▲ Math in the Media

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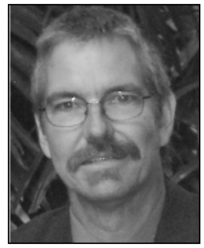

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While reading the October 23, 2010 edition of the *Globe and Mail*, an article about the Afghanistan mission caught my eye. Specifically, it was a picture of a helicopter landing and a graph of defence spending that I realized contained several opportunities for secondary math. The intention of this article is to illustrate some opportunities that emerged, rather than to focus on any single math topic. While the contents of this article may be viewed as what happens when a mathematician reads the newspaper, it could also be considered a call to find and use more images in our math classes.

A photograph of a helicopter (shown on the next page) shows a significant dust cloud, with troops and a vehicle with a trailer awaiting the helicopter's arrival. The picture highlights several mathematical shapes, but requires a grid for students to determine graphical features. The creation of a grid and reading points off the grid could be used for review of graphing in Grade 9. The choice of axes can be a discussion point. For this article, a grid has been added to the photo, using the front rotor of the helicopter as the origin and a y-axis passing through both rotors. The x-axis was made perpendicular to this, and a square grid size was chosen with half the distance between the rotors as a unit of measure. Positive y is interpreted as being behind the helicopter and positive x toward the bottom of the photo. This set-up allowed an analysis of the edge of the dust cloud as a quadratic that is opening up. Note that students can infer that the helicopter is moving because the dust cloud is not circular (a circular pattern example, suitable for modelling in MPM2D, can be seen at **www.flickr.com/photos/defenceimages/5036597936/**).

The quadratic shown at the front of the dust cloud was generated using quadratic regression based on the points marked with a small "x." The equation that resulted was:

$y = .14x^2 + .09x - 1.7 \quad r = .99$

This could be developed without using regression by examining the y-intercept and roots. In addition to the quadratic, a series of almost parallel equally-spaced “lines” are observable in the dust and so parallel, equally-spaced line segments have been drawn to model the structure. The y-intercepts form an arithmetic progression. Students in Grade 9 or 10 could derive the equations for the lines on the graph; they are:

$$y = \frac{2x}{3} + 1.7n \qquad n = 1, 2, 3, 4, 5$$

A variety of questions facilitate a deeper conversation about the interpretation:

- What is taking place in the photo? (e.g., The helicopter is coming in to pick up troops.)
- Will the vehicle with the trailer fit inside the helicopter? [Note that the helicopter has a hydraulic ramp to facilitate loading vehicles (see **en.wikipedia.org/wiki/Boeing_CH-47_Chinook for a picture**).]
- Was it reasonable to decide that the lines were parallel? Suggest a reason why parallel lines might be observed. [A teacher can use this for developing the idea of rotation of the blades causing a repeated pattern. Taking a slice, such as the y-axis, allows one to look at the pattern as a periodic function, a topic for some Grade 11 courses.]
- The arithmetic progression has been stopped after the fifth line. Is that reasonable and should greater values have been included?
- Would, or how would, the mathematical results be different if positive y were taken to be in front of the helicopter and positive x were taken to be toward the top of the photo?

Some concepts can be developed that introduce the third dimension. Perhaps a good starting point is to ask students to roughly estimate the direction of the top of the photo. This can be ascertained as roughly south because of the orientation of the shadows and knowing that Afghanistan is in the northern hemisphere. An estimate of time of day can be achieved, but requires skills beyond the secondary curriculum.

Shadow measurement, with accuracy, requires that one is specific about the direction of the sun. To determine this direction, draw a line from the hub of the front rotor of the helicopter to the location of the hub in

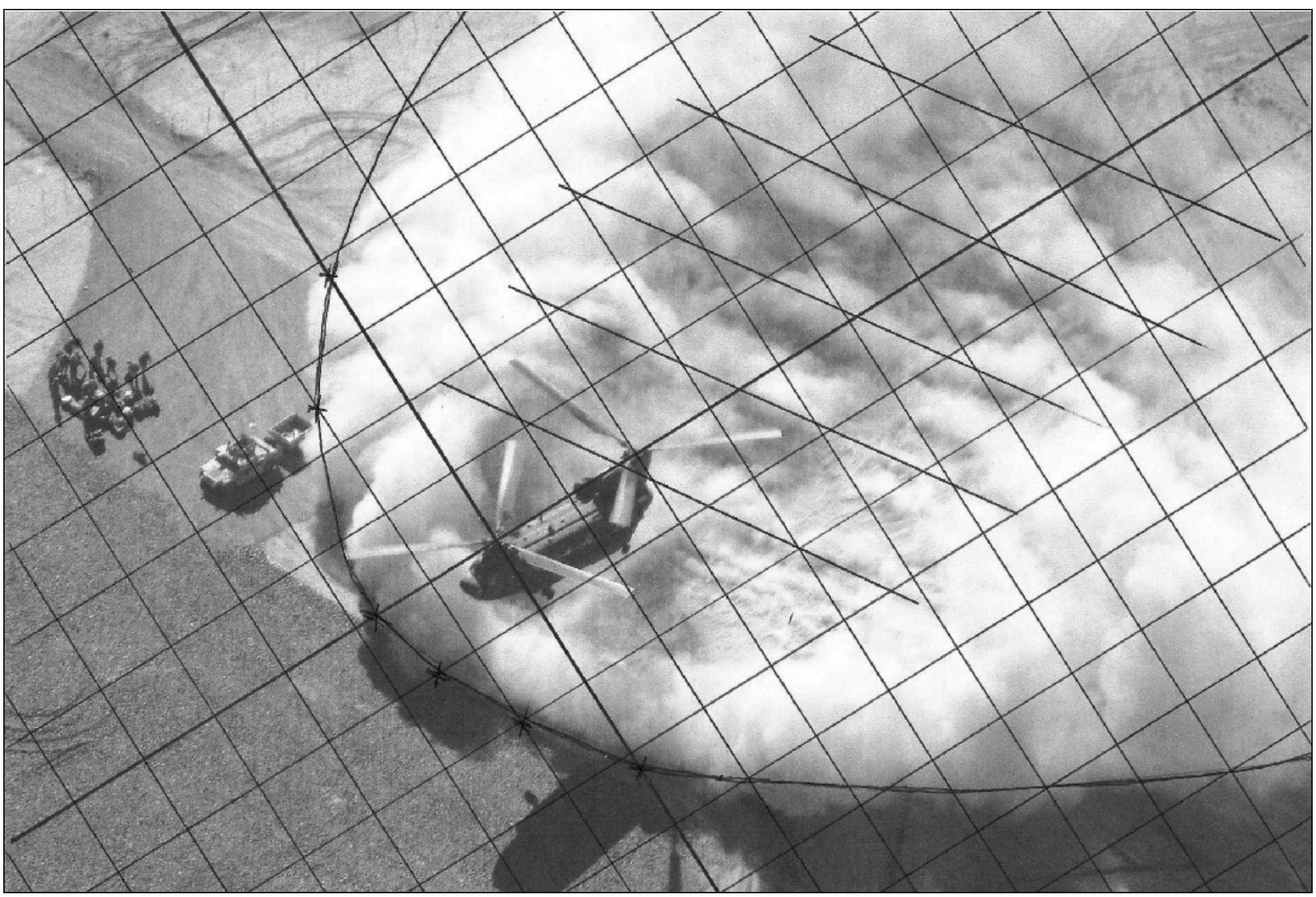


Photo by MCPL Craig Wiggins

the shadow on the ground. All measurements of shadows should be parallel to this on the photo. The vehicle can be used to measure the elevation of the sun; surprisingly, the shadow and height of the vehicle appear to be equal, suggesting that the sun has an elevation of 45°.

An elevation of 45° means the height of the helicopter off the ground is the same as the horizontal length of the shadow on the ground and, therefore, can be estimated. Firstly, measure the distance from the centre of the rotor hub to the shadow of the rotor hub in millimetres, and note that this is geometrically the same as the height of the helicopter because a 45° elevation gives a right isosceles triangle. However, a scale factor is needed to convert the measurement into real-world units, topics covered in MFM2P and MAP4C. This requires recognizing that this is a Chinook helicopter, where the rotor hubs are separated by 11.9 m (according to www.airforce-technology.com). So a measurement of the distance between the rotors on the photograph provides the conversion factor to metres. Using this method, an estimated height of the helicopter of approximately 28 m can be found. However, this is the height of the rotor hub above the ground. Since the helicopter has a height of 5.8 m, the wheels are approximately 22 m above the ground. The same calculation can be used to estimate that some of the soldiers are approximately 1.7 m tall ("Is that reasonable?").

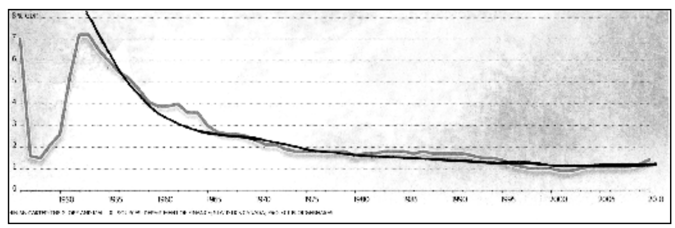
A second aspect of the *Globe and Mail* article was a graph of defence spending since the Second World War as a percentage of GDP. A selection of points spread from 1953 to 2000 were used to determine a curve of best fit. The curve that is illustrated is a reciprocal power law:

$$y = 17.07(\text{year}-1950)^{-.684} \quad r = .99$$

This could be determined using a graphing calculator or, without regression, by taking a pair of points and solving for the coefficient and exponent. It may be preferable to do this as a practical example of solving for the value of an exponent.

Some questions for students:

- How do you choose an appropriate model for the graph? (Note that a quadratic regression implies that spending will increase significantly in the future. Exponential decay may be a valid alternative to the model used here, but requires more thought about the value of y in the horizontal asymptote—as is done in MHF4U.) Students may need help to understand that a fixed percent of GDP does not mean that defence spending stays the same.
- Having chosen a model, which regression model should be used on the graphing calculator?
- The graph has periods of time where the spending exceeds the modelled value. Do these correspond to events that involved the Canadian military? Do they correspond to declines in GDP, such as recessions?
- The newspaper title for the graph says spending has "turned higher in recent years." Is this evident from the graph? (Note that GDP has been increasing.)
- Social-justice questions can be addressed by raising questions about the allocation of monies in relation to GDP and, perhaps, investigating standard of living since 1950. These discussions might be appropriate in MDM4U and MBF3C courses.



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Both the photograph and the spending graph have the potential to evoke a mathematical response, with attention to different details appropriate in different courses. The approach builds on the idea of photo math, with which *Gazette* readers are familiar, and relies on the analysis skills that we develop in the secondary math curriculum. With the increasing availability of projectors and SMART Boards™, teachers have an opportunity to utilize images and can embed higher-level mathematical concepts within the analysis. ▲