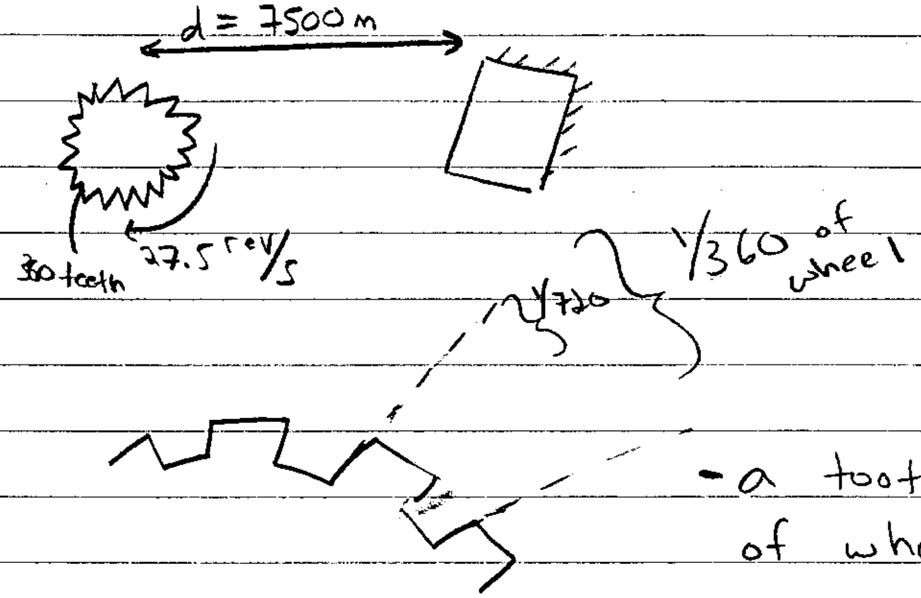
HW#8 - SOL^N - ADAM COHEN

Chapter 22 - Reflection & Refraction

②



- a tooth is $\frac{1}{720}$ of wheel

- at 27.5 rev/sec, it takes

$$t = \left(\underset{\uparrow \theta}{\frac{1}{720}}\ \cancel{rev}\right)\left(\frac{1}{27.5\,\frac{\cancel{rev}}{sec}}\right)_{\nwarrow 1/\omega} = 5.05\times10^{-5}\ s$$

$$\left(\text{recall:}\quad \omega \equiv \frac{\theta}{t}\right)$$

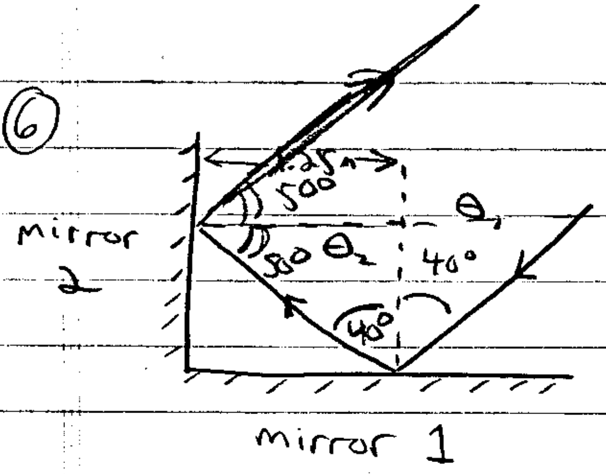
for light to go from wheel → mirror → wheel.

- so speed of light =

$$c = \frac{2d}{t} = \frac{2(7500\ m)}{505\times10^{-5}\ s} = \boxed{2.97\times10^{8}\ m/s}$$

Not bad!

⑥

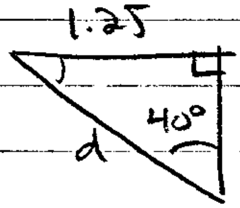


by law of reflection, angle to normal

$\theta_1 = \theta_2$

$\Rightarrow \quad \theta_2 = 40^\circ$

So we have a right triangle:



we want to know hypotenous:

$$\sin 40^\circ = \frac{1.25}{d}$$

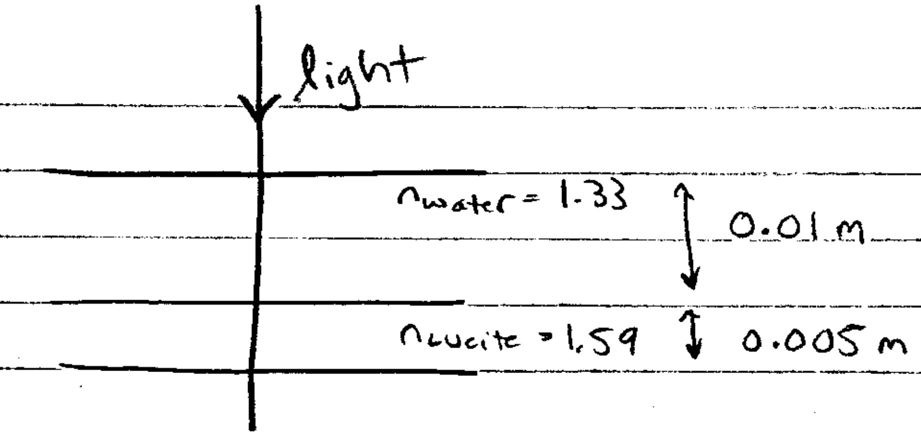
$$\Rightarrow d = \frac{1.25\,m}{\sin 40^\circ} = \boxed{1.94m}$$

· Since a triangle has 180°, the ∢ to normal on mirror 2 is 50°

· So, by law of reflection, the light is directed $\boxed{50^\circ}$ $\boxed{\text{above the horizontal}}$ after striking mirror 2.

(Note: this path is parallel to incoming beam)

⑧



in water, $v_{water} = \frac{c}{n_{water}}$

$= \frac{3\times10^8 \text{ m/s}}{1.33} = 2.256\times10^8 \text{ m/s}$

So the time in water ($v \equiv \frac{d}{t}$)

$t_{water} = \frac{d_{water}}{v_{water}} = \frac{0.01 \text{ m}}{2.256\times10^8 \text{ m/s}}$

$= 4.433\times10^{-11}$ s

in Lucite: $v_{Lucite} = c/n_{Lucite} = c/1.59 = 1.887\times10^8$ m/s

So $t_{Lucite} = 0.005/1.887\times10^8 \text{ s} = 2.65\times10^{-11}$ s

So $t_{\text{double layer}} = 7.083\times10^{-11}$ s

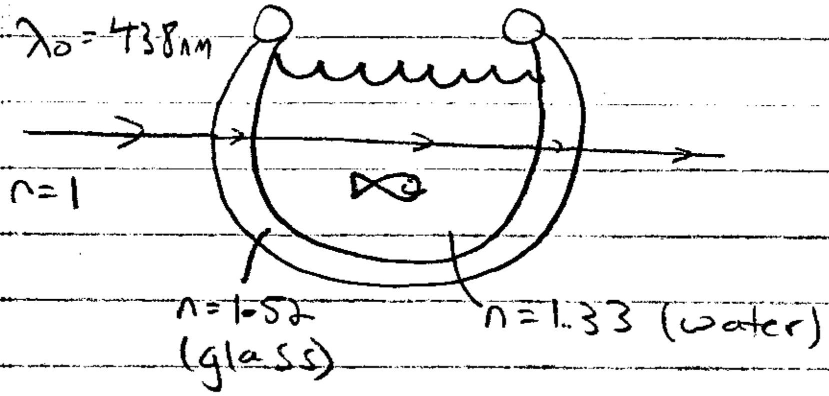
in air (n=1) $v_{air} = c$

so $t_{air} = 0.015\text{ m}/c = 5\times10^{-11}$ s

it takes $(7.083-5)\times10^{-11}$ s longer

$= \boxed{2.083\times10^{-11} \text{ s}}$

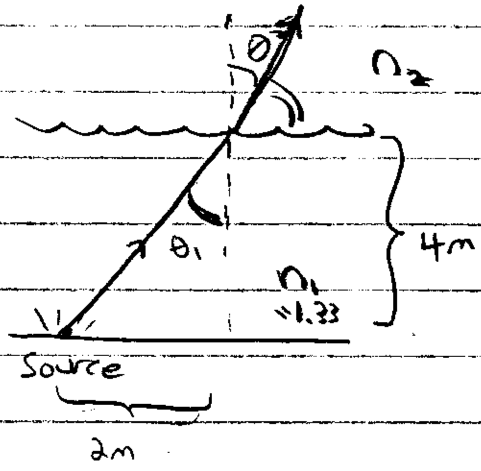
⑫



in glass $\lambda_{glass} = \frac{\lambda_0}{n} = \frac{438\,nm}{1.52} = \boxed{288\,nm}$

in water $\lambda_{water} = \frac{438\,nm}{1.33} = \boxed{329\,nm}$

⑯



get θ_1 from trigonometry:

$$\tan\theta_1 = \frac{\text{opposite}}{\text{adjacent}} = 1/2$$

$$\theta_1 = \arctan(1/2) = 26.6°$$

by Snell's Law:

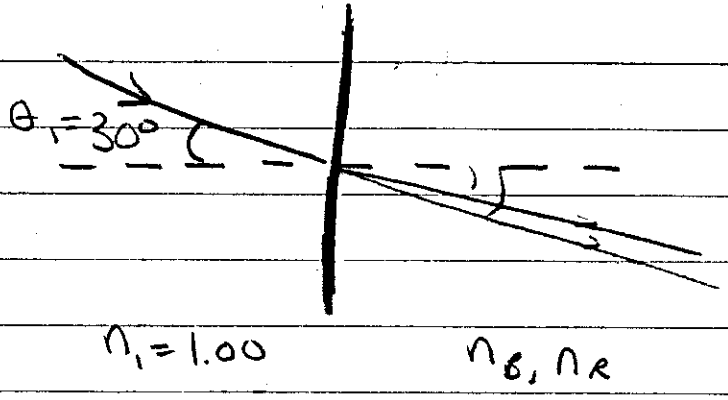
$$\underset{1.33}{n_1} \sin \underset{26.6°}{\theta_1} = \underset{1}{n_2} \sin\theta_2$$

$$\Rightarrow \sin\theta_1 = 1.33 \sin(26.6°)$$

$$\theta_1 = \arcsin(1.33 \sin(26.6°)) = 36.6°$$

The angle w/ the surface is $90° - 36.6° = \boxed{53.4°}$

㉚ $\left\{ \begin{array}{l} \text{for blue} : n_B = 1.650 \\ \text{red} : n_R = 1.615 \end{array} \right.$



by Snell's Law:

$$\underset{1}{\cancel{n_1}} \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_2 = \arcsin\left(\frac{\sin\theta_1}{n_2}\right)$$

for blue: $\theta_2 = \arcsin\left(\frac{\sin 30°}{1.650}\right) = 17.640$

red $\theta_2 = \arcsin\left(\frac{\sin 30°}{1.615}\right) = 18.035°$

the difference is: $\boxed{0.40°}$

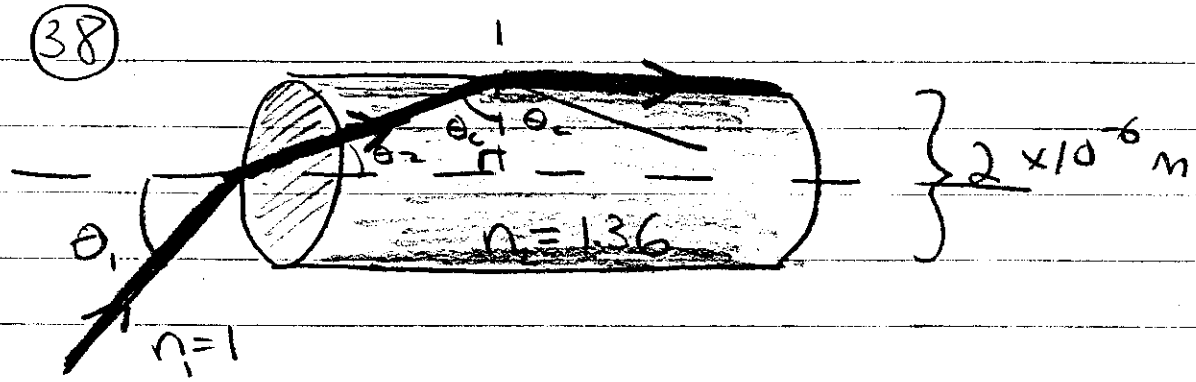
㉞ $\lambda = 589\,nm$

critical ∡: $\theta_c = \arcsin\left(\frac{n_2}{n_1}\right)$

a) $n_2 = 1.00,\ n_1 = 2.49$ ⇒ $\theta_c = \boxed{24.4°}$

b) $n_2 = 1.00,\ n_1 = 1.66$ $\theta_c = \boxed{37.0°}$

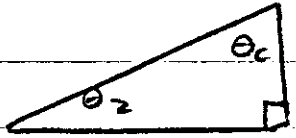
㊳



- the critical angle for pipe/air interface is:

$$\theta_c = \arcsin\left(\frac{1.00}{1.36}\right) = 47.3^\circ$$

- for total internal reflection, the incident angle on the wall of the pipe must be greater than $\theta_c = 47.3^\circ$.
- consider the Δ:



$\Rightarrow \theta_2 = 42.7^\circ$

- by Snell's Law:

$$\underset{1}{\cancel{n_1}} \sin\theta_1 = n_2 \sin\theta_2$$

$$\theta_1 = \arcsin(1.36 \sin(42.7^\circ))$$

$$\boxed{\theta_1 = 67.3^\circ}$$

- if $\theta > \theta_1 = 67.3^\circ \Rightarrow$ the light will refract out of the pipe.