a WOW Lab

BLUEPRINT

Light-Bending JELL-O

Activity Instructions

The following items will be needed for this activity:

Station 1 - Calculate the Speed of Light inside JELL-O
- red laser
- piece of red JELL-O with a straight edge
- ruler
- translucent protractor
- scientific calculator
- cue card print-outs (Mission 1)

Station 2 - Calculate the Critical Angle of JELL-O
- red laser
- piece of red JELL-O
- scientific calculator
- cue card print-outs (Mission 2)

Station 3 - Determine the Colour Absorbance of JELL-O
- one green laser
- one red laser
- one piece each of green and red JELL-O (optional: one piece each of orange and blue JELL-O)
- cue card print-outs (Mission 3)

Station 4 - Complete the Optical Course
- green laser
- one or two pieces of green JELL-O
- cue card print-outs (Mission 4)

The JELL-O activities were designed to be completed by students working in small groups, although they can also be used as a teacher demonstration.

The index of refraction determined in Mission 1 is used in Mission 2 to calculate the critical angle, so it is important to do them in order. Mission 3 can be modified if only one colour of laser is available.

WOW Briefing

Agent: 001395

Welcome to the International WOW Spy Academy. Your spy training assignment, should you choose to accept it, will focus on JELL-O waveguiding techniques. JELL-O, while tasty and jiggly, is most useful for spy-scientists because it works well as a waveguide.

What is a waveguide? Continue to find out.

JELL-O is a great tool for demonstrating and examining the properties of the reflection and refraction of waves, lenses and optics in general - all required knowledge for any aspiring WOW Spy.

You should be prepared to take on this training in small groups. Choose a name for your group. Your group will be code-named 001395.

If your group feels up to the task, please move on to your first mission. If you do not have what it takes, drop to the floor, do twenty push-ups and then proceed to your first mission.

Mission 1

Agent: 001395

Calculate the Speed of Light inside JELL-O

This mission will lead you through the process of calculating the speed of light inside a new medium. In order to accomplish this task, you must first measure the angle of incidence and the angle of refraction to then determine the index of refraction of the material in question. It is a valuable process which allows WOW Spies to identify unknown materials while in the field.

Shine the laser at the JELL-O at an angle similar to that in **figure 1.** Measure the angle of incidence, θ_1, and measure the angle of refraction, θ_2. You now know θ_1, θ_2 and $n_1 = 1.0003$ as the index of refraction of air. Use Snell's law to calculate the index of refraction of JELL-O, n_2.

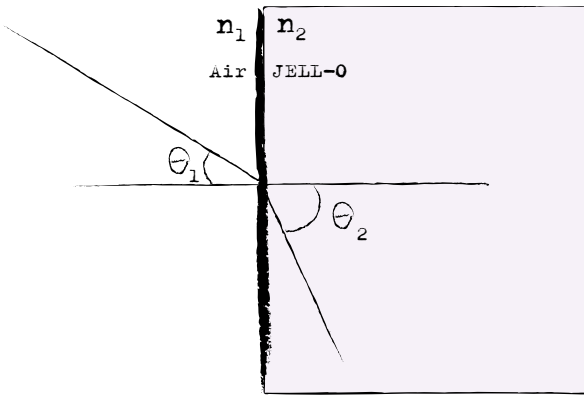


Figure 1

Use the index of refraction for JELL-O, and the known speed of light in a vacuum, to calculate the speed of light in JELL-O.

$$v_{Jell\text{-}o} = \frac{c}{n_2} = \frac{3.0 \times 10^8}{\qquad} = \_\_\_\_\_ \text{ m/s}$$

Mission completed. Congratulations, agent 001395. Continue on to the next mission.

Mission 2

Agent: 001395

Calculate the Critical Angle of JELL-O

Look at Snell's law carefully – it contains something special. Pretend that you are inside a piece of JELL-O shooting a laser through a JELL-O-to-air interface. Remember that $\sin(90°) = 1$. This means that we can manipulate Snell's law to look like this:

$$= \sin^{-1}\left(\frac{n_2}{n_1}\right)$$

So what? This equation shows that if you shoot the laser at the critical angle, θ_C, or any angle larger than the critical angle, the beam of the laser will not travel through the interface, but will stay within the JELL-O. This phenomenon is called "total internal reflection"(**Figure 2**). Notice also that the value of this special angle is dependent solely on the indices of refraction of the two materials. Total internal reflection occurs only at interfaces passing from a material with a higher index of refraction to one with a lower index of refraction.

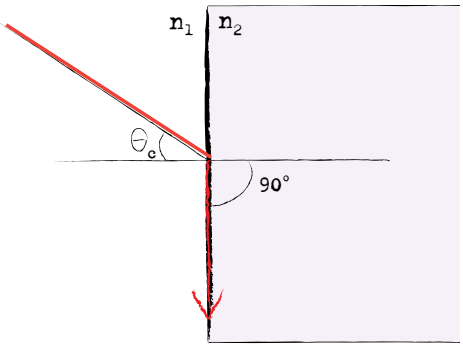


Figure 2

Calculate the critical angle of your JELL-O-to-air interface, using n_1=1.0003, for air, and n_2, for JELL-O that you found in Mission 1.

A waveguide is a medium that can direct a wave so that it travels in a desired direction: for example, fibre-optics or tv cables. A waveguide works by causing a wave to experience total internal reflection each time it hits one of its barriers. JELL-O can work as a waveguide because its index of refraction is higher than that of air.

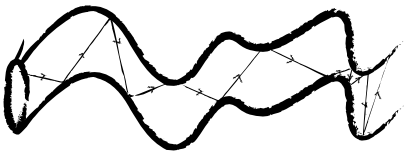


Figure 3

Try shooting a laser into a long squiggly piece of JELL-O at an angle so that the refracted beam hits the JELL-O-to-air interface at the critical angle like in **figure 3**. Can you create total internal reflection? See if you can get the beam to bounce all the way through the JELL-O. Advance to the next mission.

Mission 3

Agent: 001395

Determine the Colour Absorbance of JELL-O

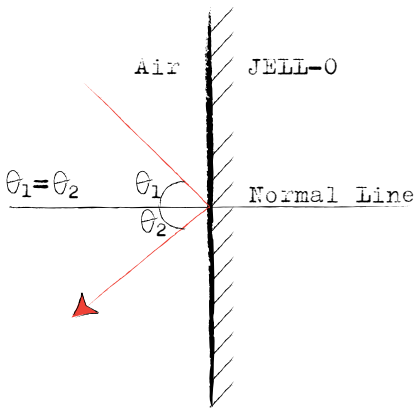
Colour is the result of reflection and absorption of light. The colour of any object is due to the light of that colour being reflected off the surface of the object. A material may absorb and reflect light differently across the visible spectrum. Any colour that is not reflected is absorbed and transformed into kinetic energy, which is then given off as heat. A red object, for example, reflects red light and absorbs the other colours to varying degrees (**Figure 4**).

Reflection, absorption and transmission are all based on fundamental chemical properties of the material being observed.

Explore how colours interact by using a red laser and pieces of different coloured JELL-O. Shine the red laser into the green piece of JELL-O. What happens? Now shine it into the red JELL-O. What happens? What about the other colours of JELL-O?

Repeat this procedure with the green laser. What does this tell you about the relationship between red and green?

Advance to the last mission.



Reflection

Figure 4

Mission 4

Agent: 001395

Complete the Optical Course

Put your knowledge of optics to the test by completing the WOW Spy Academy optical course (**Figure 5**). Find the optical course cards and use the green laser and green JELL-O pieces to try and bend the beam around the obstacles to hit the target.

INTERNATIONAL WOW SPY ACADEMY
OFFICIAL OPTICAL-COURSE 9AF6

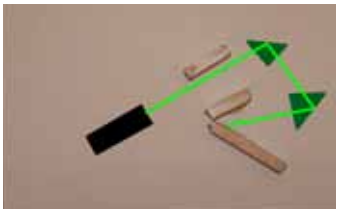


Figure 5

This is certainly the most difficult and time consuming mission of your WOW-Spy training. Once completed, you will have sucessfully completed the Optics Training Course. Congratulations!

THE INTERNATIONAL WOW-SPY ACADEMY

Certificate of Completion

Optics Training Course 1a.

Presented to

PASSED

THE INTERNATIONAL WOW-SPY ACADEMY

Certificate of Completion

Optics Training Course 1a.

Presented to

PASSED