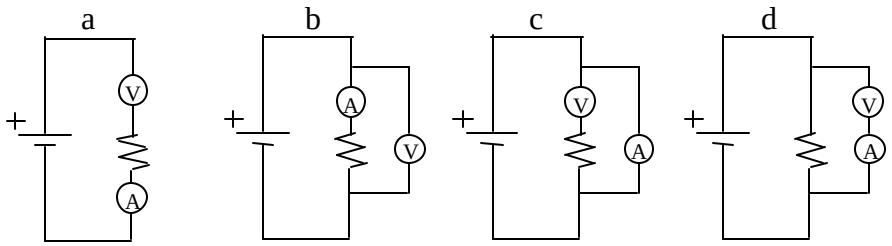
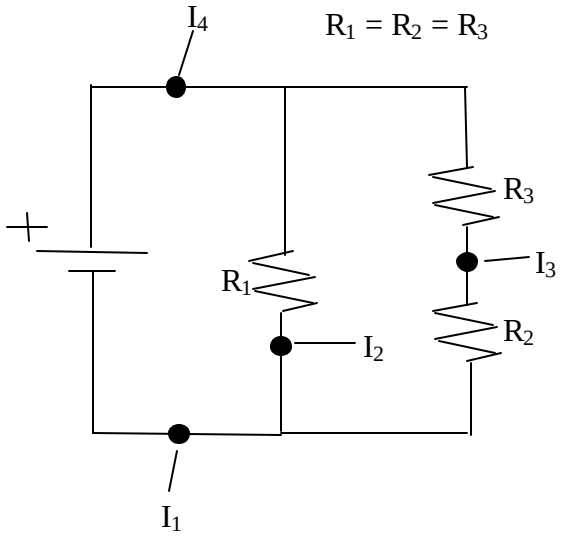
1) Which of the following circuits will measure the current and voltage across the resistor?



2) In the circuit below, which of the following best indicates the relationship between the currents, I_1, I_2, I_3 and I_4?

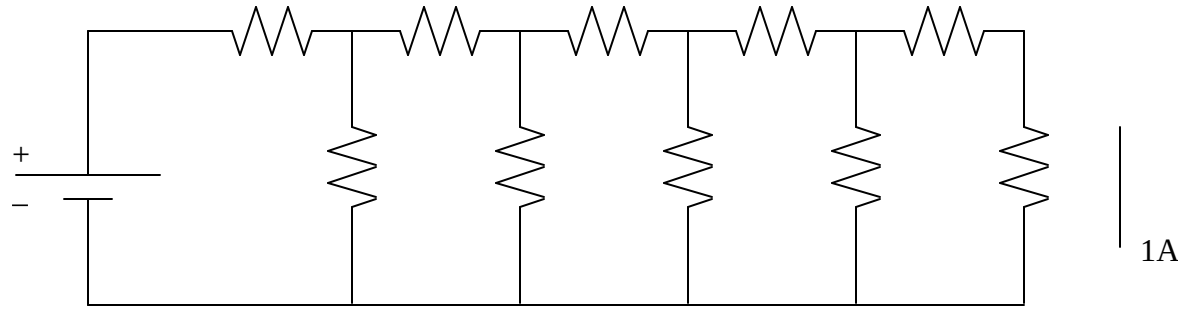


a. $I_1 < I_2 < I_3 < I_4$ b. $I_2 < I_3 < I_1 = I_4$ c. $I_3 < I_2 < I_1 = I_4$

d. $I_3 < I_2 < I_4 < I_1$ e. $I_2 < I_3 < I_4 < I_1$

3) Draw and label a circuit such that there are three resistors, R_1, R_2, R_3, with resistances (in ohms) 10, 5 and 2 respectively. A 6V battery should power the circuit and the current through R_2 should be 0.15 A.

4) In the given circuit, all resistors have a resistance of 1? , and the current going through the rightmost branch is 1A.



a) Find the voltage drop across and current through each resistor.

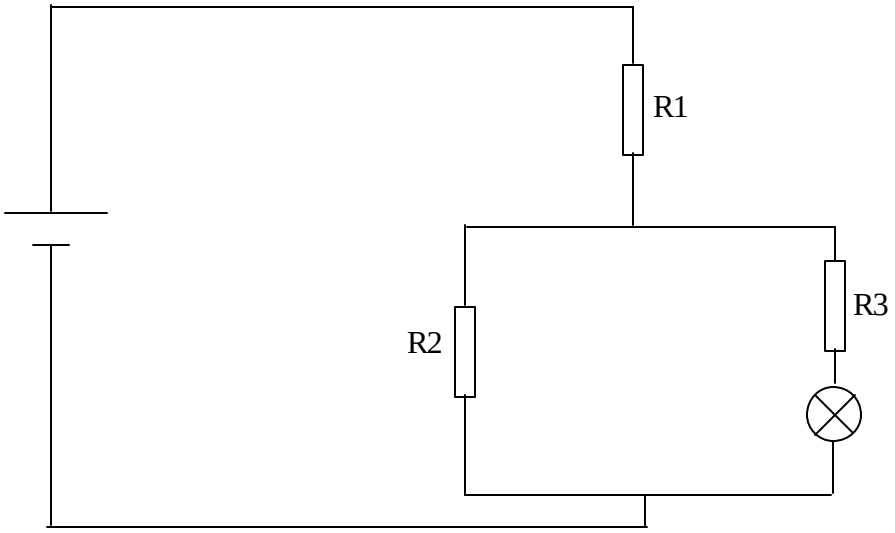
b) Looking at the voltage drops across the resistors from right to left, what interesting pattern do you notice?

5) A student arranges an electrical circuit set up as shown in the diagram below. In the following cases, describe what happens to the light from the light bulb when:

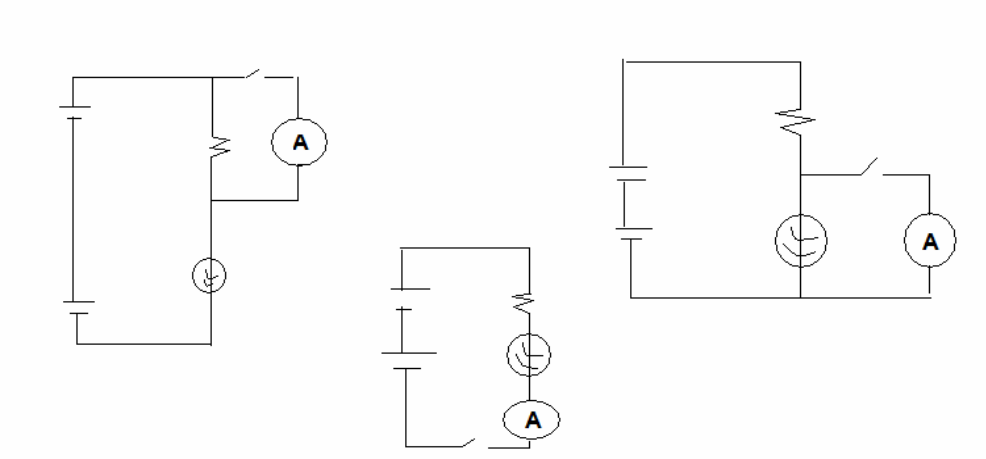
a) resistance R1 is increased

b) resistance R2 is increased

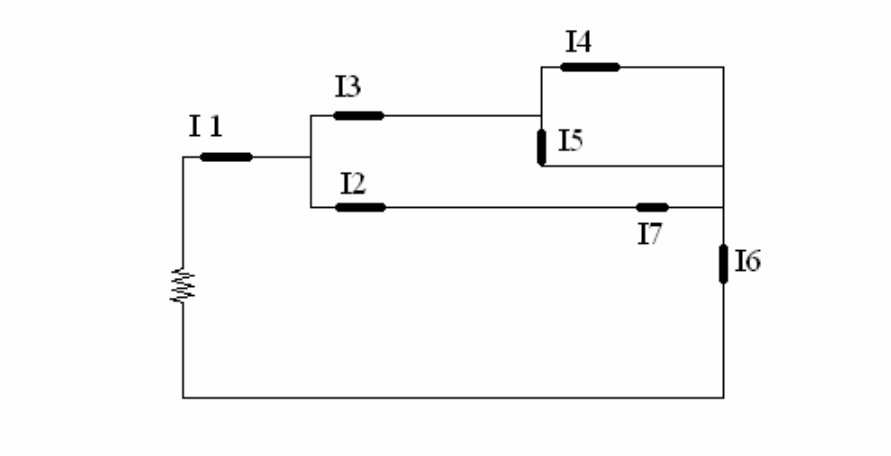
c) resistance R3 is increased



6) Of the following diagrams, which places the ammeter in the correct position to measure and accurate current? Why must an ammeter be placed in this position to measure the current accurately?

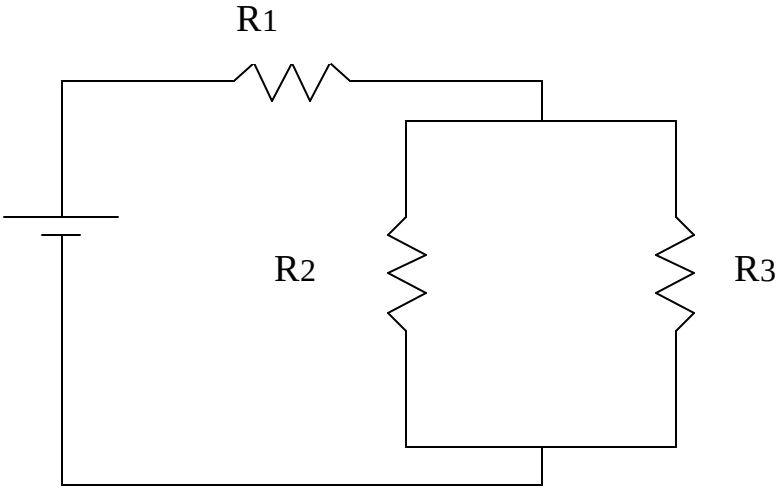


7) Complete the following table, given the above circuit diagram and the following values for the various currents (in Amperes). If any given configuration is impossible, explain why.



	Case 1	Case 2	Case 3
I1	7	4	7
I2			
I3	4	3	3
I4			
I5	1	2	1
I6			6
I7			

8) The diagram below is a circuit diagram of a battery and four resistors, with values given. R_1 = 3 ohms, R_2 = 2 ohms, the current going through R_1 is 2 amperes, and the current going through R_2 is 1 ampere. The battery is a 12V DC battery.

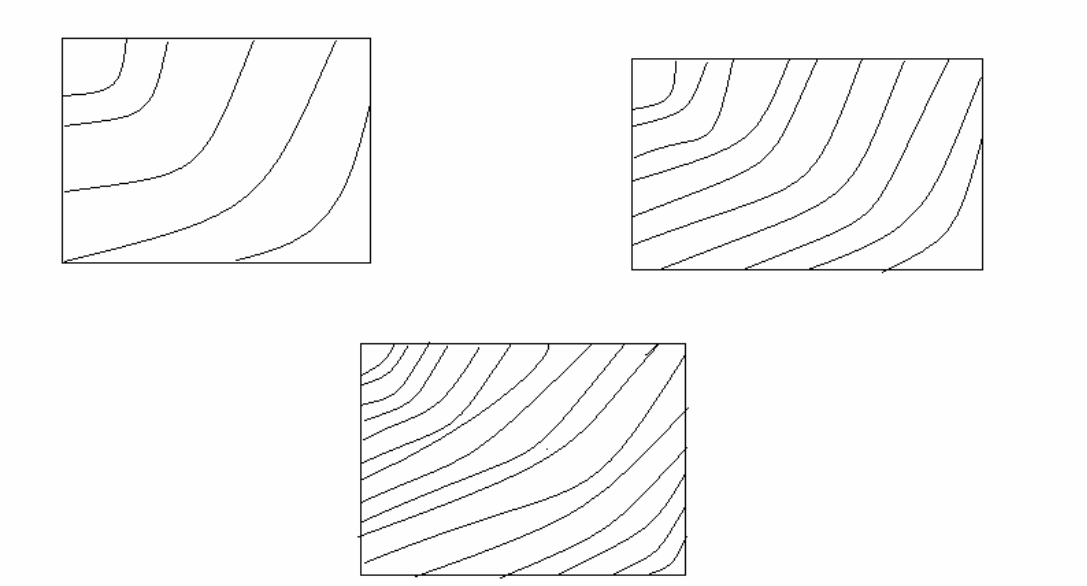


a) Place an ammeter and voltmeter in the circuit to measure the current and voltage going through resistor three.

b) Find the resistance in R_3.

c) Place a light bulb in the circuit where it would be the brightest.

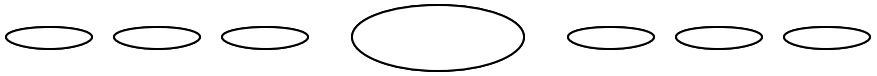
9) Consider these interference patterns made by two glass plates. Which figure has the least space between the plates? What is the relationship involving the distance between the interference lines and the space between the glass plates?



10) Towards the end of the lab on Interference of Light, we saw that soap films caused an interference in white light that created rings of different colors, in different positions, because of the different wavelength. If we were to shine a red laser through a double slit onto a screen, and then a blue laser through a double slit, what would be the difference between them, if any?

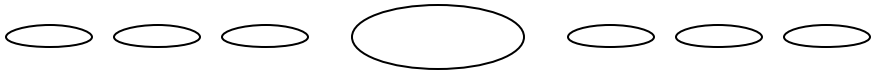
11) If the distance between slits (d) is increased in a double slit experiment, what happens to the distance between the dots that show up on the screen?

12) When a laser beam is used to illuminate a slide with slits of various widths, a pattern is recorded on a screen length L away. On your first trial, you shine the laser through the slit that is 0.08 mm wide. The pattern you observe has a central maximum of length 2.10 cm and looks like this:

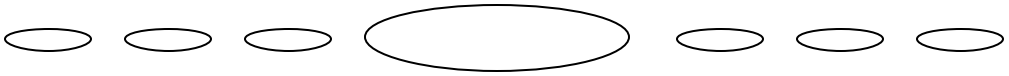


Next you decide to shine the laser through the slit that is 0.02 mm wide. What do you expect the pattern that results from this slit to look like?

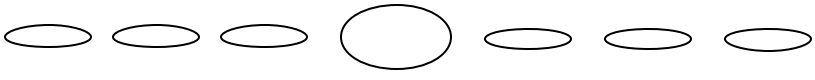
a) central maximum width of 2.10 cm



b) central maximum of width 9.5 cm

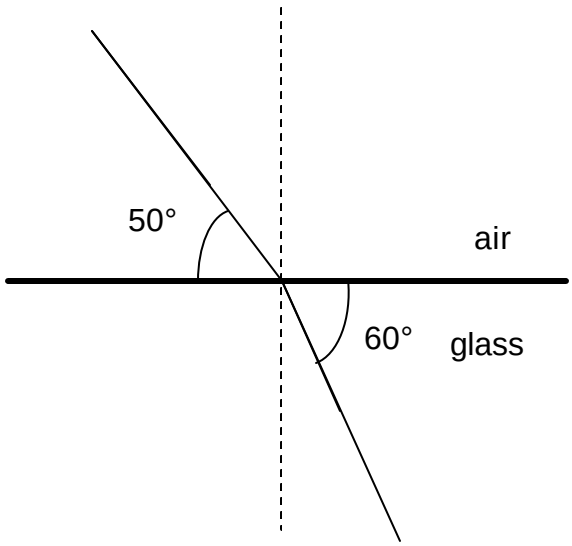


c) central maximum of width 1.00 cm



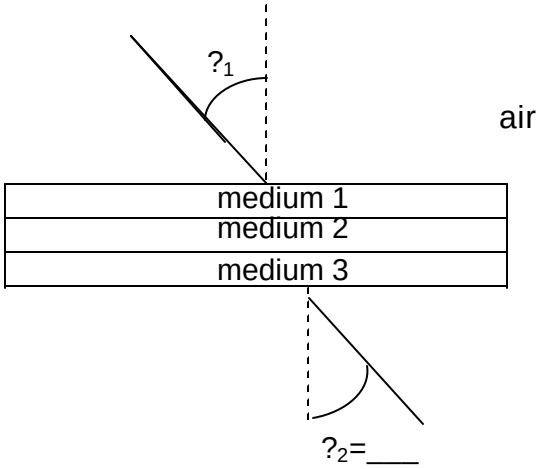
13) In Part II of the experiment on refraction of light (the part on Total Internal Reflection), will you see Total Internal Reflection if you rotate the stage of the hemisphere such that the laser beam enters the hemisphere from the flat side, instead of the curvy side (i.e. the same set up as in Part I)?

14) Light is incident on an air-glass interface, as pictured below. Calculate the index of refraction of the glass. (The index of refraction of air is given by $n_{air}=1$)



n_{glass}=_____

16) Light traveling through air ($n_{air}=1$) is incident at an angle $?_1$ on a composite block (pictured **to the right**) made of three different mediums with three different indexes of refraction (n_1, n_2, n_3). Assuming all interfaces are parallel, what is the angle of the light after it has traveled through the block back into the air? Explain how you can tell.

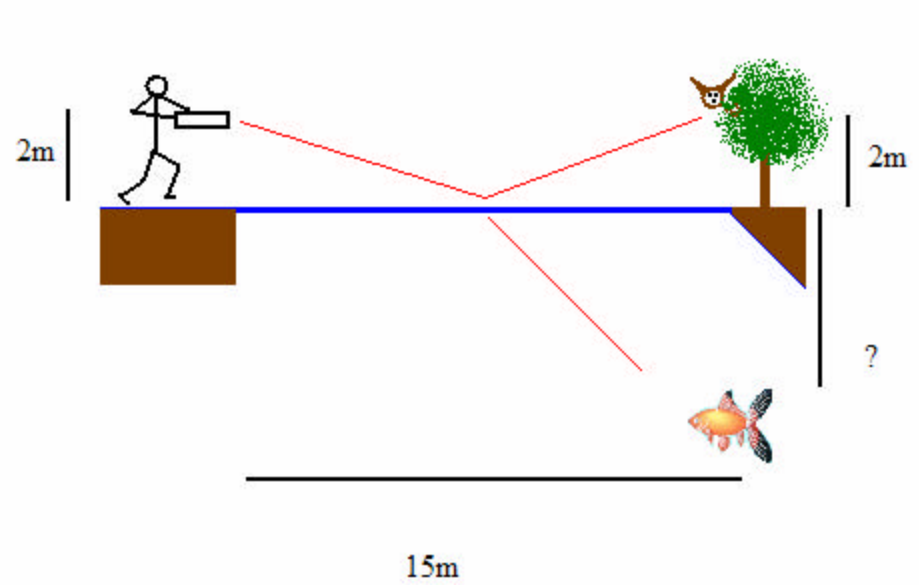


17) When shining a light beam through a transparent hemisphere to measure angles of refraction, you notice that the refractive beam disappears for incident angles greater than 35°. Assume the hemisphere is surrounded by air and the index of refraction is 1.55.

a) What is the angle of refraction just before it disappears?

b) If the hemisphere were replaced **with** a similar one with a refractive index of 1.4, would the **critical** angle **for incidence** change? Why?

18) The students of physics 212 have invented a new fishing device. It is a laser that can cook fish while they are still underwater. They student with the laser is very hungry though and wants to take advantage of his laser. He wants to cook the fish and also the squirrel both 15m away. The squirrel is 2m up. How deep must the fish be to so that the physics student's hunger is satisfied?



19) Light travels through air and hits a barrier of water (n=1.33) at an incident angle of 25 degrees.

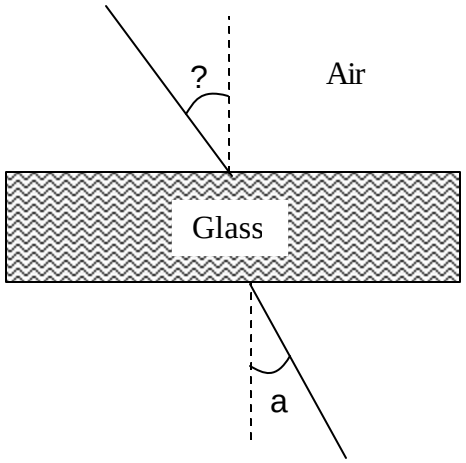
a) The angle of refraction is:

i. greater than 25 degrees
ii. smaller than 25 degrees
iii. equal to 25 degrees

b) Find this angle of refraction:

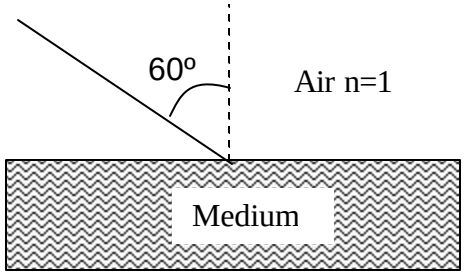
c) What would the angle of incidence need to be for total internal reflection?

20) A laser shines incident on a rectangular piece of glass at an angle, ?. Assuming that ? is less than the critical angle of total internal reflection, how does the angle a compare to ??

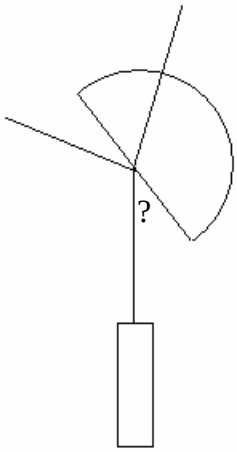


a. a < ? b. a = ? c. a > ? d. cannot be determined

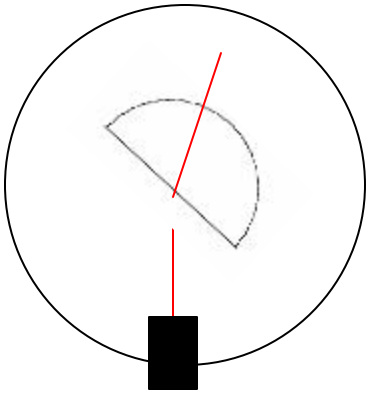
21) A laser shines on a refractive medium at an angle of incidence of 60º. What is the minimum refractive index of the medium required to exhibit total internal reflection?



22) Determine the angle ? where total reflection is first observed when light goes from air (n=1) to a material with an index of refraction of 1.28.



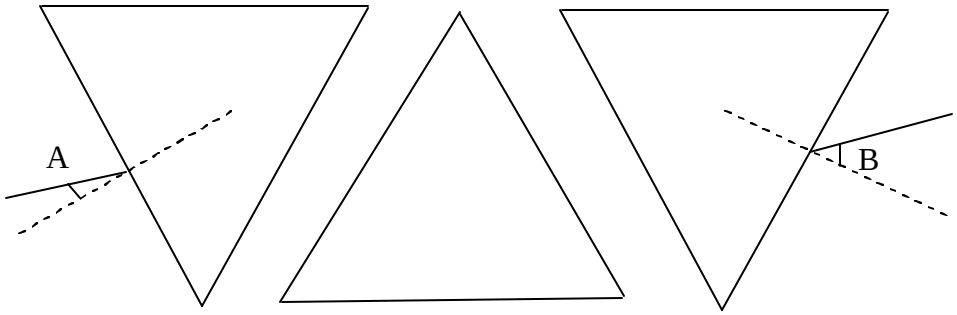
23) Laser light is shone on a hemisphere of transparent material X on a rotating platform with a protractor as shone below. The flat edge of the hemisphere is aligned **with the 0^o – 180^o line.**



a) If the angle of incidence is measured at 50 degrees, and the angle of refraction is measured at 30 degrees, what is the index of refraction of material X?

b) If the angle of incidence is 40 degrees, what is the expected angle of refraction?

24) A student arranges three identical isosceles triangular prisms made from glass as shown in the diagram below. Given that the index of refraction of glass is 1.5 and the angle of incidence, A, is 20 degrees, calculate the angle of exit, B.



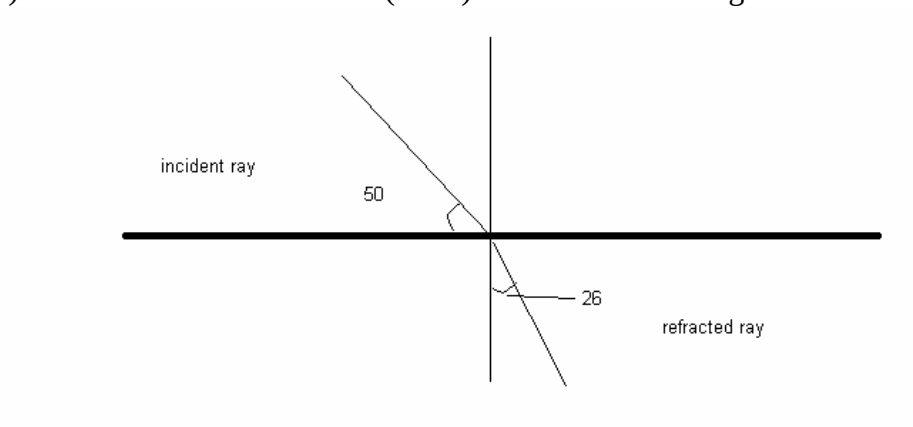
25) A beam of light of wavelength 550 nm traveling initially in air is incident on an unknown material. The incident beam makes an angle of 50 degrees with respect to the x-axis. The refracted beam makes an angle 26 degrees with the normal.

a) Find the index of refraction of the unknown material.

b) What is the critical angle for a ray incident on the air from the unknown material?

c) What happens if the angle of incidence is greater than the critical angle?

26) In the refraction of light lab, we learned about finding the critical angle that is involved in total internal reflection. Let's say that a light beam goes from a high index of refraction (n = 1.54) to a low index of refraction (n = 1). Find the critical angle.



a) You shine light onto an air-water surface. You notice that some of the light is reflected and some is transmitted. Where did your light source have to originate (air or water or either) and why?

b) Assume that $n_{air} = 1.00$ and $n_{water} = 1.33$. If the light is shone in such a way that it is at an angle of 20^o with the horizontal, what is the angle of the reflected part and what is the angle of the transmitted part (with respect to the horizontal).

27) A beam of light enter water from air at an angle of 35 degrees to the surface of the water. What is the angle of the refracted ray? (The index of refraction for water is 1.33)

28) Two identical light sources shine upon two identical photodiode detectors. The first light shines through one polarizer then through another that is oriented 45^o in relation to the first. The second light shines through one polarizer, and then another that is oriented 30^o in relation to the first, and then *another* that is oriented 30^o to the second. Which detector has a higher voltage reading?

29) There is a light source that emits light of intensity 5 W/m^2. There is one polarizer oriented with angle Theta 1 to the light source. And then there is a second polarizer oriented with angle Theta 2 to the first polarizer.

a) Angle Theta 1 is 45 degrees and angle Theta 2 is 30 degrees. What is the final intensity of the light?

b) Angle Theta 1 is 90 degrees and angle Theta 2 is 45 degrees. What is the final intensity of the light?

30) A sailor returns from a day on the water and complains about a headache from the 'glare' coming off the water. Briefly explain to the boater why he gets headaches and explain what type of sunglasses he should purchase to fix the problem. Include diagrams because the sailor never made it PHYS 212.

31) Using Figure 1 and Figure 2 below, explain using a quantum mechanical description of light and polarization states why in Figure 1 if a photon makes it through Polaroid A it can't make it through Polaroid B. Then explain the how if we place a third polarizer, C, in **<u>between</u>** the two, shown in Figure 2, if a photon makes it through A there is a probability it can make it through B.

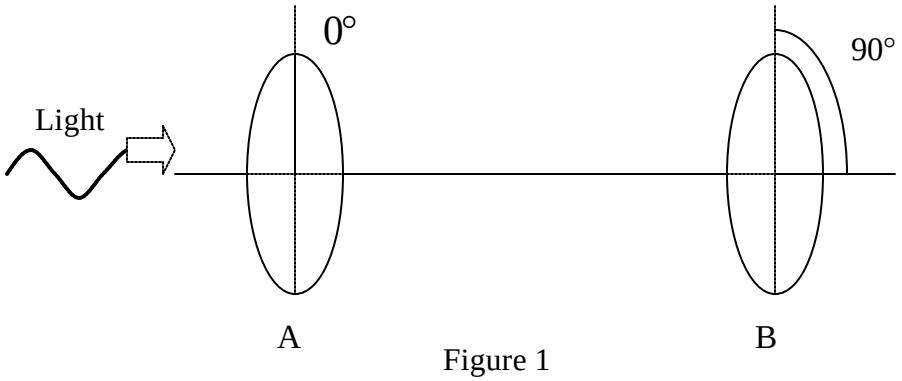


Figure 1

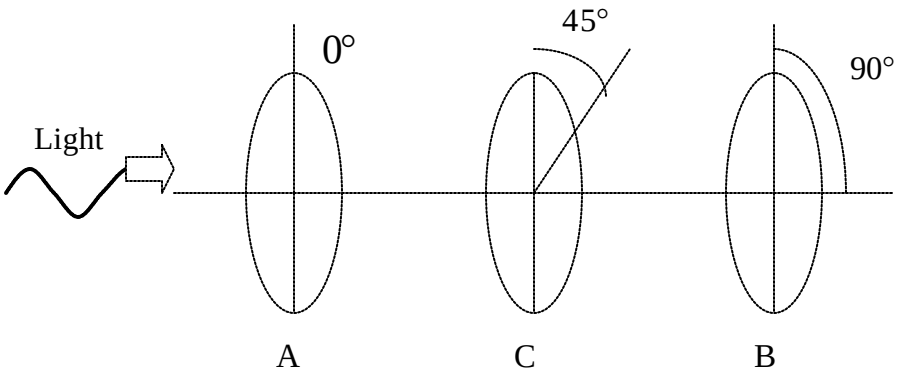
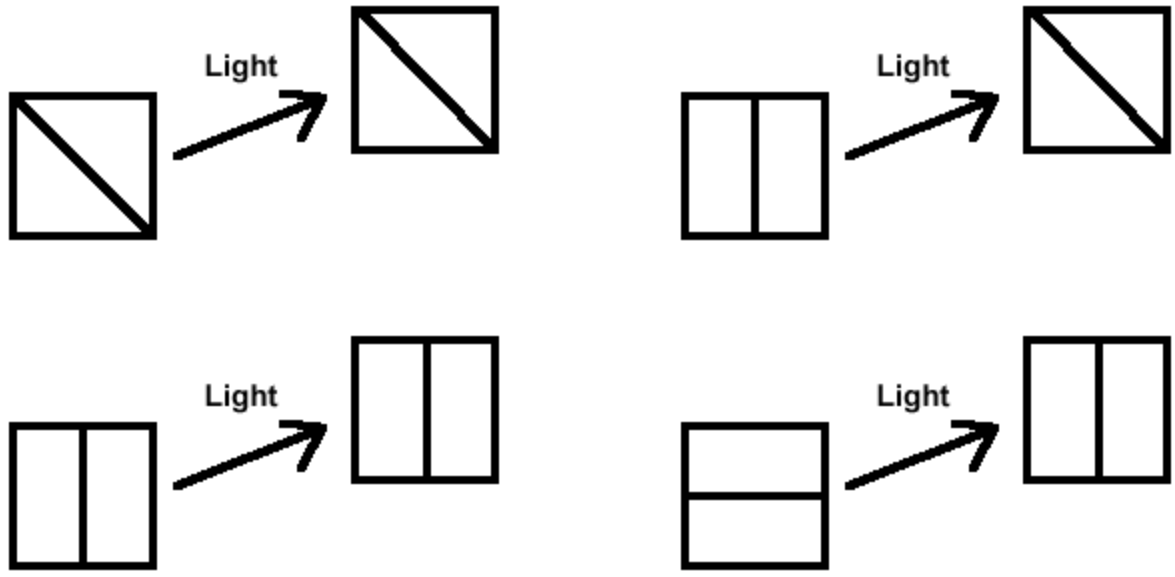


Figure 2

32) Light is passing through two polarization filters. Which alignment of their transmission axis will prevent all light from being seen on the other side.



33) You have two lenses, with focal lengths 10cm and 4cm. You want to create a telescope. How will you arrange the lenses (lens order, and distance apart) in order to see objects that are far away? What is the purpose of each lens? How would you change the set up to see objects that are much closer?

34) Batman is flying around in Batwing when he sees a blurry light with some object in it shining from the ground. He thinks it is the bat signal but will only be able to tell if he can get the object in the spotlight focused. He can tell that if it is the bat signal that it is magnified to 4 times its actual size. He also knows that there is a lens of focal length 100m above the spotlight but he is not sure how high above it is. What altitude should Batman drop to in order to clearly see the image?

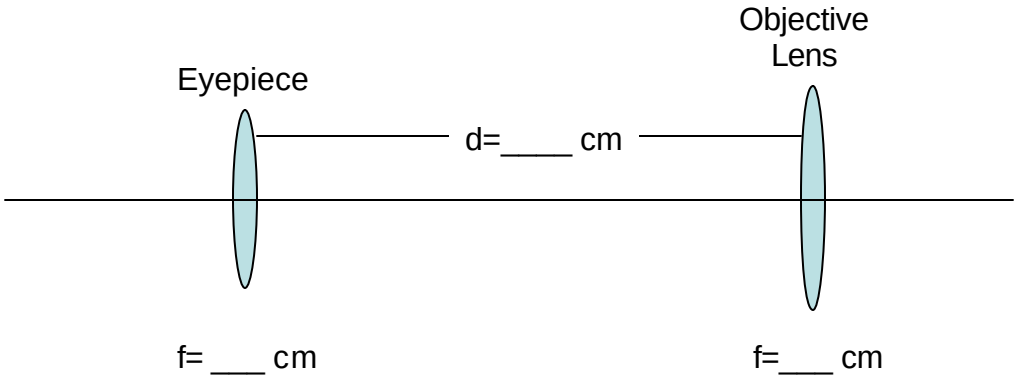
35) A lens is previously measured to have a focal length of f. For which of the following values of d_0 will you be able to obtain a focused image at some distance in front of the lens?
a).6f b).8f c)1.2f d)1.4f

36) When light is shown through a lens of focal length 10 cm, a focused image appears at a distance of 0.15 m away, determine

a) how far the lens is from the light source.

b) the magnification of the image.

37) Suppose you have two lenses at your disposal, with focal lengths 25 and 75 cm, and an optical bench. Looking out from Olin, you decide to spy on some of the engineers in Dana. There seems to be some foul play afoot, but you can't quite see, so you decide to make a telescope! If we assume Dana is really far away, how would you position your two lenses on the optical bench to create a focused image of those crazy engineers? More specifically, **how far apart would your objective lens and eyepiece need to be relative to each other**? Also, **label the focal lengths of the eyepiece and objective.**



Suddenly there's an explosion, and something flies out of the room you were spying on. Suppose this object is much closer to you than Dana. When you try to look at it with your telescope, it appears blurry. How should you adjust the relative spacing of your lenses (circle)?

Increase **Decrease** **Leave them the same**

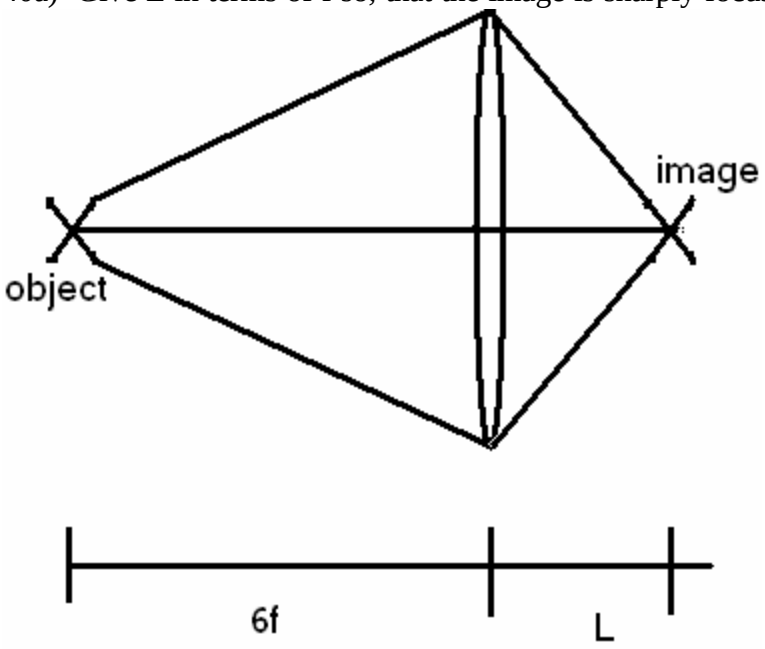
38) A pair of lenses are set up to view very distant objects. Lens A has a smaller focal length than Lens B. Make a qualitative sketch of the setup, paying specific attention to the distances between the lenses.

39) A microscope has an objective lens of focal length 1.5 cm and an eyepiece of focal length 3 cm. The lenses are separated by 25 cm.

a) How far away from the objective lens is the real image of the object?

b) How far away is the object if the final image is to be viewed at infinity?

40a) Give L in terms of f so, that the image is sharply focused.

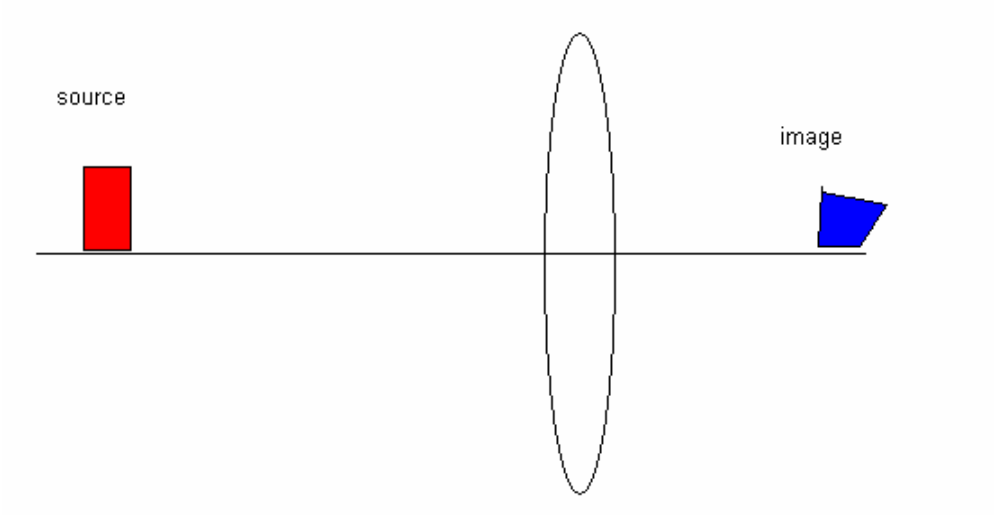


b) A second lens has a focal length 4f/5 and is placed to the right of the image **formed by the first lens**. At what distance from the object should this **second** lens be placed in order **for the image from the second lens** to be sharply focused?

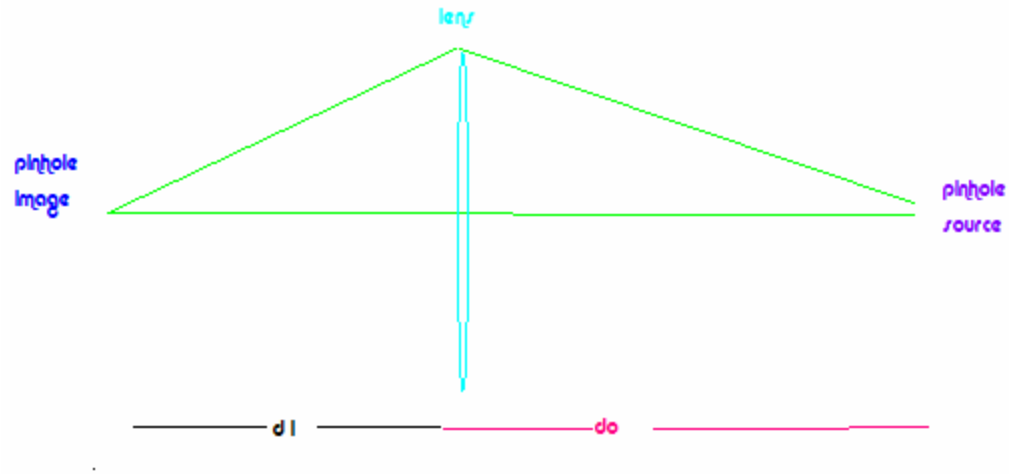
41a) Find the distance to the image from the lens in the diagram if the focal length of the lens is 10 cm and the object distance is 30 cm.

b) If a lens with a larger focal length were used with the same object distance, the image distance would (circle one)

increase decrease stay the same



42) Using the set up as shown, determine whether the distance do or di should be increased for the desired effect:



1. Increase the magnification size of the image.
2. Decrease the magnification size of the image.

What can you conclude about the proportionality relation among do, di, and the magnification?

43) Draw the classical wave interference pattern for a single slit experiment.

44) Light is sent through a double-slit device.

a) The light forms a intensity versus detector position graph similar to that of classical particles, therefore (circle all possibilities):

i. The right slit was open.
ii. The left slit was open.
iii. Both slits were open.

What does this say about the wave and/or particle properties of light?

b) A pattern similar to that of a classical wave through a double-slit appears. Therefore (circle all possibilities):

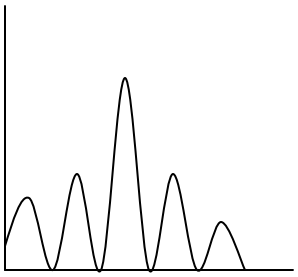
i. The right slit was open.
ii. The left slit was open.
iii. Both slits were open.

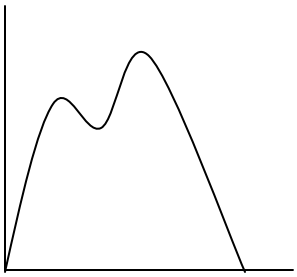
What does this say about the wave and/or particle properties of light?

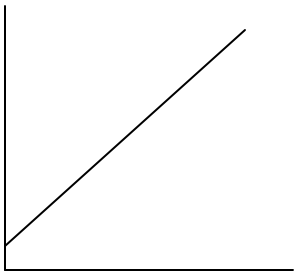
45) By sending photons through two slits into a light-tight box, you are able to investigate the intensity pattern they produce once they are detected by a PMT detector on the other side of the box.

a) Which of the following graphs is a result of sending one photon into the box at a time while both slits are open, and therefore you do not know which slit the photon enters.

i) ii) iii)







b) Does the graph you chose represent a classical wave or classical particles entering a PMT detector? Why should this surprise you?

c) When one slit is closed off, therefore only allowing the photons to go through one of the slits, how does the intensity graph change? Sketch it below and state whether it describes classical particles, classical waves, or both.

46) In the wave-particle duality experiment, you observed the patterns light made after passing through several different combinations of two slits. Which of the following explains why you saw an interference pattern when both slits were open, and you know that only one photon was in the box at any given time?

a) The photon split in half and went through both slits, then interfered with itself.

b) The photon went through one slit, and then went back in time to pass through the second slit and interfere with itself.

c) The photon spreads itself out into a wave when it passes through the slits, then gathers itself back into a particle before it hits the receptor.

d) The photon is not measured as going through either slit, so there is a probability that it goes through each slit, and these probabilities interfere to produce the pattern.

47) You are conducting a two slit experiment, through which you send light at a screen of a certain distance away.

a) According to classical physics, what would be the expected pattern for a light beam made up of particles shot at the screen?

b) What would be the expected pattern for a light beam when thought of as a classical wave?

48) In the wave-particle duality lab, you examined the intensity patterns of photons passing through two slits and detected by a PMT detector.

Circle either true (T) or false (F) for the following statements:

a) The interference pattern was obtained because the photons diffract upon passing through the slits and thus display wave properties. T F

b) The direction of motion of the PMT detector affects the intensity pattern obtained by the photons. T F

c) When both slits are open, the intensity pattern is a combination of both the classical wave and classical particle pattern, thus supporting the idea that light has both wave and particle properties. T F

d) Though small, there is a probability that two photons can interact with each other inside the box we used in the lab. T F

49) True or False:

a) Photons are sent through a double-slit screen and a detector is set-up to detect which slit they pass through. If another double-slit is set-up after the detector and before the final screen (e.g., the PMT), then the final screen will show a particle pattern.

b) If you do the same experiment as above, but this time with an electron, then you will get a wave pattern.

c) If light is thought of as a wave, then it doesn't have a probability wave.

50) Sam is annoyed by all the traffic on his road during certain times of day. He counts the number of cars that go by every minute for a whole day. Sam finds the average count rate of cars to be 33 cars/minute. In one minute during "rush hour", he counts 40 cars, and wonders whether he should write a letter of complaint to his transportation department. Is the increase the number of cars during this minute significant?

51) You perform an experiment in which you count the number of spam messages in your e-mail every day, deleting them all at the end of each day. Assume that the number of messages on any given day is random and independent of other factors. Your data for the first 3 days is as follows:

Day Number	Number of Messages
1	22
2	17
3	26

a) Based on this data, what is the probability of getting 40 spam messages on the next day?
b) Suppose you did get 40 messages the next day. How do you explain this, aside from the fact that you need better email filters?

52) The number of annual births at Raleigh Community Hospital has averaged out to 847 over the past 20 years. This past year, the number of births has increased to 873. Is it safe to assume that this is the beginning of a drastic population explosion?

53) Superman, with his super focus and super eye, is able to count the number of rain drops over a certain time interval. After watching a certain area of rain for over an hour, he comes to the average count rate of 157 raindrops/second. Suddenly it begins to pour (which makes Superman work a little bit harder). He gets a maximum count rate of 169 raindrops/second.

a) What is the expected uncertainty in the average count rate (despite Superman's super capabilities)?

b) Should Superman report to weather.com's meteorologists that he has experienced a natural phenomena with a maximum count rate of 169 raindrops/second?

54) Using the data below determine the Half Life of the unknown substance.

Time (s)	Counting rate
10	24,000
21	3,000

55) The gamma-ray radiation of an unknown material is monitored. At the beginning of the monitoring, the count rate is 22483 counts/s. Five minutes later, it is 9453 counts/s.

a) What is the half-life of the material?

What is the expected count rate

b) eight minutes and c) ten minutes after monitoring begins?

56) You find a radioactive substance with a well-known half-life of 3 hours. You know that the substance was created 10 hours ago, and that it emits gamma particles on average of about 10,000 at THIS time. What is a good estimate of how much radiation it was giving off at its creation (10 hours ago), in counts/sec? (circle the best choice)

50,142 counts/sec 1188 counts/sec 100750 counts/sec 82,460 counts/sec

57) At t = 0 the number of "red" nuclei in a substance is 150, the quantity of "blue" nuclei in the same substance is 375 and "yellow" nuclei having a quantity of 7. Assuming that the three types of nuclei are radioactively unstable, can you determine which "color" of nuclei will have the greatest population in the substance after 13 seconds? Explain your reasoning.

58) This is the data collected of the number of un-decayed nuclei at time t. Find approximate the half life of this sample.

Time (s)	# of Nuclei
0	2000
10	1724
20	1536
30	1289
40	1073
50	926

59) A sample has an initial count rate of 5000 counts/sec. Its half-life is 10 minutes. What is the count rate after 30 minutes?

60) There is a radioactive sample that is decaying from its meta-stable state down to its stable state. The following data is collected using a scintillation detector and counter-timer. The background radiation is 59 counts per minute.

Time (min)	Detection Rate (counts/min)
0	998
10	790
20	715
30	658
40	583
50	519
60	456
70	410
80	367
90	317
100	279

What is the half-life of this radioactive substance (in minutes)?

61) Given a radioactive sample you collect the following data from a scintillation detector in lab. Find the half life of the substance.

Time (sec)	detection rate (count/sec)
0	56,734
10	7,830
20	1,080
30	150
40	21

70) A radioactive substance has an initial count rate of 2,500 counts/min at the beginning of an experiment. The sample has a half-life of 13 minutes.

a) Determine the time it takes for the sample to reach an estimated count rate of 14 counts/min.

b) Based off of this information, do you think the substance will ever reach a state where it no longer emits radiation at a detectable rate? If so, what is the state?

c) True or False: If you accept the idea that half-life is how much time it takes for half of the substance to decay, then it all must decay at some point in the future.

80) In the hydrogen atom, which transition would emit a photon with the shortest frequency?

n=5 to n=2 n=4 to n=2 n=3 to n=2

81) An electron in some atom makes a transition from one state to another and emits a photon of wavelength 500 nm. If d for the diffraction grating was 1.9×10^{-6} for m=1, what was the diffraction angle for the emitted light?

82) When examining the emission spectra of the sun you notice that there are a great many more bright bands of color than in the hydrogen emission spectra. However, the major bands given off by the hydrogen atom are definitely a part of the sun's spectra.

a) Give two possible reasons for the number of color bands in the sun's spectra.

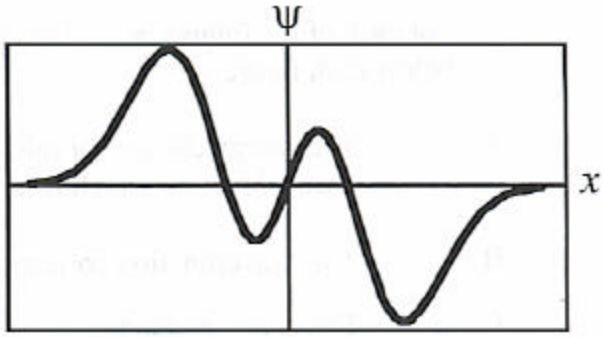
b) What may be some other practical uses for emission spectra, especially on the cosmic scale?

83) You are colorblind and are struggling through the Emission Spectra Lab. You see three distinct spectra lines for hydrogen but do not know what color goes with each line. Your lab partner tells you the first line (closest to center) corresponds to the transition from energy level 3-> 2, the second line from 4->1, and the third line (farthest away from center) from 3-> 1. Do you agree or disagree with your partner?

84) A harmonic oscillator with $E_0 = \frac{1}{2}h?$ and $E_n = (n+1/2)h?$ whose graph of the wave function is in the odd case with four bumps. For this graph the energy E = 28.

a) Which state is this system in?

b) What is the ground state energy for this system (What is E_0)?

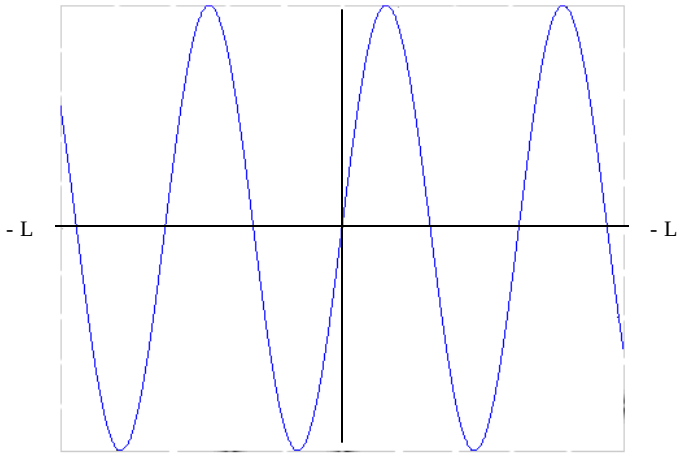


85) The following table gives the initial values for ? and ?’ in the simplified Schrödinger equation: $?'' + (E - U_0 x^2) ? = 0$, where $E = 10$, $U_0 = 20$. Fill out the rest of the table (up to 3 digits of precision), using the numerical method you have learnt.

x	?	?'	?''
0	1	0	
0.01			

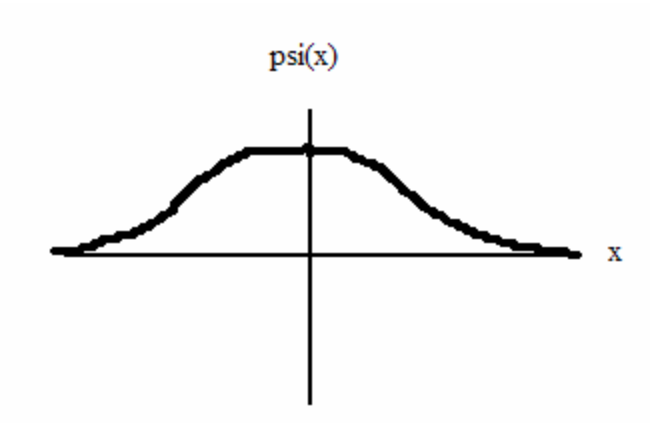
86a) What excited state does this plot most closely represent?

b) Does this wave function plot satisfy the Schrödinger equation?

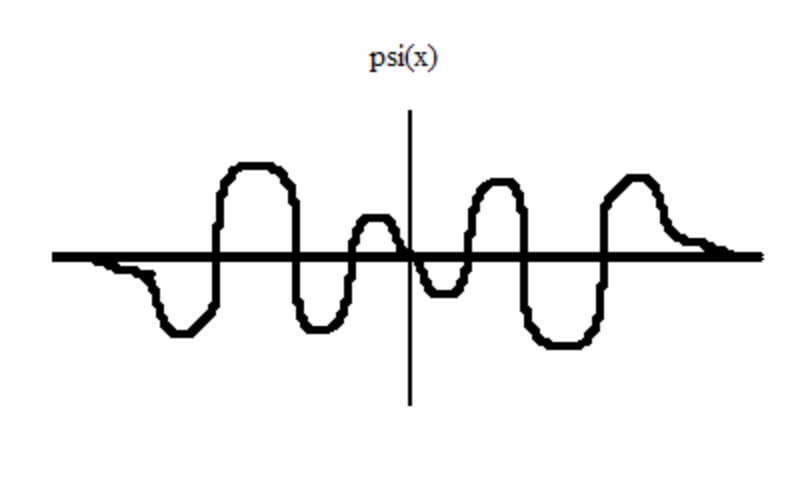


87) State whether the wave function is acceptable and what energy level it is in.

a)



b)



c)