Optical science in the infrared.

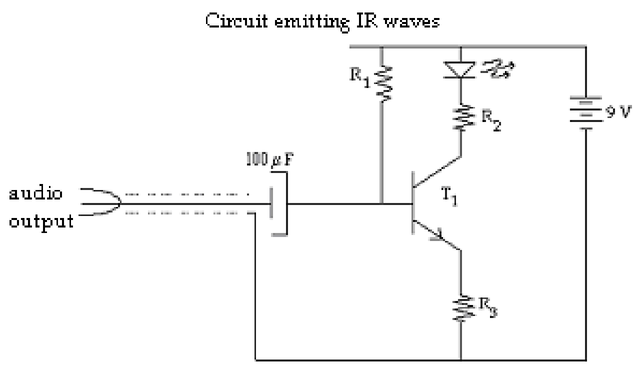
For students, it's often obvious that optical laws for white light are the same for the red or the green light of a laser.
But this doesn't seem so obvious when we use invisible electromagnetic waves, like the infrared. The below experiment shows that it's possible.

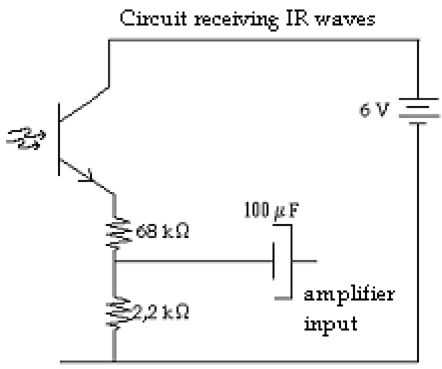
Material:

One radio with an audio output, a small amplifier, and loudspeakers.

One electronic circuit emitting IR waves (see drawing below) powered by a 9V cell (the emitting diode can be attached to a small tube, which allows to easily direct the beam and avoid its dispersion)
One electronic circuit receiving the IR waves (see drawing below)
(4 small cells, already in place in the amplifier) ;
One flat mirror; one convex lens.
Other types of lens or mirrors can also be used, as for geometrical optics.
One digital camera (a web cam or a digital camcorder can also be used)

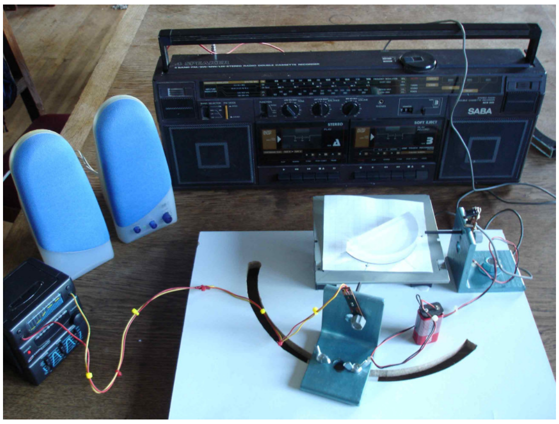
Scheme:



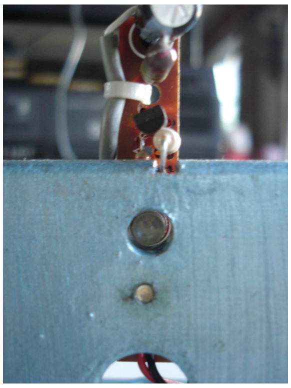


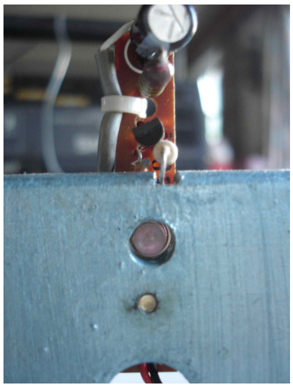
R_1 = 680 kΩ
R_2 = 68 kΩ
R_3 = 100 Ω
T_1 = 2N3904

Instructions:



Connect the emitting circuit to the audio output of the radio on which a broadcasting station has been previously set. Cut the sound of the radio.
Check that the 9V cell is connected to the emitting circuit so the photodiode is working.

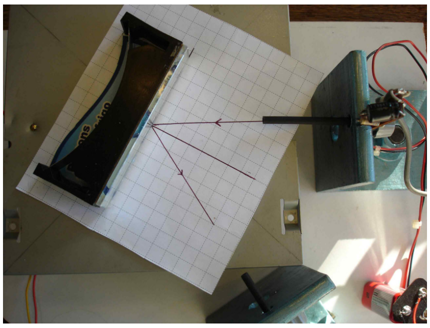




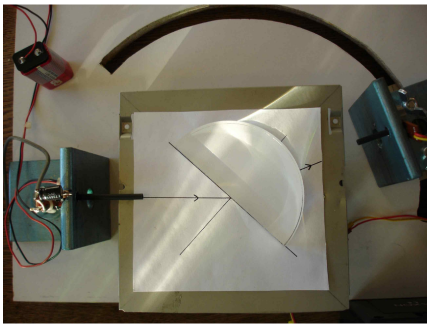
Check with the digital camera that the diode is emitting IR waves. By pointing the camera **towards** the photodiode, you can see the beam: it seems like the diode is emitting pink light. (Compare with the diode of a remote control)

When the radio is working, you can even see the frequency modulations!

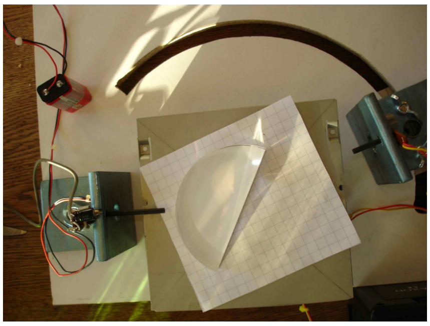
Put the phototransistor, linked to the amplifier to which are connected the loudspeakers, in front of the IR beam. When the phototransistor is exactly in front of the photodiode, you can hear the radio broadcast in the loudspeakers.
If you put your hand in between the photodiode and the phototransistor, you won't hear anything anymore.



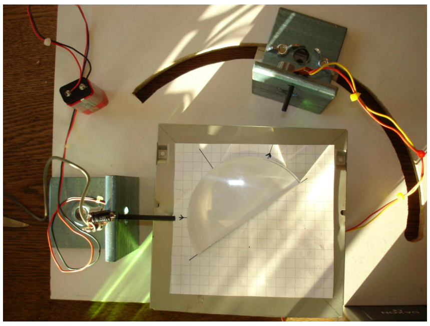
Then, place the mirror on a slanting plan in front of the IR beam. This one is then reflected. Then, if you move the phototransistor, you can find the mark of the reflected ray and observe that the angle of reflection is equal to the angle of incidence.



If you replace the mirror by a convex lens, you can observe a refraction phenomenon through the lens by the flat face. You can measure the angle of incidence and the angle of refraction in order to calculate the refractive index of the plexiglass.



If you return the lens and send an IT ray with a greater index than the limit angle, you can observe a total reflection.



You can also observe that parallel rays are converging towards a converging lens, etc. (Draw the lens on a paper sheet, isolate the rays, then move the paper sheet with the lens so that the new ray is parallel with the previous one...)