**Linear vs Non Linear Functions**

**Section 1**

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| 00:00:00 | TEACHER: Our lesson question is, what is the difference |
| 00:00:02 | between linear and non-linear functions? You just interpreted information from a table of values. Now you will learn to use the rate of change to identify linear and non-linear functions from a table. |

**Section 2**

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| 00:00:00 | TEACHER: Let's look at finding the rate of change. |
| 00:00:02 | The rate of change is the change in one quantity with respect to another quantity. We're going to use the table that you see on the right side of your screen to interpret the rate of change. First thing we need to determine is the change in the input. Now, in the table, the x column is your input. So, in order to determine the change in the input, we're |
| 00:00:22 | going to look at the value of 3 and the value of 2, and we're going to subtract to find the difference between these two values. And we take 3 subtract 2 to get a difference of 1. Now we're going to write that on the table. To get from 2 to 3, we added 1. From 3 to 4, we added the same amount, 1. 4 to 5, we added the same amount, 1. |
| 00:00:43 | Now we need to figure out the change in the output. This will be the y column on the table. We're going to take these two values, 165 and 110, and we are going to subtract to find the difference between these two values. The difference is going to be 55. So to get from 110 to 165, we added 55. To get from 165 to 220, we added 55. |
| 00:01:09 | To get from 220 to 275, we added the same amount, 55. Now that we've determined the change in the input as compared to the change in the output, we're ready to figure out or find the rate of change, which I'm going to abbreviate r.o.c., which stands for rate of change. And that equals the change in the output as you numerator over the change in the input, which is 1. And when we simplify this fraction, the rate of change |
| 00:01:35 | ends up being 55. So this is how you find the rate of change. |

**Section 4**

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| 00:00:00 | TEACHER: Finding the rate of change will help you determine |
| 00:00:02 | whether a function is linear or nonlinear. A linear function has a constant rate of change. On the other hand, a non-linear function does not have a constant rate of change. Let's use these ideas with the next example. Knowing that a linear function has a constant rate of change while a nonlinear function does not, finding the rate of change will determine whether or not a relationship in a |
| 00:00:26 | table is linear. Look at the table that's in front of you. It displays the approximate height and distance traveled by a soccer ball that was kicked across a field. Here we have time, height, and length. Time is also known as the input, and on this table, we have two outputs. Height is an output, or O, and length is another output, or |
| 00:00:48 | O. Now that we've determined the input and the outputs, remember what we did earlier in this lesson. To figure out the rate of change, you figure out the difference between the values. So let's start out with the input time. To get from 0 to 1, that's a difference of 1, so we added 1. |
| 00:01:03 | To get from 1 to 2, we added 1. From 2 to 3, we added 1. Now let's do the output. Let's do height. To get from 0 to 5.3, that's a difference of 5.3. That's what we added on. From 5.3 to 8, we added on 2.7. From 8 to 9.8, we added on 1.8. |
| 00:01:26 | You'll notice that in the height column, these are all different values. There is no constant rate of change. So this is considered a nonlinear relationship because there is no constant rate of change. Let's look at length. To get from 0 to 17, we added 17. 17 to 34, we added 17. |
| 00:01:48 | 34 to 51, we added 17. Here, we have a constant rate of change. So since it's a constant rate of change, by definition this is a linear function. So this is how you determine whether or not a relationship in a table is linear or nonlinear. |

**Section 6**

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| 00:00:00 | TEACHER: You have been answering the question, what |
| 00:00:02 | is the difference between linear and nonlinear functions? You learned how to find the rate of change from a table to identify linear functions by recognizing a constant rate of change. Now you will determine the rate of change to identify linear and nonlinear functions from a graph. |

**Section 7**

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| 00:00:00 | TEACHER: Let's learn how to find the rate of |
| 00:00:02 | change from a graph. You identified earlier the rate of change in the length of a soccer ball to be a constant rate of change of 17. Look at the graph on the right side of the screen. It displays the relationship of time to the length traveled of that same soccer ball. The rate of change of a graph is found by determining how much the function is rising or falling each time it runs. |
| 00:00:24 | Now let's figure out what that means, rising, falling, and runs. Let's look at the graph more closely. Let's look at the blue line. It starts here at the point 17 and goes all the way up to 34. So that rise or falling, that's the change on the y-axis. Well, how far did it change? |
| 00:00:42 | It changed by a rate of 17. So I'm going to mark that right next to the blue line. Now let's look at the red line. That's the run. That's the change on the x-axis. Well, how far did it run? It ran from 1 to 2. That's a difference of 1. |
| 00:00:58 | So now we have rise. And now we have run. And we compare the two values to figure out the Rate Of Change, or what I call the ROC. The rate of change is determined by putting the change in y over the change in x. So the change in y was 17, over the change in x, which is 1, which simplifies down to 17. |
| 00:01:17 | So the rate of change on the graph is 17, just like it's the same rate of change we found on the table. Now let's check it out. Is this a constant rate of change? Let's figure it out with another rise over run. Let's go up here from this point to the next point. We started out at 34. We went up to 51. |
| 00:01:37 | That's a difference of 17, or a change on the y-axis of 17. What about the run, or the change on the x-axis? Well, we went from 2 to 3. That's also a change of 1. So once again, it's 17 over 1 equals 17. So yes, it does check out. This is a constant rate of change. So since we have a constant rate of change, that tells us |
| 00:01:57 | that this graph shows a linear function, because a linear function always has a constant rate of change. So this is how you find the rate of change from a graph. |

**Section 10**

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| 00:00:00 | TEACHER: Let's see if we can find the rate of change from a |
| 00:00:02 | graph that is not a straight line. You identified in the last part of the lesson that the rate of change in the height of a soccer ball is not constant. The graph that you see here on the right side of your screen, it displays the relationship of time to the height of that same soccer ball. Once again, the rate of change of a graph is found by |
| 00:00:21 | determining how much the function is rising or falling each time that it runs. Let's see if the rate of change can be determined from this graph that is not a straight line. So we use the same process that we just learned. Here, we look at the rise, or the change on the y-axis. We went from 0 to 5.3. So that rate, or that change, is 5.3. |
| 00:00:43 | How far did we run on the x-axis? From 0 to 1. So that's a change of 1, so we put 5.3 over 1, or just 5.3 is the rate of change. Let's see if that's constant all the way throughout this graph. Let's go up here. Let's rise. |
| 00:00:58 | And let's run. Now we're going from 5.3 to 8. That's a difference or a rate of 2.7. The run is still 1. We went from 1 to 2. This time the change or the rate of change is 2.7. We have 5.3. We have 2.7. |
| 00:01:15 | Let's try it one more time. Let's go from the 0.8 to 9.8. We rose 1.8 on the y-axis. We ran 1. So our rate of change is 1.8. So yes, we can determine the rate of change. But what do you notice about those rates of change? They're not constant. |
| 00:01:32 | We have 5.3, 2.7, 1.8. Since these rates are not constant, this is considered a non-linear function. So in this case, this is how you can find the rate of change from a graph. But you can also determine whether the function is linear or nonlinear. |

**Section 12**

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| 00:00:00 | TEACHER: Now let's learn about linear and non-linear |
| 00:00:02 | functions in real-world situations. We know that there are 24 hours in one day. The total hours is a function of the days. The question we're trying to answer is, does this situation represent a linear or a non-linear function? Now remember, in order to determine linear versus non-linear functions, first we need to figure out the rate of change. |
| 00:00:22 | If the rate of change is constant, it's a linear relationship. Of it's not constant, is non-linear. And to figure out the rate of change, we can either use a table or a graph. Let's use the table that you see on the left side of your screen. We'll do that first. |
| 00:00:35 | We have days, compared to hours. Let's fill out the table. We know that there are 24 hours in 1 day. There would be 48 hours in 2 days. 72 hours in 3 days. And 96 hours in 4 days. Now let's determine the rate of change in the number of hours. |
| 00:00:51 | To get from 24 to 48, I added on 24 hours. 48 to 72, I added on another 24 hours. 72 to 96, added on another 24 hours. This is the rate of change. You'll notice it's constant. So since it's a constant rate of change, this is a linear relationship or function. Let's confirm this by using the graph that you see on the |
| 00:01:15 | right side of your screen. Let's plot the points-- 1, 24. Let's plot the second point-- 2, 48. Let's plot the next point-- 3, 72. Let's plot the next point-- |
| 00:01:30 | 4, 96. Now that we've plotted our points, I'm going to draw a line through the points. And the reason I drew the line instead of just keeping the points, is because time exists between the days. Now in order to determine the rate of change from the graph, remember it's rise over run. So let's figure out that from the graph. |
| 00:01:50 | Let's look at the first point. Here's my rise, or my change in my y-axis. And this is my run, or my change on my x-axis. I went from 24 to 48. So that was a change of 24. I ran from 1 to 2, that's one. So 24 is my rate of change. Let me confirm that with going from this |
| 00:02:09 | point to this point-- same thing. I went from 48 to 72. That's a change of 24, a run of 1. Once again, it's 24. So on my graph, I have a constant rate of change. So this confirms that there is a linear relationship or function between days and hours. |
| 00:02:27 | So this is just one way that we look at linear and non-linear functions in a real world situatio |