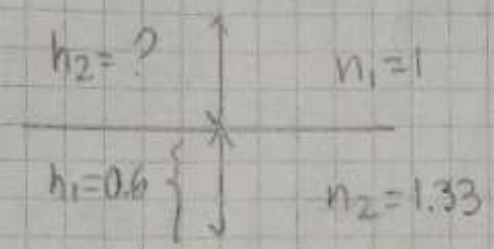
Comunicações Ópticas - Lista 1

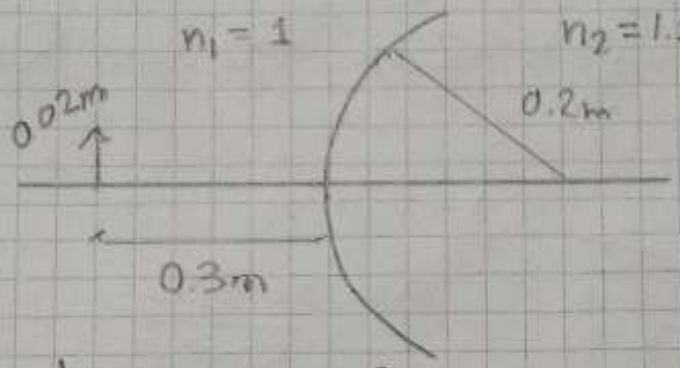
1)



$h_1 n_1 = h_2 n_2 \Rightarrow 0.6 \cdot 1 = h_2 \cdot 1{,}33$

$h_2 = 45{,}11\,cm$

2)

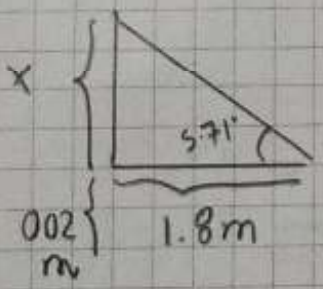


$\frac{n_1}{S_0} = \frac{n_2}{S_1} = \frac{n_2 - h_1}{R}$

$\frac{1}{0.3} + \frac{1.5}{S_1} = \frac{1.5-1}{0.2}$

$S_1 = \frac{-1.5}{0.83} = -1.8\,m$

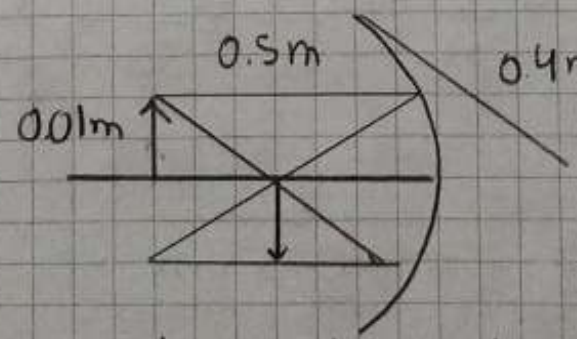
$\beta = \frac{d}{R} = 0.1 = 5.71°$



$0.1 = \frac{OP}{1.8} \rightarrow OP = 0.18$

$Tamanho = 0.18 + 0.02 = 0.2\,m$

3)

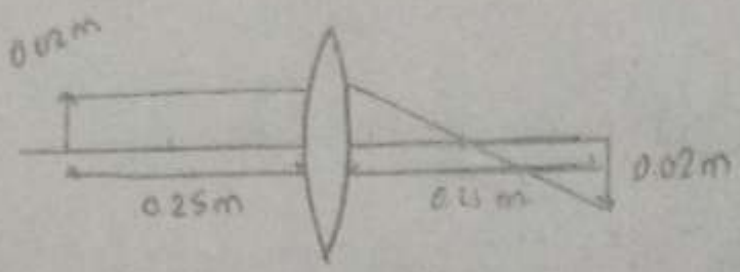


$\frac{1}{P} + \frac{1}{q} = \frac{1}{f}$

$A = \frac{1}{O} = \frac{-p'}{p} \Rightarrow \frac{1}{1} = \frac{-p'}{p} \Rightarrow 1 = -\frac{100}{3}\frac{1}{50} \leq -0.67\,m$

$\frac{1}{0.2} = \frac{1}{0.5} + \frac{1}{p_1} \rightarrow \frac{1}{p_1} = \frac{3}{100} \Rightarrow p' = \frac{100}{3}\,cm$

4)

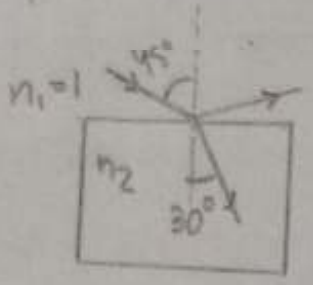


$f = 12,5cm$, $R = 25\,cm$, $o = 2\,cm$

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{p'} \Rightarrow \frac{1}{12,5} = \frac{1}{25} + \frac{1}{p'} \Rightarrow p' = 25\,cm$$

$$\frac{i}{o} = -\frac{p'}{p} \Rightarrow i = -2\,\frac{25}{25} = -2\,cm \quad \text{(Imagem Real)}$$

5)

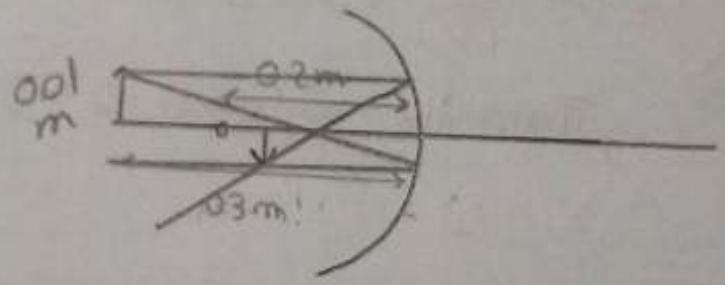


$\lambda = 5.10^{-7}m$

$$nt = \frac{sen\theta i\, ni}{sen\theta t}$$

$$nt = \frac{sen45}{sen30} = 1.41$$

6)

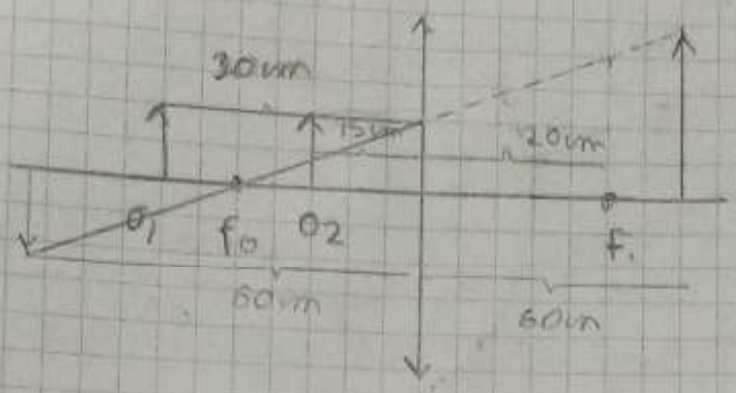


$o = 0,01m$
$p = 0,3m$
$f = 0,1m$

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{p'} \Rightarrow \frac{1}{10} = \frac{1}{30} + \frac{1}{p'} \Rightarrow p' = 15\,cm$$

$$\frac{i}{o} = -\frac{p'}{p} \Rightarrow i = -\frac{15}{30} \cdot 1 = -0.5\,cm$$

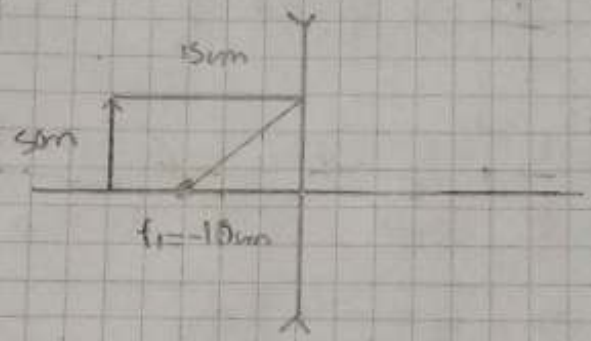
7)



$q_1 = 60cm$ $\quad I_1 = -\frac{q_1}{P} O_1 = -\frac{60}{30} 1 = -2cm$

$q_2 = -60cm$ $\quad I_2 = -\frac{q_2}{P} O_2 = \frac{60}{15} 1 = 4cm$

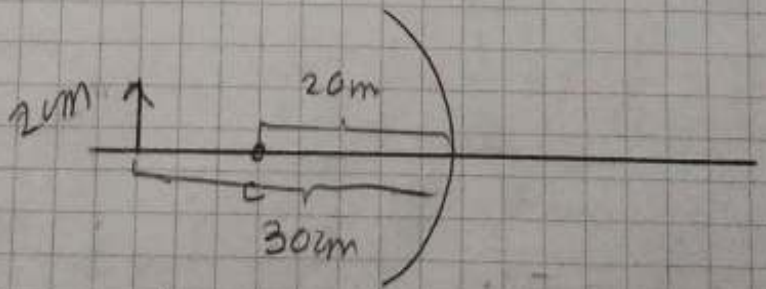
8)



$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q} \Rightarrow \frac{1}{-10} = \frac{1}{15} + \frac{1}{q} \Rightarrow q = -6cm$$

$$M = -\frac{q}{P} = -\frac{(-6)}{15} = 0.4\ cm$$

9)

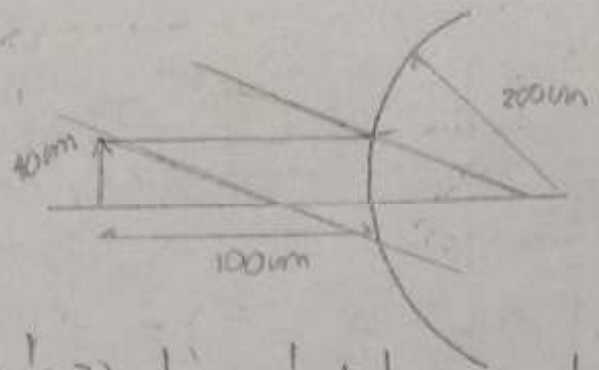


$f = 10cm$

$$\frac{1}{f} = \frac{1}{P} + \frac{1}{q} \Rightarrow \frac{1}{10} = \frac{1}{30} + \frac{1}{q} \Rightarrow q = 15cm$$

$$\frac{i}{O} = -\frac{q}{P} \Rightarrow i = -\frac{15}{30} \cdot 2 = 1\ cm$$

10)



$\frac{1}{f} - \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{100} = \frac{1}{100} + \frac{1}{q} \Rightarrow \frac{1}{q} = 0$

Imagem imprópria

11) $f = 10cm$

$M = 50$

$M = -\frac{q}{p} \Rightarrow q = -50p$

$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{f} = \frac{1}{p} + \frac{1}{50p} \Rightarrow \frac{1}{f} = \frac{50-1}{50p} \Rightarrow \frac{1}{0.1} = \frac{49}{50p}$

$p = \frac{49.01}{50} = 0098cm, \quad q = -4.9m$

12) $A = \frac{025L}{f_1 f_2} = \frac{250.160}{16\ 50} \cdot 50$

13) $f_0 = 10cm$

$M = 2\times$

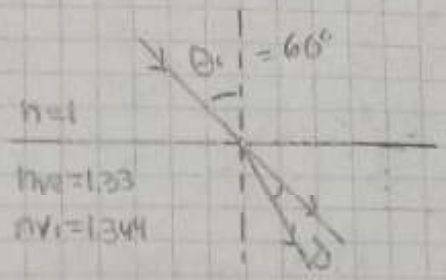
a) $-\frac{q}{p} = 2 \Rightarrow q = -2p \qquad \frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

$0.1 = \frac{1}{p} + \frac{1}{-2p} \Rightarrow 0.1 = \frac{2-1}{2p} \Rightarrow 0.1 = \frac{1}{2p} \Rightarrow p = 5cm, \quad q = -10cm$

b) $\frac{q}{p} = 2 \Rightarrow q = 2p \Rightarrow 0.1 = \frac{1}{p} + \frac{1}{2q} \Rightarrow 0.1 = \frac{2+1}{2p}$

$p = 15cm, \quad q = 30cm$

14)



$n_1 \operatorname{sen}\theta_1 = n_2 \operatorname{sen}\theta_2$

$n_2 = nve$, $\theta_2 = \operatorname{sen}^{-1}\left(\frac{n_1}{n_2}\operatorname{sen}\theta_1\right)$

$\theta_2 = 40,628°$

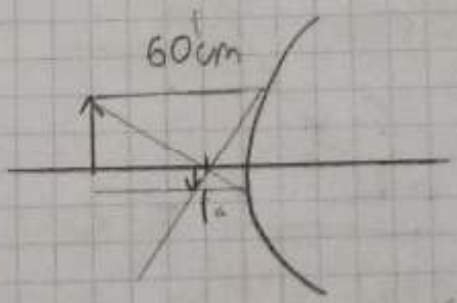
$n_2 = nv_1 \Rightarrow \theta_2 = \operatorname{sen}^{-1}\left(\frac{n_1}{n_2}\operatorname{sen}\theta_1\right) = 40,118$

$\delta = 0,509°$

15) $q_1 = 120cm$ $\quad I_1 = -\frac{120}{60}2 = -4cm$

$q_2 = 120cm$ $\quad I_2 = -\frac{(-120)}{30}2 = 8cm$

16)



$o = 60cm$

$i = 30cm$

$i = \frac{q}{p}o \Rightarrow 30 = \frac{q}{60}.60 \Rightarrow q = 30cm$

$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{f} = \frac{1}{60} + \frac{1}{30} \Rightarrow f = 20cm, R = 40cm$

17) $f = 12cm$

$o = 1,5cm$

$p = 4cm$

$\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{12} = \frac{1}{4} + \frac{1}{q}$

$q = -6cm$

$i = -\frac{q}{p}o \Rightarrow i = 2,25cm$

Imagem virtual

18) $o = 50cm$ $\quad \frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{f} = \frac{1}{10} + \frac{1}{20}$

$p = 10cm$

$q = 20cm$ $\quad f = \frac{20}{3}\ cm$

$\frac{1}{(\frac{20}{3})} = \frac{1}{25} + \frac{1}{q} \Rightarrow q = 9\ cm$ (Real, invertida)

19)

a) $n_1 \operatorname{sen}\theta_1 = n_2 \operatorname{sen}\theta_2$

$n_1 \lambda_1 = n_0 \lambda_0 \Rightarrow \lambda_0 = \frac{\lambda_1 n_1}{n_0} \Rightarrow \lambda_0 = \frac{\lambda_1}{n_0}$

b) $\lambda_0 = \frac{420\,n}{1.33} = 315,78\,nm$

20) $n = \frac{c}{v} = \frac{3.10^8}{\lambda f} = \frac{3.10^8}{4,77.10^{13}\ 3,14.10^{-6}} = 2$

a) $k = \frac{2\pi}{\lambda} \Rightarrow \frac{1}{5.10^{-7}} = \frac{2\pi}{\lambda} \Rightarrow \lambda = 3,14.10^{-6}\ m$

b) $\lambda = 1,57\ \mu m$

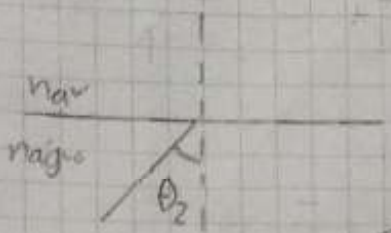
21) $\lambda = 436\,nm$ $\quad v = \frac{c}{n} = \frac{3.10^8}{1.66} = 1,8.10^8\ m/s$

a) $t = 2cm$

$n = 1.66$

b) $t = \frac{t}{v} = \frac{0,02}{1.8.10^8} = 111\,ps$

22)



$n_1 \operatorname{sen}\theta_1 = n_2 \operatorname{sen}\theta_2$

$\theta_2 = \operatorname{sen}^{-1}\left(\frac{\operatorname{sen}30}{1.333}\right) = 49,1°$

R: 40,9° acima do horizonte

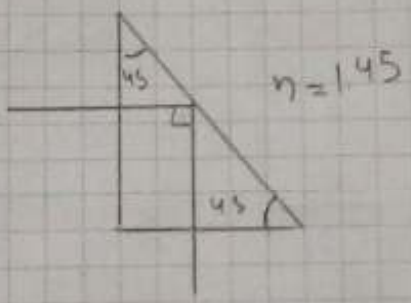
23)

$\Delta - B \quad n_v = 1.5 \quad \lambda_0 = 500nm$

$l = 1mm$

$\lambda' = \frac{500n}{1.5} = 333,33nm \Rightarrow \Delta\phi = 2\pi.10^3 rad$

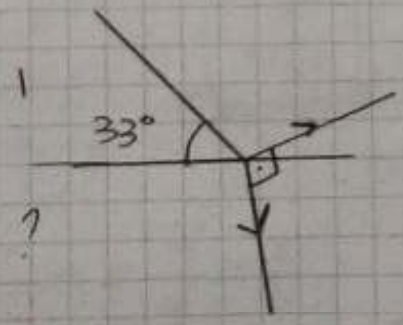
24)



$\theta c = \arcsin\left(\frac{n_2}{n_1}\right) \Rightarrow \operatorname{sen}\theta c = \frac{n_2}{n_1}$

$n_1 = \frac{n2}{\operatorname{sen}\theta c} \Rightarrow n_1 = \frac{1.45}{\operatorname{sen}45°} \Rightarrow n_1 = 2,05$

25)

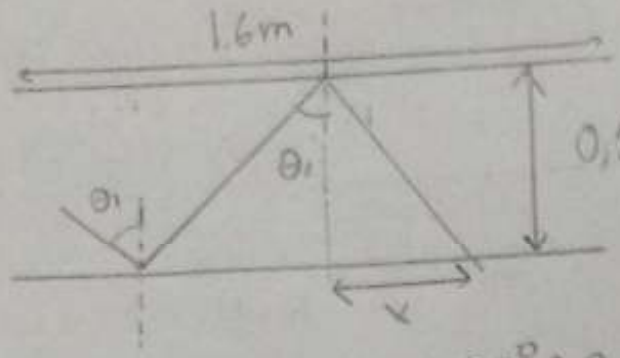


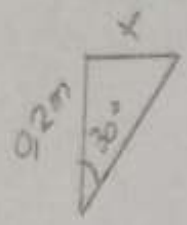
a) $\theta_{ver} = 180 - 33 - 90 = 57°$

$n_1 \operatorname{sen}\theta_1 = n_2 \operatorname{sen}\theta_2 \Rightarrow n_2 = \frac{1 \operatorname{sen}33°}{\operatorname{sen}57} = 0\,65$

b) $\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = 40.54°$

26)

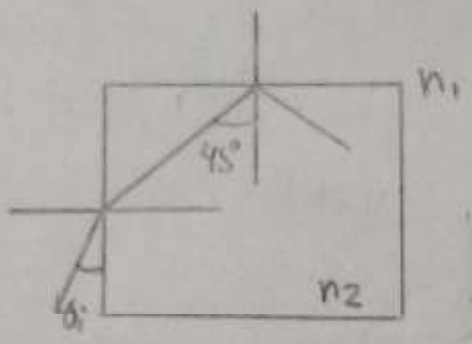




$tg\theta_1 = \frac{CO}{Ca} \Rightarrow CO = tg30° \cdot 0,2 \Rightarrow CO = 0,1155m$

$\frac{1,6m}{0,1155m} \simeq 13$ vezes

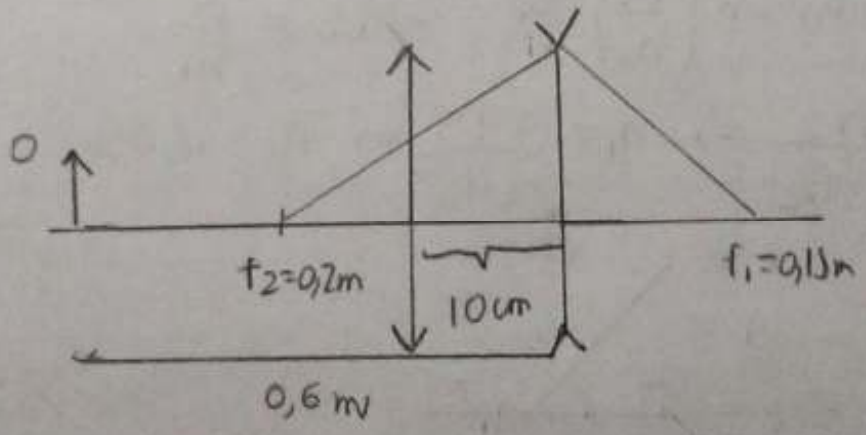
27)



$n_1 sen\theta_1 < n_2 sen45°$

$\theta_1 < sen^{-1}\left(\frac{\sqrt{2}\, n_2}{2 n_1}\right)$

28)



1) $\frac{1}{q} = \frac{1}{f} - \frac{1}{p} \Rightarrow q = \frac{1}{3}m$ $\quad \frac{I}{O} = \frac{q}{p} \Rightarrow \frac{2}{3}O$

2) $\frac{1}{q} = \frac{1}{f} - \frac{1}{p} \Rightarrow q = -0,3m$ $\quad \frac{I}{O} = \frac{q}{p} \Rightarrow 2O$

M = 2

29) $y(x,t) = 2\cos[\pi(110\,s^{-1}t - x\,m^{-1})]$

a) $\Delta = 2$

b) $x=0, t=0 \Rightarrow \phi = 0$

$x=0, t=\frac{1}{50} \Rightarrow \phi = 35°$

c) $\omega = 110\pi \Rightarrow f = 55\,Hz$

d) $-x$

30) $y(x,t) = 0.15\cos[(5/6)\pi x - 24\pi t]$

a) $\Delta = 0.15$

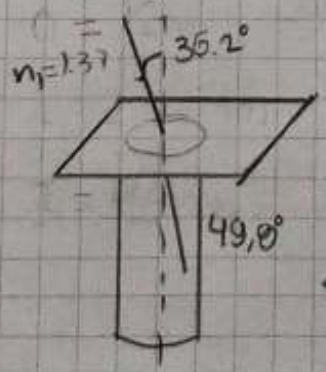
b) $x=0, t=0 \Rightarrow \phi = 0$

$x=0, t=1/50 \Rightarrow \phi = -86°$

c) $\omega = 2\pi f \Rightarrow f = 12\,Hz$

d) $+x$

32)

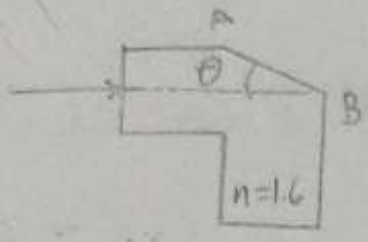


$n_1 \operatorname{sen}\theta_1 = n_2 \operatorname{Sen}\theta_2$

$n_1 = 1.333\,\frac{\operatorname{Sen}49.8°}{\operatorname{sen}36.2°} \approx 1,72$

$\operatorname{sen}\theta_{crit} = \frac{n_2}{n_1}\operatorname{sen}90 = 50.6°$

33)



$n_1 \operatorname{sen}\theta_1 = n_2 \operatorname{sen}\theta_2$

a) $1.6 \operatorname{sen}\theta_1 = 1 \operatorname{sen}90° \Rightarrow \theta_1 = \operatorname{sen}^{-1}\left(\frac{1}{1.6}\right) = 38.7°$

$\theta = 90° - \theta_1 = 51.3°$

b) $\theta_1 = \operatorname{sen}^{-1}\left(\frac{1.333}{1.6}\right) = 56,4°$

$\theta = 90° - \theta_1 = 33,6°$

34) $n_1 = 1.53$ a) $n_1 \operatorname{sen}\theta_L = n_2 \operatorname{sen}\theta_2$ ✓ 90°

$n_2 = 1$ $\theta_L = \operatorname{sen}^{-1}\left(\frac{1}{1.53}\right) = 40.8°$

b) $n_1 \operatorname{sen}\theta_c = n_2 \operatorname{sen}\theta_2$

$\theta_c = \operatorname{sen}^{-1}\left(\frac{1.33}{1.53}\right) = 60.6°$

35) $\theta_c = 42,5°$ $n_{liq} = \frac{1}{\operatorname{sen}\theta_c} = 1.48$

a; $\theta_i = 35°$

$\operatorname{sen}\theta_b = \frac{n_a \operatorname{sen}\theta_a}{n_b} = \frac{1,48 \operatorname{sen}35}{1} = 58,1°$

b) $\operatorname{sen}\theta_b = \frac{n_b \operatorname{sen}\theta_a}{n_a} = \frac{1 \operatorname{sen}35}{1.48} = 22,8°$

36) $n_2 = 1.33$

$\theta_c = 48,7°$

$n_a \operatorname{sen}\theta_c = n_b \operatorname{sen} 90°$

$n_a = \frac{n_b}{\operatorname{sen}\theta_c} = \frac{1.33}{\operatorname{sen} 48,7}$

$n_a = 1.77$

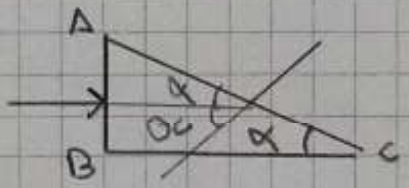
37) $\theta_c = 62°$

$\lambda = 408nm$

$n_g \operatorname{sen} 62 = n_w \operatorname{sen} 90 \Rightarrow n_g = \frac{1.33}{\operatorname{sen} 62} = 1.51$

$\lambda_w n_w = \lambda_g n_g \Rightarrow \lambda_w = \frac{408 \cdot 1.51}{1.33} n = 463nm$

38) $n_g = 1.52$



$\alpha + \theta_c = 90°$

a) AR - Vidro

$n_a \operatorname{sen}\theta_a = n_B \operatorname{sen}\theta_B \Rightarrow \theta_{CRIT} = \operatorname{sen}^{-1}\left(\frac{1}{1.52}\right)$

$\theta_{CRIT} = 41.1 \Rightarrow \alpha = 48,9°$

b) Água - Vidro

$\theta_{CRIT} = \operatorname{sen}^{-1}\left(\frac{1.33}{1.52}\right) = 61.3°$

$\alpha = 28,7°$

39) n, f, λ, v

a) f é f.

$$\lambda = \frac{\lambda_0}{n} \Rightarrow \lambda = \lambda_0 \quad (\text{Vácuo } n=1)$$

$$V = \frac{c}{n} \Rightarrow V = c \quad (\text{Vácuo } n=1)$$

b) f é f.

$$\lambda' = \frac{\lambda_0}{n'} \Rightarrow \frac{n\lambda}{n'} = \left(\frac{n}{n'}\right)\lambda$$

$$V' = \frac{c}{n'} = \frac{nV}{n'} = \left(\frac{n}{n'}\right)V$$

40) —