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1.2 Mathematical Models: A Catalog of Essential Functions

1. Many physical quantities are connected by *inverse square laws*, that is, by power functions of the form:

$$f(x) = kx^{-2}$$

In particular, the illumination of an object by a light source is inversely proportional to the square of the distance from the source. Suppose that after dark you are in a room with just one lamp and you are trying to read a book. The light is too dim and so you move $\frac{2}{3}$ ds the distance to the lamp. How much brighter is the light?

a. $\frac{3}{2}$ times
b. $\frac{9}{4}$ times
c. $\frac{9}{2}$ times
d. $\frac{4}{9}$ times
e. 3 times

ANSWER: b

2. Scientists have discovered that a linear relationship exists between the amount of flobberworm mucus secretions and the air temperature. When the temperature is 45°F, the flobberworms each secrete 8.5 grams of mucus a day; when the temperature is 75°F, they each secrete 11.5 grams of mucus a day. Find a function $M(t)$ that gives the amount of mucus secreted on a given day, where t is the temperature of that day in degrees Fahrenheit.

a. $M(t) = 0.1t + 8.5$
b. $M(t) = 10t + 8.5$
c. $M(t) = 10t + 4$
d. $M(t) = 0.1t + 4$

ANSWER: d

3. The relationship between the Fahrenheit and Celsius temperature scales is given by the linear function.

$$F = \frac{9}{5}C + 32$$

What is the F-intercept and what does it represent?

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a. $\frac{9}{5}$, Fahrenheit temperature corresponding to $0^{\circ}C$
b. $\frac{9}{5}$, Celsius temperature corresponding to $32^{\circ}C$
c. 32, Celsius temperature corresponding to $0^{\circ}F$
d. 0, Fahrenheit temperature corresponding to $32^{\circ}C$
e. 32, Fahrenheit temperature corresponding to $0^{\circ}C$

ANSWER: e

4. The monthly cost of driving a car depends on the number of miles driven. Julia found that in October it cost her $300 to drive 400 mi and in July it cost her $450 to drive 700 mi. Express the monthly cost C as a function of the distance driven d assuming that a linear relationship gives a suitable model.

a. $C = -100d + 0.5$
b. $C = 100d - 0.5$
c. $C = 0.5d + 100$
d. $C = 2d + 100$
e. $C = 0.5d - 100$

ANSWER: c

5. Classify the function as a Polynomial function, a Rational function, an algebraic function, or other.

$f(x) = x^9 + 4x^6 - 6$

a. Other
b. Algebraic
c. Polynomial
d. Rational

ANSWER: c

6. It makes sense that the larger the area of a region, the larger the number of species that inhabit the region. Many ecologists have modeled the species-area relation with a power function and, in particular, the number of species S of bats living in caves in central Mexico has been related to the surface area A measured in m^2 of the caves by the equation

$S = 0.7A^{0.3}$

(a) The cave called mission impossible near puebla, mexico, has suface area of $A = 70m^2$.

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How many species of bats would expect to find in that cave?

(b) If you discover that 3 species of bats live in cave estimate the area of the cave.

ANSWER:

a) 3 species

b) $128\ m^2$

7. The relationship between the Fahrenheit and Celsius temperature scales is given by the linear function.

$$F = \frac{9}{5}C + 32$$

Complete the table and find the slope. Round your answers to the nearest whole number.

°C	°F
15	
–15	
slope	

ANSWER: (15, 59), (–15, 5); slope = 2

8. Find the domain of the function

$$f(x) = \frac{1}{\sqrt{3} - 2\cos x}$$

a. $x \neq \frac{\pi}{6} + 2\pi n$ and $x \neq \frac{11\pi}{6} + 2\pi n$, where n is any integer

b. $x \neq \frac{11\pi}{6}$ and $x \neq \frac{11\pi}{6}$

c. $x \neq \frac{5\pi}{6} + 2\pi n$ and $x \neq \frac{7\pi}{6} + 2\pi n$, where n is any integer

d. $x \neq \frac{5\pi}{6}$ and $x \neq \frac{7\pi}{6}$

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e. $x \neq \frac{\pi}{4} + 2\pi n$ and $x \neq \frac{7\pi}{4} + 2\pi n$, where n is any integer

ANSWER: a

9. If the recommended adult dosage for a drug is D (in mg), then to determine the appropriate dosage c for a child of age a, pharmacists use the equation $c = 0.04D(a+1)$. Suppose the dosage for an adult is 900 mg. What is the slope of the graph of c and what does it represent?

a. 36 mg/yr; the rate of change of dosage with respect to age
b. 36 yr/mg; the rate of change of age with respect to dosage
c. 0.04 mg/yr; the rate of change of dosage with respect to age
d. 0.04 mg/yr; the rate of change of age with respect to dosage
e. 36 mg; the dosage for a newborn

ANSWER: a

10. Biologists have noticed that the chirping rate of crickets of a certain species is related to temperature, and the relationship appears to be very nearly linear. A cricket produces 108 chirps per minute at 70°F and 228 chirps per minute at 90°F. Find a linear equation that models the temperature T as a function of the number of chirps per minute N.

a. $T(N) = \frac{1}{6}N + \frac{312}{6}$
b. $T(N) = \frac{1}{6}N - \frac{312}{6}$
c. $T(N) = 6N - 648$
d. $N(T) = 6T - 312$
e. $N(T) = -6T + 312$

ANSWER: a

11. Classify the following function:
$f(x) = x^6(9x^4 - 4)$

a. Polynomial function
b. Power function
c. Trigonometric function
d. Rational Function
e. Exponential function

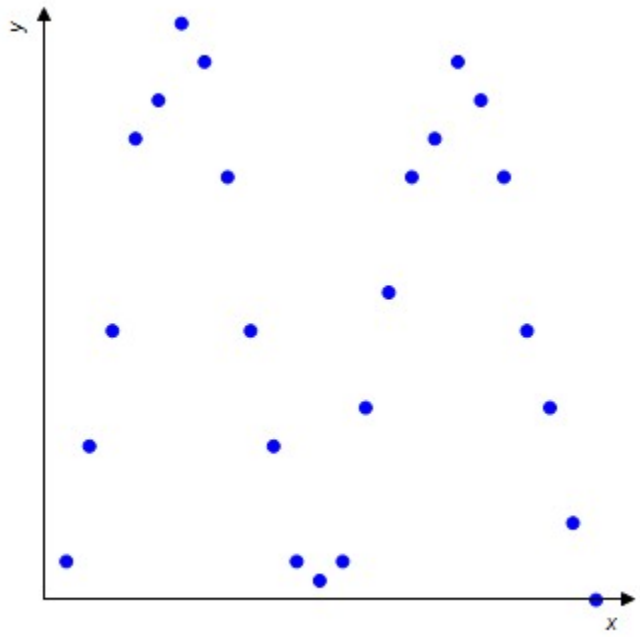
ANSWER: a

12. For the scatter plot below, what type of function might you see as a model for the data?

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a. Trigonometric function
b. Rational Function
c. Exponential Function
d. Power Function
e. Polynomial Function

ANSWER: a

13. Find an equation for the family of linear functions such that $f(6)=5$.

a. $f(x)=5+m(x-6)$
b. $f(x)=m(x-6)-5$
c. $f(x)=6+m(x-5)$
d. $f(x)=m(x+5)-5$
e. $f(x)=mx+6m-5$

ANSWER: a

14. The manager of a weekend flea market knows from past experience that if he charges x dollars for a rental space at the market, then the number y of spaces he can rent is given by the equation $y=560-8x$. What does the x-intercept indicate?

a. There will be no spaces occupied when the rental cost is $70.

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b. There will be no spaces occupied when the rental cost is $560.
c. There will be 560 spaces occupied when there is no rental cost.
d. There will be 8 spaces occupied when there is no rental cost.
e. The number of occupied spaces decreases by 5 for every $1 increase in rent.

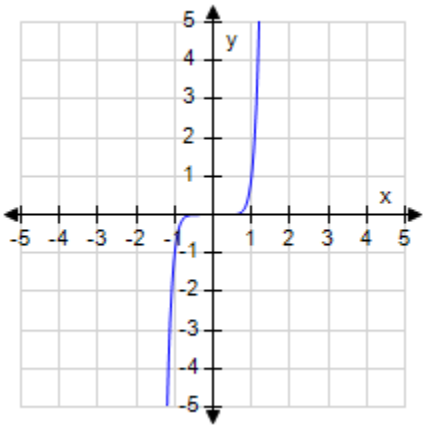
ANSWER: a

15. At the surface of the ocean, the water pressure is the same as the air pressure above the water, 13 lb/in^2. Below the surface, the water pressure increases by 4.34 lb/in^2 for every 10 ft of descent. At approximately what depth is the pressure 120 lb/in^2?

a. 247 ft
b. 276 ft
c. 30 ft
d. 56 ft
e. 359 ft

ANSWER: a

16. What is the equation of this graph?



a. $y = x^4$
b. $y = x^8$
c. $y = x^{10}$
d. $y = \sqrt[3]{x}$
e. $y = x^9$

ANSWER: e

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17. Find the domain of the function.

$$f(x)=\frac{7x+5}{x^2}$$

a. $(-\infty, 0)$

b. $\left(-\infty, -\frac{5}{7}\right] \cup \left[-\frac{5}{7}, \infty\right)$

c. $\left(-\infty, \frac{5}{7}\right] \cup \left[\frac{5}{7}, \infty\right)$

d. $(-\infty, 0) \cup (0, \infty)$

ANSWER: d

18. Find the domain of the function $f(x)=\frac{x}{7\sin x-8}$

a. $(-\infty, \infty)$

b. $\left[\frac{8}{7}, \infty\right)$

c. $[-8, 7]$

d. $[-7, 8]$

ANSWER: a

19. Find a, such that the function $f(x)=4x+\sqrt{a-x^2}$ has the domain $[-3, 3]$.

a. $a = -9$

b. $a = \sqrt{3}$

c. $a = -\sqrt{3}$

d. $a = 9$

e. $a = 3$

ANSWER: d

20. Find the domain.

$$g(u)=\sqrt{u}-\sqrt{3-u}$$

a. $(0, 3)$

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b. $(-\infty, 0]$
c. $(-3, \infty]$
d. $[0, 3]$
e. $[0, \infty)$

ANSWER: d

21. Find the range of the function.

$y = 4 + \cos x$

a. $(-\infty, \infty)$
b. $(2, \infty)$
c. $[-1, 1]$
d. $(-1, 3)$
e. $[3, 5]$

ANSWER: e

22. Find the domain of the function.

$$f(x) = \frac{7}{3x-1}$$

ANSWER: $\left\{x \middle| x \neq \frac{1}{3}\right\}$

23. Find the domain of the function.

$$f(x) = \sqrt{25-x^2}$$

ANSWER: $[-5, 5]$

24. Find the range of the function.

$$h(x) = \sqrt{36-x^2}$$

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ANSWER: $0 \le h(x) \le 6$

25. It makes sense that the larger the area of a region, the larger the number of species that inhabit the region. Many ecologists have modeled the species-area relation with a power function. In particular, the number of species S of bats living in caves in central Mexico has been related to the surface area A of the caves by the equation $S = 0.7A^{0.3}$. If you discover that nine species of bats live in a cave, estimate the area of the cave.

a. 4979 m^2

b. 1.35 m^2

c. 2125 m^2

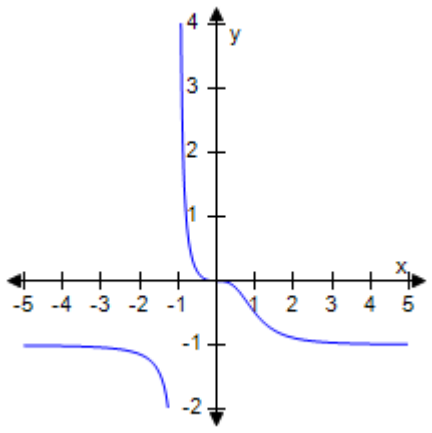
d. 2.15 m^2

ANSWER: a

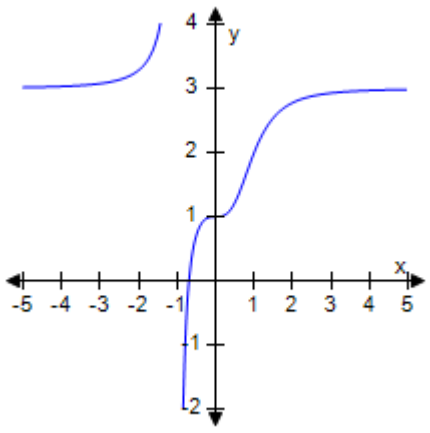
26. Plot the graph of the function f in an appropriate viewing window.

$$f(x) = \frac{x^3}{x^3+1}$$

a.



b.

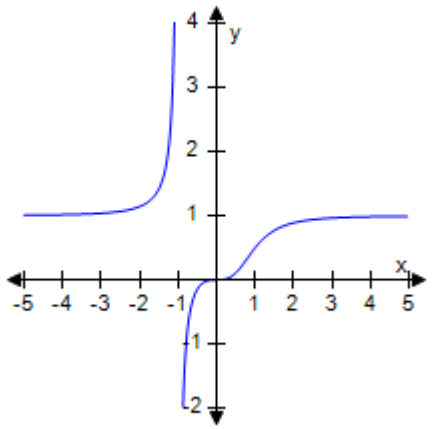


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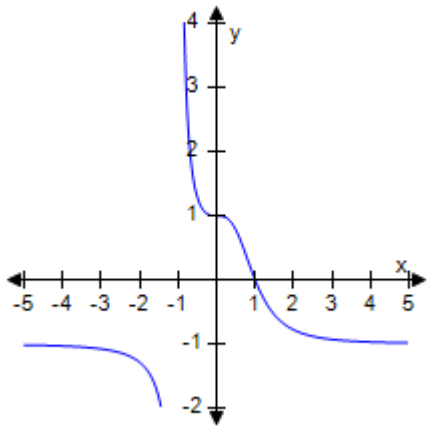
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c.



d.



ANSWER: c

27. Identify the type of the following function.

$h(r) = 3.6^r$

a. power function
b. root function
c. polynomial
d. rational function
e. algebraic function
f. trigonometric function
g. exponential function
h. logarithmic function

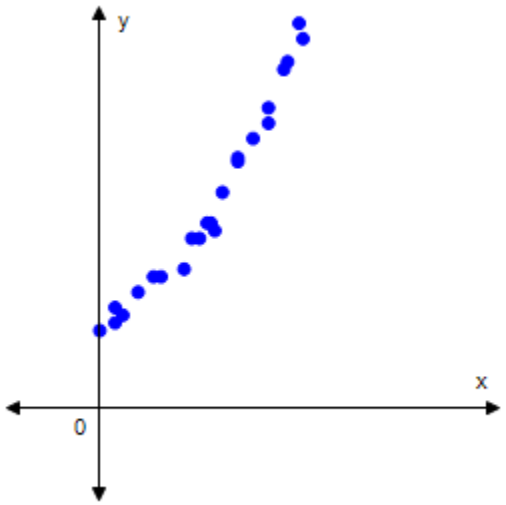
ANSWER: g

28. Decide what type of function you might choose as a model for the data displayed on the scatter plot.

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a. exponential function
b. logarithmic function
c. polynomial
d. rational function
e. trigonometric function

ANSWER: a

29. Determine the domain and range of the function $f(x) = 3^x$.

a. Domain: $(-\infty, \infty)$, range: $(0, \infty)$
b. Domain: $(0, \infty)$, range: $(-\infty, \infty)$
c. Domain: $(0, \infty)$, range: $(0, \infty)$
d. Domain: $(-\infty, \infty)$, range: $(-\infty, \infty)$
e. Domain: $(-\infty, \infty)$, range: $(3, \infty)$
f. Domain: $(3, \infty)$, range: $(-\infty, \infty)$

ANSWER: a

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