Homework- chapter 32 [5, 15, 23, 29, 37, 41, 45, 49, 55, 61]
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Q5] $\phi + (90° - \theta_1) + (90° - \theta_2) = 180° \rightarrow \phi = \theta_1 + \theta_2$

Do the same for triangle ABD

$\alpha + 2\theta_1 + 2\theta_2 = 180° \rightarrow \alpha = 180° - 2(\theta_1 + \theta_2) = 180° - 2\phi$

At point D

$\beta = 180° - \alpha = 180° - (180° - 2\phi) = \boxed{2\phi}$

Q15] $m = \frac{-d_i}{d_o} \rightarrow d_i = -md_o$

$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \rightarrow f = \frac{d_o d_i}{d_o + d_i} = \frac{d_o(-md_o)}{d_o - md_o} = \frac{md_o}{m-1}$

$= \frac{4(2.00\text{cm})}{4-1} = 2.677\text{cm}$

$r = 2f = 2(2.667\text{cm}) = \boxed{5.3\text{cm}}$

As the focal length is positive, mirror is $\boxed{\text{concave}}$

Q23] $m = \frac{-d_i}{d_o} \rightarrow d_i = -md_o$

$\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \rightarrow f = \frac{d_o d_i}{d_o + d_i} = \frac{d_o(-md_o)}{d_o - md_o} = \frac{md_o}{m-1}$

$\frac{(0.55)(3.2\text{m})}{0.55-1} = \boxed{-3.9\text{m}}$

Q29] a] $m = \frac{-d_i}{d_o} \rightarrow d_i = -md_o$

$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} \rightarrow \frac{1}{f} = \frac{1}{d_o} + \frac{1}{-md_o}$

$$= \frac{1}{d_o}\left(1 - \frac{1}{m}\right) \rightarrow \boxed{d_o = f\left(1 - \frac{1}{m}\right)}$$

b] $\left(1 - \frac{1}{m}\right) \leq 0 \rightarrow 1 \leq \frac{1}{m} \rightarrow \boxed{0 < m \leq 1}$

37] $d = ct = (3.00 \times 10^8 m/s)(10^{-8} s) = \boxed{3m}$

41] $n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightarrow \theta_1 = \sin^{-1}\left(\frac{n_2}{n_1}\sin\theta_2\right)$

$$= \sin^{-1}\left(\frac{1.00}{1.33}\sin 56.0°\right) = \boxed{38.6°}$$

45] $\tan\theta_1 = \frac{l_1}{h_1} = \frac{(2.5m)}{(1.3m)} = 1.9231 \rightarrow \theta_1 = 62.526°$

from air into water

$n_{air} \sin\theta_1 = n_{water} \sin\theta_2$;

$(1.00)\sin 62.526° = (1.33)\sin\theta_2 \rightarrow \theta_2 = 41.842°$

horizontal distance

$l = l_1 + l_2 = l_1 + h_2 \tan\theta_2$

$= 2.5m + (2.1m)\tan 41.842° = 4.38\ m \approx \boxed{4.4m}$

49] $n_1 \sin\theta_1 = \sin\theta_r \rightarrow \theta_r = \sin^{-1}(1.52 \sin 30°) = 49.46°$

$\phi = 2(\theta_r - 30°) = 2(49.46° - 30°) = \boxed{38.9°}$

using snell's law

By symmetry the angle ϕ is twice the angle of the refracted beam from the vertical

55] Using snell's law

$n_1 \sin\theta_1 = n_2 \sin\theta_2 \rightarrow (1.000)\sin 60° = (n)\sin\theta_2 \rightarrow$

$\theta_2 = \sin^{-1}\left(\frac{\sin 60°}{n}\right)$

(a)] $\tan\theta_1 = \frac{l}{h} = \frac{(7.6cm)}{(8.0cm)} = 0.95 \rightarrow \theta_1 = 43.53^\circ$

$n_{liquid} \sin\theta_1 = n_{air} \sin\theta_2 \rightarrow n_{liquid} \sin\theta_{1max} = (1.00)\sin 90^\circ \rightarrow \sin\theta_{1max} = \frac{1}{n_{liquid}}$

So,

$\sin\theta_1 \geq \sin\theta_{1max} = \frac{1}{n_{liquid}} \rightarrow \sin 6.887 \geq \frac{1}{n_{liquid}}$

$\rightarrow \boxed{n_{liquid} \geq 1.5}$

✓

Homework - chapter 33 [5, 15, 21, 27, 37, 45, 55, 65]

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Q5] a] $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \rightarrow d_i = \frac{d_o f}{d_o - f} = \frac{(10.0m)(0.105m)}{10.0m - 0.105m}$

$= 0.106m = \boxed{106mm}$

Same general calculation b] $d_i = \frac{d_o f}{d_o - f} = \frac{(3.0m)(0.105m)}{3.0m - 0.105m} = 0.109m = \boxed{109mm}$

Same general calculation c] $d_i = \frac{d_o f}{d_o - f} = \frac{(1.0m)(0.105m)}{1.0m - 0.105m} = 0.117m = \boxed{117mm}$

Small to max d] $\frac{1}{d_{o\,min}} + \frac{1}{d_{i\,max}} = \frac{1}{f} \rightarrow d_{o\,min} = \frac{d_{i\,max} - f}{d_{i\,max} f}$

$= \frac{(132mm)(105mm)}{132mm - 105mm} = 513mm = \boxed{0.513m}$

Q15] a] $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \rightarrow d_i = \frac{d_o f}{d_o - f}$; $m = \frac{d_i}{d_o} = \frac{-f}{d_o - f}$

$d_o > f$, image distance is positive, producing a real image which gives an inverted image

b] $d_o < f$, image is negative, producing a virtual image, which gives upright image

c] $d_i = \frac{(-f)f}{-f - f} = \frac{f}{2}$ $m = \frac{-d_i}{d_o} = \frac{f}{-f - f} = \frac{1}{2}$

limit of large negative object distance

$d_i = \frac{(-\infty)f}{(-\infty - f)} = f$ $m = \frac{-d_i}{d_o} = \frac{f}{-\infty - f} = 0.$

$-d_o > f$, the image is $\boxed{\text{real \& upright}}$ with

$\frac{1}{2} f < d_i < f$ & $0 < m < 1/2$.

d] $d_i = \frac{(0)f}{0-f} = 0$ $m = \frac{-d_i}{d_o} = \frac{-f}{0-f} = 1$

$0 < -d_o < f$, the image is $\boxed{\text{real \& upright}}$, with $0 < d_i < \frac{1}{2}f$ & $\frac{1}{2} < m < 1$

21] $\frac{1}{d_{o1}} + \frac{1}{d_{i1}} = \frac{1}{f_1} \rightarrow d_{i1} = \frac{d_{o1}f_1}{d_{o1}-f_1} = \frac{(35.0cm)(25.0cm)}{(35.0cm)-(25.0cm)}$

$= 87.5cm$

The image is object for the second lense, because it is beyond the second lense

$d_{o2} = 16.5cm - 87.5cm = -71.0cm$

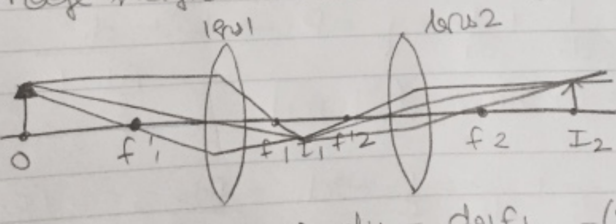
$\frac{1}{d_{o2}} + \frac{1}{d_{i2}} = \frac{1}{f_2} \rightarrow d_{i2} = \frac{d_{o2}f_2}{d_{o2}-f_2} = \frac{(-71.0cm)(25.0cm)}{(-71.0cm)-(25.0cm)}$

$= \boxed{18.5cm}$ $\boxed{\text{beyound second lenses}}$

$m = m_1 m_2 = \left(\frac{-d_{i1}}{d_{o1}}\right)\left(\frac{-d_{i2}}{d_{o2}}\right) = \frac{d_{i1}d_{i2}}{d_{o1}d_{o2}}$

$= \frac{(87.5cm)(18.5cm)}{(35.0cm)(-71.0cm)} = \boxed{-0.651\times(\text{inverted})}$

27] a] We see the image is real & upright. We estimate that it is 30 cm beyond the second lens, & that the final image height is half the original object height



b] $\frac{1}{d_{o1}} + \frac{1}{d_{i1}} = \frac{1}{f_1} \rightarrow d_{i1} = \frac{d_{o1}f_1}{d_{o1}-f_1} = \frac{(36cm)(13cm)}{(36cm)-(13cm)}$

$= 20.35cm$

$56.00 - 20.35 = 35.65$

for second lense,

$d_{o2} = 56cm - 20.35cm = 35.65cm$

image from second lense,

$$\frac{1}{d_{o2}} + \frac{1}{d_{i2}} = \frac{1}{f_2} \rightarrow d_{i2} = \frac{d_{o2}f_2}{d_{o2}-f_2} = \frac{(35.65cm)(16cm)}{(35.65cm)-(16cm)}$$

$= \boxed{29.25cm}$ beyound the second lens

Total two lenses

$$m = m_1 m_2 = \left(\frac{-d_{i1}}{d_{o1}}\right)\left(\frac{-d_{i2}}{d_{o2}}\right) = \frac{(20.35cm)(29.25cm)}{(36cm)(35.65cm)}$$

$= \boxed{0.46x}$

37] $f\text{-stop}_2 = \frac{f}{D} \; \frac{(70mm)}{(1.0mm)} = \frac{f}{70}$

$$t_1(f\text{-stop}_1)^{-2} = t_2(f\text{-stop}_2)^{-2} \rightarrow t_2 = t_1\left(\frac{f\text{-stop}_2}{f\text{-stop}_1}\right)^2$$

$$= \frac{1}{250s}\left(\frac{70}{11}\right)^2 = 0.16s \approx \boxed{\frac{1}{6}s}$$

45] a] $P = \frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{\infty} + \frac{1}{(-0.78m)} = -1.2820 \approx \boxed{1.3D}$

b] $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} = P \rightarrow d_o = \frac{d_i}{Pd_i - 1} = \frac{(-0.25)}{(-1.2820)(-0.25)-1}$

$= 0.37m \approx \boxed{37cm}$

55] a] $\frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \rightarrow d_i = \frac{fd_o}{d_o - f} = \frac{(6.00cm)(5.85cm)}{(5.85cm - 6.00cm)}$

$= \boxed{-234cm}$

b] $m = \frac{N}{f} = \frac{25.0cm}{6.00cm} = \boxed{4.17x}$

65] The focal length of the objective is just half the radius of the curvature. So for the magnification,

$$m = \frac{-f_o}{f_e} = \frac{-\frac{1}{2}r}{f_o} = \frac{3.2m}{0.028m} = -114x$$

$$\approx \boxed{-110x}$$

✓

Homework - chapter 34 [1, 5, 15, 25, 35]
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Q1] $\sin\theta_2 = \frac{vt}{AB} = \frac{-vt}{\frac{vt}{\sin\theta_1}} = \sin\theta_1 \rightarrow \boxed{\theta_2 = \theta_1}$

Q5] $d\sin\theta = m\lambda \rightarrow d\frac{x}{l} = m\lambda \rightarrow x = \frac{\lambda m l}{d}$

$x_1 = \frac{\lambda_1 m l}{d}$, $x_2 = \frac{\lambda_2 m l}{d} \rightarrow$

$\Delta x = x_2 - x_1 = \frac{(\lambda_2 - \lambda_1) m l}{d} = \frac{[(720-660)\times10^{-9}m](2)(1.0m)}{(6.8\times10^{-4}m)}$

$= 1.76\times10^{-4}m \simeq \boxed{0.2mm}$

Using small angle approximation, since $x \ll l$

Q15] $d\sin\theta = m\lambda n \rightarrow d\frac{x}{l} = m\lambda n \rightarrow x = \frac{\lambda n m l}{d}$

$x_1 = \frac{\lambda m l}{d}$, $x_2 = \frac{\lambda(m+1)}{d} \rightarrow$

$\Delta x = x_2 - x_1 = \frac{\lambda n(m+1)l}{d} - \frac{\lambda m l}{d} = \frac{\lambda n l}{d}$

$\frac{(470\times10^{-9}m)(0.500m)}{(1.33)(6.00\times10^{-5}m)} = \boxed{2.94\times10^{-3}m}$

Q25] a] $\phi_{net} = \phi_2 - \phi_1 = \left[\left(\frac{2t}{\lambda_{min}}\right)2\pi\right] - \pi$

$= \pi \rightarrow t = \frac{1}{2}\lambda_{film} = \frac{\lambda}{2n} = \frac{480nm}{2(1.33)} = \boxed{180nm}$

b] $\phi_{net} = \phi_2 - \phi_1 = \left[\left(\frac{2t}{\lambda_{film}}\right)2\pi\right] - \pi = 3\pi \rightarrow$

$t = \lambda_{film} = \frac{\lambda}{n} = \frac{480nm}{(1.33)} = \boxed{361nm}$

$\phi_{net} = \phi_2 - \phi_1 = \left[\left(\frac{2t}{\lambda_{film}}\right)2\pi\right] - \pi = 3\pi \rightarrow$

$t = \lambda_{film} = \frac{\lambda}{n} = \frac{3}{2}\ \frac{480nm}{(1.33)} = \boxed{541nm}$

c] If the tickness is less than one wavelength, there would be change in path length, & so the two reflected waves would have a phase difference of about $\phi_1 = \pi$.

35] $\frac{r_{air}}{r_{liquid}} = \frac{\sqrt{m\lambda R}}{\sqrt{m(\lambda/n)R}} = \sqrt{n} \rightarrow n = \left(\frac{r_{air}}{r_{liquid}}\right)^2$

$= \left(\frac{2.92cm}{2.54cm}\right)^2 = \boxed{1.32}$

Note : I wrote 45 instead of 43, but I have also written 43 at the very end of chapter 35 homework, so please ignore number 45.

Homework- chapter 35[3, 11, 25, 35, 45, 51, 59]

Jay Patel

Classical Physics-2 (220)

0L02- Professor U.

Q3] $D\sin\theta_m = m\lambda \rightarrow \theta_m = \sin^{-1}\left(\frac{m\lambda}{D}\right)$

$\theta_1 = \sin^{-1}\left(\frac{1\times580\times10^{-9}m}{3.8\times10^{-6}m}\right) = 8.678°$

$\theta_2 = \sin^{-1}\left(\frac{2\times580\times10^{-9}m}{3.8\times10^{-6}m}\right) = 17.774°$

$\theta = \frac{\theta_1+\theta_2}{2} = \frac{8.678°+17.774°}{2} = 13.23°$

$y = l\tan\theta_1 = (10.0m)\tan(13.23°) = \boxed{2.35m}$

Q11] a] $\sin\theta_1 = \frac{\lambda}{D} \rightarrow \theta_1 = \sin^{-1}\frac{\lambda}{D} = \sin^{-1}\frac{780\times10^{-9}m}{1.5\times10^{-6}m}$

$= 31.35°$

$\Delta\theta = 2\theta_1 = 2(31.3°) \simeq \boxed{63°}$

b] $\sin\theta_1 = \frac{\lambda}{D} \rightarrow \theta_1 = \sin^{-1}\frac{\lambda}{D} = \sin^{-1}\frac{780\times10^{-9}m}{3.0\times10^{-6}m}$

$= \boxed{15.07°}$

$\Delta\theta = 2\theta_1 = 2(15.07°) \simeq \boxed{30°}$

Q25] $\theta = 1.22\frac{\lambda}{D}$, $l = r\theta = 1.22\frac{r\lambda}{D} = 1.22$

$$\frac{(16\,ly)\left(\frac{9.46\times10^{15}m}{1\,ly}\right)(550\times10^{-9}m)}{(0.66m)} = \boxed{1.5\times10^{11}m}$$

35] $d\sin\theta = m\lambda \Rightarrow d = \frac{m_1\lambda_1}{\sin\theta_1} \Rightarrow$

$\lambda_2 = \frac{m_1}{m_2}\frac{\sin\theta_2}{\sin\theta_1}$ $\lambda_1 = \frac{2\sin 20.6°}{1\sin 53.2°}$ (632.8nm)

$= \boxed{556\,nm}$

45] a] $\Delta l = \Delta l_1 + \Delta l_1 = d(\sin\phi + \sin\theta) = \pm m\lambda$, $m = 0, 1, 2 \ldots$

Diffraction occurs at angle for which the incident light conserves interferces.

b] The $\pm$ allows for the incident angle & the diffracted angle to have +ve and -ve values.

c] $\theta = \sin^{-1}\left(-\sin\phi \pm \frac{m\lambda}{d}\right) = \sin^{-1}\left(-\sin 15° \pm \frac{550\times10^{-9}m}{0.01m/5000}\right)$

$= \boxed{0.93° \ \& \ -32°}$

51] $m\lambda = 2d\sin\phi \rightarrow \lambda = 2d\sin\phi_1$; $2\lambda = 2d\sin\phi_2$; $3\lambda = 2d\sin\phi_3$

For each equation, all we can find is the ratio $\frac{\lambda}{d} = 2\sin\phi = \frac{2}{3}\sin\phi_3$ $\boxed{NO}$ we cannot determine the wavelength or the spacing.

59] $\tan\theta_p = \frac{n_{air}}{n_{water}} \rightarrow \theta_p = \tan^{-1}\frac{n_{air}}{n_{water}}$

$= \tan^{-1}\frac{1.00}{1.33} = \boxed{36.9°}$

Second case $\sin\theta_c = \frac{n_{air}}{n_{water}} \rightarrow \theta_p = \sin^{-1}\frac{n_{air}}{n_{water}}$

$= \sin^{-1}\frac{1.00}{1.33} = \boxed{48.8°}$

Third case $\tan\theta_p = n_{water} \rightarrow \theta_p = \tan^{-1} n_{water} =$

$\tan^{-1} 1.33 = \boxed{53.1°}$

The two Brewster's angle add to give $\boxed{90.0°}$

Q43] $\tan\theta = \frac{y}{L}$, where y is the displacement

L is the distance

$\sin\theta = \frac{m\lambda}{d}$, $d = \frac{1}{610 \text{ lines/mm}}\left(\frac{1m}{10^3 mm}\right) = (1/6.1 \times 10^5)m$,

$y = L\tan\theta = L\tan\left[\sin^{-1}\frac{m\lambda}{d}\right]$

$l_1 = L\tan\left[\sin^{-1}\frac{m\lambda_{red}}{d}\right] - L\tan\left[\sin^{-1}\frac{m\lambda_{violet}}{d}\right]$

$= (0.32m)\left\{\tan\left[\sin^{-1}\frac{(1)(700\times10^{-9}m)}{(1/6.1\times10^5 m)}\right] - \tan\left[\sin^{-1}\frac{(1)(400\times10^{-9}m)}{(1/6.1\times10^5)m}\right]\right\} = 0.0706m = \boxed{7cm}$

$l_2 = L\tan\left[\sin^{-1}\frac{m\lambda_{red}}{d}\right] - L\tan\left[\sin^{-1}\frac{m\lambda_{violet}}{d}\right]$

$= (0.32m)\left\{\tan\left[\sin^{-1}\frac{(2)(700\times10^{-9}m)}{(1/6.1\times10^5)m}\right]\right.$

$= 0.3464m \approx \boxed{35cm}$

The $\boxed{\text{second order}}$ rainbow is dispersed over a larger distance