63. a. 22.3° b. 16.6°
65. 19
67. a. Dark b. 1.597
69. a. No b. 0.044° c. 4.6 mm d. 1.5 m
71. b. 0.022°, 0.058°
73. b. −11.5°, −53.1°
75. a. 0.52 mm b. 0.074° c. 1.3 m

Chapter 23

1. a. 3.3 ns b. 75 cm, 67 cm, 46 cm
3. 0.40 ns
5. 30°
7. 6.1 m
9. 433 cm
11. 16°
13. 1.39
15. 76.7°
17. 3.2 cm
19. 1.52
21. 1.48
23. 1600 nm
25. 6.0 cm behind the lens, inverted
27. 7.5 cm in front of the lens, upright
29. 68 cm
31. 200 cm
33. 36 cm
35. 40 cm in front of mirror, inverted
37. 12 cm behind mirror, upright
39. a. 3 b. B(+1.0 m, −2.0 m), C(−1.0 m, +2.0 m), D(+1.0 m, +2.0 m)
41. 10 m
43. 1.7
45. a. 87 cm b. 65 cm c. 43 cm
47. 4.0 m
49. a. Total internal reflection b. Refraction at 72° c. 18 cm
51. 1.58
53. 1.0°
55. 2.00
57. b. −15 cm, 1.5 cm, agree
59. b. 50 cm, 0.67 cm, agree
61. b. −20 cm, 0.33 cm, agree
63. 15.1 cm
65. −15 cm, 0.75 cm, behind, upright
67. Concave, 3.6 cm
69. 67 cm, 1.0 m
71. a. 5.9 cm b. 6.0 cm
73. 16 cm
75. 13 cm
79. a. $t = \frac{n_1}{c}\sqrt{x^2 + a^2} + \frac{n_2}{c}\sqrt{(w-x)^2 + b^2}$

    b. $0 = \frac{n_1 x}{c\sqrt{x^2 + a^2}} - \frac{n_2(w-x)}{c\sqrt{(w-x)^2 + b^2}}$
81. b. 1.574

Chapter 24

1. b. $s_2' = 49$ cm, $h_2' = 4.6$ cm
3. b. $s_2' = 30$ cm, $h_2' = 6.0$ cm
5. b. $s_2' = -3.33$ cm, $h_2' = 0.66$ cm
7. 5.0
9. 3.0 mm
11. 6.0 mm
13. a. Myopia b. 100 cm
15. 6.3 cm
17. 5.0 cm
19. 6.0 mm
21. a. 8.0 cm b. 1.2 cm
23. Upright image, 1.0 cm tall, 6.4 cm to left of the second lens
25. a. Both images 2.0 cm tall; one upright 10 cm left of lens, the other inverted 20 cm to right of lens.
27. a. $f_2 + f_1$ b. $\frac{f_2}{|f_1|}w_1$
29. 16 cm placed 80 cm from screen
31. 23 cm
33. 5.0 cm
35. a. +3.0 D as objective b. −1.5 c. 0.56 m
37. 4.6 mm
39. 15 km
41. a. 3.8 cm b. Sun is too bright
43. 3.5 m
45. b. $\Delta n_2 = \frac{1}{2}\Delta n_1$ c. Crown converging, flint diverging d. 4.18 cm

Chapter 25

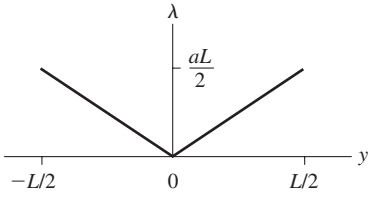
1. a. Electrons added b. 7.5×10^{10}
3. 2.5×10^{10}
5. 1.9×10^{5}
9. Right negatively charged, left positively charged
13. a. 0.056 N b. 2.9
15. a. 58 N b. 4.7×10^{-35} N c. 1.2×10^{36}
17. $-(4.1 \times 10^{-4}\ \text{N})\hat{j}$
19. a. 1.3×10^{14} m/s^2 toward bead b. 2.4×10^{17} m/s^2 away from bead
21. a. $(6.4\hat{i} + 1.6\hat{j}) \times 10^{-17}$ N

    b. $-(6.4\hat{i} + 1.6\hat{j}) \times 10^{-17}$ N c. 4.0×10^{10} m/s^2 d. 7.3×10^{13} m/s^2
23. $-4.5 \times 10^{4}\,\hat{r}$ N/C (i.e., toward the bead)
25. 3.3×10^{6} N/C, downward
27. $-6.8 \times 10^{4}\hat{i}$ N/C, $3.0 \times 10^{4}\hat{i}$ N/C, $(8.1 \times 10^{3}\,\hat{i} - 3.9 \times 10^{4}\hat{j})$ N/C
29. a. 0.36 m/s^2 toward glass bead b. 0.18 m/s^2 toward plastic bead
31. 82 nC
33. 3.1×10^{-4} N, upward
35. 4.3×10^{-3} N, 253° ccw
37. 2.0×10^{-4} N, 45° cw
39. $-1.0 \times 10^{-3}\hat{i}$ N
41. $(1.02 \times 10^{-5}\hat{i} + 2.2 \times 10^{-5}\hat{j})$ N
43. 0.68 nC
45. $(F_{\text{net}})_x = \frac{-2KQqa}{(a^2 + y^2)^{3/2}}$
47. $(2 - \sqrt{2})\frac{KQq}{L^2}$
49. $-\frac{4}{9}q$, $x = \frac{1}{3}L$
51. 6.6×10^{15} rev/s
53. a. 2.3×10^{-6} b. 4.3×10^{7} N/C, upward
55. 33 nC
57. a. 1.1×10^{18} m/s^2 b. 1.0×10^{-12} N c. 6.3×10^{6} N/C d. 69 nC
59. 0.75 μC
61. 1.8×10^{5} N/C, 60° ccw from the $+x$-axis; 1.8×10^{5} N/C, 60° cw from the $-x$-axis
63. a. (4.0 cm, 1.0 cm) b. (0.0 cm, 2.0 cm) c. (−2.0 cm, −2.0 cm)
65. a. $\vec{E}_1 = (8.5\hat{i} - 2.8\hat{j})$ kN/C, $\vec{E}_2 = 10\,\hat{i}$ kN/C,
    $\vec{E}_3 = (8.5\hat{i} + 2.8\hat{j})$ kN/C c. $27\hat{i}$ kN/C
67. 14°
69. b. 22 nC
71. b. 5.1 nC

73. 0.11 μC
75. 1.7×10^{-4} N

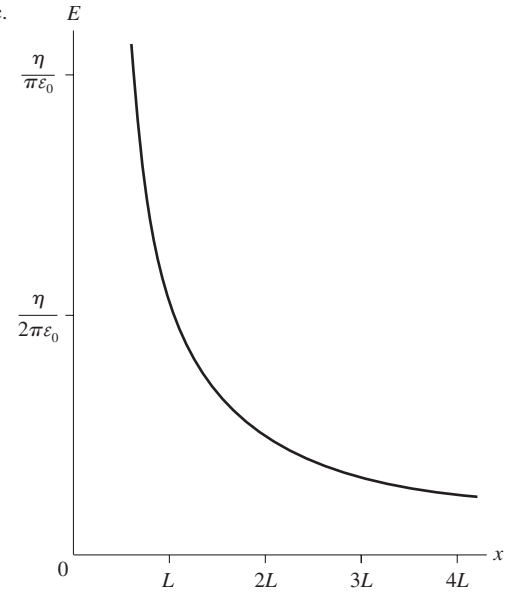
Chapter 26

1. 7.6×10^3 N/C along the $+x$-axis
3. 1.0×10^4 N/C at 11° below the $+x$-axis
5. a. 36 N/C b. 18 N/C
7. 4000 N/C
9. 1.3×10^5 N/C, 0.0 N/C, 1.3×10^5 N/C
11. a. 2.6×10^4 N/C, left b. 2.6×10^{-5} N, right
13. a. 7.6×10^4 N/C, left b. 7.6×10^{-5} N, right
15. 27 nC
17. 1.9 cm
19. 2.7×10^{11}
21. a. 3.6×10^6 N/Cb. 8.3×10^5 m/s
23. 18 cm
25. 3.1×10^{-21} N m
27. 9.0×10^{-13} N$\vec{p}$
29. a. $(-9.7 \times 10^4\hat{\imath} + 9.2 \times 10^4\hat{\jmath})$ N/C
    b. 1.34×10^5 N/C, 136°ccw from the $+x$-axis
31. $\dfrac{1}{4\pi\epsilon_0}\dfrac{Q}{L^2}(\sqrt{2}-1)(\hat{\imath}+\hat{\jmath})$
33. a. $\dfrac{2qx}{4\pi\epsilon_0(x^2+s^2/4)^{3/2}}$
    b. 0 N/C, 768,000 N/C, 576,000 N/C, 358,000 N/C, 158,000 N/C
35. a. $\dfrac{2q}{4\pi\epsilon_0}\left[\dfrac{1}{x^2}-\dfrac{x}{(x^2+d^2)^{3/2}}\right]\hat{\imath}$
37. $\dfrac{1}{4\pi\epsilon_0}\dfrac{8\lambda d}{4y^2+d^2}$
39. −0.056 nC
41. $\dfrac{Q}{4\pi\epsilon_0}\dfrac{1}{x\sqrt{x^2+L^2}}\hat{\imath} - \dfrac{Q}{4\pi\epsilon_0 Lx}\left(1-\dfrac{x}{\sqrt{x^2+L^2}}\right)\hat{\jmath}$
43. a. $\dfrac{R}{\sqrt{2}}$ b. $\dfrac{2}{3\sqrt{3}}\dfrac{Q}{4\pi\epsilon_0 R^2}$
45. c. $\dfrac{1}{4\pi\epsilon_0}\dfrac{2Q}{\pi R^2}(\hat{\imath}+\hat{\jmath})$
47. 1.41×10^5 N/C
49. 2.2 mm
51. 1.19×10^7 m/s
53. a. $\dfrac{\frac{4}{3}\pi r^3\rho g + qE}{6\pi\eta r}$ b. 0.067 mm/s c. 0.049 mm/s
55. 6.56×10^{15} Hz
57. a. $\dfrac{\text{C}^2\,\text{s}^2}{\text{kg}}$ b. $\left(\dfrac{1}{4\pi\epsilon_0}\right)^2\dfrac{2q^2\alpha}{r^5}$, toward ion
59. b. 1.0 mm
61. b. $\dfrac{R}{\sqrt{3}}$
63. 4.2×10^{-4} N
65. a.



    b. $\dfrac{4Q}{L^2}$ c. $\dfrac{8Q}{4\pi\epsilon_0 L^2}\left[1-\dfrac{x}{\sqrt{x^2+L^2/4}}\right]$
67. a. $\dfrac{2\eta}{4\pi\epsilon_0}\ln\left(\dfrac{2x+L}{2x-L}\right)\hat{\imath}$

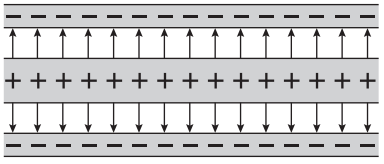
    c.

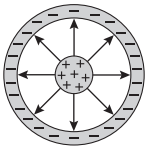


69. −2.3 nC/m
71. a. $k = \dfrac{qQ}{4\pi\epsilon_0 R^3}$ c. 2.0×10^{12} Hz

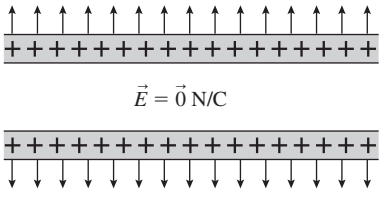
Chapter 27

1.





3.



5. No charge
7. Into the front face of the cube; field strength must exceed 5 N/C
9. 1.0 N m^2/C
11. 1.4×10^3 N/C
13. a. 0.0 N m^2/C b. 3.0×10^{-2} N m^2/C
15. 3.5×10^{-4} N m^2/C
19. $+2q$, $+q$, $-3q$
21. 0.11 kN m^2/C
23. −1.00 N m^2/C
25. 2.7×10^{-5} C/m^2
27. a. $\vec{E} = (25\hat{k})$ kN/C, upward from the plate
    b. 0.0 N/C c. 2.5 kN/C, downward from the plate
29. a. −0.39 N m^2/C, 0.23 N m^2/C, 0.39 N m^2/C, −0.23 N m^2/C b. 0 N m^2/C
31. a. −3.5 N m^2/C b. 1.2 N m^2/C
33. 0.19 kN m^2/C
35. a. 2.0 kN/C b. 0.25 kN m^2/C c. 2.2 nC
37. a. −100 nC b. +50 nC