Answers

Exercise 1.1

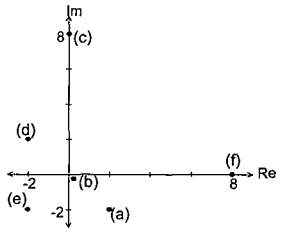
1. (a) $2, \pi/3$ (b) $2, -2\pi/3$ (c) $2, -\pi/6$
   (d) $2\sqrt{2}, 3\pi/4$ (e) $4, \pi/2$ (f) $6, -\pi/2$
2. (a) $\sqrt{5}\ cis(1.107)$ (b) $5\ cis(2.21)$
   (c) $cis\ (0.93)$ (d) $2\ cis\ (\pi/6)$ (e) $4\ cis\ (0)$
   (f) $3cis\ (-\pi/2)$
3. (a) $2i$ (b) $(3\sqrt{2}/2) - (3\sqrt{2}/2)i$
   (c) $-\sqrt{3} + i$ (d) $-3i$ (e) $-1 + i$
   (f) $-(5\sqrt{3}/2) + (5/2)i$
4. (a) $2 - 3i$, $\sqrt{13}\ cis\ (-0.98)$
   (b) $-1 + 4i$, $\sqrt{17}\ cis\ (1.82)$
   (c) $3 + 5i$, $\sqrt{34}\ cis\ (1.03)$
5. (a) $a\sqrt{5}, 2$ (b) $\sqrt{(a^2 + 1)}, -a$
   (c) $\sqrt{(a^2 + 4)}, -2/a$ (d) $(1/a)\sqrt{(a^2 + 1)}, a$

Exercise 1.2

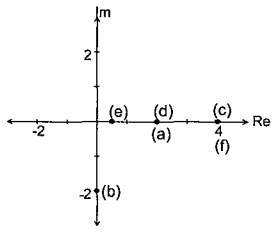
1. (a) $6\ cis\ (7\pi/12)$ (b) $9\ cis\ (-5\pi/6)$
   (c) $20\ cis\ (-7\pi/12)$ (d) $10\ cis\ (5\pi/6)$
   (e) $32\ cis\ (-3\pi/4)$ (f) $81\ cis\ (-2\pi/3)$
   (g) $(1/81)\ cis(2\pi/3)$ (h) $(1/64)\ cis(\pi/2)$
2. (a) $2\ cis\ (\pi/12)$ (b) $2\ cis\ (-\pi/12)$
   (c) $2\ cis\ (-5\pi/6)$ (d) $cis\ (\pi/2)$
   (e) $cis\ (2\pi/3)$ (f) $(1/3)\ cis\ (-\pi/2)$
   (g) $32\ cis\ (\pi/2)$ (h) $80\ cis\ (\pi)$
3. (a) $1 - \sqrt{3}i$, $(1/4) - (\sqrt{3}/4)i$
   (b) $(3\sqrt{2}/2) + (3\sqrt{2}/2)i$, $(\sqrt{2}/6) + (\sqrt{2}/6)i$
   (c) $-2\sqrt{2} - 2\sqrt{2}i$, $(-\sqrt{2}/8) - (\sqrt{2}/8)i$
   (d) $(5/2)(-\sqrt{3} + i)$, $(-\sqrt{3}/10) + (1/10)i$
   (e) $2, 1/2$ (f) $(1/2)i, 2i$
4. (a) $8\ cis\ (-\pi/2), -8i$
   (b) $4\sqrt{2}\ cis\ (3\pi/4), -4 + 4i$
   (c) $32\ cis\ (-\pi/3), 16 - 16\sqrt{3}i$
   (d) $64\ cis\ (\pi), -64$
   (e) $(1/64)\ cis\ (0), 1/64$
   (f) $(1/64)\ cis\ (\pi), -1/64$
   (g) $(1/32)\ cis\ (5\pi/6), -(\sqrt{3})/64 + i/64$
   (h) $(1/16)\ cis\ (2\pi/3), -1/32 + (i\sqrt{3})/32$
5. (a) $4\sqrt{2}cis(-\pi/4), 4 - 4i$
   (b) $4\ cis\ (\pi), -4$
   (c) $2\ cis\ (2\pi/3), -1 + \sqrt{3}i$
   (d) $27\ cis\ (\pi/2), 27i$
   (e) $(1/2)\ cis\ (-\pi/2), (-1/2)i$
   (f) $(4/9)\ cis\ (-5\pi/6), (2\sqrt{3}/9) - (2/9)i$
   (g) $(ab/9)\ cis\ (-\pi/4); (ab\sqrt{2})/18 - [(ab\sqrt{2})/18]i$
   (h) $|a/(5b)|\ cis\ (3\pi/4);$
   $(-|a|\sqrt{2})/(10|b|) + [(|a|\sqrt{2})/(10|b|)]i$
6. (a) $(2\sqrt{3}/3)\ cis\ (\pi/6), 1 + (\sqrt{3}/3)i$
   (b) $(16/9)\ cis\ (-5\pi/6), (-8\sqrt{3}/9) - (8/9)i$
   (c) $(8\sqrt{3}/3)\ cis\ (-5\pi/6), -4 - (i\,4\sqrt{3})/3$
   (d) $(1/16)\ cis(\pi), -1/16$
   (e) $(9\sqrt{3}/2)\ cis\ (\pi/6), (27/4) + (9\sqrt{3}/4)i$
6. (f) $(9\sqrt{3}/2)\ cis\ (2\pi/3), (-9\sqrt{3}/4) + (27/4)i$
   (g) $(1024/27)\ cis\ (0), 1024/27$
   (h) $(1024/27)^k\ cis\ (0), (1024/27)^k$
7. (a) $\overline{w} = a\ \text{cis}\ (-\alpha)$, $\overline{z} = b\ \text{cis}\ (-\beta)$

Exercise 1.3

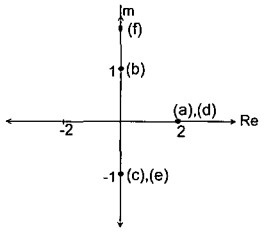
1.



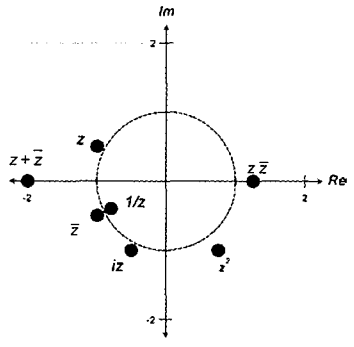
2.



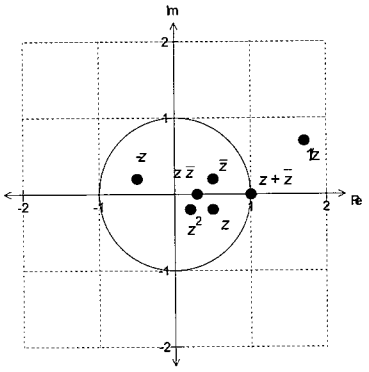
3.



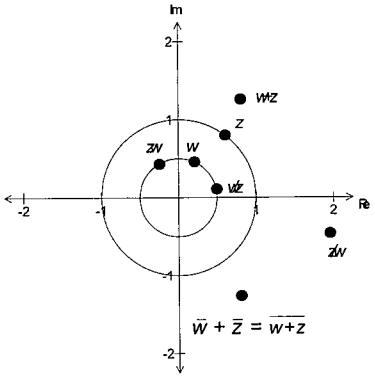
4. (a) $r\ cis\ (\theta - \pi)$ (b) $r\ cis\ (-\theta)$
   (c) $r\ cis\ (\theta - \pi/2)$ (d) $r^2\ cis\ (2\theta)$
   (e) r^2 (f) $2r\cos\theta$
   (g) $(1/r)\ cis\ (-\theta)$ (h) $(1/r)\ cis\ (\pi/2 - \theta)$
   (i) $r\ cis\ (\pi/2 - \theta)$ (j) $r^2\ cis\ (2\theta - \pi)$
   (k) $1/r^2$ (l) $2r\sin\theta\ cis\ (\pi/2)$
5.



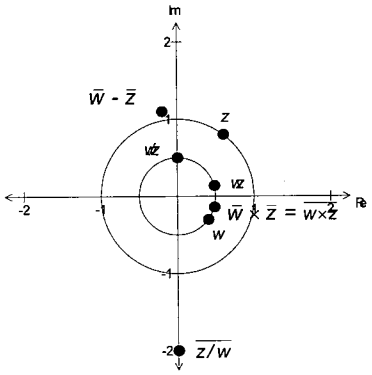
6.



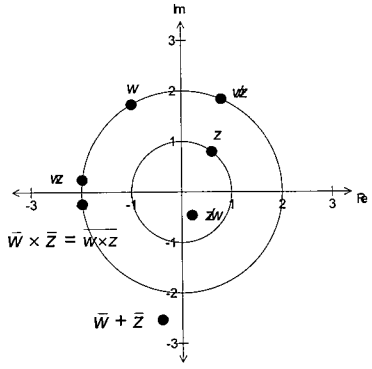
7.



8.

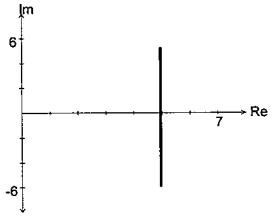


9.

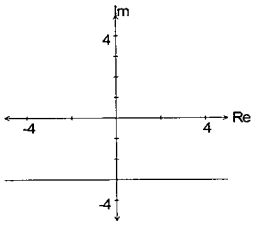


Exercise 1.4

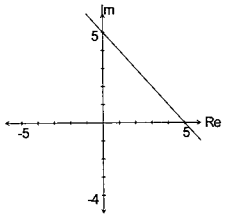
1. (a)



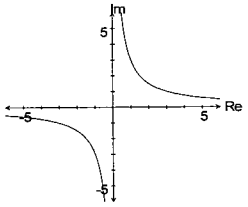
(b)



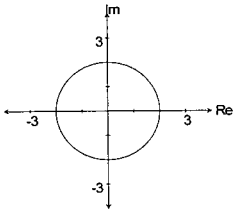
(c)



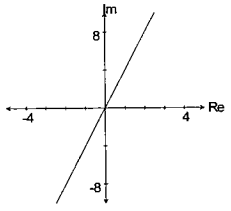
(d)



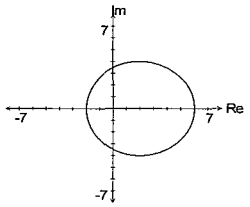
(e)



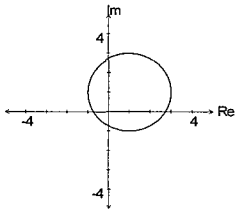
(f)



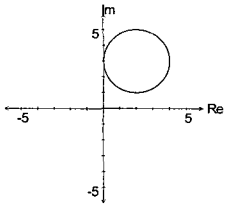
1. (g)



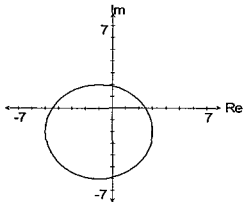
(h)



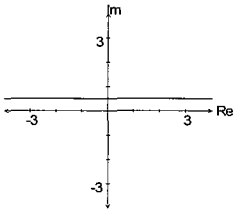
(i)



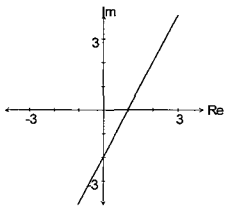
(j)



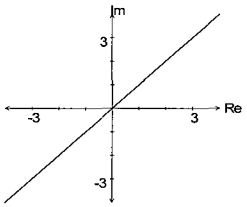
(k)



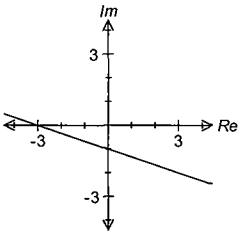
(l)



1. (m)

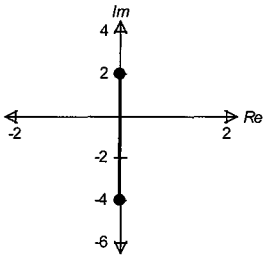


(n)

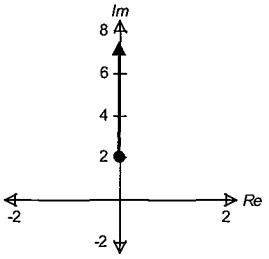


2. (a) $x = 5$ (b) $y = -3$ (c) $x + y = 5$
   (d) $xy = 3$ (e) $x^2 + y^2 = 4$ (f) $y = 4x$
   (g) $(x-2)^2 + y^2 = 16$
   (h) $(x-1)^2 + (y-1)^2 = 4$
   (i) $(x-2)^2 + (y-3)^2 = 4$
   (j) $(x+1)^2 + (y+2)^2 = 16$
   (k) $y = 1/2$ (l) $y = x-2$
   (m) $y = x$ (n) $y = (-x/3) - 1$

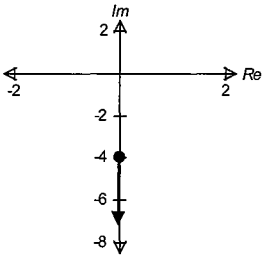
3. (a)



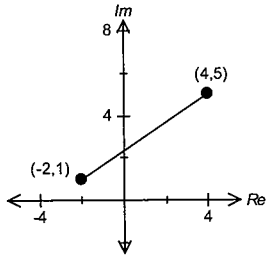
(b)



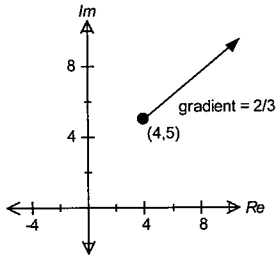
(c)



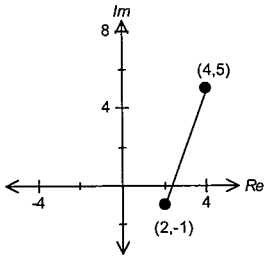
4. (a)



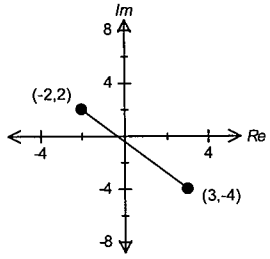
(b)



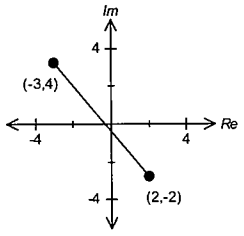
(c)



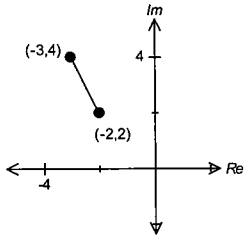
5. (a)



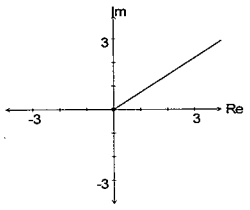
(b)



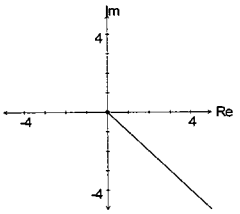
(c)



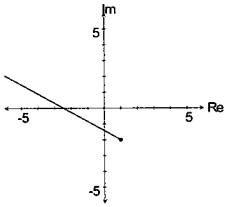
6. (a)



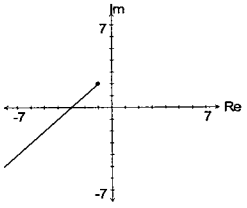
(b)



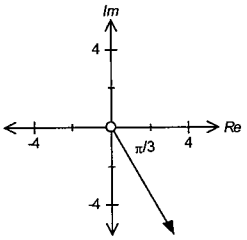
(c)



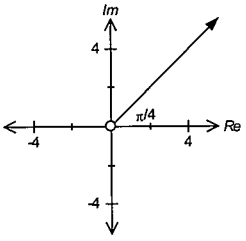
(d)



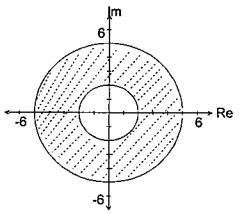
(e)



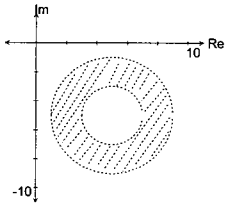
(f)



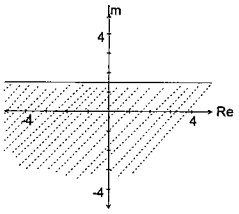
7. (a)



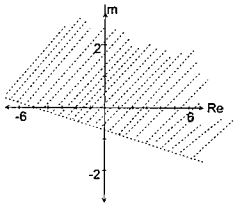
(b)



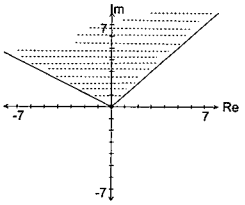
(c)



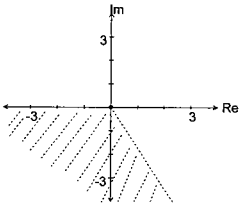
(d)



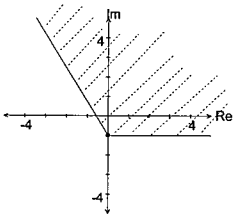
(e)



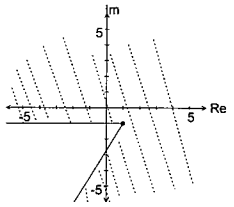
(f)



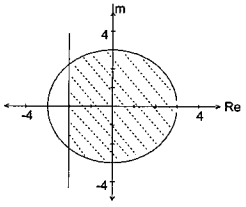
(g)



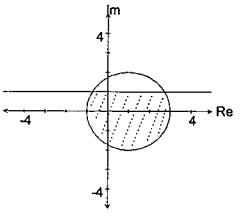
7. (h)



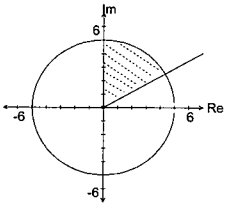
8. (a)



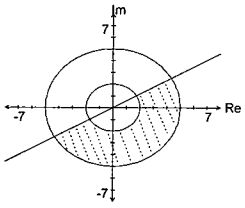
(b)



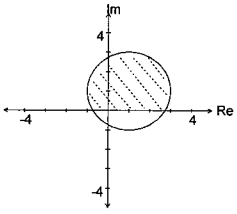
(c)



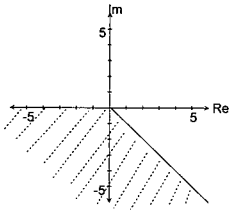
(d)



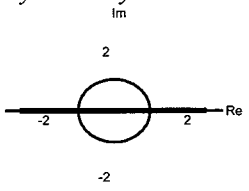
(e)



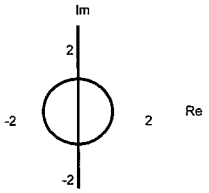
(f)



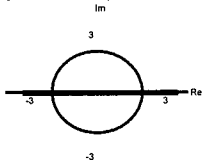
9. (a) $x^2 + y^2 = 1$ or $y = 0$



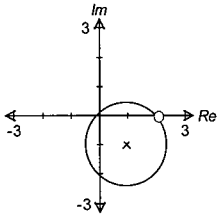
(b) $x^2 + y^2 = 1$ or $x = 0$



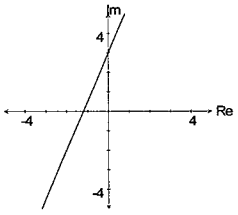
(c) $x^2 + y^2 = 4$ or $y = 0$



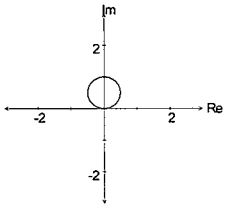
(d) $(x-1)^2 + (y+1)^2 = 2$ except the point (2,0)



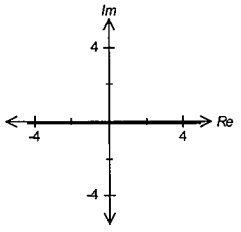
(e) $5x - 2y + 6 = 0$



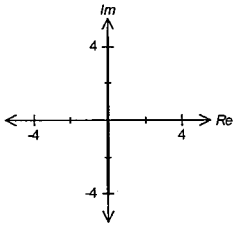
(f) $x^2 + (y - 1/2)^2 = 1/4$



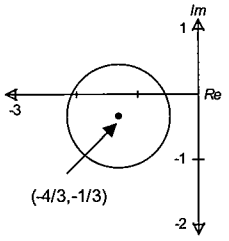
(g) $y = 0$



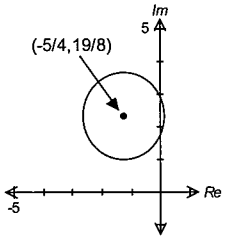
9. (h) $x = 0$



(i) $(x + 4/3)^2 + (y + 1/3)^2 = (2\sqrt{2}/3)^2$



(j) $(x + 5/4)^2 + (y - 19/8)^2 = 117/64$



10. (a) min $\sqrt{2} - 1$, max $\sqrt{2} + 1$
    (b) min $-\pi/2$ rad, max 0 rad
11. (a) $0 < |z| \le 10$
    (b) $-0.64 < \arg(z) \le 2.50$ rad
12. (a) $0 < |z| \le \sqrt{2}$
    (b) $0 < \arg(z) \le \pi/4$
13. (a) min 1, max $2 + \sqrt{2}$
    (b) min -1.25 rad, max $\pi/4$ rad
14. (a) $|z - 5| = |z - 5i|$
    (b) $|z - (1 + i)| \le 1$
    (c) $-\pi/4 \le \arg(z) \le \pi/4$
    (d) $|z - 2| \le 3$ and $|z - 6| \le 3$
    (e) $|z - (-3+2i)| + |z - (7+2i)| = |(7+2i) - (-3+2i)|$
    (f) $|z - (2 + 2i)| \le 8$ and $\pi/4 \le \arg(z) \le \pi/2$

Exercise 2.1

1. (a) *cis* $(\pi/3)$, *cis* (π), *cis* $(-\pi/3)$
   (b) 2 *cis* $(\pi/3)$, 2 *cis* (π), 2 *cis* $(-\pi/3)$
   (c) $\sqrt{2}$ *cis* $(\pi/4)$, $\sqrt{2}$ *cis* $(3\pi/4)$, $\sqrt{2}$ *cis* $(-3\pi/4)$, $\sqrt{2}$ *cis* $(-\pi/4)$
   (d) *cis* (0), *cis* $(2\pi/5)$, *cis* $(4\pi/5)$, *cis* $(-4\pi/5)$ *cis* $(-2\pi/5)$
   (e) 2 *cis* (0), 2 *cis* $(2\pi/5)$, 2 *cis* $(4\pi/5)$, 2 *cis*$(-4\pi/5)$, 2 *cis* $(-2\pi/5)$
   (f) 2 *cis* (0), 2 *cis* $(\pi/3)$, 2 *cis* $(2\pi/3)$, 2 *cis* (π), 2 *cis* $(-2\pi/3)$, 2 *cis* $(-\pi/3)$
2. (a) $0.9239 + 0.3827i$, $-0.9239 - 0.3827i$, $-0.3827 + 0.9239i$, $0.3827 - 0.9239i$
   (b) $\pm 0.9511 - 0.3090i$, $\pm 0.5878 + 0.8090i$, $-i$
   (c) $1.0696 + 0.2127i$, $-1.0696 - 0.2127i$ $-0.2127 + 1.0696i$, $0.2127 - 1.0696i$

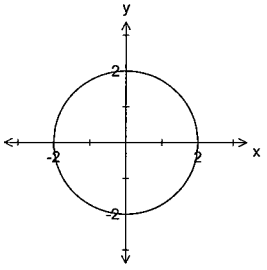
2. (d) $1.1236 + 0.2388i$, $0.1201 + 1.1424i$, $-1.0494 + 0.4672i$, $-0.7686 - 0.8536i$ $0.5743 - 0.9948i$
   (e) $1.0548 - 0.3839i$, $0.8599 + 0.7215i$, $-0.1949 + 1.1054i$, $-1.0548 + 0.3839i$, $-0.8599 - 0.7215i$, $0.1949 - 1.1054i$
   (f) -1.5, $0.75 \pm 1.2990i$
4. ± 1, $(\pm 0.5 \pm 0.8660i)$
5. $w = (-1/2) + (\sqrt{3}/2)i$, $w^2 = (-1/2) - (\sqrt{3}/2)i$, $w^3 = 1$; $z^3 = 1$
6. $3\ cis\ (\pi)$, $3\ cis\ (3\pi/5)$, $3\ cis\ (-3\pi/5)$, $3\ cis\ (\pi/5)$, $3\ cis\ (-\pi/5)$; $z^5 = -243$
7. $2\ cis\ (\pi/3)$, $2\ cis\ (2\pi/3)$, $2\ cis\ (\pi)$, $2\ cis\ (-2\pi/3)$, $2\ cis\ (-\pi/3)$, $2\ cis\ (0)$; $z^6 = 64$
8. $\sqrt{2}\ cis\ (-\pi/4)$, $\sqrt{2}\ cis\ (0)$, $\sqrt{2}\ cis\ (\pi/4)$, $\sqrt{2}\ cis\ (\pi/2)$, $\sqrt{2}\ cis\ (3\pi/4)$, $\sqrt{2}\ cis\ (\pi)$, $\sqrt{2}\ cis\ (-\pi/2)$, $\sqrt{2}\ cis\ (-3\pi/4)$; $z^8 = 16$
9. $n = 5$; $cis\ (\pm\pi/5)$, $cis\ (\pm 3\pi/5)$, $cis\ (\pi)$
10. (a) $-1/2 \pm (\sqrt{3}/2)i$, 1
    (b) $\pm i$, $\pm 2i$, ± 1
    (c) $-1/2 \pm (\sqrt{3}/2)i$, $\pm(\sqrt{3})/2 - (1/2)i$, i
    (d) $\pm(\sqrt{3}/2) + (1/2)i$, $\pm\sqrt{3} - i$, $-i$, $2i$

Exercise 2.2

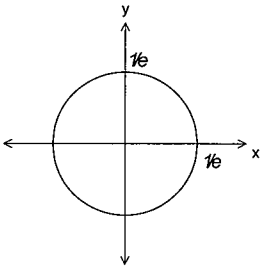
3. $\sin(\pi/6)$ *repeated*, $\sin(3\pi/2)$
4. $\cos(\pi/9)$, $\cos(5\pi/9)$, $\cos(7\pi/9)$
5. $\cos(6\theta) = 32\cos^6(\theta) - 48\cos^4(\theta) + 18\cos^2(\theta) - 1$
   (a) $\cos(\pi/12)$, $\cos(\pi/4)$, $\cos(5\pi/12)$, $\cos(7\pi/12)$, $\cos(3\pi/4)$, $\cos(11\pi/12)$
   (b) $\cos^2(\pi/12)$, $\cos^2(\pi/4)$, $\cos^2(5\pi/12)$
6. (a) $\cos(5\theta) = 16\cos^5(\theta) - 20\cos^3(\theta) + 5\cos(\theta)$
   (b) $a = 16$, $b = -4$, $c = -4$, $d = 1$
   (c) $\cos(2\pi/5)$ *repeated*, $\cos(4\pi/5)$ *repeated*

Exercise 2.3

1. (a) $2e^{i\pi}$ (b) $5e^{i3\pi/4}$
   (c) $3e^{-i\pi/6}$ (d) $\sqrt{2}e^{-i2\pi/3}$
2. (a) e^0 (b) $e^{i\pi/2}$ (c) $2e^{i\pi/3}$
   (d) $2\sqrt{2}e^{-i3\pi/4}$ (e) $2\sqrt{3}e^{-i\pi/6}$
3. (a) $cis(\pi/6)$ (b) $cis(-5\pi/6)$
   (c) $e\ cis(-\pi/4)$ (d) $(1/e^2)\ cis(\pi/3)$
4. (a) $(-1/2) + i(\sqrt{3})/2$
   (b) $(-\sqrt{2})/2) + i(\sqrt{2})/2$
   (c) $1/(2e) - i(\sqrt{3})/(2e)$
   (d) $(-e^2\sqrt{3})/2 + i(e^2)/2$
5. (a) $4e^{-i\pi/3}$ (b) $2\sqrt{2}e^{i7\pi/12}$
   (c) $\sqrt{2}e^{-i3\pi/4}$ (d) $2e^{i\pi/6}$
5. (e) 2 (f) $2e^{i\pi/2}$
   (g) $2\sqrt{2}e^{-i7\pi/12}$ (h) $2\sqrt{2}e^{-i7\pi/12}$
6. (a) $12e^{i2\pi/3}$ (b) $12e^{i2\pi/3}$
   (c) $\frac{\sqrt{2}}{4}e^{i\pi/4}$ (d) $\frac{\sqrt{2}}{4}e^{i\pi/4}$
   (e) $\sqrt{\frac{3}{2}}e^{i7\pi/12}$ (f) $\sqrt{\frac{3}{2}}e^{i7\pi/12}$
7. (a) $\frac{\sqrt{2}}{2}cis(\frac{\pi}{6})$ (b) $2\sqrt{2}\,cis(\frac{5\pi}{6})$
   (c) $\frac{\sqrt{2}}{2}cis(-\frac{\pi}{6})$ (d) $\frac{\sqrt{2}}{2}cis(-\frac{\pi}{6})$
   (e) $2\sqrt{2}\,cis(-\frac{5\pi}{6})$ (f) $2\sqrt{2}\,cis(\frac{5\pi}{6})$
12. (a) $x = 0, y = \pi$ (b) $x = \ln 2, y = \pi$
    (c) $x = \ln 2, y = 0$ (d) $x = 0, y = \pi/2$
    (e) $x = \ln\sqrt{2}, y = \pi/4$
13. (a) $a = 0, b = \pi$ (b) $a = \ln 2, b = \pi$
    (c) $a = \ln 3, b = \pi$
14. $a = \ln k^2, y = \pi$
15. Max Re$(z) = 2$, Min Im$(z) = -2$



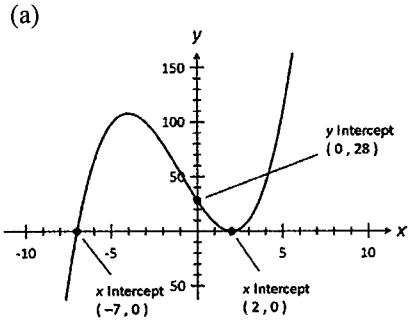
16. Min Re$(z) = -1/e$, Max Im$(z) = 1/e$



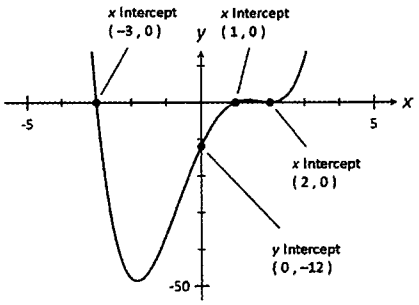
Exercise 3.1

1. $a = 6, b = -4$ 2. $k = -1$
3. $a = 2, b = 0, c = 5$ 4. $a = -3, b = 0, c = 7$
5. (a) $(x + 1)(x + 2)(x + 3)(x + 4)$
   (b) $(x + 1)^2(x + 2)^2$
   (c) $(x - 1)^2(x - 2)(x + 3)$
   (d) $(x + 1)(x - 2)(2x - 1)(2x + 1)$
   (e) $(x - 1)(2x + 1)(x^2 + 1)$
   (f) $(x - 1)(x - 2)(x^2 + 4)$

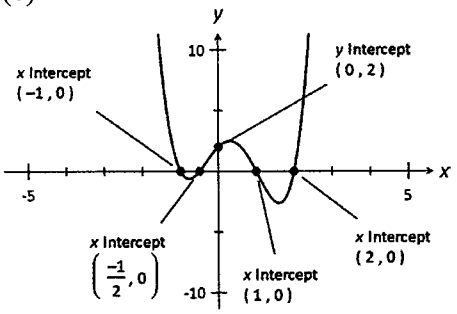
6. $(x^3 + 3)(x - 2)(x - 1)(x + 1)$
7. (a)



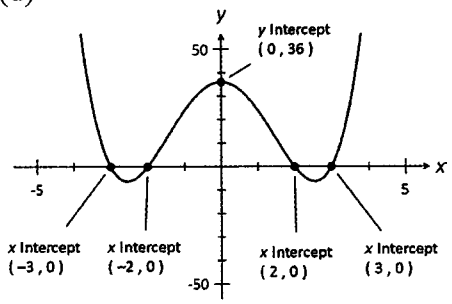
(b)



(c)



(d)



8. (a) $-1, -2$ (b) $-1, 1$
   (c) $-1, 0, 1, 1/3, 2$ (d) $-1, -1/3, 1/2, 0, 1$
   (e) $\pm 2, 1 \pm \sqrt{2}$ (f) $-1, 2$
9. $-1, 2/3, 1/2$
   (a) $-1/2, 1/3, 1/4$ (b) $\pm\sqrt{(2/3)}, \pm\sqrt{(1/2)}$
   (c) $-2/3, -1/2, 1$ (d) $-1, 3/2, 2$
10. $-3, -1/2, 2$
    (a) $-2, 1/2, 3$ (b) $\pm\sqrt{2}$
    (c) $-2, -1/3, 1/2$ (d) $-1/2, 1/3, 2$

Exercise 3.2

1. (a) $(x^2 - 2x + 8), -23$; $x, 8x - 7$
   (b) $3x^2/2 - 7x/4 - 39/8, 57/8; 3x - 2, -16x + 16$
1. (c) $-2x^2 + 4x - 7/2, 17/2; -2x + 4, -9x + 9$
   (d) $6x^3 + 7x^2 + 16x + 27, 64$
   $6x^2 - 5x + 26, -25x + 114$
   $3x - 4, 3x^2 + 5x + 2$
2. $p = 1, q = 3$ 3. $p = 12/5, q = -24/5$
4. $p = -5, q = 7$ 5. $p = 3, q = 5$
6. $a = 1, b = -5$ 7. $a = -35, b = -23$
8. $a = 1, b = -2$
9. $p = 9, q = -2, r = -11$
10. $p = -8, q = 3, r = 9$
11. $a = 3, b = 4$
12. $a = 6, b = -7$
13. (b) $a = -3, b = -2$ (c) $5(2x + 3)$
14. $a = 2, b = 1, c = 3$; 103

Exercise 3.3

1. (a) $(z - i)(z + i)(z + 2)$
   (b) $(z - 2i)(z + 2i)(z + 2)$
   (c) $(2z + i)(2z - i)(z - 1)$
   (d) $(z - (1 - i))(z - (1 + i))(z + 4)$
2. $a = -4, b = 16$; $(z - 4i)(z + 4i)(z - 4)$
3. $a = -2, b = 4$; $(z - 1 - i)(z - 1 + i)(z + 2)$
4. $a = 6, b = -15$; $1 \pm 2i, \pm\sqrt{3}$
5. $a = 16, b = 4$; $-2 \pm i, \pm i/2$
6. $a = 9, b = 2$; $-1 \pm \sqrt{2}i, \pm i/3$
7. (a) $\pm 1, \pm i\sqrt{2}$ (b) $-1, 2, -1 \pm i$
   (c) $-1, 3, 1 \pm i\sqrt{2}$ (d) $\pm 2i, 2 \pm i$
8. (a) $1, \pm(\sqrt{2})/2 \pm i(\sqrt{2})/2$
   (b) $\pm 1, \pm(\sqrt{2})/2 \pm i(\sqrt{2})/2$
   (c) $\pm 1, \pm 1/2 \pm i(\sqrt{3})/2$
   (d) $\pm 1, \pm 1/2 \pm i(\sqrt{3})/2$
9. $a = 6, b = 0, c = 1$ 10. $a = 4, b = 4, c = 4$

Exercise 4.1

1. (a) Not an onto function.
   (b) Not an onto function.
   (c) Not an onto function.
   (d) Is an onto function.
2. (a) Many to one function.
   (b) Many to one function.
   (c) One to one function.
3. (a) One to one function.
   (b) Many to one function.
   (c) One to one function.
   (d) Many to one function.
   (e) One to one function.
   (f) Many to one function.
   (g) One to one function.
   (h) Many to one function.
   (i) Many to one function.
   (j) Many to one function.
4. (a) $(-\infty, 3/2]$ or $[3/2, \infty)$
   (b) $(-\infty, -2]$ or $[-2, \infty)$
   (c) $(-\infty, -1)$ or $(-1, \infty)$
   (d) $\mathbb{R}$
   (e) $(-\infty, 2]$ or $[2, \infty)$
   (f) $(-\infty, 5/2]$ or $[5/2, \infty)$

4. (g) $[-7, -2]$ or $[-2, 3]$ (h) $[-2, 2]$ or $[2, 6]$
   (i) $[-2, 0]$ or $[0, 2]$ (j) $(-\infty, 0]$ or $[2, \infty)$
5. (a) $[-\pi/4, \pi/4]$ (b) $[0, 2\pi]$
   (c) $[-3\pi/4, \pi/4]$ (d) $[0, \pi/2]$
   (e) $[-\pi, 0) \cup (0, \pi]$
   (f) $[-\pi/2 - \tan^{-1}(4/3), \pi/2 - \tan^{-1}(4/3)]$

Exercise 4.2

1. (a) Yes (b) No
   (c) Yes (d) No
2. (a) Yes (b) Yes
   (c) Yes (d) Yes
3. (a) Yes (b) No
   (c) Yes (d) No
4. (a) Yes (b) No
   (c) Yes (d) No
5. (a) x^2 (b) $(x-3)^2 + 3$
   (c) $x - 6$ (d) $(x^2 + 3)^2 + 3$
6. (a) $1/x^2$ (b) $1/(x+1)^2 - 1$
   (c) $(x+1)/(x+2)$ (d) $(x^2 - 1)^2 - 1$
7. (a) e^{1+2x} (b) $1 + 2e^x$
   (c) e^{e^x} (c) $3 + 4x$
8. (a) $1 + x$ (b) $1/(2 - x)$
   (c) $(x - 1)/x$ (d) $x/(2x + 1)$
9. (a) Domain for f: $\mathbb{R}$, Range for f: $\mathbb{R}$
   Domain for g: $\mathbb{R} - \{0\}$
   Range for g : $\mathbb{R} - \{0\}$
   (b) $\mathbb{R} - \{5\}$
   (c) $1/(5 - x)$; $\mathbb{R} - \{5\}$, $\mathbb{R} - \{0\}$.
10. (a) Domain for f: $\mathbb{R}$, Range for f: $[-5, \infty)$
    Domain for g: $[-1, \infty)$
    Range for g : $[0, \infty)$
    (b) $[-1, \infty)$
    (c) $x - 4$; $[-1, \infty)$, $[-5, \infty)$
11. $(1, \infty)$; x, $(1, \infty)$, $(1, \infty)$
12. $(-\infty, 1] \cup [1, \infty)$; $1 + |x|$, $(-\infty, -1] \cup [1, \infty)$, $[2, \infty)$
13. (a) $ln(1 + \sin x)$; Not a function.
    (b) $\sin(ln\, x) + 1$; Is a function. $\mathbb{R}^+$, $[0, 2]$
14. (a) 5^{25-x}; Is a function. $(-\infty, 25]$, $\mathbb{R}^+$
    (b) $25 - 5^x$; Not a function.
15. $g(x) = x + 5$ 16. $g(x) = 1/(x - 2)$
17. $g(x) = -1/[2(x + 1)]$ 18. $f(x) = 5 - x$
19. $f(x) = 2x - 3$ 20. $g(x) = (x - 3)^2 + 1$
21. $g(x) = (x - 1)/(3x - 1)$

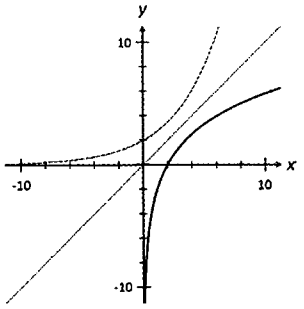
Exercise 4.3

1. (a) Yes; domain $\mathbb{R}^+$, range $\mathbb{R}$
   (b) No, $[-1, \infty)$ or $(-\infty, -1]$;
   domain $\mathbb{R}_0^+$, range $[-1, \infty)$ or $(-\infty, -1]$
   (c) No, $[-1, \infty)$ or $(-\infty, -1]$;
   domain $(-\infty, 1]$, range $[-1, \infty)$ or $(-\infty, -1]$
   (d) Yes; domain $[0, \infty)$ range $[1, \infty)$
2. (a) Yes (b) No
   (c) No (d) Yes
   (e) Yes (f) Yes
   (g) Yes (h) Yes
   (i) No (j) No
3. (a) $(x - 3)/2$ (b) $-(4 + x)/5$
   (c) $4 \pm \sqrt{x}$ (d) $2 \pm \sqrt{(1 - x)}$
   (e) $(-5 \pm \sqrt{x})/2$ (f) $x^{1/3}$
   (g) $[ln(x) - 1]/2$ (h) $(e^x - 1)/2$
   (i) $(x - 1)/x$ (j) $(1 - x)/(x + 1)$
   (k) $x^2 - 1$ (l) $(1 + x^2)/x^2$
4. (a) $x \geq -4$ or $x \leq -4$;
   $f^{-1}(x) = -4 + \sqrt{x}$, domain $x \geq 0$, range $y \geq -4$;
   $f^{-1}(x) = -4 - \sqrt{x}$, domain $x \geq 0$, range $y \leq -4$
   (b) $x \geq 2$ or $x \leq 2$;
   $f^{-1}(x) = 2 + \sqrt{(x - 1)}$, domain $x \geq 1$, range $y \geq 2$
   $f^{-1}(x) = 2 - \sqrt{(x - 1)}$, domain $x \geq 1$, range $y \leq 2$
   (c) $x \geq 0$ or $x \leq 0$;
   $f^{-1}(x) = \sqrt{(x + 1)}$, domain $x \geq -1$, range $y \geq 0$
   $f^{-1}(x) = -\sqrt{(x + 1)}$, domain $x \geq -1$, range $y \leq 0$
   (d) $x \geq -1$ or $x \leq -1$;
   $f^{-1}(x) = -1 + \sqrt{(x - 1)}$, domain $x \geq 1$, range $y \geq -1$
   $f^{-1}(x) = -1 - \sqrt{(x - 1)}$, domain $x \geq 1$, range $y \leq -1$
   (e) $x \geq 0$ or $x \leq 0$;
   $f^{-1}(x) = \sqrt{[(1/x) - 1]}$, domain $0 < x \leq 1$, range $y \geq 0$
   $f^{-1}(x) = -1\sqrt{[(1/x) - 1]}$, domain $0 < x \leq 1$, range $y \leq 0$
   (f) $x > 1$ or $x < 1$;
   $f^{-1}(x) = 1 + \sqrt{(1/x)}$, domain $x > 0$, range $y > 1$
   $f^{-1}(x) = 1 - \sqrt{(1/x)}$, domain $x > 0$, range $y < 1$
   (g) $-\pi/2 \leq x \leq \pi/2$;
   $f^{-1}(x) = \sin^{-1} x$, domain $-1 \leq x \leq 1$, range $-\pi/2 \leq y \leq \pi/2$
   (h) $0 \leq x \leq \pi/2$;
   $f^{-1}(x) = (\cos^{-1} x)/2$, domain $-1 \leq x \leq 1$, range $0 \leq y \leq \pi/2$

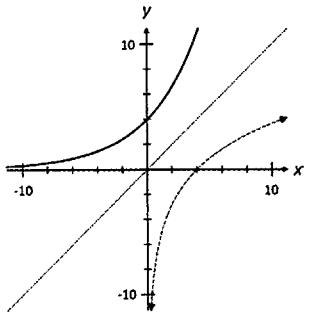
4. (i) $-\pi < x < \pi$;
   $f^{-1}(x) = \tan^{-1} x$, domain $\mathbb{R}$,
   range $-\pi < y < \pi$
5. (a) $\sqrt{(1 - e^{x})}$; $(-\infty, 0]$, $[0, 1)$
   (b) $e^{\sqrt{1-x}}$; $(-\infty, 1]$, $[1, \infty)$
   (c) $ln(1 - x^{2})$; $1 - (ln\, x)^{2}$
6. (a) $(x - 1)/2$; $4 - 1/x$; $(3 - 1/x)/2$
7. (a) $x^{2} - 1$; $1/x - 1$; $1/(x^{2} - 1) - 1$
8. (a) Domain of f: $\mathbb{R}_0^+$. Domain of g: $\mathbb{R}_0^+$.
   (b) Domain of f: $\mathbb{R}_0^+$. Domain of g: $\mathbb{R}_0^+$.
9. (a) Domain of f: $(-\infty, 1]$.
   Domain of g: $\mathbb{R}_0^+$.
   (b) Domain of f: $(-\infty, 1]$.
   Domain of g: $\mathbb{R}_0^+$.
10. Domain of f: $(-1, \infty)$. Domain of g: $(0, \infty)$.

Exercise 5.1

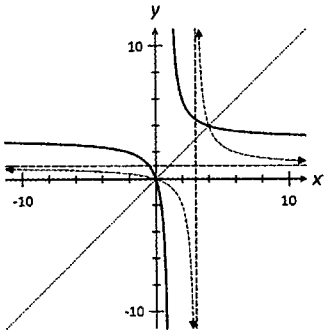
1. (a)



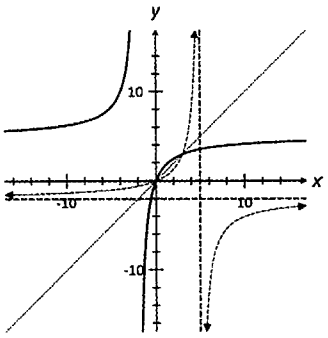
(b)



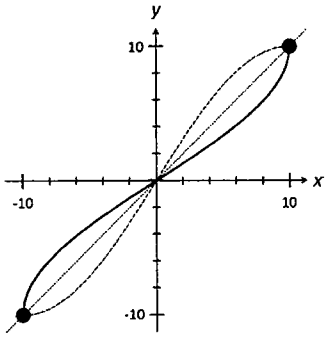
(c)



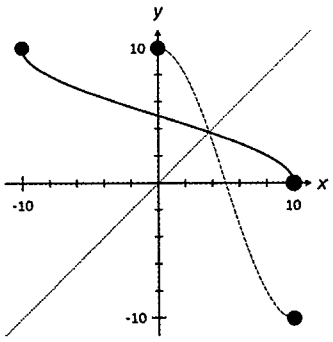
1. (d)



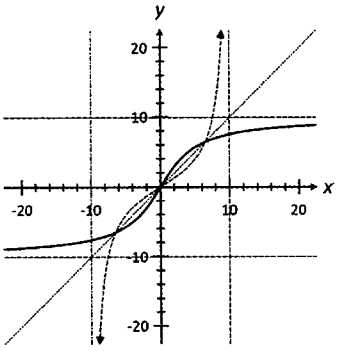
2. (a)



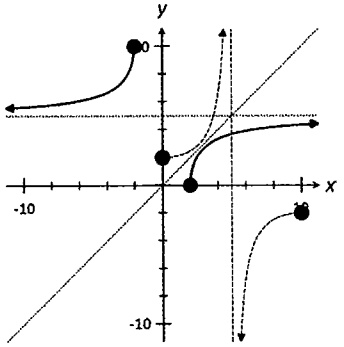
(b)



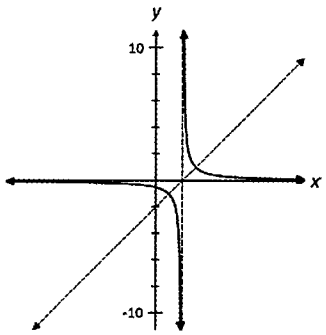
(c)



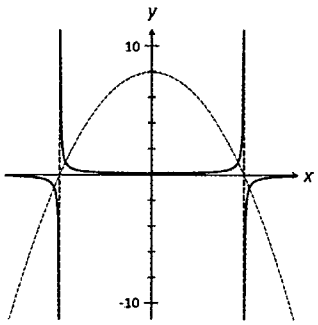
(d)



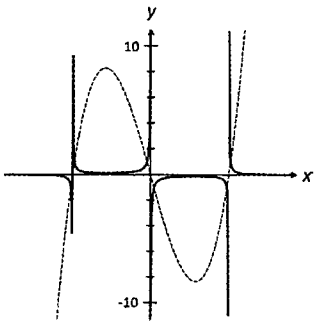
3. (a)



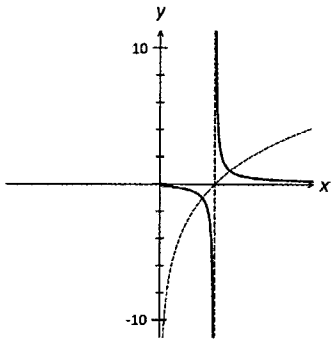
(b)



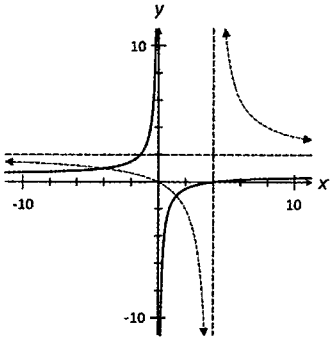
(c)



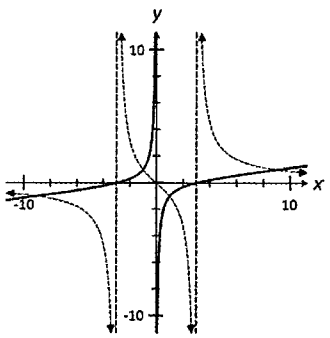
(d)



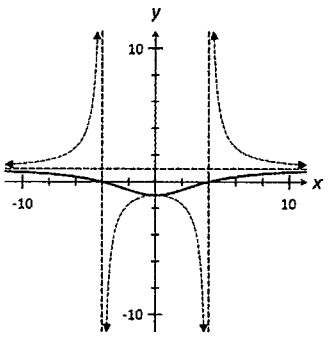
4. (a)



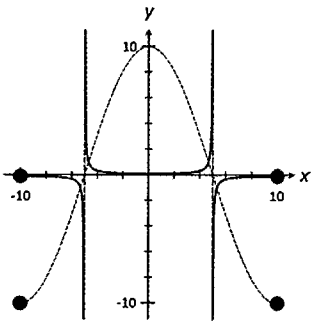
4. (b)



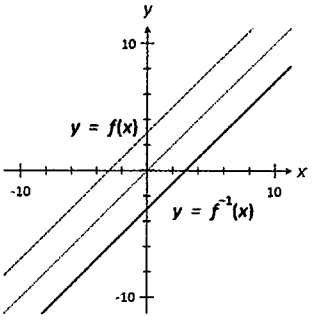
(c)



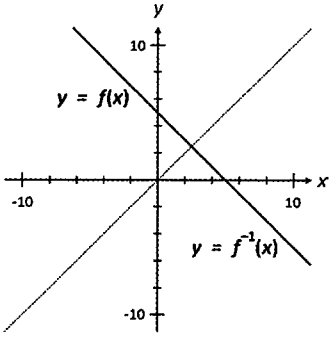
(d)



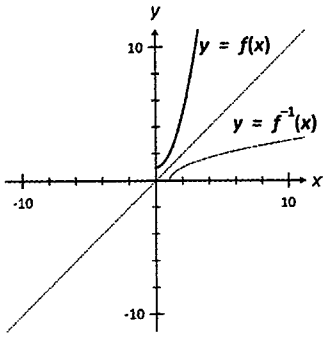
5. (a)



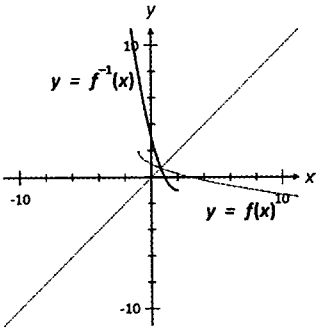
(b)



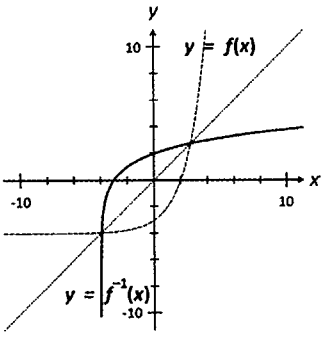
5. (c)



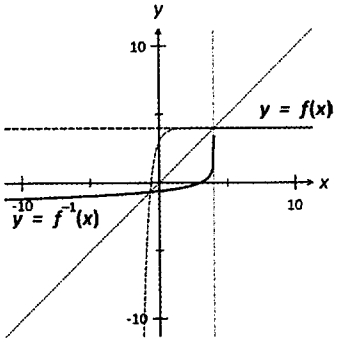
(d)



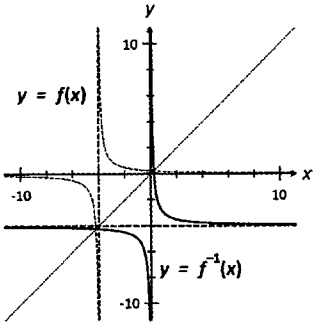
(e)



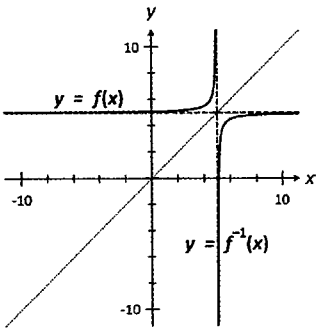
(f)



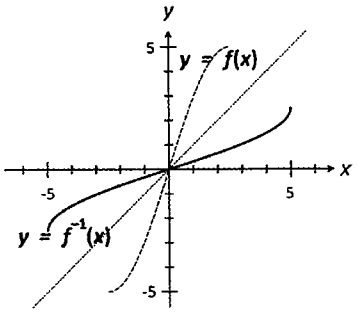
(g)



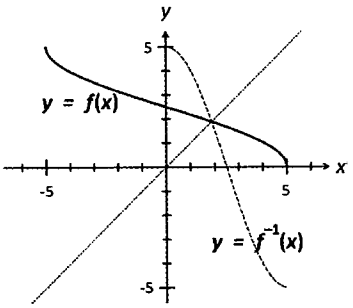
5. (h)



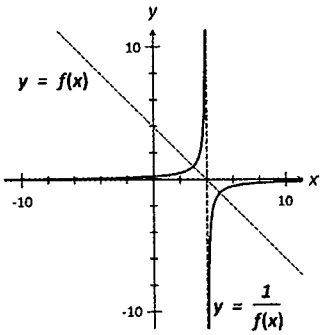
(i)



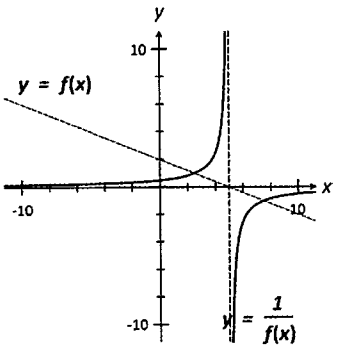
(j)



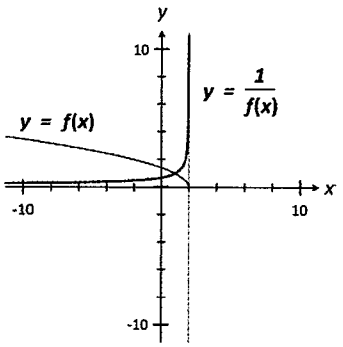
6. (a)



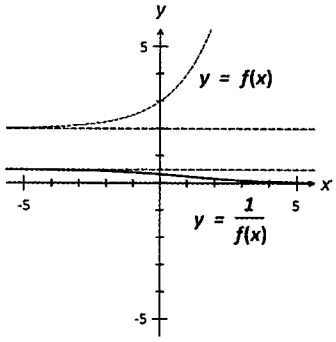
(b)



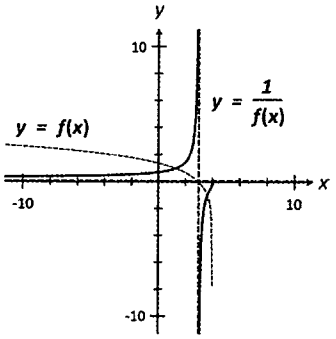
6. (c)



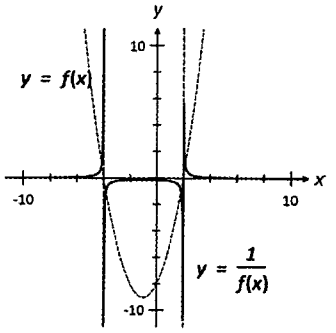
(d)



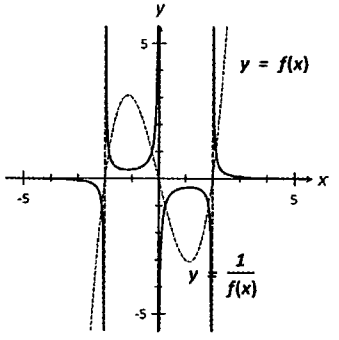
(e)



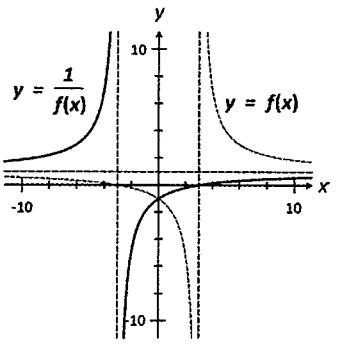
(f)



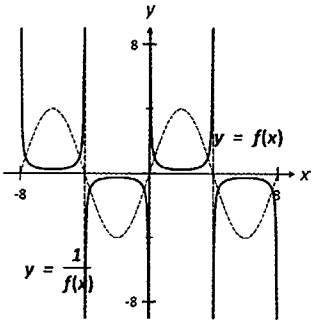
(g)



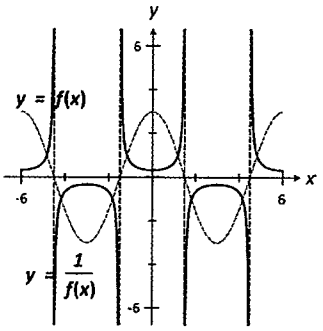
6. (h)



(i)

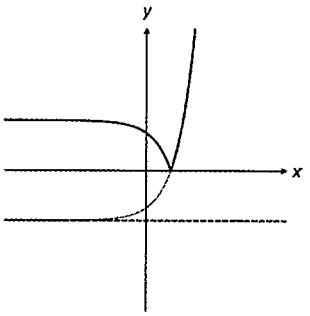


(j)

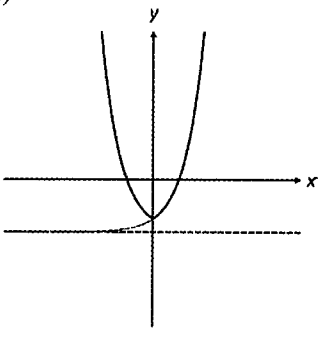


Exercise 5.2

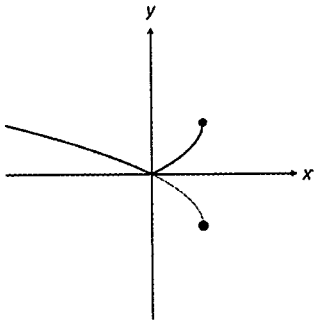
1. (a) (i)



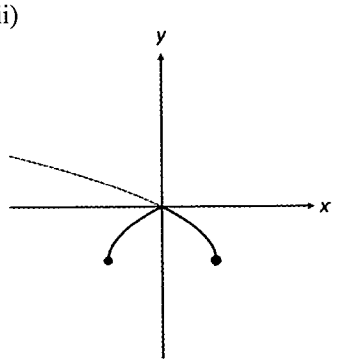
(ii)



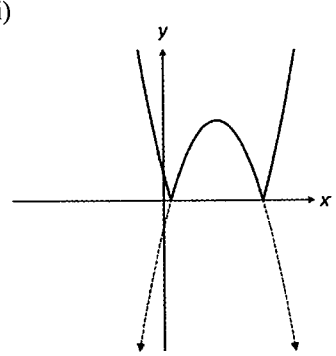
1. (b) (i)



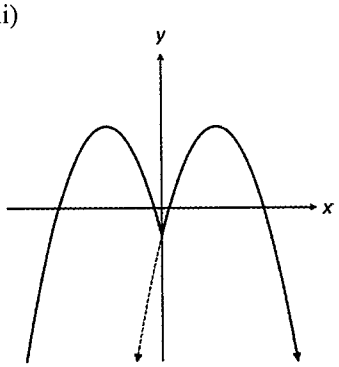
(ii)



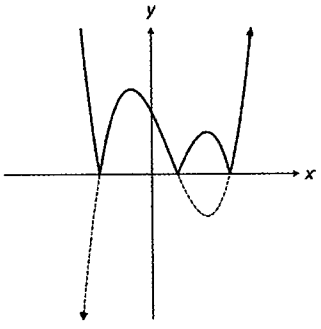
(c) (i)



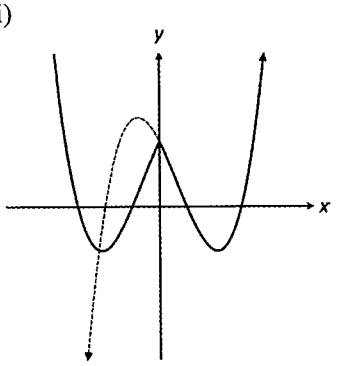
(ii)



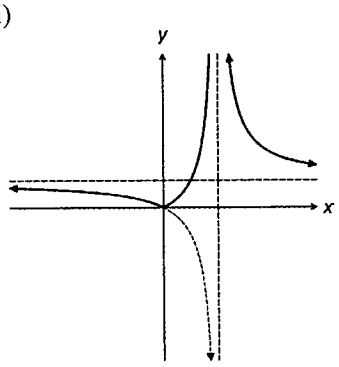
(d) (i)



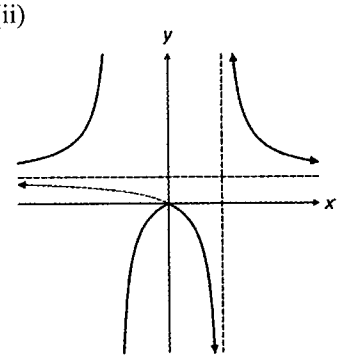
1. (d) (ii)



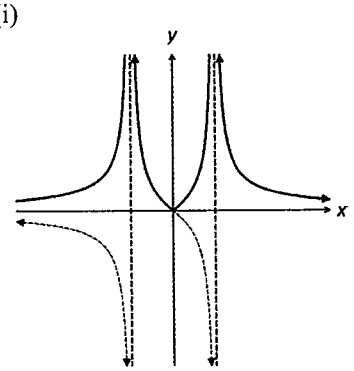
(e) (i)



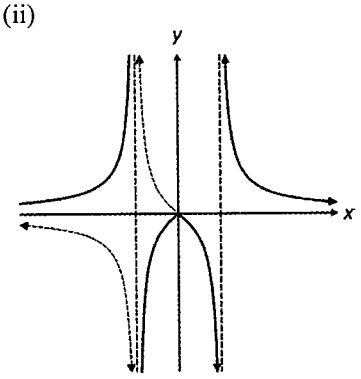
(ii)



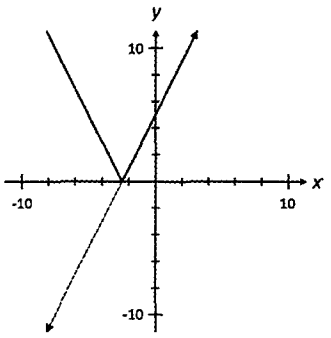
(f) (i)



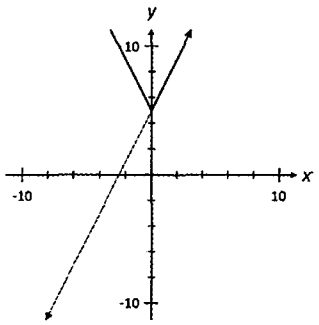
(ii)



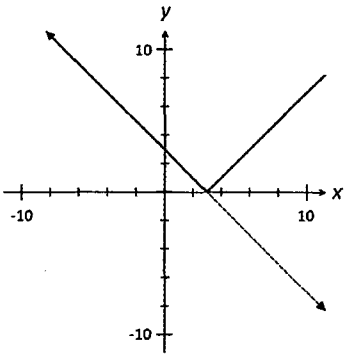
2. (a) (i) $|f(x)| = \begin{cases} -(2x+5) & x < -2.5 \\ 2x+5 & x \geq -2.5 \end{cases}$



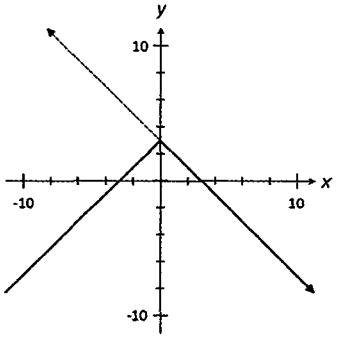
(ii) $f(|x|) = \begin{cases} -2x+5 & x < 0 \\ 2x+5 & x \geq 0 \end{cases}$



(b) (i) $|f(x)| = \begin{cases} 3-x & x < 3 \\ -(3-x) & x \geq 3 \end{cases}$

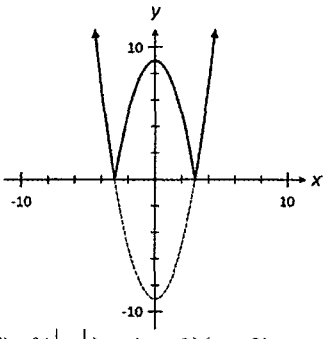


(ii) $f(|x|) = \begin{cases} 3+x & x < 0 \\ 3-x & x \geq 0 \end{cases}$

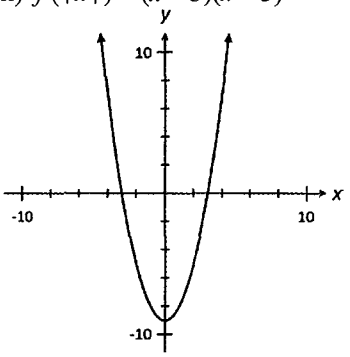


2. (c) (i)

$|f(x)| = \begin{cases} (x+3)(x-3) & x < -3, x > 3 \\ -(x+3)(x-3) & -3 \leq x \leq 3 \end{cases}$

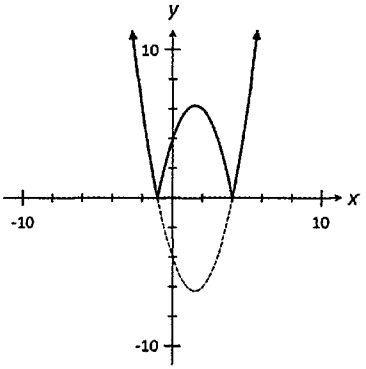


(ii) $f(|x|) = (x+3)(x-3)$

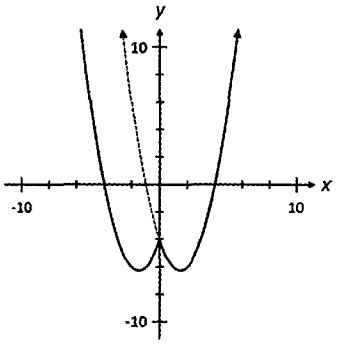


(d) (i)

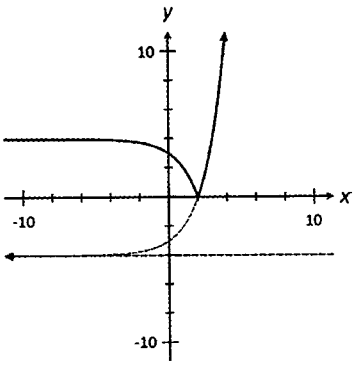
$|f(x)| = \begin{cases} x^2 - 3x - 4 & x < -1, x > 4 \\ -x^2 + 3x + 4 & -1 \leq x \leq 4 \end{cases}$



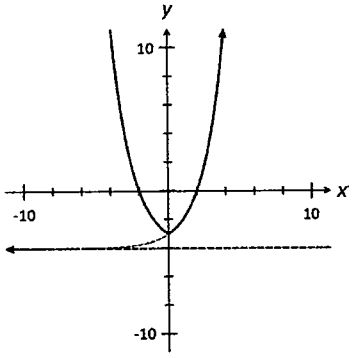
(ii) $f(|x|) = \begin{cases} x^2 + 3x - 4 & x < 0 \\ x^2 - 3x + 4 & x \geq 0 \end{cases}$



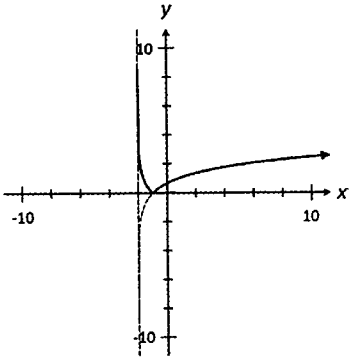
2. (e) (i) $|f(x)| = \begin{cases} 4-2^x & x<2 \\ 2^x-4 & x\geq 2 \end{cases}$



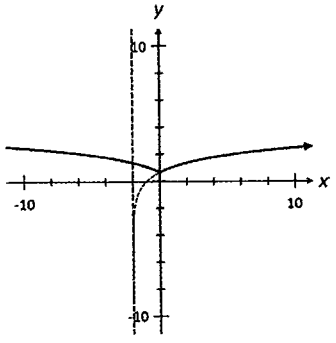
(ii) $f(|x|) = \begin{cases} 2^{-x}-4 & x<0 \\ 2^x-4 & x\geq 0 \end{cases}$



(f) (i) $|f(x)| = \begin{cases} -ln(x+2) & x<-1 \\ ln(x+2) & x\geq -1 \end{cases}$

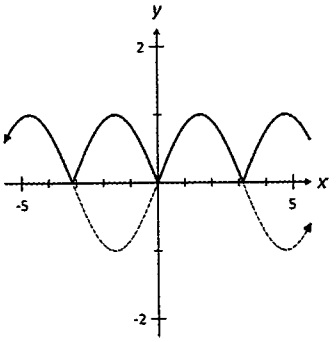


(ii) $f(|x|) = \begin{cases} ln(-x+2) & x<0 \\ ln(x+2) & x\geq 0 \end{cases}$

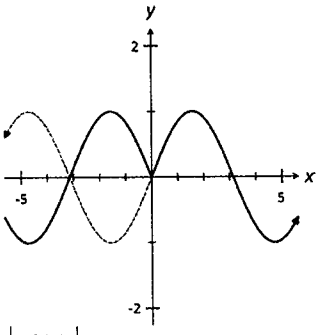


2. (g) (i)

$|f(x)| = \begin{cases} -\sin x & (2n-1)\pi < x < 2n\pi \\ \sin x & 2n\pi \leq x \leq (2n+1)\pi \end{cases}$

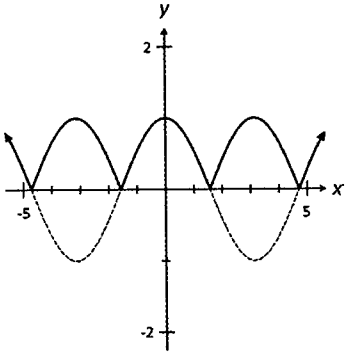


(ii) $f(|x|) = \begin{cases} \sin(-x) & x<0 \\ \sin(x) & x\geq 0 \end{cases}$

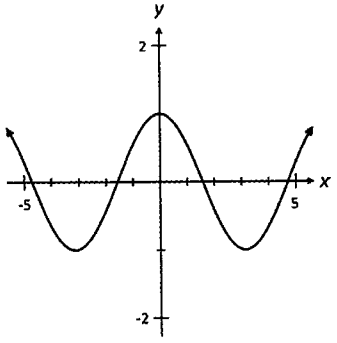


(h) (i) $|f(x)| =$

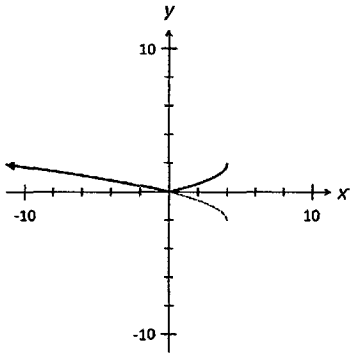
$$\begin{cases} -\cos x & \dfrac{(4n+1)\pi}{2} < x < \dfrac{(4n+3)\pi}{2} \\ \cos x & \dfrac{(4n-1)\pi}{2} \leq x \leq \dfrac{(4n+1)\pi}{2} \end{cases}$$



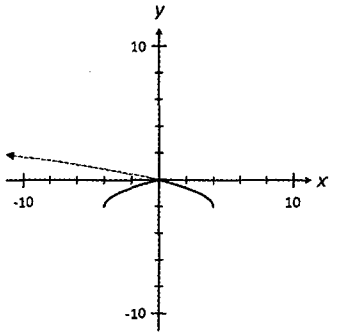
(ii) $f(|x|) = \begin{cases} \cos(-x) & x<0 \\ \cos(x) & x\geq 0 \end{cases}$



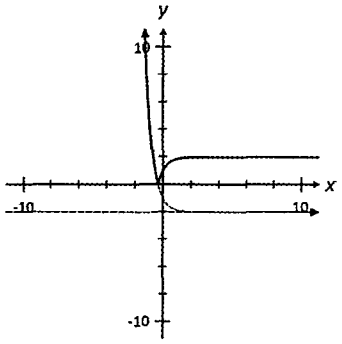
2. (i) (i) $|f(x)| = \begin{cases} \sqrt{4-x}-2 & x<0 \\ 2-\sqrt{4-x} & x \geq 0 \end{cases}$



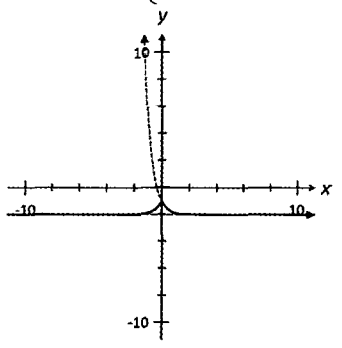
(ii) (i) $f(|x|) = \begin{cases} \sqrt{4+x}-2 & x<0 \\ \sqrt{4-x}-2 & x \geq 0 \end{cases}$



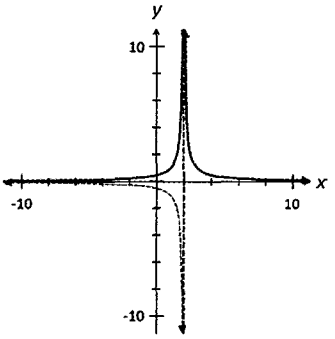
(j) (i) $|f(x)| = \begin{cases} e^{-2x}-2 & x < \dfrac{-ln2}{2} \\ 2-e^{-2x} & x \geq \dfrac{-ln2}{2} \end{cases}$



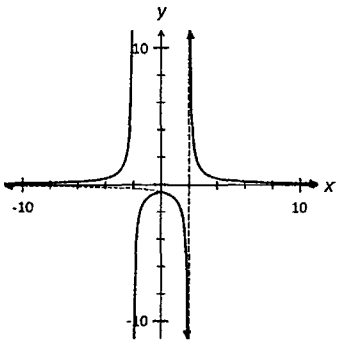
(ii) $f(|x|) = \begin{cases} e^{2x}-2 & x<0 \\ e^{-2x}-2 & x \geq 0 \end{cases}$



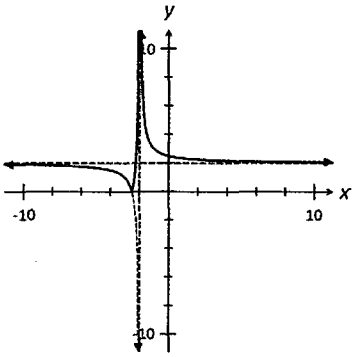
2. (k) (i) $|f(x)| = \begin{cases} -1/(x-2) & x<2 \\ 1/(x-2) & x>2 \end{cases}$



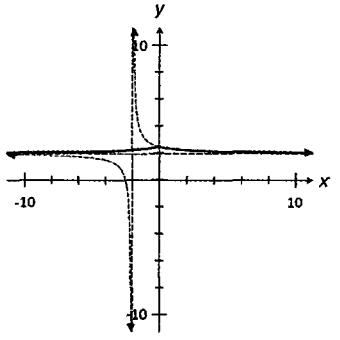
(ii) (i) $f(|x|) = \begin{cases} 1/(-x-2) & x<2 \\ 1/(x-2) & x>2 \end{cases}$



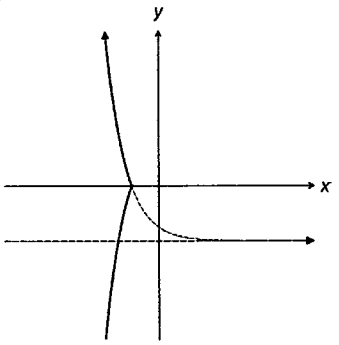
(j) (i) $|f(x)| = \begin{cases} -(1/(2+x)+2) & x<-5/2 \\ 1/(2+x)+2 & x>-5/2 \end{cases}$



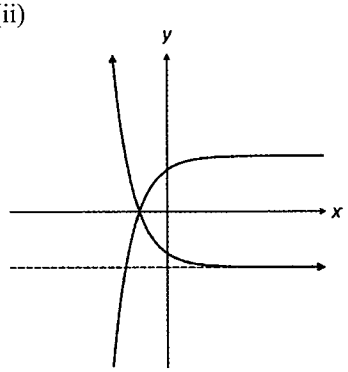
(ii) $f(|x|) = \begin{cases} 2+1/(2-x) & x<0 \\ 2+1/(2+x) & x>0 \end{cases}$



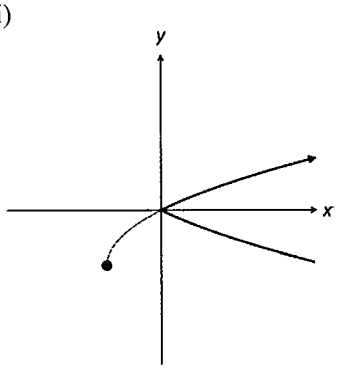
3. (a) (i)



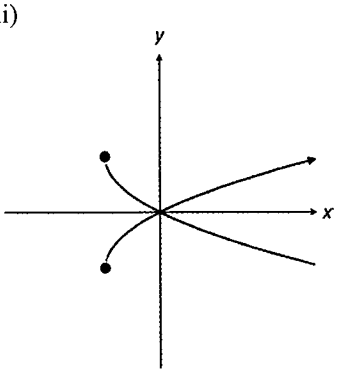
(ii)



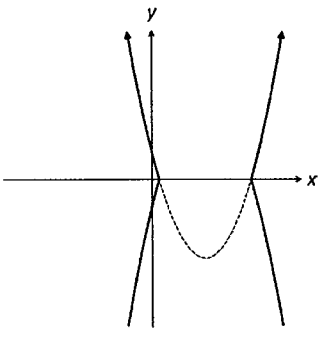
(b) (i)



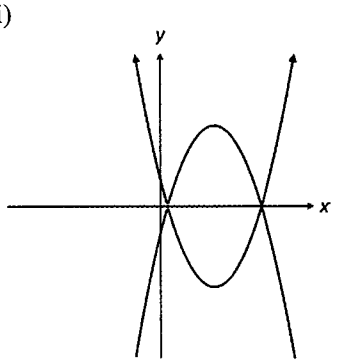
(ii)



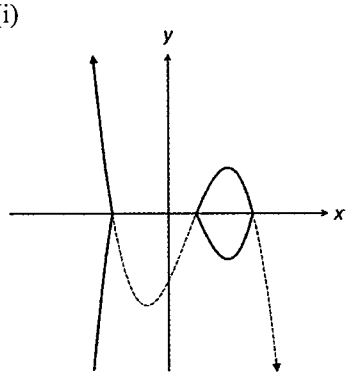
(c) (i)



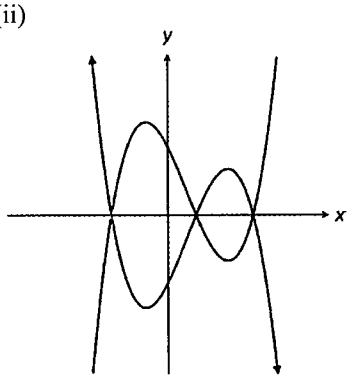
1. (c) (ii)



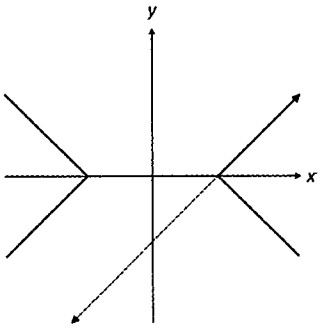
(d) (i)



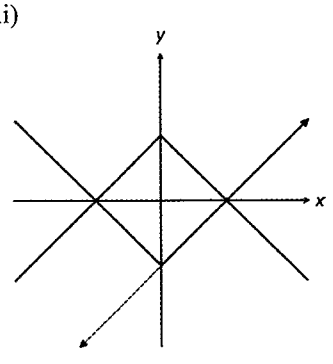
(ii)



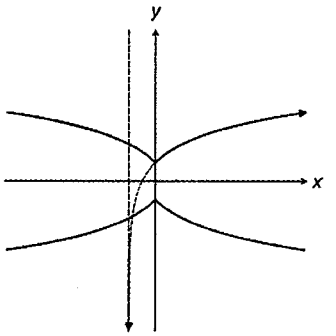
4. (a) (i)



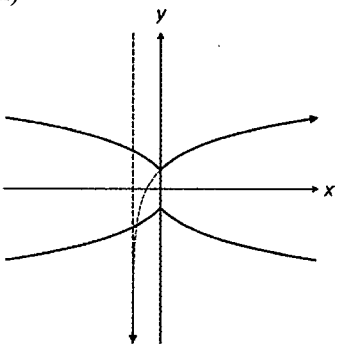
(ii)



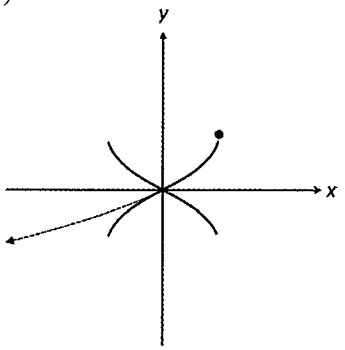
4. (b) (i)



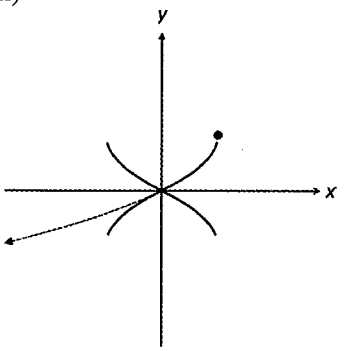
(ii)



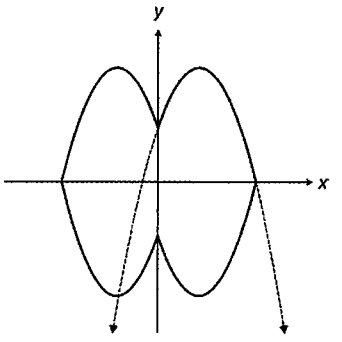
(c) (i)



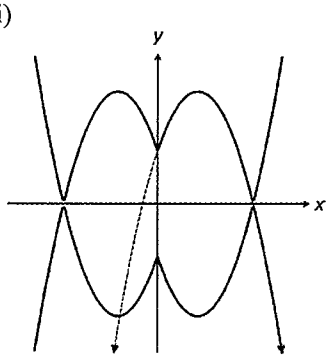
(ii)



(d) (i)

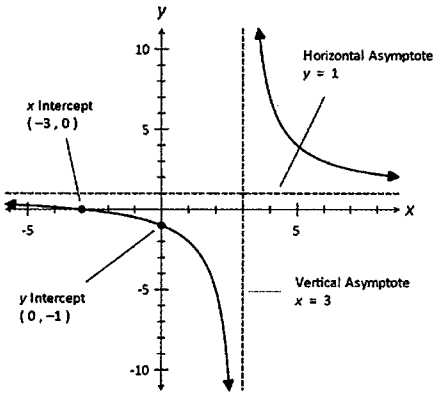


4. (d) (ii)

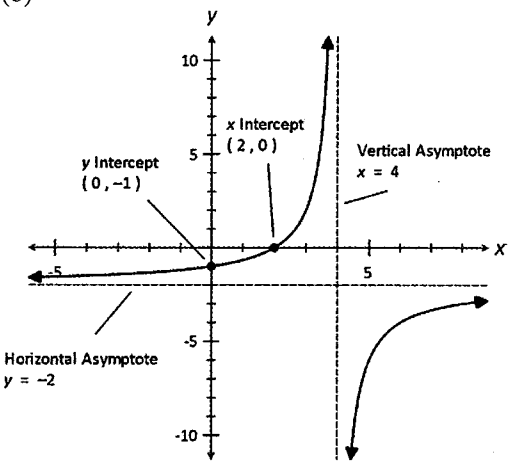


Exercise 5.3

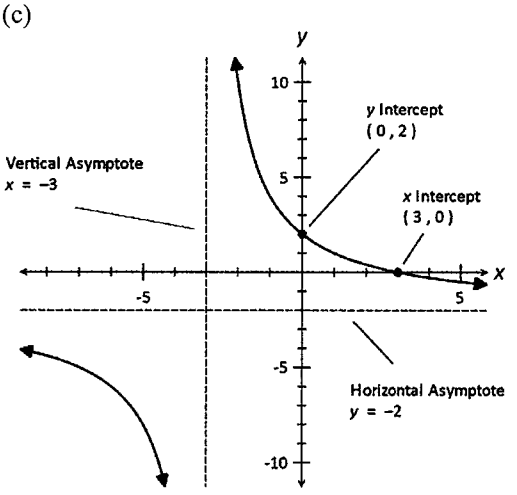
1. (a)



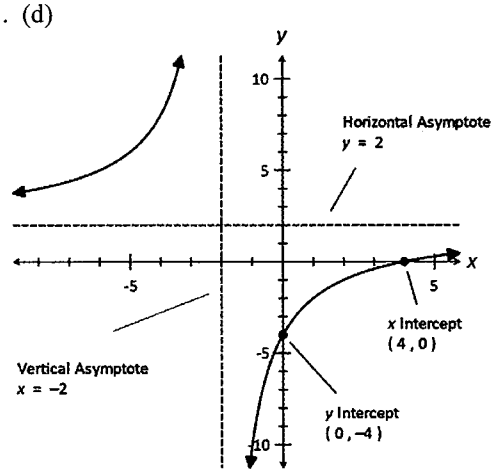
(b)



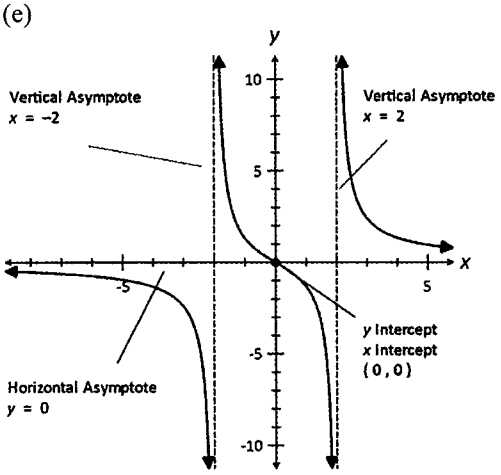
(c)



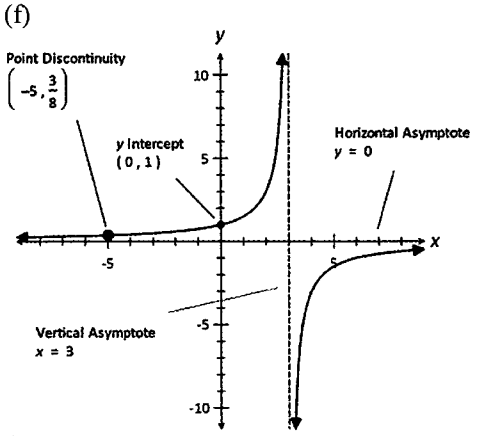
1. (d)



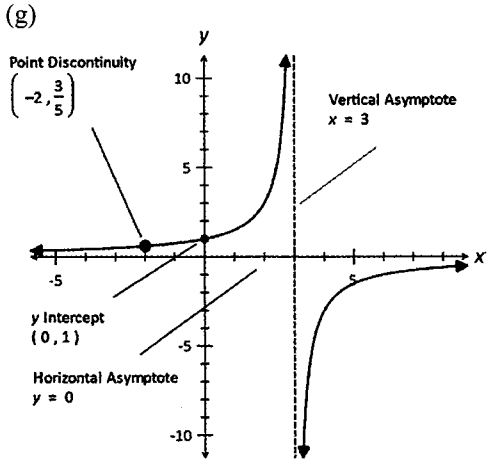
(e)



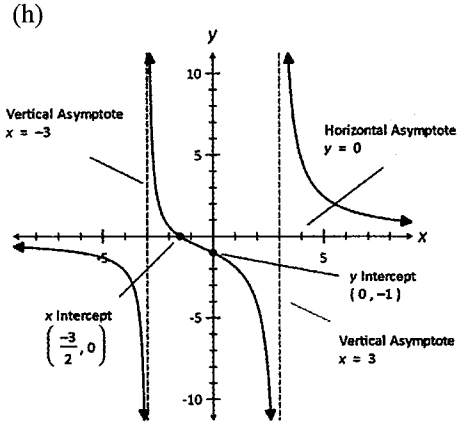
(f)



(g)

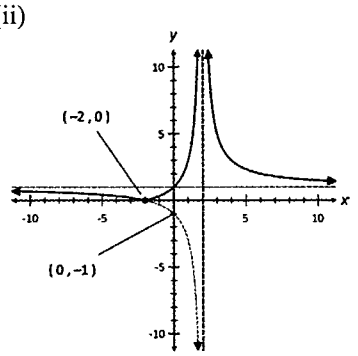


1. (h)

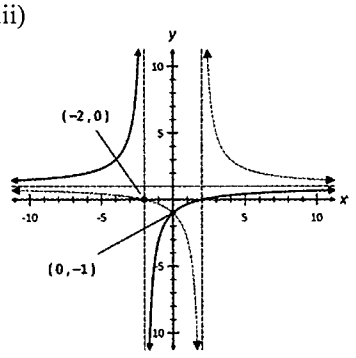


2. (a) (i) $y = (x + 2)/(x - 2)$

(ii)

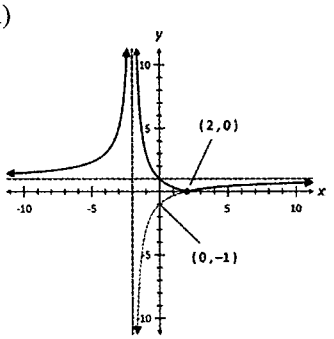


(iii)

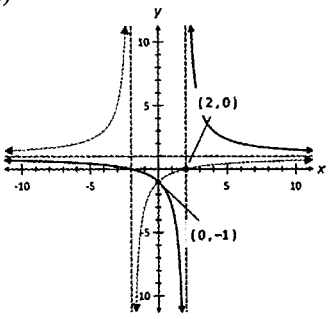


(b) (i) $y = (x - 2)/(x + 2)$

(ii)

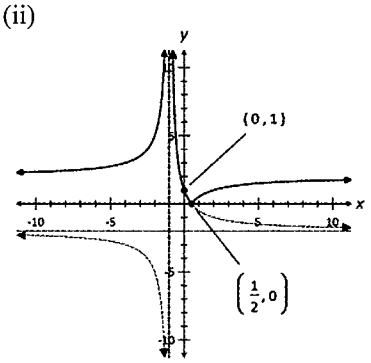


(iii)

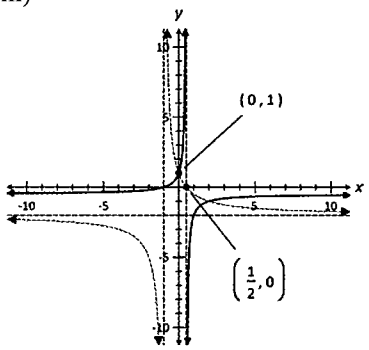


2. (c) (i) $y = (1 - 2x)/(x + 1)$

(ii)

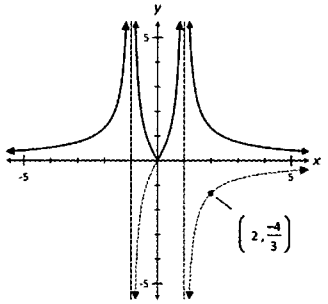


(iii)

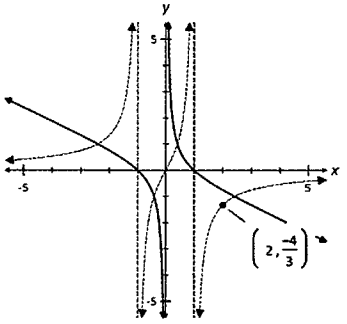


3. (a) $a = 2, b = 0, c = 1$

(b)

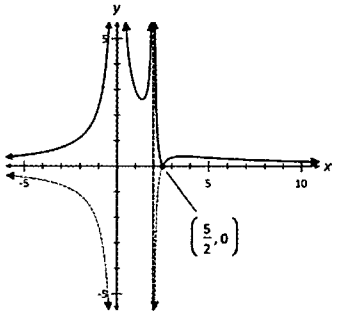


(c)

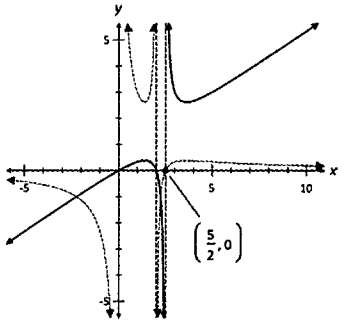


4. (a) $a = 2, b = -5, c = 1, d = 2$

(b)

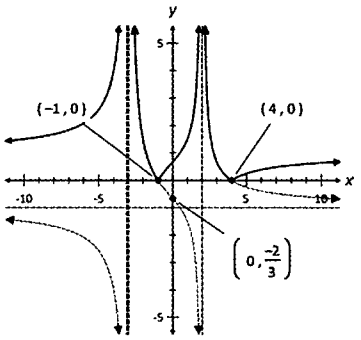


4. (c)

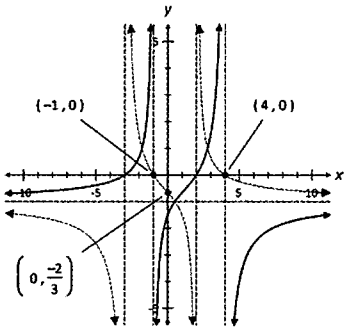


5. (a) $a = 4, b = 1, c = 3, d = -2$

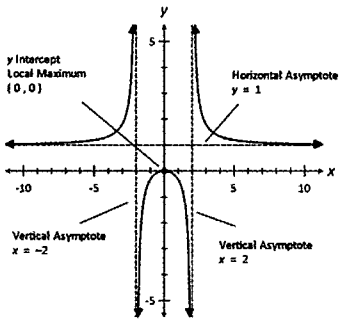
(b)



(c)

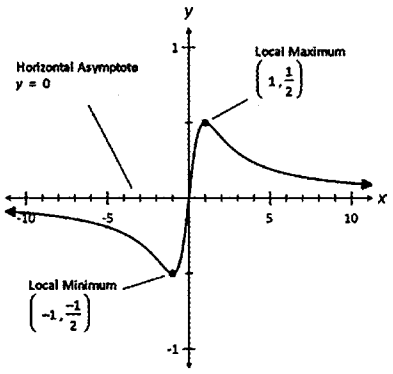


6. $a = k, b = -k, c = -2k, d = 4k$, k is a real no.
7. $a = 2, b = -1, c = 3, d = -1$
8. $a = -1, b = 1, c = 1, d = -2$
   or $a = 1, b = -1, c = 1, d = -2$
9. $a = 1, b = -1, c = 1, d = 2, e = 3, f = -3$
   ($ab = 1$ and $ad = -2$)
10. (a) intercepts (0, 0)
    asymptotes $x = -2, x = 2, y = 1$
    (b) $a = -8$
    (c) max point (0, 0)
    (d)

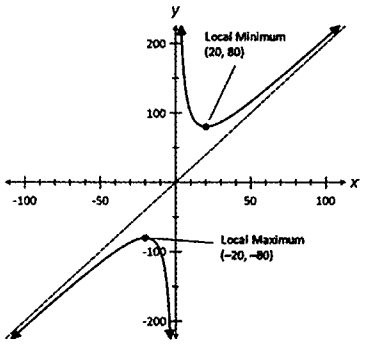


11. (a) intercepts (0, 0); asymptotes $y = 0$
    (b) $a = 1, b = 1$

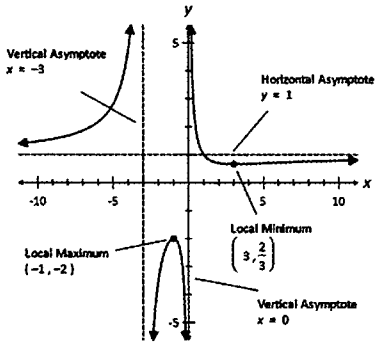
11. (c) min point $(-1,-1/2)$, max point $(1, 1/2)$
(d)



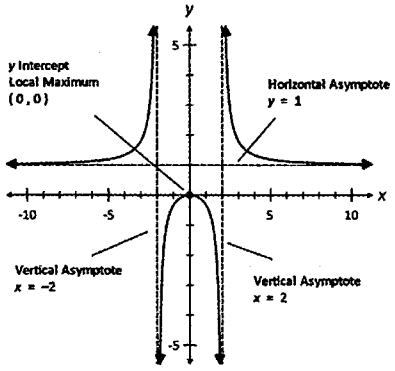
12. (a) no intercepts; asymptotes $x = 0$, oblique asymptote $y = 2x$
(b) $a = 2$, $b = -800$
(c) min point (20, 80), max point (–20, –80)
(d)



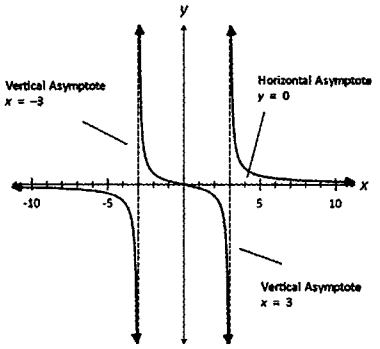
13. (a) no intercepts
asymptotes $x = 0$, $x = -3$, $y = 1$
(b) $a = 1$, $b = -3$ or $a = -3$, $b = 1$
(c) min point (3, 2/3), max point (–1, –2)
(d)



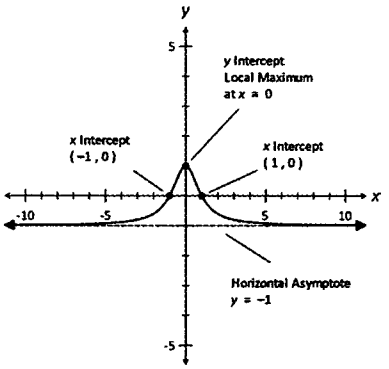
14.



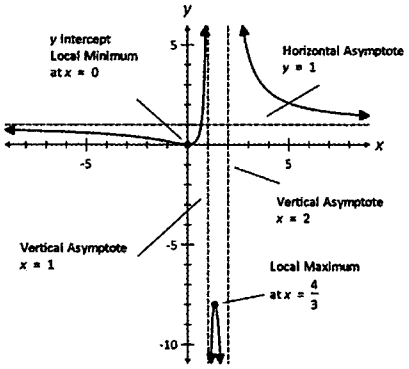
15.



16.

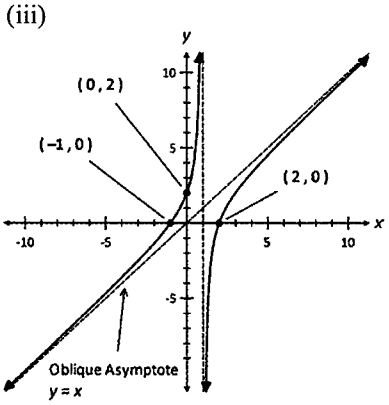


17.



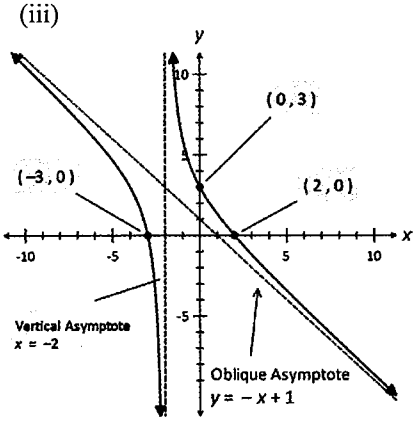
Exercise 5.4

1. (a) (i) $y = x - 2/(x - 1)$
(iii)



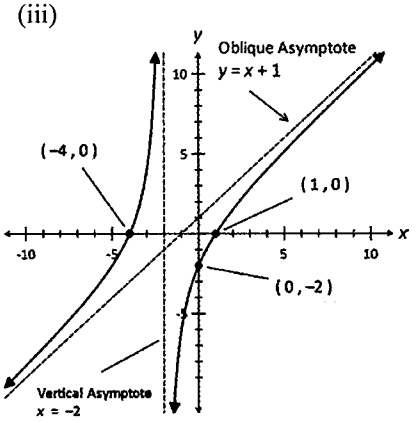
1. (b) (i) $y = -x + 1 + 4/(x + 2)$

(iii)



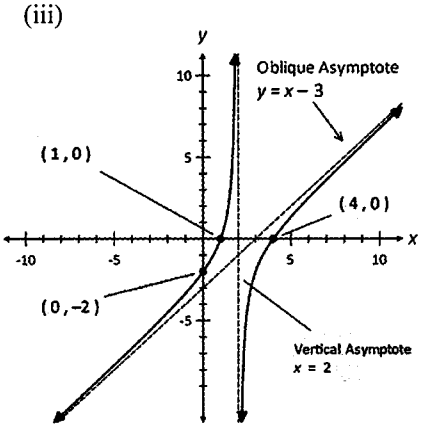
(c) (i) $y = x + 1 - 6/(x + 2)$

(iii)



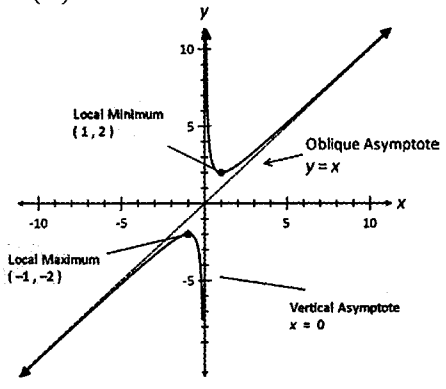
(d) (i) $y = x - 3 - 2/(x - 2)$

(iii)



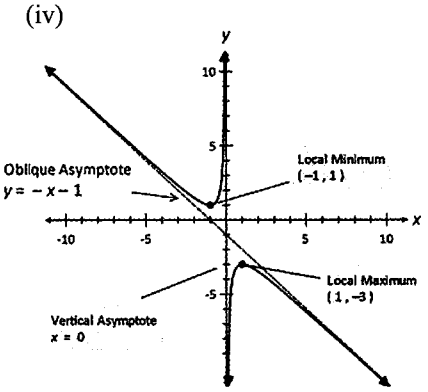
2. (a) (i) $y = x + 1/x$

(iv)



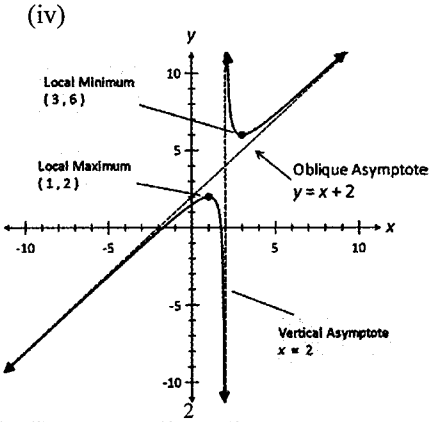
2. (b) (i) $y = -x - 1 - 1/x$

(iv)



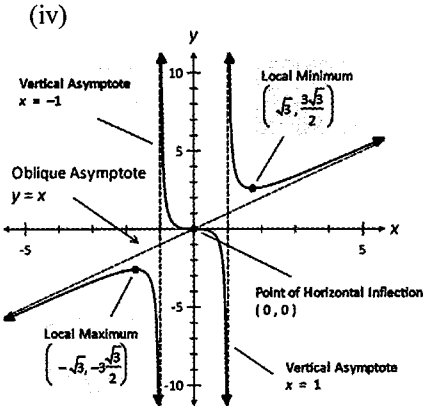
(c) (i) $y = x + 2 + 1/(x - 2)$

(iv)



(d) (i) $y = x + x/(x^2 - 1)$

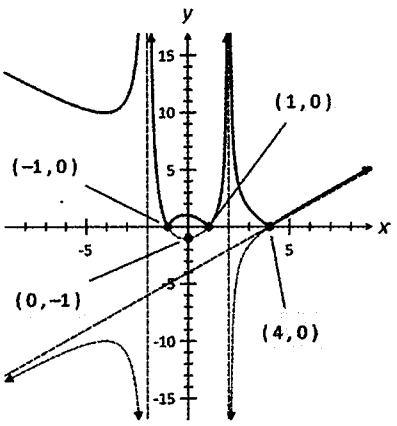
(iv)



3. (a) $y = x - 4$

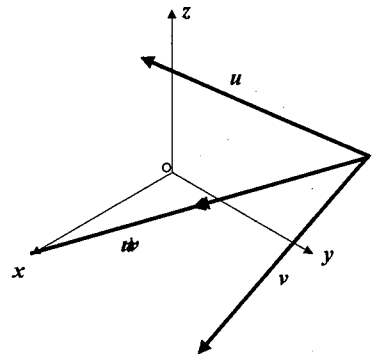
(b) $b = -4, c = -1, d = 4, n = -4$

(c)

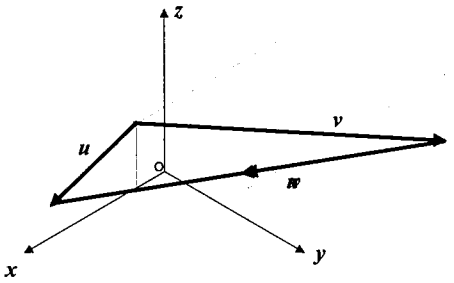


Exercise 6.1

1. (a)



(b)



2. (a) $< 10, 3, 2 >$ (b) $< 4, -15/2, 11 >$
3. (a) $\pm 3\sqrt{43}$ (b) $10 \pm 10\sqrt{3}$
4. $< 8, -8, 8 >$
5. (a) $((\sqrt{83})/83) < 5, -3, 7 >$
   (b) $-10((\sqrt{83})/83) < 5, -3, 7 >$
6. (a) $\sqrt{(17/10)} < -1, 0, -3 >$
   (b) $((\sqrt{3})/(2\sqrt{17})) < 0, -1, -4 >$
7. (a) $((\sqrt{59})/\sqrt{30}) < 2, -5, -1 >$
   (b) $(-10/\sqrt{17}) < -1, 0, 4 >$
8. (a) $(5/\sqrt{6}) < -1, 1, 2 >$
   (b) $(-10/\sqrt{6}) < -1, 1, 2 >$
9. $\pm (1/\sqrt{3}) < 1, -2, 1 >$
10. $\pm 2\sqrt{6}$ 11. 0 or 1
12. (a) $\alpha = 1, \beta = -1$ (b) $\alpha = 1, \beta = 1$
14. $\alpha = -\beta/2$
15. $\alpha = 2, \beta = 4$ or $\alpha = 3, \beta = 5$
16. $5\alpha + 4\beta = 45$
17. (a) $(1/3) < -3, 1, 10 >$
    (b) $(1/5) < -8, 24, 52 >$
18. $< -32, -14, 65 >$
19. $(1/2) < 26, -10, -5 >$
20. (a) 90° (b) 35.3° (c) 85.3° (d) 52.8°
21. (a) perpendicular (b) Neither
    (c) Parallel, opposite direction
    (d) Parallel, same direction
22. (a) $(5/\sqrt{13}) < 0, 3, 2 >$ or equivalent.
    (b) $(100/\sqrt{2}) < 1, 0, 1 >$ or equivalent.
    (c) $(10/\sqrt{5}) < 2, 0, 1 >$ or equivalent.
    (d) $(20/3) < 2, 2, 1 >$ or equivalent.
23. $a = b = \sqrt{5}$ 24. $a = -9/8, b = 4$
25. $a = (\sqrt{2})/2, b = \pm (\sqrt{2})/2$
27. (a) $(1/3) < 2, 2, -1 >$ (b) $< 1, 1, 1 >$
28. (a) $(-5/9) < 2, -1, -2 >$
    (b) $- < 0, 1, 2 >$
29. $(1/16) < -5, 18, -7\sqrt{3} >$
30. $(1/9) < -2, 16, 28 >$
31. (a) $< 1, -1, 1 >, < 0, 0, 0 >$
    (b) $< 1, -1, 1 >, < 0, 0, 0 >$
32. (a) $< 2, 1, 3 >, < 3, -9, 1 >$
    (b) $< 3, -9, 1 >, < 2, 1, 3 >$
33. $\sqrt{(38/51)}$ 34. $(\sqrt{5})/6$
35. $(\sqrt{2})/2$

Exercise 6.2

3. (a) $< 5, 4, -7 >$ (b) $< -6, -15, -8 >$
4. $[(\sqrt{3})/3] < 1, -1, 1 >$ 5. $(10\sqrt{3}) < 1, -1, -1 >$
6. (a) $a = 1, b = -1$ (b) $m = 2, n = 2$
   (c) $a = 3, b = -2$ (d) $a = 3, b = -4$
7. 40 8. 4 9. 18
10. (a) $(\sqrt{219})/15$ (b) $(\sqrt{154})/77$
11. $(\sqrt{2})/10$ 12. (a) $10\sqrt{2}$ (b) $5\sqrt{2}$
13. (a) $2\sqrt{77}$ (b) $\sqrt{77}$

Exercise 7.1

1. (a) $\boldsymbol{r} = < 2, 1, 0 > + \lambda < 4, 5, -1 >$
   (b) $\boldsymbol{r} = < 0, 0, 5 > + \lambda < 0, 2, -1 >$
   (c) $\boldsymbol{r} = < 1, 1, -1 > + \lambda < 1, 2, -1 >$
   (d) $\boldsymbol{r} = < \sqrt{2}, 0, 1 > + \lambda < 0, -1, 1/5 >$
2. Equivalent answers including:
   (a) $\boldsymbol{r} = < 0, -2, 0 > + \lambda < 0, -2, -2 >$
   (b) $\boldsymbol{r} = < 1, 2, 1 > + \lambda < -2, -3, 3 >$
   (c) $\boldsymbol{r} = < 1, 2, 5 > + \lambda < 3, 1, -2 >$
   (d) $\boldsymbol{r} = < 0.5, -0.1, 0.4 > + \lambda < 0.1, 0.4, 0.3 >$
3. (a) $\lambda = 2$ (b) $\lambda = -5$
4. $m = 4$ 5. $m = 4$
6. $< 13, -2, 11 >$ is the only point not on the line
7. (a) $\boldsymbol{r} = < 0, 3 > + \lambda < 1, -2 >$
   (b) $\boldsymbol{r} = < 0, -1 > + \lambda < 3, 4 >$
   (c) $\boldsymbol{r} = < 0, 3 > + \lambda < 4, -3 >$
8. Gradient $= -3$; $y = -3x + 6$
9. $x = 3 + \lambda, y = 1 - 2\lambda$; $2x + y = 7$
10. (a) $\boldsymbol{r} = < -1, 2, 0 > + \lambda < 1, -3, 0 >$
    (b) $\boldsymbol{r} = < 1, 2, 4 > + \lambda < 2, -1, -1 >$
    (c) $\boldsymbol{r} = < 1, -4, 5 > + \lambda < 1, 1, 3 >$
    (d) $\boldsymbol{r} = < 0, 2, 10 > + \lambda < 6, 1, 1 >$
11. (a) $(x - 5)/2 = (y + 2)/(-3) = (z + 1)/5$
    (b) $(x + 1)/(-2) = y - 5 = (z - 3)/(-4)$
    (c) $(4x - 3)/2 = (3y + 2)/(-2) = 4z/5$
    (d) $3(x - 1)/2 = -5(y + 1) = 5(z + 1)/3$
12. (a) $(x + 1) = (y + 2)/(-3) = (z - 2)/6$
    (b) $(x + 1)/(-2) = (y + 5)/5 = (z - 6)/(-2)$
13. (a) $x = y = z$
    (b) $(x + 1)/(-6) = (y - 3)/(-3) = (z - 4)/(8)$
    (c) $(x - 3) = (z + 1)/(-2), y = 4$
    (d) $x = 10, z = -5$

14. (a) $\boldsymbol{r} = <\lambda, 2 + 5\lambda, 3 - 2\lambda>$
    (b) $\boldsymbol{r} = <0, -1 - \lambda, 5 + 3\lambda>$
    (c) $\boldsymbol{r} = <(-1 - 3\lambda)/2, (-1 - 4\lambda)/2, (-5 + 5\lambda)/3>$
    (d) $\boldsymbol{r} = <1 + 5\lambda)/4, (1 - 6\lambda)/3, -(2 - 3\lambda)/6>$
15. $\boldsymbol{r} = <1, 2, 3> + \lambda <5, -2, 0>$ or equivalent
16. $\boldsymbol{r} = <2, 2, -2> + \lambda <1, -2, 0>$ or equivalent
17. (a) $x = a + \lambda u, y = b + \lambda v, z = c + \lambda w$
    (b) $\lambda = (x - a)/u = (y - b)/v = (z - c)/w$
18. (a) Lines intersect at $<13, 17, 4>$.
    (b) Lines do not intersect.
19. $m \neq -7$ 20. $m = (-3n + 22)/(n - 6)$
21. (a) 90° (b) 65.9°
22. $\boldsymbol{r} = <1, 2, 1> + \lambda <2, 2, 1>$ or equivalent

Exercise 7.2

1. (a) -2 (b) 4 (c) $-34/5$ (d) ± 5
2. (a) No (b) No (c) Yes (d) No
3. (a) $\boldsymbol{r} . <2, -3> = -19$
    (b) $\boldsymbol{r} . <-5, 10> = -50$
    (c) $\boldsymbol{r} . <10, 3> = -16$ or equivalent
    (d) $\boldsymbol{r} . <5, -4> = 58$ or equivalent
4. (a) $\boldsymbol{r} . <6, 1> = 17$
    (b) $\boldsymbol{r} . <3, -4> = -36$
    (c) $\boldsymbol{r} . <8, -3> = -81$ or equivalent
    (d) $\boldsymbol{r} . <7, 2> = 31$ or equivalent
5. (a) $\boldsymbol{r} . <1, 2> = 20$
    (b) $\boldsymbol{r} . <-4, 3> = 0.7$
    (c) $\boldsymbol{r} . <3, 10> = -155$ or equivalent
    (d) $\boldsymbol{r} . <-2.7, 0.8> = 2.27$ or equivalent
6. (a) $\boldsymbol{r} = <0, -6> + \lambda <2, 1>$ or equivalent
    (b) $\boldsymbol{r} = <-2, 0> + \lambda <8, -5>$ or equivalent
    (c) $\boldsymbol{r} = <-5, 0> + \lambda <4, \sqrt{3}>$ or equivalent
7. (a) No intersection (b) No intersection
    (c) $<5, 7>$ (d) $<-2, 0>$
8. (a) 0° (b) 45°

Exercise 7.3

1. (a) -16 (b) $-9/8$ (c) $-3/2$ (d) $-6/5$
2. (a) Only $<2, 2, 4>$ is on the plane.
    (b) Both points are not on the plane.
3. (a) $\boldsymbol{r} . <4, 0, 3> = 5$
    (b) $\boldsymbol{r} . <-3, 7, 10> = 26$
    (c) $\boldsymbol{r} . <1, 4, 1> = 33$
    (d) $\boldsymbol{r} . <4, 8, -11> = -120$
4. (a) $\boldsymbol{r} . <-1, 0, 2> = -11$
    (b) $\boldsymbol{r} . <3, -2, -2> = 23$
    (c) $\boldsymbol{r} . <-4, 7, 9> = -17$
    (d) $\boldsymbol{r} . <1, 10, -10> = -27/4$
5. (a) $<0, 4, -8>$ (b) $<8, 11, -1>$
    (c) $<-1, 8, -7>$ (d) $<-15/2, 5, -21/4>$
6. Equivalent answers including:
    (a) (i) $\boldsymbol{r} . <1, 0, 0> = 0$
    (ii) $\boldsymbol{r} = \lambda <0, 1, 0> + \mu <0, 0, 1>$
    (b) (i) $\boldsymbol{r} . <1, 1, 1> = 8$
    (ii) $\boldsymbol{r} = <1, 2, 5> + \lambda <4, 0, -4> + \mu <1, -1, 0>$
6. (c) (i) $\boldsymbol{r} . <1, -1, 1> = -1$
    (ii) $\boldsymbol{r} = <-2, 3, 4> + \lambda <-5, -7, -2> + \mu <8, 0, -8>$
    (d) (i) $\boldsymbol{r} . <-67, 11, -12> = -254$
    (ii) $\boldsymbol{r} = <4, 10, 8> + \lambda <2, -2, -13> + \mu <-1, -5, 1>$
7. Equivalent answers including:
    (a) $\boldsymbol{r} . <-4, -2, 1> = 3$
    (b) $\boldsymbol{r} . <-11, -38, 13> = -72$
8. Equivalent answers including:
    (a) $\boldsymbol{r} . <0, 2, 1> = -1$
    (b) $\boldsymbol{r} . <-28, 5, 21> = 45$
9. (a) $\boldsymbol{r} . <2, 8, 9> = -27$
    (b) $\boldsymbol{r} . <-6, 3, 1> = 11$
10. Equivalent answers including:
    (a) $\boldsymbol{r} . <6, 0, 1> = 27$
    (b) $\boldsymbol{r} . <2, -1, 0> = -13$
11. (a) $3z = 5$ (b) $-2y = 5$
    (c) $-2x - 4y + 3z = 10$
    (d) $5x + 2y - 6z = 25$
12. (a) $\boldsymbol{r} . <1, 0, 0> = 5$
    (b) $\boldsymbol{r} . <1, 1, 0> = 1$
    (c) $\boldsymbol{r} . <0, 1, 1> = 6$
    (d) $\boldsymbol{r} . <2, -3, 4> = 8$
13. $<19, -3, -21>$

Exercise 7.4

1. (a) 53.1° (b) 22.2° (c) 20.9° (d) 32.6°
2. 0.57 or 7.43 3. 1.05 or 19.75
4. $\boldsymbol{r} = <3 + 5\lambda, 2 + 2\lambda, -1 - 8\lambda>$
5. (a) 90° (b) 90° (c) 76.1° (d) 87.9°
6. -0.79 or 58.29 7. -19.62 or 3.62
8. $m = 2 \pm \sqrt{(n^2 + 3)}$ 9. 55.5°
10. $\boldsymbol{r} . <1, -3, 0> = -1$ or equivalent

Exercise 7.5

1. (a) $|\boldsymbol{r} - <3, 4, 0>| = 3$;
    $(x - 3)^2 + (y - 4)^2 + z^2 = 9$
    (b) $|\boldsymbol{r} - <-1, 2, 2>| = 5$;
    $(x + 1)^2 + (y - 2)^2 + (z - 2)^2 = 25$
    (c) $|\boldsymbol{r} - <-1, 2, -5>| = \sqrt{10}$;
    $(x + 1)^2 + (y - 2)^2 + (z + 5)^2 = 10$
    (b) $|\boldsymbol{r} - <1, 4, -5>| = 4$;
    $(x - 1)^2 + (y - 4)^2 + (z + 5)^2 = 16$
2. $2\sqrt{2}$
3. $<1, 2, 1>$ or $(-1/3) <11, 8, 11>$
4. (a) Outside (b) Inside
5. (a) $|\boldsymbol{r} - <-1, 2, -3>| = 5$
    (b) $|\boldsymbol{r} - <1/2, 3/2, 1>| = (5\sqrt{6})/6$
6. (a) $<1, 6, 0>$ or $(1/3) <-8, -4, 11>$
    (b) $<5, -3, -2>$ or $(1/3) <-5, 11, 14>$
9. $|\boldsymbol{r} - <-2, 2, -3>| = \sqrt{26}$

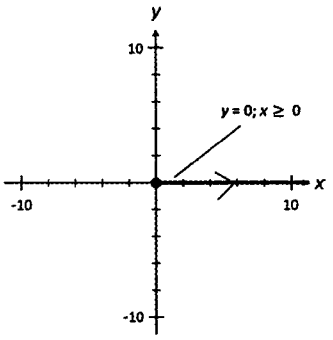
10. (a) Circle with equation $y^2 + z^2 = 64$
    (b) No intersection.
11. (a) Circle with equation $y^2 + z^2 = 99/4$
    (b) At the point (1, 0, 5)

Exercise 7.6

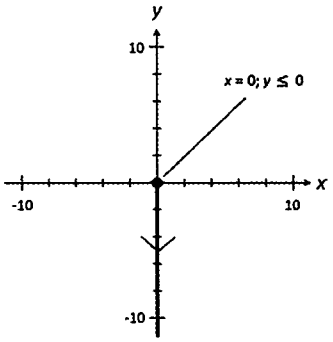
1. (a) $(2\sqrt{357})/17$ (b) $(\sqrt{445})/5$
   (c) $(3\sqrt{2310})/35$ (d) $(3\sqrt{2})/2$
2. $k = 7$ or -13
3. $k = 0$ or -6
4. (b) $\sqrt{5}$
5. (b) $(2\sqrt{138})/69$
6. (a) $(3\sqrt{21})/7$ (b) $(13\sqrt{42})/21$
7. (a) 2 (b) 2
   (c) 1 (d) 5
   (e) $5\sqrt{6}$ (f) 6
8. $2 \pm 10\sqrt{6}$
9. $-2/3$
10. (a) $\sqrt{10}$ (b) $\sqrt{2}$
11. 2/3
12. 3
13. 1/3
14. $(3\sqrt{14})/14$

Exercise 8.1

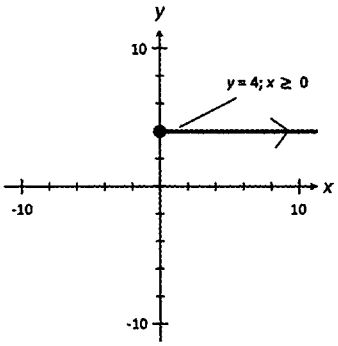
1. (a) $y = 0$



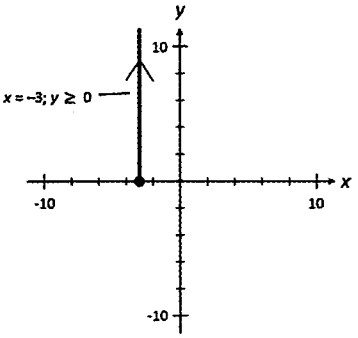
(b) $x = 0$



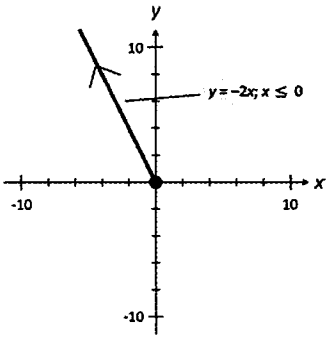
(c) $y = 4$



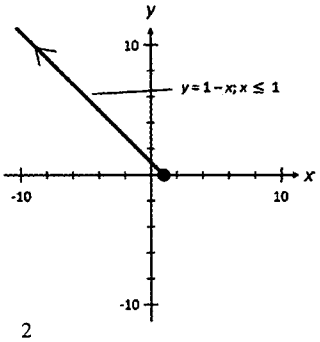
1. (d) $x = -3$



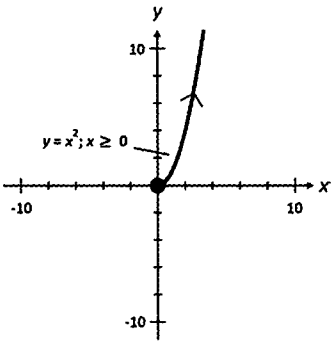
(e) $y = -2x$



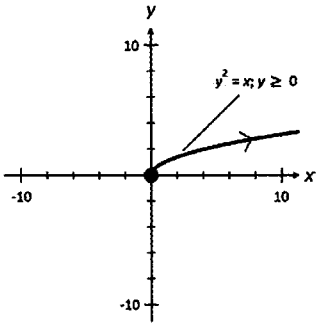
(f) $y = 1 - x$



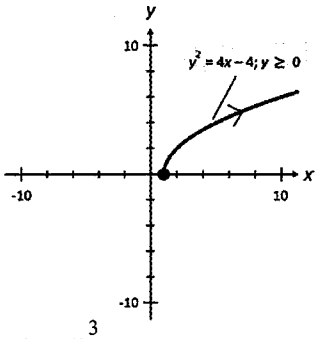
(g) $y = x^2$



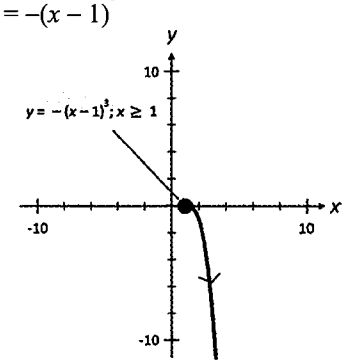
(h) $y^2 = x$



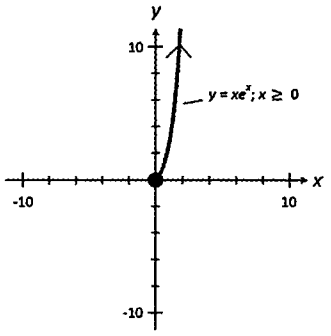
1. (i) $y^2 = 4x - 4$



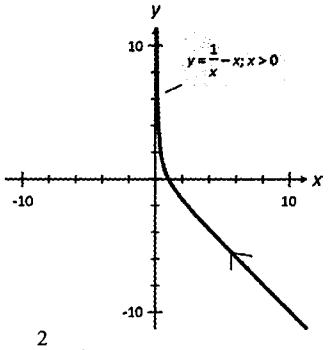
(j) $y = -(x-1)^3$



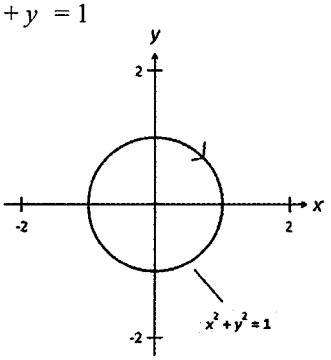
(k) $y = x e^x$



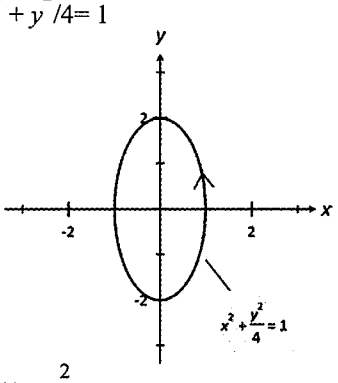
(l) $y = -x + 1/x$



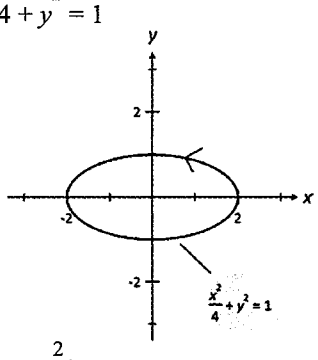
2. (a) $x^2 + y^2 = 1$



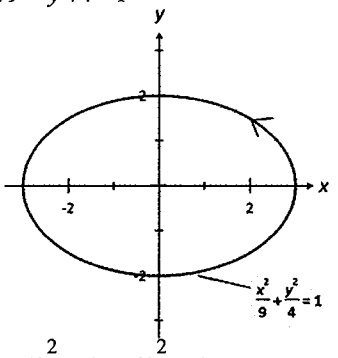
2. (b) $x^2 + y^2/4 = 1$



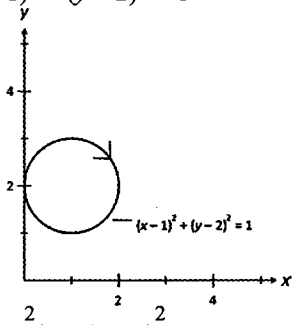
(c) $x^2/4 + y^2 = 1$



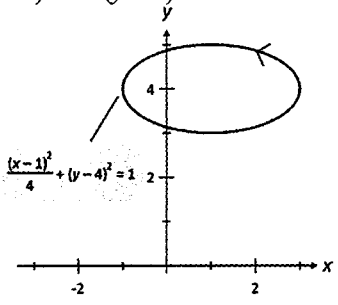
(d) $x^2/9 + y^2/4 = 1$



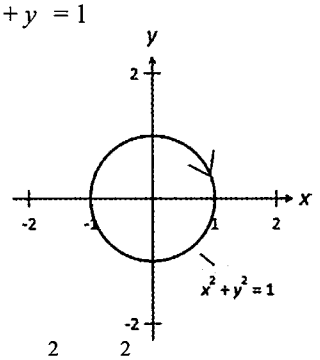
(e) $(x-1)^2 + (y-2)^2 = 1$



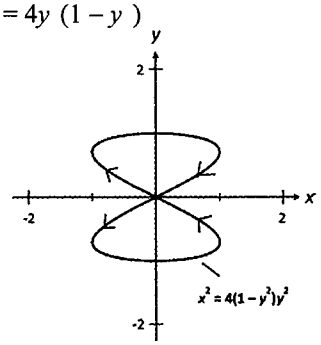
(f) $(x-1)^2/4 + (y-4)^2 = 1$



2. (g) $x^2 + y^2 = 1$



(h) $x^2 = 4y^2(1 - y^2)$



Exercise 8.2

1. (a) Collide at $t = 2$
   (b) Path of A: $\boldsymbol{r} = \lambda < 1, -2 >$
   Path of B: $\boldsymbol{r} = < 2, -9 > + \mu < 2, 1 >$
   Intersect at $< 4, -8 >$.
2. (a) Do not collide.
   (b) Path of P: $\boldsymbol{r} = < 0, 1 > + \lambda < 1, 1 >$
   Path of Q: $\boldsymbol{r} = < -1, 0 > + \mu < 2, 3 >$
   Intersect at $< -1, 0 >$.
3. (a) $< 5 + t, 2 + t, -10 + 5t >$ m
   (b) 20.8 sec (c) 25.0 sec
4. (a) $a = -5, b = 10, c = -15$ (b) 10 am
5. (a) 5.1 sec and 6.1 sec after 0800 hrs
   (b) 134.4 m, 5.6 sec after 0800 hours.
6. (a) 563.8 m, 0.5 sec before 1 pm
   (b) 3.9 sec before 1 pm and 2.8 sec after 1 pm
7. (a) $\mathbf{OA}(t) = < 100 + 10t, 90 - 40t, 80 + 60t >$ m
   $\mathbf{OB}(t) = < -200 + 22t, 150 - 42.4t, -80 + 66.4t >$ m
   (b) Collide 25 sec after 0800 hours at
   $< 350, -910, 1580 >$ m.
8. Collision at 6.45 am at $< -5, 110, 0.8 >$ km
9. Interception at 4.30 pm at $< 225, 105, 4.7 >$ nm
10. A and C will collide at 11 am at $< 25, 21, 10 >$.
11. (a) $< x - 4, y - 6, z + 0.15 >$ ms^{-1}
    (b) $< 800, -800, -40 >$ m
    (c) $x = 5, y = 5, z = -0.2$
12. $x = 0.49, y = 3.12, z = -0.12$
13. (a) No intersection. (b) $< -10, 5, 10 >$
    (c) $< 10, 0, 4 >$ (d) No intersection.
14. The two vehicles do not collide.
    Their paths do not intersect.
15. The two vehicles do not collide.
    Their paths intersect at $< 430, 410, 10.9 >$ m.

Exercise 9.1

Please refer to Solution Manual for this text.

Exercise 9.2

Please refer to Solution Manual for this text.

Exercise 10.1

1. (a) $x = 4, y = 1, z = 2$
   (b) $x = 1, y = 2, z = 3$
   (c) $x = 1, y = 4, z = -2$
   (d) $x = 3, y = 3, z = 3$
   (e) $x = 2, y = 1, z = 1$
   (f) $x = -3, y = -4, z = 6$
   (g) $x = 1, y = 2, z = 4$
   (h) $x = -1, y = 2, z = -5$
   (i) $x = -2, y = 12, z = 2$
2. (a) $x = 5, y = 6, z = 1$
   (b) $x = -2, y = 4, z = 3$
   (c) $x = 1, y = 2, z = 3$
   (d) $x = 1/2, y = 1/2, z = -5/8$
3. (a) $x = 2, y = 4, z = -1$
   (b) $x = 3, y = -4, z = 3$
   (c) $x = 3, y = 9/2, z = 9/2$
   (d) $x = 5/2, y = 1, z = 1/4$
4. (a) $x = 4/5, y = 4/5, z = 4/5$
   (b) $x = 5, y = 10, z = 20$
   (c) $x = -1, y = -1, z = 1/2$
   (d) $x = \pm\sqrt{3}, y = \pm\sqrt{2}, z = \pm 1$
5. (a) $x = 1, y = 2, z = -4$ (b) No solution.

Exercise 10.2

1. A costs \$4.90, B costs \$3.90, C costs \$6.50
2. 15 P type, 14 Q type, 13 R type houses
3. 70 of A, 100 of B and 120 of C
4. NBL final \$32, AFL final \$18, Concert \$27
5. (a) 20 of P, 15 of Q, 25 of R
   (b) 4 of P, 3 of Q, 5 of R
6. 10 of A, 15 of B and 18 of C
7. $x = 70, y = 80, z = 60$
8. $x = 5, y = 1, z = 3$
9. 500 of 0 – 1 years, 1700 of 2 – 8 years and
   200 of 9 – 10 years
10. (a) 2 red bricks, 8 white bricks, 20 blue bricks
    (b) 1005 of A, 620 of B, 750 of C
11. Any reasonable whole number for n.
12. (a) $x = 20, y = 40, z = 50$
    (b) Loop flow between the junctions
    C, D and B.
    (c) $k = -11.2$ litres/hour
13. $< t + 4, -t - 1, t >$ $t \in \mathbb{R}$
14. $< 2t + 13, t + 6, t >$ $t \in \mathbb{R}$

Exercise 10.3

1. (a) Equations 1 & 2 inconsistent.
   (b) Equation 1 + Equation 2 inconsistent
   with Equation 3.
   (c) Equations 1 & 2 inconsistent.
   (d) Equation 2 – Equation 1 inconsistent
   with Equation 3.

2. (a) Equations 1 & 2 are identical.
   (b) Equation 1 – Equation 2 similar to Equation 3.
   (c) 2 × Equation 1 + Equation 2 similar to Equation 3.
   (d) Equation 2 – Equation 1 similar to Equation 3.
3. (a) (i) $p \neq 0, q$ any no. (ii) $p = 0, q \neq 1$
   (iii) $p = 0, q = 1$
   (b) (i) $p \neq 3, q$ any no. (ii) $p = 3, q \neq \frac{1}{2}$
   (iii) $p = 3\ q = \frac{1}{2}$
   (c) (i) $p \neq -1$ (ii) $p = -1$
   (iii) No value for p
   (d) (i) $p \neq 1, p \neq -2$; any real number for q
   (ii) $p = 1$ and $q \neq 1$ or $p = -2$ and $q \neq 1$
   (iii) $p = 1$ and $q = 1$ or $p = -2$ and $q = 1$
   (e) (i) $p \neq -1$ and $p \neq -2$
   (ii) $p = -1$ (iii) $p = -2$
   (f) (i) $p \neq 3$ (ii) No value for p
   (iii) $p = 3$
4. (a) System will always have no solutions.
   (b) (i) System will always have solutions.
   (ii) $k \neq 4, k \in \mathbb{R}$
   $x = 19/7, y = -11/7, z = 0$
   (iii) $k = 4$
   $x = (19 - t)/7, y = (5t - 11)/7$
   $z = t, t \in \mathbb{R}$
   (c) (i) System will always have solutions.
   (ii) $k \neq 7, k \in \mathbb{R}$
   $x = 0, y = -1, z = 2$
   (iii) $k = 7$
   $x = (14 - 7t)/19, y = (3 - 11t)/19$
   $z = t, t \in \mathbb{R}$
   (d) (i) $k \neq -5, k \in \mathbb{R}$
   (ii) Not possible.
   (iii) $k = -5$
   $x = 1 - t, y = 1 - t, z = t, t \in \mathbb{R}$
5. $k = 5/4, 2$ 6. $a = 9, b = 1$
7. (a) $\left(\begin{array}{ccc|c} 1 & 3 & 1 & 16 \\ 1 & 4 & 3 & 23 \\ 1 & 2 & 4 & 19 \\ 1 & 5 & 3 & p \end{array}\right)$
   (b) Variations possible,
   $\left(\begin{array}{ccc|c} 1 & 3 & 1 & 16 \\ 0 & -1 & -2 & -7 \\ 0 & 0 & -5 & -10 \\ 0 & 0 & -2 & -30+p \end{array}\right)$
   (c) $p = 26$
8. (a) $k = 1$
   (b) $k = -2$
   $x_1 = -5 + 4t, x_2 = 8 - 6t, x_3 = t, x_4 = 5 - 4t$
   (c) $k \neq 1$ **and** $k \neq -2, k \in \mathbb{R}$
   $x_1 = (k + 1)/(1 - k), x_2 = (2k + 1)/(k - 1),$
   $x_3 = (2k - 3)/(2k - 2), x_4 = (k + 1)/(k - 1)$
9. $\frac{1}{3}\begin{pmatrix} 2 & 1 & 1 \\ -1 & 1 & 1 \\ -2 & -1 & 2 \end{pmatrix}$

Exercise 11.1

1. (a) $[(-2/\sqrt{x})]/(1 - \sqrt{x})^3$
   (b) $e^{-x}/\sqrt{(1 - 2e^{-x})}$
   (c) $2(\cos x - 2 \sin 2x)(\sin x + \cos 2x)$
   (d) $1/[2\,(1 + x)\sqrt{(1 + ln\,(1 + x))}]$
   (e) $-\sec^2 x\, e^{-\tan x}$
   (f) $\pi \sin 2(1 + \pi x)$
   (g) $(-\pi \sin \pi x)/(1 + \cos \pi x)$
   (h) $-2(x - 1)\, e^{-(x-1)^2}$
   (i) $-8x/(1 - x^2)$
   (j) $(-\text{cosec}^2(1 + \sqrt{x}))/(-2\sqrt{x})$
   (k) $e^{1+x} \sec(e^{1+x}) \tan(e^{1+x})$
   (l) $2x\, 2^{1+x^2}\, ln\, 2$
2. (a) $2x \sin \omega x + \omega x^2 \cos \omega x$
   (b) $(1/(2\sqrt{x}))e^{\cot x} - (\sqrt{x})\,\text{cosec}^2 x\, e^{\cot x}$
   (c) $4(1 + 2x) \tan \omega x^2 + 2\omega x\,(1 + 2x)^2 \sec^2 \omega x^2$
   (d) $2(x + 1)\, e^{(x+1)^2}\, ln \cos^2 x - 2\, e^{(x+1)^2} \tan x$
   (e) $(\sin x \sin^2 \pi x)\, e^{-\cos x} + (\pi \sin 2\pi x)\, e^{-\cos x}$
   (f) $-2 \sin 2x \sin^2 x + (\sin 4x)/2$
   (g) $1/x + (\sec^2 x)/(\tan x)$
   (h) $-2x\, e^{-x^2}\,(ln\, x + 2x) + e^{-x^2}\,(1/x + 2)$
   (i) $x\, ln\,(1 + e^x) + (x^2 e^x)/(2(1 + e^x))$
   (j) $2/x - 1/(1 + x)$
   (k) $e^{1+x}\,[ln\, 2x - ln\,(1 - x)]$
   $+ e^{1+x}\,(1/x + 1/(1 - x)$
   (l) $2x\,[ln\, x - 2x - 2\, ln\,(1 + x)]$
   $+ x^2\,[1/x - 2 - 2/(1 + x)]$
3. (a) $\dfrac{2x(1-2x)+2(1+x^2)}{(1-2x)^2}$
   (b) $\dfrac{1}{2\sqrt{x}(1+\sqrt{x})^2}$
   (c) $2/(1 + \cos 2x)$
   (d) $\dfrac{2e^{2x}+4}{(1+2e^{-2x})^2}$
   (e) $\dfrac{e^{-2\cos x}(2\sin x - 4e^{\sin x}\sin x + 2e^{\sin x}\cos x)}{(1-2e^{\sin x})^2}$

3. (f) $[1 - ln(1 + 2x)]/(1 + 2x)^2$

(g) $\dfrac{2x(1+e^{2x})ln(1+e^{2x}) - 2x^2e^{2x}}{(1+e^{2x})[ln(1+e^{2x})]^2}$

(h) $\dfrac{e^{\sin x}(\cos x + e^{-\cos x}\cos x - e^{-\cos x}\sin x)}{(1+e^{-\cos x})^2}$

(i) $\dfrac{e^x}{(1+e^x)^2}\sec^2\dfrac{e^x}{(1+e^x)}$

(j) $\dfrac{-e^{\left(\frac{x}{x-1}\right)}}{(x-1)^2}$ (k) $\dfrac{-e^{\left(\frac{\cos x}{1+\sin x}\right)}}{(1+\sin x)}$

(l) $\dfrac{x(1-ln(1+x^2))}{(1+x)^2}$

4. (a) $\dfrac{3}{2\sqrt{x}} + 3 + \dfrac{3\sqrt{x}}{2}, \dfrac{-3}{4x^{3/2}} + \dfrac{3}{4\sqrt{x}}$

(b) $\dfrac{e^{-x}}{2}(1-e^{-x})^{-1/2}$,

$\dfrac{-e^{-x}}{4}(1-e^{-x})^{-3/2}(2-e^{-x})$

(c) $-2\sin 4x, -8\cos 4x$

(d) $1/(1+x), -1/(1+x)^2$

(e) $-e^{-\sin x}\cos x, e^{-\sin x}(\sin x + \cos^2 x)$

(f) $2\tan x + 2\tan^3 x,\ 2 + 8\tan^2 x + 6\tan^4 x$

5. $4(x+2)\cos x - (x^2 + 4x - 1)\sin x$

Exercise 11.2

1. (a) $6(x-1)$ (b) $-2/x^3$

(c) $(x-1)/(2x^{3/2})$ (d) $\pm 1/\sqrt{x}$

2. (a) $(2t^2 - 1)/(t^2 + 1)$ (b) $(6t-1)^2/(6t^2+1)$

(c) $(t^2+1)^2/(t^2-1)^2$ (d) $(1-t)^2/(1-2t)^2$

3. (a) $\pm x/\sqrt{(4-x^2)}$ (b) $\pm (x-2)/\sqrt{(4x-x^2)}$

(c) $\pm[\sqrt{(1-x^{2/3})}]/x^{1/3}$ (d) $-4x$

Exercise 11.3

1. (a) $-(2x+3y)/(3x+2y)$

(b) $(2x-y)/(x+2y)$

(c) $(1-y^2-2xy)/(x^2+2xy)$

(d) $-(y+4x^{3/2}y^{1/2})/(x+4y^{3/2}x^{1/2})$

(e) $-(e^y + ye^x)/(e^x + xe^y - 1)$

(f) $y(4 - y - 2x\,ln\,y)/(x^2 + xy)$

2. (a) $[2x\cos y + y\cos x]/[x^2\sin y - \sin x]$

(b) $\dfrac{\sin y \sin x - e^{\cos y}}{\cos y\cos x - x\sin y\, e^{\cos y}}$

2. (c) $\dfrac{3 + y\sin xy - 4\tan y}{4x\sec^2 y - x\sin xy}$

(d) $y/[e^y\sin(e^y) - x - \cot(y)]$

(e) $-y^2/[x^2(1+y^2e^y)]$

(f) $-(y^2 + 2y - 1)/[x(y+1)]$

3. (a) $2x\,(dx/dt) + 2y\,(dy/dt)$

(b) $\cos x\,(dx/dt) - \sin y\,(dy/dt)$

(c) $-2e^{-2x}(dx/dt) + 0.05e^{0.05y}(dy/dt)$

(d) $2xy\,(dx/dt) + x^2\,(dy/dt)$

(e) $e^{-x}\sin \pi y\,(dx/dt) + \pi e^{-x}\cos \pi y\,(dy/dt)$

(f) $ln(1 + \tan y)\,(dx/dt)$
$+ [(x\sec^2 y)/(1 + \tan y)]\,(dy/dt)$

(g) $(1/y)(dx/dt) - (x/y^2)(dy/dt)$

(h) $e^{2x}(1 - e^{-y})[2(dx/dt)$
$+ e^{-y}(dy/dt)]/(1 + e^{-y})^2$

(i) $[(1 + \cos x)\cos y\,(dy/dt)$
$+ \sin x \sin y\,(dx/dt)]/(1 + \cos x)^2$

Exercise 11.4

1. (a) $2^x\,ln(2)$ (b) $x^x[1 + ln\,x]$

(c) $2^{2x+1}\,ln\,2$ (d) $2x^{\ln(x)-1}\ln(x)$

(e) $x^{\sin x}\{\cos(x)\,ln(x) + [\sin(x)]/x\}$

(f) $x^{\cos x}\{[\cos(x)]/x - \sin(x)\,ln(x)\}$

(g) $(1+x)^x\{ln(1+x) + x/(1+x)\}$

(h) $-(1/x)^x[ln(x) + 1]$

(i) $[(ln\,x)^{ln\,x}][\,ln(ln(x) + 1]/x$

2. (a) $2/(1-x)^2$

(b) $(x^4 + 3x^2 + 2x)/(1-x^3)^2$

(c) $(-x^4 + 2x^3 + 3x^2 - 2x + 1)/(1-x^3)^2$

(d) $(1+x^2)(-2x^4 + 6x^2 + 4x)/(1-2x^3)^2$

(e) $-2(1-2x)^2(8-x)/(x+2)^5$

(f) $-(2+\sqrt{x})(\sqrt{x}+8)/[2\sqrt{x}(\sqrt{x}-1)^4)]$

(g) $1/[(2x)^{1/2}(1-3x)^{3/2}]$

(h) $1/[2(1+x)^{1/2}(3x+4)^{3/2}]$

(i) $2x/[(1+x^2)^{1/2}(1-x^2)^{3/2}]$

Exercise 12.1

1. (a) $y = -x+1$

(b) $y = -2x/3 + 2/3$; $y = 2x/3 - 11/3$

(c) $y = -x/2 + \pi/3$

(d) $y = -x/2 - 3/2$

2. $y = -x + 1$ 3. $y = -12x + 3$

4. $(-2, 0)$ & $(2, -2)$ 5. $(2, -2)$ & $(-2, 2)$

6. $(1, -1)$ & $(-1, 1)$

7. $(1, 2n\pi), (-1, (2n+1)\pi)$ & $(0, (4n+1)\pi/2)$ for $n \in \mathbb{Z}$
8. (a) $y = -2$ (b) $x = -2$
9. (a) $x = -2$ (b) $y = 0, y = 3/2$
10. (a) $x = \pm\pi\sqrt{(-(4n+1))}$ for $n \in \mathbb{Z}^-$
    (b) $y = -0.7391$

Exercise 12.2

1. 0.1
2. -2.5
3. (a) $3/20$ (b) $(\sqrt{3})/10$
4. (a) $-(\pi\sqrt{3})/45$ (b) $-(6\sqrt{3})/\pi$
5. 2 cm s^{-1}; 0.8 cms^{-1}
6. 0.031 mms^{-1}; 0.016 $mm\ s^{-1}$
7. 0.0025 m/min
8. (a) 4π $cm^3\ s^{-1}$ (b) 8π $cm^2\ s^{-1}$
9. 0.032 cms^{-1}; 63.08 $cm^3\ s^{-1}$
10. 0.10 m/min
11. -1 cm/min
12. 0.0019 cm/min
13. $-0.031\ ms^{-1}$
14. 0.052 ms^{-1}
15. 0.18 ms^{-1}
16. -22.86 m/min
17. 1/100 rad/sec.
18. $-1/250$ rad/sec
19. 2.4 cms^{-1}
20. 50.27 cm/min
21. 54.66 km/min
22. 11.17 ms^{-1}
23. $-11.12\ ms^{-1}$
24. 26.8 ms^{-1}
25. 0.96 cm/min

Exercise 13.1

1. $x \sin(x) + \cos(x) + C$
2. $e^x[\sin(x) + \cos(x)]/2 + C$
3. $2[x\ ln(x) - x] + C$
4. $x e^x - e^x + x^2/2 + C$
5. $\frac{1}{2}e^{x^2} + C$
6. $-e^{\cos(x)} + C$
7. $-[e^{-x}[\sin(x) + \cos(x)]/2 + C$
8. $-(x^2 + 2x + 2)e^{-x} + C$
9. $-e^{-x}(1+x) - x^2/2 + C$
10. $x^3/3 + x^2[2\ ln(x) - 1]/4 + C$
11. (a) $(\sqrt{x}+1)^2 + C$ (b) $e^x + C$
    (c) $(\sqrt{x}+1)^2 + e^x + C$ (d) $x^2/2 + (\sqrt{x}+1)^2 + C$

Exercise 13.2

1. (a) $4\sqrt{x} + C$ (b) $3(\sqrt{x})/2 + C$
   (c) $-1/[4(2t+1)^2] + C$
   (d) $-(1-4x)^{1/2} + C$ (e) $(x+1)^4/4 + C$
   (f) $-1/x - 2/x^2 - 4/(3x^3) + C$
   (g) $x^7/7 + x^4/2 + x + C$
   (h) $t^7/7 - 3t^5/5 + t^3 - t + C$
2. (a) $(1+x^2)^4/2 + C$ (b) $-(1-2x^2)^{3/2}/2 + C$
   (c) $-(1-x^3)^{-3}/3 + C$ (d) $4(1+x^3)^{1/2} + C$
   (e) $(2x+x^2)^4/8 + C$ (f) $-(2x-x^2)^{-2}/2 + C$
   (g) $(1-1/x)^4/4 + C$ (h) $2(1+\sqrt{x})^5/5 + C$
3. (a) $8e^{0.05x} + C$ (b) $-5e^{-0.1x} + C$
   (c) $(e^{2x})/2 + C$ (d) $-(e^{-6x})/3 + C$
   (e) $2e^{2x} + 4e^x + x + C$
   (f) $x - e^x + C$
   (g) $(e^{2x})/2 + 4x - 2e^{-2x} + C$
   (h) $-(e^{-2x})/2 + 4x - 4e^{-x} + C$
4. (a) $\frac{e^{2x^2}}{16} + C$ (b) $\frac{-3e^{-x^2}}{4} + C$
   (c) $\frac{e^{1+x^2}}{2} + C$ (d) $e^{x^2-4} + C$
   (e) $\frac{e^{x^2+2x}}{2} + C$ (f) $\frac{(1+e^x)^5}{5} + C$
   (g) $(1/3)(e^{2x} - 1)^{3/2} + C$
   (h) $(-1/8)(1 + 2e^x)^{-4} + C$

Exercise 13.3

1. (a) $(2/3)\ ln|1 + 3x| + C$
   (b) $(-4/5)\ ln|2 - 5x| + C$
   (c) $x^2/8 - x + ln|x| + C$
   (d) $-1/(3x) + 2\ ln|x| + 4x + (4x^2)/3 + C$
   (e) $x - 2\ ln|x| - 1/x + C$
   (f) $x + 3\ ln|x| - 3/x - 1/(2x^2) + C$
   (g) $(-7/6)\ ln|1 - 3x^2| + C$
   (h) $(-1/2)\ ln|2x^3 - 1| + C$
2. (a) $(-1/2)\ ln|x^2 - 8x| + C$
   (b) $3\ ln|x^2 + 3x| + C$
   (c) $ln|1 + x| + C$
   (d) $(-5/4)\ ln|1 + 2e^{-2x}| + C$
   (e) $(3/4)\ ln|1 + 2e^{x^2}| + C$
   (f) $(1/2)\ ln|e^{2x} + e^{-2x}| + C$
   (g) $6\ ln|1 + \sqrt{x}| + C$
   (h) $(-3/2)\ ln|1 + 1/x| + C$
   (i) $ln|ln\ x| + C$
3. (a) $x^2 + C$ (b) $x^6/3 + C$
   (c) $2x^6/3 + C$ (d) $\sqrt{x} + x/2 + C$

Exercise 13.4

1. (a) $(\sin 2x)/2 + C$ (b) $\cos(1 - 2t) + C$
   (c) $(\tan (1 + 2x))/2 + C$
   (d) $(-1/\pi)\ ln|\cos \pi x| + C$
   (e) $(-3/2) \cot (4t/3) + C$
   (f) $(1/2)\ ln|\sin 3x| + C$
   (g) $-((\sqrt{2})/\pi) \cot (1 + \pi t) + C$
   (h) $(5/3\pi) \tan (\pi x + 1) + x/3 + C$
   (i) $(1/(3\pi)) \cot (\pi x) + x/3 + C$
2. (a) $(-1/2) \cos^5 2x + C$
   (b) $(-1/4) \sin^4 (1 - x) + C$
   (c) $(3/2) \tan^2 x + C$
   (d) $(-1/4) \cot^4 x + C$
   (e) $(1 + \sin x)^4/4 + C$
   (f) $(1 - 2 \cos 2x)^{3/2}/6 + C$
   (g) $-(1 + \cot x)^4/4 + C$
   (h) $2 (1 + \tan x)^{1/2} + C$
   (i) $(1 + \cot 2x)^{-3}/6 + C$
3. (a) $(-1/(2\pi))\ ln|1 - \sin 2\pi x| + C$
   (b) $(-1/2)\ ln|1 + \cos (2x + 1)| + C$
   (c) $(-1/2)\ ln|\cos 2x - \sin 2\pi x| + C$
   (d) $(1/2)\ ln|1 + \tan 2x| + C$
   (e) $(-3/4)\ ln|1 + 2 \cot 2x| + C$
   (f) $(-1/2)\ ln|1 - 2 e^{\sin x}| + C$
4. (a) $(1/4) \sin^2 2x + C$
   (b) $(-1/3) \cos^3 2x + C$
   (c) $(1/2) \sin 2x + C$
   (d) $(1/4) \sin 4x + C$
   (e) $ln\ |\sin 2x| + C$
   (f) $(1/2) \tan x + C$
5. (a) $(1/2) \tan 2x + C$
   (b) $(1/10) \tan^5 2x + C$
   (c) $(2/3) (1 + \tan x)^{3/2} + C$
   (d) $(-1/4) (1 + 2 \tan x)^{-2} + C$
   (e) $(\pi + \tan 2x)^{1/2} + C$
   (f) $(-1/2)\ ln|3 - 2 \tan x| + C$
6. (a) $(-1/2) \cot 2x + C$
   (b) $(-1/(5\pi)) \cot^5 \pi x + C$
   (c) $(-2/3) (1 + \cot x)^{3/2} + C$
   (d) $(-1/3) (1 - \cot x)^{-3} + C$
   (e) $(-2/3) (4 + 3 \cot x)^{1/2} + C$
   (f) $-ln|2 + \cot x| + C$
7. (a) $-\cos x + C$ (b) $(\sin 3x)/3 + C$
   (c) $(-1/\pi) \cos (\pi x + \pi/6) + C$
   (d) $(-1/3)\ ln|\cos 3x| + C$
8. (a) $\cos x + C$ (b) $(\sin^2 x)/2 + C$
   (c) $-ln|\cos \sqrt{x}| + C$

Exercise 13.5

1. (a) $[x - (\sin 8x)/8]/2 + C$
   (b) $(1/4)[3x/2 - (1/\pi) \sin (2\pi x) + (1/8\pi) \sin (4\pi x)] + C$
   (c) $(1/2)\{t - (1/4) \sin[2(1 - 2t)]\} + C$
   (d) $(1/2)\{x + [\sin (4\pi x)]/(4\pi)\} + C$
   (e) $[-1/(2\pi)]\{\cos (2\pi t) - [\cos^3 (2\pi t)]/3\} + C$
   (f) $(2/\pi)\{\sin (\pi x/2) - [\sin^3 (\pi x/2)]/3\} + C$
   (g) $(-1/\pi)\{\cos (\pi t) - (2/3) \cos^3 (\pi t) + (1/5) \cos^5 (\pi t)\} + C$
   (h) $(-1/\pi)\{\sin (1 - \pi x) - (1/3) \sin^3 (1 - \pi x)\} + C$
   (i) $(2/\pi)\{\cos [1 - (\pi x/2)] - (2/3) \cos^3 [1 - (\pi x/2)] + (1/5) \cos^5 [1 - (\pi x/2)] + C$
2. (a) $[1/(2\pi)] \sin^2 (\pi t) + C$ or $[-1/(4\pi)] \cos (2\pi t) + C$
   (b) $[2/(3\pi)] \sin^3 (\pi x/2) + C$
   (c) $[-1/(9\pi)] \cos^3 (3\pi x) + C$
   (d) $[1/(3\pi)] \sin^6 (\pi x) + C$
   (e) $(1/8) [x - (\sin 2x)/2] + C$
   (f) $(1/\pi)\{[\sin^3 (\pi t)]/3 - [\sin^5 (\pi t)]/5\} + C$
   (g) $(-1/2)\{[\cos^3 (2x)]/3 - [\cos^5 (2x)]/5\} + C$
   (h) $1/\cos (x) + \cos (x) + C$
   (i) $-1/\sin (x) - \sin (x) + C$

Exercise 13.6

1. (a) $(1 + 2x)^7/14 + C$
   (b) $-(1 - 2t)^{3/2}/3 + C$
   (c) $4 (x^2 + 1)^{3/2}/3 + C$
   (d) $4 (1 + x^{3/2})^{3/2}/9 + C$
   (e) $-(9 - 4x^2)^{1/2}/2 + C$
   (f) $4(x^3 - 8)^{1/2}/3 + C$
2. (a) $4 (4 + \sqrt{x})^{5/3}/5 - 16 (4 + \sqrt{x})^{3/2}/3 + C$
   (b) $2 (1 + x)^{5/2}/5 - 2 (1 + x)^{3/2}/3 + C$
   (c) $(-2/3) (1 - x)^{3/2} + (4/5) (1 - x)^{5/2} - (2/7)(1 - x)^{7/2} + C$
   (d) $(1/32) [2 (1 + 2x)^{11/2}/11 + 8 (1 + 2x)^{9/2}/9 + 12 (1 + 2x)^{7/2}/7 + 8 (1 + 2x)^{5/2}/5 + 2 (1 + 2x)^{3/2}/3] + C$
   (e) $(1/4) [(2x + 1) - ln|2x + 1| + C$
   (f) $(x + 2) - 4ln|x + 2| - 5/(x + 2) + C$
   (g) $4 (4 + x)^{3/2}/3 - 16 (4 + x)^{1/2} + C$
   (h) $2(2 + \sqrt{x} - 2\ ln|2 + \sqrt{x}|) + C$

3. (a) $\sin x^2 + C$
   (b) $(-3\cos(x^2 + 1))/2 + C$
   (c) $(\tan(2x^2)/4 + C$ (d) $-2ln|\cos x^2| + C$
   (e) $(\sin(2x^2 + 1)/4 + C$
   (f) $(-\cos(2 + x^3))/3 + C$
4. (a) $(1 + \sqrt{x})^4/2 + C$ (b) $(1 + ln|x|)^3/3 + C$
   (c) $[2x + 3 + ln|2x + 3|]/4 + C$
   (d) $1/(1 - x) + 3ln|1 - x| - (1 - x) + C$
   (e) $2(x + 9)^{3/2}/3 - 16(x + 9)^{1/2} + C$
   (f) $2[(1 + \sqrt{x})^3/2 - 3(1 + \sqrt{x})^2/2$
   $+ 3(1 + \sqrt{x}) - ln|1 + \sqrt{x}|] + C$
   (g) $(-1/2)\cos(x^2) + C$
   (h) $2\sin(\sqrt{x}) + C$ (i) $\cos(1/x) + C$
   (j) $-\sin(e^{-x}) + C$ (k) $(1/2)\tan(x^2) + C$
   (l) $-1/[3\tan(x^3)] + C$

Exercise 13.7

1. (a) $-2(4 - x^2)^{1/2} + C$
   (b) $(-1/4)(9 - 4t^2)^{1/2} + C$
   (c) $\tan^{-1} x + C$
   (d) $(1/15)\tan^{-1}(3x/5) + C$
2. (a) $-\cos^{-1}(x/2) + C$
   (b) $(-1/2)\cos^{-1}(2x/3) + C$
   (c) $[\sin^{-1} x + x\sqrt{(1 - x^2)}]/2 + C$
   (d) $-2\cos^{-1}(x/2) + (x\sqrt{(4 - x^2)})/4 + C$
   (e) $-\sqrt{(1 - x^2)} - \sin^{-1} x + C$
   (f) $-2\sqrt{(16 - x^2)} - \cos^{-1}(x/4) + C$
3. (a) $[\tan^3 x]/3 + [\tan^5 x]/5 + C$
   (b) $(2/3)[3\tan x + 2]^{1/2} + C$

Exercise 13.8

1. (a) $x - 2\,ln|x + 2| + C$
   (b) $x/2 - (5/4)\,ln|2x + 1| + C$
   (c) $-3x/2 - (1/4)\,ln|1 - 2x| + C$
2. (a) $(1/2)\,ln|(x - 1)/(x + 1)| + C$
   (b) $(3/14)\,ln|2x + 1| + (2/7)\,ln|x - 3| + C$
   (c) $(-13/24)\,ln|3x + 2| - (9/8)\,ln|2 - x| + C$
   (d) $(-2/3)\,ln|2x - 1| + (5/3)\,ln|x - 2| + C$
   (e) $x - (3/5)\,ln|x + 2| + (8/5)\,ln|x - 3| + C$
   (f) $(1/2)\,ln|x + 1| + (1/10)\,ln|x - 3|$
   $- (3/5)\,ln|x + 2| + C$
3. (a) $ln|x/(x - 1)| - 2/(x - 1) + C$
   (b) $3ln|x| + 1/x - 3ln|x + 1| + C$
3. (c) $3ln|x + 1| + 1/(x + 1) - 3ln|x + 2| + C$
   (d) $x - 1/[2(x - 1)] + (5/4)ln|x - 1|$
   $- (1/4)\,ln|x + 1| + C$
   (e) $3/[4(x + 2)] + (3/16)ln|x - 2|$
   $+ (13/16)\,ln|x + 2| + C$
   (f) $x - 28/[3(x - 3)] + (1/9)ln|x|$
   $+ (53/9)\,ln|x - 3| + C$
4. (a) $-ln|x + 1| + (1/2)\,ln|x^2 + 1| + C$
   (b) $-2\,ln|x + 1| + ln|x^2 + x + 1| + C$
   (c) $ln|x - 1| + ln|x^2 + x - 1| + C$

Exercise 14.1

1. (a) $(1/2)\,ln(3/2)$ (b) $-5ln2 + 3ln3$
   (c) $4ln3 - 7ln2$
2. (a) $1 + 5ln2 - 4ln3$ (b) $1 + (3/2)ln3 - ln2$
   (c) $-5/2 + 3ln2 + 2ln3$
3. (a) $-1/2 - 3ln2 + 2ln3$
   (b) $1/8 + (1/4)ln2 - (1/4)ln3$
   (c) $5/4 + (3/4)ln2 + (1/4)ln3$
4. (a) $3ln2$ (b) $-4\,ln2$ (c) $2ln3 - 3ln2$

Exercise 14.2

1. (a) $2[-(2\sqrt{3})/5 + (16\sqrt{2})/15]$
   (b) $2[8ln2 - 4ln3 - 1]$ (c) $2 - ln3$
   (d) $-26/3 + (28\sqrt{2})/3$
2. (a) 2 (b) 1 (c) 1/2
3. (a) $\pi/12$ (b) $\pi/18$ (c) $\pi/8$

Exercise 14.3

1. (a) 8/3 (b) 16/3 (c) 8 (d) 1/3
2. (a) 9/8 (b) 2 (c) $2(\sqrt{2} - 1)$
   (d) $e^2/2 + 1/e - 3/2$
3. (a) 1/6 (b) 9/2 (c) 13/6 (d) 13/6
4. (a) 2 (b) 9/2 (c) $5/3 - 2ln2$
   (d) $8/3 - 2ln3 + 2ln2$
5. (a) $\pi/8 + (\sqrt{3})/2 - 1$ (b) $(\sqrt{3})/2 + \pi/2$
6. $(1/2)[5 + ln(45/64)]$
7. 4 8. $8 - \pi/3$ 9. $9\pi/4$
10. (a) 2.9540 (b) 9.8633
    (c) 4.1045 (d) 18.6768
11. (a) 0.6321 (b) 0.8415
    (c) 0.7372 (d) 1.8887
12. (a) 32/3 (b) 9/2
    (c) $(32\sqrt{2})/3$ (d) 16/5
13. (a) $3/4 - 2b + 3b^2/2 - b^4/4$
    (b) $b^4/4 - 3b^2/2 + 2b + 51/4$
    (c) $b^4/4 - 3b^2/2 + 2b + 51/4$

Exercise 14.4

1. (a) $16\pi/15$ (b) $512\pi/15$ (c) $16\pi/15$
   (d) $\pi/105$ (e) π^2 (f) π^2
2. (a) 3.35 (b) 342.96 (c) 154.57
   (d) 17.40 (e) 35.02 (f) 2.47
   (g) 9.42 (h) 3.35
3. (a) 1.57 (b) 7.33 (c) 0.71
   (d) 9.07 (e) 0.52 (f) 7.87
   (g) 113.10 (h) 201.06
4. (a) 64.72 (b) 37.70 (c) 724.10
   (d) 3.14 (e) 40.74

Exercise 15.1

1. (a) 1.09 error 0.7%
   (b) 1.069 error −1.2%
   (c) 1.0807 error −0.16%
2. (a) 9.0009 error 0.01%
   (b) −68.3344 error 0.0015%
3. (a) 0.7469 (b) 0.3103
4. (a) 8.7733 (b) 1.4558
5. (a) 6.7965 (b) 1.4035

Exercise 16.1

1. (a) $y = ln|x^2 + 1| - 4$
   (b) $y = (-1/2)ln|(x-1)(x+1)^3| + 2$
   (c) $y = -4ln|x+1| + 5\ ln|x+2| - 4\ ln 2$
   (d) $y = -\sin^{-1}(x)$ (e) $y = \tan^{-1}(2x)$
   (f) $y = \sin^{-1}(x) + x\sqrt{(1-x^2)}$
2. $y = -2\pi x + \sin(2\pi x)$ 3. $y = \sin^2(x) - 2$
4. $y = -12\cos(x) + 4\cos^3(x) + 4$
5. $y = 6(x+1)^{5/2} - 10(x+1)^{3/2} + 2$
6. $y = -2x + 2\ ln|2x+1| + 2$

Exercise 16.2

1. (a) $y = 100e^{0.02t}$ (b) $y = 50e^{3t}$
   (c) $y = 202e^t - 2$ (d) $y = [4 + 1196e^{-3t}]/3$
   (e) $y = [-1 + 501e^{-10t}]/5$
   (h) $y = (1/2)(1 + 399e^{-20t})$
2. $dy/dt = 0.03y$ with $y(0) = 100\ 000$
3. $dP/dt = P/3$ with $P(0) = 100\ 000$
4. 4 620 981 yrs
5. 194.34 yrs, 839.91 yrs
6. 1.33 rads 7. 0.46g
8. (a) 2.23% (b) 0.288%
9. (a) $k = 0.067\ 29$ (b) 22.9 min
10. (a) $k = 0.030\ 31$ (b) 81.3 min
11. $I = 2(1 - e^{-4t})$ 12. (b) 69.31 min
13. (a) $a = 80, b = 25$
    (b) $m = 2\ 000, n = 1\ 500, k = 1/25$
    (c) 1.72 min (d) $500 \le Q < 2\ 000$
14. (a) $a = 16, b = 62.5$
    (b) $m = 1\ 000, n = 9\ 000, k = -2/125$
    (c) 111.98 min (d) $1\ 000 < Q \le 10\ 000$

Exercise 16.3

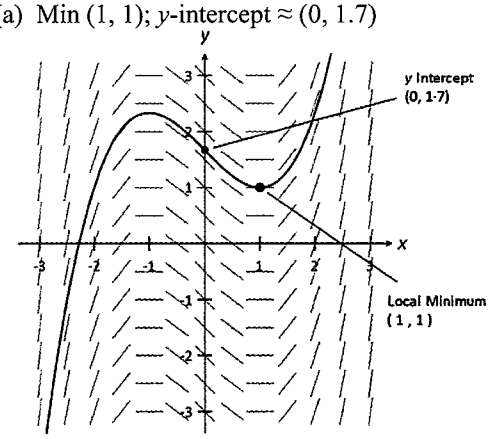
1. (a) $dP/dt = 0.2P(1 - P/1000)$
   $= 0.0002P(1000 - P)$
   (b) $dP/dt = 0.1P(1 - P/500)$
   $= 0.0002P(500 - P)$
   (c) $dP/dt = 0.5P(1 - P/10\ 000)$
   $= 0.000\ 05P(10\ 000 - P)$
   (d) $dP/dt = 0.25P(1 - P/5000)$
   $= 0.000\ 05P(5000 - P)$
2. (a) $P = 1000/(1 + 19e^{-2t})$
   (b) $P = 100/(1 + 4e^{-0.05t})$
   (c) $C = 50/(1 + 9e^{-0.1t})$
   (d) $\theta = 1000/(1 + 24e^{-0.05t})$
3. (a) $y = 200/(1 + e^{-4t})$
   (b) $P = 100/(1 + 9e^{-t})$
   (c) $P = 50/(1 + 0.25e^{-0.2t})$
   (d) $x = 100/(1 + 4e^{-0.5t})$
4. (a) $P = 100/(1 + 3e^{-0.05t})$
   (b) 21.97 years
5. (a) $P = 20\ 000/(1 + 99e^{-0.08t})$
   (b) 181.2 years
6. (a) $P = 2000/(1 + 199e^{-10t})$
   (b) 3 weeks
7. 394 minutes to reach 49.9g/L
8. 11.6 days
9. 15.2 hours
10. Yes, if the company is able to attract about 338 families on its opening day.
11. $k = 0.1099$
12. $k = 0.06592$
13. $dP/dt = 0.1P(1 - P/1000]$
14. $y = (4e^{2t} - 3)/(3 - 2e^{2t})$

Exercise 16.4

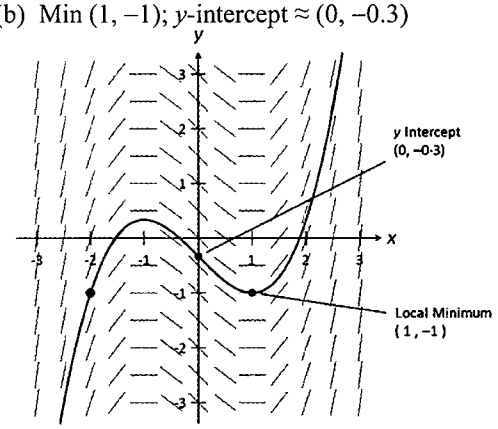
1. (a) $y = ln|x| + x^2/2 + A$
   (b) $y = A(x-1) - 1$
   (c) $y = \pm\sqrt{(1 - A\,e^{x^2}/x^2)}$
   (d) $y = Ae^{\cos x}$
2. (a) $y = \sqrt{(e^x + 3)}$
   (b) $y = ln[(1 + x^2)/2]$
   (c) $y^2/2 + y = ln(x+1) + 3/2$
   (d) $y = 3xe^{x-1} - 1$ (e) $y = x$
   (f) $y = \pm\sqrt{(1/\sin^2 x - 1)}$

Exercise 16.5

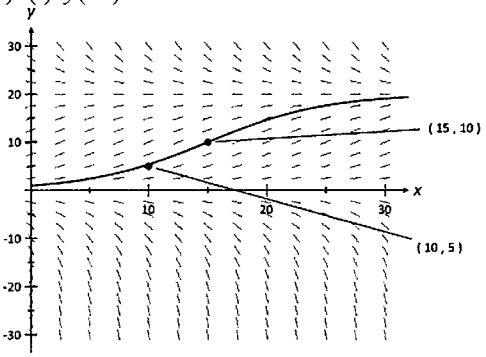
1. (a) Min (1, 1); y-intercept $\approx$ (0, 1.7)



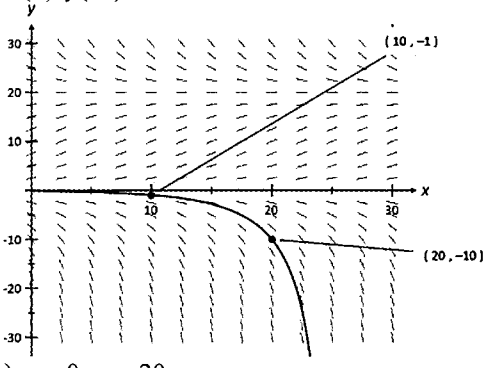
(b) Min (1, −1); y-intercept $\approx$ (0, −0.3)



2. (a) (i) $y(10) \approx 5$

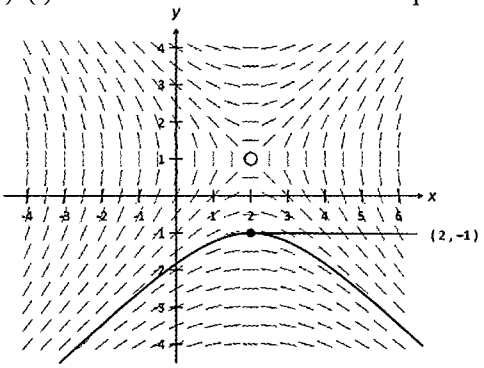


(ii) $y(10) \approx -1$

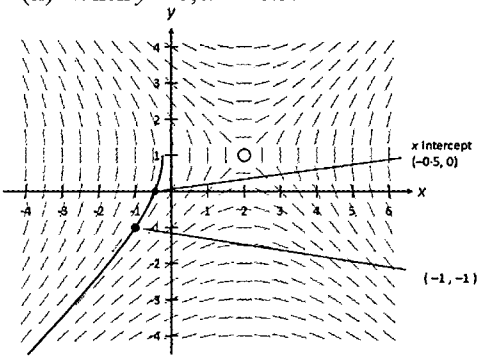


(b) $y = 0$, $y = 20$

3. (a) (i) Curve does not have an x-intercept.



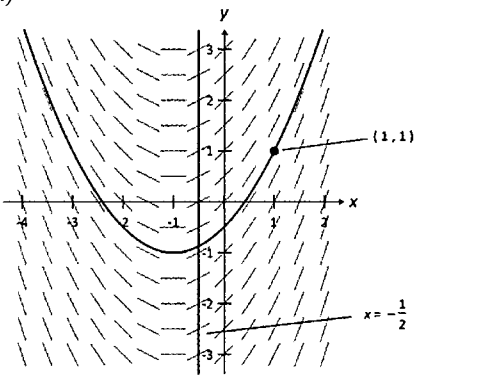
(ii) When $y = 0$, $x \approx -0.5$.



(b) $y = x - 1$ where $x \neq 2 \cap y \neq 1$

4. Slope field has zero gradient for $x = 2$ and infinite gradient for $y = 1$; hence C.
   Isocline with gradient −2 is $y = -x/2 + 2$

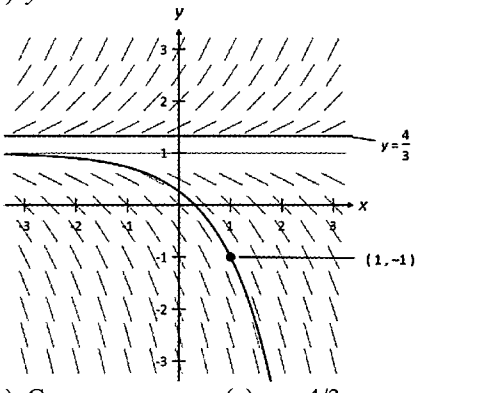
5. (a)



(b) Slope field has zero gradient for $x = -1$, hence, A.

(c) $x = -1/2$.

6. (a) $y \approx 0.3$



(b) C (c) $y = 4/3$

7. (a) $dy/dx = 1$ (b) $dy/dx = -2$
   (c) $dy/dx = x^2$ (d) $dy/dx = -y^2$
   (e) $dy/dx = xy$ (f) $dy/dx = (x-1)/y$

Exercise 17.1

1. (a) −0.35 m (b) 0.79 s
   (c) 3.64 m (d) 3.99 m
2. (a) $3\pi/4$ s, -14.92 ms^{-1} (b) 4.81 ms^{-1}
3. (a) $0.4637 + (n\pi/2)$ sec. $n = 0,1,2,3,\ldots$
4. (a) -8 ms^{-2} (b) 2 ms^{-1}
5. (a) $\pi/3$ s (c) $0, \pi/2, \pi$ s
6. (a) 8 ms^{-1} (b) 16/3 m (c) 2 ms^{-1}
7. (a) 0 (b) 1 sec
8. (a) $x = -2 + 2e^{2t}$ (b) $a = 8e^{2t}$
9. (a) -21 ms^{-2} (b) 0, 2 m
10. (a) 4 ms^{-1} (b) 1.76 ms^{-2}
11. (a) -2π ms^{-1} (b) 1/2 second
12. (a) 9/2 ms^{-1} (b) 121/30 m
13. (a) $v = 4(1 - e^{-t})$ (b) 4 ms^{-1}
14. (a) $v = -5(1 - e^{-2t})$ (b) -5 ms^{-1}
15. (a) $v = (g/k)(1 - e^{-kt})$ (b) g/k
16. $v = (5/4)\sqrt{(1 - e^{-32x})}$; 5/4 ms^{-1}
17. $v = 2(1 + e^{-100t})/(1 - e^{-100t})$; 2 ms^{-1}
18. $v = \pm(1/k)\sqrt{(1 - e^{-2gk^2x})}$
19. (a) $v = \sqrt{(16 - 9x^2)}$
    (b) $-4/3 \le x \le 4/3$; $0 \le v \le 4$
20. (a) $v = 2\sqrt{(4x - x^2)}$
    (b) $0 \le x \le 4$; $0 \le v \le 4$
21. (a) $v = 4/\sqrt{x}$ (b) $x = (6t + 64)^{2/3}$
22. (a) $v = -2(x^2 + 1)$ (b) $x = -\tan(2t)$

Exercise 17.2

1. $x = 10 \sin 2t$ 2. $h = 5 \cos(5\pi t)$
3. $y = 4 \sin(3t + \pi/6)$
4. $Q = 10\sqrt{2} \sin(4\pi t - \pi/4)$
5. (a) $x = 3 \sin(2\pi t)$ (b) 3 cm, 1 second
   (c) 6π cms^{-1} (d) 0.05, 0.45 seconds.
6. (a) $x = 4 \cos(4\pi t)$ (b) 0
   (c) $\pm 8\pi\sqrt{3}$ cms^{-1}
7. (a) $10 \sin(t + \pi/3)$ (b) $0 \le$ speed ≤ 10
   (c) $\pm 5\sqrt{3}$ cm
8. (a) 2π cms^{-1} when $t = (2n + 1)$ sec. at $x = 0$
   (b) 0 cms^{-1} when $t = 2n$ sec. at $x = \pm 4$ cm
   (c) 32 cm
9. (a) $2\pi/15$ cms^{-1}; $2\pi^2/225$ cms^{-2}
   (b) (i) $x = \pm\sqrt{3}$ cm (ii) $x = -1$ cm
10. (a) $\theta = 5 \sin(\pi t/12 - \pi/6)$
    (b) Min Temp 10 C at 8 pm
    (c) 16 hours
11. (a) $h = 0.2 \cos(\pi t/14 + \pi/3)$
    (b) ± 0.14 m (c) 0.14 m
12. (a) $x = 0.2 \sin(\pi t/14 + \pi/2) + 0.3$
    (b) (i) $-\pi/70$ (ii) 0 (c) 0.46 mg
13. (a) (i) $\pm 2.27^{\circ}$C/hr (ii) $\pm 2.61^{\circ}$C/hr
    (b) 66.7% (c) 30°C
14. (a) $h = 4 + 0.5 \sin(\pi t/6)$
    (b) 4.5 hours (c) 0.13 m/hour
15. (a) $x = \pm 6\sqrt{3} \sin(\sqrt{2}\, t + \alpha)$
    (b) $12\sqrt{3}$ cms^{-2}
16. (b) 100 cm 17. (b) $\pm 2\pi\sqrt{105}$
18. (a) 2 minutes, 10 (b) 2 minutes, 10
19. (a) 2 seconds, 10 cm (b) $\pm 3\sqrt{11}$

Exercise 18.1

1. (a) $< 1/t, e^t, e^{-t} - te^{-t} >$;
   $< -1/t^2, e^t, -2e^{-t} + te^{-t} >$
   (b) $< 2\cos 2t, -2\sin 2t, 2(1 + \tan^2 2t) >$;
   $< -4\sin 2t, -4\cos 2t, 8(1 + \tan^2 2t) >$
   (c) $< -1/t^2, 1/(t+1)^2, -1/(t-1)^2 >$;
   $< 2/t^3, -2/(t+1)^3, 2/(t-1)^3 >$
   (d) $< -\pi \sin \pi t\, e^{\cos \pi t}, \pi \sin \pi t\, e^{-\cos \pi t}, \pi \cos \pi t\, e^{\sin \pi t} >$;
   $< \pi^2 \sin^2 \pi t\, e^{\cos \pi t} - \pi^2 \cos \pi t\, e^{\cos \pi t}, \pi^2 \sin^2 \pi t\, e^{-\cos \pi t} + \pi^2 \cos \pi t\, e^{-\cos \pi t}, \pi^2 \cos^2 \pi t\, e^{\sin \pi t} - \pi^2 \sin \pi t\, e^{\sin \pi t} >$
2. $2 + 4t$; $t = -1/2$ 3. $0 \le t \le 2\pi$
4. $0, \pi/2, \pi, 3\pi/2, 2\pi$ 5. $n = 4$
6. $(2t + 4t^3)/[2\sqrt{(4 + t^2 + t^4)}]$
7. $\{\sqrt{[5(t+1)^4 + 1]}\}/(t+1)^2$
8. $4 + 6t^2$; 4 9. No solution
10. $\pi/4, 3\pi/4, 5\pi/4, 7\pi/4$
11. (a) $< a, 2\sin t, 3\cos t > + \boldsymbol{c}$; $< 0, 2, -3 >$
    (b) $< t + \ln t, t - \ln t, \ln(1 + t) > + \boldsymbol{c}$;
    $< 1 + \ln 2, 1 - \ln 2, \ln(3/2) >$
12. (a) $\sqrt{2}, \pi/2$ (b) $\sqrt{5}, 2.64$
13. $< t - t^2 + 1, 4t + 1, t^2/2 >$
14. $< \cos \pi t, t, -1 + 2\sin \pi t >$
15. $< -1, t^3, -t^2 >$
16. $< -\sin \pi t, 1 - \cos \pi t, \pi t - \sin \pi t >$
17. 50

Exercise 18.2

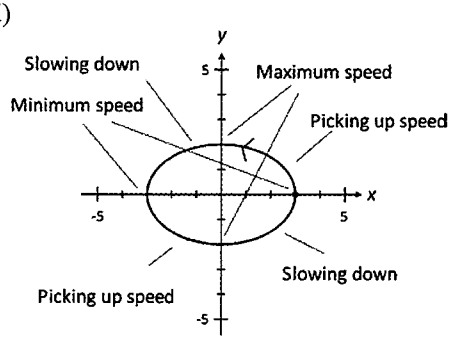
1. (a) $< 10, 20, -8 >$ (b) $< -8, 18, 34 >$
   (c) $< 0, 0, 1 + \ln 2 >$ (d) $< 0, 1, \pi/4 >$

2. (a) $< 7, -4, 150 >$ (b) $< -101, 99, 22 >$
   (c) $< 1 + 6\pi, 1 + 2\pi, -2\pi >$
   (d) $< 8\pi - 1, 1, 8\pi^3 >$
3. (a) $< 0, 0, 2 >$; $\sqrt{10}$ ms^{-1}
   (b) 0^o (d) 3.05 m
4. (b) 45^o, 1 ms^{-1} (c) $< 0, 0, 0 >$
5. (a) 1 sec. (b) 0.54 m
   (c) 1 sec.
6. (a) Min of 0 cm when $t = 2n\pi$ sec.
   Max of $2\sqrt{2}$ cms^{-1} when $t = (2n + 1)\pi$ sec.
   (b) $t = 0, \pi/2, \pi, 3\pi/2, 2\pi$ sec.
7. (b) $x - 1 = 2 - y = z - 1$
8. (a) 143.3^o (b) 2 s, $< -16/3, 3, -2 >$
   (c) $x = t^3/3 - 4t, y = t + 1, z = -2t + 2$
9. (a) $t = 2$ sec. at $< 0, -4, 8 >$
   (b) 17.1^o
10. (a) $t = 1$ sec. at $< 2, 0, 0 >$
    (b) 10.89^o

Exercise 18.3

1. P: $0\boldsymbol{i} + 2\boldsymbol{j}, x^2 + y^2 = 4$ clockwise;
   Q: $2\boldsymbol{i}, x^2 + y^2 = 4$ anti–clockwise
   R: $2\boldsymbol{i}, x^2 + y^2 = 4$ clockwise
2. (a) In the direction of the positive y–axis;
   $2\pi/3$ to the positive x–axis
   (b) $-\pi\boldsymbol{j}$ (c) 1/2
3. (a) 1
   (b) $x^2 + y^2 = 1/(16\pi^2)$; anti-clockwise
   (d) 1
4. $\boldsymbol{a} \bullet \boldsymbol{v} = 0$ for all t.
5. (a) $-i$ (b) $4\pi^2 i$
   (c) $t = (4n + 3)/8$ sec. for $n = 0, 1, 2, 3, \ldots$
6. (a) $\boldsymbol{j}$ (b) $(-\pi^2/4)\boldsymbol{j}$
   (c) $t = (6n + 2)/3$ sec. for $n = 0, 1, 2, 3, \ldots$
7. (a) $t = n\pi$ sec. for $n = 0, 1, 2, 3, \ldots$.
   (b) $(n + 1/6)\pi$ sec. for $n = 0, 1, 2, 3, \ldots$
   (c) $x^2 + (y - 2)^2 = 1$; clockwise
8. (a) $x^2 + y^2 = 1$; anti-clockwise
   (b) $\sqrt{2}\,\boldsymbol{i} + \sqrt{2}\,\boldsymbol{j}$ or $-\sqrt{2}\,\boldsymbol{i} - \sqrt{2}\,\boldsymbol{j}$
   (c) $t = (4n + 1)\pi/8$ sec. for $n = 0, 1, 2, 3, \ldots$
9. No collision
10. (a) $0, \pi/2, \pi, 3\pi/2, 2\pi$
    (b) $\sqrt{(9 - 5\cos^2 t)}$
    (c) Max speed = 3 when $t = \pi/2$ at (0, 2),
    and $t = 3\pi/2$ at (0, –2);
    Min speed = 2 when $t = 0$ & 2π at (3, 0)
    and $t = \pi$ at (–3, 0).

10. (d)



11. (a) 2π (b) $0, \pi/2, \pi, 3\pi/2, 2\pi$
    (c) At $(0, -4)$ when $t = (4n + 1)\pi/2$, $-3\boldsymbol{i}$;
    At $(0, 4)$ when $t = (4n + 3)\pi/2$, $3\boldsymbol{i}$;
    (d) At $(3, 0)$ when $t = 2n\pi$, $-4\boldsymbol{j}$;
    At $(-3, 0)$ when $t = (2n + 1)\pi$, $4\boldsymbol{j}$;
12. Period 2π; $(x - 2)^2/9 + (y - 4)^2/25 = 1$
13. (a) 3 m (b) $\pm 12\pi^2\,\boldsymbol{i}$
    (c) $t = n/2$ sec. for $n = 0, 1, 2, 3, \ldots$
    (d) $t = (4n + 3)/8$ sec. for $n = 0, 1, 2, 3, \ldots$
14. (a) $13\sqrt{2}/2$ cm
    (b) $x^2/25 + y^2/144 = 1$, clockwise
    (c) $\boldsymbol{r} = 5\boldsymbol{i}$ for $t = 2n$ sec. for $n = 0, 1, 2, 3, \ldots$
    $\boldsymbol{r} = -5\boldsymbol{i}$ for $t = (2n + 1)$ sec. $n = 0, 1, 2, 3, \ldots$
    (d) $t = (6n + 5)/6$ sec. for $n = 0, 1, 2, 3, \ldots$
15. (a) Min 3 cms^{-1}, Max 4 cms^{-1}
    (b) $\pm 3\,\boldsymbol{i}$ or $\pm 4\,\boldsymbol{j}$
    (c) $t = n\pi$ sec. for $n = 0, 1, 2, 3, \ldots$
16. (a) $(x - 1)^2/9 + (y - 2)^2/16 = 1$, anti-clockwise
    (b) $2\sqrt{5}$ cm or $\sqrt{37}$ cm or $2\sqrt{2}$ cm or $\sqrt{5}$ cm
17. $t = 0.64$ sec. at $(-2.4, 2.4)$, $\boldsymbol{v}_P = 1.8\boldsymbol{i} + 3.2\boldsymbol{j}$,
    $\boldsymbol{v}_Q = -1.2\boldsymbol{i} - 0.8\boldsymbol{j}$
18. When $t = \pi$ sec at $(1, -2)$; π radians

Exercise 18.4

1. (a) $30\boldsymbol{i} + (30\sqrt{3} - 9.8t)\boldsymbol{j}$, 5.6^o to the horizontal
   (b) 95.6^o (c) 10.60 sec., 318 m
2. (a) $106.07\boldsymbol{i} + 61.97\boldsymbol{j}$ (b) 20.7^o
   (c) 1.93 s, 5.28 s (d) $y = x - 0.0392x^2$
3. (a) $< 20t, 20t - 4.9t^2 >$
   (b) 45^o
   (c) $< 17.25, 13.61 >$ when $t = 0.86$ sec.
   (d) 93.7 m
4. (a) $< 25\sqrt{3}, 25 - 9.8t >$;
   $< 25\sqrt{3}t, 25t - 4.9t^2 + 150 >$
   (b) 8.64 sec.
   (c) -54^o to the horizontal
   (d) 374.3 m
5. (a) $< 50, -9.8t >$; $< 50t, (100 - 4.9t^2) >$
   (b) 4.52 sec. (c) 225.88 m
   (d) -41.52^o to the horizontal

6. (a) 13 ms^{-1} (b) 2.975 m
   (c) 2.75 m
   (d) 9.52 ms^{-1}, -58.31^{o} to the horizontal
7. (a) $p = 30t_0$, $q = (30\sqrt{3})t_0 - 4.9t_0^2$
   (b) 7.07 sec.
   (c) 244.90 m up the slope of the hill
8. (a) $y = x\tan(20^{o}) - 4.9x^2/[400\cos^2(20^{o})]$
   or $y = -0.0139x^2 + 0.364x$
   (b) 18.89 m (c) 19.10 m
   (d) $t = 0$ sec
9. (a) $< 8.09, -18.62 >$ (b) 20.30 m
   (c) 20.34 m (d) 11.5^{o}
10. (a) 4 sec. (b) $< 72, 17.6 >$
11. 20 sec. ; $40\sqrt{5}$ m 12. (b) 3/10
13. (a) $< 3t^2 - 2, 2t >$ (b) $< 6t, 2 >$
    (c) 0, 2/3
14. (a) $< 20, 10 >$ (b) 5
    (c) 106.89
15. (a) 48.01^{o} above the horizontal
    (b) 26.9 m (c) 20 m when $t = 2$ sec.
    (d) $< 32, 0 >$ when $t = 4$ sec.
16. (a) 14 m (b) $< 14, 10 >$
    (c) 17.20 m (d) 20.34 m

Exercise 19.1

1. (a) $\bar{X} \sim N(100, 12^2/20)$
   (b) 0.3385 (c) 0.0312
2. (a) $\bar{X} \sim N(72, 8^2/50)$
   (b) 0.0987 (c) 0.4615
3. (a) $n = 74$ (b) $70 \le n \le 79$
4. (a) $n = 25$ (b) $25 < n < 100$
5. (a) 3 (b) $\mu = 3$, $\sigma = (\sqrt{3})/7$
   (c) $3 < n < 12$
6. (a) 18 (b) $\mu = 18$, $\sigma = 2/\sqrt{3}$
   (c) $48 < n < 108$
7. (a) Since, $X \sim$ Normal, $\bar{X} \sim N(1.7, 0.026^2)$
   (b) 0.6497 (c) 0.9728
8. (a) Since, $X \sim$ Normal,
   $\bar{X} \sim N(875, 11.7^2/\sqrt{20})$
   (b) 0.3346 (c) 0.0280
   (d) $n \ge 61$
9. (a) Since, $X \sim$ Normal, $\bar{X} \sim N(175, 8.5206^2)$
   (b) $n = 90$ (c) 8
   (d) 1812
10. (a) Since, $X \sim$ Normal, $\bar{X} \sim N(163, 9.8387^2)$
    (b) $n = 67$ (c) 35
    (d) 162
11. (a) 15, $(\sqrt{42})/2$; 15, $(\sqrt{42})/10$
    (b) $5 \le k \le 10$
12. (a) 95, $(\sqrt{19})/2$; 95, $(\sqrt{19})/12$
    (b) $3 \le k \le 18$
13. (a) 0.6, $(\sqrt{57})/10$ (b) 0.6, $(\sqrt{19})/20$
14. (a) $P(X = x) = 1/8$ $x = 1, 2, 3, \ldots, 7, 8$
    $\mu = 4.5$, $\sigma = 2.2913$
    (b) 4.5, 0.3819
15. (a) $P(X = x) = 1/6$ $x = 1, 2, 3, 4, 5, 6$
    $\mu = 3.5$, $\sigma = 1.7078$
    (b) 3.5, 0.4270 (c) $19 \le n \le 291$

Exercise 19.2

1. (a) $\bar{X} \sim N(200, 35^2/60)$ (b) 0.9866
2. (a) $\bar{X} \sim N(4.5, 1.2^2/80)$ (b) 0.5439
3. (a) $\bar{X} \sim N(12, 4/3)$ (b) 1/12 (c) 0.6135
4. (a) $\bar{X} \sim N(28, 108/49)$
   (b) (i) 1/18 (ii) 0.4110 (c) $n \ge 82$
5. (a) 12 min (b) $\bar{X} \sim N(12, 49/90)$
   (c) (i) 3/7 (ii) 0.08767 (d) 0.1660
6. (a) If $n < 30$, distribution for $\bar{X}$ is not known,
   mean = 2, s.d. = $(\sqrt{3})/(15\sqrt{n})$.
   If $n \ge 30$, by the CLT, $\bar{X} \sim$ Normal
   mean = 2, s.d. = $(\sqrt{3})/(15\sqrt{n})$.
   (b) (i) 0.6824 (ii) 0.8068
   The prob. of an event occurring increases as sample size n increases.
   (c) $n \ge 134$ (d) 0.9145
7. (a) (i) 0.8286 (ii) 0.9584 (b) $n = 240$
8. (a) (i) 0.7558 (ii) 0.8364 (b) 127.4 min.
9. (a) (i) 0.4115 (ii) 0.4718 (b) 87.2 min.
10. (a) $\bar{X} \sim N(0.15, 51/2000)$ (b) 0.1490
    (c) 29
11. (a) $\bar{X} \sim N(11/2, 33/200)$
    (b) (i) 3/10 (ii) 0.8907 (c) 89
12. (a) $\bar{X} \sim N(7, 91/1000)$
    (b) (i) 0.3556 (ii) 0.4995 (c) 50
13. (a) $P(X = x) = 1/8$ for $x = 1, 2, 3, \ldots, 7, 8$
    (b) $\bar{X} \sim N(9/2, 7/48)$ (c) 0.9048 (d) 0.7042
14. (a) $P(X = x) = 1/6$ for $x = 1, 2, 3, 4, 5, 6$
    Mean = 7/2
    (b) $\bar{X} \sim N(7/2, 5/84)$ (c) 0.0202 (d) $n \ge 12$
15. (a) 5, $3(\sqrt{2})/2$ (b) 5, 3/10
    (c) 0.9044 (d) 0.6408
16. (a) $P(X = x) = \dfrac{\binom{7}{x}\binom{3}{3-x}}{\binom{10}{3}}$ for $x = 0, 1, 2, 3$
    Mean = 21/10
    (b) $\bar{X} \sim N(21/10, 49/5000)$ (c) 0.1562

Exercise 19.3

1. (a) $\bar{X} \sim N(20, 0.3^2)$ (b) $N(20, 0.3^2)$
2. (a) $\bar{X} \sim N(100, (7\sqrt{2}/10)^2)$
   (b) $N(100, (7\sqrt{2}/10)^2)$
3. $\bar{X} \sim N(50, 1/2)$
4. (a) $\bar{X} \sim N(3, 9/400)$ (b) $N(3, 9/400)$
5. (a) $\bar{X} \sim N(2, 1/250)$ (b) $N(2, 1/250)$

6. (a) 15, $(5\sqrt{3})/3$ (b) $\bar{X} \sim N(15, 5/48)$
   (b) N(15, 5/48)
7. (a) 0, $(\sqrt{15})/5$ (b) N(0, 1/200)

Exercise 20.1

1. (a) 59.54, 5.7844 (b) 59.54, 5.7844
2. (a) 13.5, 8.7115 (b) $N(13.5, 1.1246^2)$
3. $\bar{X} \sim N(100, 9/8)$; N(100, 9/8)
4. $\bar{X} \sim N(10, 1/5000)$; N(10, 1/5000)
5. (a) 1, $(\sqrt{30})/6$; $\bar{X} \sim N(1, (\sqrt{30}/60)^2)$
   (b) N(0, 1)
6. (a) 5, $(5\sqrt{3})/3$; $\bar{X} \sim N(5, (\sqrt{3}/6)^2)$
   (b) N(0, 1); approx. N(0, 1)
7. (a) 1.1, 0.9434, 0.9595
   (b) 0.5708
8. (a) 11.4, 5.1743, 5.2628
   (b) 0.9367

Exercise 20.2

1. (a) $\bar{X} \sim N(33.7, 1.0733^2)$
   (b) (i) 33.7 ± 2.76 (ii) 33.7 ± 1.88
   (c) $n \geq 23$
2. (a) $\bar{X} \sim N(201.4, 3.525^2)$
   (b) (i) 201.4 ± 5.80 (ii) 201.4 ± 7.65
   (c) $n \geq 48$
3. (a) $\bar{X} \sim N(5.4, 0.12^2)$
   (b) (i) 5.4 ± 0.24 (ii) 5.4 ± 0.34
   (c) $n \geq 98$
4. (a) (i) 20.7 ± 0.57 (ii) 20.7 ± 1.14
   (b) $n \geq 46$
5. (a) (i) 0.3341 (ii) 0.01606
   (b) (i) 485 ± 5.76 (ii) 485 ± 6.13
   (c) $n \geq 25$
6. (a) 0.9431 (b) 125 ± 4.89 (c) $n \geq 28$
7. (a) 0.1030 (b) 12 ± 1.55 (c) 79.4%
8. (a) 0.9605 (b) 2.5 ± 0.089 (c) 88.6%
9. (a) 183 ± 1.18 (b) 90.4% (c) $n \geq 60$
10. (a) 1.645 (b) $29.8 \leq \mu \leq 30.2$
11. (a) $9.993 \leq \mu \leq 10.007$
    $9.991 \leq \mu \leq 10.009$
    $9.988 \leq \mu \leq 10.012$
    (b) No cause.
12. (a) $999.81 \leq \mu \leq 1000.19$
    $999.77 \leq \mu \leq 1000.23$
    $999.70 \leq \mu \leq 1000.3$
    (b) No cause.

Exercise 20.3

1. Significant at 10%, 5% and 1% levels.
2. Significant at 10% and 5% but not at 1%.
3. Significant at 10%, 8% and 2% levels.
4. (a) Significant at 5% level.
   (b) 15.7%
5. (a) 5.9% (b) (i) $n \geq 55$ (ii) $n \geq 39$
6. (a) 2.5% (b) (i) $n \geq 107$ (ii) $n \geq 62$

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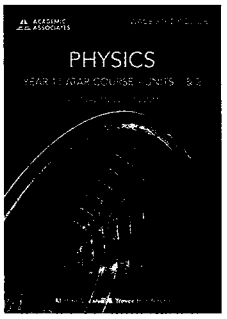

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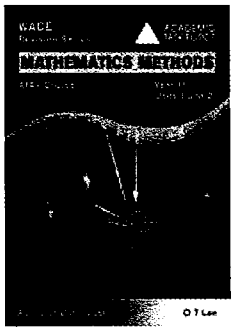

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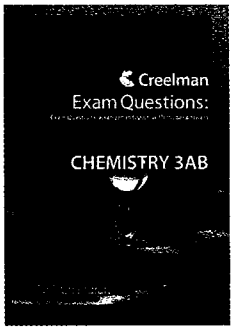

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