5.06 *Functional Notation, Functions, Domain, and Range*

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ANSWERS TO ALL EXERCISES ARE INCLUDED AT THE END OF THIS PAGE

There is a special notation called **functional notation** that is frequently used in mathematics when one variable is described in terms of another. The notation **f(X)** [read "f of X"] is often used to name a second variable. Instead of writing "Y = 3X + 2" you sometimes write "f(X) = 3X + 2" or "g(X) = 3X + 2" or perhaps even "Y(X) = 3X + 2". Any letter may be used. This notation indicates that "f" or "g" or "Y" is a function of "X", or that it can be expressed in terms of "X". To find the value of f(2), just replace each X with the value 2. To find the value of f(4), replace each X with the value 4. To find the value of f(-3), replace each X with the value -3.

Complete the following exercises:

1. f(X) = 3X + 2

a) f(0) = 3( ) + 2
= ___________

b) f(2) =
=

c) f(4) =
=

d) f(-3) =
=

e) f($) = 3( ) + 2

f) f(*) = ___________

g) f(###) = ___________

h) f(Junk) = ___________

2. g(X) = -3X + 5

a) g(0) = -3( ) + 5
= ___________

b) g(2) =
=

c) g(4) =
=

d) g(-3) =
=

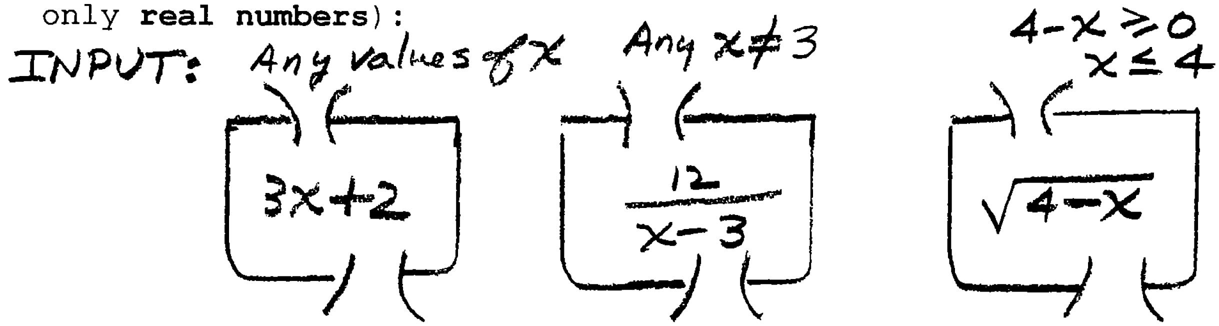
e) g($) = ___________

f) g(*) = ___________

g) g(###) = ___________

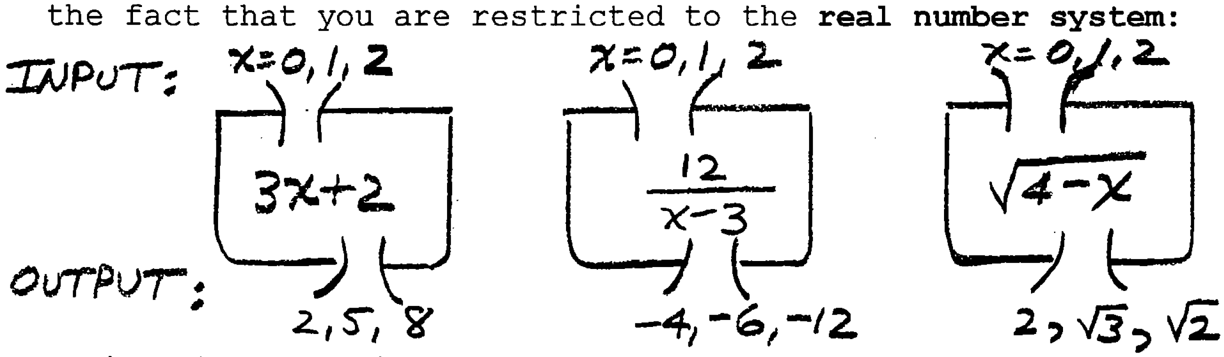
h) g(Junk) = ___________

This concept can further be explained by use of **"function machines."** Consider the following examples (for this section, use only **real numbers**):



Each of these machines consists of an "input spout", a formula, and an "output spout". Whenever a number is dropped into the input spout the number is substituted in place of the X in the formula. The result becomes the output value. These machines, therefore, have three parts: input, calculation (formula), and output.

When operating any machine, it is nice to know what kinds of fuel will run the machine. Even more important, what kinds of fuel will **not** permit the machine to operate? Recall the machines and the fact that you are restricted to the **real number system:**



Notice that the first machine **"3X + 2"** will run on <u>anything</u>. The second machine $\frac{12}{X-3}$ will run on <u>almost anything</u>--the value of X=3 is <u>not</u> allowed, since X=3 would require **division by zero,** which is not allowed. What values of X would be acceptable input for the third machine $\sqrt{4-X}$ (assume you are dealing with **real numbers**)? In this third machine, the values such as X=1, X=2, X=3, X=4 are all acceptable. However, if X>4, the result is a negative radicand, which is not acceptable in the real number system. These illustrate the **two requirements of the real number system:**

I. Denominators cannot equal zero,

II. Radicands of <u>even</u> radicals must be greater than or equal to zero.

Instead of drawing "function machines", it is usually more convenient to use **f(X) = 3X + 2**, **g(X)** = $\frac{12}{X - 3}$, or **h(X)** = $\sqrt{4 - X}$.
Frequently the notation **Y = 3X + 2**, **Y** = $\frac{12}{X - 3}$, or **Y** = $\sqrt{4 - X}$ is used. Any such equation that shows a **relationship** between two variables (such as X and Y) is defined to be a **relation.** When for each value of X (input) there is a unique value of Y (output), the equation is defined to be a **function.** In other words, a **function** is a **relation** that has a special **uniqueness property.** Furthermore, the set of all possible (permissible) **X values (input)** is defined to be the **domain.** The set of all possible **Y values (output)** is defined to be the **range.**

DOMAIN

To find the **domain,** you must begin with the function (or equation) in the form **"Y = _____."** If the equation is not in this form, then you must first solve for **Y** so as to have this form. Then, remember that there are two operations that are <u>not</u> permitted in the real number system:

I. DENOMINATORS cannot equal zero;

II. RADICANDS of <u>even</u> radicals must be greater than or equal to zero.

Based upon this, there are four main categories of domain problems to be solved in this course:

I. If there is a **denominator,** then: **Denominator ≠ 0.**
II. If there is an **<u>even</u> radical,** then: Set **radicand ≥ 0.**
III. If there is an **<u>even</u> radical/denominator:** Set **radicand > 0.**
IV. *<u>Usually</u>,* (for now, at least!) if there are **no denominators and no radicals** (this is the easiest case of all), then there are **no restrictions,** and the **domain is all real values.**

Here are the four categories of domain problems with examples of each type.

I. If there is a **denominator**, then: **Denominator $\neq$ 0.**

EXAMPLE: $Y = \dfrac{X - 2}{X^2 - 9}$. **Denominator:** $X^2 - 9 \neq 0$

$(X-3)(X+3) \neq 0$

$X \neq 3$ and $X \neq -3$

D: All X except $X = \pm 3$.

Notice that the numerator "X-2" is irrelevant to the problem!

II. If there is an **<u>even</u> radical**, then: Set **radicand** $\geq$ **0.**

EXAMPLE: $Y = \sqrt{X - 4}$. **Radicand:** $X - 4 \geq 0$

$X \geq 4$

D: $[4, \infty)$

III. If there is an **<u>even</u> radical-denominator:** Set **radicand > 0.**

EXAMPLE: $Y = \dfrac{X - 2}{\sqrt{X - 4}}$. **Radicand:** $X - 4 > 0$

$X > 4$

D: $(4, \infty)$

Notice that the numerator factor "X-2" is not relevant!

IV. If there are **no denominators and no radicals**, then there are *<u>usually</u>* **no restrictions**, and the **domain is all real values.**

EXAMPLES: $Y = 4$ **D: All reals** or $(-\infty, \infty)$

$Y = 3X - 6$ **D: All reals** or $(-\infty, \infty)$

$Y = X^2 + 3X - 4$ **D: All reals** or $(-\infty, \infty)$.

EXERCISES. Find the domain for each of the following functions.

1. $Y = \dfrac{12}{X + 3}$ **2.** $Y = \dfrac{2X}{X + 4}$ **3.** $Y = \dfrac{X - 2}{X^2 - 16}$ **4.** $Y = \dfrac{X + 3}{X^2 - 2X - 8}$

Denom $\neq$ 0

______ $\neq$ 0

D: $X \neq$ ______

5. $Y = \sqrt{X + 6}$ 6. $Y = \sqrt{X - 6}$ 7. $Y = \sqrt{6 - X}$ 8. $Y = \sqrt{2X + 5}$

D: X + 6 ≥ 0

X ≥ ___

D: [,)

9. $Y = \dfrac{X}{\sqrt{X + 6}}$ 10. $Y = \dfrac{X + 6}{\sqrt{X - 6}}$ 11. $Y = \dfrac{X - 2}{\sqrt{6 - X}}$ 12. $Y = \dfrac{3X - 12}{\sqrt{2X + 5}}$

13. $Y = X - 2$ 14. $Y = 3X + 12$ 15. $Y = X^2 - 4$ 16. $Y = 2$

17. $Y = \dfrac{X - 6}{X + 6}$ 18. $Y = \dfrac{X + 1}{\sqrt{2X - 6}}$ 19. $Y = 6 - X$ 20. $Y = \sqrt{12 - 2X}$

21. $Y = \sqrt{2X - 6}$ **22.** $Y = \dfrac{x - 3}{\sqrt{2X + 16}}$ **23.** $Y = \dfrac{X + 4}{X^2 - 4X}$ **24.** $Y = 2X + 5$

25. $Y = \dfrac{X - 6}{X^2 + 9}$ **26.** $Y = \dfrac{X}{X^2 - 16}$ **27.** $Y = \dfrac{X - 3}{\sqrt{2 + X}}$ **28.** $Y = \dfrac{2X + 5}{X^2 - 4X - 12}$

Denom $\neq$ 0

$X^2 + 9 \neq 0$

True for all real values of X.

D: (,)

29. $Y = \dfrac{4 + x}{X^2 - 64}$ **30.** $Y = \dfrac{X^2 - 6X}{\sqrt{4 - X}}$ **31.** $Y = \dfrac{X + 4}{X^2 + 25}$ **32.** $Y = \dfrac{X^2 - 16}{X^2 - 25}$

33. $Y = \dfrac{X - 6}{\sqrt{X}}$ **34.** $Y = X^2 - 16$ **35.** $Y = \sqrt{6 + 9X}$ **36.** $Y = \dfrac{X^2 - 6X + 5}{X}$

In 37-56, do you remember "quadratic inequalities"?
("BETWEENNESS" and "EXTREMES"!)

37. $Y = \sqrt{X^2-16}$

38. $Y = \sqrt{X^2 - 49}$

39. $Y = \sqrt{16 - X^2}$

40. $Y = \sqrt{49 - X^2}$

41. $Y = \dfrac{X - 9}{\sqrt{X^2-25}}$

42. $Y = \dfrac{3X}{\sqrt{X^2-49}}$

43. $Y = \dfrac{3X}{\sqrt{49-X^2}}$

44. $Y = \dfrac{X - 2}{\sqrt{9-X^2}}$

45. $Y = \dfrac{X - 9}{\sqrt{X^2+25}}$

46. $Y = \dfrac{3X}{\sqrt{X^2 + 49}}$

47. $Y = \dfrac{3X}{\sqrt{9 - X}}$

48. $Y = \sqrt{X - 4}$

49. $Y = X^2 - 9$

50. $Y = X^2 + 9$

51. $Y = \dfrac{3X}{49-X^2}$

52. $Y = \dfrac{X - 2}{\sqrt{9+X^2}}$

53. $Y = \sqrt{X^2-5X-6}$

54. $Y = \dfrac{X - 7}{\sqrt{X^2-5X-6}}$

55. $Y = \sqrt{6+5X-X^2}$

56. $Y = \dfrac{3X}{X^2-2X-15}$

57. $Y = X^2-2X-15$

58. $Y = \sqrt{X^2-2X-15}$

59. $Y = \dfrac{3X}{\sqrt{15+2X-X^2}}$

60. $Y = \dfrac{3X}{\sqrt{X^2-2X-15}}$

Frequently the equation of the function is not given in the form **Y =** _______. In such cases, in order to find the **domain**, it is necessary to solve the equation for **Y**, as in **literal equations**, so as to write the equation in the form **Y =** ______.

61. $2X + 3Y = 6$

$3Y = -2X + 6$

$Y =$

No variables in denom,
no radicals. Therefore,
D: (,)

62. $7X + 4Y = 16$

63. $7X + XY = 14$

$XY =$ __________

$Y =$

Denominator $\neq 0$

D: ______________

64. $XY - 3X = 2$

65. $Y(X^2 - 4) = 12X$

Divide both sides by (X^2-4)

$Y =$ __________

D: ______________

66. $Y(X^2 - 25) = 12X$

67. $Y(X^2 + 4) = 12X$

68. $4X - 3Y = 12$

69. $XY - 5X = 10$

70. $5X - 5XY = 4$

71. $XY - 5Y = X^2$

(First factor the Y!)

72. $XY + 5Y = X^2$

73. $X^2Y - 4Y = 6X$

74. $X^2Y - 16Y = 6X$

75. $X^2Y + 4Y = 6X$

76. $X^2Y + 16Y = 6X$

77. $XY = 2X - 4Y$

$XY + 4Y = 2X$ (Get all "Y" terms on one side; get all "non-Y" terms on the other side.)

$Y(X + 4) = 2X$ (Factor out the "Y" common factor! Note: This is the key step--don't forget!)

$$Y = \frac{2X}{X + 4}$$

Denom $\neq 0$

______ $\neq 0$

D: $X \neq$ ______ (See #2)

78. $XY = 3X + 5Y$

79. $XY - 3 = 3X - 6Y$

80. $3XY + 4X = 6Y - 8$

81. $X^2Y = 9Y + 6X$

82. $X^2Y = 4XY + 6$

83. $X^2Y = 5XY - 6Y + 4X$

84. $X^2Y = 4XY + 12Y + 4X$

85. $X^2Y = 4XY - 6X + 5Y$

86. $Y^2 = 4$

$Y = \pm$ ____

D: ____________

87. $Y^2 = X$

$Y = \pm$ ____

____ ≥ 0

D: [,)

88. $Y^2 = X - 4$

D: [,)

89. $Y^2 = 4 - X$

90. $Y^2 = 4 + X$

FUNCTIONS and RELATIONS

Each of the equations in the previous domain and range exercises represents a **relation.** In other words, in each equation there was a **relationship** between the variables **X** and **Y.** When for each value of X, there is a unique value of Y, the equation is defined to be a **function.** In other words, a **function** is a **relation** that has a special **uniqueness property.** What makes an equation not a function is the possibility of having two values of Y for a given X value. Therefore, whenever there is a **"Y = ± ____"** or a **"Y^2"** or **Y** raised to any **even power** involved in the equation, it is usually not a function. On the other hand, if the equation may be solved for Y and written in the form **"Y = ____"**, as in **functional notation "f(X) = ____"**, then it is a **function!**

One additional thought before the exercises, consider inequalities, such as **$Y < X + 2$.** Remember that, when graphed, inequalities, result in a **shaded area.** In any shaded area, for any given X value, there will be more than one, unique Y value. It is safe to conclude that shaded areas, and therefore inequalities, do not represent functions.

EXERCISES: Determine which of the following represent functions.

1. $Y = X^2$
2. $Y = X^2 + 4$
3. $X = Y^2 - 4$
4. $X = Y^2$
5. $Y = \sqrt{X}$
6. $Y = \sqrt{X - 6}$
7. $Y = \sqrt[3]{X}$
8. $Y = \sqrt[3]{X + 5}$
9. $Y = \pm\sqrt{X}$
10. $Y = \pm\sqrt[3]{X - 6}$
11. $Y = \pm\sqrt{X + 5}$
12. $Y = \sqrt[4]{X}$

13. $X^2 + Y^2 = 9$ 14. $X^2 - Y^2 = 9$ 15. $X^2 + Y = 9$

16. $X^3 + Y^3 = 9$ 17. $X^3 - Y^3 = 9$ 18. $X^2 - Y = 9$

19. $Y = 3X + 5$ 20. $4X - 12Y = 12$ 21. $2X + 3Y = 5$

22. $Y = -X - 3$ 23. $2X + Y^2 = 9$ 24. $2X^3 + Y^2 = 12$

25. $Y = 6$ 26. $Y = \pm 6$ 27. $X = 6$ 28. $X = -3$

29. $Y = \pm 3$ 30. $Y = -4$ 31. $Y = X^3 + 6X$

32. $Y = \dfrac{X^2 - 6X}{\sqrt{4 - X}}$ 33. $Y = \dfrac{X + 4}{X^2 + 25}$ 34. $Y = \dfrac{X^2 - 16}{X^2 - 25}$

35. $Y < X + 2$ 36. $3X - Y > 6$ 37. $3X - Y \geq 6$ 38. $Y \geq 3X$

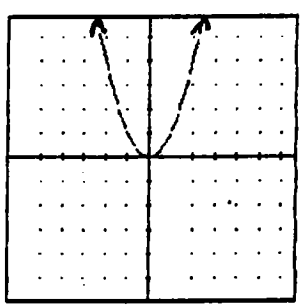
FUNCTIONS, DOMAIN, and RANGE
BY GRAPHING

Until now, the concepts of domain, range, and functions were presented from the perspective of **X,Y equations**. That is, given an equation in X and Y, you could determine the **domain** (the **set of all permissible X values**), the **range** (the **set of all resulting Y values**), and you could determine if it is a **function** (if **each Y value has a unique X value**). From the graph of the equation, it is also possible (even easier!) to determine the domain and range, and to determine if the equation represents a function. Consider the following two examples:

FUNCTION: $Y = X^2$

For any value of X, there is a unique Y value.

$X = 0 \rightarrow Y = 0^2 = 0$
$X = 1 \rightarrow Y = 1^2 = 1$
$X = 2 \rightarrow Y = 2^2 = 4$
$X = 3 \rightarrow Y = 3^2 = 9$
$X = -1 \rightarrow Y = (-1)^2 = 1$
$X = -2 \rightarrow Y = (-2)^2 = 4$



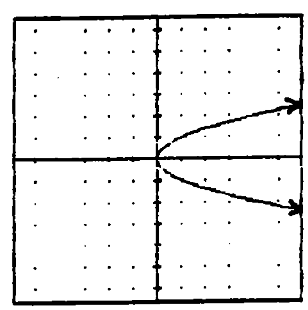
From the graph, if no vertical line crosses the graph in more than one point, then <u>**it is a function!**</u>

NOT FUNCTION: $X = Y^2$

If you pick values of X, say

If $X = 0 \rightarrow Y^2 = 0$, so $Y = 0$
$X = 1 \rightarrow Y^2 = 1$, so $Y = \pm 1$
$X = 4 \rightarrow Y^2 = 4$, so $Y = \pm 2$
$X = 9 \rightarrow Y^2 = 9$, so $Y = \pm 3$

(Since $X=Y^2$, X cannot be negative)



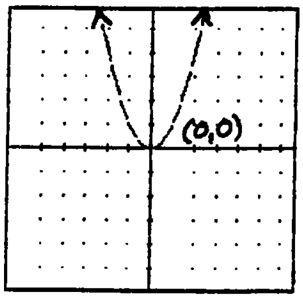
If any vertical line crosses the graph in **two or more points, then <u>it is NOT a function!</u>**

DEFINITION: **A function is a set of points such that no two distinct points have the same X-coordinate.**

RULE: **If <u>any</u> vertical line crosses a graph in two or more points, then it is <u>NOT</u> a function!**

Study the following examples to understand how to determine: **a) if the graph represents a function**, and how the **b) domain** and **c) range** can be determined from the graph.

EXAMPLE 1: $Y = X^2$

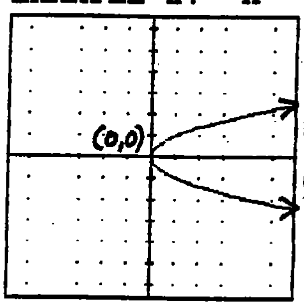


a) Function? Since no vertical line crosses the graph more than once, **it IS a function.**

b) Domain: Values of X extend all the way to the right and all the way to the left. Consider the equation $\mathbf{Y=X^2}$. Any value of X is permissible.
D: all reals or **$(-\infty, \infty)$**

c) Range: Values of Y are all on or above the X-axis. Considering the equation $\mathbf{Y=X^2}$, Y values are obtained from the squares of the X-values. Therefore,
R: $Y \geq 0$ or **$[0, \infty)$**

EXAMPLE 2: $X = Y^2$

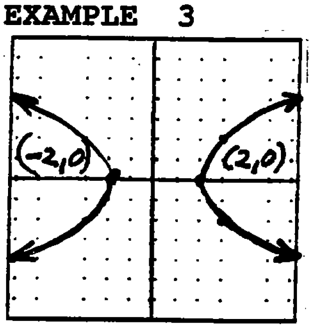


a) Function? **NOT a function**, since a vertical line crosses the graph in two points.

b) Domain: Values of X are on or to the right of the Y-axis.
D: $X \geq 0$ or **$[0, \infty)$**

c) Range: Values of Y extend all the way up and all the way down. Therefore, there are no restrictions on Y.
R: all reals or **$(-\infty, \infty)$**

EXAMPLE 3



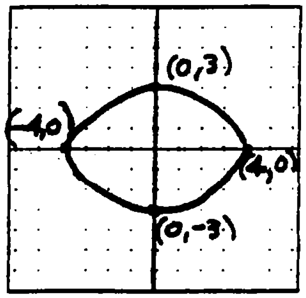
a) Function? **NOT a function**, by vertical line test.

b) Domain: X-values extend from X=2 to the right and from X=-2 to the left. No values of the graph are between -2 and 2.
D: $X \geq 2$ or $X \leq -2$, or
$(-\infty, -2] \cup [2, \infty)$

c) Range: Y-values go all the way up and all the way down. Therefore, no restrictions on Y.
R: all reals or **$(-\infty, \infty)$**

In the following exercises, from the graphs determine:
a) if a function **b) Domain** **c) Range.**

1.



a) Function? Can you draw a vertical line that crosses the graph twice? ______.

Circle one: Then it **(is, is not)** a function.

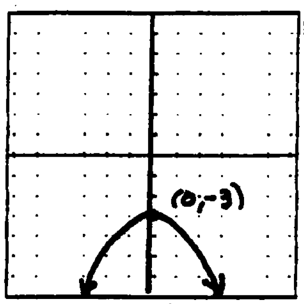
b) Domain: X values extend from ____ to ____.

D: Int. notation ________________.

c) Range: Y extends from _____ to _____.

R: Int. notation ________________.

2.



a) Function? Can you draw a vertical line that crosses the graph twice? ______.

Circle one: Then it **(is, is not)** a function.

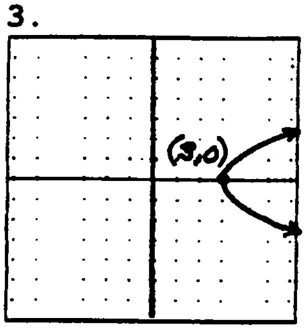
b) Domain: X values extend from ____ to ____.

D: Int. notation ________________.

c) Range: Y values are all at or below ____.

R: Int. notation **(- ∞,** ____**]**.

3.

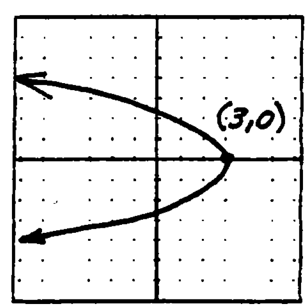


a) F? ______

b) D: ________

c) R: ________

4.

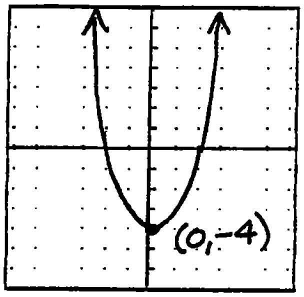


a) F? ______

b) D: ________

c) R: ________

5.



a) F? ______

b) D: ________

c) R: ________

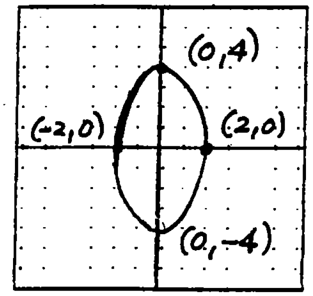
Note: Graph extends upward and right and left without bound!

6.

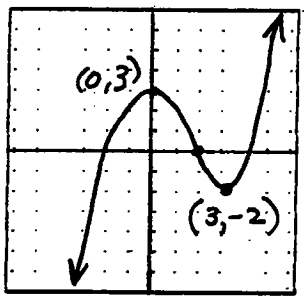
a) F? ______

b) D: ________

c) R: ________



7.



a) F? ______

b) D: ________

c) R: ________

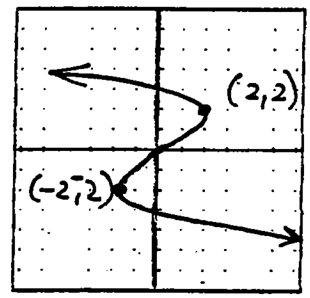
Note: Graph extends upward + right, downward + left, without bound.

8.

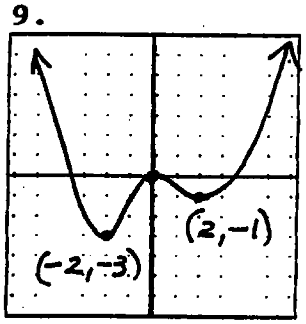
a) F? ______

b) D: ________

c) R: ________



9.



a) F? ______

b) D: ________

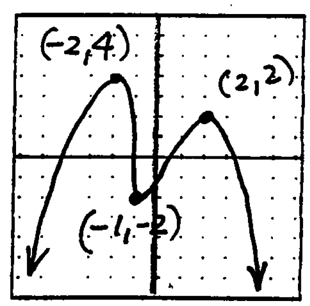
c) R: ________

10.

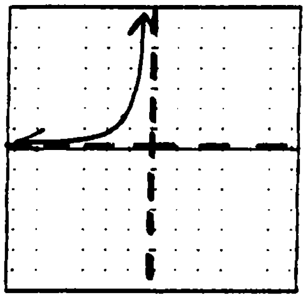
a) F? ______

b) D: ________

c) R: ________



11.



Note: This graph never touches the x or y axis.

a) F? ________

b) D: (,)

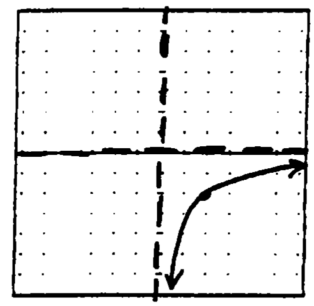
c) R: (,)

12.

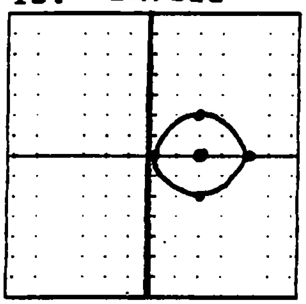
a) F? ________

b) D: ________

c) R: ________



13. CIRCLE



C= (2,0) r=2

a) F? ________

b) D: ________

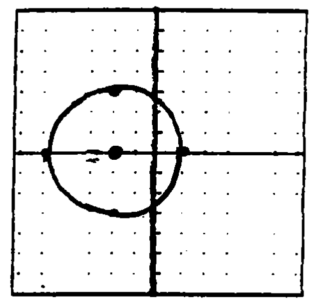
c) R: ________

14. CIRCLE

a) F? ________

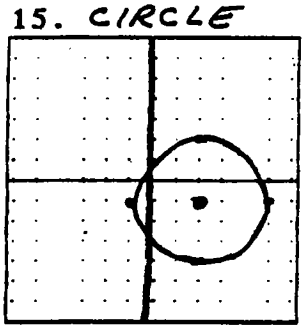
b) D: ________

c) R: ________



C = (-2,0) r = 3

15. CIRCLE



C=(2,-1) r=3

a) F? ________

b) D: ________

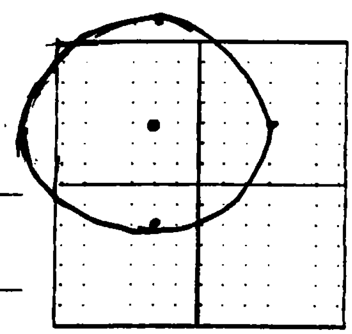
c) R: ________

16. CIRCLE

a) F? ________

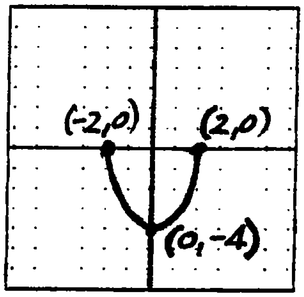
b) D: ________

c) R: ________



c(-2,3) r=5

17.



a) F? ________

b) D: ________

c) R: ________

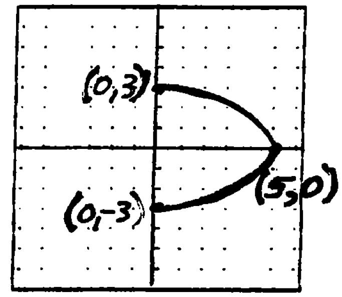
NOTE: This graph stops!

18.

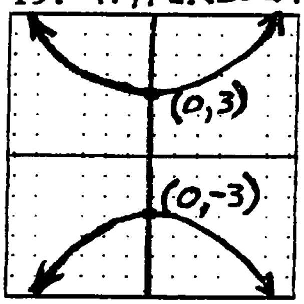
a) F? ________

b) D: ________

c) R: ________



19. HYPERBOLA



a) F? ________

b) D: ________

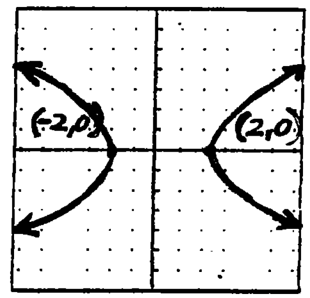
c) R: ________

20. HYPERBOLA

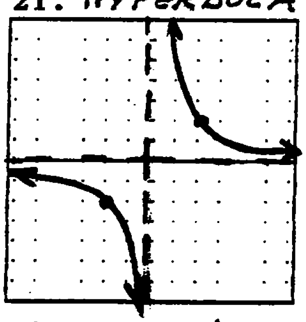
a) F? ________

b) D: ________

c) R: ________



21. HYPERBOLA



a) F? ________

b) D: ________

c) R: ________

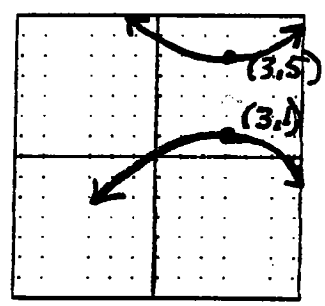
Never touches
x or y axis!

22. HYPERBOLA

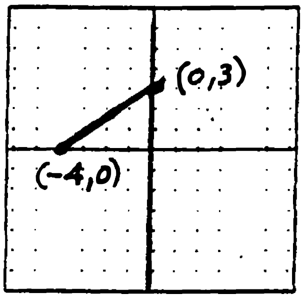
a) F? ________

b) D: ________

c) R: ________



23. *LINE SEGMENT*



a) F? ______

b) D: ________

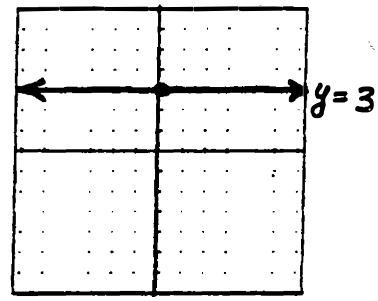
c) R: ________

24. *HORIZONTAL LINE*

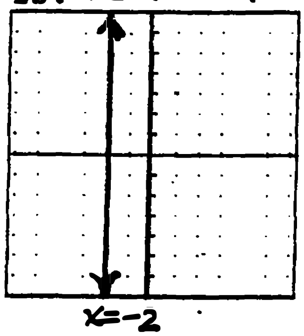
a) F? ______

b) D: ________

c) R: ________



25. *VERTICAL LINE*



a) F? ______

b) D: ________

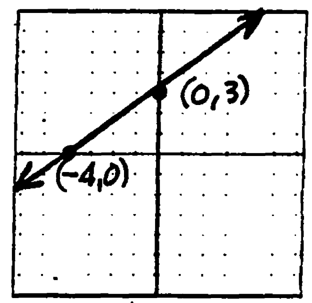
c) R: ________

26. *LINE*

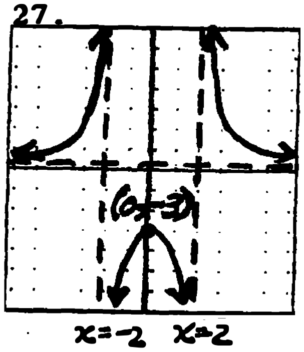
a) F? ______

b) D: ________

c) R: ________



27.



a) F? ______

b) D: ________

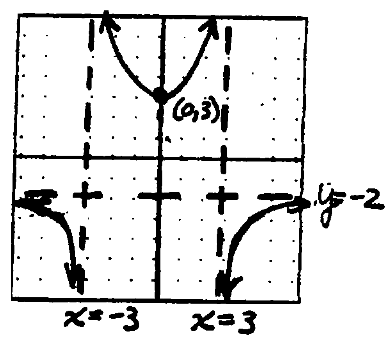
c) R: ________

28.

a) F? ______

b) D: ________

c) R: ________



NOTE: Graph never touches dotted lines (or asymptotes!)

ANSWERS 5.06

p. 427: 1a) 2; b) 8; c) 14; d) -7; e) 3$+2; f) 3*+2; g) 3(###)+2 h) 3(Junk)+2. 2a) 5; b) -1; c) -7; d) 14; e) -3$+5; f) -3*+5; g) -3(###)+5; h) -3(Junk)+5.

p. 430-437:

1. All $X\neq-3$; **2.** All $X\neq-4$; **3.** All $X\neq\pm4$; **4.** All $X\neq-2,4$
5. $[-6,\infty)$; **6.** $[6,\infty)$; **7.** $(-\infty,6]$; **8.** $[-2.5,\infty)$; **9.** $(-6,\infty)$
10. $(6,\infty)$; **11.** $(-\infty,6)$; **12.** $(-2.5,\infty)$; **13.** $(-\infty,\infty)$;
14. $(-\infty,\infty)$; **15.** $(-\infty,\infty)$; **16.** $(-\infty,\infty)$; **17.** All $X\neq-6$;
18. $(3,\infty)$; **19.** $(-\infty,\infty)$; **20.** $(-\infty,6]$; **21.** $[3,\infty)$ **22.** $(-8,\infty)$
23. All $X\neq0,4$; **24.** $(-\infty,\infty)$; **25.** $(-\infty,\infty)$; **26.** All $X\neq\pm4$;
27. $(-2,\infty)$; **28.** All $X\neq-2,6$; **29.** All $X\neq\pm8$; **30.** $(-\infty,4)$;
31. $(-\infty,\infty)$; **32.** All $X\neq\pm5$; **33.** $(0,\infty)$; **34.** $(-\infty,\infty)$;
35. $[-\frac{2}{3},\infty)$; **36.** All $X\neq0$; **37.** $(-\infty,-4]\cup[4,\infty)$;
38. $(-\infty,-7]\cup[7,\infty)$; **39.** $[-4,4]$; **40.** $[-7,7]$;
41. $(-\infty,-5)\cup(5,\infty)$; **42.** $(-\infty,-7)\cup(7,\infty)$; **43.** $(-7,7)$;
44. $(-3,3)$; **45.** $(-\infty,\infty)$; **46.** $(-\infty,\infty)$; **47.** $(-\infty,9)$;
48. $[4,\infty)$; **49.** $(-\infty,\infty)$; **50.** $(-\infty,\infty)$; **51.** All $X\neq\pm7$;
52. $(-\infty,\infty)$; **53.** $(-\infty,-1]\cup[6,\infty)$; **54.** $(-\infty,-1)\cup(6,\infty)$;
55. $[-1,6]$; **56.** All $X\neq-3,5$; **57.** $(-\infty,\infty)$; **58.** $(-\infty,-3]\cup[5,\infty)$;
59. $(-3,5)$; **60.** $(-\infty,-3)\cup(5,\infty)$; **61.** $(-\infty,\infty)$; **62.** $(-\infty,\infty)$;
63. All $X\neq0$; **64.** All $X\neq0$; **65.** All $X\neq\pm2$; **66.** All $X\neq\pm5$;
67. $(-\infty,\infty)$; **68.** $(-\infty,\infty)$; **69.** All $X\neq0$; **70.** All $X\neq0$;
71. All $X\neq5$; **72.** All $X\neq-5$; **73.** All $X\neq\pm2$; **74.** All $X\neq\pm4$;
75. $(-\infty,\infty)$; **76.** $(-\infty,\infty)$; **77.** All $X\neq-4$; **78.** All $X\neq5$;
79. All $X\neq-6$; **80.** All $X\neq2$; **81.** All $X\neq\pm3$; **82.** All $X\neq0,4$;
83. All $X\neq2,3$; **84.** All $X\neq-2,6$; **85.** All $X\neq-1,5$; **86.** $(-\infty,\infty)$;
87. $[0,\infty)$; **88.** $[4,\infty)$; **89.** $(-\infty,4]$; **90.** $[-4,\infty)$.

p.438-439:

1.F; 2.F; 3.NF; 4.NF; 5.F; 6.F; 7.F; 8.F; 9.NF; 10.NF;
11.NF; 12.F; 13.NF; 14.NF ; 15.F; 16.F; 17.F; 18.F; 19.F;
20.F; 21.F; 22.F; 23.NF; 24.NF; 25.F; 26.NF; 27.NF;
28.NF; 29.NF; 30.F; 31.F; 32.F; 33.F; 34.F; 35.NF; 36.NF;
37.NF; 38.NF.

p.442-446:

1. NF; D: $[-4,4]$; R: $[-3,3]$; 2. F; D: $(-\infty,\infty)$; R: $(-\infty,-3]$;
3. NF; D: $[3,\infty)$; R: $(-\infty,\infty)$; 4. NF; D: $(-\infty,3]$; R: $(-\infty,\infty)$;
5. F; D: $(-\infty,\infty)$; R: $[-4,\infty)$; 6. NF; D: $[-2,2]$; R: $[-4,4]$;
7. F; D: $(-\infty,\infty)$; R: $(-\infty,\infty)$; 8. NF; D: $(-\infty,\infty)$; R: $(-\infty,\infty)$;
9. F; D: $(-\infty,\infty)$; R: $[-3,\infty)$; 10. F; D: $(-\infty,\infty)$; R: $(-\infty,4]$;
11. F; D: $(-\infty,0)$; R: $(0,\infty)$; 12. F; D: $(0,\infty)$; R: $(-\infty,0)$;
13. NF; D: $[0,4]$; R: $[-2,2]$; 14. NF; D: $[-5,1]$; R: $[-3,3]$;
15. NF; D: $[-1,5]$; R: $[-4,2]$; 16. NF; D: $[-7,3]$; R: $[-2,8]$;
17. F; D: $[-2,2]$; R: $[-4,0]$; 18. NF; D: $[0,5]$; R: $[-3,3]$;
19. NF; D: $(-\infty,\infty)$; R: $(-\infty,-3]\cup[3,\infty)$;
20. NF; D: $(-\infty,-2]\cup[2,\infty)$; R: $(-\infty,\infty)$;
21. F; D: All $X\neq0$; R: All $Y\neq0$;
22. NF; D: $(-\infty,\infty)$; R: $(-\infty,1]\cup[5,\infty)$;
23. F; D: $[-4,0]$; R: $[0,3]$;
24. F; D: $(-\infty,\infty)$; R: Y must be 3;
25. NF; D: X must be -2; R: $(-\infty,\infty)$;
26. F; D: $(-\infty,\infty)$; R: $(-\infty,\infty)$;
27. F; D: All $X\neq\pm2$; R: $(-\infty,-3]\cup(0,\infty)$;
28. F; D: All $X\neq\pm3$; R: $(-\infty,-2)\cup[3,\infty)$.