

SECTION 4.1

29. $f(x) = 4x - 1$, $g(x) = -2x + 5$

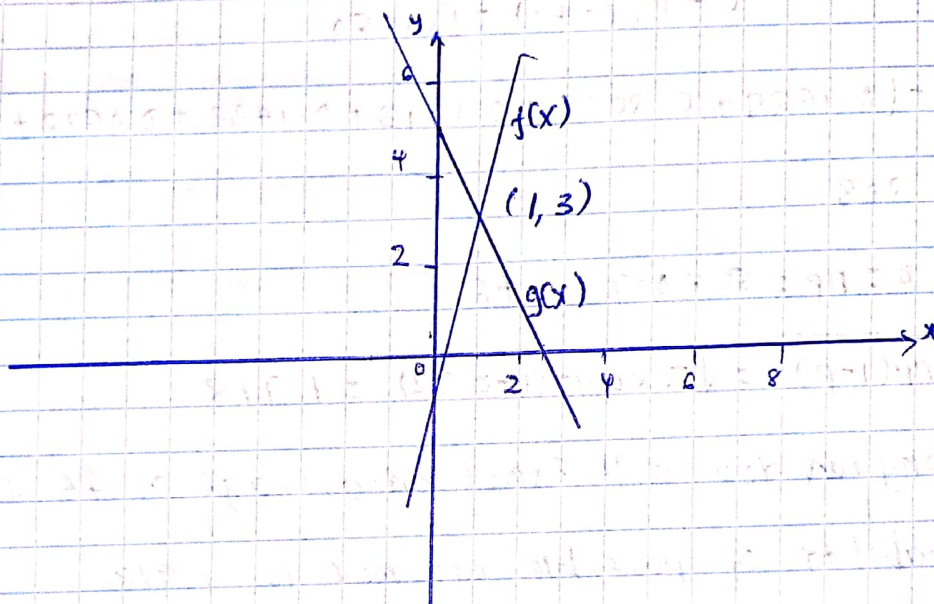
(a) $f(x) = 0 = 4x - 1$
 $4x - 1 = 0$
 $4x = 1$ $x = \frac{1}{4}$

(b) Solve $f(x) > 0$
 $4x - 1 > 0$
 $4x > 1$
 $x > \frac{1}{4}$

(c) $f(x) = g(x)$
 $4x - 1 = -2x + 5$
 $6x = 6$
 $x = 1$

(d) $f(x) \leq g(x)$
 $4x - 1 \leq -2x + 5$
 $6x \leq 6$
 $x \leq 1$

(e)



33. (a) $f(x) = g(x)$
 $x = -4$

(b) $f(x) > g(x)$
 $x < -4$

37. $C(x) = 2.5x + 85$

(a) $C(40) = 2.5(40) + 85 = 185$ dollars

(b) $C(x) = 2.5x + 85 = 245$
 $2.5x = 160$
 $x = 64$ miles

(c) $C(x) = 2.5x + 85 = 150$
 $2.5x = 65$
 $x = 26$ miles

(d) Domain = $[0, \infty)$

$$41. \quad S(p) = -600 + 50p$$

$$D(p) = 1200 - 25p$$

$$(a) \quad S(p) = D(p)$$

$$-600 + 50p = 1200 - 25p$$

$$75p = 1800$$

$$p = 24 \quad \text{Units}$$

$$(b) \quad D(p) > S(p)$$

$$1200 - 25p > -600 + 50p$$

$$1800 > 75p$$

$$24 > p$$

$$p < 24$$

(c) The price will increase

SECTION 4.3

$$15. \quad f(x) = x^2 - 1 \quad \text{Graph C}$$

$$19. \quad f(x) = x^2 - 2x + 2 \quad \text{Graph G}$$

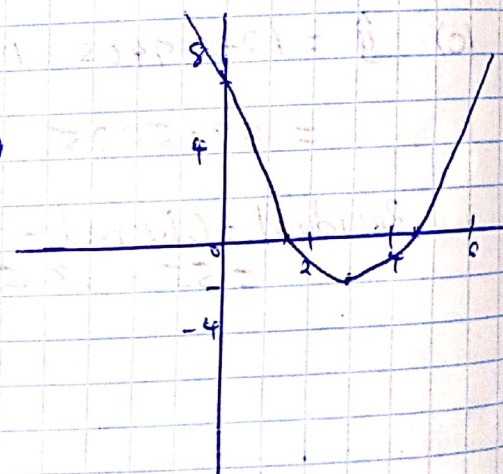
$$23. \quad f(x) = (x-3)^2 - 2$$

$$(a) \quad \text{Vertex} = (3, -2)$$

axis of symmetry, $x = 3$

(b) The graph concaves up.

(c)

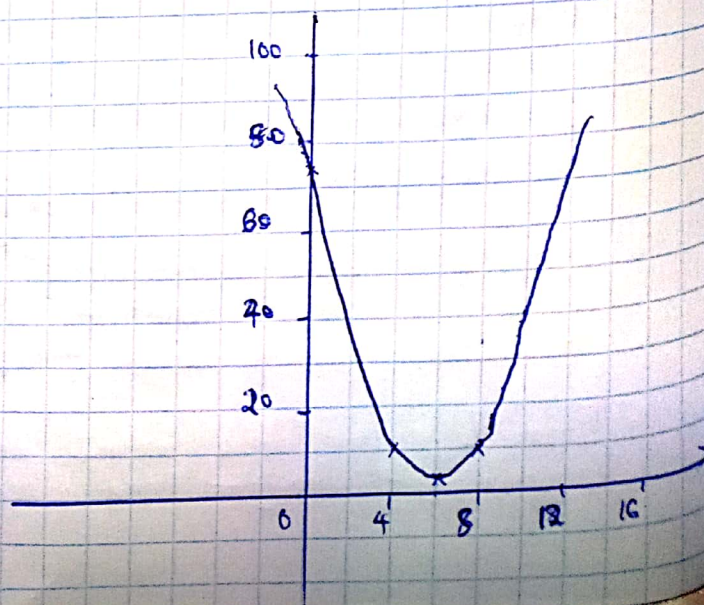


$$27. \quad f(x) = 2(x-6)^2 + 3$$

$$(a) \quad \text{Vertex} = (6, 3)$$

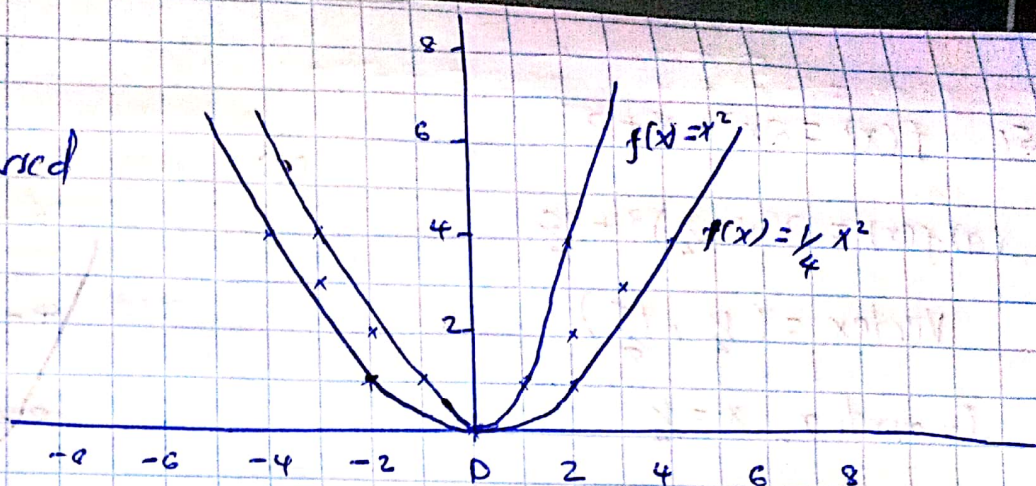
axis of symmetry, $x = 6$

(b) It concaves up



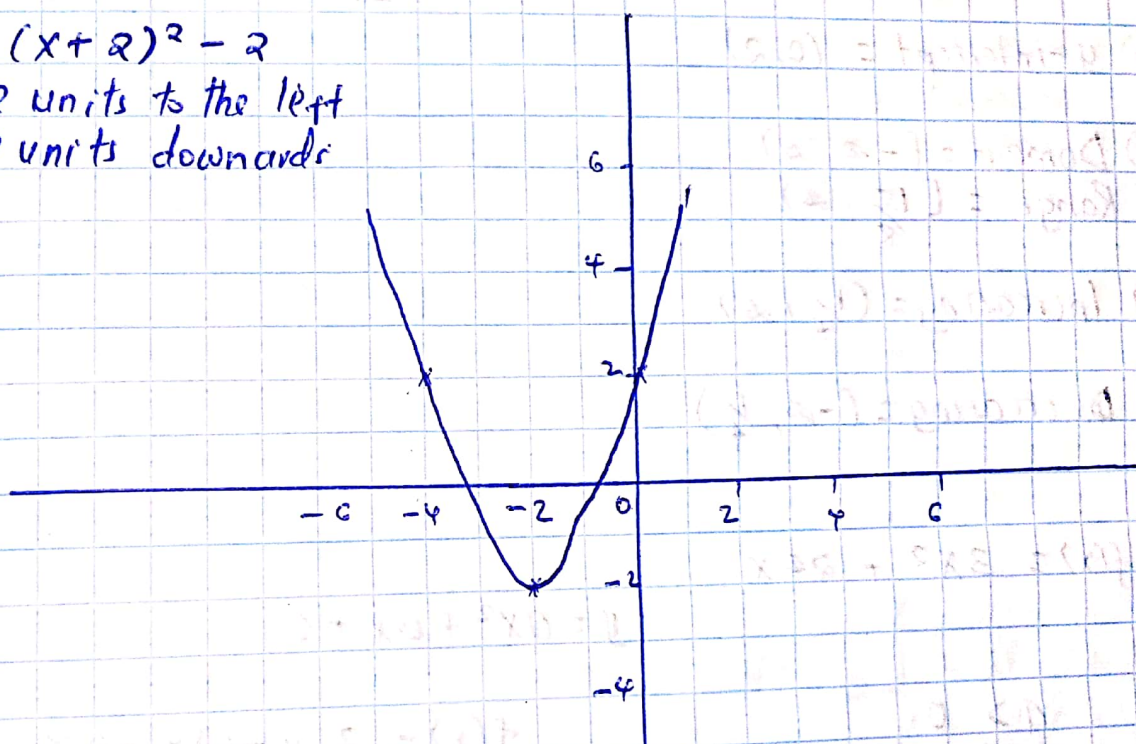
31. $f(x) = \frac{1}{4}x^2$

Vertically compressed



35. $f(x) = x^2 + 4x + 2$

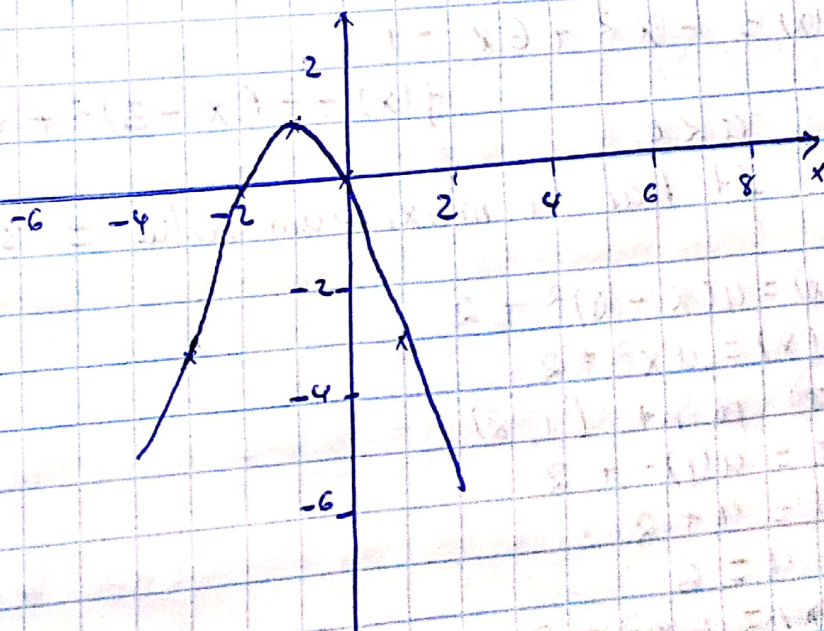
$f(x) = (x+2)^2 - 2$
 Shift 2 units to the left
 Shift 2 units downwards



39. $f(x) = -x^2 - 2x$

$f(x) = -(x+1)^2 + 1$

Shift 1 unit to the left
 Shift 1 unit upwards
 Reflect about x-axis



51. $f(x) = 2x^2 - x + 2$

(a) $f(x) = 2(x - \frac{1}{4})^2 + \frac{15}{8}$

Vertex = $(\frac{1}{4}, \frac{15}{8})$

Symmetric, $x = \frac{1}{4}$

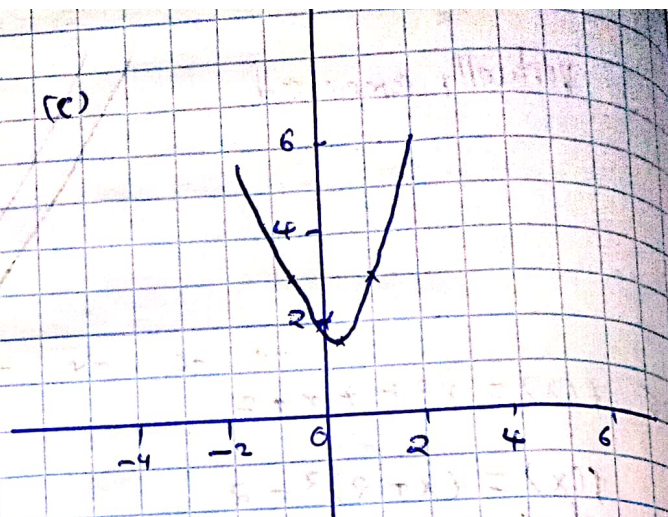
Graph is concave up

(b) y-intercept = $(0, 2)$

(d) Domain = $(-\infty, \infty)$
Range = $[\frac{15}{8}, \infty)$

(e) Increasing = $(\frac{1}{4}, \infty)$

Decreasing = $(-\infty, \frac{1}{4})$



65. $f(x) = 3x^2 + 24x$

$y = ax^2 + bx + c$

$a > 0$

$f(x) = 3(x + 4)^2 - 48$

It has a minimum value = -48

66. $f(x) = -x^2 + 6x - 1$

$f(x) = -(x - 3)^2 + 8$

$a < 0$

It has a maximum value = 8

73. $f(x) = a(x - 0)^2 + 2$

$f(x) = ax^2 + 2$

at point $(1, 8)$

$8 = a(1)^2 + 2$

$8 = a + 2$

$a = 6$

$f(x) = 6x^2 + 2$

$a = 6$

$b = 0$

$c = 2$

43. $f(x) = x^2 + 2x$

- (a) $f(x) = (x+1)^2 - 1$
 vertex $= (-1, -1)$
 Axis of symmetry, $x = -1$
 Graph is concave up.

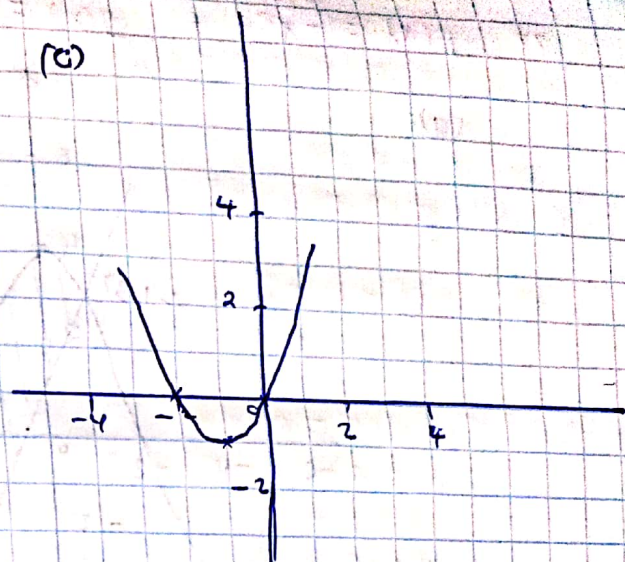
- (b) y-intercept $= (0, 0)$
 x-intercept $= (0, 0), (-2, 0)$

- (d) Domain $= (-\infty, \infty)$
 Range $= [-1, \infty)$

- (e) Increasing $= (-1, \infty)$
 Decreasing $= (-\infty, -1)$

- (f) $f(x) > 0 : (-\infty, -2) \cup (0, \infty)$

$f(x) < 0 : (-2, 0)$



47. $f(x) = x^2 + 2x - 8$

- (a) $f(x) = (x+1)^2 - 9$
 Vertex $= (-1, -9)$
 Axis of symmetry, $x = -1$
 Graph is concave up.

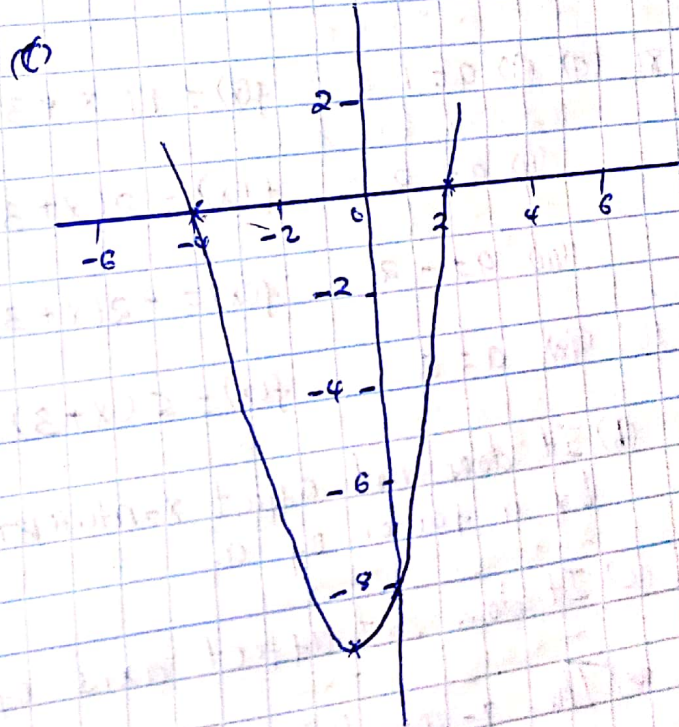
- (b) y-intercept $= (0, -8)$
 x-intercept $= (2, 0), (-4, 0)$

- (d) Domain $= (-\infty, \infty)$
 Range $= [-9, \infty)$

- (e) Increasing $= (-1, \infty)$
 Decreasing $= (-\infty, -1)$

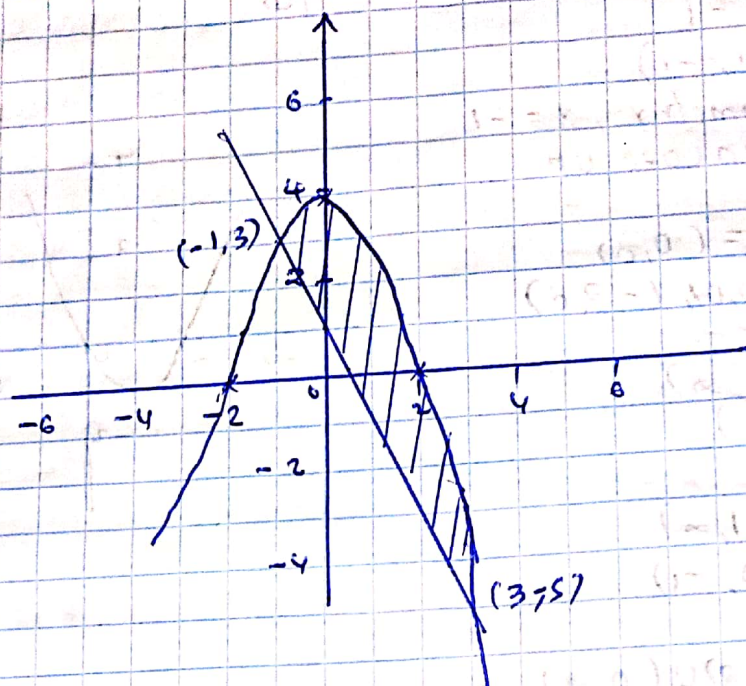
- (f) $f(x) > 0 : (-\infty, -4) \cup (2, \infty)$

$f(x) < 0 : (-4, 2)$



77. $f(x) = -x^2 + 4$ $g(x) = -2x + 1$

(a)



(b) $-x^2 + 4 = -2x + 1$
 $x^2 - 2x - 3 = 0$
 $(x-3)(x+1) = 0$
 $x = 3, -1$

81 (a) (i) $a = 1$ $f(x) = 1(x+3)(x-1)$

(ii) $a = 2$ $f(x) = 2(x+3)(x-1)$

(iii) $a = -2$ $f(x) = -2(x+3)(x-1)$

(iv) $a = 5$ $f(x) = 5(x+3)(x-1)$

(b) It does not affect x-intercept but changes the y-intercept by a factor of a.

(c) It does not affect axis of symmetry

(d) The y-coordinate is changes by factor of a.

(e) Midpoint = $-\frac{-3+1}{2} = -1$
 They are the same

SECTION 4.4

$$S: \quad x = -p + 100$$

$$p = 100 - x$$

SECTION 4.4

$$S: \quad x = -5p + 100$$

$$(a) \quad R = xp = (-5p + 100)p = 100p - 5p^2$$

$$(b) \quad x \geq 0 \quad 100 - 5p \geq 0$$

$$-5p \geq -100$$

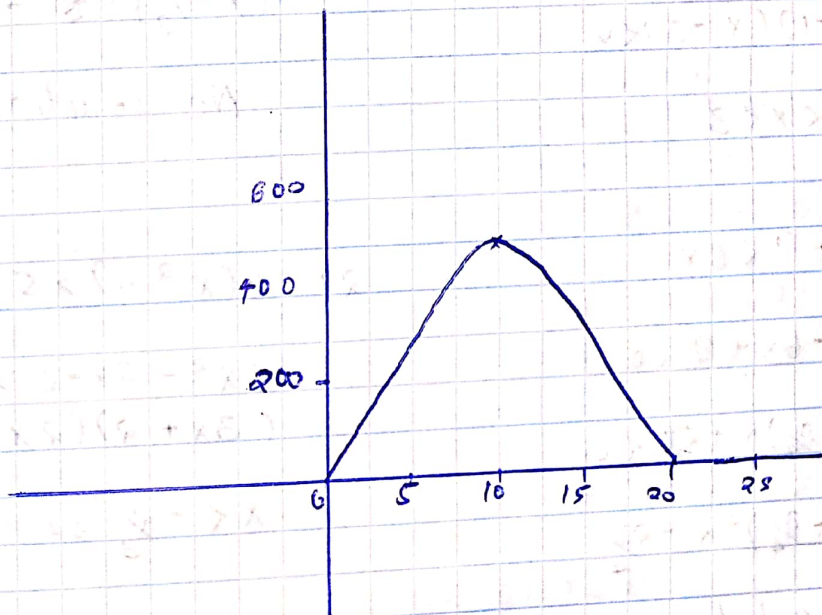
$$5p \leq 100$$

$$\cancel{[0, 100]} \quad [0, 20]$$

$$(c) \quad p = -\frac{b}{2a} = -\frac{100}{2(-5)} = 10 \text{ dollars}$$

$$(d) \quad R(10) = 100(10) - 5(10)^2 = 500 \text{ dollars}$$

$$(e) \quad x = 100 - 5(10) = 50$$



$$(g) \quad 480 = 100p - 5p^2$$

$$5p^2 - 100p + 480 = 0$$

$$5(p^2 - 20p + 96) = 0$$

$$(p - 12)(p - 8) = 0$$

$$p = 12, p = 8$$

Between $p = 8$ and $p = 12$

SECTION 4.5

3. (a) $(-\infty, -2) \cup (2, \infty)$

(b) $f(x) \leq 0$
 $[-2, 2]$

5. (a) $g(x) \geq f(x)$
 $[-2, 1]$

(b) $f(x) > g(x)$
 $(-\infty, -2) \cup (1, \infty)$

7. $x^2 - 3x - 10 < 0$
 $(x+2)(x-5) < 0$

$x < -2$ and $x > 5$

$-2 < x < 5$

11. $x^2 - 9 < 0$
 ~~$(x+3)(x-3) < 0$~~
 $x^2 < 9$
 $x \leq \sqrt{9}$
 $-3 < x < 3$

13. $x^2 + x > 12$
 $x^2 + x - 12 > 0$
 $(x+4)(x-3) > 0$
 $x < -4$ or $x > 3$

15. $2x^2 \leq 5x + 3$
 $2x^2 - 5x - 3 < 0$
 $(2x+1)(x-3) < 0$
 $-\frac{1}{2} < x < 3$

17. $x^2 - x + 1 \leq 0$
 $(x - \frac{1}{2})^2 \leq -\frac{3}{4}$
 No solution

19. $4x^2 + 9 < 6x$

$4x^2 - 6x + 9 < 0$

$4(x - \frac{3}{4})^2 + \frac{27}{4} < 0$

$4(x - \frac{3}{4})^2 < -\frac{27}{4}$

No solution

21. $6(x^2 - 1) > 5x$

$6x^2 - 5x - 6 > 0$

$(3x+2)(2x-3) > 0$

$x < -\frac{2}{3}$ or $x > \frac{3}{2}$

23. $f(x) = x^2 - 1$, $g(x) = 3x + 3$

(a) $x^2 - 1 = 0$
 $x = -1, 1$

(b) $3x + 3 = 0$
 $x = -1$

(c) $x^2 - 1 = 3x + 3$
 $x^2 - 3x - 4 = 0$
 $(x - 4)(x + 1) = 0$
 $x = -1, 4$

(d) $f(x) > 0$
 $(-\infty, -1) \cup (1, \infty)$

(e) $g(x) \leq 0$
 $[-\infty, -1]$

25. $f(x) = -x^2 + 1$
 $g(x) = 4x + 1$

(a) $-x^2 + 1 = 0$
 $x = -1, 1$

(b) $4x + 1 = 0$
 $x = -\frac{1}{4}$

(c) $-x^2 + 1 = 4x + 1$
 $x^2 + 4x = 0$
 $x(x + 4) = 0$
 $x = 0, x = -4$

(d) $f(x) > 0$
 $-1 < x < 1$

(e) $g(x) \leq 0$
 $x \leq -\frac{1}{4}$

24. $f(x) = -x^2 + 3$, $g(x) = -3x + 3$

(a) $-x^2 + 3 = 0$
 $x^2 = 3$, $x = -\sqrt{3}, \sqrt{3}$

(b) $-3x + 3 = 0$
 $3x = 3$, $x = 1$

(c) $-x^2 + 3 = -3x + 3$
 $-x^2 + 3x = 0$
 $x(-x + 3) = 0$
 $x = 0, x = 3$

(d) $f(x) > 0$
 $-\sqrt{3} < x < \sqrt{3}$

(e) $g(x) \leq 0$
 $x \geq 1$

26. $f(x) = -x^2 + 4$
 $g(x) = -x - 2$

(a) $-x^2 + 4 = 0$
 $x = -2, 2$

(b) $-x - 2 = 0$
 $x = -2$

(c) $-x^2 + 4 = -x - 2$
 $x^2 - x - 6 = 0$
 $(x - 3)(x + 2) = 0$
 $x = 3, x = -2$

(d) $f(x) > 0$
 $-2 < x < 2$

(e) $g(x) \leq 0$
 $x \geq -2$

$$27. \begin{aligned} f(x) &= x^2 - 4 \\ g(x) &= -x^2 + 4 \end{aligned}$$

$$(a) \begin{aligned} x^2 - 4 &= 0 \\ x &= 2, -2 \end{aligned}$$

$$(b) \begin{aligned} -x^2 + 4 &= 0 \\ x &= 2, -2 \end{aligned}$$

$$(c) \begin{aligned} x^2 - 4 &= -x^2 + 4 \\ 2x^2 &= 8 \\ x^2 &= 4 \\ x &= -2, 2 \end{aligned}$$

$$(d) \begin{aligned} f(x) &> 0 \\ x &< -2 \text{ or } x > 2 \end{aligned}$$

$$(e) \begin{aligned} g(x) &\leq 0 \\ x &\leq -2 \text{ or } x \geq 2 \end{aligned}$$

$$29. \begin{aligned} f(x) &= x^2 - x - 2 \\ g(x) &= x^2 + x - 2 \end{aligned}$$

$$(a) \begin{aligned} x^2 - x - 2 &= 0 \\ (x-2)(x+1) &= 0 \\ x &= 2, x = -1 \end{aligned}$$

$$(b) \begin{aligned} x^2 + x - 2 &= 0 \\ (x+2)(x-1) &= 0 \\ x &= -2, x = 1 \end{aligned}$$

$$(c) \begin{aligned} x^2 - x - 2 &= x^2 + x - 2 \\ 2x &= 0 \\ x &= 0 \end{aligned}$$

$$(d) \begin{aligned} f(x) &> 0 \\ x &< -1 \text{ or } x > 2 \end{aligned}$$

$$(e) \begin{aligned} g(x) &\leq 0 \\ -2 &\leq x \leq 1 \end{aligned}$$

$$28. \begin{aligned} f(x) &= x^2 - 2x + 1 \\ g(x) &= -x^2 + 1 \end{aligned}$$

$$(a) \begin{aligned} x^2 - 2x + 1 &= 0 \\ (x-1)(x-1) &= 0 \\ x &= 1 \end{aligned}$$

$$(b) \begin{aligned} -x^2 + 1 &= 0 \\ x^2 &= 1 \\ x &= -1, 1 \end{aligned}$$

$$(c) \begin{aligned} x^2 - 2x + 1 &= -x^2 + 1 \\ 2x^2 - 2x &= 0 \\ 2x(x-1) &= 0 \\ x &= 0, x = 1 \end{aligned}$$

$$(d) \begin{aligned} f(x) &> 0 \\ x &< 1 \text{ or } x > 1 \end{aligned}$$

$$(e) \begin{aligned} g(x) &\leq 0 \\ x &\leq -1 \text{ or } x \geq 1 \end{aligned}$$

SECTION 4TR

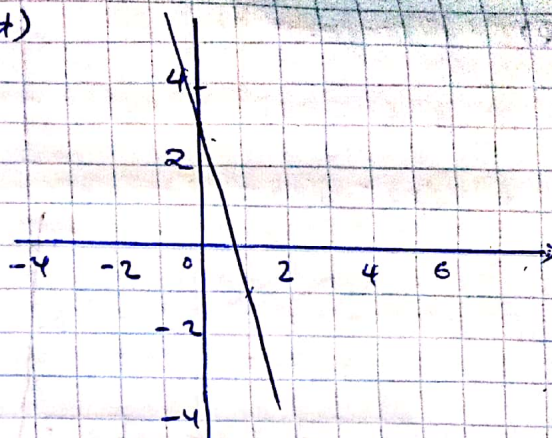
1. $f(x) = -4x + 3$

(d)

(a) slope = -4
y-intercept = (0, 3)

(b) -4

(c) Decreasing



3. $G(x) = -2x^2 + 4x + 1$

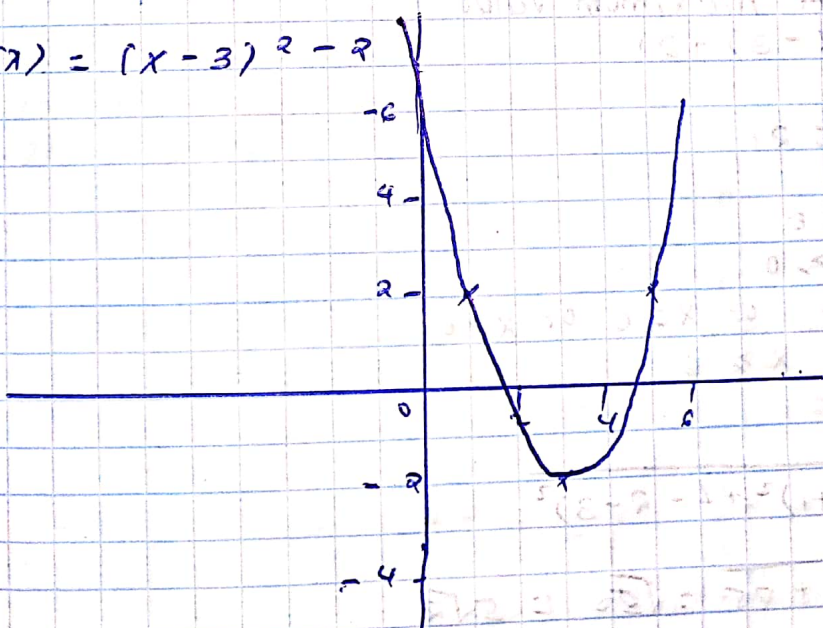
y-intercept: $y = -2(0)^2 + 4(0) + 1 = 1$
(0, 1)

x-intercept: $-2x^2 + 4x + 1 = 0$

$$x = \frac{-4 \pm \sqrt{16 - 4(-2)(1)}}{2(-2)} = \frac{-4 \pm \sqrt{24}}{-4}$$

$$= \frac{-2 \pm \sqrt{6}}{-2} = \frac{2 \pm \sqrt{6}}{2}, \frac{2 + \sqrt{6}}{2}$$

5. $f(x) = (x-3)^2 - 2$



6. (a) Concave up

(b) $f(x) = 3(x-2)^2 - 8$
vertex = (2, -8)

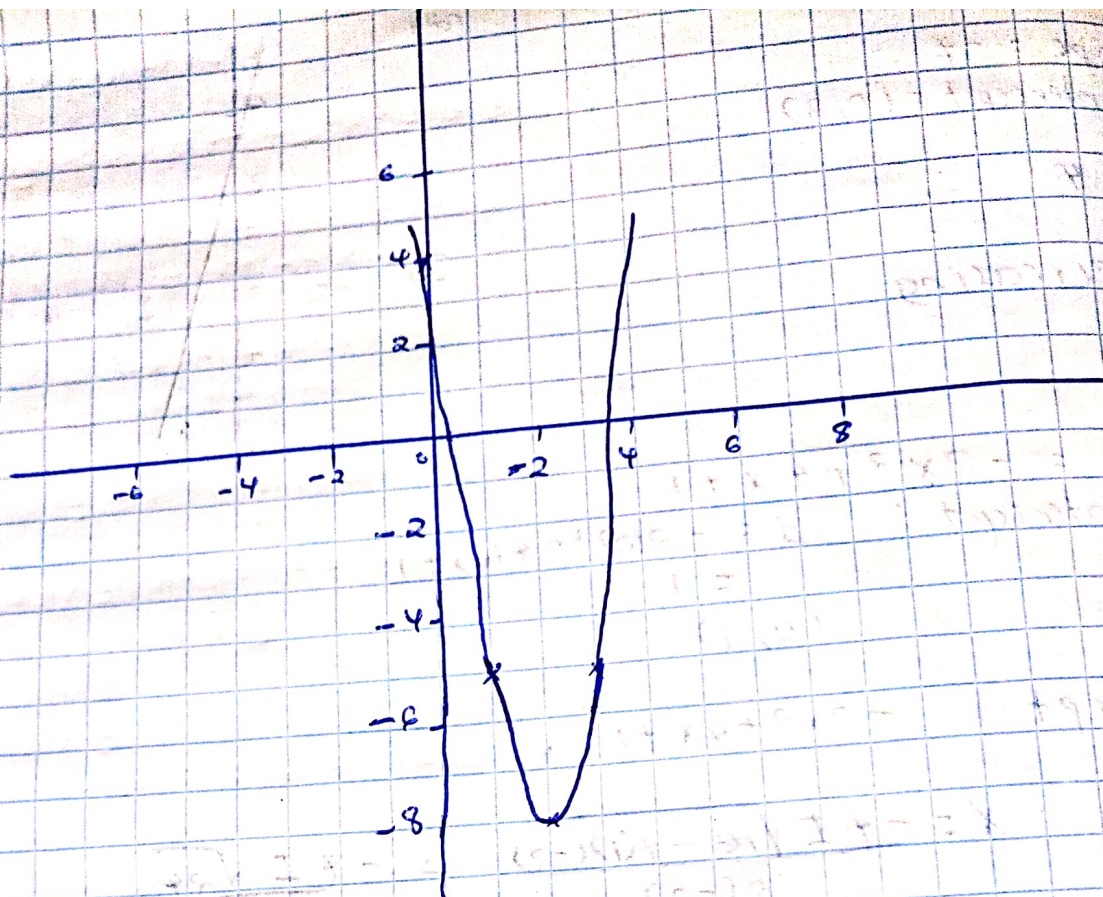
(c) Axis of symmetry, $x = 2$

(d) y: $y = 3(0-2)^2 - 8 = 8$ (0, 8)

x: $3x^2 - 12x + 4 = 0$

$$x = \frac{6 \pm 2\sqrt{6}}{3}, \frac{6 + 2\sqrt{6}}{3}$$

f(x)



7. $f(x) = -2x^2 + 12x + 3$

$a < 0$

Minimum value Maximum value

$f(x) = -2(x-3) + 21$

Value = 21

8. $x^2 - 10x + 24 \geq 0$

$(x-4)(x-6) \geq 0$

$x \leq 4$ or $x = 4$ or $x = 6$ or $x > 6$

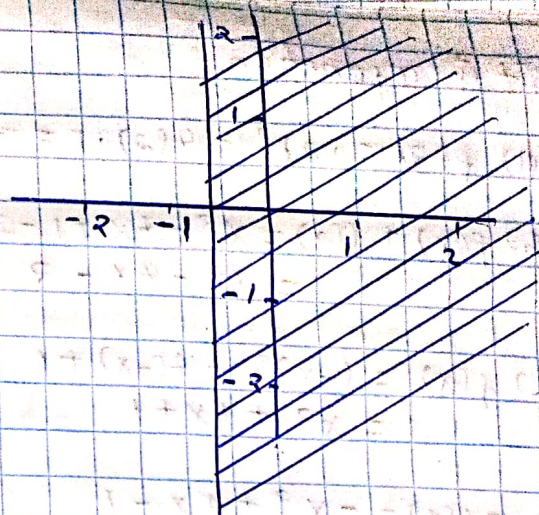
$x \leq 4$ or $x \geq 6$

1. Distance = $\sqrt{(4+1)^2 + (-2-3)^2}$

$= \sqrt{25 + 25} = \sqrt{50} = 5\sqrt{2}$

Midpoint = $\left(\frac{-1+4}{2}, \frac{3-2}{2} \right) = (1.5, 0.5)$

$$3. \begin{aligned} 5x + 3 &\geq 0 \\ 5x &\geq -3 \\ x &\geq -\frac{3}{5} \end{aligned}$$



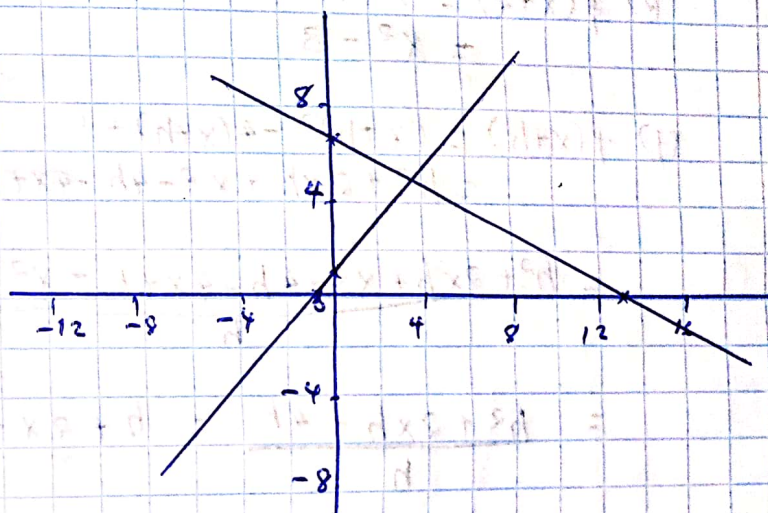
$$5. y = 2x + 1$$

slope of the line = $-\frac{1}{2}$

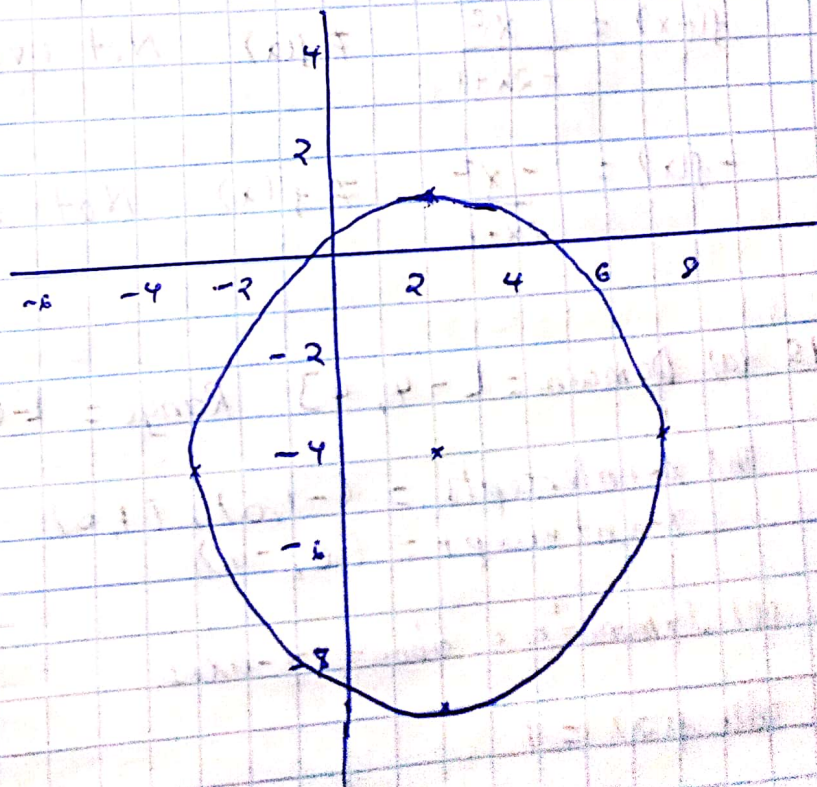
$$y - 5 = -\frac{1}{2}(x - 3)$$

$$y = -\frac{1}{2}x + \frac{3}{2} + 5$$

$$y = -\frac{1}{2}x + \frac{13}{2}$$



$$6. \begin{aligned} x^2 + y^2 - 4x + 8y - 5 &= 0 \\ (x - 2)^2 + (y + 4)^2 &= 25 \end{aligned}$$



7. It is a function

8 (a) $f(2) = (2)^2 - 4(2) + 1 = -3$

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

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

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

(e) $f(x+2) = (x+2)^2 - 4(x+2) + 1$
 $= x^2 - 3$

(f) $f(x+h) = (x+h)^2 - 4(x+h) + 1$
 $= h^2 + 2xh + x^2 - 4h - 4x + 1$

$= \frac{h^2 + 2xh + x^2 - 4h - 4x + 1 - x^2 + 4x - 1}{h}$

$= \frac{h^2 + 2xh - 4h}{h} = h + 2x - 4$

12. $f(x) = \frac{x^2}{2x+1}$

$f(-x) = \frac{x^2}{-2x+1} \neq f(x)$ Not even

$-f(x) = \frac{-x^2}{2x+1} \neq f(x)$ Not odd.

15 (a) Domain = $[-4, 4]$ Range = $[-1, 3]$

(b) x-intercepts = $(-1, 0), (1, 0)$
y-intercept = $(0, -1)$

(c) Symmetric about y-axis

(d) $f(2) = 1$

(e) $f(x) = 3$ $x = -4, x = 4$

(f) $f(x) < 0$ $(-1, 1)$

$$41. f(x) = (x-1)(x+1)(x-3) \\ = x^3 - 3x^2 - x + 3$$

$$45. f(x) = (x+5)(x+2)(x-3)(x-5) \\ = x^4 - x^3 - 31x^2 + 25x + 150$$

$$49. f(x) = a(x+2)(x-3)(x-5)$$

$$36 = a(2+2)(2-3)(2-5)$$

$$a = 3$$

$$f(x) = 3(x+2)(x-3)(x-5) \\ = 3x^3 - 18x^2 - 3x + 90$$

$$59. f(x) = 3(x-7)(x+3)^2$$

$$(a) \quad 7, \text{ multiplicity } 1 \\ -3, \text{ multiplicity } 2$$

$$(b) \quad \text{Crosses } x\text{-axis at } 7 \\ \text{Touches } x\text{-axis at } -3$$

$$(c) \quad n = \text{no. of degrees} - 1 \\ = 3 - 1 = 2$$

$$(d) \quad \text{Falls on far left, rises on far right}$$

$$65. f(x) = (x-5)^3(x+4)^2$$

$$(a) \quad 5, \text{ multiplicity } 3 \\ -4, \text{ multiplicity } 2$$

$$(b) \quad \text{Crosses } x\text{-axis at } 5 \\ \text{Touches } x\text{-axis at } -4$$

$$(c) \quad n = 5 - 1 = 4$$

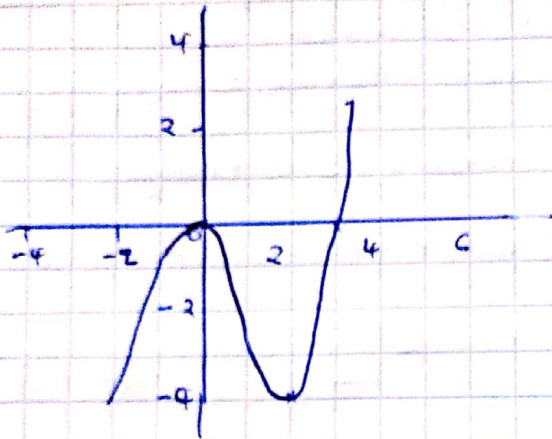
$$(d) \quad \text{Falls on far left, rises on far right}$$

71. Zeros = -1, 1, 2

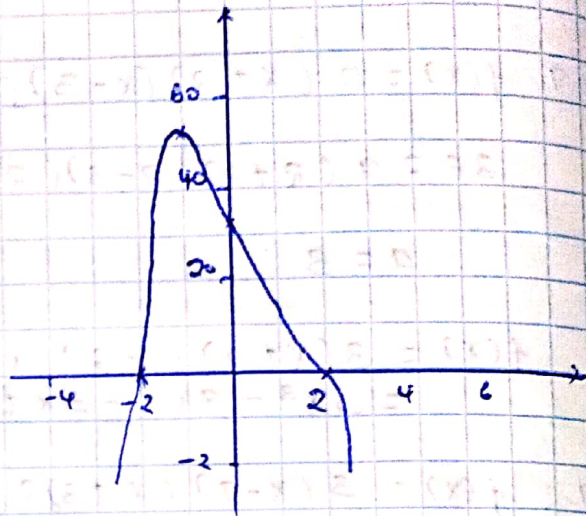
Degree = $n+1 = 2+1 = 3$

SECTION 5.2

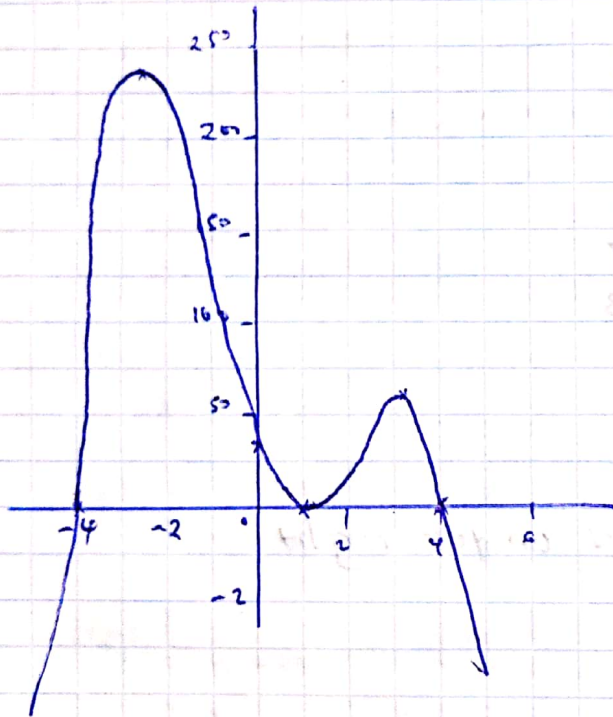
5. $f(x) = x^2(x-5)$



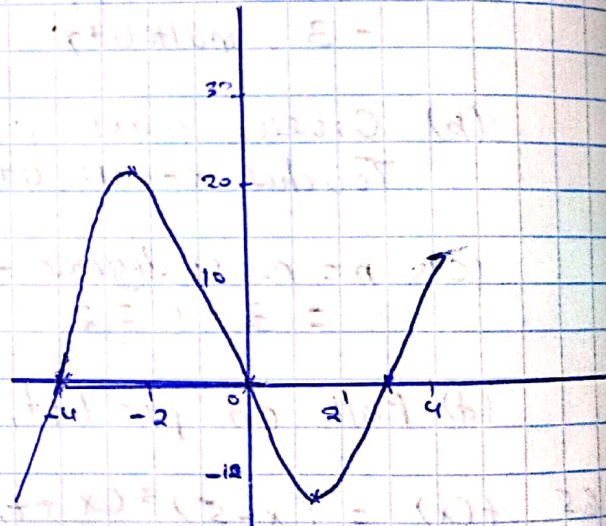
9. $f(x) = -2(x+2)(x-3)^3$



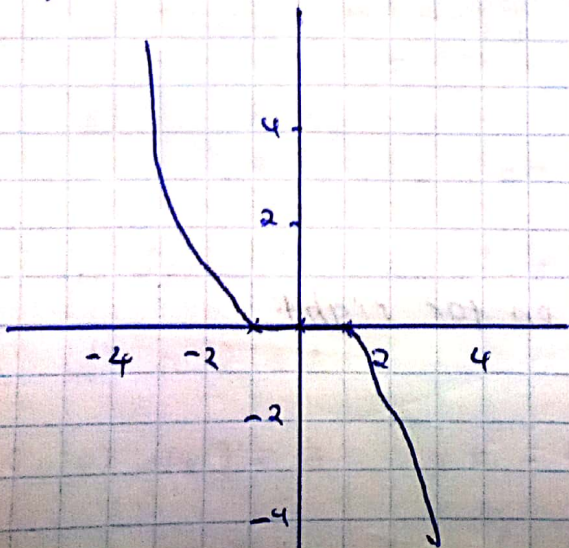
17.



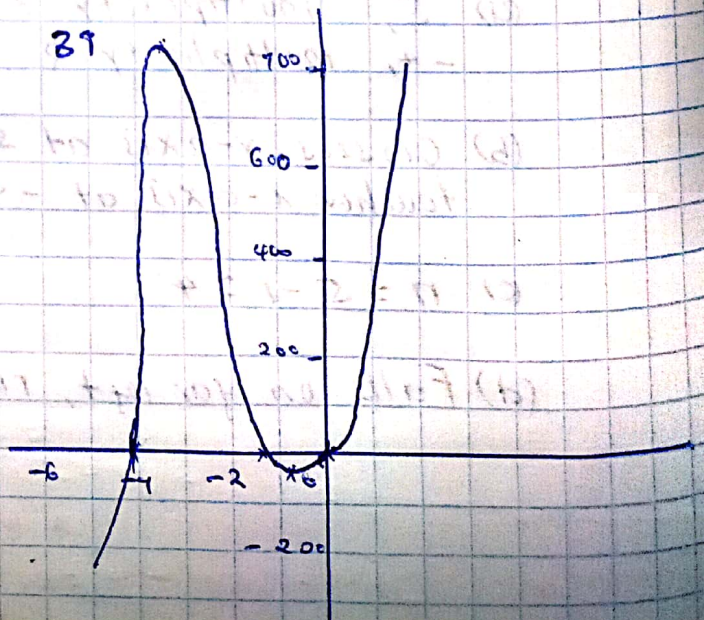
38. $f(x) = x^3 + x^2 - 12x$



37. $f(x) = -x^5 + x^4 + x^3 + x^2$



39



SECTION 5.3

15. $R(x) =$

33. $F(x) = 2 + \frac{1}{x}$

Domain = $(-\infty, 0) \cup (0, \infty)$

Range = $(-\infty, 2) \cup (2, \infty)$

Vertical asymptote, $x = 0$

Horizontal, $y = 2$

35. $R(x) = \frac{1}{(x-1)^2}$

Domain = $(-\infty, 1) \cup (1, \infty)$

Range = $(0, \infty)$

Vertical, $x = 1$

Horizontal, $y = 0$

41. $G(x) = 1 + \frac{2}{(x-3)^2}$

Domain = $(-\infty, 3) \cup (3, \infty)$

Range = $(1, \infty)$

Vertical, $x = 3$

Horizontal, $y = 1$

45. $R(x) = \frac{3x}{x+4}$

Vertical, $x = -4$

Horizontal, $y = 3$

49. $T(x) = \frac{x^3}{x^4 - 1}$

Vertical, $x = -1, x = 1$

Horizontal, $y = 0$

55. $G(x) = \frac{x^4 - 1}{x^2 - x}$

Vertical, $x = 0$

Oblique asymptote

$$\begin{array}{r}
 x^2 - x \overline{) x^4 - 1} \\
 \underline{x^4 - x^3} \\
 -x^3 - 1 \\
 \underline{-x^3 - x^2} \\
 x^2 - 1 \\
 \underline{x^2 - x} \\
 x - 1
 \end{array}$$

asymptote, $y = x^2 + x + 1$

SECTION 5.5

19. $(x-4)^2(x+6) < 0$
 $x < -6$

25. $(x+2)(x-4)(x-6) \leq 0$

$x < -2$	$f(x) < 0$
$x = -2$	$f(x) = 0$
$-2 < x < 4$	$f(x) > 0$
$x = 4$	$f(x) = 0$
$4 < x < 6$	$f(x) < 0$
$x = 6$	$f(x) = 0$
$x > 6$	$f(x) > 0$

$x \leq 2$ or $4 \leq x \leq 6$

27. $x^3 - 4x^2 - 12x > 0$
 $x(x^2 - 4x - 12) > 0$
 $x(x+2)(x-6) > 0$

$x < -2$	$f(x) < 0$
$x = -2$	$f(x) = 0$
$-2 < x < 0$	$f(x) > 0$
$x = 0$	$f(x) = 0$
$0 < x < 6$	$f(x) < 0$
$x = 6$	$f(x) = 0$
$x > 6$	$f(x) > 0$
$-2 < x < 0$	or $x > 6$

$$37. \frac{(x-2)(x+2)}{x} \leq 0$$

$x < -2$	$f(x) < 0$
$x = 0$	$f(x) = 0$
$-2 < x < 0$	$f(x) > 0$
$x = 0$	$f(x) = 0$
$0 < x < 2$	$f(x) < 0$
$x = 2$	$f(x) = 0$
$x > 2$	$f(x) > 0$

$$x \leq -2 \text{ or } 0 < x \leq 2$$

$$41. \frac{x+4}{x-2} \leq 1$$

$$\frac{x+4}{x-2} - 1 \leq 0$$

$$\frac{x+4 - (x-2)}{x-2} \leq 0$$

$$\frac{6}{x-2} \leq 0 \quad \text{Divide by 6}$$

$$\frac{1}{x-2} \leq 0$$

$x < 2$	$f(x) < 0$
$x = 2$	$f(x) = 0$
$x > 2$	$f(x) > 0$

$$x < 2$$

$$48. \frac{x+1}{x-3} \leq 2$$

$$\frac{x+1}{x-3} - 2 \leq 0$$

$$\frac{x+1 - 2(x-3)}{x-3} \leq 0$$

$$\frac{-x+7}{x-3} \leq 0$$

$x < 3$	$f(x) < 0$
---------	------------

$x = 3$	$f(x) = 0$
---------	------------

$3 < x < 7$	$f(x) > 0$
-------------	------------

$x = 7$	$f(x) = 0$
$x > 7$	$f(x) < 0$

$$x < 3 \text{ or } x \geq 7$$

SECTION 5.6

$$11. f(2) = 4(2)^3 - 3(2)^2 - 8(2) + 4$$

$$= 8$$

$$\text{Remainder} = 8$$

$$f(2) \neq 0$$

It is not a factor

$$14. f(2) = 4(2)^4 - 15(2)^2 - 4 = 0$$

$x-2$ is a factor

$$17. f(-4) = 4(-4)^6 - 64(-4)^4 + (-4)^2$$

$$-15 = 1$$

$$\text{Remainder} = 1$$

$x+4$ is not a factor

$$20. f(-\frac{1}{3}) = 3(-\frac{1}{3})^4 + (-\frac{1}{3})^3 - 3(-\frac{1}{3})^2$$

$$\text{Remainder} = 2$$

$x+\frac{1}{3}$ is not a factor

$$21. \text{No. of Zeros} = 7$$

$$f(x) = -4x^7 + x^3 - x^2 + 2$$

3 changes

$$f(-x) = 4x^7 + x^3 - x^2 + 2$$

$$\text{Positive} = 3 \text{ or } 1$$

$$\text{Negative} = 2 \text{ or } 0$$

24. No. of zeros = 5

$$f(x) = -3x^5 + 4x^4 + 2$$

$$f(-x) = 3x^5 + 4x^4 + 2$$

Positive = 1

Negative = 0

27. $f(x) = -x^4 + x^2 - 1$

No. of zeros = 4

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

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

Positive = 2 or 0

Negative = 2 or 0

33. $f(x) = 3x^4 - 3x^3 + x^2 - x + 1$

$$p = \pm 1 \quad q = \pm 1, \pm 3$$

$$\frac{p}{q} : \pm 1, \pm \frac{1}{3}$$

37. $f(x) = -9x^3 - x^2 + x + 3$

$$p : \pm 1, \pm 3$$

$$q : \pm 1, \pm 2, \pm 4$$

$$\frac{p}{q} : \pm 1, \pm 2, \pm \frac{1}{4}, \pm \frac{1}{2}$$

45. $f(x) = x^3 + 2x^2 - 5x - 6$

$$p : \pm 1, 2, 3, 6$$

$$q : \pm 1$$

$$\frac{p}{q} : \pm 1, 2, 3, 6$$

$$(x+1) \overline{) \begin{array}{r} x^3 + 2x^2 - 5x - 6 \\ x^3 + x^2 \\ \hline x^2 - 5x - 6 \\ x^2 + x \\ \hline -6x - 6 \\ -6x - 6 \\ \hline 0 \end{array}}$$

$$(x+1)(x^2 + x - 6)$$

$$(x+1)(x-2)(x+3)$$

57. $x^4 - x^3 + 2x^2 - 4x - 8 = 0$

Rational zeros = $\pm 1, 2, 4, 8$

$$x+1 \overline{) \begin{array}{r} x^4 - x^3 + 2x^2 - 4x - 8 \\ x^4 + x^3 \\ \hline -2x^3 + 2x^2 - 4x - 8 \\ -2x^3 - 2x^2 \\ \hline 4x^2 - 4x - 8 \\ 4x^2 + 4x \\ \hline -8x - 8 \\ -8x - 8 \\ \hline 0 \end{array}}$$

$$(x+1)(x^3 - 2x^2 + 4x - 8)$$

$$(x+1)(x^2(x-2) + 4(x-2))$$

$$(x+1)(x^2 + 4)(x-2) = 0$$

$$x \neq -1 = 0$$

$$x = -1$$

or

$$x^2 + 4 = 0$$

$$x^2 = -4$$

$$x = -2i, 2i$$

or

$$x - 2 = 0 \quad x = 2$$

$$x = -1, 2, 2i, -2i$$

SECTION 5.7

11 Remaining zeros = $-i, 3-i$

13 zeros = $-i, -5i$

17. zeros = $4-9i, -7+2i$

25 $3i, -3i$

$(x-3i), (x+3i)$

$$25. f(x) = x^3 - 5x^2 + 9x - 45$$

$$\begin{array}{r|rrrr} 3i & 1 & -5 & 9 & -45 \\ & & 3i & -7-15i & 45 \\ \hline & 1 & -5+3i & -15i & 0 \end{array}$$

$$\begin{array}{r|rrrr} -3i & 1 & -5+3i & -15i & \\ & & -3i & 15i & \\ \hline & 1 & -5 & 0 & \end{array}$$

$$(x-5) = 0$$

$$x = 5$$

SECTION 5 C.R

$$5. f(x) = (x+2)^3$$

shifted 2 units to the left

$$7. f(x) = (x-1)^4 + 2$$

shifted 1 unit to the right
shifted 2 units upwards

$$12. R(x) = \frac{x+2}{x^2-9}$$

Vertical, $x = -3, x = 3$
Horizontal, $y = 0$

$$21. x^3 + x^2 < 4x + 4$$

$$x^3 + x^2 - 4x - 4 < 0$$

$$x^2(x+1) - 4(x+1) < 0$$

$$(x^2-4)(x+1) < 0$$

$$(x+2)(x-2)(x+1) < 0$$

$$x < -2$$

$$f(x) < 0$$

$$x = -2$$

$$f(x) = 0$$

$$-2 < x < -1$$

$$f(x) > 0$$

$$x = -1$$

$$f(x) = 0$$

$$-1 < x < 2 \quad f(x) < 0$$

$$x = 2 \quad f(x) = 0$$

$$x > 2 \quad f(x) > 0$$

$$x < -2 \text{ or } -1 < x < 2$$

$$25. \frac{x^2 - 8x + 12}{x^2 - 16} > 0$$

$$\frac{(x-2)(x-6)}{(x+4)(x-4)} > 0$$

$x < -4$	$f(x) > 0$
$x = -4$	$f(x) = \infty$
$-4 < x < 2$	$f(x) < 0$
$x = 2$	$f(x) = 0$
$2 < x < 4$	$f(x) > 0$
$x = 4$	$f(x) = \infty$
$4 < x < 6$	$f(x) < 0$
$x = 6$	$f(x) = 0$
$x > 6$	$f(x) > 0$

$$x < -4 \text{ or } 2 < x < 4 \text{ or } x > 6$$

27.

-2	1	-2	15	-2
		-2	8	-2
1	-4	23	-48	

27

-2	1	-2	0	15	-2
		-2	8	-16	2
1	-4	8	-1	0	

g is a factor of f

28.

	5	4	3	2	1	
4	12	0	-8	0	0	1
	48	192	736	2944	1176	47104
12	48	184	736	2944	1176	47105

g is not a factor of f

33.

$$\frac{p}{q} : \pm \frac{1, 2}{1, 2, 4}$$

$$(x+2)(4x^2 - 4x + 1)$$

$$(x+2)(4x^2 - 2x - 2x + 1)$$

$$(x+2)(2x(2x-1) - 1(2x-1))$$

$$(x+2)(2x-1)(2x-1) = 0$$

$$x = -2$$

$$x = \frac{1}{2}$$

34.

$$\frac{p}{q} : \pm \frac{1, 2, 4, 5, 10, 20}{1}$$

$$(x-2)(x^3 - 2x^2 + 5x - 10)$$

$$(x-2)(x^2(x-2) + 5(x-2))$$

$$(x-2)(x^2 + 5)(x-2) = 0$$

$$x - 2 = 0$$

$$x = 2$$

$$x^2 + 5 = 0$$

$$x^2 = -5$$

$$x = \pm \sqrt{-5}$$

35.

$$x^4 + 2x^3 + 11x^2 + x - 6 = 0$$

$$\frac{p}{q} : \pm \frac{1, 2, 3, 6}{1, 2}$$

$$(x-2)(2x^3 + 6x^2 + x + 3)$$

$$(x-2)(2x^2(x+3) + 1(x+3))$$

$$(x-2)(2x^2 + 1)(x+3) = 0$$

$$x - 2 = 0$$

$$x = 2$$

$$2x^2 + 1 = 0$$

$$x^2 + \frac{1}{2} = 0$$

$$x = -3$$

SECTION 6.1

$$13. f(x) = 2x, g(x) = 3x^2 + 1$$

$$(f \circ g)(4) = 2(3(4)^2 + 1)$$

$$= 98$$

$$(g \circ f)(2) = 3(2(2))^2 + 1$$

$$= 49$$

$$(f \circ f)(1) = 2(2(1)) = 4$$

$$(g \circ g)(0) = 3(3(0)^2 + 1)^2 + 1$$

$$= 4$$

$$17. f(x) = \sqrt{x}, g(x) = 5x$$

$$(f \circ g)(4) = \sqrt{5(4)} = 2\sqrt{5}$$

$$(g \circ f)(2) = 5\sqrt{2}$$

$$(f \circ f)(1) = \sqrt{\sqrt{1}} = 1$$

$$(g \circ g)(0) = 5(5(0)) = 0$$

$$23. f(x) = 2x + 3, g(x) = 4x$$

$$(a) f \circ g = 2(4x) + 3$$

$$= 8x + 3$$

$$(b) g \circ f = 4(2x + 3)$$

$$= 8x + 12$$

$$(c) f \circ f = 2(2x + 3) + 3$$

$$= 4x + 9$$

$$(d) g \circ g = 4(4x) = 16x$$

$$33. f(x) = \sqrt{x}, g(x) = 2x + 5$$

$$(a) f \circ g = \sqrt{2x + 5}$$

$$(b) g \circ f = 2\sqrt{x} + 5$$

$$(c) f \circ f = \sqrt{\sqrt{x}} = x$$

$$(d) g \circ g = 2(2x + 5) + 5$$

$$= 4x + 15$$

$$39. f(x) = 2x, g(x) = \frac{1}{2}x$$

$$(f \circ g)(x) = 2(\frac{1}{2}x) = x$$

$$(g \circ f)(x) = \frac{1}{2}(2x) = x$$

$$47. H(x) = (2x + 3)^4$$

$$f(x) = x^4, g(x) = 2x + 3$$

$$43. f(x) = 9x - 6, g(x) = \frac{1}{9}(x + 6)$$

$$(f \circ g)(x) = 9(\frac{1}{9}(x + 6)) - 6 = x$$

$$(g \circ f)(x) = \frac{1}{9}(9x - 6 + 6) = x$$

$$51. H(x) = |2x + 1|$$

$$f(x) = |x|$$

$$g(x) = 2x + 1$$

SECTION 6.2

17. Not one-to-one

18. One-to-one

21. f is one-to-one

23. f is not one-to-one

33. $f(x) = 3x + 4$, $g(x) = \frac{1}{3}(x - 4)$

$$f(g(x)) = 3\left(\frac{1}{3}(x - 4)\right) + 4$$

$$= x - 4 + 4 = x$$

$$g(f(x)) = \frac{1}{3}(3x + 4 - 4) = \frac{3x}{3} = x$$

37. $f(x) = x^3 - 8$, $g(x) = \sqrt[3]{x + 8}$

$$f(g(x)) = (\sqrt[3]{x + 8})^3 - 8$$

$$= x + 8 - 8 = x$$

$$g(f(x)) = \sqrt[3]{(x^3 - 8) + 8} = \sqrt[3]{x^3} = x$$

43. $f(x) = 3x$

(a) $x = 3y$

$$y = \frac{x}{3} \quad f^{-1}(x) = \frac{1}{3}x$$

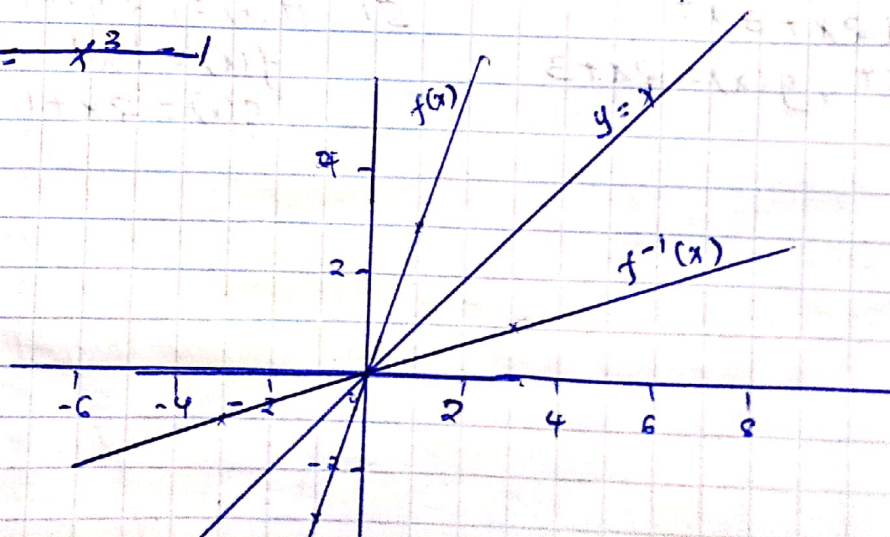
(b) Domain $f : (-\infty, \infty)$

Domain $f^{-1} : (-\infty, \infty)$

Range $f : (-\infty, \infty)$

Range $f^{-1} : (-\infty, \infty)$

47. $f(x) = x^3 - 1$



47. $f(x) = x^3 - 1$

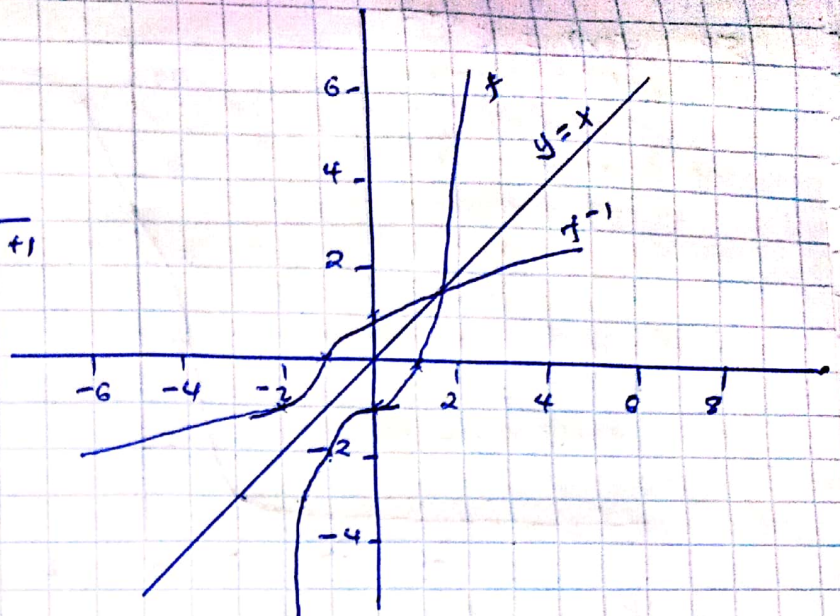
(a) $x = y^3 - 1$

$y^3 = x + 1$

$y = \sqrt[3]{x+1} \quad f^{-1}(x) = \sqrt[3]{x+1}$

(b) Domain $f: (-\infty, \infty)$
Range $f: (-\infty, \infty)$

Domain $f^{-1}: (-\infty, \infty)$
Range $f^{-1}: (-\infty, \infty)$



49. $f(x) = x^2 + 4 \quad x \geq 0$

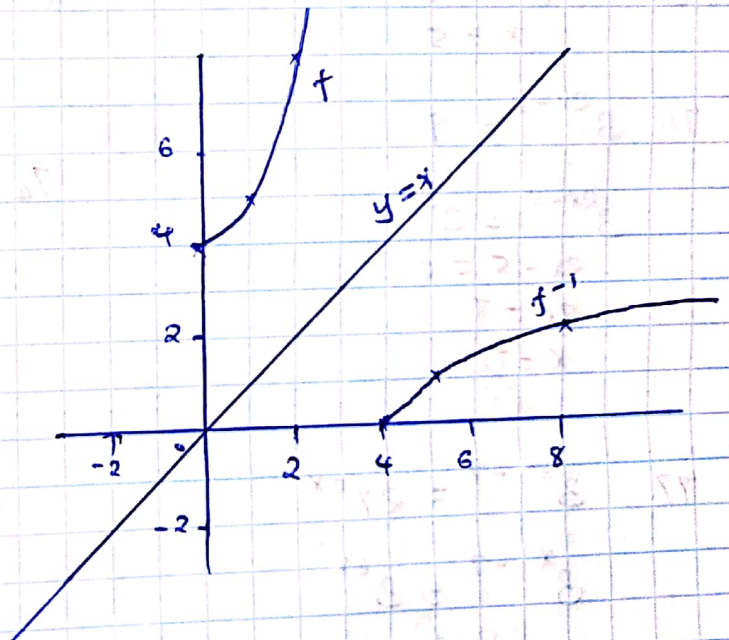
(a) $x = y^2 + 4$

$y^2 = x - 4$

$y = \sqrt{x-4} \quad f^{-1}(x) = \sqrt{x-4}$

(b) Domain $f: [0, \infty)$
Range $f: [4, \infty)$

Domain $f^{-1}: [4, \infty)$
Range $f^{-1}: [0, \infty)$



SECTION 6.3

17. $2^{3.14} = 8.815$

21. $(1 + 0.04)^6 = 1.265$

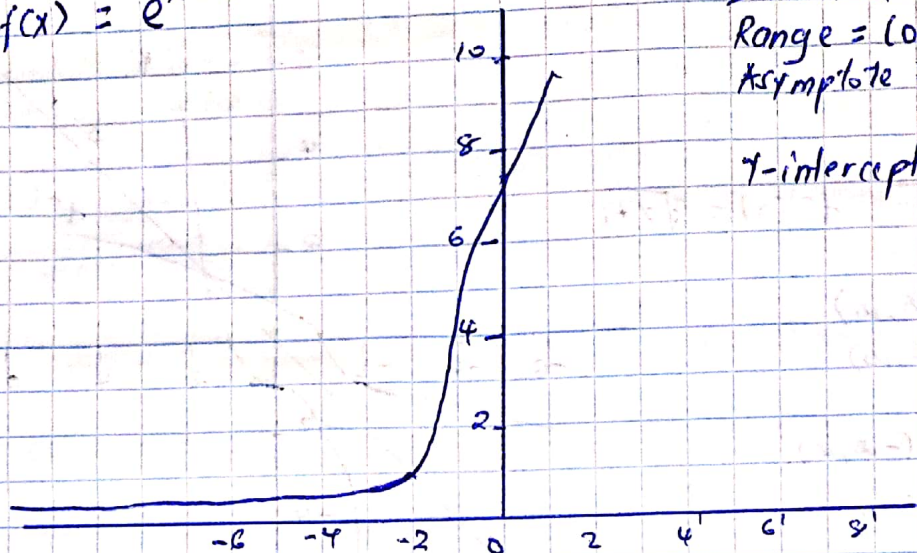
25. $e^{1.2} = 3.32$

37. Graph B $y = 3^{-x}$

39. Graph D $y = -3^{-x}$

43. Graph E $y = 3^x - 1$

59. $f(x) = e^{x+2}$



Domain = $(-\infty, \infty)$
Range = $(0, \infty)$
Asymptote: $y = 0$

y-intercept = $(0, e^2)$

65. $6^x = 6^5$
 $x = 5$

68. $3^{-x} = 81$
 $3^{-x} = 3^4$
 $x = -4$

71. $3^{2x-5} = 9$

$$\begin{aligned} 3^{2x-5} &= 3^2 \\ 2x-5 &= 2 \\ 2x &= 7 \\ x &= \frac{7}{2} \end{aligned}$$

74. $4^{x^2} = 2^x$

$$\begin{aligned} 2^{2x^2} &= 2^x \\ 2x^2 &= x; 2x^2 - x = 0 \\ x(2x-1) &= 0 \\ x &= \frac{1}{2}, x = 0 \end{aligned}$$

77. $3^{x^2-7} = 27^{2x}$

$$3^{x^2-7} = 3^{6x}$$

$$x^2 - 7 = 6x$$

$$\begin{aligned} x^2 - 6x - 7 &= 0 \\ (x-7)(x+1) &= 0 \\ x &= 7, x = -1 \end{aligned}$$

80. $9^{2x} \cdot 27^{x^2} = 3^{-1}$

$$\begin{aligned} 3^{4x} \cdot 3^{3x^2} &= 3^{-1} \\ 4x + 3x^2 &= -1 \\ 3x^2 + 4x + 1 &= 0 \\ (3x+1)(x+1) &= 0 \\ x &= -\frac{1}{3}, x = -1 \end{aligned}$$

SECTION 6.4

16. $3^x = 4.6$

$$\log_3(4.6) = x$$

13. $9^2 = 1.6$

$$\log_9(1.6) = 2$$

19. $\log_2 8 = 3$

$$2^3 = 8$$

22. $\log_b 4 = 2$

$$b^2 = 4$$

25. $\ln 4 = x$

$$e^x = 4$$

$$28. \log_5(8) = 1.$$

$$31. \log_{1/5}(125)$$

$$= -\log_5(125)$$

$$= \log_5(5^3) = -3 \log_5(5) = -3$$

$$34. \log \sqrt[3]{100} = \log(100)^{1/3}$$

$$= \frac{1}{3} \log_{10}(10)^2$$

$$= \frac{2}{3} \log_{10}(10)$$

$$= \frac{2}{3}$$

$$38. \ln e^3$$

$$= 3 \ln(e)$$

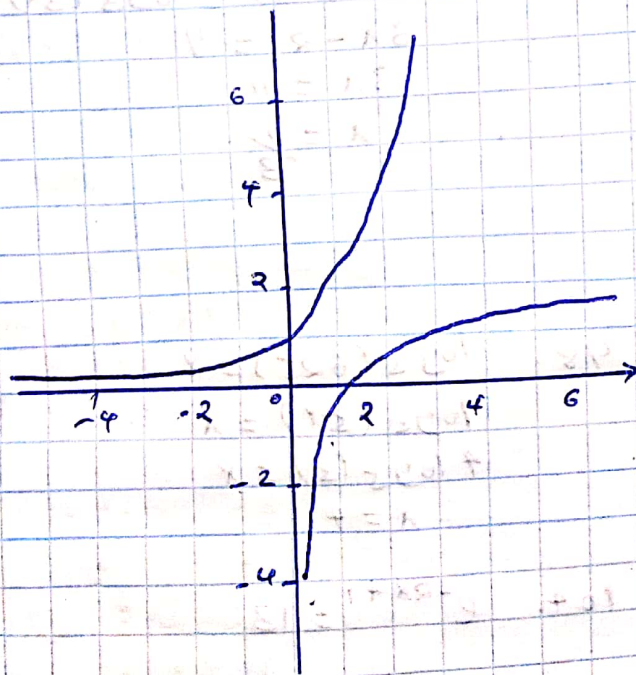
$$= 3$$

$$51. \ln\left(\frac{e}{3}\right) = 0.511$$

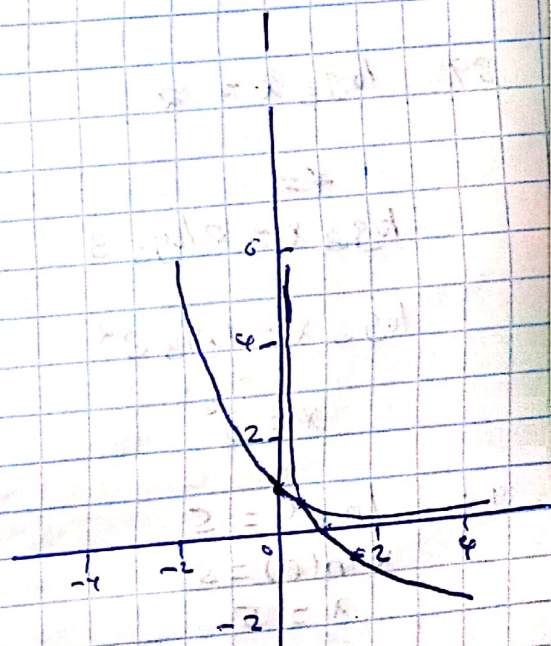
$$53. \frac{\ln\left(\frac{1}{3}\right)}{0.04} = 30.099$$

$$55. \frac{\ln 4 + \ln 2}{\log 4 + \log 2} = 2.303$$

61.



63



67. Graph D $y = -\log_3(-x)$

73. $f(x) = \ln(x+4)$

(a) Domain: $(-4, \infty)$

(c) Range: $(-\infty, \infty)$

Asymptote: $x = -4$

(d) $x = \ln(y+4)$

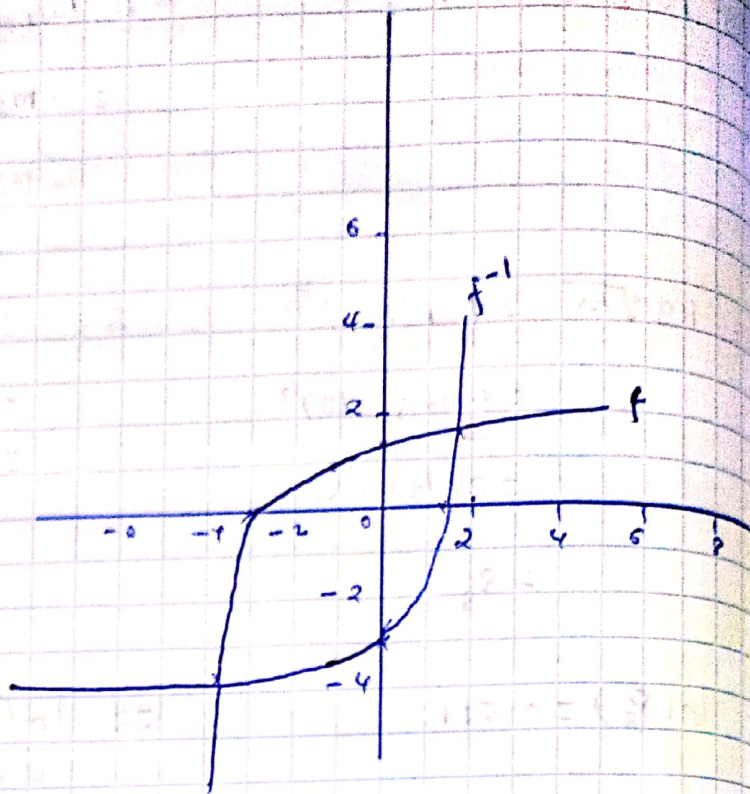
$e^x = y+4$

$y = e^x - 4$

$f^{-1}(x) = e^x - 4$

(e) Domain: $(-\infty, \infty)$

Range: $(-4, \infty)$



89. $\log_3 x = 2$

$\neq$

$\log_3 x = 2 \log_3 3$

$\log_3 x = \log_3 3^2$

$x = 3^2$

95. $\ln e^x = 5$

$x \ln(e) = 5$

$x = 5$

92. $\log_3 (2x-2) = 2 \log_3 3$

$\log_3 (3x-2) = \log_3 (3^2)$

$3x-2 = 9$

$3x = 11$

$x = \frac{11}{3}$

98. $\log_5 (625) = x$

$\log_5 (5^4) = x$

$4 \log_5 (5) = x$

$x = 4$

101. $e^{3x} = 10$

$\ln(e^{3x}) = \ln(10)$

$3x \ln(e) = \ln(10)$

$3x = \ln(10)$

$x = \frac{\ln(10)}{3}$

104. $e^{-2x+1} = 13$

$-2x+1 = \ln(13)$

$-2x = \ln(13) - 1$

$x = \frac{1}{2} - \frac{\ln(13)}{2}$

107. $\log_2 (8^x) = -6$

$\log_2 (8^x) = -6 \log_2 (2)$

$\log_2 (8^x) = \log_2 (2^{-6})$

$8^x = 2^{-6}$

$2^{3x} = 2^{-6}$

$3x = -6$

$x = -2$

SECTION 6.5

$$16. 13 \cdot \log_7 7^{29} = 29 \log_7 7 \\ = 29$$

$$17. 9^{\log_9(3)} \\ = 3$$

$$21. \log_5 35 - \log_5 7 \\ = \log_5 \left(\frac{35}{7} \right) = \log_5(5) \\ = 1$$

$$37. \log_6(36x) = \log_6 36 + \log_6 x \\ = 2 + \log_6 x$$

$$41. \ln(ex) = \ln(e) + \ln(x) \\ = 1 + \ln(x)$$

$$45. \log_a(u^2 v^3) = \log_a u^2 + \log_a v^3 \\ = 2 \log_a u + 3 \log_a v$$

$$51. \log \left[\frac{x(x+2)}{(x+3)^2} \right] \\ = \log(x) + \log(x+2) - 2 \log(x+3)$$

$$60. \log_2 \left(\frac{1}{x} \right) + \log \left(\frac{1}{x^2} \right) \\ = \log_2 \left(\frac{1}{x} \cdot \frac{1}{x^2} \right) = \log_2 \left(\frac{1}{x^3} \right)$$

$$15. \ln e^{-4} = -4 \ln(e) \\ = -4$$

$$19. \log_8 2 + \log_8 4 \\ \log_8(2 \times 4) = \log_8(8) \\ = 1$$

$$23. \log_2 6 \cdot \log_6 8 \\ = \frac{\log 6}{2} \times \frac{\log 8}{\log 6} = \frac{\log 8}{\log 2} \\ = \frac{3 \log 2}{\log 2} \\ = 3$$

$$39. \log_5 y^6 \\ 6 \log_5 y$$

$$43. \ln \left(\frac{x}{e^x} \right) = \ln(x) - \ln(e^x) \\ = \ln(x) - x \ln(e) \\ = \ln(x) - x$$

$$48. \ln(x \sqrt{1+x^2}) \\ = \ln(x) + \ln(1+x^2)^{1/2} \\ = \ln(x) + \frac{1}{2} \ln(1+x^2)$$

$$57. 3 \log_5 u + 4 \log_5 v \\ \log_5 u^3 + \log_5 v^4 \\ = \log_5(u^3 v^4)$$

$$63. \ln \left(\frac{x}{x-1} \right) + \ln \left(\frac{x+1}{x} \right) - \ln(x^2-1) \\ \ln \left(\frac{x}{x-1} \cdot \frac{x+1}{x} \right) = \ln \left(\frac{1}{(x-1)^2} \right) \\ = -\ln(x-1)^2$$

$$66. 21 \log_3 \sqrt[3]{x} + \log_3 (9x^2) - \log_3 9$$

$$21 \log_3 (x)^{\frac{1}{3}} + \log_3 (3x)^2 - \log_3 9$$

$$7 \log_3 (x) +$$

$$\log_3 (x)^7 + \log_3 (3x)^2 - \log_3 9$$

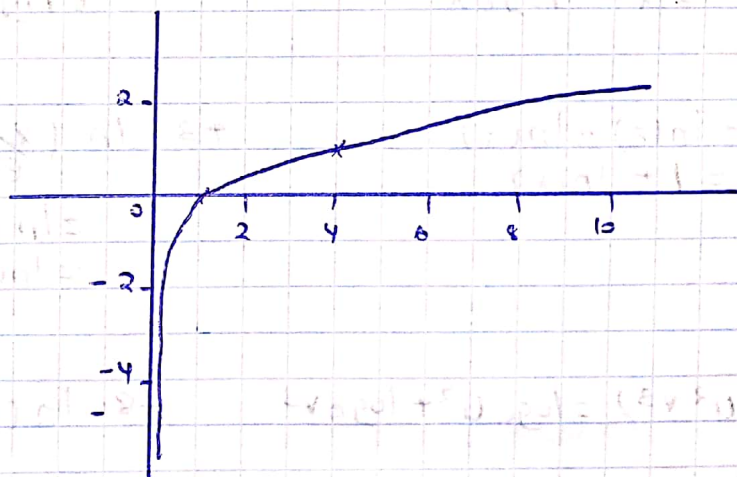
$$\log_3 \left(\frac{x^7 \cdot (3x)^2}{9} \right) = \log_3 (x^9)$$

$$69. 2 \log_2 (x+1) - \log_2 (x+3) - \log_2 (x-1)$$

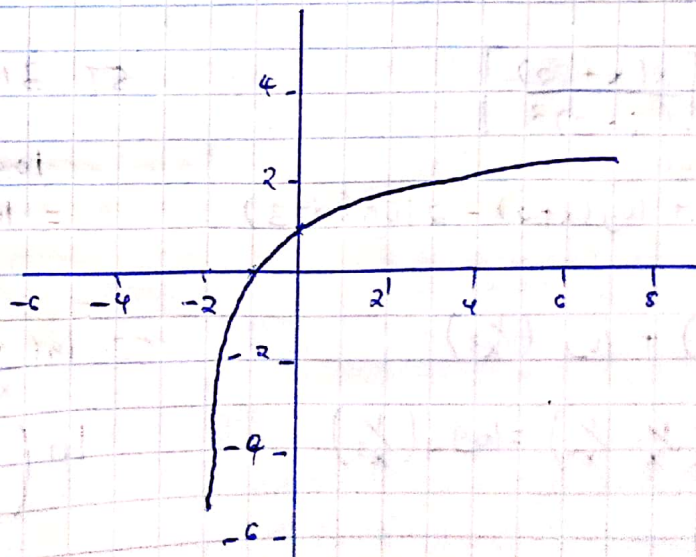
$$= \log_2 \left(\frac{(x+1)^2}{(x+3)(x-1)} \right)$$

$$71. \log_3 21 = \frac{\log 21}{\log 3} \approx 2.771$$

$$79. y = \log_4 x$$



$$81. y = \log_2 (x+2)$$



SECTION 6.6

5. $\log_4 x = 2$

$$x = 4^2 = 16$$

9. $\log_4 (x+4) = \log_4 (15)$

$$x+4 = 15$$

$$x = 11$$

18. $2\log_5 x = 3\log_5 4$

$$\log_5 x^2 = \log_5 4^3$$

$$x^2 = 64$$

$$x = 8$$

24. $\log (2x) - \log (x-3) = 1 = \log 10$

$$\frac{2x}{x-3} = 10$$

$$2x = 10x - 30$$

$$-8x = -30$$

$$x = \frac{15}{4}$$

30. $\ln(x+1) - \ln x = 2$

$$\ln(x+1) - \ln x = 2 \ln e = \ln e^2$$

$$\frac{x+1}{x} = e^2$$

$$x+1 = xe^2$$

$$x - xe^2 = -1$$

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

$$x = \frac{-1}{1 - e^2} = \frac{1}{e^2 - 1}$$

7. $\log_2 (5x) = 4$

$$\log_2 (5x) = 4 \log_2 2 = 4 \log_2 2^4$$

$$5x = 2^4 = 16$$

$$x = \frac{16}{5}$$

13. $\log_5 |2x-1| = \log_5 13$

$$|2x-1| = 13$$

$$2x-1 = 13 \quad \text{or} \quad 2x-1 = -13$$

$$2x = 14$$

$$2x = -12$$

$$x = 7$$

$$x = -6$$

21. $\log x + \log (x+15) = 2$

$$\log x + \log (x+15) = 2 \log 10 = \log 10^2$$

$$x(x+15) = 100$$

$$x^2 + 15x - 100 = 0$$

$$(x-5)(x+20) = 0$$

$$x = 5, x = -20 \text{ (Not valid)}$$

$$x = 5$$

27. $\log_8 (x+6) = 1 - \log_8 (x+4)$

$$= \log_8 (x+6) = \log_8 8 - \log_8 (x+4)$$

$$x+6 = \frac{8}{x+4}$$

$$(x+6)(x+4) = 8$$

$$x^2 + 10x + 24 = 8$$

$$x^2 + 10x + 16 = 0$$

$$(x+2)(x+8) = 0$$

$$x = -2, x = -8 \text{ (False)}$$

$$x = -2$$

33. $\log_{\frac{1}{3}} (x^2+x) - \log_{\frac{1}{3}} (x^2-x) = -1$

$$\log_{\frac{1}{3}} (x^2+x) - \log_{\frac{1}{3}} (x^2-x) = -\log_{\frac{1}{3}} \left(\frac{1}{3}\right)$$

$$\frac{x^2+x}{x^2-x} = \left(\frac{1}{3}\right)^{-1} = 3$$

$$x^2+x = 3x^2-3x$$

$$2x^2-4x = 0$$

$$2x(x-2) = 0$$

$$x = 2, x = 0 \text{ (False)}$$

$$37. \log_5(x-3) - \log_5 8 = \log_5 2$$

$$\frac{(x-3)^2}{8} = 2$$

$$x-3 = \sqrt{16}$$

$$x = 7$$

$$(x-3)^2 = 16$$

$$x^2 - 6x + 9 = 16$$

$$x^2 - 6x - 15 = 0$$

$$37. 2\log_5(x-3) - \log_5 8 = \log_5 2$$

$$\frac{(x-3)^2}{8} = 2$$

$$(x-3)^2 = 16$$

$$x-3 = \pm 4$$

$$x = 7, x = -1$$

$$x = 4+3, x = -4+3$$

$$x = 7, x = -1 \text{ (False)}$$

$$45. 2^{x-5} = 8 = 2^3$$

$$x-5 = 3$$

$$x = 8$$

$$49. 8^{-x} = 1.2$$

$$\ln(8^{-x}) = \ln(1.2)$$

$$-x \ln(8) = \ln(1.2)$$

$$x = \frac{-\ln(1.2)}{\ln(8)}$$

$$53. 3^{1-2x} = 4^x$$

$$(1-2x) \ln(3) = x \ln(4)$$

$$\ln(3) - 2x \ln(3) = x \ln(4)$$

$$3x \ln$$

$$x \ln(4) + 2x \ln(3) = \ln(3)$$

$$x(\ln(4) + 2\ln(3)) = \ln(3)$$

$$x = \frac{\ln(3)}{\ln(4) + 2\ln(3)} = \frac{\ln(3)}{2\ln(6)}$$

SECTION 6.8

1. $P(t) = 500 e^{0.02t}$

(a) $P(0) = 500$ insects

(b) Growth rate = 2%

(c) $800 = 500 e^{-0.02t}$

$$e^{0.02t} = 1.6$$

$$0.02t = \ln(1.6)$$

$$t = \frac{\ln(1.6)}{0.02} = 23.5 \text{ days}$$

(d) $500 e^{0.02t} = 1000$

$$e^{0.02t} = 2$$

$$0.02t = \ln(2)$$

$$t = \frac{\ln(2)}{0.02} = 34.66 \text{ days}$$

3. $A(t) = A_0 e^{-0.0244t}$

(a) Decay rate = $0.0244 = 2.44\%$

(b) $A(10) = 500 e^{-0.0244(10)}$

$$= 391.744 \text{ days grams}$$

(c) $400 = 500 e^{-0.0244t}$

$$e^{-0.0244t} = 0.8$$

ln

$$-0.0244t = \ln(0.8)$$

$$t = 9.145 \text{ years}$$

(d) $250 = 500 e^{-0.0244t}$

$$e^{-0.0244t} = 0.5$$

$$-0.0244t = \ln(0.5)$$

$$t = 28.408 \text{ years}$$

2. $A(t) = A_0 e^{-0.087t}$

(a) Decay rate = 8.7%

(b) $A(9) = 100 e^{-0.087(9)}$

$$= 0.0272 \text{ grams}$$

(c) $70 = 100 e^{-0.087t}$

$$e^{-0.087t} = 0.7$$

$$-0.087t = \ln(0.7)$$

$$t = 4.1 \text{ years}$$

(d) $50 = 100 e^{-0.087t}$

$$e^{-0.087t} = 0.5$$

$$-0.087t = \ln(0.5)$$

$$t = 7.967 \text{ years}$$

2. $N(t) = 1000 e^{0.01t}$

(a) $N(0) = 1000$

(b) Growth rate = 1%

(c) $N(4) = 100 e^{0.01(4)}$

$$= 104.081 \text{ bacteria}$$

$$= 1041 \text{ bacteria}$$

(d) $1700 = 1000 e^{0.01t}$

$$e^{0.01t} = 1.7$$

$$0.01t = \ln(1.7)$$

$$t = 53.06 \text{ hours}$$

(e) $2000 = 1000 e^{0.01t}$

$$e^{0.01t} = 2$$

$$0.01t = \ln(2)$$

$$t = 69.31 \text{ hours}$$

5.

$$(a) N(t) = N_0 e^{kt}$$

$$(b) 1000 e^{k \cdot 1} = 1800$$

$$e^k = 1.8$$

$$k = \ln(1.8) = 0.58779$$

$$N(t) = 1000 e^{0.58779t}$$

$$N(3) = 1000 e^{0.58779(3)}$$

$$= 5832$$

$$(c) 1000 e^{0.58779t} = 10000$$

$$e^{0.58779t} = 10$$

$$0.58779t = \ln(10)$$

$$t = 3.92 \text{ days}$$

6.

$$(a) N(t) = N_0 e^{kt}$$

$$(b) 800 = 500 e^{k \cdot 1}$$

$$e^k = 1.6$$

$$k = \ln(1.6)$$

$$k = 0.47$$

$$N(5) = 500 e^{0.47 \times 5}$$

$$= 5243$$

$$(c) 20000 = 500 e^{0.47t}$$

$$e^{0.47t} = 40$$

$$0.47t = \ln(40)$$

$$t = 7.85 \text{ hours}$$

$$7. (a) N(t) = N_0 e^{kt}$$

$$(b) 2 = e^{18k}$$

$$2 = e^{\frac{18}{12}k}$$

$$\frac{18}{12}k = \ln(2)$$

$$k = 0.4621$$

$$N(2) = 10,000 e^{0.4621(2)}$$

$$= 25198.42$$

$$8. (a) N(t) = N_0 e^{kt}$$

$$(b) 800000 = 900000 e^{2k}$$

$$\frac{8}{9} = e^{2k}$$

$$2k = \ln\left(\frac{8}{9}\right)$$

$$k = -0.05889$$

$$N(4) = 900,000 e^{-0.05889(4)}$$

$$= 711111$$

$$9. A(t) = A_0 e^{kt}$$

$$5 = 10 e^{1690k}$$

$$e^{1690k} = 0.5$$

$$1690k = \ln(0.5)$$

$$k = -0.00041$$

$$A(50) = 10 e^{-0.00041(50)}$$

$$= 9.797 \text{ grams}$$

$$10. \ln(0.5) = 1.3 \times 10^7 k$$

$$k = -5.3319 \times 10^{-10}$$

$$A(100) = 10 e^{-5.3319 \times 10^{-10} \times 100}$$

$$= 10$$

$$A(1000) = 10 e^{-5.3319 \times 10^{-10} \times 1000}$$

$$= 10$$

$$11. \frac{1}{2} A_0 = A_0 e^{kt}$$

$$0.5 = e^{5730k}$$

$$5730k = \ln(0.5)$$

$$k = -0.000121$$

$$0.3 A_0 = A_0 e^{-0.000121t}$$

$$e^{-0.000121t} = 0.3$$

$$-0.000121t = \ln(0.3)$$

$$t = 9952.81$$

SECTION 6 REVISION

$$1. f(x) = 3x - 5, g(x) = 1 - 2x^2$$

$$(a) (f \circ g)(2) = 3(1 - 2(2)^2) - 5 = -26$$

$$(b) (g \circ f)(-2) = 1 - 2(3(-2) - 5)^2 = -241$$

$$(c) (f \circ f)(4) = 3(3(4) - 5) - 5 = 16$$

$$(d) (g \circ g)(-1) = 1 - 2(1 - 2(-1)^2)^2 = -1$$

7(a) It is one-to-one.

$$(b) \{(2, 1), (5, 3), (8, 5), (10, 6)\}$$

$$9. f(x) = 5x - 10, g(x) = \frac{1}{5}x + 2$$

$$f(g(x)) = 5\left(\frac{1}{5}x + 2\right) - 10 = x + 10 - 10 = x$$

$$g(f(x)) = \frac{1}{5}(5x - 10) + 2 = x - 2 + 2 = x$$

$$13. f(x) = \sqrt{x - 2}$$

$$x = \sqrt{y - 2}$$

$$x^2 = y - 2$$

$$y = x^2 + 2 \quad f^{-1}(x) = x^2 + 2$$

$$\text{Domain } f: [2, \infty)$$

$$\text{Range } f: [0, \infty)$$

$$\text{Domain } f^{-1}: [0, \infty)$$

$$\text{Range } f^{-1}: [2, \infty)$$

$$15. (a) f(4) = 3^4 = 81$$

$$(b) g(9) = \log_3(9) = 2$$

$$(c) f(-2) = 3^{-2} = \frac{1}{9}$$

$$(d) g\left(\frac{1}{27}\right) = \log_3\left(\frac{1}{27}\right) = -3$$

$$17. \log_5 u = 13$$

$$5^{13} = u$$

$$23. \log_3\left(\frac{4v^2}{w}\right) =$$

$$= \log_3 4 + 2\log_3 v - \log_3 w$$

$$27. 3 \log_4 x^2 + \frac{1}{2} \log_4 \sqrt{x}$$

$$\log_4 x^6 + \log_4 x^{\frac{1}{4}}$$

$$\log_4 (x^6 \cdot x^{\frac{1}{4}})$$

$$28. \ln\left(\frac{x-1}{x}\right) + \ln\left(\frac{x}{x+1}\right) - \ln(x^2-1)$$

$$= \ln\left(\frac{\frac{x-1}{x} \cdot \frac{x}{x+1}}{x^2-1}\right) = \ln\left(\frac{\frac{x-1}{x+1}}{x^2-1}\right)$$

$$= \ln\left(\frac{1}{(x+1)^2}\right)$$

$$= -\ln(x+1)^2$$

$$37. 3^{x^2+x} = 3^{\frac{1}{3}}$$

$$x^2+x = \frac{1}{3}$$

$$x^2+x-\frac{1}{3} = 0$$

$$x_{1,2} = \frac{-1 \pm \sqrt{1 + \frac{4}{3}}}{2}$$

$$x = \frac{-3 \pm \sqrt{21}}{6}$$

$$39. 5^x = 3^{x+2}$$

$$x \ln(5) = (x+2) \ln(3)$$

$$x \ln(5) = x \ln(3) + 2 \ln(3)$$

$$x \ln(5) - x \ln(3) = 2 \ln(3)$$

$$x (\ln(5) - \ln(3)) = 2 \ln(3)$$

$$x = \frac{2 \ln(3)}{\ln(5) - \ln(3)}$$

$$41. \log_3(x-2)^{\frac{1}{2}} = 2$$

$$\log_3(x-2)^{\frac{1}{2}} = 2 \log_3 3$$

$$(x-2)^{\frac{1}{2}} = 3^2 = 9$$

$$x-2 = 81$$

$$x = 83$$

$$45. e^{1-x} = 5$$

$$(1-x) \ln e = \ln(5)$$

$$1-x = \ln(5)$$

$$x = 1 - \ln(5)$$

$$48. P = 25 e^{0.1d}$$

$$(a) P(4) = 25 e^{0.1(4)}$$

$$= 37.296 \text{ W}$$

$$(b) 50 = 25 e^{0.1d}$$

$$2 = e^{0.1d}$$

$$0.1d = \ln(2)$$

$$d = 6.931 \text{ dB}$$