Chapter 27 Review – Diffraction

1. What does it mean to say two sources are coherent? The waves emitted by the sources maintain a constant phase relation.

2. What is the condition for constructive interference from two coherent sources? When the difference in path lengths is an integer number of wavelengths.

3. What is the relation between the angle \( \theta \) for which constructive interference occurs and the separation \( d \) of the coherent sources of wavelength \( \lambda \)?

\[
\sin \theta = m \frac{\lambda}{d} \quad m = 0, 1, 2, 3
\]

4. What is the relation between the angle \( \theta \) for which destructive interference occurs and the separation \( d \) of the coherent sources of wavelength \( \lambda \)?

\[
\sin \theta = \left( m + \frac{1}{2} \right) \frac{\lambda}{d} \quad m = 0, 1, 2, 3
\]

5. How does the angle to a point of constructive interference depend on wavelength, all other factors equal? This indicates that different wavelengths will have different locations for maxima. The larger the wavelength the larger the angle.

6. What is a consequence of wavelength dependence if one is using a white light source in the Young’s two-slit experiment? Color separation similar to that which occurs due to wavelength dependent refraction (dispersion).

7. What is thin-film interference? Interference that is the result of a thin layer of a material that lies over the top of another material wherein light the reflects from the bottom of the thin film interferes with light that reflects from the top of the film.

8. What happens to the frequency of light when it enters a thin-film? The frequency is the same.

9. What happens to the wavelength of light when it travels through the film? The ratio of velocity to wavelength for the light will remain the same. This can only happen if the wavelength changes by the same factor that the velocity changes.

10. What is the relation between the wavelength that reflects from the top surface of the film and the wavelength of the light traveling through the film?

\[
\lambda_{\text{film}} = \frac{\lambda_{\text{vacuum}}}{n_{\text{film}}} \quad \Rightarrow \quad \frac{V_{\text{film}}}{\lambda_{\text{film}}} = \frac{c}{\lambda_{\text{vacuum}}} \quad \Rightarrow \quad \lambda_{\text{film}} = \left[ \frac{V_{\text{film}}}{c} \right] \lambda_{\text{vacuum}}
\]

11. Summarize the phase rules for reflection at a boundary between two materials of different indices of refraction. Let \( n_i \) refer to the material where the incident light originates. Reflection off the boundary results in a half-wavelength phase change if \( n_2 > n_1 \).

12. Why does one see different colors at different parts of a soap bubble? The thickness of the bubble is different in different places. The resulting constructive and destructive interference results in different colors at these places.

13. What is an interferometer? A device that can be used to measure the wavelength of light by utilizing interference between two light waves.

14. What is the purpose of the compensating plate in the Michelson interferometer? To assure that the two arms of the interferometer have equal passages through the beam splitter and compensating plate.

15. What is Huygen’s principle? Every point on a wave front acts as a source of tiny wavelets that move forward with the same speed as the wave; the wave front at a later instant is the surface that is tangent to the wavelets.
16. For single-slit interference, what is the relationship between slit width \( W \), the angle \( \theta \) to the first minimum and wavelength \( \lambda \)? \[
\sin \theta = m \frac{\lambda}{W}, \quad m = 0, 1, 2, 3, ...
\]

17. What is resolving power? The ability of an optical system to distinguish between two closely spaced objects. The optical systems are typically microscopes and telescopes.

18. What is resolving power equation? \[
\sin \theta = 1.22 \frac{\lambda}{D}
\] where \( \theta \) is the angle between two objects, \( D \) is the diameter of the opening, and \( \lambda \) is the wavelength.

19. Express the Rayleigh criterion in radians. \[
\theta_{\text{min}} = 1.22 \frac{\lambda}{D}
\]

20. What is a diffraction grating? A device with a large number of very closely spaced slits that produces interference when light passes through it.

21. What is the equation for the location of principal maxima of a diffraction grating? \[
\sin \theta = m \frac{\lambda}{d}, \quad m = 0, 1, 2, 3,... \quad \text{where } \theta \text{ is the angle between the zeroth order maxima and the higher order maxima, } d \text{ is the distance center-to-center between adjacent slits, and } \lambda \text{ is the wavelength.}
\]

22. How can one calculate the slit separation distances from the number of lines per cm? \[d = \frac{1}{\text{number of lines \ cm}}\]

Chapter 27 Homework Problems

1, 5, 15, 19, 23, 31, 41