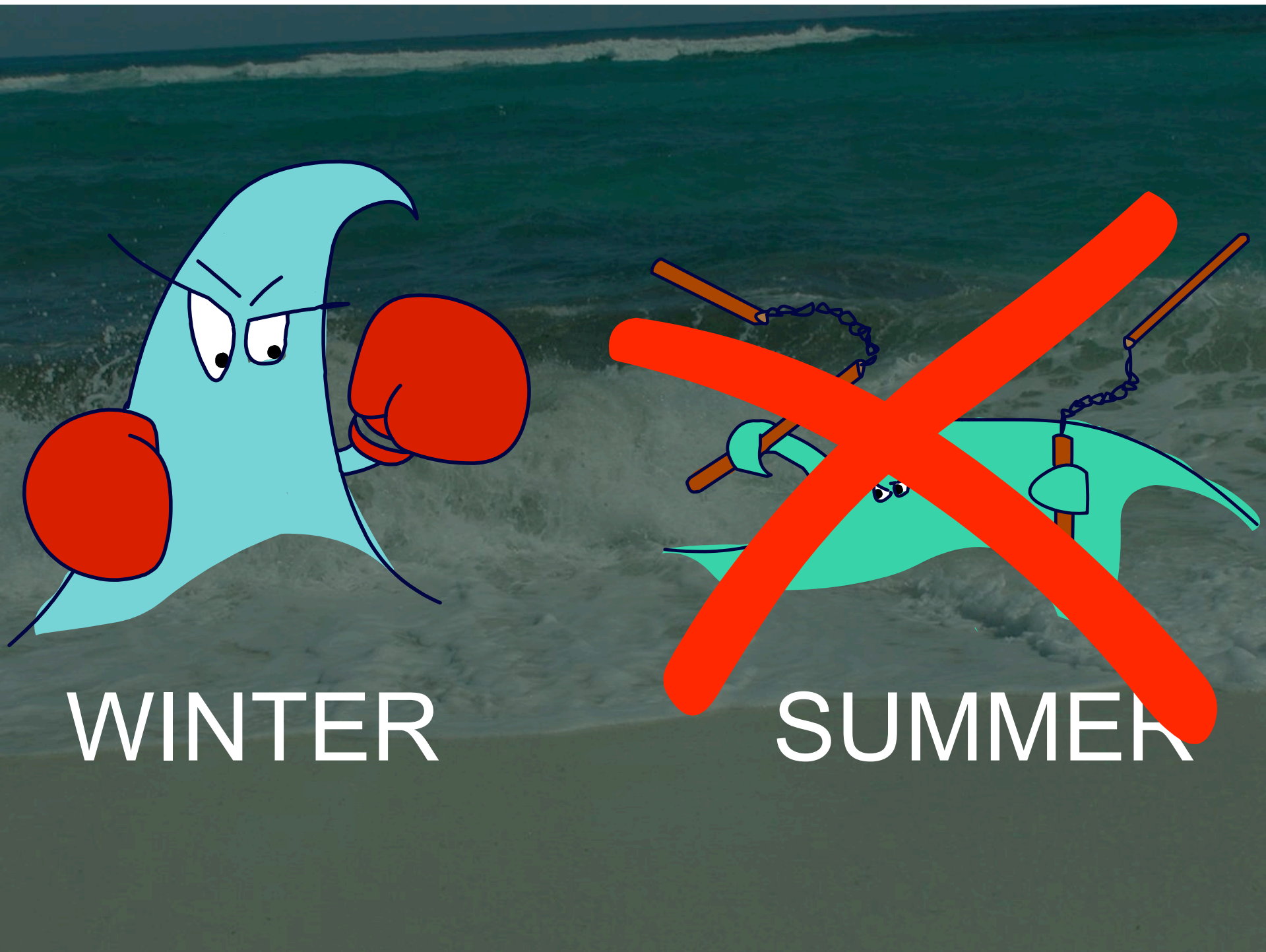
A photograph of a beach with waves crashing onto the shore. The water is a deep blue-green color, and the waves are white with foam. The sand is a light tan color. The sky is a clear, pale blue.

# Wave-induced changes in beach profile and porous flow

Hallie Torrey  
University of Washington  
May 2008

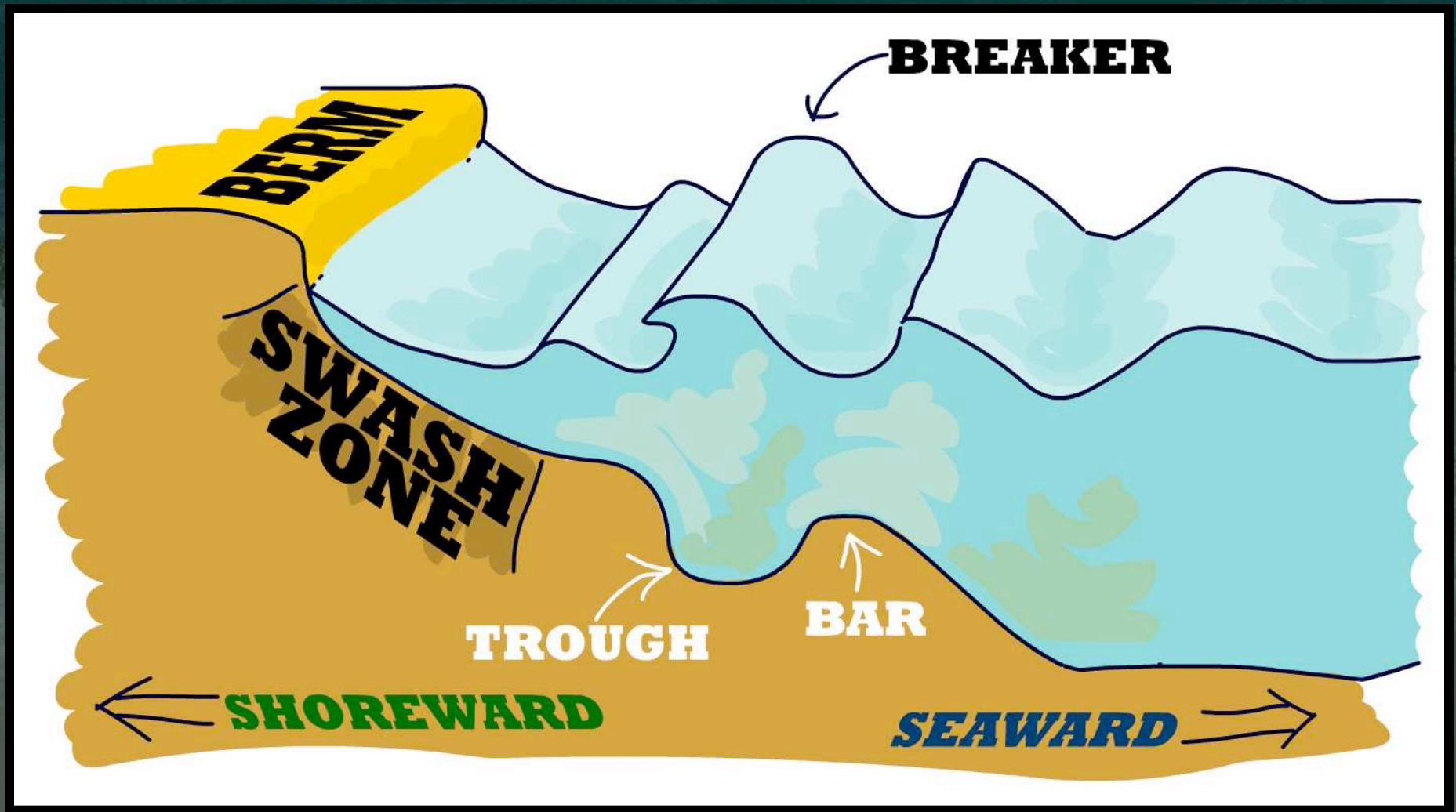


WINTER

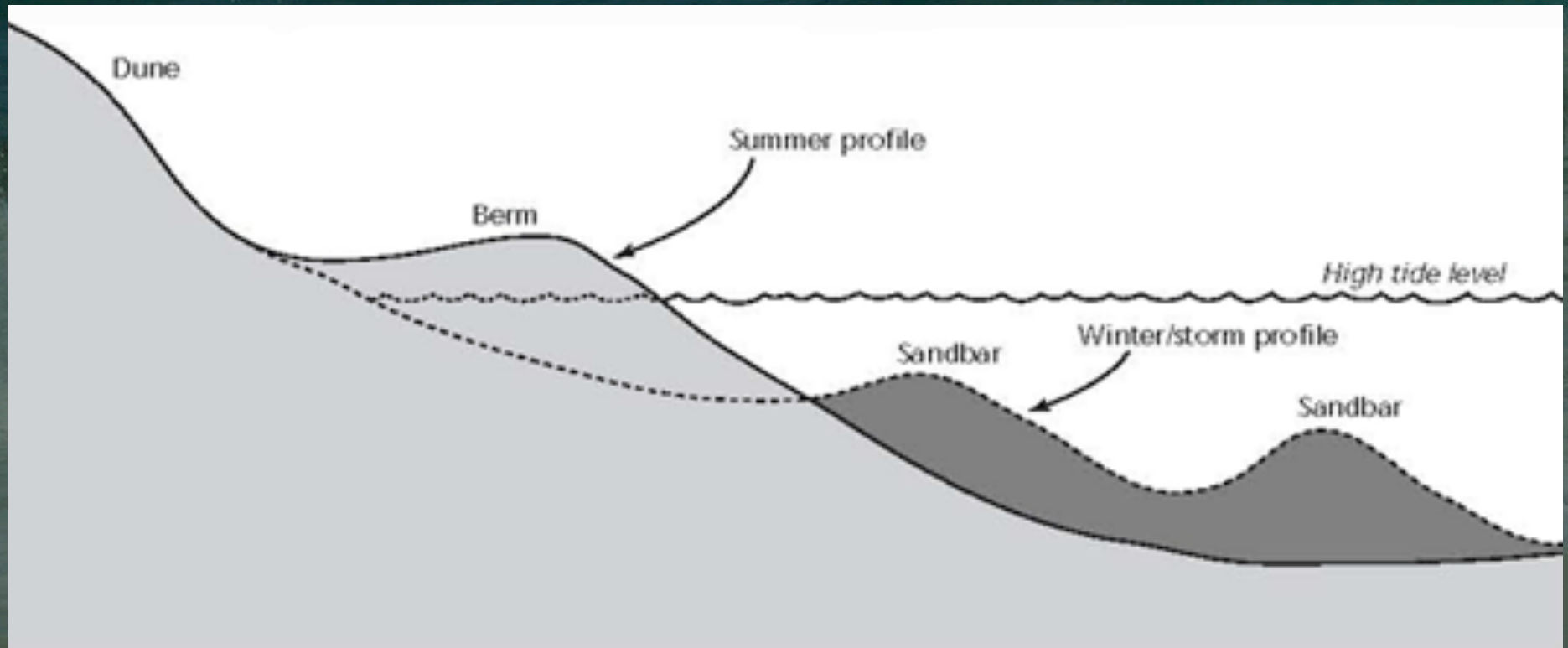
SUMMER



# Terminology



# Winter vs. Summer



Costa Maya



Florida



# North Beach, Ocean Shores



October, 1995



June, 2001

# On average...

Winter

Summer

Height

3 m

1.5 m

Length

180 m

300 m

Steepness =  $H/L$

1/60

1/200

Energy Flux = ...

10.26 kW/m

3.31 kW/m



# Energy Flux

$$= c_g (KE+PE)$$

	<u>Winter</u>	<u>Summer</u>
Height		
Length	3 m	1.5 m
Steepness	180	300 m
SS	m	1/200

$$\begin{aligned}\text{Group Velocity} &= \frac{1}{2} (\text{Phase Speed in Deep Water}) \\ &= \frac{1}{2} (gL/2\pi)^{1/2}\end{aligned}$$

WINTER: 8.38 m/s

SUMMER: 10.82 m/s

$$\text{Kinetic Energy} + \text{Potential Energy} = \frac{1}{8} (\rho_0 g H^2)$$

WINTER: 1,225 kg/s<sup>2</sup>

SUMMER: 306.25 kg/s<sup>2</sup>

$$\text{Energy Flux} = c_g (KE+PE)$$

WINTER: 10.26 kW/m

SUMMER: 3.31 kW/m



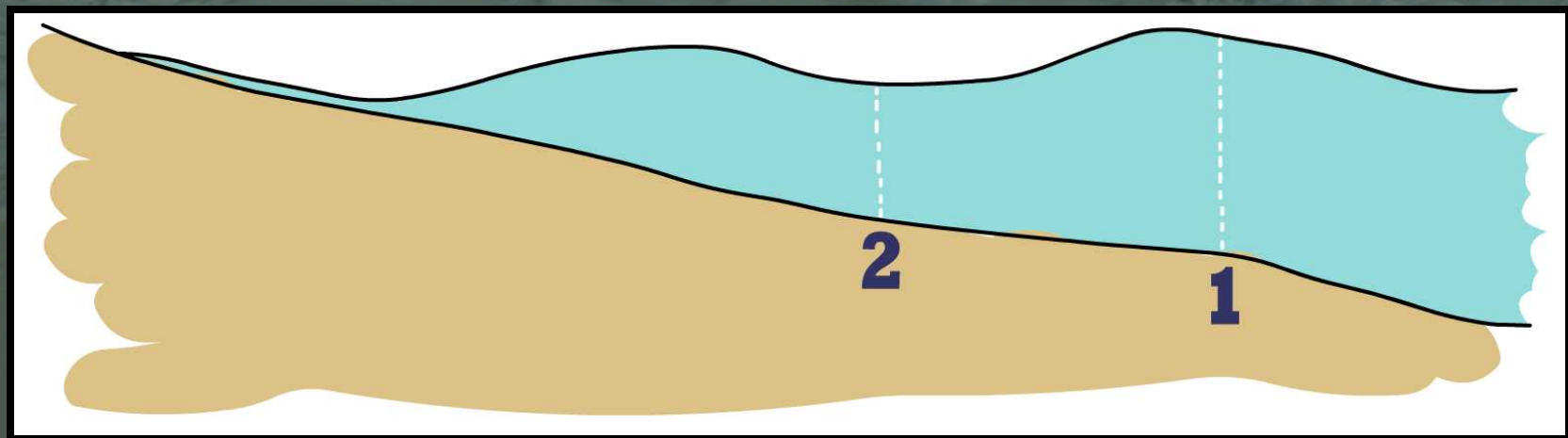
# Breaking Waves

For shallow water waves,

$$c_g = c = (gD)^{1/2}$$

As a wave travels, energy flux is constant:

$$E_1 c_1 = E_2 c_2 \quad E_1/E_2 = c_2/c_1$$



# Breaking Waves

CHANGE IN WAVE HEIGHT:

$$E_1/E_2 = c_2/c_1 \rightarrow \frac{1/8 (\rho_0 g H_1^2)}{1/8 (\rho_0 g H_2^2)} = \frac{(g D_2)^{1/2}}{(g D_1)^{1/2}}$$

$$\rightarrow H_1/H_2 = (D_2/D_1)^{1/4}$$

CHANGE IN WAVE STEEPNESS:

Use dispersion relation:

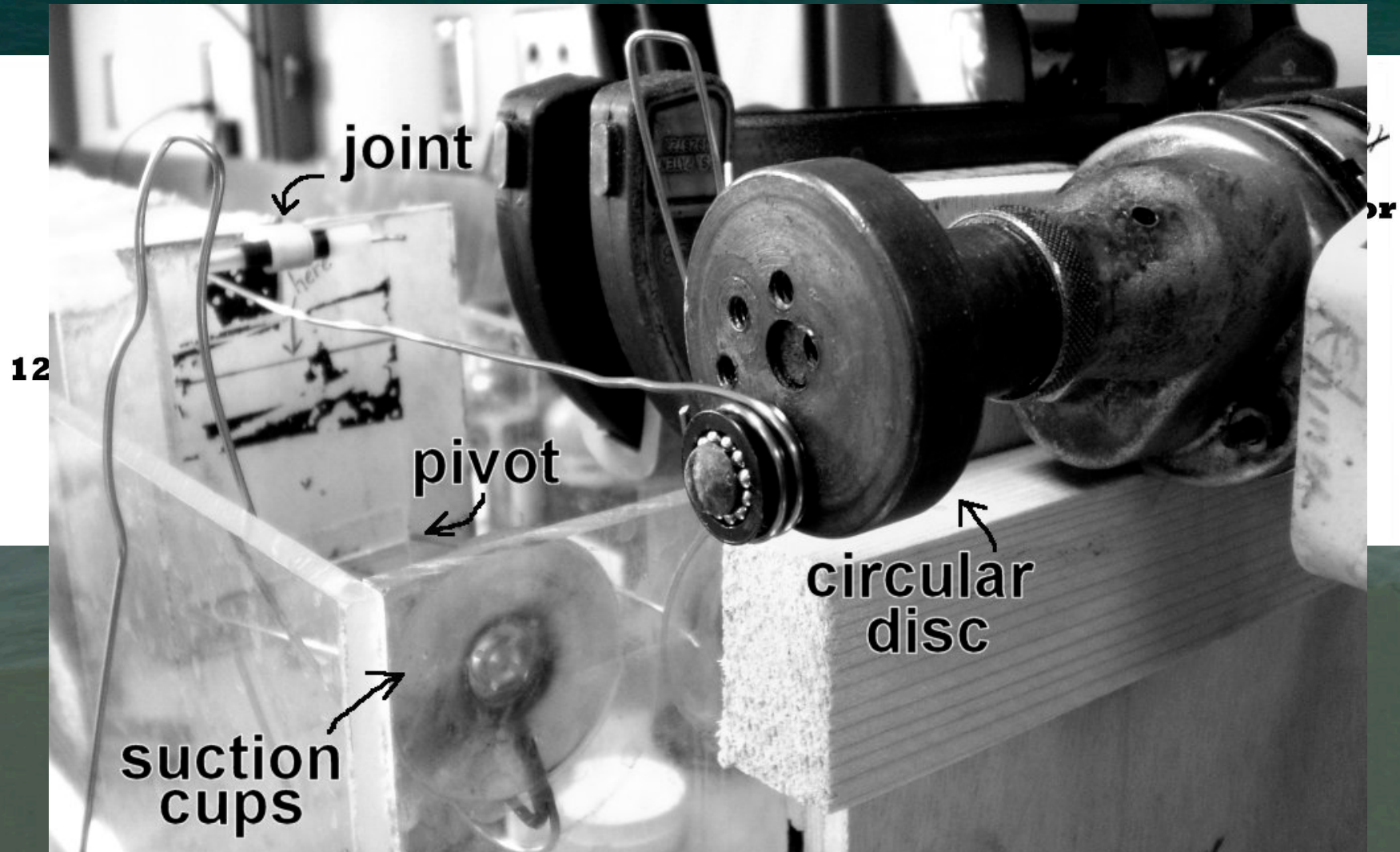
$$\omega^2 = gD/L_s \rightarrow 1/L_s = \omega/(gD)^{1/2}$$

$$H/L_s \sim D^{-1/4} \cdot \omega/(gD)^{1/2} = D^{-3/4} \cdot \omega/g^{1/2}$$



# MY EXPERIMENT

## Apparatus



# MY EXPERIMENT

Observations

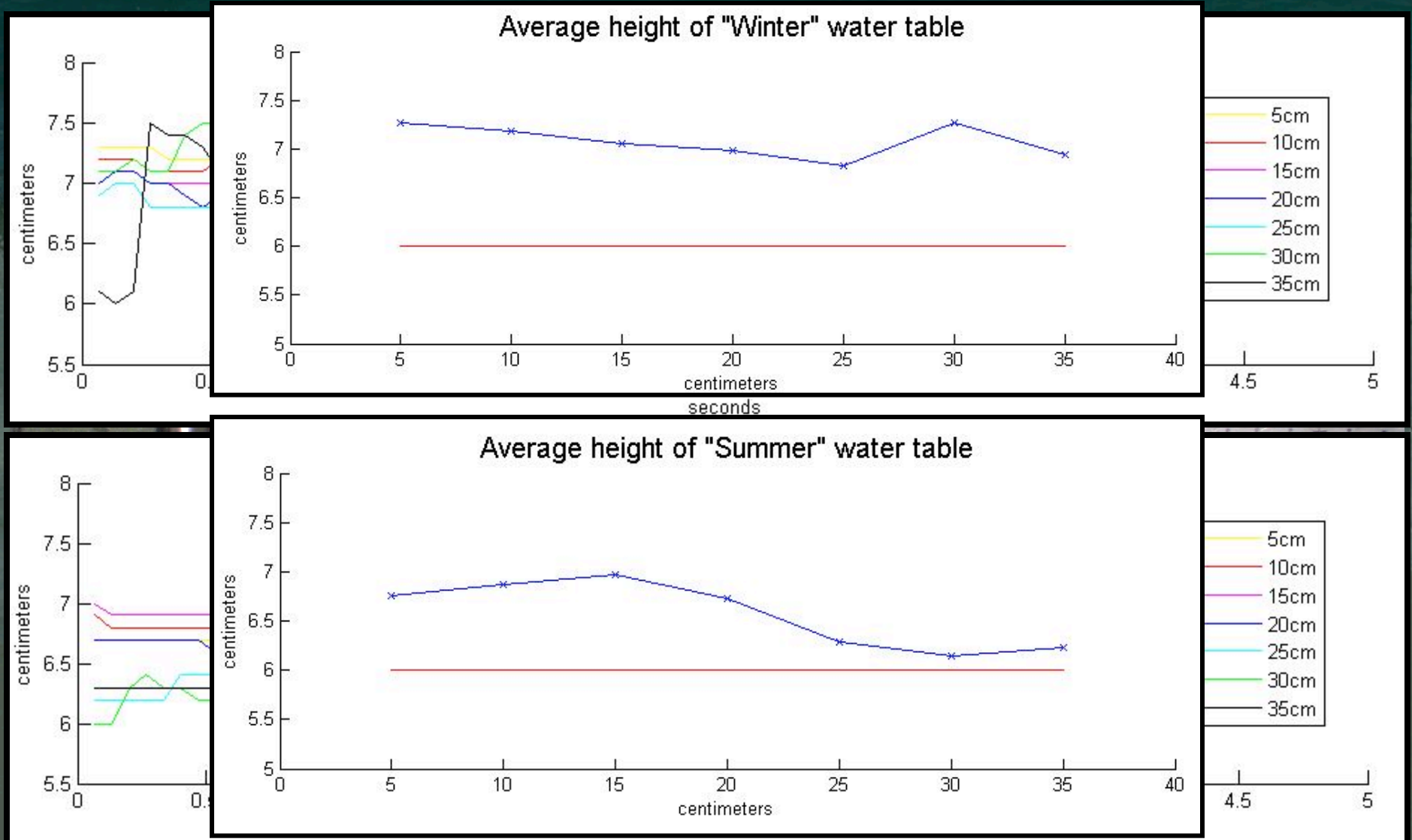
... cue the movies!!!





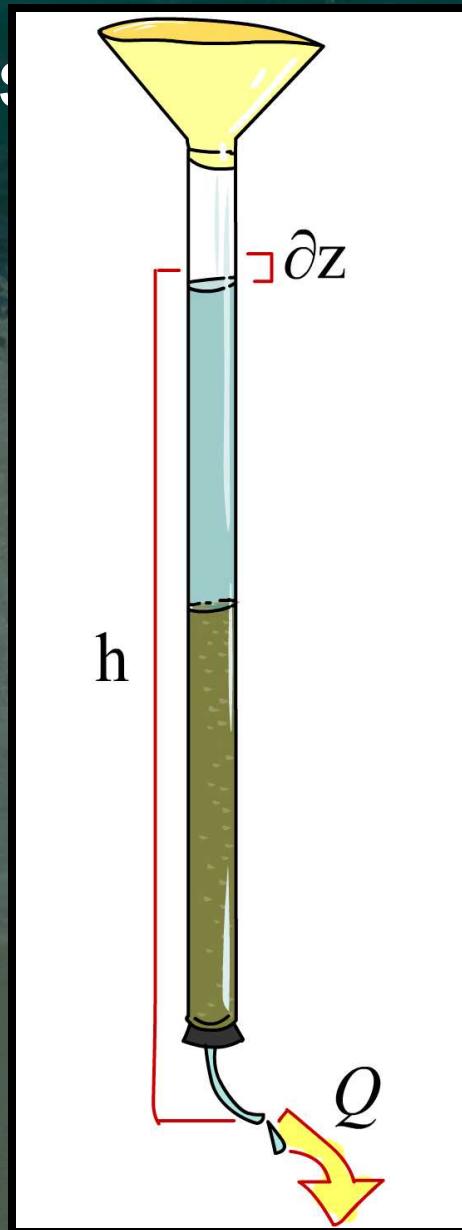
# MY EXPERIMENT

## Observations



# MY EXPERIMENT

Apparatus

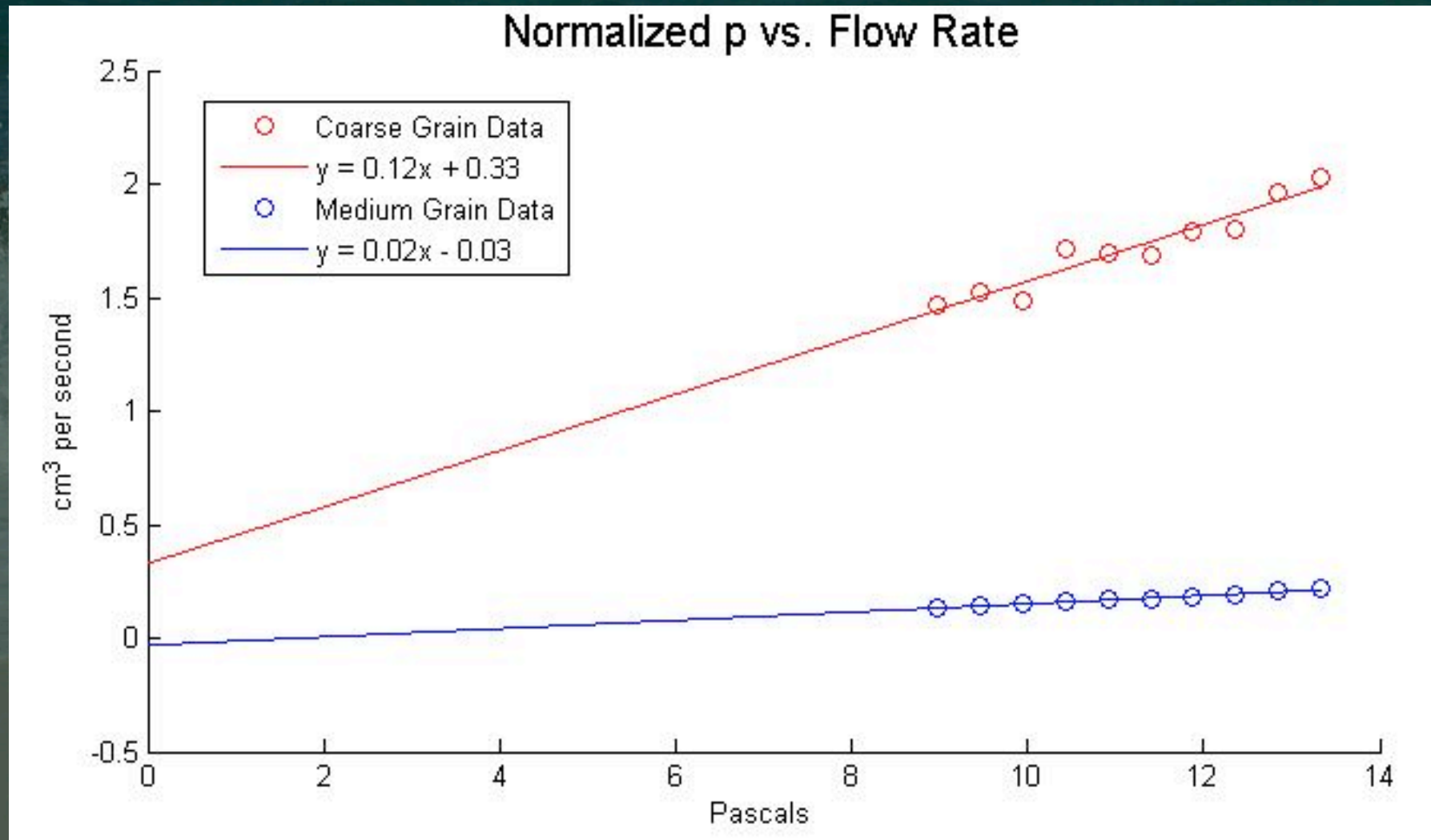


$$Q = G \cdot p$$



# MY EXPERIMENT

## Observations



# Governing Equations

Conservation of  
Momentum:

$$\vec{u} = K \nabla p = \nabla \Phi$$

Conservation of Mass:

$$\frac{\partial \rho}{\partial \tau} = -\rho \nabla \cdot \vec{u}$$

$$0 = \nabla \cdot \vec{u}$$

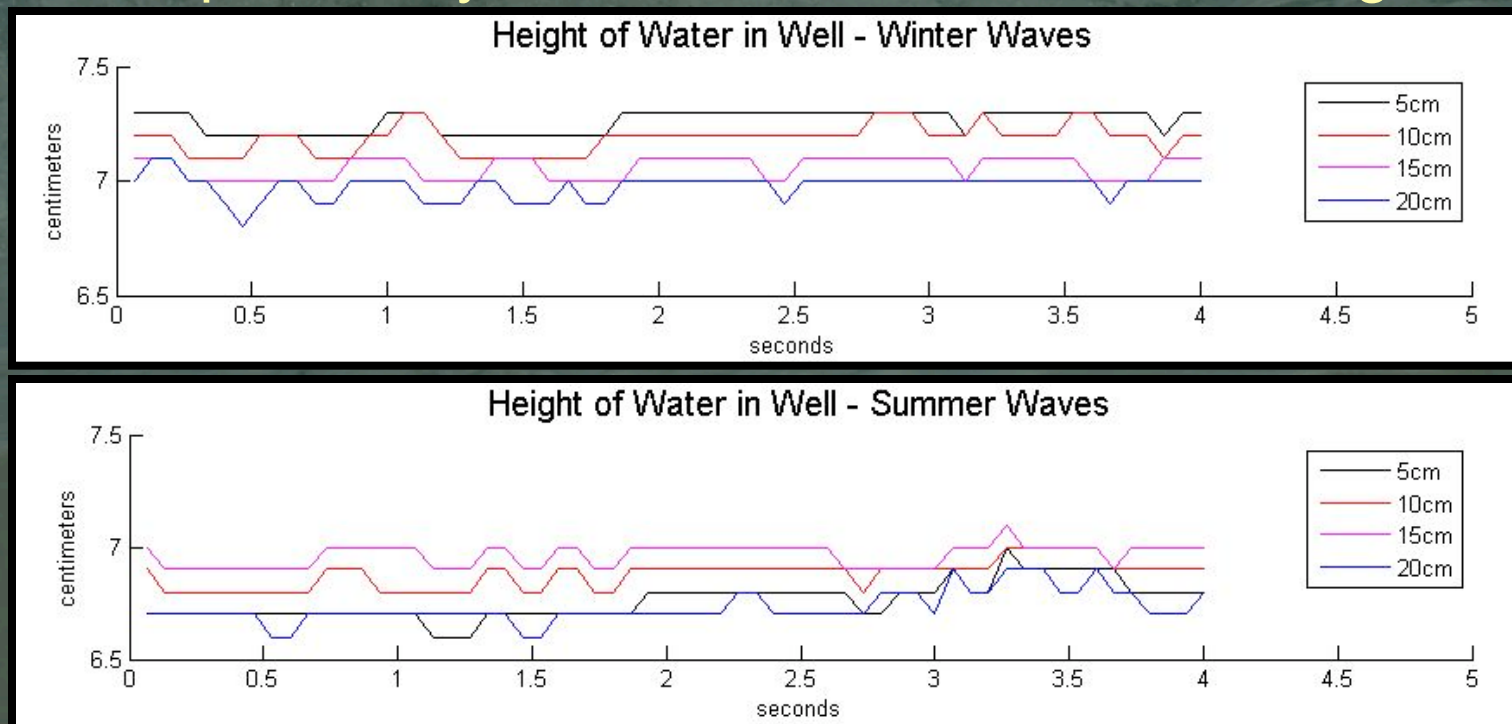
$$\Rightarrow \frac{\partial^2 \Phi}{\partial x^2} + \frac{\partial^2 \Phi}{\partial y^2} = \nabla^2 \Phi = 0$$



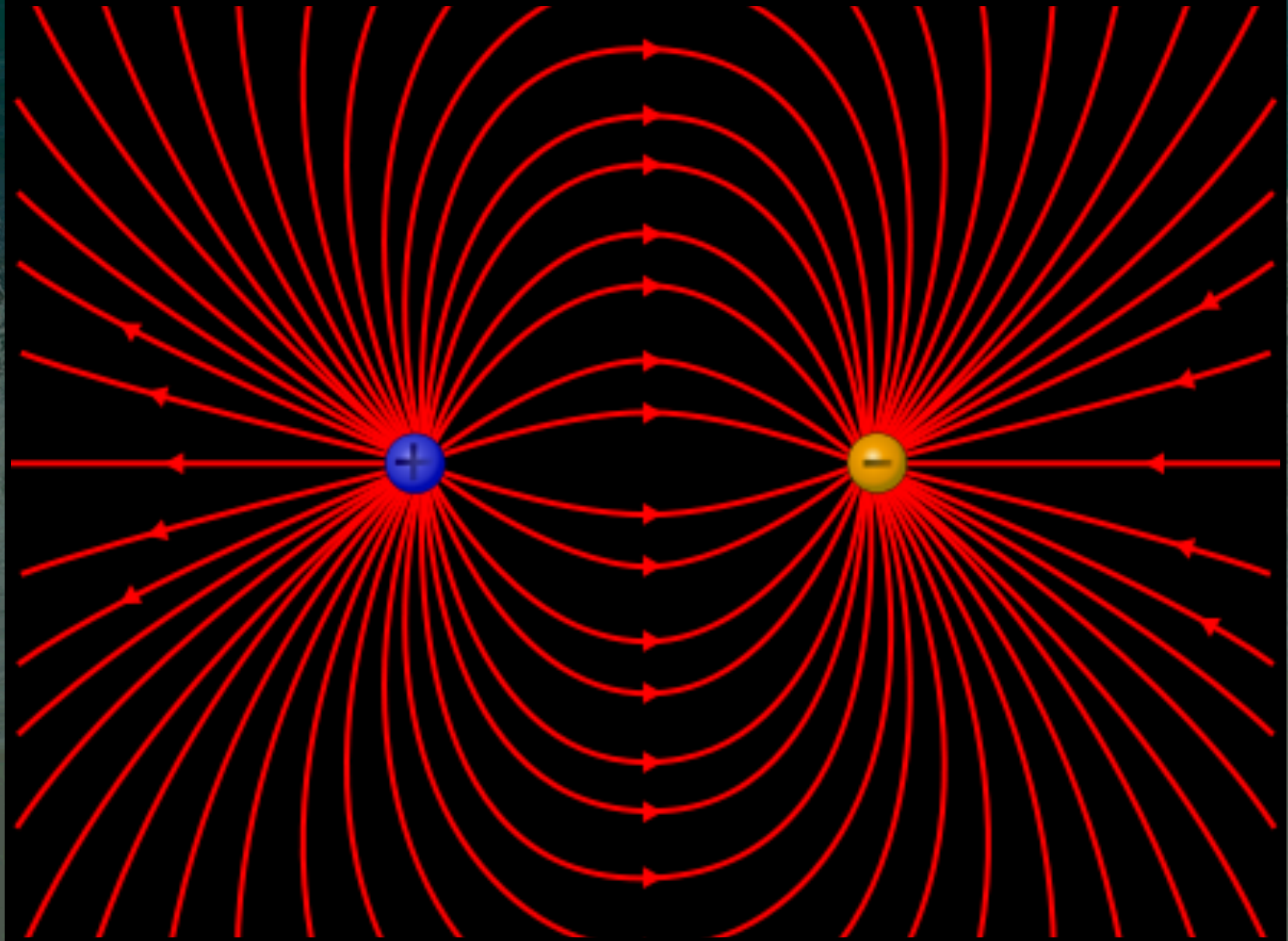
# ELLIPTIC!

$$\nabla^2 \Phi = 0$$

Boundary conditions are periodic.  
Is the periodicity “felt” INSTANTLY within the region?

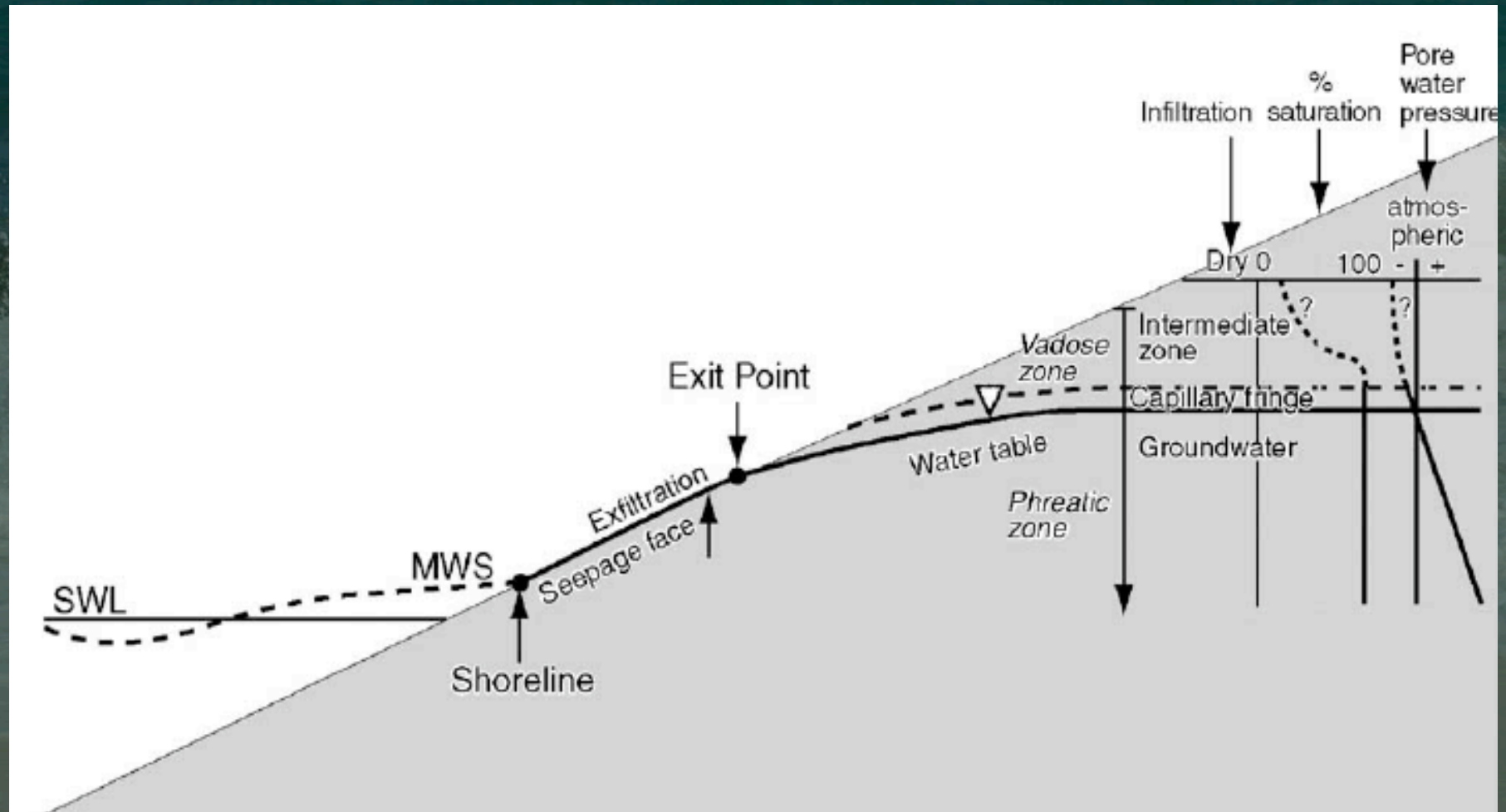


# Ohm and Darcy





# So-and-so said...\*



\* Consider it paraphrasing.

So-and-so said...\*

“Use the Boussinesq equation!”

$$\frac{\partial h}{\partial t} = \frac{K}{s} \frac{\partial}{\partial x} \left( h \frac{\partial h}{\partial x} \right)$$

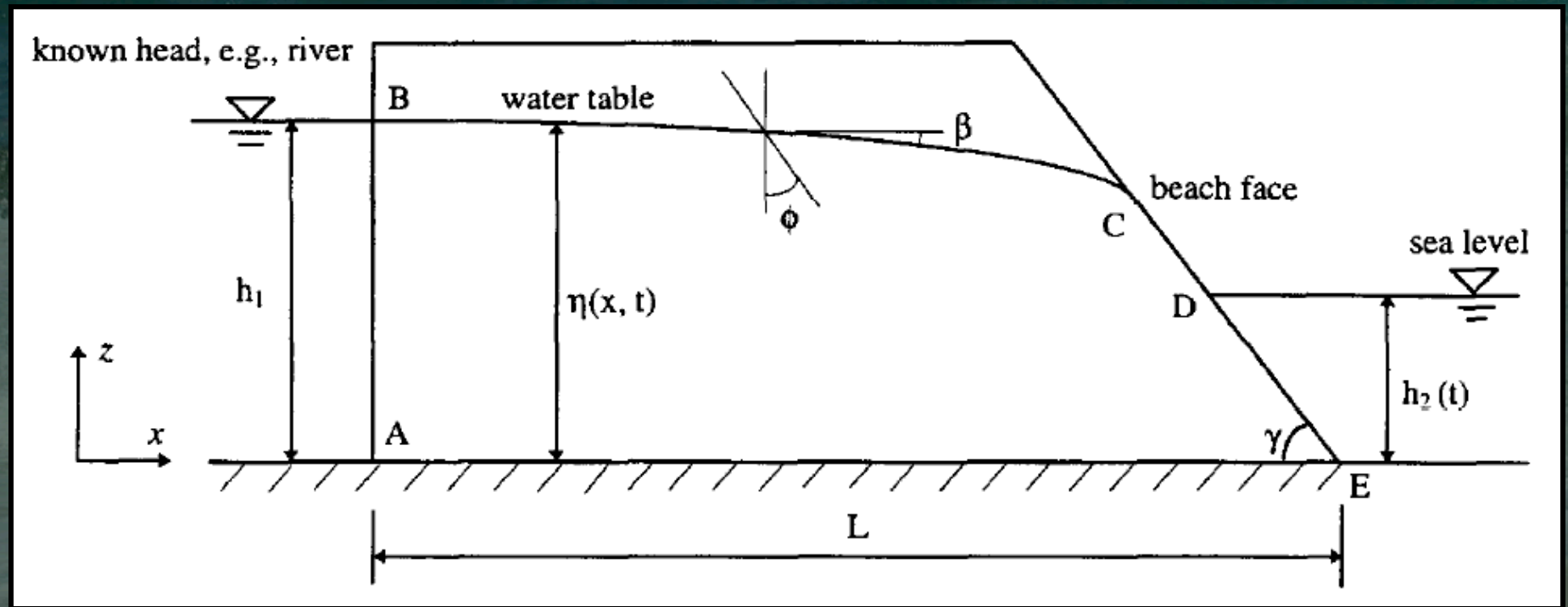
“Assume the Dupuit-Forchheimer approximation!”

\* Consider it paraphrasing



So-and-so said...\*

“Solve Laplace’s Equaion!”



\* Consider it paraphrasing.

So-and-so said...\*

“Solve Laplace’s Equaion!”

(d)

A high-contrast, black and white photograph showing a person's arm and hand. The arm is extended from the left, and the hand is positioned towards the right. A very bright, circular highlight is visible on the back of the hand, suggesting a strong light source. The background is dark and textured. In the top left corner of the image, there is a small circular logo containing the letter 'd'.

\* Consider it paraphrasing.







# References

- [1] Cardenas, M. Bayani and J.L. Wilson, "Exchange across a sediment-water interface with ambient groundwater discharge." Elsevier Ltd (Copyright 2007)
- [2] Cardenas, M. Bayani and J.L. Wilson, "Hydrodynamics of coupled flow above and below a sediment-water interface with triangular bedforms." Elsevier Ltd (Copyright 2006)
- [4] Komar, Paul D., Beach Processes and Sedimentation. Prentice Hall, Inc, Englewood Cliffs, New Jersey, 1976
- [8] Turner, Ian L. and Gerhard Masselink, "Swash infiltration-exfiltration and sediment transport." Journal of Geophysical Research, 103 (1998), No C13, pp 30,813-30,824

Plus more!