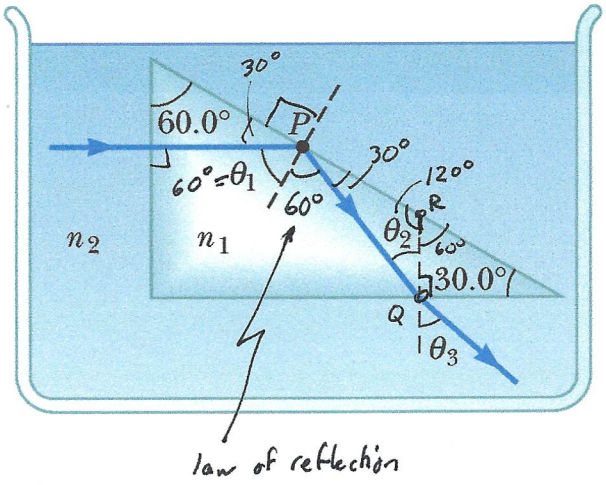
Name: Key

Physics 4C Spring 2020 Test 6 (Optics)

1. A 30°–60°–90° prism with refractive index n_1 is submerged in a liquid of refractive index n_2. A ray of light is incident normal to one face of the prism, as shown, and undergoes total internal reflection at point P. The exit angle of the ray is $\theta_3 = 45°$.



(a) Show by labelling angles on a diagram that $\theta_2 = 30°$. [4 pts]

(b) Find the ratio n_1/n_2. [5 pts]

(c) Now suppose a substance is dissolved in the liquid increasing its refractive index ($n_2 \to n_3$) until a refracted beam just appears at P. Assume the beam reflected at P is still visible. What is the exit angle θ_3 now? [6 pts]

a) ΔPQR: $30° + 120° + \theta_2 = 180°$

$\Rightarrow \theta_2 = 30°$

b) at Q:

$n_1 \sin\theta_2 = n_2 \sin\theta_3$

$\frac{n_1}{n_2} = \frac{\sin\theta_3}{\sin\theta_2}$

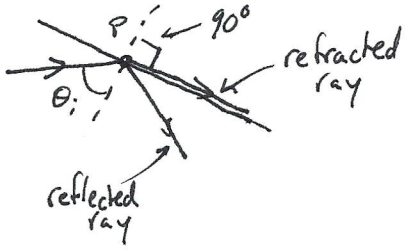
$\frac{n_1}{n_2} = \frac{\sin 45°}{\sin 30°}$

$= \frac{1/\sqrt{2}}{1/2}$

$= \frac{2}{\sqrt{2}}$

$\frac{n_1}{n_2} = \sqrt{2}$

c) When ray just appears into liquid at point P:



@ P:

$n_1 \sin\theta_i = n_3 \sin 90°$

$\theta_i = \theta_c = 60°$

$\frac{n_3}{n_1} = \sin 60°$

$\frac{n_3}{n_1} = \frac{\sqrt{3}}{2}$

at Q:

$n_1 \sin\theta_2 = n_3 \sin\theta_3$

$\sin\theta_3 = \frac{n_1}{n_3} \sin\theta_2$

$\sin\theta_3 = \frac{2}{\sqrt{3}} \sin 30°$

$= \frac{2}{\sqrt{3}} \cdot \frac{1}{2} = \frac{1}{\sqrt{3}}$

$\theta_3 = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

$\theta_3 = 35.3°$