} = \frac{1}{f_{obj}} - \frac{1}{d_o} = \frac{1}{30\text{ cm}} - \frac{1}{500\text{ cm}} = 0.03133 \Rightarrow d_i = 31.92\text{ cm}$$

To make image at ∞, the image made by objective will have to be on focal point of eyepiece.

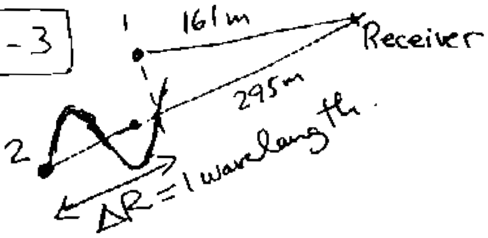
$$L = 31.92\text{ cm} + 5\text{ cm} = 36.9\text{ cm}$$

27-69



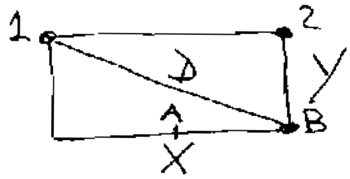
$$\tan\beta = \frac{h_i}{f_e} = \frac{f_o \tan 0.5^\circ}{f_e} = \frac{530}{2.5}\tan 0.5^\circ \Rightarrow \beta \simeq 10.5^\circ$$

$\boxed{28-3}$



$\Delta R = 295\,m - 161\,m = 134\,m$

$\boxed{28-5}$



A hears a maximum because is at equal distance from ① and ② –

B hears a maximum because the path difference $D-Y$ is a wavelength (or multiple)

So $D - Y = \sqrt{X^2+Y^2} - Y = \sqrt{3^2+1.5^2} - 1.5 = 1.85\,m$

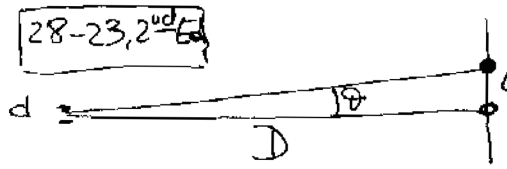
$$f = \frac{v_{sound}}{\lambda} = \frac{343\ m/s}{1.85\,m} = 185\ Hz$$

$\boxed{28-15}$ $d\sin\theta = m\lambda \Rightarrow \lambda = \frac{d\sin\theta}{m} = \frac{48\times10^{-5}\,m\ \sin 0.0990^\circ}{2} = 415\ nm$ (a)

(b) If d increases but θ is constant then λ has to increase

(c) $\lambda = \frac{d\sin\theta}{m} = \frac{68\times10^{-5}\sin 0.0990^\circ}{2} = 587\ nm.$

$\boxed{28-21}$ $\boxed{28-23, 2^{nd}\ Ed}$



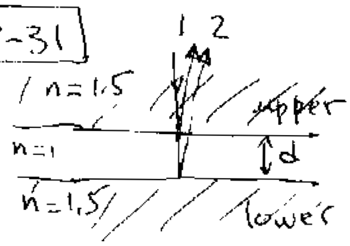
$\Delta y = 2.5\,cm = D\tan\theta$

For $m=1$, $d\sin\theta = \lambda$

Angles are small, so $\tan\theta \approx \sin\theta \approx \theta = \frac{\Delta y}{D} = \frac{\lambda}{d}$

So $D = d\frac{\Delta y}{\lambda} = \frac{2.2\times10^{-5}\,m \times 2.5\times10^{-2}\,m}{6.328\times10^{-7}\,m} = 0.869\,m$

$\boxed{28-31}$



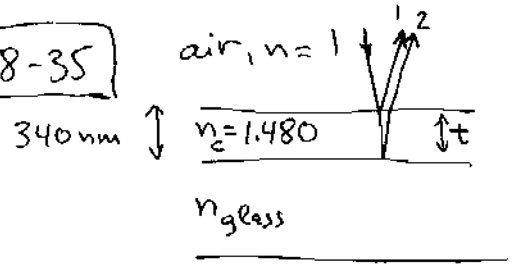
There is a phase inversion for ray 2 at lower plate.
Relevant wavelength is wavelength in air.
Constructive interference: $2d = \frac{1}{2}\lambda, \frac{3}{2}\lambda$, etc
Destructive interference: $2d = m\lambda$

In problem $d = 600$ nm, so (a) $2d = 1200\ nm = 2\times\underbrace{600\,nm}_{\lambda}$
destructive

(b) $\lambda = 800$ nm $\quad \frac{800\ nm}{600\ nm} = \frac{4}{3} = \frac{\lambda}{d} \Rightarrow$ constructive interference.

(c) $\lambda = 343$ nm $\quad \frac{343\ nm}{600} = \quad 0.57 = \frac{4}{7} \Rightarrow$ constructive interference.

$\boxed{28\text{-}35}$



(a) if $n_{glass} = 1.35$ there is a phase inversion only at air-coating surface

Destructive interference:

$$2t = m\frac{\lambda}{n_c}$$

So $2t\,n_c = 2 \times 340\,\text{nm} \times 1.48 = 1006.4\,\text{nm}$.

So for $m = 2$ (two wavelengths), $\lambda = \frac{1006.4\,\text{nm}}{2} = 503.2\,\text{nm}$.

$m = 3 \quad \lambda = \frac{1006.4}{3} = 335.5\,\text{nm} < 400\,\text{nm}$ -

(b) $n_{glass} = 1.675$, then there is a phase inversion also at coating/glass surface -

To get cancellation on reflection, $2t = (m+\frac{1}{2})\frac{\lambda}{n_c}$, with $m = 0, 1, 2 \ldots$

$\lambda = \frac{2t\,n_c}{m+\frac{1}{2}}$ - For $m = 0$, $4t\,n_c = 4 \times 340\,\text{nm} \times 1.48 =$

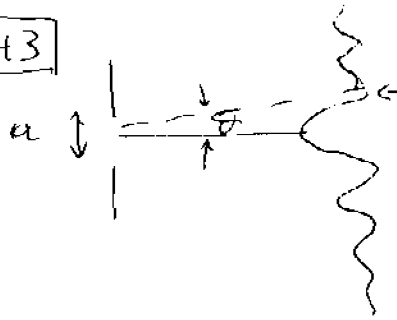
$= 1006.4\,\text{nm}$.

$m = 2, \; m+\frac{1}{2} = \frac{5}{2} \Rightarrow \lambda = \frac{1{,}006.4 \times 2}{5} = 402.6\,\text{nm}$.

$m = 3, \; m+\frac{1}{2} = \frac{7}{2} \Rightarrow \lambda = \frac{1{,}006.4 \times 2}{7} = 287.5\,\text{nm}$

$m = 1, \; m+\frac{1}{2} = \frac{3}{2} \Rightarrow \lambda = \frac{1006.4 \times 2}{3} = 670.9\,\text{nm}$

$\boxed{28\text{-}43}$



← dark fringes when

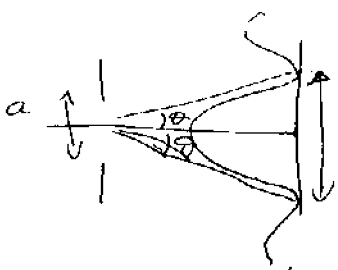
$a \sin\theta = m\lambda$

and maximum θ is 90°, $\sin\theta = 1$

$$m_{max} = \frac{a}{\lambda} = \frac{8000\,\text{nm}}{553\,\text{nm}} = 14.5$$

or 14 zeroes

$\boxed{28\text{-}51}$



For slit,

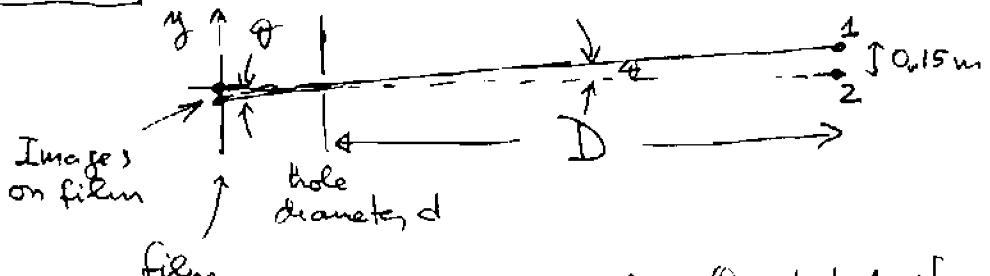
← $a \sin\theta = \lambda \Rightarrow \sin\theta = \frac{\lambda}{a} = \frac{540 \times 10^{-9}\,\text{m}}{130 \times 10^{-3}\,\text{m}}$

For circular aperture, angular aperture $\approx 2 \times 1.22\frac{\lambda}{d} = 1.22 \times \frac{540 \times 10^{-9}}{130 \times 10^{-3}} \times 2 =$

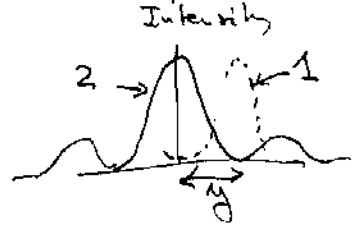
$= 1 \times 10^{-5}$ radians.

(b) $\Delta y = 2f\tan\theta \approx 2f\theta = 2 \times 640\,\text{mm} \times \frac{1 \times 10^{-5}\,\text{radians}}{2} = 0.064\,\text{mm}$

28-53 Pinhole camera has a circular aperture of diameter, d



(a) Images can be differentiated if maximum from Source 1 falls on first zero from source 2

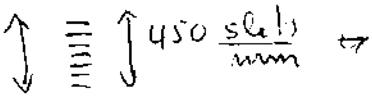


1^{st} zero $\Rightarrow$ $1.22\frac{\lambda}{d} = \sin\theta \approx \theta$.

$$\theta = 1.22 \times \frac{520\times10^{-9}\,m}{0.5\times10^{-3}\,m} = 1.27\times10^{-3}\ \text{radians}$$

(b) $0.15\,m = D\tan\theta \Rightarrow D \approx \frac{0.15\,m}{\theta} = 118\,m \approx 120\,m = 0.12\,km$

28-63 For diffraction grating



Slits separation $\equiv d = \frac{1\,mm}{450}$

Maxima occur when $d\sin\theta = m\lambda$. Two wavelengths in this problem are $430\times10^{-9}\,m$ (v) and 630×10^{-9} (r)

$$\sin\theta = \frac{m\lambda}{d} = \frac{m\lambda\times450}{10^{-3}m}$$

violet: $\sin\theta = \frac{m\times430\times10^{-9}m\times450}{10^{-3}m} = 1.935\times10^{-1}\times m$

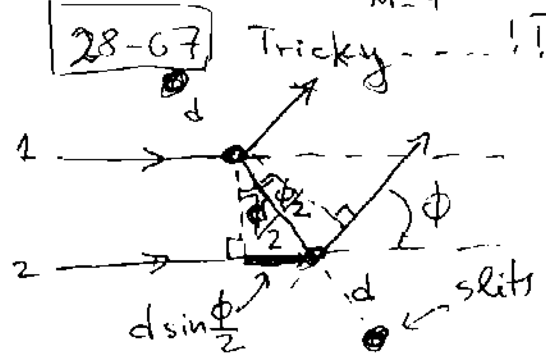
$$\begin{cases} m=1 & \theta_v = 11.16^\circ \\ m=2 & \theta_v = 22.8^\circ \\ m=3 & \theta_v = 35.5^\circ \\ m=4 & \theta_v = 50.7^\circ \\ m=5 & \theta_v = 75.4^\circ \\ m=6 & \text{impossible} \end{cases}$$

red $\sin\theta = \frac{m\times630\times10^{-9}m\times450}{10^{-3}m} = 2.835\times10^{-1}\times m$

$$= \begin{cases} m=1 & \theta_R = 16.5^\circ \\ m=2 & \theta_R = 34.5^\circ \\ m=3 & \theta_R = 58.3^\circ \\ m=4 & \text{impossible} \end{cases}$$

Order of colors on screen, from center
V, R, V, R, V, V, R, V

28-67 Tricky....!!! This is how crystal diffraction works ....



d is the separation between slits (dots)
Ray 2 travels an extra distance over Ray 1 which is $2d\sin\phi_2$. If this is a multiple of λ one gets a maximum of intensity.