## The answers to all of the exercises are on the third page.

The level curves below represent temperatures $T$ on a rectangular sheet of metal. The temperatures are in degrees Fahrenheit, and the distances are in feet (with $x$-values being on the horizontal axis and $y$-values on the vertical, as usual). Use the plot to answer the questions below it; give units with all answers for which they are appropriate. Answers will be approximate, but should be reasonably close.


1. Give the temperature at $(7,3)$, using the notation $T(x, y)$. (In other words, write " $T(7,3)=\ldots$ ".
2. Estimate each of the following temperatures. Your answer should be within a degree or two of the answers provided.
(a) $T(13,4)$
(b) $T(11,5)$
(c) $T(A)$, the temperature at point $A$
3. Determine whether the temperature is increasing, decreasing, or constant (not increasing or decreasing) at each of the points given and in the direction given.
(a) At $(6,8)$ and in the positive $x$-direction
(b) At $(6,8)$ and in the negative $y$-direction
(c) At $(12,3)$ and in the positive $x$-direction
(d) At $(12,3)$ and in the positive $y$-direction
(e) At $(4,3)$ and in the positive $x$-direction
4. Use the graph at the top left of page 786 of the textbook for the following.
(a) Estimate the density of seawater when the salinity is 32.5 ppt and the temperature is $5^{\circ} \mathrm{C}$.
(b) Write your answer to (a) using function notation.

The table to the right gives the wind-chill temperature $W$ (in degrees Fahrenheit) for various actual temperature/wind speed combinations (in that order). Wind speed is in miles per hour and actual temperature is given in degrees Fahrenheit. Use it to answer the questions below, assuming that $W=W(T, v)$. (Table from the National Weather Service.)

|  | Actual Temperature ( ${ }^{\circ} \mathrm{F}$ ) |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\bar{v}$ | -10 | 0 | 10 | 20 | 30 | 40 |
|  | 5 | -22 | -11 | 1 | 13 | 25 | 36 |
|  | 10 | -28 | -16 | -4 | 9 | 21 | 34 |
|  | 15 | -32 | -19 | -7 | 6 | 19 | 32 |
|  | 20 | -35 | -22 | -9 | 4 | 17 | 30 |

5. Give the value of $W(10,15)$, with units. Then write a short sentence telling what this tells us. (Your sentence should mention three numbers, with their units!)
6. In a sentence, describe the effect of wind speed on the wind-chill temperature. Your sentence should be something like "As wind speed increases, ...".
7. In the same way, describe the effect actual temperature on the wind-chill temperature.

In some location the temperature $T$ in degrees Fahrenheit of the ground at a depth of $d$ feet and at time $t$ days from some zero date is modeled by

$$
T(d, t)=30 e^{-0.2 d} \cos (0.0172 t-0.2 d)+60 .
$$

8. Find the temperature at a depth of 2 feet and on the 50 th day, rounded to the nearest hundredth. (Your calculator should always be in radians unless we are working specifically with degrees.) Give your answer using concise mathematical notation that tells not only the answer, but what it represents. That is, give your answer using function notation. (See Exercise 1.)
9. Give your answer to (a) as a sentence that makes it clear what both the question and answer are.
10. Find $T(4,200)$. Then write a sentence containing three numbers that expresses your result.
11. Give another value of $t$ for which you would expect to obtain the same temperature as you got for Exercise 9 , at the same depth. Check to see if your guess is correct.

Graph each of the following. Label intercepts, and draw in asymptotes for hyperbolas.
12. $x^{2}+y^{2}=12$
13. $\frac{x^{2}}{5}+\frac{y^{2}}{16}=1$
14. $\frac{x^{2}}{25}-\frac{y^{2}}{12}=1$
15. $x^{2}-y^{2}=-1$ (Hint: Begin by multiplying both sides by negative one.)
16. $9 x^{2}+16 y^{2}=144$
17. $8=3 x-2 y$ (Hint: Take advantage of $y=m x+b$ form.)
18. $\frac{x^{2}}{5}+\frac{y^{2}}{16}=0$ (Hint: Remember that the graph is all points $(x, y)$ that make the equation true.)
19. Sketch the graph of $z=\frac{y^{2}}{4}-\frac{x^{2}}{9}$ when
(a) $x=3$
(b) $z=1$
(c) $y=4$
(d) $z=-4$
20. Graph $\frac{y^{2}}{4}-\frac{x^{2}}{9}=0$. (Hint: solve for $y$, remembering the $\pm$ when you square root both sides.)

## Solutions on the next page.

1. $T(7,3) \approx 53^{\circ} \mathrm{F}$
2. (a) $T(13,4) \approx 76^{\circ} \mathrm{F}$
(b) $T(11,5) \approx 92^{\circ} \mathrm{F}$ ? (The value must be greater than $90^{\circ} \mathrm{F}$, but is otherwise difficult to determine.)
(c) $T(A) \approx 79^{\circ} \mathrm{F}$
3. (a) increasing
(b) decreasing
(c) decreasing
(d) increasing
(e) constant
4. (a) $1.0257 \mathrm{~kg} / \mathrm{m}^{3}$
(b) $\rho(32.5,5)=1.0257 \mathrm{~kg} / \mathrm{m}^{3}$
5. $W(10,15)--7^{\circ} \mathrm{F}$ When the actual temperature is $10^{\circ} \mathrm{F}$ and the wind speed is 15 mph , the wind chill temperature is $-7^{\circ} \mathrm{F}$.
6. As the wind speed increases, the wind-chill temperature decreases.
7. As the actual temperature increases, the wind-chill temperature increases.
8. $T(2,50)=78.02^{\circ} \mathrm{F}$
9. At a depth of two feet and on the fiftieth day, the temperature is $78.02^{\circ} \mathrm{F}$.
10. At a depth of four feet and on the 200th day, the temperature is $48.18^{\circ} \mathrm{F}$.


11. 




16.

18. The graph is a single point at the origin.





