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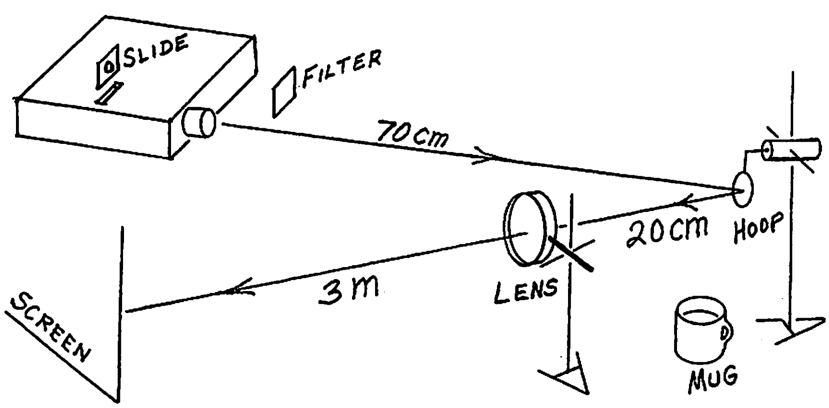
Dispersion - spectra via reflection and interference. The colors produced by the thin films of soap bubbles and motor oil spills have always dazzled us. Fortunately, we can easily reproduce these thin films and their colors and can explain via the wave theory of light what we see.

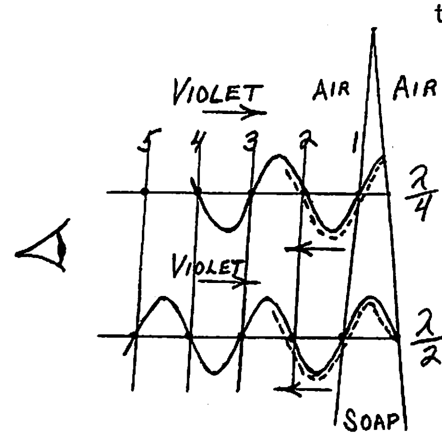
Due to gravity, a soap film in the vertical plane "drains" (slides) down, forming a "wedge" of film of increasing thickness toward the bottom. (See Diagram.) Light reflects off of the front surface and the inside of the back surface of the film. When the reflected light from both surfaces is in phase, constructive interference occurs and a bright color results. Of course, the different colors correspond to the different thicknesses of the "wedge", and thus, each color has its own bright location. Simply, it is a "best fit" situation, that is, the color violet, a short wavelength ($\lambda$), will be located or "fit" in the thinner part of the "wedge" compared to the color red, a long $\lambda$, in the thicker part. The pattern will repeat on down the "wedge". Because the soap film continues to "drain", the pattern will continue to move downward, following the change in thickness of the "wedge".

The initial set-up and projection for classroom observation is illustrated in the diagram below.

Diagram:




the "wedge": (profile)
inside of back surface reflection




(incomplete explanation)

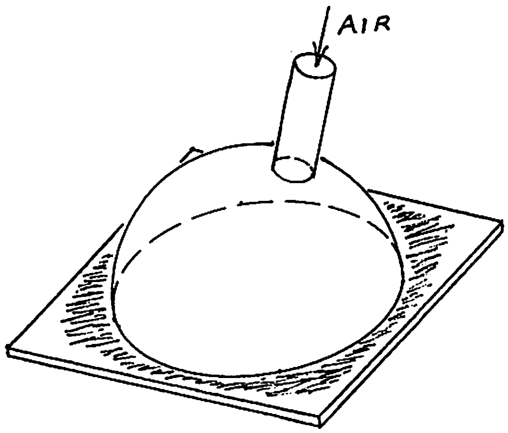
Materials: slide projector, metal slide, filter (red?), wire hoop, coffee mug, soap solution, convex lens ( 11 cm dia., f = 20 cm), screen

Preparation: Prepare a soap solution of 1 part Joy liquid detergent to 32 parts water. 10 ml of Joy and 320 ml of water should be enough for the entire set of demos. With brass wire (#16), make a hoop; bend it around a 1½" dia. pipe (PVC?) to get a nice circle less than 1 3/4" in dia. Fasten it to a short dowel with tape. Make an aluminum or steel 2" x 2" slide with a 3/8" dia. aperature to narrow the projector's beam. Mount everything on ring stands as illustrated. Right-angle clamps are useful, also.

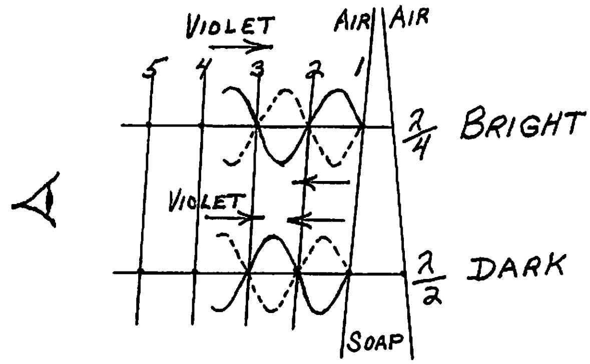
Presentation: With everything in place, raise the "soap" mug to wet the hoop and form a good film. Make final adjustments, especially moving the convex lens to get a sharp image of the colors on the screen. Because you are working with a real image, the top of the hoop and the colors will be inverted, or the "draining" will appear to move upward. When the film breaks, dunk the hoop again and watch the process repeat. Next, insert a filter (red?) in the beam to observe a monochromatic light pattern of red(?) and dark lines (bands).

Addendum: A simple, but dramatic, demo on the same theme as above is the large hemispheric soap bubble illustrated below. The colors emerge as concentric circles (bands) like latitude lines on a globe due to the "draining". With a little practice, the same soap solution formula, and an open-ended tennis ball "can", you can easily create these dazzling, colorful bubbles on a table or counter top.

Diagram:




the "wedge": front surface reflection




(completes the explanation)

Materials: a large, waterproof surface (2'sq. plastic sheet?), an open-ended tennis "can" <u>or</u> a piece of PVC pipe, 2" I.D., 8" long, soap solution ( 1 part Joy, 32 parts water)

Presentation: Students may gather around the bubble to see the colors better. Spread the soap solution out on the waterproof surface. Touch the bottom of the "can" or PVC pipe in the solution to acquire a film across the bottom opening. Carefully lift the "can" while blowing softly, but steadily, into the "can". You will see the bubble slowly take shape. Keep lifting and blowing until a large size is reached. Carefully "slip" the "can" off of the bubble with a quick, smooth hand motion and watch the colors emerge and move about. The soap solution formula (ratio) generally dictates the length of time the bubble will last. Experiment. The number of soap bubble demos is endless. However, this is a good one to start with.

Addendum: Use the diagram above right to complete the explanation of what is seen in the "wedge". Carefully draw the second set of sine curves above <u>in ink</u> on (along) the first set on p. 1 . You will note that when the dashed (reflected) curves are in phase, the region is bright; when the dashed curves are out of phase, the region is dark. However, since red's $\lambda$ is about twice that of violet's, violet's dark region will become red's bright region. Thus, between violet's and red's bright regions, all of the other colors will have their bright regions or "best fits". Neat!

OHP transparencies - were developed for classroom instruction. Make transparencies of Part I and Part II; cut off the bottom (the "slider" wave) of Part II along the faint dashed line. Place Part I on the OHP and begin the explanation (asking questions about the rules of wave reflection?). Set up the explanation of Part II using the "slider" wave on top of Part I. Slide the "wave" forward the proper number of spaces: from 2 to 1 for $\lambda/4$ and from 3 to 1 for $\lambda/2$. Replace Part I with Part II to see the result. Now remove Part II and replace it with Part I; add Part II as an overlay. The positions (phasing) of the dashed lines (the reflected light) tell the final story of the bright and dark regions and thus, the dispersion (separation) of the colors.

# THE "WEDGE"

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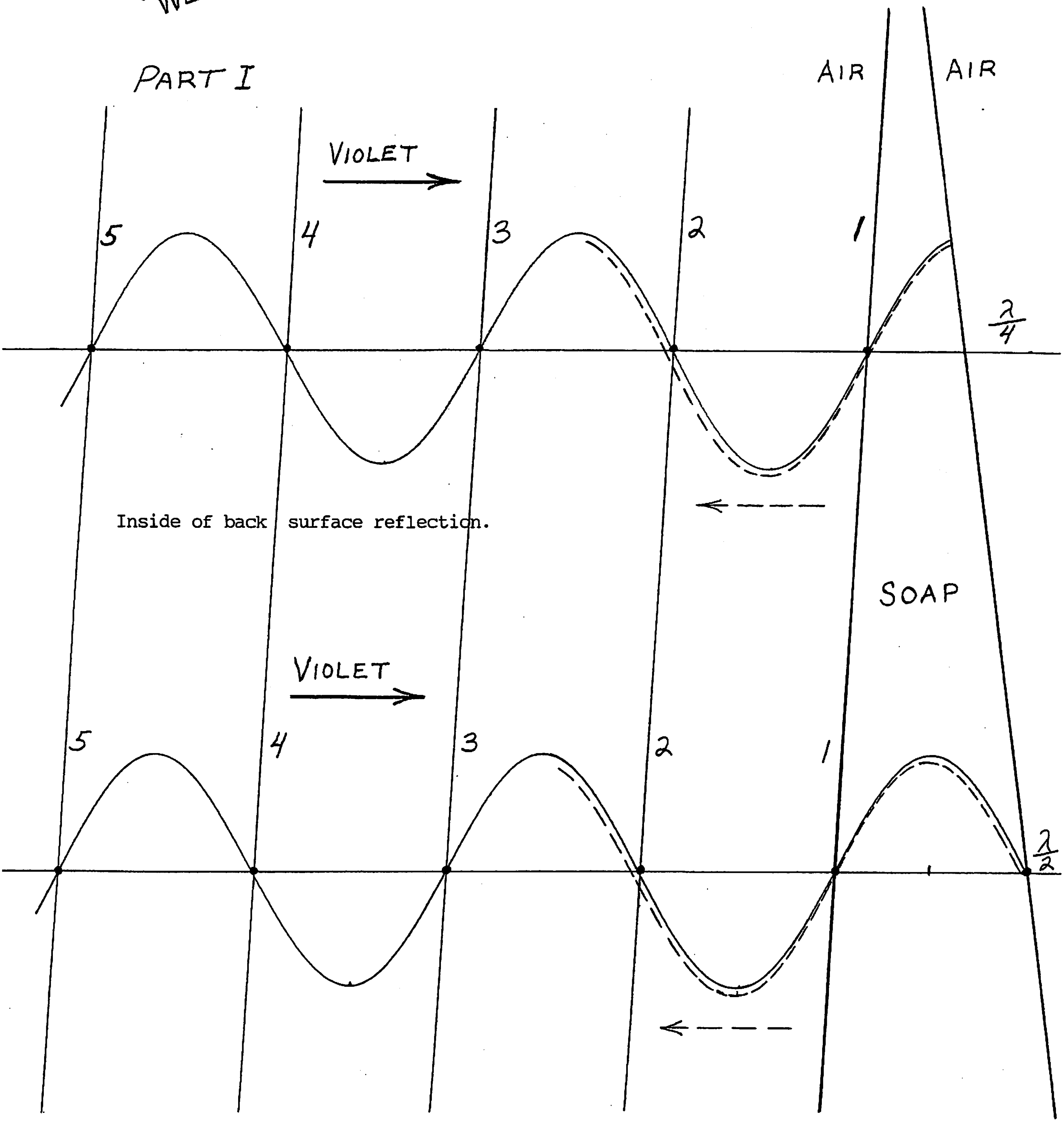
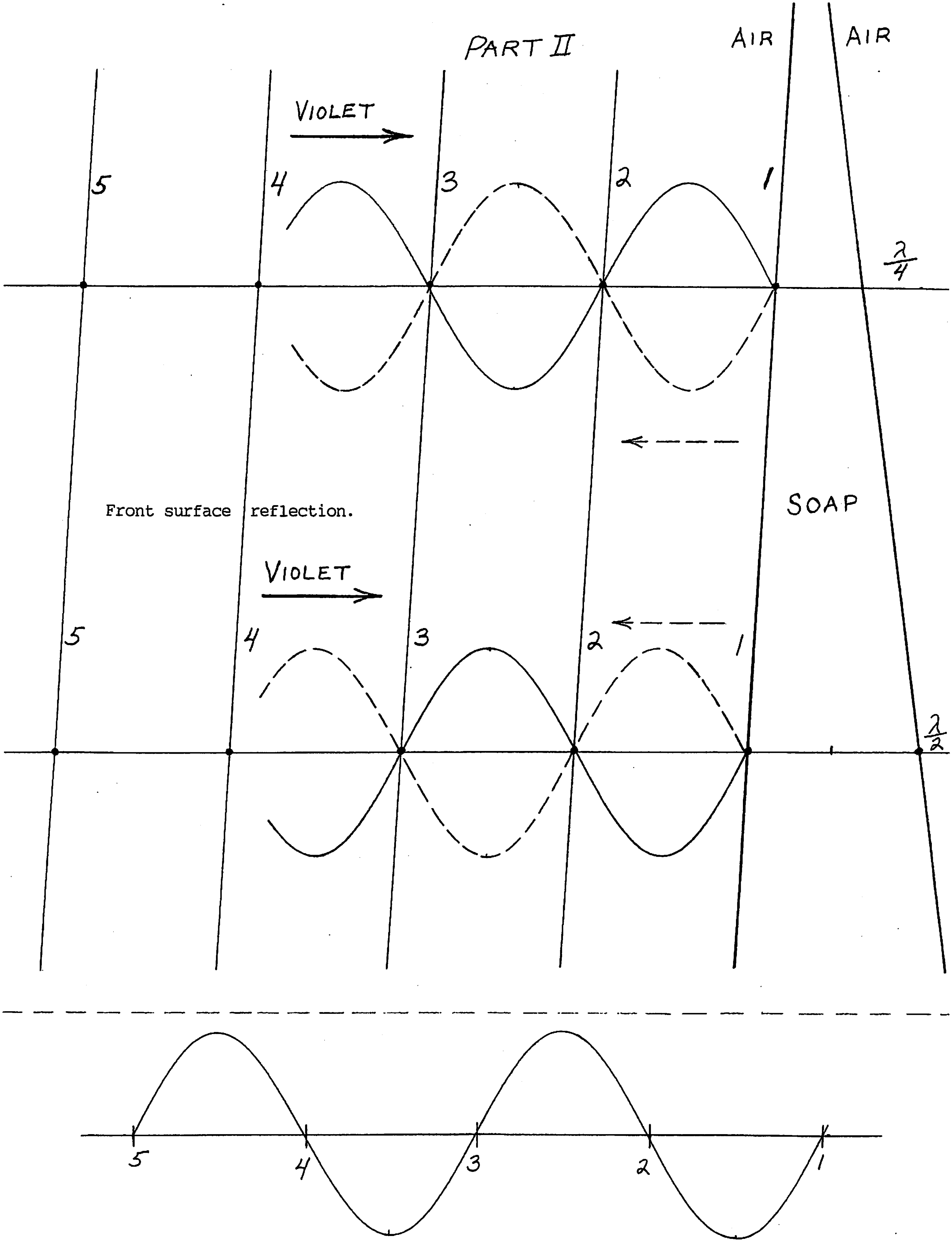
## PART I




PART II
AIR
AIR
VIOLET
5
4
3
2
1
λ/4
SOAP
Front surface reflection.
VIOLET
5
4
3
2
1
λ/2
5
4
3
2
1