

# Demo #1: Fishtank Optics

2.71/2.710 - Optics

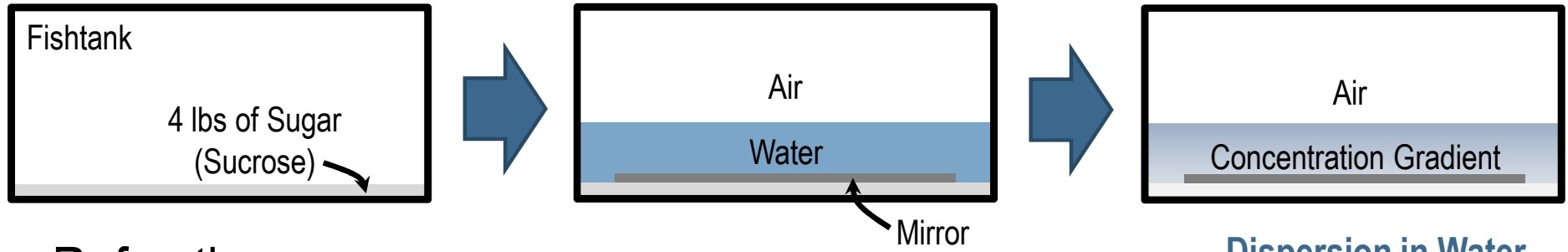
Mechanical Engineering  
MIT

02/15/2012

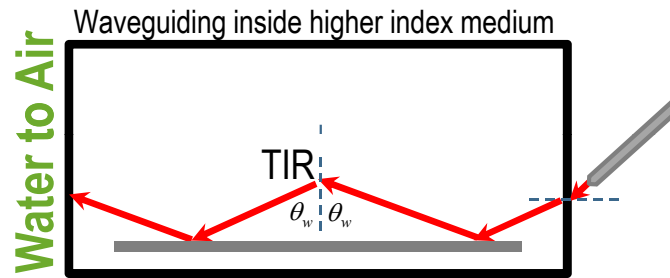
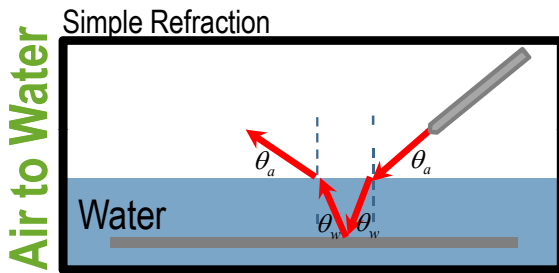
Matt Klug

# Demo #1: Fishtank Optics

## Setup:



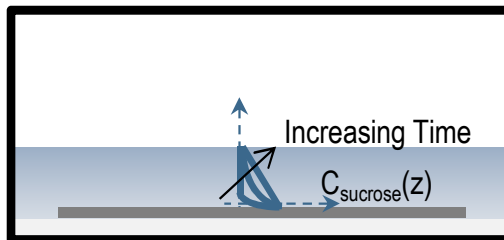
## Refraction: $n_a \sin \theta_a = n_w \sin \theta_w$



$$n_a \sin\left(\frac{\pi}{2}\right) = n_w \sin \theta_{w-crit}$$

Critical Angle for Total Internal Reflection  $\theta_w > \theta_{w-critical}$  then ray reflected, not refracted  $\rightarrow \theta_{w-crit} = \sin^{-1}\left(\frac{n_a}{n_w}\right) \approx \sin^{-1}\left(\frac{1}{1.33}\right) \approx 48^\circ$

## GRAdient-Index (GRIN) Medium:



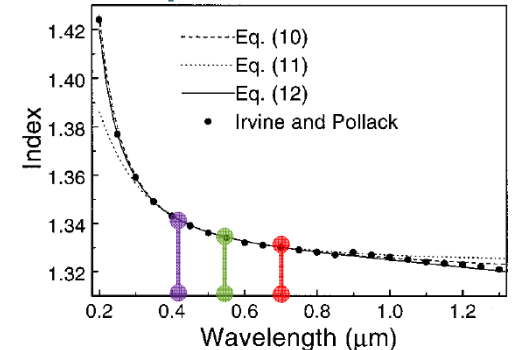
## Scaling Analysis:

$L = \sqrt{D\tau}$ ;  $D = 0.6 \cdot 10^{-9} \text{ m}^2 / \text{s}$  ← Diffusivity of Sucrose in Water

if  $L = 10 \text{ cm}$ ;  $\tau = \frac{L^2}{D} = 193 \text{ days}$  ← Time for Sucrose to Diffuse to Surface

if  $\tau = 3 \text{ days}$ ;  $L = 1.24 \text{ cm}$  ← Extent of Sucrose Diffusion from Bottom

## Dispersion in Water



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Air to Water, ( $\theta_a = 45^\circ$ )

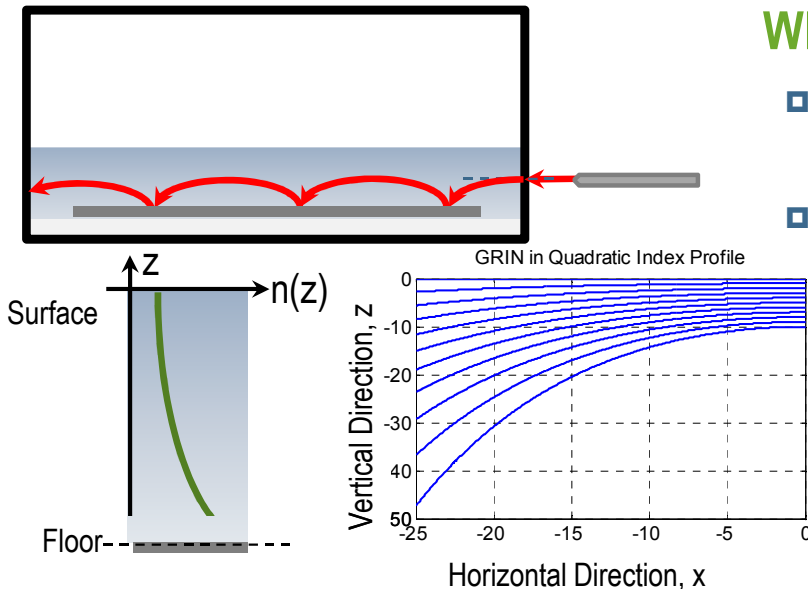
Color	$\lambda$ [nm]	$n_{\text{water}}(\lambda)$	$\theta_w$ (deg)
Red	650	1.331	22.06
Green	532	1.338	21.94
Violet	405	1.345	21.82

Dispersion not readily observable in demo. Lack precision and beams spread.

Concentration gradient exists only very close to tank bottom!

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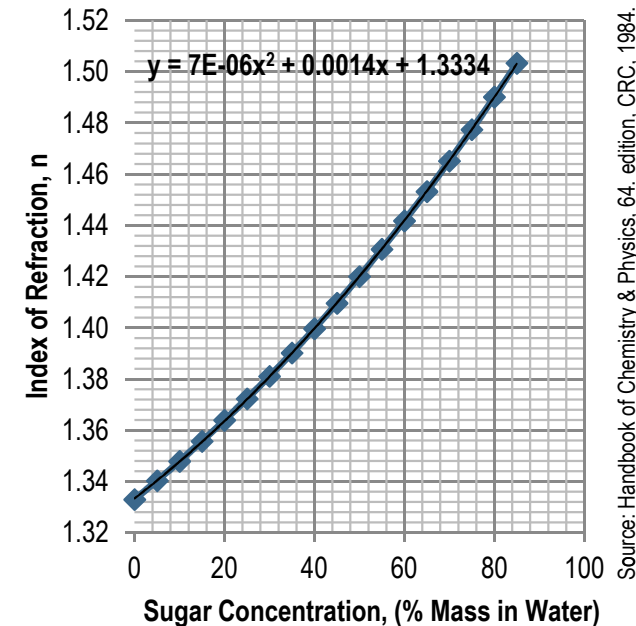
## GRADIENT-INDEX (GRIN) Medium:



### What do we observe?

- Light will bend due to local index gradient,  $n(z)$
- Reflection will occur off mirrors located on tank floor

### $n$ vs. Sucrose Concentration

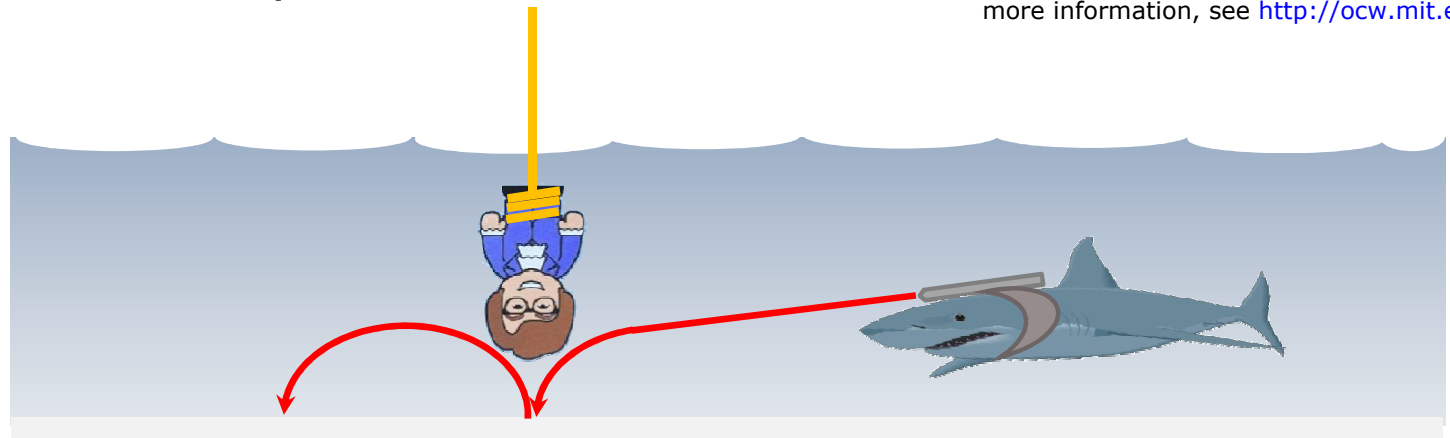


Source: Handbook of Chemistry & Physics, 64. edition, CRC, 1984.

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## Would a GRIN be helpful in a difficult situation?

Image of Dr. Evil removed due to copyright restrictions.



- Would Austin avoid impending doom-by-laser in a GRIN medium?
- Better off with high tensile strength dental floss: Laser light would bend the same as the shark's sight. If the shark sees Austin, it can toast him with a "frickin' laser beam".

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