Answers to selected problems from Essential Physics, Chapter 25

1. (a) decrease (b) increase (c) decrease (d) decrease

3. (a) The second-order ($m = 2$) spectrum. (b)

   (c) 667 nm

5. The laser is shining on a single slit. We observe that the central maximum is significantly brighter than, and twice as wide as, the other maxima. This happens only with the single slit.

7. About 35 cm.

9. (a) 7:1 (b) 16.2 μm

11. The blue light. The film thickness for completely constructive interference is proportional to the wavelength. The blue light has a smaller wavelength than the red light, so the region of the film that first produces constructive interference for blue light is thinner, and therefore closer to the top, than the region of film that gives constructive interference for red light.

13. (a) 212 Hz (b) 106 Hz

15. (a) 0.52 m or 5.5 m (b) 2.4 m or 13.3 m
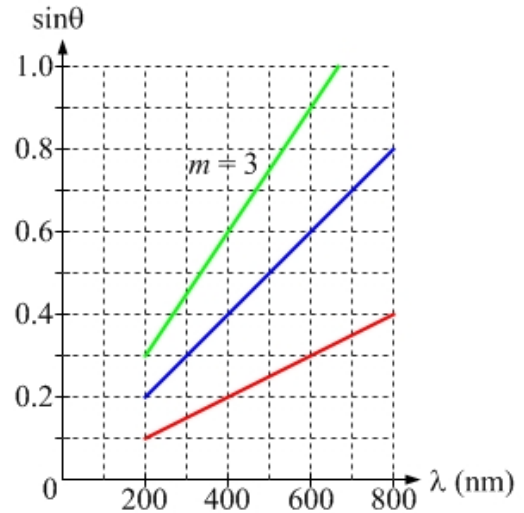
17. 33.5°

19. 500 nm

21. (a) 15 mm (b) 120 μm

23. (a) 8.2 cm (b) 500 m

25. (a) $\Delta_t = \dfrac{\lambda_{film}}{2}$ (b) $\Delta_b = 2t$ (c) $\Delta = 2t - \dfrac{\lambda_{film}}{2}$ (d) $2t - \dfrac{\lambda_{film}}{2} = m\lambda_{film}$

   (e) $t_{min} = \dfrac{\lambda_{film}}{4} = 100$ nm

27. (a) $\Delta_t = \dfrac{\lambda_{film}}{2}$ (b) $\Delta_b = 2t + \dfrac{\lambda_{film}}{2}$ (c) $\Delta = 2t$ (d) $2t = \left(m + \dfrac{1}{2}\right)\lambda_{film}$

   (e) 400 nm

29. (a) 1060 nm   (b) 38.2°, 27.3°, and 24.1°, respectively

31. The technician should stop when the film looks green (520 nm wavelength). Following the five-step method gives $2t = m\lambda_{film}$, which can be solved to find a wavelength in vacuum (or air) of 520 nm.

33. 126 nm

35. (a) 48.6°   (b) 53.1°

37. (a) 4.0 cm   (b) Yes, the wavelength decreases to 75% of the original wavelength, so the distance between the spots also decreases to 75% of the original distance. The distance is 3.0 cm.

39. (a) constructive (b) 480 nm and 600 nm (c) 436 nm, 533 nm, and 686 nm

41. (a) 1140 nm   (b) $1896 \text{ nm} \le d < 2528 \text{ nm}$

43. 948 nm

45. (a) 12 (b) 1.4 μm (c) Yes, the 8th and 12th fringes are also missing.

47. (a) 550 nm (b) 2740 nm

49. The width of the single slit is 111 μm.

51. 0.4 m

53. (a) 150 nm. (b) Yes, case D. Cases C and D give the same equation, and involve the same medium as the thin film, resulting in the same thin-film thickness for constructive interference. Cases A and B have a different equation for constructive interference, and the thin film is a different medium, resulting in a different film thickness for constructive interference.

55. One possibility is $n = 1.125$. Another possibility is $n = 2.25$.

57. 825 Hz and 1375 Hz

59. (a) 20 wavelengths   (b) destructive (c) This time there would be 25 wavelengths, but the result would still be destructive interference.