

# Exploring Materials: Thin Films

## Activity 1:

1. Write your name on a strip of black paper.
2. Slide the paper into the pan. Make sure it is completely under water.
3. Use the brush to drip one drop of nail polish onto the surface of the water. The polish will spread out into a thin film.
4. Hold one end of the paper and lift it up out of the water. The film of nail polish will stick to the paper. **Does the nail polish still look clear?**

**Describe what the thin film looks like:**

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***What's going on?*** The nail polish spreads out into a super-thin film, which creates iridescent, rainbow colors on the paper. The thin film is only a few hundred nanometers thick, about as thick (or thin!) as a soap bubble. The film is slightly thicker in some places and thinner in others. As the thickness of the film changes, the color changes.



### CRITICAL THINKING

**Besides nail polish, what other substances can create thin films?**

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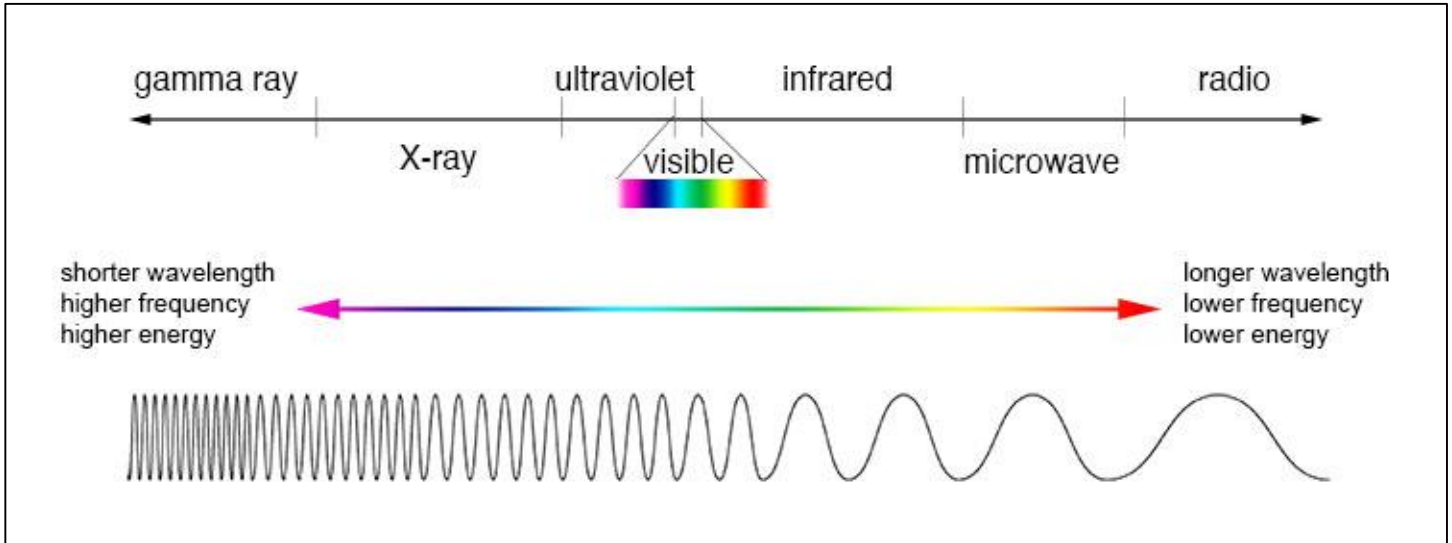
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**Why do some thin films have beautiful colors?**

Thin films reflect light differently depending on how **thick** or **thin** they are in certain places. Because the light is reflected differently off of different areas, you see different colors. White light is made up of all wavelengths, or colors, of light.

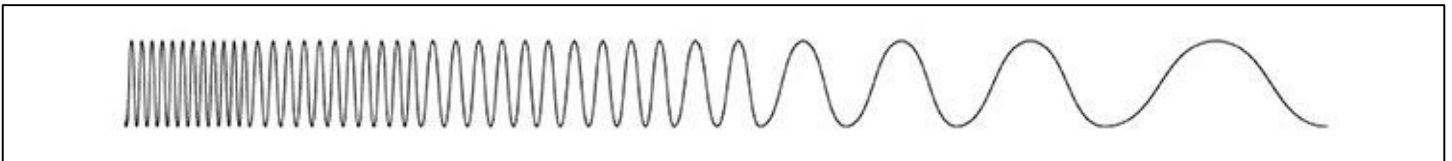
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## Activity 2: Wavelengths



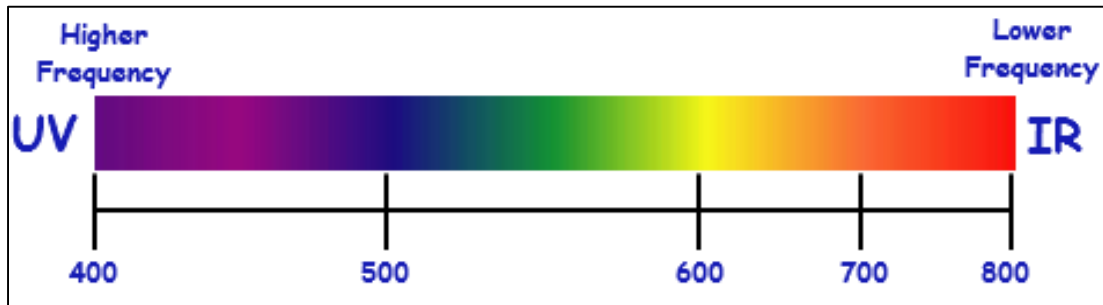
Light travels in waves. Just like water waves, light waves have **crests** (high points) and **troughs** (low points).

1. In the picture below , label the crest of the light wave and the trough of the light wave.



Notice the wavelengths are longer for the color red and get progressively shorter as they move to purple. This is because different colors of light have different wavelengths. The wavelength of visible light ranges from about 400-700 nanometers. The nanostructures of iridescent feathers, shells, and wings are in this same size range. So are thin films.

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2. Looking at the spectrum above, what color would a wavelength of 500 nanometers have?
3. What color would a wavelength of 650 nanometers have?

**CHECKPOINT!** Which color has the longer wavelength: red or purple?

Which color has the higher frequency: red or purple?

Wavelengths that are “in-sync,” hitting both the front and back of the film, are reflected back to your eyes as bright colors. Different wavelengths are in sync at different parts of the film, depending on its thickness. Many beautiful things in nature get their iridescent colors this way—through the constructive interference of light. Bird feathers, butterfly wings, shells, and beetle shells all have nano-sized, semi-transparent layers that create an iridescent effect when they reflect light.

**Constructive interference:** when reflected wavelengths have **crests** that overlap, they reinforce each other and the reflected color is bright.

**Destructive interference:** when reflected wavelengths have **troughs** that overlap, the waves cancel each other out and the reflected color is dim.

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## Activity 3: Thin Films

Observe the peacock feather. Notice how in some places the colors are bright, while in other places the colors are dim.

The bright colors have overlapping \_\_\_\_\_

While the dim colors have overlapping \_\_\_\_\_

### How are thin films used?

Scientists are developing thin films to use as computer memory and in solar cells. Flexible thin film batteries can be made by printing onto plastic, thin metal foil or paper. Thin films are expected to have cheaper manufacturing and materials costs than conventional materials.

### How is this nano?

Nanotechnology takes advantage of special properties at the nanoscale to create new materials and devices. Researchers are creating thin film batteries, solar cells, electronic displays, and coatings for different surfaces.

### SUMMARY

Describe the most interesting thing you have learned during this exercise. What would you still like information on? How will you find the information you need to answer your questions?