Chapter 7: Linear Functions and Inequalities

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The absolute value gives us the “size” or **magnitude** of a number. The absolute value of a number can be thought of as “the distance a number is from zero”. The absolute value of a number will always be positive because distance cannot be negative.

**Exercise #1:** Find each of the following.
(a) \(|-7| = \)
(b) \(|6 - 4| = \)
(c) \(|10 - 4| = \)
(d) \(|-5 + 5| = \)

**Exercise #2:** For the function \(f(x) = |x - 4| + 7\) which of the following is the value of \(f(1)\)? Show the calculations that lead to your answer.

- [1] 10
- [3] 12
- [4] 4

**Exercise #3:** Consider the absolute value function \(f(x) = |x|\). Do the following:
(a) Evaluate \(f(-7)\) and \(f(4)\).
(b) Fill out the table below and graph the function over this interval.

<table>
<thead>
<tr>
<th>(x)</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(f(x))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(c) What is the minimum value of the function on this interval? What is the maximum?

(d) Over what **domain** interval is \(f(x)\) increasing?

(f) What is the Range of this function?
**Exercise #4:** Consider the absolute value function \( f(x) = |x| - 2 \). Do the following:

(a) Evaluate \( f(-4) \) and \( f(6) \).

(b) Fill out the table below and graph the function over the interval \(-3 \leq x \leq 3\)

<table>
<thead>
<tr>
<th>( x )</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(c) What did the \(-2\) do to the function?

(d) Over what domain interval is \( f(x) \) decreasing?

(e) What is the Range of this function?

**Exercise #5:** Consider the absolute value function \( f(x) = -|x| \). Do the following:

(a) Evaluate \( f(-4) \) and \( f(6) \).

(b) Create a table and graph the function

(c) What did the negative symbol do to the function?

(d) Over what domain interval is \( f(x) \) decreasing?

(e) What is the minimum value of the function on this interval? What is the maximum?

(f) What is the range of this function?
Evaluate each of the following using the provided functions:

\[ f(x) = |3x - 5| \quad g(x) = |x + 4| - 2 \quad h(x) = -|2x + 1| - 6 \]

1.) \( f(3) \)
2.) \( h(-5) \)
3.) \( g(6) \)
4.) \( h(4) \)
5.) \( g(-1) \)
6.) \( f(8) \)

7.) Consider the absolute value function \( f(x) = |x + 3| \) only on the interval \(-6 \leq x \leq 2\).

(a) Evaluate \( f(-5) \) and \( f(2) \) without a calculator.

(b) Graph this function over the interval \(-6 \leq x \leq 2\).
Create your table below.

\[
\begin{array}{c|cccccccc}
 x & -6 & -5 & -4 & -3 & -2 & -1 & 0 & 1 & 2 \\
\hline
 y & & & & & & & & & \\
\end{array}
\]

(c) Over which of the following intervals is \( f(x) \) always increasing?

\[ [1] \ -6 < x < -3 \quad [2] \ -4 < x < 0 \quad [3] \ -2 < x < 1 \quad [4] \ -5 < x < 2 \]

(d) State the range of \( f(x) \) on this domain interval.
Consider the absolute value function \( f(x) = |x + 3| \). Do the following:

(a) Evaluate \( f(-4) \) and \( f(6) \).

(b) Fill out the table below and graph the function over this interval.

<table>
<thead>
<tr>
<th></th>
<th>(-6)</th>
<th>(-5)</th>
<th>(-4)</th>
<th>(-3)</th>
<th>(-2)</th>
<th>(-1)</th>
<th>(0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(c) What did the +3 do to the function?

(d) Over what domain interval is \( f(x) \) decreasing?

(e) What is the minimum value of the function on this interval?

Review Section:

Officials in a town use a function, \( C \), to analyze traffic patterns. \( C(n) \) represents the rate of traffic through an intersection where \( n \) is the number of observed vehicles in a specified time interval. What would be the most appropriate domain for the function?

1. \( \{-\infty, -2, -1, 0, 1, 2, 3 \ldots\} \)
2. \( \{-2, -1, 0, 1, 2, 3\} \)
3. \( \left\{0, \frac{1}{2}, 1, \frac{3}{2}, 2, 2 \frac{1}{2}\right\} \)
4. \( \{0, 1, 2, 3 \ldots\} \)

10. If \( A = 3x^3 + 5x - 6 \) and \( B = -2x^2 - 6x + 7 \), then \( A - B \) equals:

1. \( -5x^2 - 11x + 13 \)
2. \( 5x^2 + 11x - 13 \)
3. \( -5x^2 - x + 1 \)
4. \( 5x^2 - x + 1 \)
Homework Answers

Name: ____________________________________________ Date: ___________ Period: _______
Algebra I
Abs. Value - 7A HW

1.) \( f(3) = 4 \)  
2.) \( h(-5) = -15 \)  
3.) \( g(6) = 8 \)  

4.) \( h(4) = -15 \)  
5.) \( g(-1) = 1 \)  
6.) \( f(8) = 19 \)  

7.) a.) \( f(-5) = 2 \)  
   b.) \( f(2) = 5 \)  

<table>
<thead>
<tr>
<th>( x )</th>
<th>-6</th>
<th>-5</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

c.) \([3]\)  
d.) Range = \(0 < y < 5\)  

8.) a.) \( f(-4) = 1 \)  
   b.) \( f(6) = 10 \)  

<table>
<thead>
<tr>
<th>( x )</th>
<th>-6</th>
<th>-5</th>
<th>-4</th>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f(x) )</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

c.) \(+3\) shifted the function 3 units to the left  
d.) \(\{-6 < x < -3\}\)  
e.) Minimum value: \(y = 0\)  

9.) (4)  
10.) (2)
**Step functions** are another type of function that is related to the linear family. Step functions are piecewise functions that produce graphs that look like stair steps. They reduce any number within a given interval into a single number. Typically parking garages, boat rentals, or any place that charges per segment of an hour, are actually using a step function rather than a linear function. Step functions are discontinuous.

**Example of a Step Function:**

\[
 f(x) = \begin{cases} 
  -3; & x < -2 \\
  0; & -2 \leq x \leq 1 \\
  3; & x > 1 
\end{cases}
\]

**End points:**
- **Open circle when the end point of the interval is not included**
- **Closed circle when the endpoint of the interval is included**
- **Arrow when the segment goes on forever (infinite)**

**Exercise #1:** Consider the step function given by \( f(x) = \begin{cases} 
  2 & 0 \leq x \leq 5 \\
  6 & 5 \leq x \leq 10 
\end{cases} \)

(a) Evaluate each of the following. After you do your evaluation, write down what coordinate point must lie on the graph as a result of the calculation.

\[
 f(0) = \\
 f(2) = \\
 f(4) = \\
 f(5) = \\
 f(7) = \\
 f(10) =
\]

(b) Graph the step function on the grid to the right.
Step Functions often arise in the real world whenever the output to a particular function is constant over particular ranges. Here’s an example.

**Exercise #3** At a local amusement park, the park charges an admission based on age. Graph the amount of money a person would have to pay for admission based on their age. Remember that someone who is one day short of 4 years old can consider themselves three and under.

<table>
<thead>
<tr>
<th>Age Range</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 and under</td>
<td>Free</td>
</tr>
<tr>
<td>8 and under</td>
<td>$4.00</td>
</tr>
<tr>
<td>16 and under</td>
<td>$8.00</td>
</tr>
<tr>
<td>17 and older</td>
<td>$12.00</td>
</tr>
</tbody>
</table>
1) Morgan can start wrestling at age 5 in Division 1. He remains in that division until his next odd birthday when he is required to move up to the next division level. Which graph correctly represents this information?

(1) (2) (3) (4)

2) The table below lists the total cost for parking for a period of time on a street in Albany, N.Y. The total cost is for any length of time up to and including the hours parked. For example, parking for up to and including 1 hour would cost $1.25; parking for 3.5 hours would cost $5.75.

Graph the step function that represents the cost for the number of hours parked.

<table>
<thead>
<tr>
<th>Hours Parked</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>2.50</td>
</tr>
<tr>
<td>3</td>
<td>4.00</td>
</tr>
<tr>
<td>4</td>
<td>5.75</td>
</tr>
<tr>
<td>5</td>
<td>7.75</td>
</tr>
<tr>
<td>6</td>
<td>10.00</td>
</tr>
</tbody>
</table>
3.) For each of the following step functions, produce a graph on the grid given.

(a) \( f(x) = \begin{cases} -4 & -5 \leq x < 0 \\ \frac{3}{4} & 0 \leq x \leq 5 \end{cases} \)

(b) \( g(x) = \begin{cases} 10 & 0 \leq x < 4 \\ 7 & 4 \leq x < 8 \\ 4 & 8 \leq x \leq 12 \end{cases} \)

4.) Postage rates on envelopes are a great example of **step functions**. There is a fixed price for a certain range of weights and then another fixed price for another range of weights, etcetera. Below is the graph of one such price structure.

(a) According to this graph, what would be the postage rate on a letter weighing 1.5 ounces?

(b) What would be the postage rate on a letter weighing exactly 3.0 ounces?

(c) Write a piecewise defined function for the postage rates:

(d) Why would it be incorrect to state that the range of this function is \( 0.50 \leq y \leq 1.15 \)?

---

**Review Section:**

5) When solving the equation \( 4(3x^2 + 2) - 9 = 8x^2 + 7 \), Emily wrote \( 4(3x^2 + 2) = 8x^2 + 16 \) as her first step. Which property justifies Emily's first step?

[1] addition property of equality
[2] commutative property of addition
[3] multiplication property of equality
[4] distributive property of multiplication over addition
8.) \( f(2) = 3 \quad g(2) = -3 \) They are not equivalent

9.) GRAPHS

10.) a.) $0.70$
    b.) $1.15$
    c.) Piecewise function
    d.) It is incorrect because this would mean that every value between 0.50 and 1.15 would be hit for some weight.

11.) [1]

12.) [4]

13.) Answer is not typed. \( 3x^3 + 2x^2 + 11x - 13 \)
At this point we've looked at graphs of linear functions and more general functions as simply being plots of input/output pairs. And, for functions, this makes a lot of sense. But, more generally, we want to be able to define points that lie on the graph of an equation or on an inequality with a simple test/definition.

**Graphing Equations and Inequalities**

The connection between graphs and equations/inequalities is a simple one:
1. Any coordinate pair \((x, y)\) that makes the equation of inequality true lies on the graph.
2. The entire graph is a collection of all of the \((x, y)\) pairs that make the equation of inequality true.

**Exercise #1:** Consider the linear equation \(y = 4x + 2\)
(a) Does the point \((2, 10)\) lie on the graph of this equation? Justify your answer.
(b) Does the point \((-1, 4)\) lie on the graph of this equation? Justify your answer.

**Exercise #2:** The equation \(y = 2x^2 - x + 5\) describes a parabola. Does the point \((3, 20)\) lie on its graph? Justify how you found your answer.

In the next lesson, we will graph inequalities. In this lesson we will determine if particular points will lie on the graph of an inequality.

**Exercise #3:** Determine for each of the following inequalities whether the point given lies on the graph.
(a) \((4, 1)\) for \(y > 2x - 5\)
(b) \((2, 8)\) for \(x + y \leq 10\)
We can even determine, with some additional calculations, whether a point is a solution to a system of equations or a system of inequalities. You've studied systems before and we will devote the next unit to them. But, with a simple definition you can “easily” tell whether points are solutions.

**SYSTEMS OF EQUATIONS**

A system of equations is a collection of two or more equations joined by the AND truth condition. Because the AND condition is only true when all of its components are true, the solution set of a system is:

The collection of all points that result in all equations or inequalities being true.

**Exercise #4:** Determine if the point (3,1) is a solution to the system of equations shown below. Justify your answer.

\[
y = 2x - 5 \quad \text{and} \quad y = -4x + 13
\]

**Exercise #5:** Does the point (5,15) lie in the solution set of the system of inequalities show below?

\[
y \geq 4x - 7 \quad \text{and} \quad y < x^2 - 10
\]
You can even mix equations and inequalities because the answer always depends on whether all conditions are true or not.

**Exercise #6:** Is the point (−2,5) a solution to the system shown below? Justify your answer carefully.

\[
y > \frac{4-x}{2} \quad \text{and} \quad y = 3x + 11
\]
1.) Which of the following points lie on the graph of $y = 3x - 5$?
   [1] (1, -5)        [2] (2,0)

2.) Which one of the following points does not lie on the graph $y = \frac{1}{2}x + 3$?
   [1] (10,8)       [2] (-2,2)
   [3] (0,3)       [4] (-6, -3)

3.) Which of the following points would not lie on the line $y = 7$?
   [1] (-2,7)      [2] (7, -1)
   [3] (0,7)      [4] (5,7)

4.) For the inequality $y > 4x + 1$ determine if each of the following points does or doesn't lie in its solution. Show the work that leads to your answer.
   (a) (2,15)      (b) (4,10)      (c) (-3, -8)

5.) Determine if the point (4,7) is a solution to the system of equations shown below. Justify your answer.
   $y = 2x - 1$ and $y = \frac{1}{2}x + 5$
6.) One of the following two points lies in the solution set of the system of inequalities below. Determine which point it is and explain why your choice lies in the solution set and the other does not.

\[ x + y < 10 \text{ and } y \geq \frac{2}{3}x - 2 \]

(6,1) \hspace{1cm} (3,5)

7.) James quickly sketched the graph of \( y = -4x + 10 \) and \( y = 2x + 3 \). His graph is shown. Explain how you know that his graph is inaccurate.

8.) The point (4,20) lies on the line \( y = mx + 8 \), for some value of \( m \).

(a) If \( m = 2 \) will the point (4,20) lie on the line? How can you tell?

(b) Find the value of \( m \) for which the point (4,20) will lie on the line.
9.) Which value of x satisfies the equation \( \frac{7}{3}(x + \frac{9}{28}) = 20 \)

- [1] 8.25
- [2] 19.25
- [3] 8.89
- [4] 44.92

10.) A company that manufactures radios first pays a start-up cost, and then spends a certain amount of money to manufacture each radio. If the cost of manufacturing \( r \) radios is given by the function \( (r) = 5.25r + 125 \), then the value 5.25 best represents:

- [1] the start-up cost
- [2] the profit earned from the sale of one radio
- [3] the amount spent to manufacture each radio
- [4] the average number of radios manufactured

11.) A ball is thrown into the air from the edge of a 48-foot-high cliff so that it eventually lands on the ground. The graph below shows the height, \( y \), of the ball from the ground after \( x \) seconds. For which interval is the ball’s height always decreasing?

- [1] 0 \( \leq \) \( x \) \( \leq \) 2.5
- [2] 0 \( < \) \( x \) \( < \) 5.5
- [3] 2.5 \( < \) \( x \) \( < \) 5.5
- [4] \( x \) \( \geq \) 2

12.) Given:  
\[ L = \sqrt{2} \quad M = 3\sqrt{3} \]
\[ N = \sqrt{16} \quad P = \sqrt{9} \]
Which expression results in a rational number?

- [1] \( L + M \)
- [2] \( M + N \)
- [3] \( N + P \)
- [4] \( P + L \)
1.) [3]

2.) [4]

3.) [2]

4.) a.) yes  
   b.) no  
   c.) yes

5.) yes

6.) (6,1) no  
    (3,5) yes

7.) $y = -4x + 10$  
    $(1,6)$  
    $y = 2x + 3$  
    $(1,5)$

   His graph is inaccurate because at the point of intersection, the solution (output) must be the same for both functions.

8.) a.) no  
    b.) $m = 3$

9.) [1]

10.) [3]

11.) [3]

12.) [3]
When we solved and graphed inequalities with only one variable (ex: \( x \geq 3 \)), we moved on to compound inequalities (AND/OR). We would graph both inequalities on the same number line and decide what to keep based on whether it was an AND or an OR problem. When we graphed linear equations on the coordinate plane we moved on to solving systems of equations graphically.

When we graph inequalities in two variables on the coordinate plane, we do not graph compound inequalities. We move on to solving systems of inequalities. It takes a little from both inequalities with one variable and solving systems graphically.

**To Graph the Inequality:**

\[
y > \frac{1}{4} x + 3
\]

**Step 1:** Graph the line.

\[
y > \frac{1}{4} x + 3
\]

\[
m = \frac{\Delta y}{\Delta x} = \frac{1}{4} \left( \frac{1}{\rightarrow 4} \right)
\]

\[
b = 1\text{pt } y\text{-intercept } = (0,b) = (0,3)
\]

- Decide if the line is “open or closed”

This is the same as if the circle on the number line is “open or closed”

- if the line is OPEN = Dashed Line
- if the line is CLOSED = Solid Line

**Step 2:** Test a point one unit above the \( y \)-intercept and unit below the \( y \)-intercept:

<table>
<thead>
<tr>
<th>( A ) (0, 4) ( y &gt; \frac{1}{4} x + 3 )</th>
<th>( B ) (0, 2) ( y &gt; \frac{1}{4} x + 3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 4 &gt; \frac{1}{4} (0) + 3 )</td>
<td>( 2 &gt; \frac{1}{4} (0) + 3 )</td>
</tr>
<tr>
<td>( 4 &gt; 3 )</td>
<td>( 2 &gt; 3 )</td>
</tr>
<tr>
<td><strong>TRUE</strong></td>
<td><strong>FALSE</strong></td>
</tr>
</tbody>
</table>

**Step 3:** Shade towards the “true” point in this case (0,4)

When you “test”, you must do it in the original equation!
Examples:

1) $6x - 9y \geq 36$

State one point in the solution: 

State one point not in the solution:
2) $y - 3 > -2(x + 1)$

State one point in the solution: State one point not in the solution:
3) $12x + 9y < 27$

State one point in the solution:

State one point not in the solution:

4) $y \geq 4$

State one point in the solution:

State one point not in the solution:
5) \( y + 4 \geq -3(x - 3) \)

State one point in the solution:

State one point not in the solution:

6) \( 4x + y < y - 24 \)

State one point in the solution:

State one point not in the solution:
So, we have graphed linear functions and in the last lesson learned that the points that lie on a graph are simply the \((x, y)\) pairs that make the equation true. Graphing an inequality in the \(xy\)-plane is the same.  

**Graphing Inequalities**

To graph an inequality simply means to plot (or shade) all \((x, y)\) pairs that make the inequality true.

**Exercise #1:** Consider the inequality \(y > x + 3\).

(a) Determine whether each of the following points lies in the solution set (and thus on the graph of) the given inequality.

\[
\begin{align*}
(2,7) & \quad (0,1) & \quad (1,4)
\end{align*}
\]

(b) Graph the line \(y = x + 3\) on the grid below in dashed form. Why are the points that lie on this line *not* part of the solution set of the inequality?

(c) Plot the three points from part (a) and use them to help you share the proper region of the plane that represents the solution set of the inequality.

(d) Choose a fourth point that lies in the region you shaded and show that it is in the solution set of the given inequality.

(e) The point \((10,12)\) cannot be drawn on the graph grid above, so it is difficult to tell if it falls in the shaded region. Is \((10,12)\) part of the solution set of this inequality? Show how you arrive at your answer.
There are some challenges to graphing linear inequalities, especially if the out, $y$, has not been solved for. Let's look at the worst case scenario.

**Exercise #2:** Consider the inequality $3x - 2y \geq 2$

(a) Rearrange the left-hand side of this inequality using the commutative property of addition.

(b) Solve this inequality for $y$ by applying the properties of inequality.

(c) Shade the solution set of this inequality on the graph paper below.

(d) Pick a point in the shaded region and show that it is a solution to the original inequality.

The final type of inequality that we should be able to graph quickly and effectively is one that involves either a horizontal line or a vertical line.

**Exercise #3:** Shade the solution set for each of the following inequalities in the $xy$-planes provided. First, state in your own words the $(x, y)$ pairs that the inequality is describing.

(a) $y < 4$  
   Explain in your own words:

(b) $x \geq -2$  
   Explain in your own words:
1.) Determine which of the following points lie in the solution set of the inequality \( y \geq 2x - 4 \) and which do not. Justify each choice.
(a) (5,4) 
(b) (0, -1) 
(c) (10,16) 
(d) (2, -1) 

2.) Which of the following points lies in the solution set of the inequality \( y \geq 3x + 10? \)
[1] (1,10) \hspace{1cm} [2] (-1,3) 
[3] (4,20) \hspace{1cm} [4] (2,16) 

3.) Which of the following points does not lie in the solution set to the inequality \( y \geq -\frac{1}{3}x + 5? \)
[1] (6,3) \hspace{1cm} [2] (-6,5) 
[3] (-3,8) \hspace{1cm} [4] (12,3) 

4.) Which of the following linear inequalities is shown graphed?
[1] \( y < \frac{3}{2}x - 1 \) \hspace{1cm} [2] \( y \leq \frac{2}{3}x - 1 \) 
[3] \( y > \frac{2}{3}x - 1 \) \hspace{1cm} [4] \( y \geq \frac{3}{2}x - 1 \) 

5.) Graph the solution set to the inequality shown. State one point that lies in the solution set and one point that does not lie in the solution set.
\( y < -2x + 4 \)

One point in the solution: \hspace{1cm} One point not in the solution:
6.) Rearrange the inequality below so that it is easier to graph and then sketch its solution set on the grid given. Be careful when dividing by a negative and remember to switch the inequality sign.

\[ x - 2y \leq 6 \]

One point in the solution: One point not in the solution:

7.) Graph the solution set to each of the following inequalities.

(a) \( y \leq -4 \) 

(b) \( x > 1 \)

Review Section:
8.) Sam and Odel have been selling frozen pizzas for a class fundraiser. Sam has sold half as many pizzas as Odel. Together they have sold a total of 126 pizzas. How many pizzas did Sam sell?

9.) The Jamison family kept a log of the distance they traveled during a trip, as represented by the graph below. During which interval was their average speed the greatest?
   [1] the first hour to the second hour
   [2] the second hour to the fourth hour
   [3] the sixth hour to the eighth hour
   [4] the eighth hour to the tenth hour

10.) The graph of \( y = f(x) \) is shown. Which point could be used to find \( f(2) \)?

11.) The formula for the volume of a cone is \( V = \frac{1}{3} \pi r^2 h \). The radius \( r \), of the cone may be expressed as:
    [1] \( \sqrt[3]{\frac{3V}{\pi h}} \)
    [2] \( \sqrt[3]{\frac{V}{3\pi h}} \)
    [3] \( 3 \sqrt[3]{\frac{V}{\pi h}} \)
    [4] \( \frac{1}{3} \sqrt[3]{\frac{V}{\pi h}} \)
Homework Answers

Algebra I

Graphs of Linear Inequalities

1.) a.) no         b.) yes
     c.) yes         d.) no

2.) [4]

3.) [2]

4.) [1]

5.) GRAPH

6.) GRAPH

7.) a.) GRAPH     b.) GRAPH

8.) [2]

9.) [1]

10.) [1]

11.) [1]