

Lift Data

Teacher Notes



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TI-Nspire CAS



Investigation



Student



90min

Aim

To explore data generated from the altitude of lifts in high rise buildings over a period of time. Students will use authentic data to graph and analyse the altitude of a lift over a period of time in order to determine travel time, speed and the number of floors visited.

National Curriculum Statement: Solve problems involving direct proportion. Explore the relationship between the graphs and equations corresponding to simple rate problems. (ACMNA208)

ScOT: Constants, Rates (Ratio), Direct proportion

Equipment

For this activity you will need:

- TI-Nspire CAS
- TI-Nspire CAS file: Lift Data

Students can use digital technologies to compare the altitudes and speeds of several lifts.

Problem Description

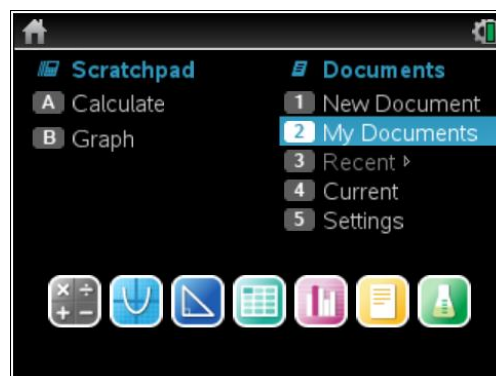
The altitude of a lift graphed over time provides useful information about the direction of travel, speed, idle time and usage. The altitude data was obtained using the altimeter in a wireless dynamic sensor. The three data sets were obtained from two different lifts. One lift is located in Chicago and the other is in the Gold Coast. Data is located in **Lists & Spreadsheet** under the following headings: **time1_mins, altitude1_m** for lift 1, **time2_mins, altitude2_m** for lift 2 & **time3_mins, altitude3_m** for lift 3. Students will use **Data & Statistics** to graph the lift data; then they will determine if the relationship is linear or non-linear, calculate the upward and downward speed of a lift, and finally identify which data sets belong to the same lift.

Technology

During this activity, students will need to use the TI-Nspire file: "Lift Data". This file can be distributed using TI-Navigator, the TI-Nspire docking station or the teacher/student software. To distribute the file using the Teacher software, use the **Tools** menu and select the **Transfer Tool**. Locate the TI-Nspire file on your computer and then start the transfer. Once the file is transferred to the first handheld, unplug the handheld and continue plugging in each student's handheld device. Once all the students have the file, stop the transfer. Note that students can also transfer files from one handheld device to another from within the **My Documents** folder. Note also that multi-port USB connectors can be used to transfer files to several handhelds at the one time.

This activity requires access to the “Lift Data” TI-Nspire document. This document should be loaded on your device before proceeding.

Once the document is on your handheld, press **home** and select **My Documents**. Locate the “Lift Data” document and press **enter** to open.



Navigate to page 1.2 (shown opposite). Use the arrow keys to scroll across to view the column headings or down to view the data.

Some of the altitude readings are negative. The dynamic wireless sensor's altimeter will assign the point (0, 0) as the origin. Upward movement will be assigned positive altitude, whereas downward movement will be assigned negative altitude.

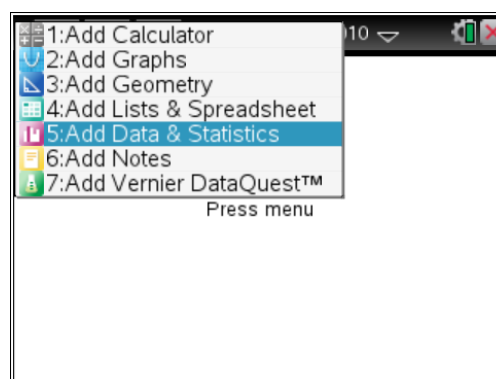
 A screenshot of the TI-Nspire spreadsheet view for the document '*Lift Data'. The spreadsheet has three columns: A time1_mins, B altitude1_m, and C time2_mins. The data is as follows:

	A time1_mins	B altitude1_m	C time2_mins
1	0	0	0
2	0.01	-0.272355	0.01
3	0.02	0	0.02
4	0.03	-0.544709	0.03
5	0.04	-0.817064	0.04

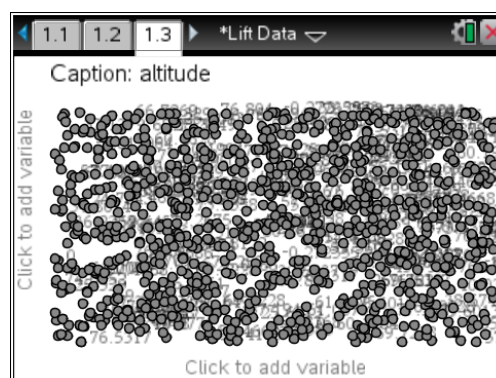
Graphing the data for lift 1

Step 1

Press **home** or **ctrl + I** and select **Add Data & Statistics** to insert a new page.

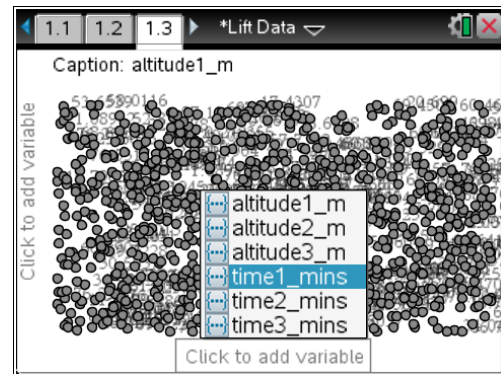


All of the points should appear on the screen.

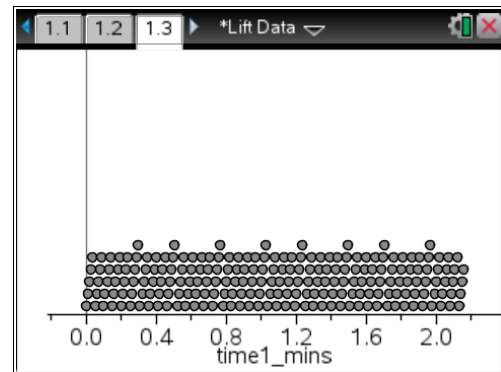


Step 2

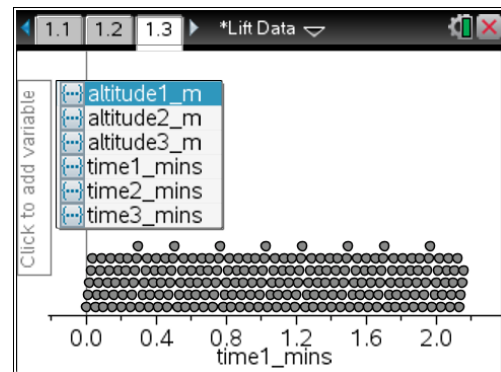
Press **tab** or use the **mouse** to highlight a list of variables for the horizontal axis. Select **time1_mins**.



A dot plot of the data will appear.

**Step 3**

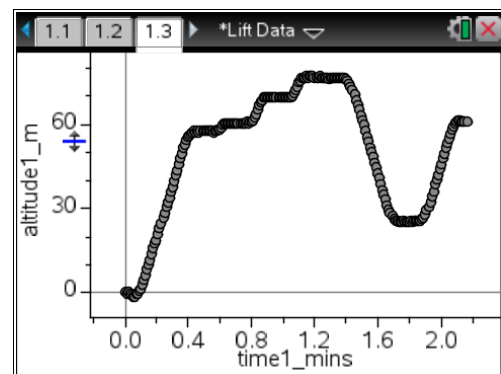
Press **tab** or use the **mouse** to highlight a list of variables for the vertical axis. Select **altitude1_m**.



A scatter plot of the data will appear.

The altitude is in metres and the time is in minutes.

Notice that there is a slight downward movement of the lift just near the origin before it starts to ascend. The dynamic wireless device has been sensitive enough to record this drop as a negative altitude.



Questions

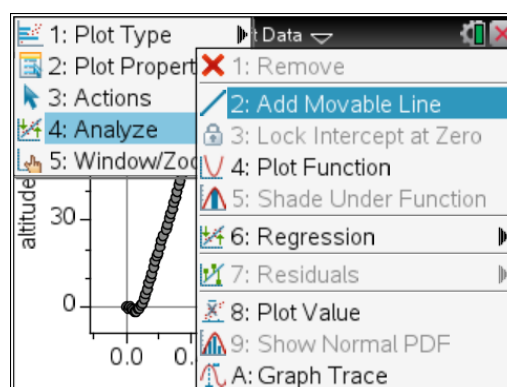
- What is the approximate maximum altitude reached by the lift?
Approximate maximum altitude = 77 metres. Use the mouse to hover over the highest point on the graph or alternatively use the table in Lists & Spreadsheet to determine the highest point. The exact value is 77.3487 metres.
- What is the approximate total travel time for the lift?
Approximate total travel time = 2.16 minutes (or 130 seconds)
- How many floors did the lift visit? Don't include the starting floor?
The lift visited 6 floors.

Estimating the speed of a lift by using a moveable line

The motion of the elevator between floors (when presented as a graph) is represented by a series of straight lines. Long straight lines represent trips between floors that are well separated, whereas a short straight line could represent a trip between two adjacent floors. These straight lines are referred to as “linear” and the slope of these lines represents the speed of a lift which should be constant between floors.

Step 1

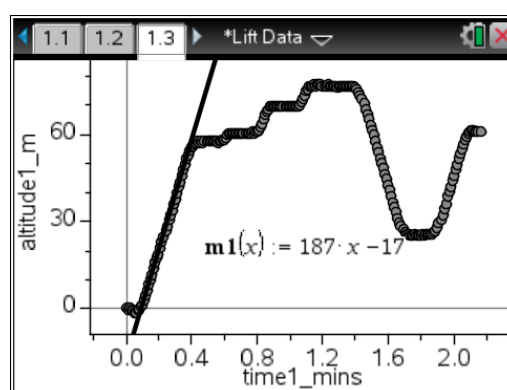
Press **menu > Analyse > Add Moveable Line**.



Step 2

Adjust the position of the moveable line by using the arrows until it matches the first linear section of the lift data. An equation will appear on screen. In this example, the equation is $m1(x) = 187x - 17$ so the speed of the lift is 187 metres/minute. This is approximately 3 metres/second.

$$[\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{187}{60} = 3.12 \text{ metres/sec}]$$



Note: There will be some variation between students' results based on the placement of the moveable line. Greater accuracy is obtained when the computer view is used (rather than the handheld view).

Determining the lift speed from a table of values

The lift speed can also be determined by finding the gradient from a table of values on page 1.2.

$$\text{Gradient (m)} = \frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1}$$

Using the highlighted data;

$$\text{Gradient (m)} = \frac{20.699 - 18.7925}{0.21 - 0.2} = \frac{1.9065}{0.01} = 190.65 \text{ metres/min}$$

This speed agrees quite closely with the previous result of 187 metres/minute.

	A time1_mins	B altitude1_m	C time2_mins
20	0.19	17.4307	0.19
21	0.2	18.7925	0.2
22	0.21	20.699	0.21
23	0.22	22.8778	0.22
24	0.23	24.7843	0.23

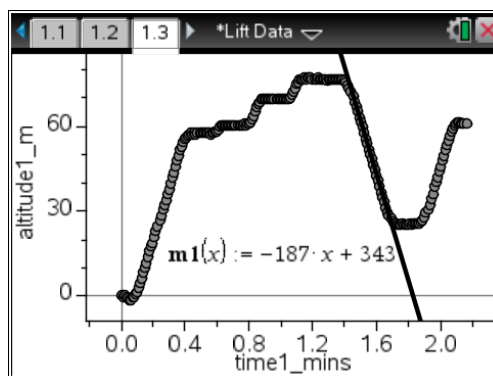
Note: There is some variation using adjacent pairs of data points separated by 0.01 minutes. A more accurate result would be obtained over a greater period of time.

Questions (continued)

4. Determine the approximate downward speed for the lift by using the moveable line.

The approximate downward speed is -187 metres/minute.

Note: The upward speed and the downward speed should be equal as the same pulley mechanism is used for both up and down trips. There will be variation between students based on the position of their moveable line.



5. Determine the approximate downward speed for the lift by determining the gradient from a table of values. Compare this with the speed obtained in question 4.

$$\begin{aligned} \text{Gradient (m)} &= \frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{66.7269 - 68.6334}{1.47 - 1.46} \\ &= \frac{-1.9065}{0.01} \end{aligned}$$

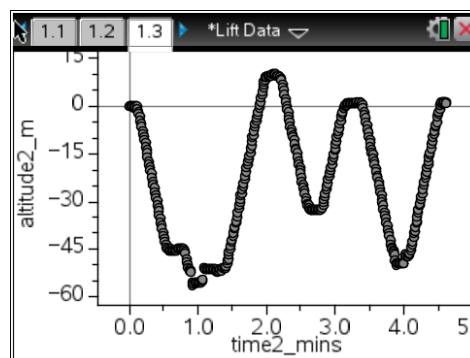
$$= -190.65 \text{ metres/minute}$$

This is quite close to the speed obtained in Q 4.

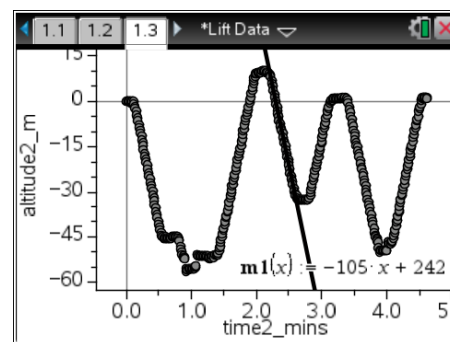
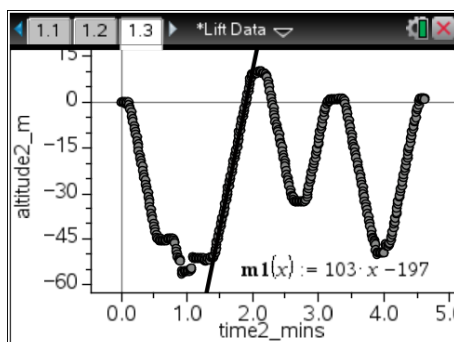
	A time1_mins	B altitude1_m	C time2_mins
146	1.45	70.8122	1.45
147	1.46	68.6334	1.46
148	1.47	66.7269	1.47
149	1.48	65.0928	1.48
150	1.49	63.1863	1.49

6. Graph altitude2_m v's time2_mins for lift 2. What is the total travel time for the lift and how many floors does the lift visit including the starting and finishing floors?

The total travel time is approximately 4.5 minutes. Alternatively by using the table of values in Lists & Spreadsheet, the last entry is 4.62 minutes. The origin (0, 0) for this lift was the 17th floor so the initial downward movement is recorded as a negative altitude.



7. Determine the downward and upward speeds for the lift by using a moveable line and by finding the gradient from a table of values.



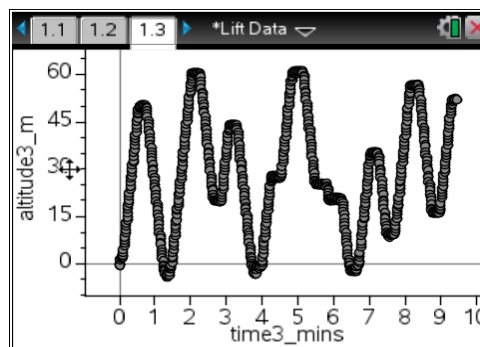
	C time2_mins	D altitude2_m	E time3_mins
146	1.45	-46.845	1.45
147	1.46	-45.7556	1.46
148	1.47	-44.6662	1.47
149	1.48	-43.8491	1.48
150	1.49	-42.7597	1.49

	C time2_mins	D altitude2_m	E time3_mins
242	2.41	-11.9836	2.41
243	2.42	-13.073	2.42
244	2.43	-13.6177	2.43
245	2.44	-14.7072	2.44
246	2.45	-15.7966	2.45

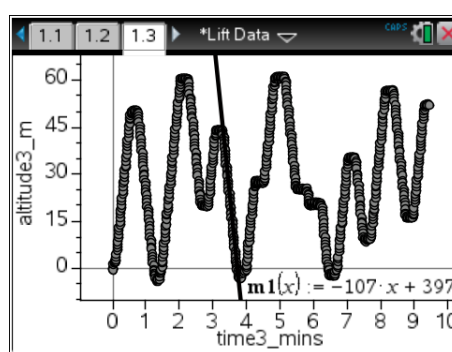
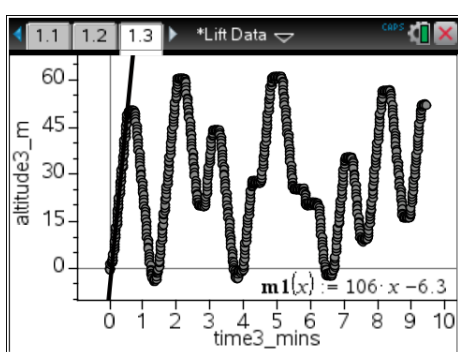
Moveable line method	Gradient method (table of values)
Upward speed = 103 metres/min	Upward speed = $\frac{-44.6662 - -45.7556}{1.5 - 1.49} = 108.94$ m/min
Downward speed = -105 metres/min	Downward speed = $\frac{-14.7072 - -13.6177}{2.44 - 2.43} = -108.95$ m/min

8. Graph altitude3_m v's time3_mins for lift 3. What is the total travel time for the lift and how many floors does the lift visit including the starting and finishing floors?

The total travel time is just under 9.5 minutes.
 Exactly 9.42 minutes by using the mouse or Lists & Spreadsheet. The number of floors visited is 17. The origin (0, 0) for this lift is the ground floor. The lift does go to the basement car park which is assigned as a negative altitude.



9. Determine the downward and upward speeds for the lift by using a moveable line and a table of values.



E	time3_mins	F	altitude3_m	G	H
29	0.28		21.516		
30	0.29		22.6054		
31	0.3		23.6949		
32	0.31		24.7843		
33	0.32		26.1461		

E	time3_mins	F	altitude3_m	G	H
349	3.48		23.6949		
350	3.49		22.3331		
351	3.5		21.516		
352	3.51		20.4266		
353	3.52		19.3372		

Moveable line method	Gradient method (table of values)
Upward speed = 106 metres/minute	Upward speed = $\frac{24.7843 - 23.6949}{0.31 - 0.3} = 108.94 \text{ m/min}$
Downward speed = -107 metres/minute	Downward speed = $\frac{20.4266 - 21.516}{3.51 - 3.5} = -108.94 \text{ m/min}$

10. Two of the three data sets represent the same lift. Which two data sets represent the same lift?

Based on similar speeds, lift 2 and lift 3 are the same lifts. Lifts 2 and 3 have roughly the same speed, around 105 metres/minute. Lift 1 has a speed around 190 metres/minute. In this example, the best way to compare lifts is by their speeds.