screen

University of Maryland
Department of Physics

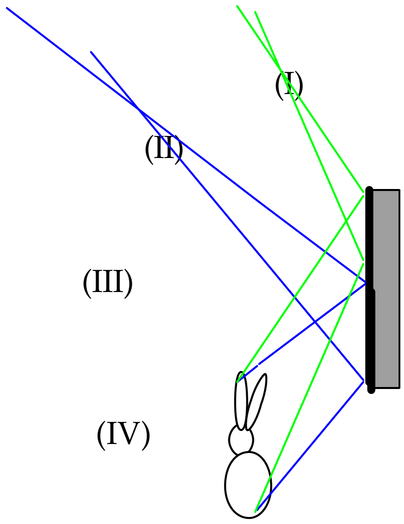
Spring 2002 **Laura Lising**
Physics 122 **May 8, 2003**

Makeup Exam #2 Solutions

Multiple choice questions.

Just the answer counts for these. (8 points each)

1) A rabbit puppet is near a mirror. From which point(s) can you see the entire image of the rabbit?



a) I only

b) I and II

c) II and III

d) III only

e) III and IV

f) None.

Draw light leaving the tail and see if it can reflect to the point of interest; ditto from the ears. Angle out = angle in, and you can see that points I and II can see both ends of the bunny.

2) The figure below shows several of the light rays coming off an object and passing through a lens. Where could you put your eye to see an image of the candle?

a) I, II, III, or IV

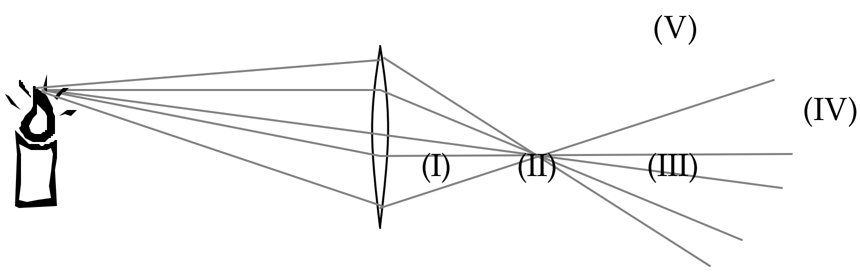
b) I, II, or III

c) I or II

d) III or IV

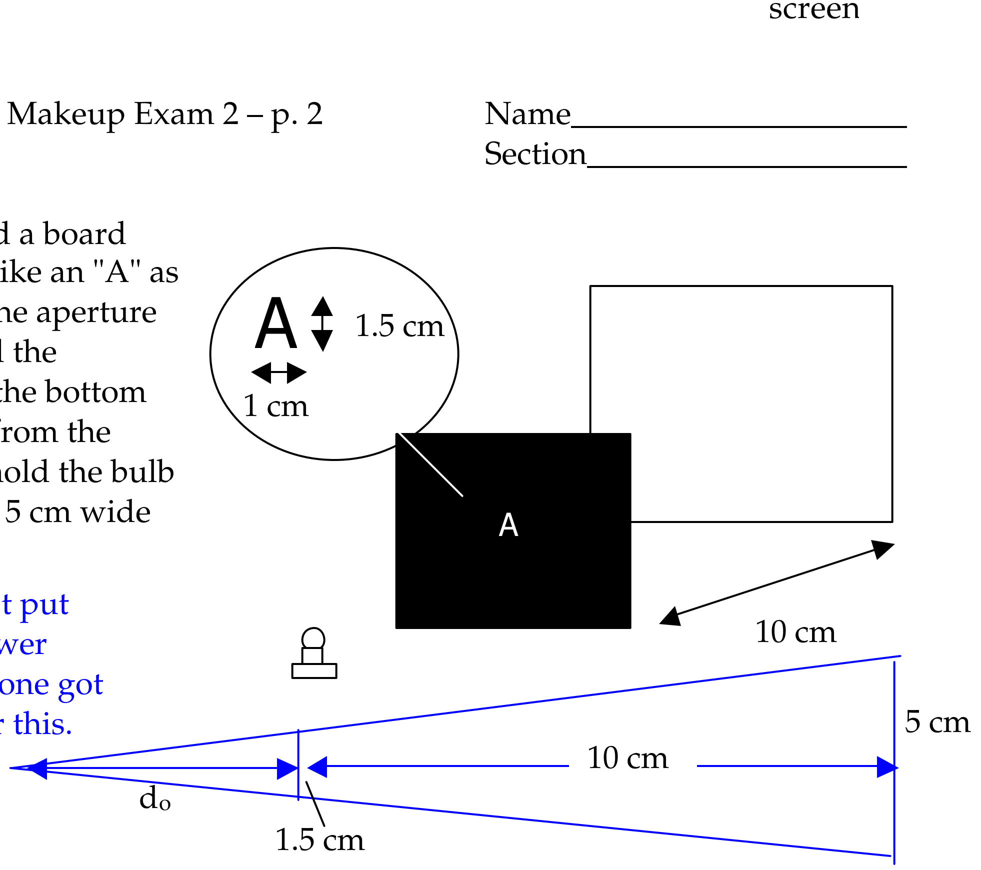
e) From any point.

f) From no point.



To see an image of the top of the candle, you need to be able to see light coming from it. That rules out V. If you put your eye at I, light can hit it, but you wouldn't see an image, meaning your two eyes wouldn't agree that the light is coming from the same point. At point II, you also couldn't see an image. In fact, all the light from the top of the candle is converging at that point. If you put your eye right there, you could see light, but if you moved your eye ever so slightly (or looked with the other eye) you wouldn't see any light at all, let alone light that all comes from the same point. At III and IV, you can see light coming from that point in space – trace back the lines of sight, and that's where the light came from.

3) You a small light bulb and a board with an aperture shaped like an "A" as shown. The screen and the aperture board are 10 cm apart and the aperture is 1 cm wide on the bottom and 1.5 cm tall. How far from the aperture do you need to hold the bulb to get a bright spot that is 5 cm wide on the bottom?

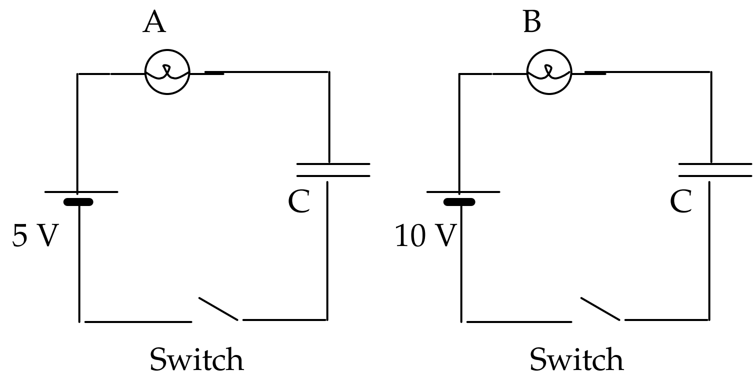


a) 1 cm
b) 2 cm
c) 5/3 cm
d) 10 cm
e) 20 cm

Oops, I didn't put the right answer there. Everyone got full credit for this.

Similar triangles:
$d_o/1.5\text{ cm} = (d_o+10\text{ cm})/(5\text{ cm})$ $5d_o = 1.5d_o + 10$. Solve for $d_o = 5/2 = 2.5$ cm.

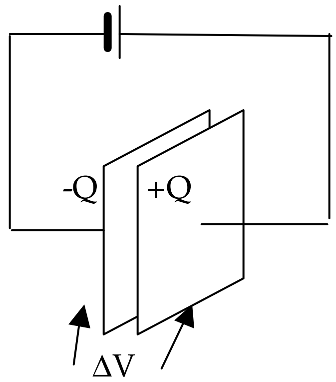
4) You have two circuits, each with a battery, a capacitor, and a bulb. The capacitors and bulbs are identical, but one circuit has a higher voltage battery. If you close both switches at the same time, which of the following statements are true?



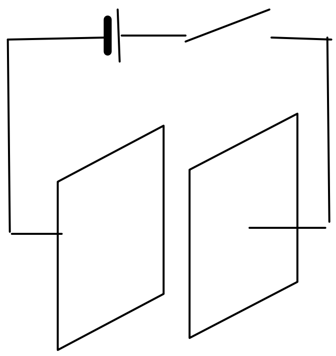
a) A and B will light equally bright, but B will light for longer.
b) B will light brighter than A, and B will light for longer.
c) A and B will light equally bright, and for about the same amount of time.
d) B will light brighter than A, but they will light for about the same amount of time.
e) B will light brighter than A, and both will stay lit until the switches are opened again.

At first, there is no voltage difference across the capacitors because there is no charge built up yet. Thus, the full voltage drop, equal to the rise across each battery, is across each bulb. So A has 5 V across it and B has 10 V. Since the bulbs are identical, this means that the current through B will be greater than through A and B will be brighter. However, the time constant for the charging process is the same for both bulbs since the time constant τ is equal to RC and R and C are the same for both. So the bulbs will light for about the same amount of time. This makes sense because the charge is going onto the capacitor at right faster (higher current), but it's going to have a greater final charge since it will end up with a voltage difference of 10 V instead of 5 V. (And $Q=C\Delta V$)

5) Suppose you have two parallel plates hooked up to opposite sides of a battery as shown. Opposite charges (+Q and -Q) have built up on the two plates and there is a voltage difference (ΔV) between them. **First,** you open the switch as shown below (taking care not to touch any of the conducting surfaces or wires), and **then** you move the two plates farther apart from each other. What happens?



a) The amount of charge on the two plates increases and the voltage difference decreases.
b) The amount of charge decreases and the voltage difference stays the same.
c) The amount of charge and the voltage difference both stay the same.
d) The amount of charge stays the same and the voltage difference increases.
e) The amount of charge increases and the voltage difference stays the same.



Switch opened **before** plates moved apart

If there isn't a complete circuit, current won't flow. That's because the charge on the right hand plate could go off into the wire, but not much really, since the charge has so little room to spread out there. It's happier spread out over the face of the capacitor plate. That's why it's on the plate in the first place. One the right hand side, the charge doesn't want to flow into the battery if charge can't flow out. Remember, the battery is trying to keep it's voltage difference, and if a bunch of charge comes in one side but none leaves the other side, that changes the voltage difference. Thus the charge doesn't change. But the capacitance does. The capacitance goes down as you move the plates apart. Since $\Delta V = Q/C$, as the capacitance goes down, the voltage difference goes up. (the charges are less happy crowded on the plates when there isn't an oppositely charged plate nearby. Without that pulling force, the pressure of the charges increases.)

Another way to think about it is that the plates attract. So that you have to do work to pull them farther apart. You're doing work on the system, putting energy in, so there's more potential energy. Since there's more potential energy and the same amount of charge, there's more potential energy per unit of charge, more potential.

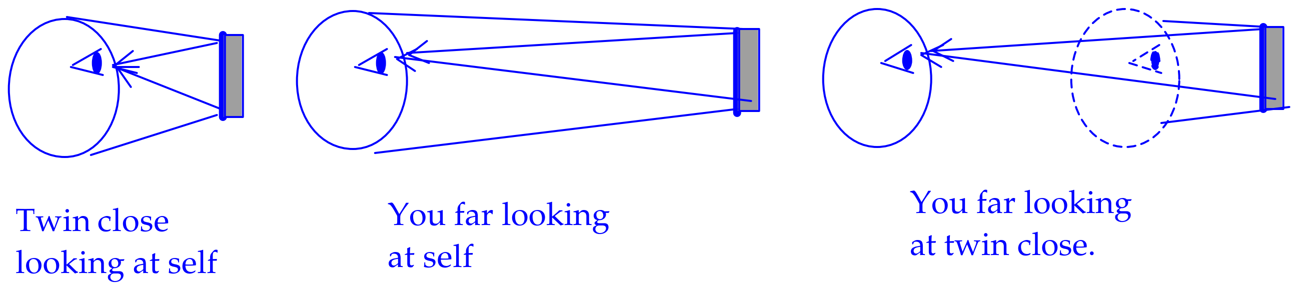
6) Suppose you had an identical (evil?) twin standing next to you , looking at the bathroom mirror and making the soap lines where he or she saw her eyes and mouth and extending the lines to both sides of the mirror. You should be able to look at the lines and see his or her mouth and eyes right on the lines, too. But now suppose you back away from the mirror. What will you see?

a) More of your twin's face in between the lines (both eyes and mouth will now be between the lines.)

b) The same amount of your twin's face between the lines and the lines will still line up at mouth and eyes.

c) The same amount of your twin's face between the lines but the lines will no longer line up at your twin's mouth and eyes.

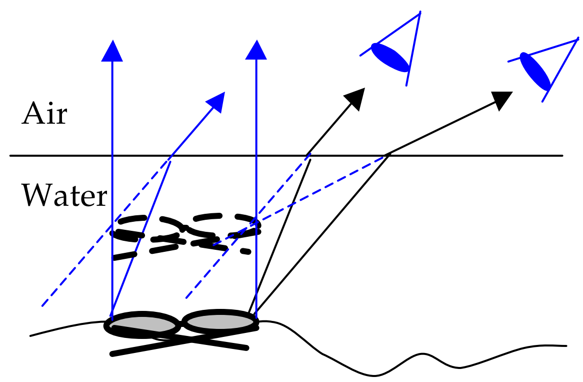
d) Less of your twin's face (both eyes and mouth will now be outside the lines.



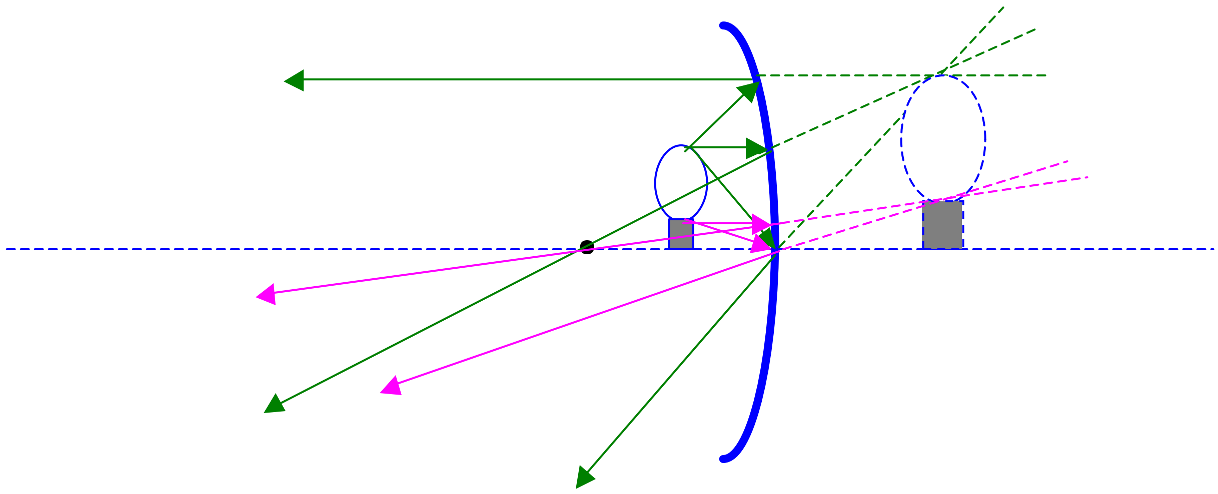
Short answer questions, with explanations. For these, you do need to explain.

7) (12 pts) You are standing at the edge of a still pond and lean over to look at your lovely reflection, but then your sunglasses fall into the pond and sit still at the bottom. Do you see the sunglasses higher or lower than they actually are? The question I'm asking is, is there an image of the sunglasses at a different place than they actually are, and where is that image? I've drawn a few rays of light to help you out. You may want to draw more. Is the image inverted? Is it the same size as the original or is it magnified or reduced?

The light from each point on the glasses goes out in all directions bends at the surface of the water (away from the normal as shown) and hits you in the eye above the water. Using the Mel and Taylor technique we can find each point on the image by following back the lines of sight to the intersection point and we see the glasses higher and the same size.

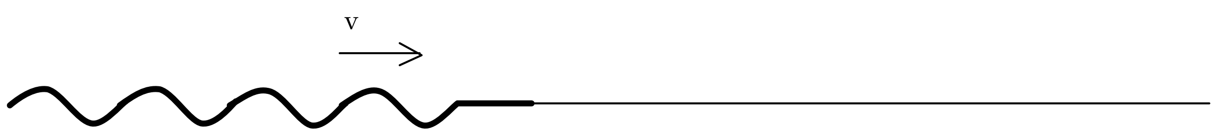


8) (13 pts.) Explain why when you bring an object very close to the inside of a spoon, you see an image that isn't flipped. Where is the image? Draw a diagram.



As shown, if the object is close to the mirror (less than the focal length), the image is behind the mirror and is magnified. Many of you drew correct diagrams for an object farther away, like I did in class and in homework and showed that the image was in front of the mirror and flipped upside down. But then some of you drew a diagram showing the image in front of the mirror and right-side up, drawing lines reflecting off the mirror at angles nothing like equal on each side, and completely ignoring the rules we found about parallel rays and the focal points, etc. Is this because you remembered the result of my finding the image but not the process? Study the process much more carefully than the result! Remember how bad memory is! And remember the tricks your mind can play on you if it already expects a result.

9) (25 points total - look at individual point assignments to figure out the time you should spend!) A thick spring and a thinner spring are connected to each other – the thick spring has more mass per unit of length. A series of waves starts traveling from the thick spring to the thin one, a distance of $\lambda = 1$ cm between the peaks, a frequency of 4 wave peaks going by every second.



a) (6 pts) From the information given, what is the speed of the waves on the thick spring?
One peak travels 1 cm in 1/4 of a second, so the speed is 4 cm/s. Or, same thing, $v = f\lambda$ gives 4 cm/s.

b) (6 pts) Suppose the speed of the waves on the thinner spring is 12 cm/sec. What would be the frequency and wavelength on the thinner spring?
Any spot on the rope is going to do exactly what the hand (flick) does. So if the flick goes up 4 time per second, then any spot on the rope goes up and down 4 times per second and someone sitting at that point sees 4 peaks per second go by. The dot that is right at the juncture of the two ropes will do the same thing as any other dot on the heavy rope, the same as the flick. And

if this point is moving up and down like the flick, that's the same as if you were actually flicking the light rope the same way. So the frequency stays the same in the light rope. Thinking about how the waves form, we see that frequency and amplitude are properties of the flick, while speed is a property of the medium and wavelength depends on both.

Another argument is just like the one we made for light waves entering water. If the frequency changes, that means a different number hit the end of the rope per second than were leaving the flicking hand per second. That would mean peaks are piling up somewhere which we know won't happen.

So, just like for light entering water, the frequency stays the same but the wavelength changes. The speed is 3 x faster, so the peaks can cover 3 x the distance in that 1/4 of a second between them. So the wavelength would now be 3 cm. Or, same thing: $12\ cm/s = f\lambda = 4\ s^{-1}\lambda$ gives $\lambda =$ 3 cm.

c) (3 pts.) Would the amplitude of the waves on the thinner spring be greater, less, or the same as the original amplitudes on the thick spring?

I already made an argument above that the end of the heavy string "flicks" the light string. And I concluded that the frequency and amplitude are flick things, not medium things like the speed, so the amplitude cannot change. Another way to think about it is that the end of the heavy string goes up to the original amplitude and stops before coming back down. So it drags the neighboring point on the light string with it, but can't drag it farther.

Some of you were thinking that the waves would get stretched out on the lighter string - longer wavelength, smaller amplitude. This may be object reasoning rather than event reasoning. I'm not sure. Anyway, this doesn't happen and if you think about the energy in the wave you can see why the amplitude must stay the same. The energy is in kinetic energy- bits of the string moving up and down- and potential energy from the stretched parts. If you were to have longer wavelength on the thick string that had the same energy, it would have lower amplitude . Longer wavelength means more bits of the string moving at a given moment and more stretched bits of string, too. So to have the same energy, you 'd have to have lower amplitude (less speed, less stretch). Energy is conserved moving from one string to another. In the lighter spring the wavelength increases - more bits moving and more bits stretched - but each bit now weighs less and has less kinetic energy. So the amplitude needs to stay the same to keep the same total energy.

d) (10 pts.) Compare the wave speed you found in part (a), for the thicker part of the spring, with the 12 cm/sec wave speed in the lighter part of the spring. Are these the same or different? Why does that make sense?

It makes sense that the wave speed would be different because the speed is a property of the medium and the lighter spring is a different medium. We discovered that wave speed increased as you increased the tension (T) and decreased as you increased the mass/unit length (μ). This made sense because reason the wave speed changes is that changing properties of the medium changes the thing that's like "reaction time." Less mass per unit length means less reaction time, faster wave speed.