Ch 38

1. $\lambda = 587.5 \times 10^{-9}$ m

$a = 0.75 \times 10^{-3}$ m

$y = 0.85 \times 10^{-3}$ m

$l = ?$

$$\frac{y}{l} = \frac{m\lambda}{a}$$

$$l = \frac{ya}{m\lambda}$$

$$= \frac{0.85 \times 10^{-3} \times 0.75 \times 10^{-3}}{1 \times 587.5 \times 10^{-9}}$$

$$= 1.085 \text{ m}$$

b) $2y = 0.85 \times 10^{-3}$ m

$= 1.7$ mm

2. $l = 0.5$ m

$\lambda = 690 \times 10^{-9}$

$\Delta y_{3-1} = 3 \times 10^{-3}$ m

$a = ?$

$$\Delta y = \frac{3l\lambda}{a} - \frac{l\lambda}{a}$$

$$3 \times 10^{-3} = \frac{2l\lambda}{a}$$

$$a = \frac{2 \times 0.5 \times 690 \times 10^{-9}}{3 \times 10^{-3}}$$

$= 0.23$ m

3. $a = 0.5 \times 10^{-3}$ m

a) $\lambda = 500 \times 10^{-9}$ m

$$\theta = \frac{\lambda}{a}$$

$$= \frac{500 \times 10^{-9}}{0.5 \times 10^{-3}}$$

$$= 1 \times 10^{-3} \text{ rad}$$

b) $\theta = 0.1°$

$\lambda = 3 \times 10^{-3}$ m

$$\theta = \frac{1.22\lambda}{D}$$

$$D = \frac{1.22\lambda}{\theta}$$

$$= \frac{1.22 \times 3 \times 10^{-3} \times 180}{0.1\ \pi}$$

$$= 2.1 \text{ m}$$

4. 250 g → 1 mm

1 → 1000 mm

$$\frac{250 \times 1000}{1} = 250 \times 10^3 \text{ grooves/m}$$

$$d = \frac{1}{250 \times 10^3}$$

$= 4 \times 10^{-6}$ m

$\lambda_1 = 400 \times 10^{-9}$ m

$\lambda_2 = 700 \times 10^{-9}$ m

$d \sin\theta = m\lambda$

assume $\sin\theta = 1$ (max values)

$d = m\lambda$

$m = \frac{d}{\lambda}$

$= \frac{4 \times 10^{-6}}{700 \times 10^{-9}}$

$= 5.71$

∴ 5 orders max

b) $m = \frac{d}{\lambda}$

$= \frac{4 \times 10^{-6}}{400 \times 10^{-9}}$

$= 10$ orders

5. $\theta = 12.6°$

$d = 0.25$ mm

$m = 1$

$2d\sin\theta = m\lambda$

$\lambda = \frac{2d\sin\theta}{m}$

$= \frac{2 \times 0.25 \times 10^{-3} \times \sin(12.6)}{1}$

$= \frac{2 \times 0.25 \times 10^{-9} \times \sin(72.0)}{1}$

$= 0.109 \text{ nm}$

b) $\lambda = 0.109 \times 10^{-9}$

$\theta = 90$

$d = 0.25 \times 10^{-9}$

$2d \sin\theta = m\lambda$

$m = \frac{2d \sin\theta}{\lambda}$

$= \frac{2 \times 0.25 \times 10^{-9} \times 1}{0.109 \times 10^{-9}}$

$= 4.587$

$\therefore$ 4 orders

6. $\theta = 48°$

$n_1 = 1$

$\tan\theta = \frac{n_2}{n_1}$

$n_2 = (\tan 48) \times 1$

$= 1.111$

Ch 37

1. $d = 0.32 \times 10^{-3} \text{ m}$

$\lambda = 500 \times 10^{-9}$ —

$\theta_1 = -30°$

$\theta_2 = 30°$

$d \sin\theta = m\lambda$

$$m_1 = \frac{d\sin\theta_1}{\lambda}$$

$$= \frac{0.32\times10^{-3}\sin(-30)}{500\times10^{-9}}$$

$$= -320$$

$$m_2 = \frac{d\sin\theta_2}{\lambda}$$

$$= \frac{0.32\times10^{-3}\times\sin(30)}{500\times10^{-9}}$$

$$= 320$$

$\therefore$ range $= [-320, 320]$

$$= -320 \le m \le 320$$

Total maxima $= 320 + 320 + 1 = 641$

2. $\lambda = 530\times10^{-9}$ —
$d = 0.1\times10^{-3}$ —
$l = 2$ —
$\delta y = ?$ $\quad m = 0, 1$

$$\frac{dy}{l} = \left(m+\frac{1}{2}\right)\lambda$$

$$y = \frac{\lambda l\left(m+\frac{1}{2}\right)}{d}$$

$$\delta y = \frac{\lambda l(3/2)}{d} - \frac{\lambda l(1/2)}{d}$$

$$= \frac{\lambda l}{d}$$

$$= \frac{530 \times 10^{-9} \times 2}{0.3 \times 10^{-3}}$$

$$= 3.53 \text{ mm}$$

3. a) $d = 0.5 \times 10^{-3}$ m

$l = 3.3$ —

$y = 3.4 \times 10^{-3}$ m

$m = 1$

$\lambda = ?$

$$\frac{dy}{l} = m\lambda$$

$$\lambda = \frac{dy}{lm}$$

$$= \frac{0.5 \times 10^{-3} \times 3.4 \times 10^{-3}}{3.3 \times 1}$$

$$= 515 \text{ nm}$$

b) $\lambda = 620 \times 10^{-9}$ —

$m = 1$

$\theta = 15^\circ$

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

$$d = \frac{m\lambda}{\sin\theta}$$

$$= \frac{620 \times 10^{-9}}{\sin 15^\circ}$$

$$= 2.4 \ \mu m$$

4. $\lambda = 589 \times 10^{-9}$ m
$l = 2$ m
$m = 9$
$y = 7.26 \times 10^{-3}$ m
$d = ?$

$$\frac{dy}{l} = \left(m + \frac{1}{2}\right)\lambda$$

$$d = \frac{l\lambda\left(m + 1/2\right)}{y}$$

$$= \frac{2 \times 589 \times 10^{-9}\left(9 + 1/2\right)}{7.26 \times 10^{-3}}$$

$$= 1.54 \text{ mm}$$

5. $l = 1.2$ m
$d = 0.12 \times 10^{-3}$ m
$\lambda = 500 \times 10^{-9}$ m
$\phi = ? = \frac{2\pi}{\lambda} d \sin\theta$

a) $\theta = 6.5^\circ$

$$\phi = \frac{2\pi}{\lambda} d \sin\theta$$

$$= \frac{2\pi}{500 \times 10^{-9}} \times 0.12 \times 10^{-3} \sin(0.5^\circ)$$

$$= 13.16 \text{ rad}$$

b) $y = 5 \times 10^{-3}$ m

$$\phi = \frac{2\pi}{\lambda} \frac{dy}{\ell}$$

$$= \frac{2\pi}{500\times10^{-9}} \times 0.12\times10^{-3} \times \frac{5\times10^{-3}}{1.2}$$

$$= 2\pi \text{ rad}$$

c) $\theta = ?$ $\phi = 0.333$ rad

$$\phi = \frac{2\pi}{\lambda} d\sin\theta$$

$$\sin\theta = \frac{\lambda\phi}{2\pi d}$$

$$\theta = \sin^{-1}\left(\frac{\lambda\phi}{2\pi d}\right)$$

$$= \sin^{-1}\left(\frac{500\times10^{-9}\times 0.333}{2\pi \times 0.12\times10^{-3}}\right)$$

$$= 0.0126^\circ$$

$$= (12.57\times10^{-3})^\circ$$

d) $S = \frac{\lambda}{4} = \frac{yd}{\ell}$

$$\sin\theta = \frac{y}{\ell}$$

$$d\sin\theta = \frac{dy}{\ell}$$

$$d\sin\theta = \frac{\lambda}{4}$$

$$\theta = \sin^{-1}\left(\frac{\lambda}{4d}\right)$$

$$= \sin^{-1}\left(\frac{500\times10^{-9}}{4\times 0.5\times10^{-3}}\right)$$

$= 0.0797°$

$= 9.68 \times 10^{-2}°$

6. $n = 1.33$

a) $t = 120 \times 10^{-9}$ m

$2nt = (m + 1/2)\lambda$

$\lambda = \frac{2nt}{(m+1/2)}$

$= \frac{2 \times 1.33 \times 120 \times 10^{-9}}{1/2}$

$= 638$ nm

b) $2nt = (m + 1/2)\lambda$

($2nt$: Constant)

$t \uparrow \quad m \downarrow$

c) $2nt = (m + 1/2)\lambda$

$t = \frac{(m+1/2)\lambda}{2n}$

@ $m = 0$

$t = 120$ nm

@ $m = 1$

$t = \frac{(3/2)\ 638}{2.66}$

$= 359.77$ nm

@ $m = 2$

$L = 600\ m \longrightarrow$

7. $2nL = m\lambda$

$\lambda_{cons} = \frac{2nL}{m}$

$\lambda_{desc} = \frac{2nL}{m+0.5}$

$\frac{\lambda_{cons}}{\lambda_{desc}} = \frac{2nL/m}{2nL/(m+0.5)}$

$= \frac{m+0.5}{m}$

$= 1 + \frac{1}{2m}$

$\frac{640}{\Pi L} = 1 + \frac{1}{2m}$

$\frac{1}{2m} = \frac{1}{4}$

$m = 2$

$2nL = m\lambda$

$L = \frac{2 \times 640}{2 \times 1.45}$

$= 572\ m \longrightarrow$

Chapter 36

1. $p = 10$

$f = 20$

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$$

$$= \frac{1}{20} - \frac{1}{50}$$

$$q = 33.3 \text{ cm}$$

$$M = \frac{-q}{p} = \frac{-100/3}{50}$$

$$= -0.66$$

q +ve ⇒ real
M -ve ⇒ Inverted

2. $f = -40$
$p = 30$
$q = ?$

$$q = \frac{1}{\frac{1}{f} - \frac{1}{p}}$$

$$= -12$$

Images are upright

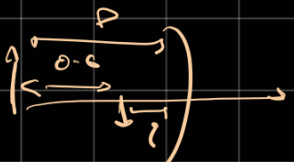
/ $p = 60$
$q = ?$

$q = -15$

3. $M = -4$

$$\frac{-q}{v} = -4$$

$q = 4p$



$q - p = 0.6$

$3p = 0.6$

$p = 0.2\text{m}$

$q = 0.8\text{m}$

$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$

$f = 16\text{cm}$

b) $M = 0.5 = \frac{q}{p}$

$q = -0.5p$

$q + p = 60$

$\frac{3}{2} = 60$

$p = 40\text{cm}$

$q = -20\text{cm}$

$\frac{1}{20} + \frac{1}{40} = \frac{1}{f}$

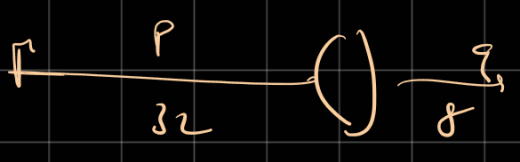
$f = -0.4\text{m}$

4. $\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$

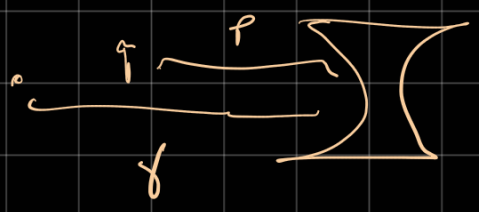
$f = 6.4\text{cm}$

$M = -0.25$

converging



5 $f = -32$



$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{q} = \frac{1}{-32} - \frac{1}{20}$$

$q = -12.31$ cm

front the lens

$$M = \frac{160/13}{20}$$

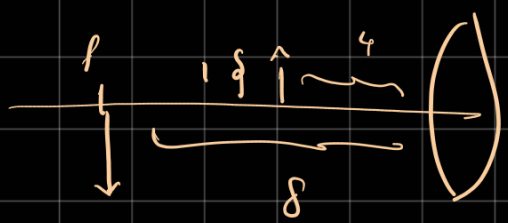
$= 0.62$

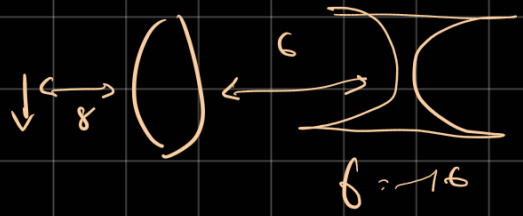
image is virtual, upright

6 $\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$= \frac{1}{8} - \frac{1}{14}$

$q = -8$ cm





$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$= \frac{-1}{16} - \frac{1}{14}$

$q = -7.46$

$M = \frac{7.46}{14}$

$= 0.533$

$M = 0.533 \times 2$

$= 1.066$

$\frac{h'}{h} = 1.066$

$a' = 1.06\ cm$

Height of image = 1.06 cm

position = 7.46 cm in front of lens 2

upright

virtual

7. $f = 65\ mm$

$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$= \frac{1}{65} - \frac{1}{\infty}$

$= \frac{1}{65}$

$p = 65\ mm$

$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$= \frac{1}{} - \frac{1}{}$

$\frac{6T}{}$ 2000

$q = 67.18$ mm

lens must be moved 2.18 cm to the left

8. $P = \frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

$= \frac{1}{\infty} - \frac{1}{0.25}$

$= -4$ dioptres

diverging lens / concave lens

9. $f = 5$ cm

$\frac{1}{P} = \frac{1}{f} - \frac{1}{q} \Rightarrow \frac{1}{P} = \frac{1}{5} + \frac{1}{25}$

$p = 4.17$ cm

b) $M = \frac{-q}{p} = \frac{25}{4.17}$

$= 6$

10. $L = 23$

$f_e = 2.5$

$f_o = 0.4$

$M = \frac{-23}{0.4}\left(\frac{25}{2.5}\right)$

$= -575$

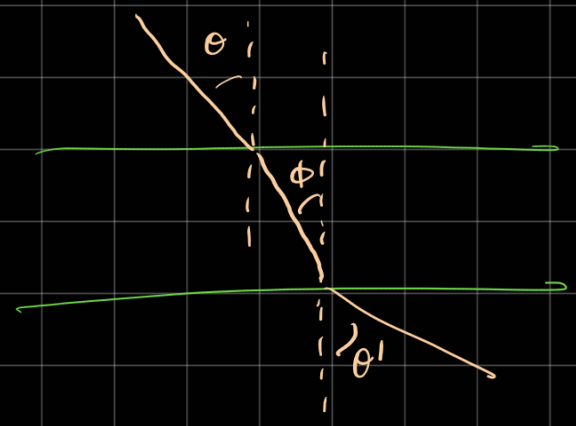
11. $m = \frac{-f_o}{f_e} = -\frac{20}{2.5 \times 10^{-2}}$

$= 800$

upside down

Chapter 35

1.



$n_1 \sin\theta = n_2 \sin\phi$

$\theta_1 = \sin^{-1}\left(\frac{n_2}{n_1}\sin\varphi\right)$

$= 1.48 \sin$

$= 30.41$

$n_1 \sin\varphi = n_2 \sin\theta'$

$\theta' = \sin^{-1}\left(\frac{n_1}{n_2}\sin\varphi\right)$

$= 22.37°$

2. $\theta_1 = 30°$

$\theta_2 = 19.24$

$n_1 = 1$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2}$

$= 1.52$

$n = \frac{\lambda}{}$

λ_m

$\lambda_m = \frac{632.8\ nm}{1.52}$

$\lambda_m = 416.32\ nm$

$V = \frac{c}{n} = \frac{3\times10^8}{1.52} = 197\times10^6\ m/s$

$f = \frac{c}{\lambda} = \frac{3\times10^8}{632.8\times10^{-9}} = 4.74\times10^{14}$

3. $\theta = 50°$

$n = 1.455 \quad \lambda = 600\ nm$

$n = 1.468 \quad \lambda = 410\ nm$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

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

↓ red

$= \sin^{-1}\left(1.455\ \sin 50\right)$

$\theta_2 = 46.677$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$\theta_2 = \sin^{-1}\left(1.468\ \sin 50\right)$

2. $f = \frac{R}{2} = \frac{-40}{2} = -20\ cm$

$q \Rightarrow -ve$

$p = 30$

$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$p = 60$

$\frac{1}{q} = \frac{-1}{20} - \frac{1}{60}$

$= -\frac{1}{20} - \frac{1}{30}$

$q_2 = -12$

$M = \frac{-q_2}{P} = \frac{-(-12)}{30} = +\frac{12}{30}$

$\therefore$ upright

$q = -15$

$M = -\frac{(-15)}{30} = +\frac{15}{30}$

$\therefore$ upright

3. $M = \frac{q}{p} = -4$

$q = 4p$

$q - p = 0.6$

$3p = 0.6$

$p = 0.2$

$q = 0.8$

$\frac{1}{20} + \frac{1}{80} = \frac{1}{f}$

$f = 0.16\ m$

b) $q \Rightarrow$ -ve

$f \Rightarrow$ -ve

$q - p = 0.6$

$M = 0.5$

$$M = -\frac{q}{p} = 0.5$$

$$q = -0.5p$$

$$|q| + p = 0.6$$

$$1.5p = 0.6$$

$$p = 0.4\ m$$

$$q = -0.2m$$

$$\frac{1}{p} - \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{40} - \frac{1}{20} = \frac{1}{f}$$

$$f = -40\ cm$$

41. $p = 32$

$q = 8$

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$\frac{32}{32} \quad 6$

$f = 6.4$ cm

$M = \frac{-1}{p} = \frac{-8}{32} = -0.25$

$\therefore f > 0 \quad \therefore$ converging

Sol: $f \Rightarrow -ve$

$f = -32$

$p = 20$

$\frac{1}{q} = \frac{1}{f} - \frac{1}{p}$

$= \frac{-1}{32} - \frac{1}{20}$

$q = -12.31$ cm

$M = \frac{-q}{p} = \frac{-(-160/13)}{20}$

$= 0.62$

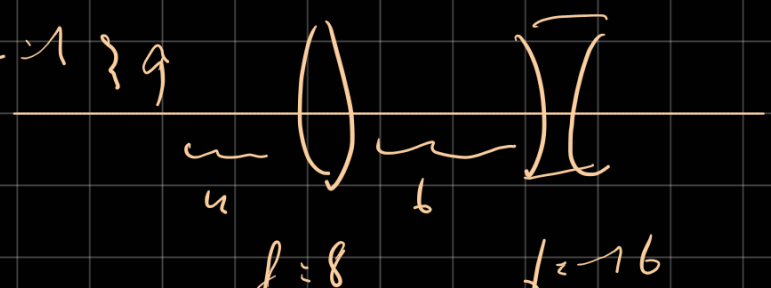
$\therefore q < p$

∴ virtual

∴ $M > 0$

upright

6.



$$\frac{1}{q} = \frac{1}{b} - \frac{1}{p}$$

$$= -\frac{1}{8} - \frac{1}{4}$$

$$q = -8$$

$$M = -\frac{-8}{4} = 2$$

$$p = 8 + 6 = 14$$

$$\frac{1}{q} = \frac{1}{b} - \frac{1}{p}$$

$$= -\frac{1}{16} - \frac{1}{14}$$

$$q = -7.46\ \text{cm}$$

$M = \frac{-(-16/11)}{14} = 0.533$

$M_{total} = M_1 M_2 = 2 \times 0.533$

$= 1.066$

$\therefore M > 0$

upright

$\therefore q < 0$

virtual

$\frac{h'}{h} = M$

$h' = Mh = 1.066\ cm$

7- $p = \infty$

$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = \frac{1}{65} - \frac{1}{\infty}$

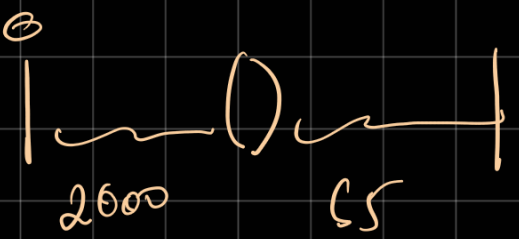
$q = 65\ cm$

$p = 2000\ cm$

$$\frac{1}{q} = \frac{1}{6} - \frac{1}{p}$$

$$= \frac{1}{61} - \frac{1}{2000}$$

$$q = 67.18 \text{ cm}$$



$f = 65$

2.18 cm

lens should be moved $(67.18 - 65)$ to the left

8 $P = \frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

$$= \frac{1}{\infty} + \frac{1}{-0.25} = -4 \text{ dioptres}$$

$\therefore P < 0$

diverging

9. $f = 5$ cm

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}$$

$$\frac{1}{p} = \frac{1}{6} + \frac{1}{9}$$

$$= \frac{1}{5} + \frac{1}{25}$$

$$p = 4.166 \text{ cm}$$

$$m = 1 + \frac{25}{f}$$

$$= 1 + \frac{25}{5} = 1 + 5 = 6$$

10. $l = 23$

$f_e = 2.5$

$f_0 = 0.4$

$$M = -\left(\frac{L}{f_0}\right)\left(\frac{25}{f_e}\right) = -575$$

11. $$m = -\frac{f_0}{f_e} = \frac{-20}{2.5 \times 10^{-2}} = -800$$

inverted

2. $\theta = 30°$

$\theta' = 15.24$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$$n_2 = \frac{n_1 \sin\theta_1}{\sin\theta_2} = 1.52$$

$\lambda = 632.8\,nm$

$$f = \frac{c}{\lambda} = \frac{3\times10^8}{632.8\times10^{-9}} = 4.74\times10^{14}\ Hz$$

$$n = \frac{c}{v} \Rightarrow v = \frac{c}{n} = \frac{3\times10^8}{1.52} = 197.37\ Mm/s$$

$$n = \frac{\lambda}{\lambda_n}$$

$$\lambda_n = \frac{\lambda}{n} = \frac{632.8}{1.52} = 416.32\,nm$$

3- $\theta = 80^\circ$

$n_1 = 1.455$ $\quad \lambda = 600\,nm$

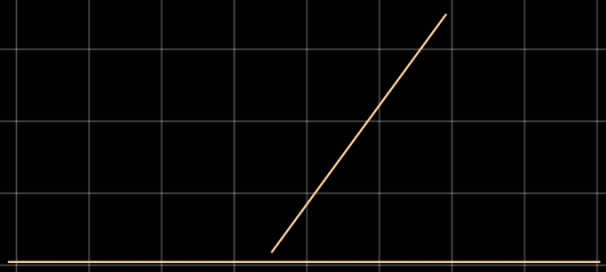
$n_2 = 1.468$ $\quad \lambda = 410$ —

$n_{red}\ \theta_{red} = n_{air} \sin\theta_{air}$

$$\theta_{red} = \sin^{-1}\left(\frac{n_{air}\sin\theta_{air}}{n_{red}}\right)$$

Dispersion $= \theta_{red} - \theta_{violet}$

$= 0.314°$



4- $\theta = 30°$

$\theta = 22°$

$n_{air} \sin\theta_{air} = n_w \sin\theta_w$

$$n_w = \frac{\sin\theta_{air}}{\sin\theta_w}$$

$$\theta_c = \sin^{-1}\left(\frac{n_{air}}{n_w}\right) = \sin^{-1}\left(\frac{\sin\theta_w}{\sin\theta_{air}}\right)$$

$= 48.590°$