SLOPE CALCULATION

By Joe Griffith, February 2014

Objectives – Upon completion of this chapter, you will be able to:

- Read the rise-over-run from a topographic map.
- Convert the rise-over-run into a slope angle in degrees.

Most of the time in backcountry travel the angles that demand our attention are the horizontal angles: heading, bearing, and wind direction. We do not usually need precise values for the vertical angle, slope. Avalanche hazards do, however, depend on the tilt of the snowpack, with the highest hazard occurring within a relatively narrow range of angles. The ability to recognize these slopes on your topographic map can significantly increase your safety when traveling among mountains loaded with snow.

Figure 1 shows the range of the most hazardous slopes, those within the gray wedge. Mountains are not smooth geometrical objects, of course, but we will not worry about vertical variations in the terrain smaller than the contour spacing because topographic maps do not show them. We just need the average slope at a given location.

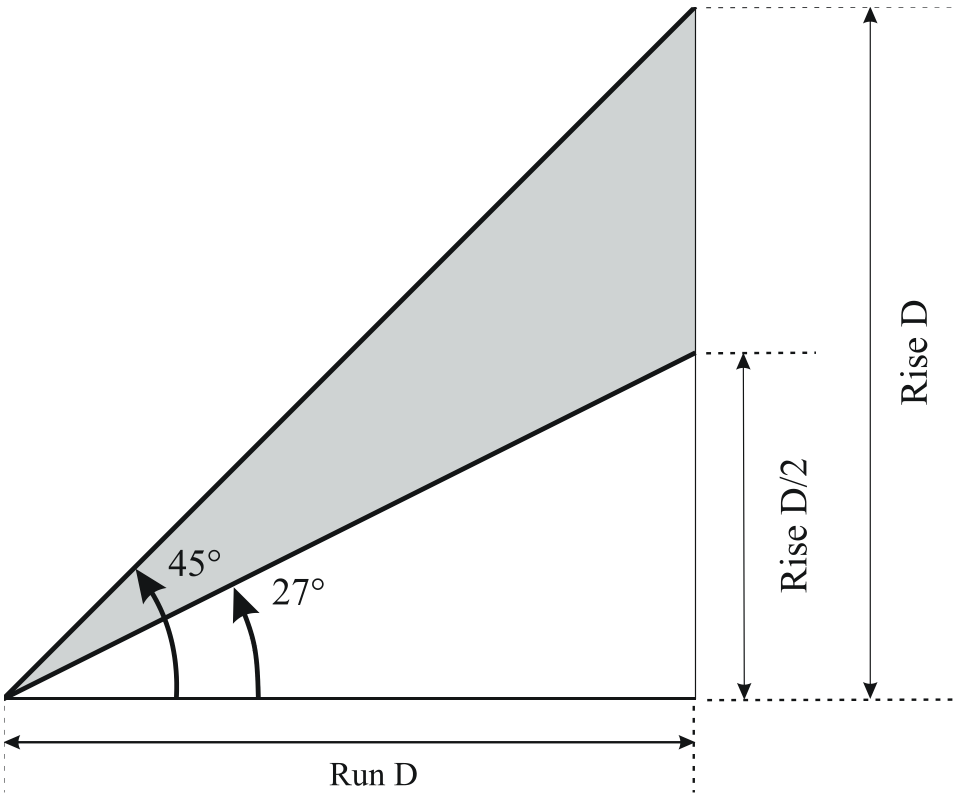

Figure 1 Slopes in the gray wedge are those most likely to avalanche. The range in degrees is between 27° (often rounded to 30°) and 45°, while the range in rise-over-run is between ½ and 1.

Figure 1 includes two ways to describe the tilt. The slope angle in degrees and the ratio of the rise over the run are equivalent measures of the tilt. Figure 2 shows the basic geometric relationship. Inclinometers used in the field measure angles in degrees so most discussions of avalanche hazards give the slope in degrees. Topographic maps, on the other hand, naturally yield the ratio of the elevation gain (rise) over the horizontal distance (run). You need a way to convert rise-over-run into degrees. They are connected by a simple formula, which can be easily used either in a spreadsheet or with a pocket calculator. If you dislike formulas we will show you how to use a spreadsheet that we provide on the Student Manual webpage. For those of you who are comfortable with math, we conclude with instructions on how to use the formula with a calculator.

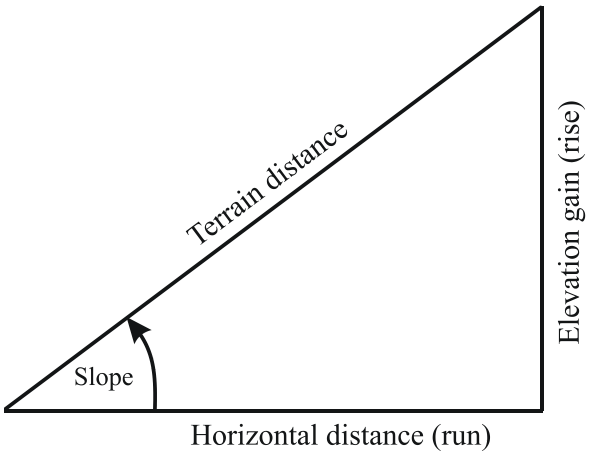

Figure 2 A triangle showing the geometric relationships among the quantities discussed in the text.

As an example consider the map in Figure 3, which has a scale of 1:24000 and a contour interval of 40 feet. Using the inches scale on a compass we find that the space between adjacent index contours at this location is 1/8 inch.

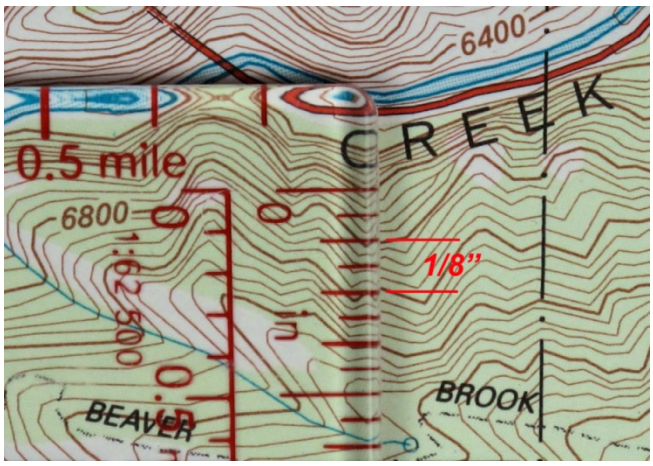

Figure 3 Slope measurement with an inches scale on a 1:24000 map with a 40-foot contour interval.

For this combination of scale and contour interval we have provided a spreadsheet Slope_Calculator.xls (Figure 4) that allows you to calculate the slope in degrees by simply entering the contour separation into cell B4. You can find the spreadsheet at http://www.hikingdenver.net/schools/wts/student-manual. It can be used on any personal computer, tablet, or smartphone capable of running a Microsoft Excel™ spreadsheet. It is not necessary to have Microsoft Office™ to use it, since free software for Excel spreadsheets is available for the common operating systems.

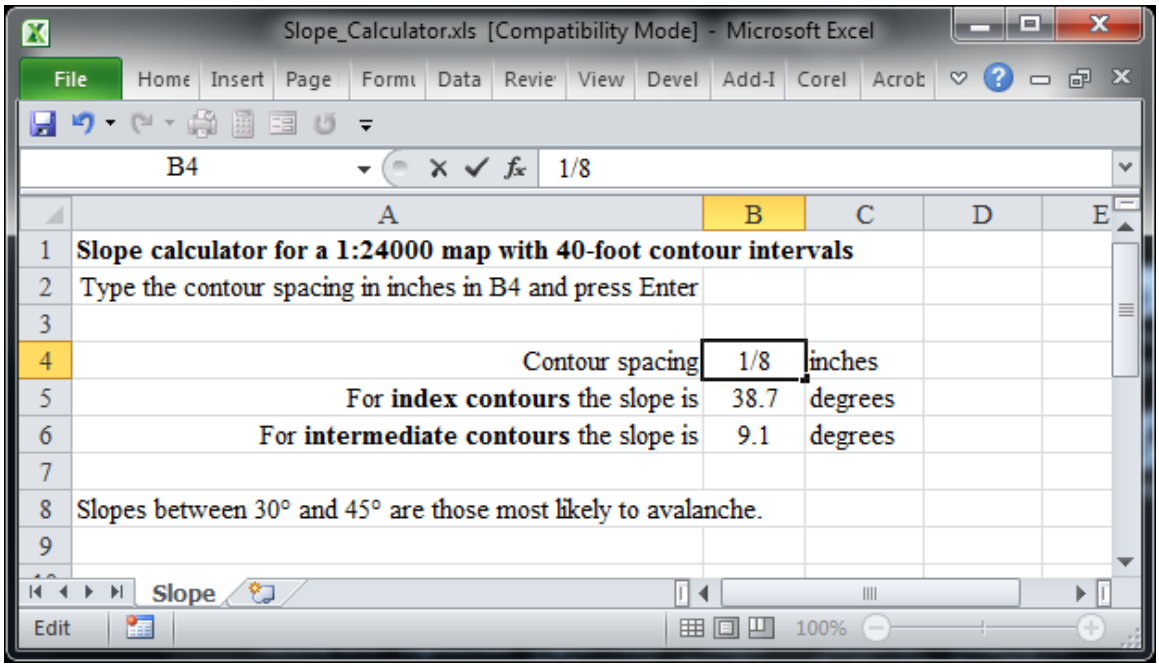

Figure 4 Spreadsheet Slope_Calculator.xls for calculating the slope in degrees with a 1:24000 map having 40-foot contour spacing.

Though the spreadsheet is convenient it is not necessary since any calculator with trigonometric functions will suffice. We begin by calculating the rise and the run for our example in Figure 3. The rise between adjacent index contours is 5 times 40 feet or 200 feet. For the 1:24000 scale on this map, 1 inch is equal to 2000 feet in the field, so the run between the contours is 2000 feet/inch * 1/8 inch. The slope in degrees is now easy to calculate using the inverse tangent, also called the arctangent or atan:

$$\mathbf{slope[deg] = inv\ tan(rise/run)}.$$

Substituting our numbers into the formula gives us

$$\text{inv tan}(200/(2000 * \tfrac{1}{8})) = 38.7°.$$

If you do not have a scientific calculator, Microsoft Windows™ provides one under Accessories. If it starts up in Standard mode you will need to switch it to Scientific mode with the View pull-down menu.

Figure 5 The calculator provided as an Accessory in Microsoft Windows 7™. It is shown in Scientific mode.

To get the slope set the radio button to Degrees. Calculate the rise over the run, which turns out to be 0.8 for Figure 3. Click the Inv button, and then click the tan button. The calculator's display will show the desired slope, 38.7°. As long as you correctly calculate the rise and the run, the formula works for any topographic map.