1. A Newton’s rings apparatus uses a planoconvex lens (one side convex and one side flat) made of plastic with refractive index 1.30, placed on a flat glass plate. The radius of curvature of the lens is 5.5 m and the diameter of the lens is 2.5 cm. The wavelength of the light used is 550 nm.
   i) How many dark rings are seen?
   ii) The apparatus is immersed in water. How many dark rings are seen now?

2. How far apart do two objects on the moon’s surface have to be, so that they can be resolved by a telescope whose objective has a diameter of 100 in? Assume that the distance between the earth and the moon is 400,000 km and that the light used has a wavelength of 550 nm.

3. A plane wavefront falls normally on a screen which has a slit cut out. The slit is 0.73 mm wide. A screen is placed 2.5 m away, and the separation between the central maximum and the first minimum of the diffraction pattern is measured to be 1.7 mm. What is the wavelength of the light?

4. A diffraction experiment has two wide slits cut out in an opaque screen. The width of the slits is related to the separation between them by \( d = 5D \). How many bright interference fringes are seen between the second diffraction minimum to the left of the center and the second diffraction minimum to the right of the center?

5. Light of wavelength 598 nm falls normally on a slit that is 0.023 mm wide. What is the total number of dark fringes seen on a distant infinite screen? What is the ratio of the intensity of the maximum that occurs immediately before this dark fringe, to the intensity at the center of the screen?

6. A diffraction grating consists of \( N \) narrow slits that are equally spaced, with a distance \( d \) between adjacent slits.
   i) Light of wavelength \( \lambda \) is incident normally on the grating, and the image is observed on a distant screen. Show that
   \[
   I(\theta) \propto \frac{\sin^2[N\pi(d \sin \theta)/\lambda]}{\sin^2[\pi(d \sin \theta)/\lambda]}
   \]
   (1)
   using the following trigonometric result:
   \[
   \cos(\alpha) + \cos(\alpha + \phi) + \cos(\alpha + 2\phi) + \ldots \cos(\alpha + (N-1)\phi)
   = \text{Re}[e^{i\alpha} + e^{i(\alpha+i\phi)} + \ldots e^{i\alpha+i(N-1)\phi}]
   = \text{Re}\left[\frac{e^{i\alpha}e^{iN\phi} - 1}{e^{i\phi} - 1}\right]
   = \text{Re}\left[\frac{e^{i\alpha+i(N-1)\phi/2}e^{iN\phi/2} - e^{-iN\phi/2}}{e^{i\phi/2} - e^{-i\phi/2}}\right]
   = \text{Re}\left[\frac{e^{i\alpha+i(N-1)\phi/2}\sin(N\phi/2)}{\sin(\phi/2)}\right]
   = \cos(\alpha + (N-1)\phi/2)\frac{\sin(N\phi/2)}{\sin(\phi/2)}.
   \] (2)
(Here the symbol Re denotes the real part of a complex expression, and we have used the result derived earlier in this course: $e^{i\beta} = \cos \beta + i \sin \beta$, which is an important mathematical identity.)

ii) At what values of $\sin \theta$ is the intensity a maximum? Refer to Figure 35-18 (b) in your book; we are only interested in the big peaks.

7. i) For the same diffraction grating as in the previous problem, what is the width $\Delta(\sin \theta)$ of each maximum? Refer to Figure 35-18(b) in your book; we are only interested in the big peaks.

ii) If the incident light is a mixture of two wavelengths, $\lambda_1 = 550 nm$ and $\lambda_2 = 552 nm$, what is the minimum value of $N$ for which the $m = 2$ maxima of the two wavelengths do not overlap?

8. Unpolarized light of intensity $I_0$ is sent through three polarizers. The axis of the second polarizer is at an angle $\theta$ to the first, and the axis of the third polarizer is at an angle $\pi/2$ to the first polarizer. What is the transmitted intensity as a function of $\theta$, and its maximum possible value?