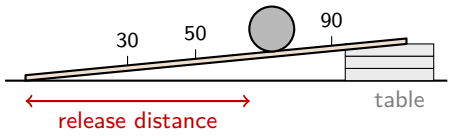
Warmup: Rolling Can

Adapted from Principles of Mathematics 10, McGraw-Hill Ryerson, 2007.

Work in a group of three or four. A phone timer is fine today.

Roles. Keep the same roles for every roll.

- **Releaser:** holds the can on the mark with a ruler across the board in front of it, counts "3, 2, 1, go," and lifts the ruler straight up on "go" without pushing.
- **Timer:** starts on "go" and stops when the front edge of the can reaches the bottom edge of the board.
- **Recorder:** writes each time in the table, to 0.01 s.
- **Catcher** (if four): stops the can and hands it back.



Set-up. The board rests on books so the 100 cm mark is about 9 cm above the table. Each mark is measured from the bottom edge; line the can's front edge up with it. Roll three times from each mark, from rest.

1. **Before you roll:** Which quantity does your group set before each trial, and which do you measure during it? So which is the independent variable, and which is the dependent variable?

_____

_____

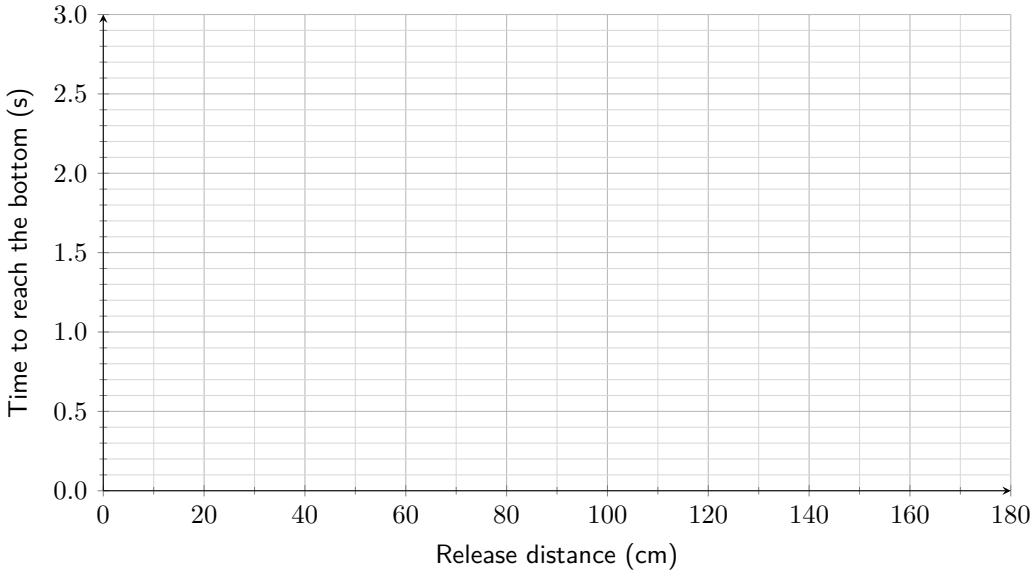
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Release distance (cm)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Average (s)
30				
40				
50				
60				
70				
80				
90				
100				

2. **Plot.** Plot your averages on the grid, release distance across and time up.



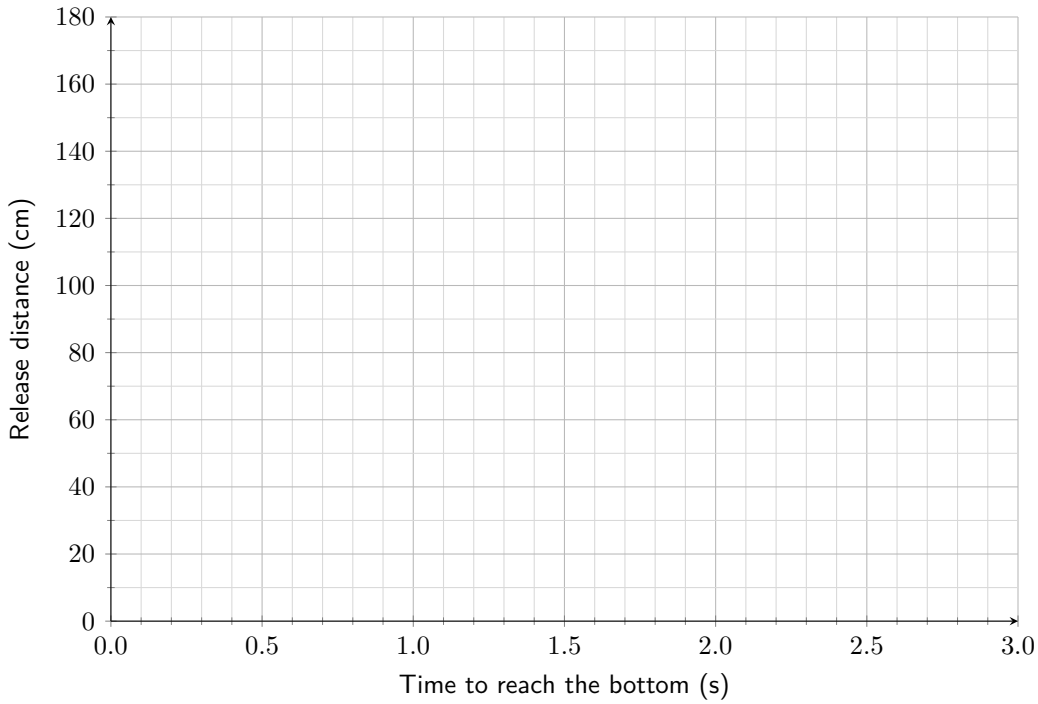
3. **Describe.** Describe the relationship between release distance and time in words.

4. **Draw.** Draw one smooth curve of best fit, with about as many points above it as below it.

5. **Predict.** Use your curve to predict the time for a release from 160 cm on a longer board with the same slope. Show your reading on the graph. Is this interpolation or extrapolation?

   Predicted time: _____ s Interpolation or extrapolation? _____

6. **The other way round.** Plot the same averages on this grid, with time across and release distance up.



Which of your two graphs looks like half of a parabola? What does the other one look like?

7. **Look back.** Both graphs show the same relation. Why can the shape change?

Warmup: Rolling Can — Sample Answers

Adapted from Principles of Mathematics 10, McGraw-Hill Ryerson, 2007.

The real answers come from your group's own rolls. The table and graphs below are *sample data* to show what a complete warmup looks like. Answers in words are model sentences; other answers that are well argued are fine.

Set-up note for the teacher

Per group: a board at least 1.2 m long and smooth (a shelf board works), a stack of books, one full, unopened can of soup (the same kind for every group), a metre stick or measuring tape, masking tape and a marker for the marks, a ruler to hold the can, and a stopwatch or phone timer. D block borrows the set.
Before class: raise the top end so the 100 cm mark sits about 9 cm above the table, an angle of about 5°. Mark 30, 40, . . . , 100 cm along the board, each measured from the bottom edge.
Why the shallow angle matters: a hand-started stopwatch is off by about 0.1 to 0.2 s each time. At about 5° the can takes about 1 s from 30 cm and about 1.8 s from 100 cm. Neighbouring marks differ by only about 0.1 s, so averaging three trials matters, but the whole spread of times is far bigger than the timing error and the curve shows. A steeper ramp gives times under a second, and the curve disappears into the noise. Keep the same timer for every roll.

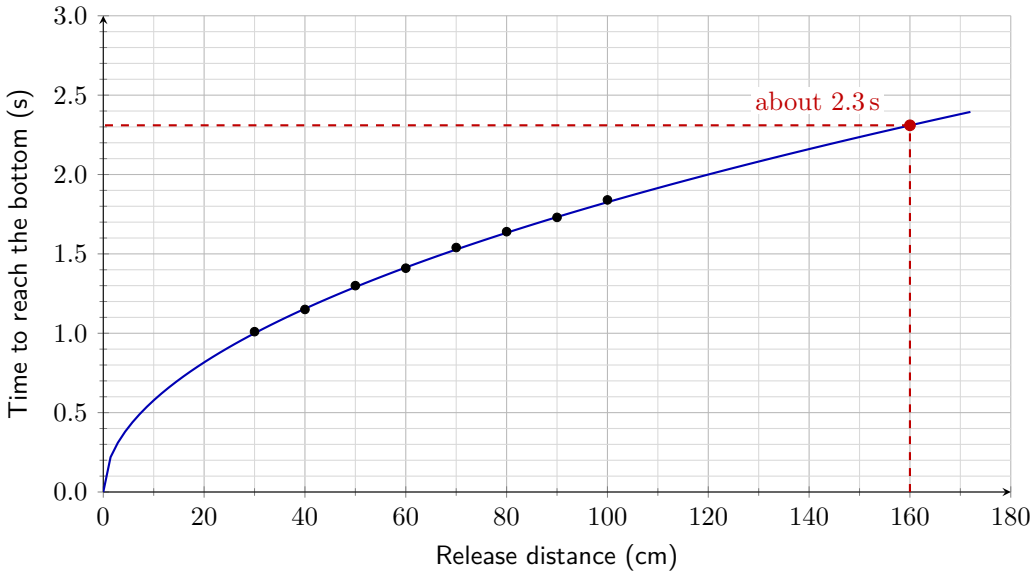
Sample data. Times to the nearest 0.01 s; averages to two decimal places.

Release distance (cm)	Trial 1 (s)	Trial 2 (s)	Trial 3 (s)	Average (s)
30	0.97	1.04	1.02	**1.01**
40	1.18	1.12	1.16	**1.15**
50	1.31	1.26	1.33	**1.30**
60	1.40	1.45	1.38	**1.41**
70	1.55	1.50	1.57	**1.54**
80	1.61	1.66	1.64	**1.64**
90	1.75	1.70	1.73	**1.73**
100	1.80	1.86	1.85	**1.84**

1. **Before you roll:** Which quantity does your group set before each trial, and which quantity do you measure during it? So which is the independent variable, and which is the dependent variable?

   We set the release distance before each trial, and we measure the time to reach the bottom. The release distance is the independent variable, so it goes on the horizontal axis; the time depends on it, so time is the dependent variable.

2. Plot. Sample averages, a curve of best fit (question 4), and the 160 cm reading (question 5).



3. Describe. Describe the relationship between release distance and time in words.

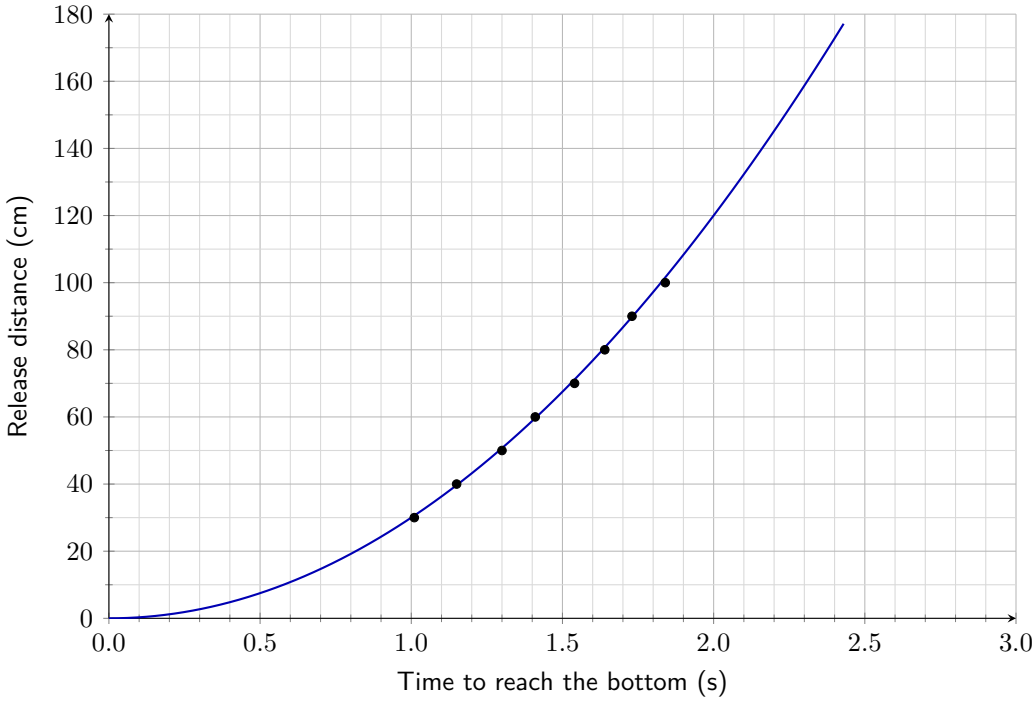
As the release distance increases, the time increases. The points do not lie on a straight line: they rise quickly at first and then flatten out. On the whole, each extra 10 cm adds less time than the 10 cm before it, because the can is already moving faster when it reaches the lower part of the board.

4. Draw. A smooth curve through the middle of the points, as on the graph in question 2. Extended to the left, it should reach $(0, 0)$: a can released 0 cm from the bottom is already there. Near the origin the curve is very steep.

5. Predict. Use your curve to predict the time for a release from 160 cm on a longer board with the same slope. Show your reading on the graph. Is this interpolation or extrapolation?

About 2.3 s (reading on the graph). Accept 2.1 to 2.5 s. This is extrapolation: the longest release in the data is 100 cm, so the curve has to be extended beyond the data, and the prediction is less certain.

6. The other way round. The same sample averages with the axes swapped.



Which of your two graphs looks like half of a parabola? What does the other one look like?

The graph with time across and distance up looks like the right half of a parabola that opens upward, with its vertex at the origin. The graph with distance across and time up is that same curve lying on its side: it starts out steep and then flattens, like half of a parabola that opens to the right.

The teaching point: *distance against time* is the quadratic relation. The sample curve is $d = 30t^2$ (d in cm, t in s), a parabola with its vertex at the origin; only the right half appears because time cannot be negative. Groups need not find an equation today; Card 8 of the Discussion returns to this graph.

7. Look back. Both graphs show the same relation. Why can the shape change?

Both graphs use exactly the same pairs of numbers; only the roles of the axes are swapped. Swapping the axes flips the picture over the diagonal, so the same pattern looks different on paper. A curve that rises steeply and flattens out in one direction rises slowly and then steeply in the other.