Day 4 ① PH 424

Last time

$$\psi_{Left} = Re\left[Ae^{i(k_1x-\omega t)} + Be^{i(-k_1x-\omega t)}\right]$$

$$\psi_{Right} = Re\left[Ce^{i(k_2x-\omega t)}\right]$$

where A, B & C can be complex numbers.

Boundary conditions put constraints on A, B & C.

$$\boxed{A + B = C}$$

$$\boxed{k_1A - k_1B = k_2C}$$

Solve for $\frac{B}{A}$ to find fraction of amplitude that is reflected

$$\frac{B}{A} = \frac{k_1 - k_2}{k_1 + k_2}$$

(Check in limit μ_2 very heavy)

Similarly, solve for $\frac{C}{A}$ to find fraction transmitted

$$\frac{C}{A} = \frac{2k_1}{k_1 + k_2}$$

We can make these eqns more general, so it doesn't depend on the particular value of k_1 that we send at the interface

$$\frac{B}{A} = \frac{k_1 - k_2}{k_1 + k_2}$$

[use $V_1 = \frac{\omega}{k_1}$, $V_2 = \frac{\omega}{k_2}$]

$$= \frac{\frac{\omega}{V_1} - \frac{\omega}{V_2}}{\frac{\omega}{V_1} + \frac{\omega}{V_2}}$$

$$= \frac{V_2 - V_1}{V_2 + V_1}$$

(check in limit that V_2 is slow).

Now look at the animation on website.

[Note: $\frac{B}{A}$ is called a reflection coefficient.
Some people like to defn $R = -\frac{B}{A}$.]

Reflection and transmission coefficients can also be expressed in terms of impedences.

$$\boxed{\frac{B}{A} = \frac{Z_1 - Z_2}{Z_1 + Z_2}}$$

Impedance is a familiar concept in electrical circuits

$$Z \equiv \frac{V}{I}$$

(where V & I could be dc quantities, or oscillating quantities).

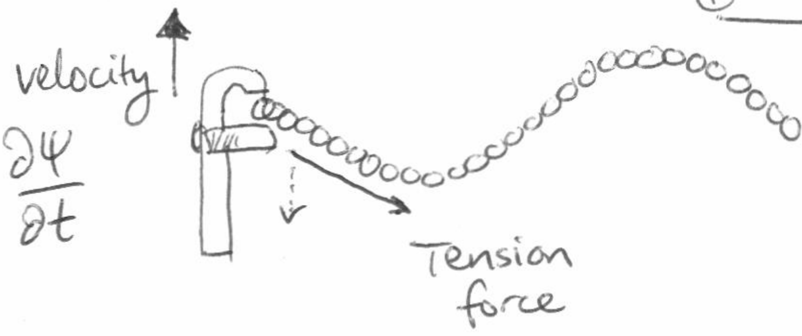
Less familiar concept for stretched strings.

For a stretched string

$$Z \equiv \frac{F_{applied}\Big|_{\text{at end of stretched string}}}{\frac{\partial \psi}{\partial t}\Big|_{\text{at end of stretched string.}}} = \sqrt{\mu \tau}$$

(μ = mass density, τ = tension.)

The result $\sqrt{\mu\tau}$ is not too hard to derive.
You can also check that it makes sense by playing with a slinky.



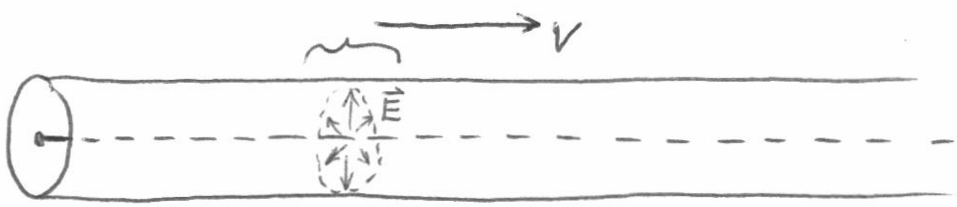
→ launch a traveling wave of amplitude A, wave vector k.

The downward component of tension is $\tau \underbrace{Ak}_{\text{slope}} \cos\omega t$

The velocity $\frac{\partial \psi}{\partial t} = A\omega \cos\omega t$

Ratio of $\frac{\text{Force}}{\text{Velocity}} = \frac{\tau k}{\omega} = \frac{\tau}{v} = \sqrt{\mu \tau}$

Ready to start the co-axial cable lab



Generate a region of high $\vec{E}$ field that will propogate down the cable.

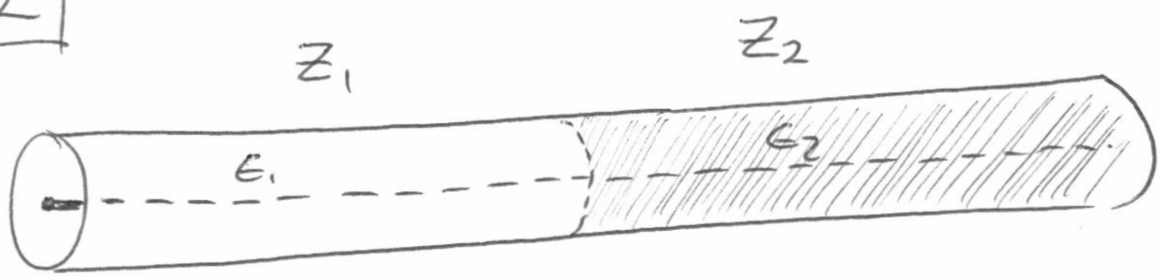
A voltmeter can be used to observe the propogation of the electro-magnetic pulse down the cable.

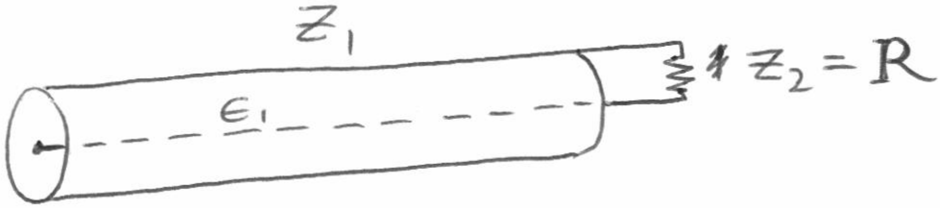
PART 1

Measure propogation speed.

discuss what affects propogation speed.

PART 2





Mimic a cable mismatch by using a variable resister.

Measure the reflections.

Assignment for Friday:

Bring your data plotted as