

Reviewing for second midterm

Some of these ideas are definitions or assumptions of the model – those are the foothold ideas we use as the basis for reasoning. Other ideas are reasoned results – when it’s a reasoned result, you should be able to explain where it came from, how it arises from the definitions and assumptions of the model, and you should be able to respond to conflicting lines of reasoning. I’m not going to list all the results, just a few core examples. Memorize foothold ideas; use them to figure out these and other results.

I’m only including ideas since the last midterm on this sheet – e.g. I’m not listing “current in = current out,” but of course that’s still part of understanding circuits.

Electric Field, Potential, and Potential Energy

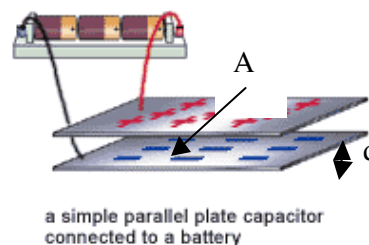
- Foothold idea: The electric field is the force per unit charge: $E=F/q$.
- Foothold idea: The potential difference (i.e. voltage difference) between two locations in space is the potential energy difference per unit charge: $\Delta V=\Delta P.E./q$.

Magnetism

- Not the same as electric charge! Arises from the *motion* of electric charge – electric current causes magnetism. (We talked about magnets a little bit, but I won’t ask anything about them on this exam.)

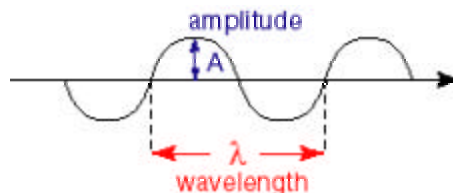
Capacitors

- Foothold idea: Capacitance $C=Q/\Delta V$, where ΔV is the potential difference, Q (and $-Q$) are the charges on the plates of the capacitor. 1 Farad = 1 Coulomb/1 Volt
- Reasoned result: Parallel plate capacitor with area A of plates and spacing d . $C=\epsilon_0 A/d$. (ϵ_0 = constant)
- Measured value: $\epsilon_0=9 \times 10^{-12}$ Farads/meter.
- Reasoned result: Time constant for discharging or charging for a circuit with a resistor in series with a capacitor: $\tau=RC$.



Waves

- Foothold: A wave is a propagation of something happening – the spring moving, the air vibrating, the water rising, etc.
- Foothold: Pulses passing each other add by superposition (adding displacements that would have happened with each wave separately point by point.) Effects can add or cancel.
- Result: v_{wave} , the wave pulse travel speed (or wave speed for a periodic wave) depends on the properties of the medium – the “reaction time” it takes one part of the medium to react to what happened to the adjacent part. Higher spring tension makes a faster reaction, higher mass of the string per unit of length makes a slower reaction.
- Result: v_{wave} does NOT depend on properties of the pulse like amplitude or pulse width.
- The relationship between the pulse length, the wave speed and the time it takes to make the pulse (the “flick” time) is $l=v_{\text{wave}}t$.
- Foothold: Amplitude is the maximum height of the wave; wavelength is the length of the wave. Period is the time for a full cycle; frequency is the number of cycles per second.
- Result: This is similar to the relationship between wavelength (λ) for periodic waves, the wave speed the period (T). $\lambda=v_{\text{wave}}T$, for the same reasons as $l=v_{\text{wave}}t$. $\lambda=v_{\text{wave}}T$, is equivalent to $\lambda=v_{\text{wave}}/f$, since the frequency f is the number of flicks per unit time or $1/T$.



the
and

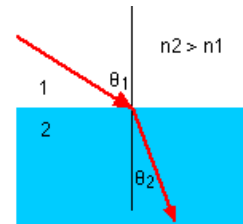
Light

- **Foothold:** We see when light hits us in the eye.
- **Foothold:** Some things emit light and some things only reflect light from other sources.
- **Foothold:** Light travels in straight lines unless it hits something or enters a new medium.
- **Foothold:** Light reflects from mirrors at the same angle it hit (angle of reflection = angle of incidence). Light reflects from most surfaces in all directions. (Many things fall in between, partly mirror-like.)



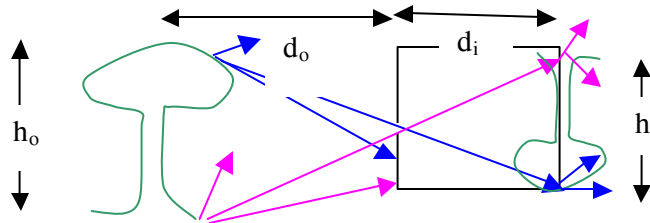
- **Foothold:** In the model so far, light is tiny particles that bounce around and hit things.
- **Result:** For any light source or non-mirror object reflecting light, we can think of every tiny point on that object as a point source of light, spraying light out in all directions.

- **Foothold:** When light enters a new medium, it refracts if *index of refraction* is different from medium it is leaving. index of refraction if higher in the medium it enters, it bends the line perpendicular to the surface, and if the index of refraction is smaller it bends away from this perpendicular. The formula that describes this is called Snell's law: $n_2 \sin \theta_2 = n_1 \sin \theta_1$. (I won't test you on Snell's Law on this exam.)



the
If the
toward
line.
 $n_1 \sin \theta_1 =$

- **Result:** We found that when you have a small pinhole you can get an picture of an object on a screen. The relationship between the size of the object and the picture is given by $h_i = h_o d_o / d_i$

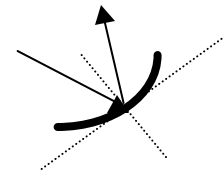


- **Result:** We see an image of a point on an object at a location where different lines of sight on the same point intersect – the place in space where light is or seems to be coming from, tracing back along the lines of sight. To make an image of an object, you have to have a one-one correspondence of each point on the object with specific points in space at the image. The pinhole makes that correspondence by only letting through a single ray (or just a small hole's worth) from each point on the object; a mirror or lens makes that correspondence out of multiple rays from each point on the object.

- **Definition:** An image is “virtual” if light only appears to come from that point in space (e.g. behind the mirror); an image is “real” if the light actually passes through the place where we see the image. (E.g. that floating image of the bulb.)

- **Result:** When light bounces from a curved mirror, it bounces as if it is hitting a flat mirror tangential to the curved surface at the place it hits.

- **Foothold:** Mirrors and lenses can be shaped to have *focal points*, such that any ray light that comes in to the mirror or lens parallel to the centerline (the axis of symmetry through the center) goes out along a line passing through the focal point. Or, a ray of light that comes in along a line passing through a focal point goes out parallel to the centerline. Lenses have two focal points, one on each side; mirrors have only one.



- **Result:** Focal points are useful for finding the location of images, because they show how the light reflects or refracts for particular rays leaving points on the object.