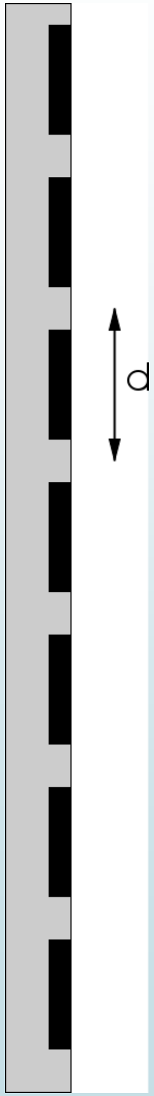
# Diffraction and Interference – Learning Outcomes

- Demonstrate the wave nature of light.
- HL: Derive the diffraction grating formula.
- Solve problems about diffraction gratings.
- Discuss interference in thin films.

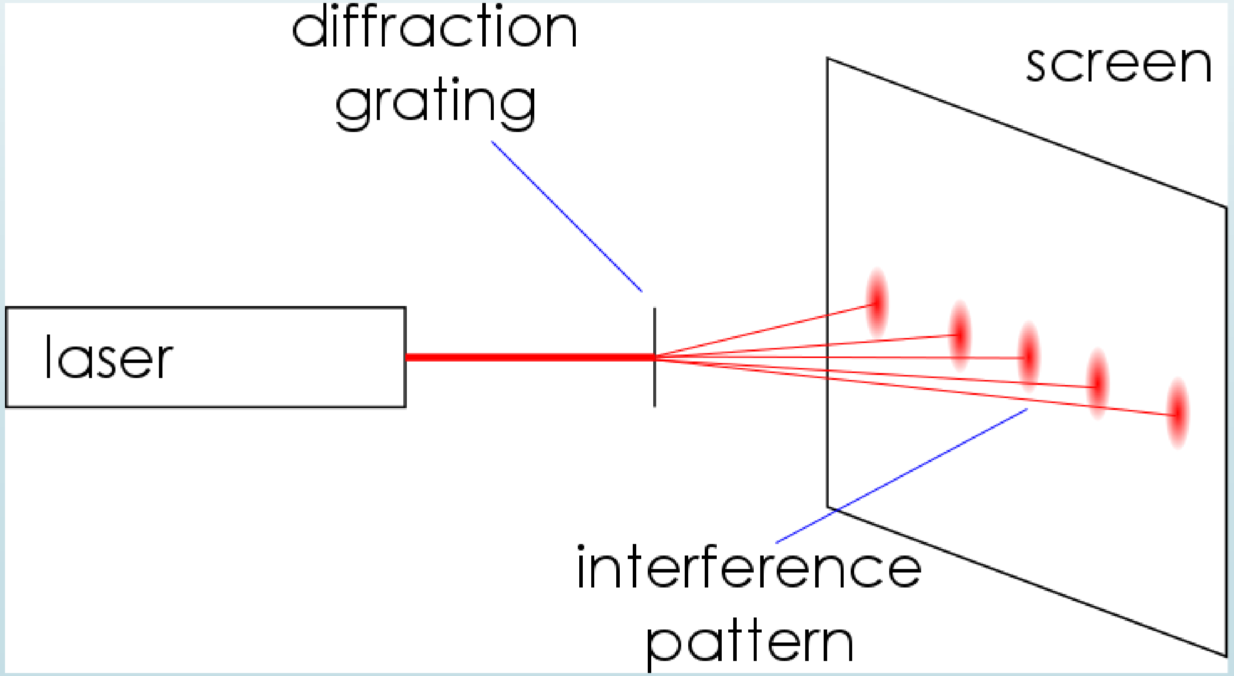
# Diffraction Gratings

- Diffraction gratings are pieces of transparent material with lines etched on it.
- The lines prevent light from passing through, so light passing between the lines behaves as if it passed through slits (i.e. it diffracts).
- Gratings are usually described as having some number of lines per mm (e.g. 400 lines per mm).
- The distance between adjacent gaps, *d* is the inverse of this (e.g. $\frac{1}{400}$ mm).



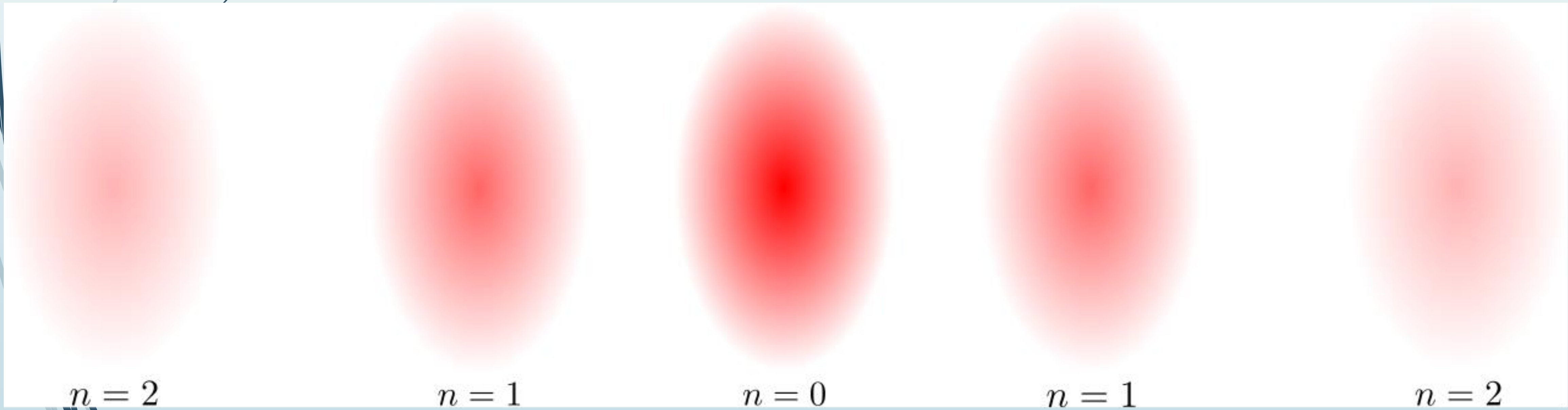
# To Demonstrate the Wave Nature of Light

1. Shine a laser at a diffraction grating.
2. Place a screen behind the grating and observe that an interference pattern is produced on the screen.
3. Only waves interfere with each other, so light must be a wave.



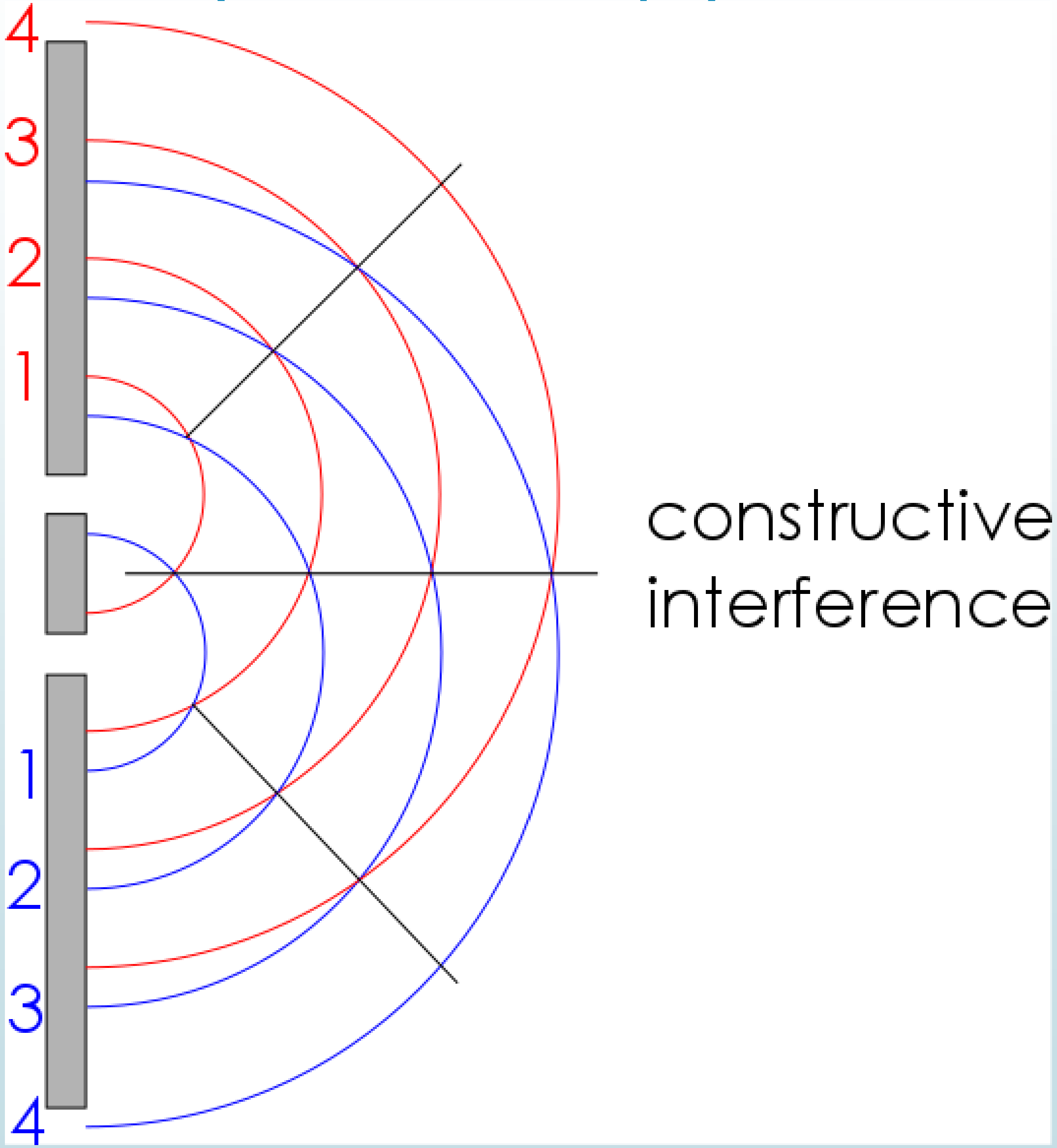
# Interference Pattern

- Interference patterns are a series of bright spots ("fringes") caused by constructive interference.
- The central fringe (n=0) is the brightest, with fringes getting dimmer either side as order increases (n=1, 2, 3…)



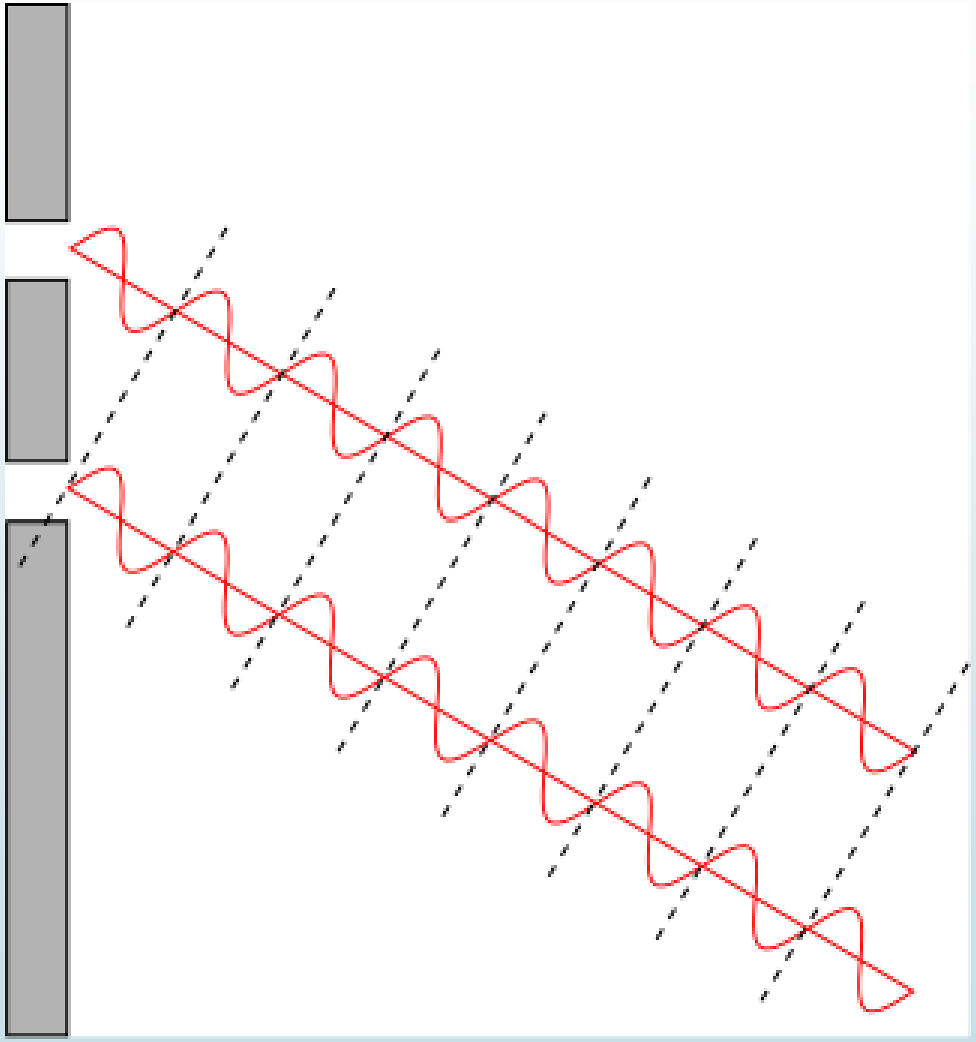
# HL: Derive $n\lambda = d\sin\theta$ (the set-up)

- Consider two sources of waves next to each other.
- Constructive interference occurs when the waves are in phase.
- It also occurs when they are exactly 1 cycle apart (or 2, 3, 4 … cycles)



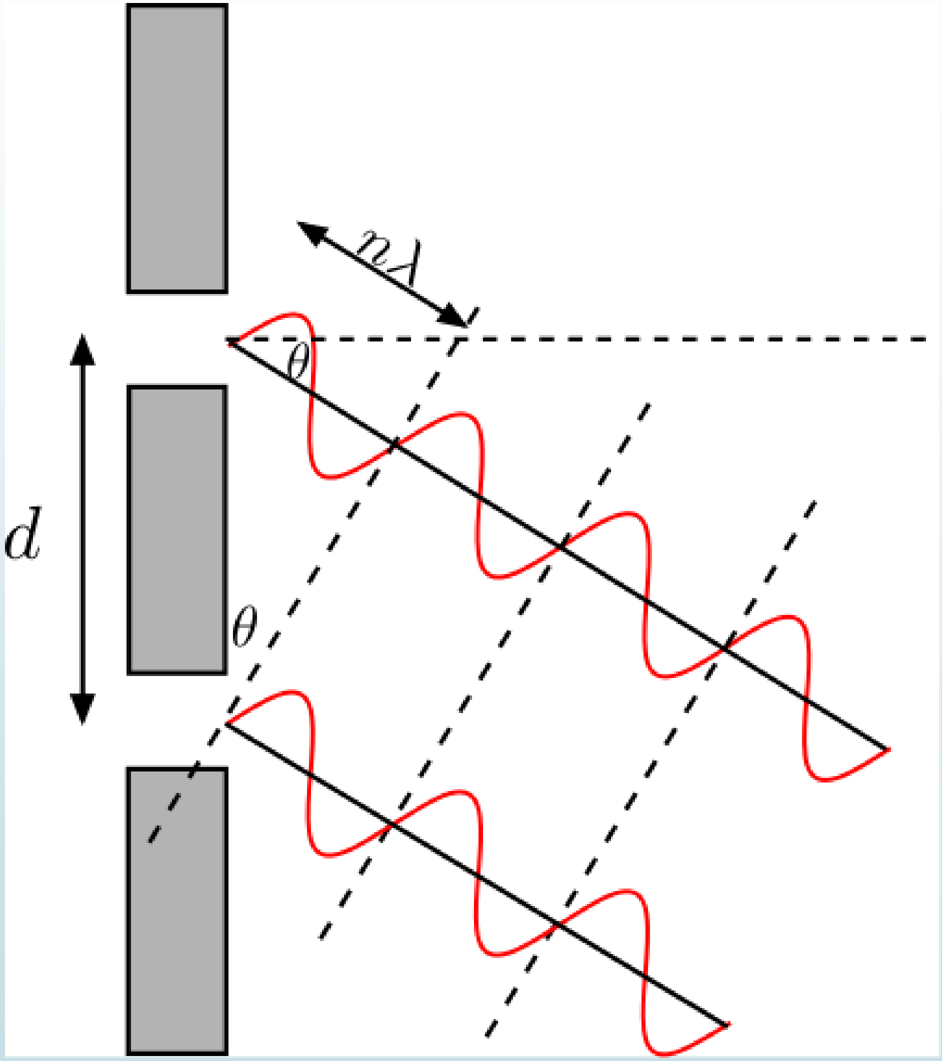
# HL: Derive $n\lambda = dsin\theta$ (the set-up)

- As we only care about single directions, go back to the ray picture.
- Rays are emitted in all directions.
- We single out the rays that cause constructive interference – they are in phase and travelling in the same direction.



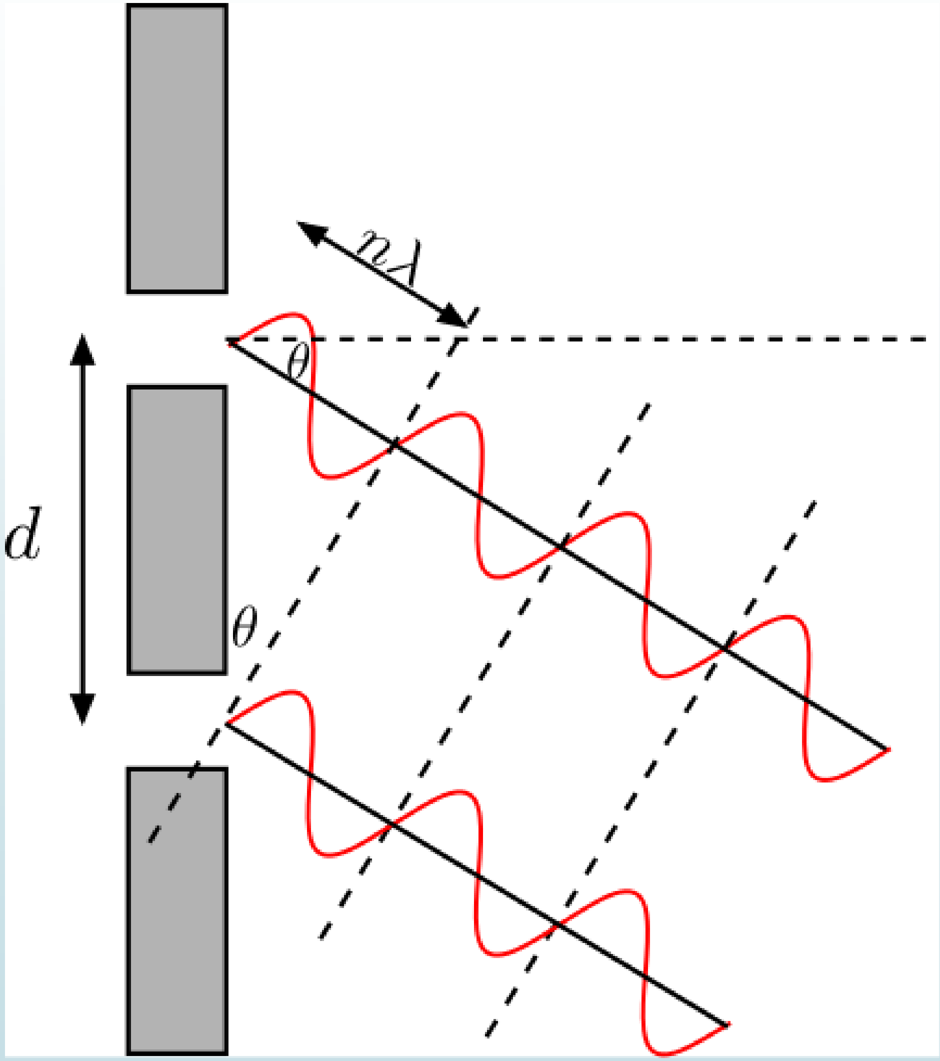
# HL: Derive $n\lambda = dsin\theta$ (the derivation)

- Consider rays emerging from a diffraction grating at an angle $\theta$ from the normal.
- If the path difference between the rays is a whole number of wavelengths, they will arrive in phase.
- i.e. constructive interference occurs if the path difference is $n\lambda$.



# HL: Derive $n\lambda = dsin\theta$ (the derivation)

- Let the distance between lines be $d$.
- By trigonometric identity,
- $sin\theta = \frac{n\lambda}{d}$
- Rearranging gives
- $n\lambda = dsin\theta$



$$n\lambda = dsin\theta$$

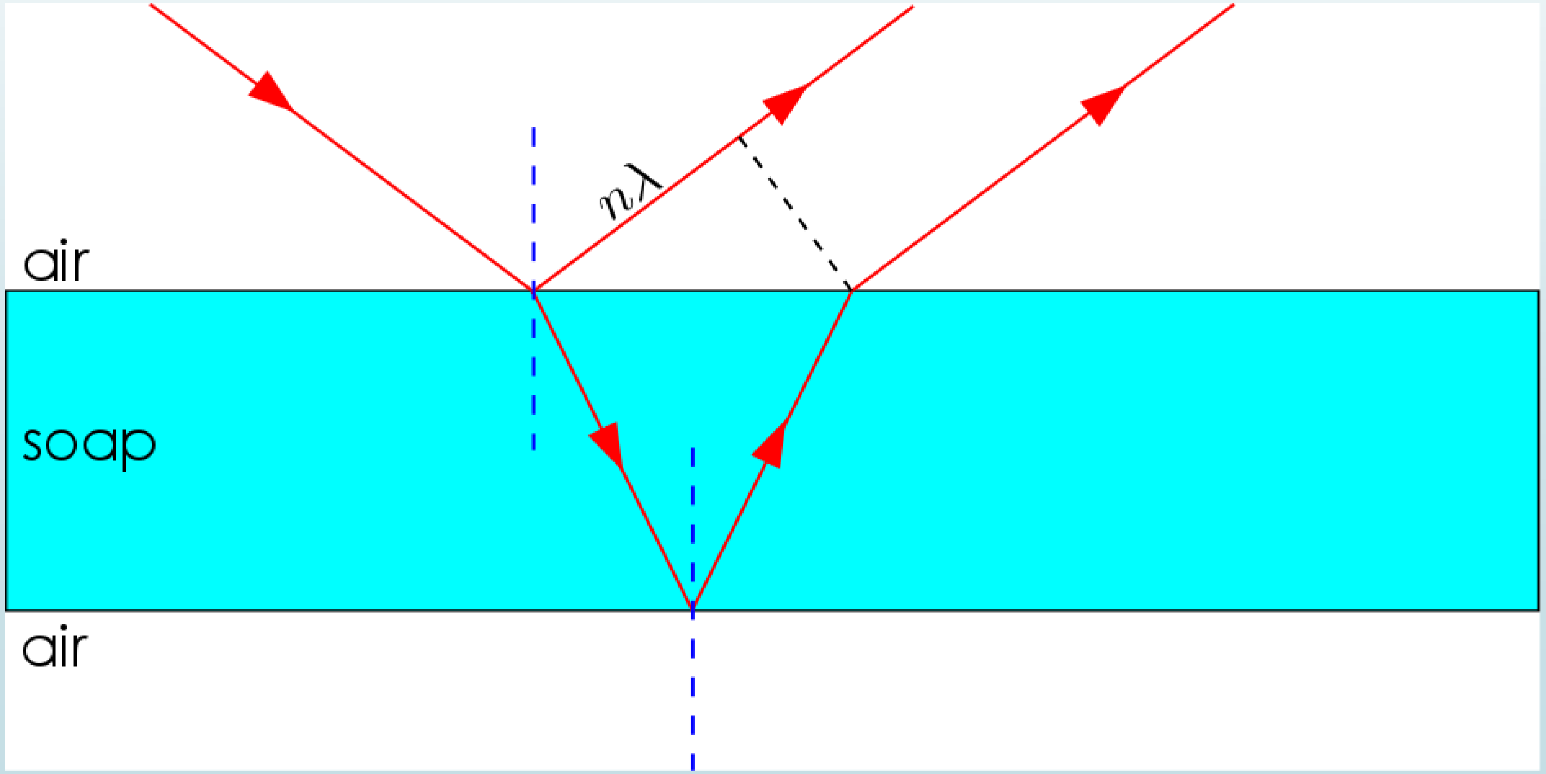


# Solve Problems

- e.g. Red light falls on a diffraction grating with 400 lines per mm. The second order diffracted image is at 30° from the central fringe. Find the wavelength of the light.
- e.g. A diffraction grating has 350 lines per mm rules on it. Light of wavelength 520 nm falls on it. What is the highest order fringe formed?
- e.g. A monochromatic (single-colour) light source is shined on a diffraction grating with 100 lines per mm. A diffraction pattern is formed on a screen 2 m from the grating. If the distance between the fourth order fringes is 80 cm, what is the wavelength of the light source?

# Interference in Thin Films

- Light striking a film will reflect at both boundaries.
- If the reflected rays are a whole number of cycles apart (i.e. if the path difference of the reflected rays is $n\lambda$), constructive interference will occur.



# Interference in Thin Films

- Due to the wavelength dependence, different colours undergo interference at different angles, creating rainbow effects.