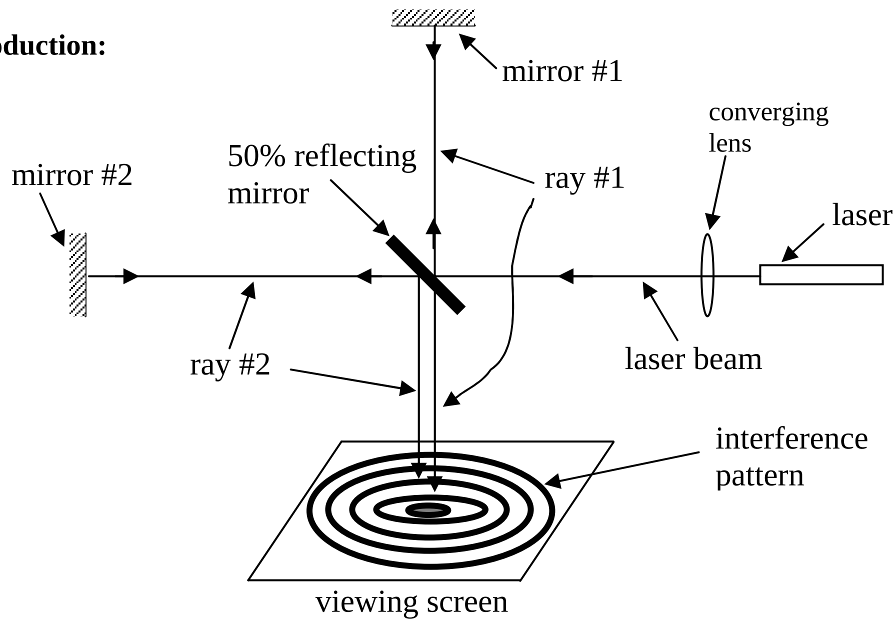
The Michelson Interferometer

Purpose: 1. To measure the wavelength of light emitted by a laser pointer
2. To gain experience with the principles of light wave interference using the Michelson interferometer.

Equipment: pointer laser, laser tripod, Michelson interferometer with converging lens, viewing screen, bubble level

Introduction:



A single light ray (coming from the laser) can be split into two separate rays by using a beam splitter which is a 50% reflecting mirror. The figure shows such a ray that has been divided into ray #1 and ray #2. Ray #1 is reflected by the beam splitter while ray #2 passes through the beam splitter. The two rays each travel towards plane mirrors that are carefully aligned to return the rays back along the same path. As they return to the beam splitter, they are once again transmitted and reflected so they recombine into a single ray that heads toward a viewing screen. Since the two rays have traveled along separate paths they find themselves out of phase when they recombine. As you learned in class, light waves, like sound waves can interfere with one another. Thus, an interference pattern will be formed when the two rays arrive at the viewing screen. The positions of the light and dark areas coincide with areas (concentric rings in this case) of constructive and destructive interference.

Procedure:

Notes: 1. Please exercise extreme caution in using the laser. Be aware at all times where the laser is pointing when it is turned on. Do not turn the laser on until your viewing screen is in place to intercept the beam and prevent it from traveling towards other students. Even a low power laser is capable of causing eye damage.
2. Be careful to not touch the mirrors or other optical components with your fingers!

1. Do **not** turn the laser on! Set up the laser in its tripod and arrange the Michelson interferometer (without the converging lens) so that the system looks something like the setup shown in the above figure. Think carefully about where the laser beam will go as it travels through the interferometer and place the viewing screen in a position to intercept the emerging beam. Ask your instructor to check out your setup and give you the okay to turn on your laser.
2. Once the laser is turned on you should see two sets of red spots on your screen (one from each mirror). This next step involves careful adjustment of mirrors #1 and #2 so that the two sets of spots move on top of one another to form a single set of spots. Slowly turn one of the adjustment screws on the back of one the mirrors to move one of

the sets either horizontally or vertically to align it with the other set. Complete the process by moving the other adjustment screw to bring the two sets into a single set. When you have finished, rays #1 and #2 will be recombined to allow them to produce an interference pattern. If you have trouble with this part, ask for help.

3. Now place the converging lens in the path of the laser beam as it leaves the laser. This will spread the interference pattern across the viewing screen making it easily visible. You should now see the classic bulls eye pattern of light and dark rings associated with the Michelson interferometer. Move the lens both vertically and horizontally, if necessary, to center the pattern on your screen. This procedure requires some time and a delicate hand to accurately position the lens.
4. Once the pattern meets with the approval of your instructor, gently turn the micrometer head to advance its mirror forward or backward. As you do this, you should see the pattern of interference rings (fringes) move into or out of the center of the pattern. Notice that the body of your micrometer is marked with numbers that indicate the number of microns that the mirror is moved. Slowly turn the knob (in a direction so that the numbers on the micrometer dial are increasing) until the “0” mark lines up with the reference line. You are now ready to begin counting interference fringes.
5. Put a pencil mark on one of the fringes and slowly begin turning the micrometer knob. Count the number of fringes that pass by this mark. At the same time keep an eye on the micrometer scale (it may complete more than one rotation). Continue until you have counted 100 fringes. Record the final reading on the micrometer scale and the total number of microns moved by the mirror. Repeat this process two more times. Average your three readings and record this number.
6. The wavelength of your laser light is related to the distance moved by the mirror in the following relation:

$$\Delta x = N \lambda/2$$

where Δx is the distance moved by the mirror, λ is the wavelength of light and N is the number of fringes counted. Solve this equation for the wavelength of the laser light. Obtain the approximate wavelength of the laser light from your instructor and find the percent difference between your result and the accepted value.