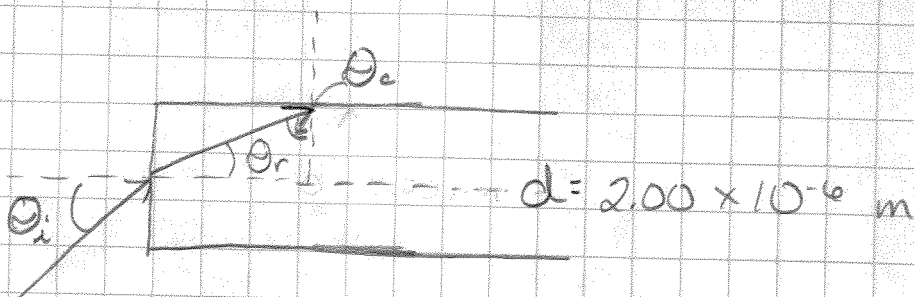


$$n_1 = 1.36 \text{ (pipe)}$$

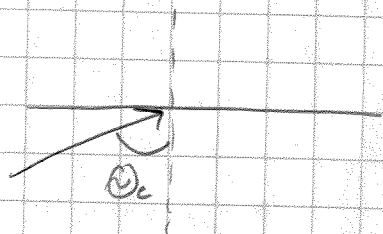
$$n_2 = 1.00 \text{ (air)}$$

$$\theta_i = ?$$



Find θ_c for pipe to air boundary:

$$\sin \theta_c = \frac{n_2}{n_1} = \frac{(1.00)}{(1.36)}$$



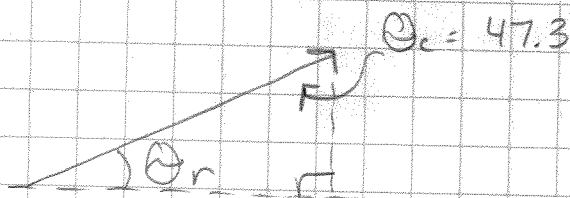
$$\theta_c = 47.3^\circ$$

By geometry, find θ_r

$$\theta_r + \theta_c = 90^\circ$$

$$\theta_r + (47.3^\circ) = 90^\circ$$

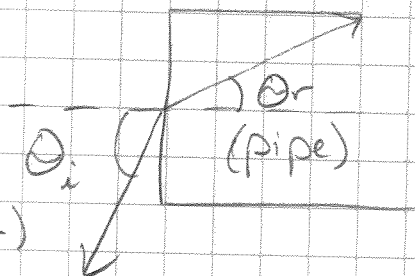
$$\theta_r = 42.7^\circ$$



Find θ_i from Snell's Law

$$n_{\text{air}} \cdot \sin \theta_i = n_{\text{pipe}} \cdot \sin \theta_r \quad (\text{air})$$

$$(1.00) \cdot \sin \theta_i = (1.36) \cdot \sin (42.7^\circ)$$



$$\boxed{\theta_i = 67.2^\circ}$$