Chapter 4 answers

4 – 2 Answers

1. Continuous on [−5,1] Yes
   \[ f'(x) = 2x + 4 \]
   Differentiable on (−5 , 1) Yes
   \[ f(-5) = 0 \quad f(1) = 0 \]
   \[ x = -2 \]

2. Continuous on [2,4] Yes
   \[ f'(x) = -4x + 12 \]
   Differentiable on (2,4) Yes
   \[ f(2) = 0 \quad f(4) = 0 \]
   \[ x = 3 \]

3. Continuous on [−2,2] Yes
   \[ f'(x) = 8x - 2 \]
   Differentiable on (−2 , 2) Yes
   \[ f(-2) = 20 \quad f(2) = 12 \]

4. Conditions not met.

5. Continuous on [−1,1] Yes
   \[ f'(x) = \frac{2}{3\sqrt{x}} \]
   Differentiable on (−1,1) NO
   \[ x = \frac{5}{2} \]

6. Continuous on [−7,1] Yes
   \[ f'(x) = f'(x) = -4x + 12 \]
   Differentiable on (−7,1) Yes
   \[ f(-7) = -9 \quad f(1) = -9 \]
   \[ x = 3 \]

7. Continuous on [−2,2] Yes
   \[ f'(x) = 4x^3 - 4x \]
   Differentiable on (−2,2) Yes
   \[ f(-2) = 8 \quad f(2) = 8 \]
   \[ x = 0 \text{ or } 1 \text{ or } -1 \]

8. Continuous on [−3,3] Yes
   \[ f'(x) = 3x^2 - 3 \]
   Differentiable on (−3,3) Yes
   \[ f(-3) = 36 \quad f(3) = 18 \]

9 Continuous on [0,\pi] Yes
   \[ f'(x) = \cos(x) \]
   Differentiable on (0 , \pi) Yes
   \[ f(0) = 0 \quad f(\pi) = 0 \]
   \[ x = \frac{\pi}{2} \]

10. Continuous on [0,2\pi] Yes
    \[ f'(x) = -\sin(x) \]
    Differentiable on (0,2\pi) Yes
    \[ f(0) = 1 \quad f(2\pi) = 1 \]
    \[ x = \pi \]

11. Continuous on [−1,1] No
    Conditions not met.

12. Continuous on [−2,2] Yes
    \[ f'(x) = \frac{2x}{-x^2 + 5} \]
    Differentiable on (−2,2) Yes
    \[ f(-2) = 0 \quad f(2) = 0 \]
    \[ x = 0 \]
13. Continuous on $[1, 2]$ Yes
   Differentiable on $(1, 2)$ Yes
   \[ f(1) = 3 \quad f(2) = 15 \]
   \[ x = \frac{3}{2} \]

14. Continuous on $[-1, 3]$ Yes
   Differentiable on $(-1, 3)$ Yes
   \[ f(-1) = 13 \quad f(3) = 1 \]
   \[ x = 1 \]

15. Continuous on $[2, 5]$ Yes
   Differentiable on $(2, 5)$ Yes
   \[ f(2) = 1 \quad f(5) = 2 \]
   \[ x = \frac{13}{4} = 3.25 \]

16. Continuous on $[1, 10]$ Yes
   Differentiable on $(1, 10)$ No
   Cannot use MVT

17. Continuous on $[1, 4]$ Yes
   Differentiable on $(1, 4)$ Yes
   \[ f(1) = 1 \quad f(4) = 4 \]
   \[ x = 2 \]

18. Continuous on $\left[\frac{1}{2}, 2\right]$ Yes
   Differentiable on $\left(\frac{1}{2}, 2\right)$ Yes
   \[ f\left(\frac{1}{2}\right) = 3 \quad f(2) = \frac{3}{2} \]
   \[ x = 1 \]

19. Continuous on $[0, 1]$ Yes
    Differentiable on $(0, 1)$ Yes
    \[ f(0) = 0 \quad f(1) = 1 \]
    \[ x = \frac{8}{27} \]

20. Continuous on $[0, 2\pi]$ Yes
    Differentiable on $(0, 2\pi)$ Yes
    \[ f(0) = 0 \quad f(2\pi) = 2\pi \]
    \[ x = \frac{\pi}{2} \text{ and } \frac{3\pi}{2} \]

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**Section 4–3A**

1. Intervals Increasing $(-\infty, -2) \cup (1, \infty)$
   Intervals Decreasing $(-2, 0) \cup (0, 1)$
   x value of maximum point(s) $x = -2$
   x value of minimum point(s) $x = 1$

2. Intervals Increasing $(-\infty, -2)$
   Intervals Decreasing $(-2, 1) \cup (1, \infty)$
   x value of maximum point(s) $x = -2$
   x value of minimum point(s) None

3. Intervals Increasing $(-\infty, -3) \cup (-2, 0)$
   Intervals Decreasing $(-3, -2) \cup (0, \infty)$
   x value of maximum point(s) $x = -3, 0$
   x value of minimum point(s) $x = -2$

4. Intervals Increasing None
   Intervals Decreasing $(-\infty, 1) \cup (1, 2) \cup (2, \infty)$
   x value of maximum point(s) None
   x value of minimum point(s) None

5. Intervals Increasing $(-1, 0)$
   Intervals Decreasing $(-\infty, -1) \cup (0, 1) \cup (1, \infty)$
   x value of maximum point(s) $x = 0$
   x value of minimum point(s) $x = -1$

6. Intervals Increasing $(1, \infty)$
   Intervals Decreasing $(-\infty, -1) \cup (-1, 0) \cup (0, 1)$
   x value of maximum point(s) None
   x value of minimum point(s) $x = 1$
7. Intervals Increasing \((\infty, 0) \cup (0, 2)\)  
Intervals Decreasing \((2, \infty)\)  
x value of maximum point(s) \(x = 2\)  
x value of minimum point(s) None

8. Intervals Increasing \((\infty, -1) \cup (2, \infty)\)  
Intervals Decreasing \((-1, 0) \cup (0, 2)\)  
x value of maximum point(s) \(x = -1\)  
x value of minimum point(s) \(x = 2\)

9. Intervals Increasing \((\infty, -2) \cup (0, 3)\)  
Intervals Decreasing \((-2, \infty) \cup (3, \infty)\)  
x value of maximum point(s) \(x = -2, 3\)  
x value of minimum point(s) \(x = 0\)

10. Intervals Increasing \((-\frac{1}{2}, 0) \cup (0, 2)\)  
Intervals Decreasing \((-\infty, -1/2) \cup (0, 2)\)  
x value of maximum point(s) \(x = 0\)  
x value of minimum point(s) \(x = -1/2, 2\)

11. Rel. maximum point(s) \((-1, 4)\)  
Rel. minimum point(s) \((1, -4)\)  
Absolute maximum value. None  
Absolute minimum value None

12. Rel. maximum point(s) \((0, 0)\)  
Rel. minimum point(s) \((-3, -81), (3, -81)\)  
Absolute maximum value. None  
Absolute minimum value -81

13. Rel. maximum point(s) None  
Rel. minimum point(s) None  
Absolute maximum value. None  
Absolute minimum value None

14. Rel. maximum point(s) None  
Rel. minimum point(s) \((3, -27)\)  
Absolute maximum value. None  
Absolute minimum value -27

15. Rel. maximum point(s) \((-2, 32)\)  
Rel. minimum point(s) \((2, -32)\)  
Absolute maximum value. None  
Absolute minimum value None

16. Rel. maximum point(s) \((1, 13)\)  
Rel. minimum point(s) None  
Absolute maximum value. None  
Absolute minimum value 13

17. Rel. maximum point(s) \((0, 16)\)  
Rel. minimum point(s) \((-2, 0) \text{ and } (2, 0)\)  
Absolute maximum value. None  
Absolute minimum value 0

18. Rel. maximum point(s) \((0, 0) \text{ and } (2, 0)\)  
Rel. minimum point(s) \((1, -1)\)  
Absolute maximum value. 0  
Absolute minimum value None

19. Rel. maximum point(s) None  
Rel. minimum point(s) \((-1, -\frac{1}{e})\)  
Absolute maximum value. None  
Absolute minimum value -\frac{1}{e}

20. Rel. maximum point(s) \((-2, \frac{4}{e^2})\)  
Rel. minimum point(s) \((0, 0)\)  
Absolute maximum value. None  
Absolute minimum value None

The function has a lower bound of 0 but it has no minimum value
21. Rel. maximum point(s) (0.2)  
   Rel. minimum point(s) None  
   Absolute maximum value 2  
   Absolute minimum value

   **The function has a lower bound of 0 but it has no minimum value**

22. Rel. maximum point(s) (1, 1/2)  
   Rel. minimum point(s) (−1, −1/2)  
   Absolute maximum value 1/2  
   Absolute minimum value −1/2

23. Rel. maximum point(s) (−3, 0)  
   Rel. minimum point(s) (−1, −2√2)  
   Absolute maximum value None  
   Absolute minimum value None

24. Rel. maximum point(s) (0, 0) (4, 0)  
   Rel. minimum point(s) (4, −3√2)  
   Absolute maximum value None  
   Absolute minimum value None

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**Section 4–3B**

<table>
<thead>
<tr>
<th></th>
<th>rel. max. points</th>
<th>rel. min. points</th>
<th>Left Endpoint</th>
<th>Right Endpoint</th>
<th>Ab. min. value</th>
<th>Ab. max. value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>(1,1)</td>
<td>(0,0)</td>
<td>(−2,28)</td>
<td>(3,−27)</td>
<td>−27</td>
<td>28</td>
</tr>
<tr>
<td>2.</td>
<td>(−4,32)</td>
<td>(0,0)</td>
<td>(−5,25)</td>
<td>(1,7)</td>
<td>0</td>
<td>32</td>
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<tr>
<td>3.</td>
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<td>(1,−1/2)</td>
<td>(−2,40)</td>
<td>(2,8)</td>
<td>−1/2</td>
<td>40</td>
</tr>
<tr>
<td>4.</td>
<td>(−1,4) and (1,4)</td>
<td>(0,0)</td>
<td>(−2,−32)</td>
<td>(2,−32)</td>
<td>−32</td>
<td>4</td>
</tr>
<tr>
<td>5.</td>
<td>(3/2, 47/4)</td>
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<td>(0.5)</td>
<td>(4, −7)</td>
<td>−7</td>
<td>47/4</td>
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<tr>
<td>6.</td>
<td>(1/2,1/4)</td>
<td>(0,0)</td>
<td>(−1,7)</td>
<td>(2,−20)</td>
<td>−20</td>
<td>7</td>
</tr>
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Chapter 4 answers
<table>
<thead>
<tr>
<th>7.</th>
<th>rel. max. points</th>
<th>rel. min. points</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(-\sqrt{2}, 4\sqrt{2})$</td>
<td>$(\sqrt{2}, -4\sqrt{2})$</td>
<td></td>
</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$(-2, 4)$</td>
<td>$(3, 9)$</td>
<td></td>
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<td>Ab. min. value</td>
<td>Ab. max. value.</td>
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<tr>
<td>$-4\sqrt{2}$</td>
<td>$9$</td>
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<table>
<thead>
<tr>
<th>8.</th>
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</thead>
<tbody>
<tr>
<td>$(\sqrt{5}, 10\sqrt{5})$</td>
<td>$(-\sqrt{5}, -10\sqrt{5})$</td>
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<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
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</tr>
<tr>
<td>$(-2, -22)$</td>
<td>$(5, -50)$</td>
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<td>Ab. min. value</td>
<td>Ab. max. value.</td>
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<tbody>
<tr>
<td>none</td>
<td>$\left(-1, -\frac{1}{e}\right)$</td>
<td></td>
</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$\left(-2, -\frac{2}{e^2}\right)$</td>
<td>$(1, e)$</td>
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<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
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</tr>
<tr>
<td>$-1/e$</td>
<td>$e$</td>
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</thead>
<tbody>
<tr>
<td>$(\frac{-2}{e^2}, 4)$</td>
<td>$(0, 0)$</td>
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</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$\left(-\frac{3}{e^3}, \frac{9}{e^3}\right)$</td>
<td>$(2, 4e^2)$</td>
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</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
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<tr>
<td>$0$</td>
<td>$4e^2$</td>
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</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$(4, -1)$</td>
<td>$(7, -2)$</td>
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</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
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</tr>
<tr>
<td>$-2$</td>
<td>$-1$</td>
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<table>
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<tr>
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<td></td>
</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$(2, 2)$</td>
<td>$(6, 0)$</td>
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</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
<td></td>
</tr>
<tr>
<td>$2$</td>
<td>$18$</td>
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<th>13.</th>
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<td></td>
</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$(1, 1)$</td>
<td>$(e, e+1)$</td>
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</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
<td></td>
</tr>
<tr>
<td>$1$</td>
<td>$e+1$</td>
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<th>14.</th>
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<tbody>
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<td></td>
</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$(\frac{1}{e^2}, \frac{-2}{e^2})$</td>
<td>$(e, e)$</td>
<td></td>
</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
<td></td>
</tr>
<tr>
<td>$-\frac{2}{e^2}$</td>
<td>$e$</td>
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<table>
<thead>
<tr>
<th>15.</th>
<th>rel. max. points</th>
<th>rel. min. points</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>$(-2, -1/4)$</td>
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</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
<td></td>
</tr>
<tr>
<td>$-1/4$</td>
<td>none</td>
<td></td>
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<table>
<thead>
<tr>
<th>16.</th>
<th>rel. max. points</th>
<th>rel. min. points</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(2, 1/4)$</td>
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<td></td>
</tr>
<tr>
<td>Left Endpoint</td>
<td>Right Endpoint</td>
<td></td>
</tr>
<tr>
<td>$(-2, -3/4)$</td>
<td>$(4, 3/16)$</td>
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</tr>
<tr>
<td>Ab. min. value</td>
<td>Ab. max. value.</td>
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</tr>
<tr>
<td>$-1/4$</td>
<td>$1/4$</td>
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<tr>
<td>Problem</td>
<td>Approximate Values</td>
<td>Left Endpoint</td>
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</tr>
<tr>
<td>17</td>
<td>(0, 6)</td>
<td>(−1, 3)</td>
</tr>
<tr>
<td>18</td>
<td>(0, 0)</td>
<td>(3, 3/5)</td>
</tr>
<tr>
<td>19</td>
<td>(0, 0)</td>
<td>(−2, −4/3)</td>
</tr>
<tr>
<td>20</td>
<td>(−4, −8)</td>
<td>(0, 0)</td>
</tr>
<tr>
<td>21</td>
<td>(π, 3/2)</td>
<td>(0, −1/2)</td>
</tr>
<tr>
<td>22</td>
<td>(π, 2)</td>
<td>(2π, −1/2)</td>
</tr>
<tr>
<td>23</td>
<td>(3π/4, √2)</td>
<td>(0, −1)</td>
</tr>
<tr>
<td>24</td>
<td>(π, 1)</td>
<td>(0, 1)</td>
</tr>
</tbody>
</table>
Section 4–4

1. Concave up intervals. \((-\infty,0) \cup (2,\infty)\)
   Concave down intervals. \((0,2)\)
   Inflection point(s). \((0,0)\) and \((2,-16)\)

2. Concave up intervals. \((6,\infty)\)
   Concave down intervals. \((-\infty,0) \cup (0,6)\)
   Inflection point(s). \((6,0)\)

3. Concave up intervals. \((-1/2,0)\cup(0,\infty)\)
   Concave down intervals. \((-\infty,-1/2)\)
   Inflection point(s). \(\left(-\frac{1}{2}, e^{2}\right)\)

4. Concave up intervals. \((0,\infty)\)
   Concave down intervals. \((-\infty,-3) \cup (-3,0)\)
   Inflection point(s). \((0,0)\)

5. Concave up intervals. none
   Concave down \((-\infty,-1) \cup (-1,1) \cup (1,\infty)\)
   Inflection point(s). None

6. Concave up intervals. \((0,\infty)\)
   Concave down intervals. \((-\infty,0)\)
   Inflection point(s). \((0,0)\)

7. Concave up intervals. \((0,\pi/2)\)
   Concave down intervals. \((-\pi/2,0)\)
   Inflection point(s). \((0,0)\)

8. Concave up intervals. \((\pi,2\pi)\)
   Concave down intervals. \((0,\pi)\)
   Inflection point(s). \((\pi,\pi)\)

9. Concave up intervals. \((0,2)\)
   Concave down intervals. \((-\infty,0) \cup (2,\infty)\)
   Inflection point(s). \((0,0)\) and \((2,16)\)

10. Concave up intervals. \((-\infty,-1) \cup (0,\infty)\)
    Concave down intervals. \((-1,0)\)
    Inflection point(s). \((0,0)\) and \((-1,-1)\)

11. Concave up intervals. \((-\infty,-1) \cup (1,\infty)\)
    Concave down intervals. \((-1,1)\)
    Inflection point(s). \((-1,3/2)\) and \((1,3/2)\)

12. Concave up intervals. \((-\infty,-2) \cup (2,\infty)\)
    Concave down intervals. \((-2,2)\)
    Inflection point(s). None

4– 5

Curves shown in class. You can use an online graphing tool to see the graphs or use a graphing calculator if desired.

1. The relative maximum points.
   none

   The relative minimum points.
   \((3,-27)\)

   The inflection points.
   \((0,0)\) \((2,-16)\)

2. The relative maximum points.
   \((-2,0)\)

   The relative minimum points.
   \((0,-4)\)

   The inflection points.
   \((-1,-2)\)
3. The relative maximum points.
   none
The relative minimum points.
(1, −27)
The inflection points.
(2, −16) (4, 0)
The maximum value for \( f(x) \).
125
The minimum value for \( f(x) \).
−27

4. The relative maximum points.
   \((1, 1/e)\)
The relative minimum points.
   none
The inflection points.
   \((2, 2/e^2)\)
The maximum value for \( f(x) \).
   \(1/e\)
The minimum value for \( f(x) \).
   \(−e\)

5. The relative maximum points.
   none
The relative minimum points.
   none
The inflection points.
   \((0, 0)\)
The maximum value for \( f(x) \).
   none
The minimum value for \( f(x) \).
   none

6. The relative maximum points.
   none
The relative minimum points.
   \((0, 0)\)
The inflection points.
   none
The maximum value for \( f(x) \).
   none
The minimum value for \( f(x) \).
   0

7. The relative maximum points.
   none
The relative minimum points.
   \((0, 0)\)
The inflection points.
   none
The maximum value for \( f(x) \).
   none
The minimum value for \( f(x) \).
   25

8. The relative maximum points.
   \((−1, 2)\)
The relative minimum points.
   \((1, −2)\)
The inflection points.
   \((0, 0)\)
The maximum value for \( f(x) \).
   none
The minimum value for \( f(x) \).
   none

9. The relative maximum points.
   \((0, −2)\)
The relative minimum points.
   \((4, 6)\)
The inflection points.
   none
The maximum value for \( f(x) \).
   none
The minimum value for \( f(x) \).
   none

10. The relative maximum points.
    \((1, 2)\)
The relative minimum points.
     \((−1, −2)\)
The inflection points.
     \((-\sqrt{3}, 0) (\sqrt{3}, 0) \sqrt{3}, \sqrt{3})\)
The maximum value for \( f(x) \).
     2
The minimum value for \( f(x) \).
     −2
11. The relative maximum points. none
   The relative minimum points. 
   (0, 0)
   The inflection points.
   \(-\frac{1}{3}, \frac{3}{4}\), \(\frac{1}{3}, \frac{3}{4}\)
   The maximum value for \(f(x)\).
   none
   The minimum value for \(f(x)\).
   0

12. The relative maximum points. none
   The relative minimum points. none
   The inflection points.
   (0, 0)
   The maximum value for \(f(x)\).
   \(\frac{1}{2}\)
   The minimum value for \(f(x)\).
   \(-\frac{1}{2}\)

4–6

1. The two numbers are 3 and 6. The maximum product is 108.

2. \(x = 125\) \(y = 250\). The plot is 250 feet along the back and feet by 125 feet on the 2 sides. The maximum area encloses 31250 square feet.

3. \(x = 12\) and \(y = 9\). The large rectangular pen is 12 feet by 18 feet.

4. The large rectangular pen is 50 feet by 125 feet and encloses 62500 square feet.

5. \(x = 5\) To create a box with the maximum volume from our cardboard square, we would need to cut in 5 inches from each side. The volume of the box will be 2000 cubic inches.

6. \(x = 3\) To create a box with the maximum volume from the piece of cardboard, you would need to cut in 3 inches from each side. The volume of the box will be 486 cubic inches.

7. \(x = 4\) The bottom is 4 feet by 4 feet. The height is 2 feet. The maximum volume is 32 cubic feet.

8. \(x = 3\) and \(y = 3\) The bottom of the box is 3 meters by 4 meters. The height is 3 meters
   The minimum cost is $330

9. \(x = 50\) feet of shrubs \(y = 60\) feet of fencing. Minimum cost is $3000

10. \(R = 1\) foot \(h = 1\) foot The maximum volume is \(\pi\) cubic feet.

11. \(r = 2\) meters \(h = 5\) meters. The minimum cost is approximately $754

12. \(\sqrt{5}\)

13. Add 20 new trees and get a maximum yield of 256,000 oranges.

14. Reduce the price to 9.50 a ticket. That will create 28,500 spaces sold and produce a maximum revenue of $270,750

16. \(x = 3\) km. The minimum cost is $41,976. This is compared to the maximum cost of $52,000 for running the pipeline all 8 km on the river bank and 4 km under the river.
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<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>( dy = (12x^3 - 2)dx )</td>
<td>2.</td>
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<tr>
<td>4.</td>
<td>( dy = \frac{dx}{\sqrt{2x - 5}} )</td>
<td>5.</td>
</tr>
<tr>
<td>7.</td>
<td>( dy = (xe^x + e^x)dx )</td>
<td>8.</td>
</tr>
<tr>
<td>10.</td>
<td>( dy = .0025 )</td>
<td>11.</td>
</tr>
<tr>
<td>13.</td>
<td>( dy = .02 )</td>
<td>14.</td>
</tr>
<tr>
<td>16.</td>
<td>( \sqrt[3]{9} \approx 2.083 )</td>
<td>17.</td>
</tr>
<tr>
<td>19.</td>
<td>7.2 sq. in.</td>
<td>20.</td>
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