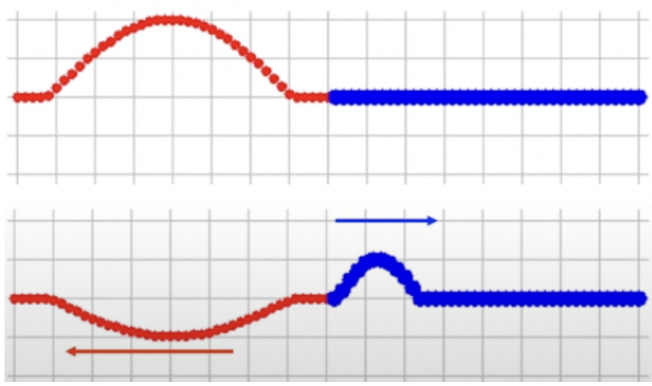
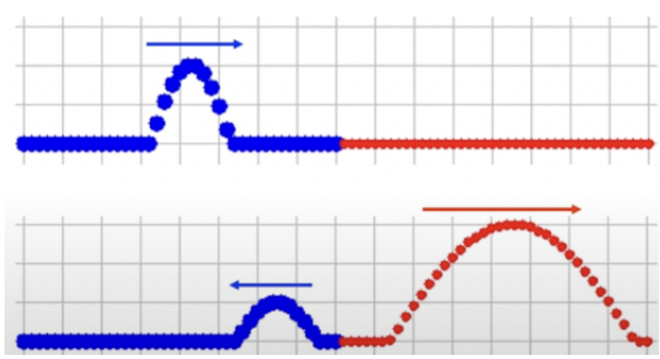
CAS PY 106

Prelecture Note 32

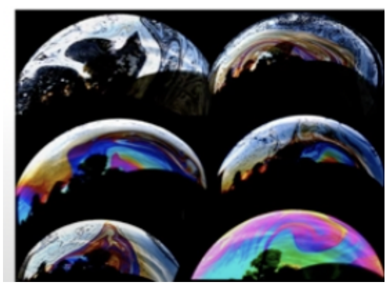
1. Reflection of Waves
    a. When a wave reflects from a fixed end, it reflects upside down
    b. When a wave reflects from a free end, it reflects upright
    c. When a wave traveling on a light string reflects from a heavy string, the knot acts like a fixed end. Part of the wave is transmitted, and the rest is reflected upside down
    d. 
    e. When a wave traveling on a heavy string reflects from a light string, the knot acts like a free end. Part of the wave is transmitted, and the rest is reflected upright
    f. 
2. The reflection of light

a. Light waves, or other EM waves, experience a 180 degrees phase shift when reflecting from a higher-n medium (n2 > n1). This is equivalent to a shift of half a wavelength

b. Waves reflecting from a medium of lower index of refraction experience no phase shift

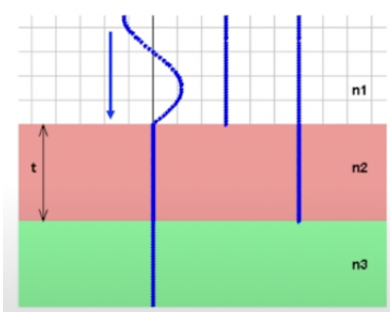
3. Thin-film interference

a. Thin-film interference: interference between light waves reflecting off the top surface of a film with waves reflecting from the bottom surface. To obtain a nice colored pattern, the thickness of the film has to be comparable to the wavelength of light

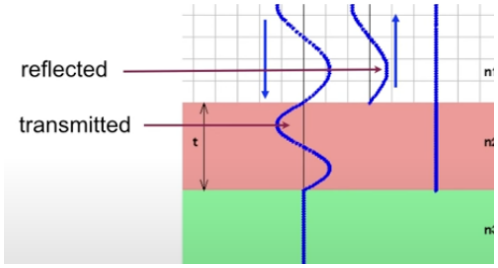
b. 

4. Thin films - sequence of events

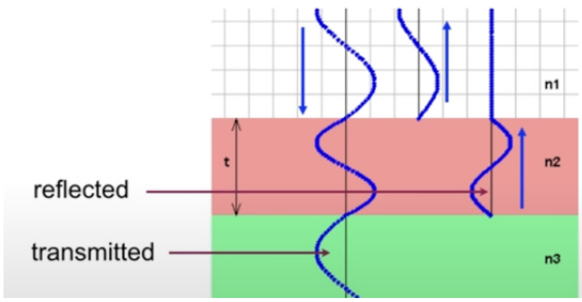
a. A wave is incident on the top surface of the film

b. 

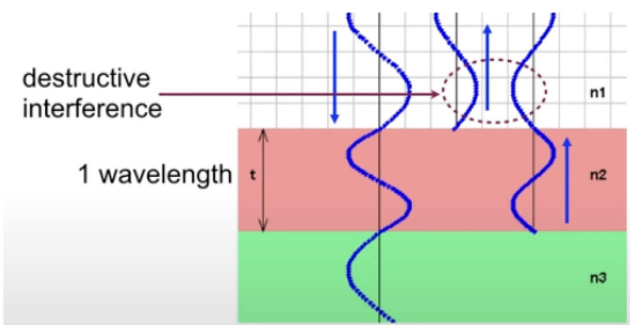
c. The incident wave is partly reflected (possibly experiencing an inversion) and partly transmitted. The reflected wave is moved to the right here so we can see it

d. 

e. The wave also partly reflects off the bottom surface of the film (the pink material), possibly experiencing an inversion. The reflected wave is moved to the far right

f. 

g. The two reflected waves interfere with one another. The film thickness needs to be just right if we want completely constructive or completely destructive interference

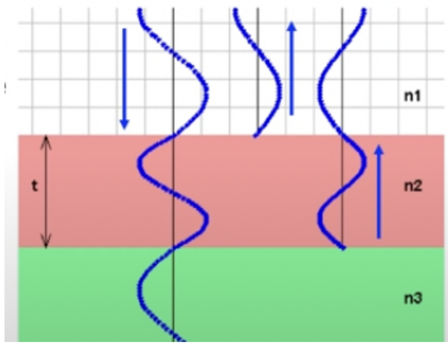
h. 

5. Thin films- a systematic approach

    a. Use the five-step method to analyze thin films.

b. The basic idea is to determine the effective path-length difference between the wave reflecting from the top surface of the film and the wave reflecting from the bottom surface

c. The effective path-length difference accounts for the extra distance of 2t traveled by the wave that reflects from the bottom surface, and any inversions upon reflection

d. 

e. For a wave that gets inverted when it reflects, that is equivalent to a half-wavelength shift

f. However, we have three media, and thus three different wavelengths

g. Because we are trying to match the wave that goes into the film with the wave bouncing off the top, it is the wavelength in the film that appears in the equations

h. Step 1 - Determine delta t, the shift for the wave reflecting from the top surface of the film

i.
$$\text{If } n_2 > n_1, \quad \Delta_t = \frac{\lambda_{film}}{2}$$

$$\text{If } n_2 < n_1, \quad \Delta_t = 0$$

j. Step 2 - Determine delta b, the shift for the wave reflecting from the bottom surface of the film. We have at least 2t, from the extra distance traveled

If $n_3 > n_2$,

$$\Delta_b = 2t + \frac{\lambda_{film}}{2}$$

k. If $n_3 < n_2$, $\Delta_b = 2t$

l. Step 3 - Find the effective path-length difference

$$\Delta = \Delta_b - \Delta_t$$

m.

n. Step 4 - Bring in the appropriate interference condition, depending on the situation

For constructive interference, $\Delta = m\lambda_{film}$

For destructive interference, $\Delta = (m + 1/2)\lambda_{film}$

o.