The Topographic Sand Box, a Tool for Improved Understanding and Visualization of Topographic Maps

Stephen C. Kuehn *sckuehn@concord.edu* Department of Physical Sciences, Concord University, PO Box 1000, Athens, WV 24712, USA

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1 Abstract

Understanding topographic maps and visualizing the 3-D information contained is a common challenge for introductory earth science students. To address this problem, a laboratory mapping exercise has been developed using a set of sand box models (four to five for a 20-student class). Each model is constructed to exhibit one or more topographic features (e.g. steep vs. shallow slopes, hill, valley, ridge, depression). All contain a shoreline which serves as the zero elevation reference. Working in small groups, the students begin by constructing contour lines on the surface of the sand.

The next task is to construct a paper map. This requires measuring the size of the sand box and devising an appropriate scale for the paper map. When completed, each map is labeled with much of the same supporting information that accompanies a standard topographic map: written scale, scale bar, north arrow, contour interval, etc. The exercise also includes the labeling of several bench mark elevations, discussion of precision and accuracy of the bench marks, construction of a topographic profile, and labeling of topographic features on the map. "Aerial" photographs are taken of all of the boxes and are shared with the entire class. When all of the maps have been completed, the class is taken on a tour/discussion of all of the sand boxes.

To provide further practice and reinforcement, a follow-up exercise is assigned which uses a topographic map draped over the 3-D topography in Google Earth. This provides further visualization of the relationships between contours and the landscape that they represent. With this preparation, students proceed to working with standard quadrangle maps the following week.

Informal observation of students at work suggests a higher level of engagement than was seen during a paper-based contouring exercise. Student enthusiasm also appears to be improved.

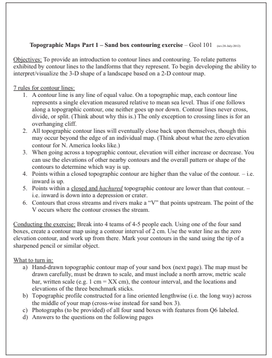
Acknowledgements & References

The sand box exercise was inspired in 2010 by an outdoor contouring exercise conducted at Washington and Lee University by David Harbor and Paul Low. During a period of cold, icy weather an indoor substitute was needed, and that eventually developed into the exercise presented here.

Readily discoverable references to any use of a sand box to aid in teaching topographic maps are few (see below), and each uses a different approach. The Owen, Rayner, and Stuart references can all be examined via a Google book search.

Owen, C., Pirie, D., and Draper, G., 2010, Earth Lab: Exploring the Earth Sciences: Brooks Cole. (see pages 191-192)
Rayner, W.H. and Stubbins, J.R., 1921, Sand Box Employed in Teaching Topographic Mapping: Engineering News-Record, v. 87, no. 20, pp. 810-811.
Roach, J., 2012, Augmented reality sandbox lets rain flow from your hands http://www.nbcnews.com/technology/futureoftech/augmented-reality-sandbox-lets-rain-flow-your-hands-758341
Stuart, E.R., 1918, Map Reading and Topographical Sketching: McGraw-Hill, New York. (see page 62)

2 Sand Box Exercise



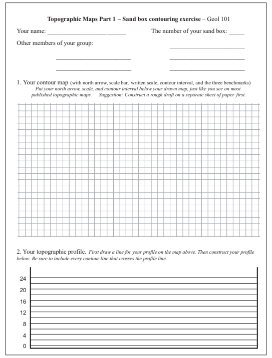
Topographic Maps Part 1 – Sand box contouring exercise – Geol 101 (rev.28-July-2012)

Objectives: To provide an introduction to contour lines and contouring. To relate patterns exhibited by contour lines to the landforms that they represent. To begin developing the ability to interpret/visualize the 3-D shape of a landscape based on a 2-D contour map.

7 rules for contour lines:
1. A contour line is any line of equal value. On a topographic map, each contour line represents a single elevation measured relative to mean sea level. Thus if one follows along a topographic contour, one neither goes up nor down. Contour lines never cross, divide, or split. (Think about why this is.) The only exception to crossing lines is for an overhanging cliff.
2. All topographic contour lines will eventually close back upon themselves, though this may occur beyond the edge of an individual map. (Think about what the zero elevation contour for N. America looks like.)
3. When going across a topographic contour, elevation will either increase or decrease. You can use the elevations of other nearby contours and the overall pattern or shape of the contours to determine which way is up.
4. Points within a closed topographic contour are higher than the value of the contour. – i.e. inward is up.
5. Points within a closed and *hachured* topographic contour are lower than that contour. – i.e. inward is down into a depression or crater.
6. Contours that cross streams and rivers make a "V" that points upstream. The point of the V occurs where the contour crosses the stream.

Conducting the exercise: Break into 4 teams of 4-5 people each. Using one of the four sand boxes, create a contour map using a contour interval of 2 cm. Use the water line as the zero elevation contour, and work up from there. Mark your contours in the sand using the tip of a sharpened pencil or similar object.

What to turn in:
a) Hand-drawn topographic contour map of your sand box (next page). The map must be drawn carefully, must be drawn to scale, and must include a north arrow, metric scale bar, written scale (e.g. 1 cm = XX cm), the contour interval, and the locations and elevations of the three benchmark sticks.
b) Topographic profile constructed for a line oriented lengthwise (i.e. the long way) across the middle of your map (cross-wise instead for sand box 3).
c) Photographs (to be provided) of all four sand boxes with features from Q6 labeled.
d) Answers to the questions on the following pages



Topographic Maps Part 1 – Sand box contouring exercise – Geol 101

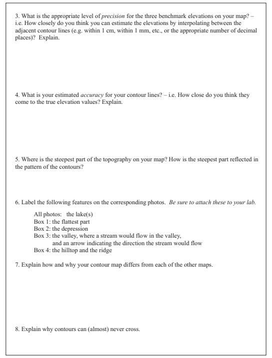
Your name: ____________ The number of your sand box: _____

Other members of your group: ____________

1. Your contour map (with north arrow, scale bar, written scale, contour interval, and the three benchmarks)
Put your north arrow, scale, and contour interval below your drawn map, just like you see on most published topographic maps. Suggestion: Construct a rough draft on a separate sheet of paper first.

2. Your topographic profile. *First draw a line for your profile on the map above. Then construct your profile below. Be sure to include every contour line that crosses the profile line.*

24
20
16
12
8
4
0



3. What is the appropriate level of *precision* for the three benchmark elevations on your map? – i.e. How closely do you think you can estimate the elevations by interpolating between the adjacent contour lines (e.g. within 1 cm, within 1 mm, etc., or the appropriate number of decimal places)? Explain.

4. What is your estimated *accuracy* for your contour lines? – i.e. How close do you think they come to the true elevation values? Explain.

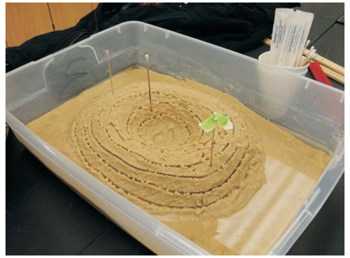
5. Where is the steepest part of the topography on your map? How is the steepest part reflected in the pattern of the contours?

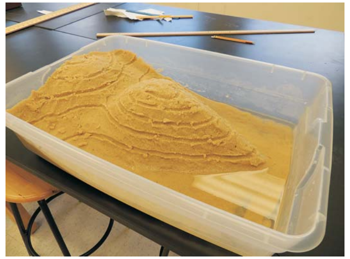
6. Label the following features on the corresponding photos. *Be sure to attach these to your lab.*

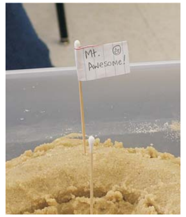
All photos: the lake(s)
Box 1: the flattest part
Box 2: the depression
Box 3: the valley, where a stream would flow in the valley, and an arrow indicating the direction the stream would flow
Box 4: the hilltop and the ridge

7. Explain how and why your contour map differs from each of the other maps.

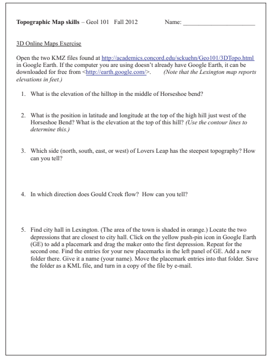
8. Explain why contours can (almost) never cross.







3 Google Earth Follow-Up



Topographic Map skills – Geol 101 Fall 2012 Name: ____________

3D Online Maps Exercise

Open the two KMZ files found at http://academics.concord.edu/sckuehn/Geo101/3DTopo.html in Google Earth. If the computer you are using doesn't already have Google Earth, it can be downloaded for free from <http://earth.google.com/>. *(Note that the Lexington map reports elevations in feet.)*

1. What is the elevation of the hilltop in the middle of Horseshoe bend?
2. What is the position in latitude and longitude at the top of the high hill just west of the Horseshoe Bend? What is the elevation at the top of this hill? *(Use the contour lines to determine this.)*
3. Which side (north, south, east, or west) of Lovers Leap has the steepest topography? How can you tell?
4. In which direction does Gould Creek flow? How can you tell?
5. Find city hall in Lexington. (The area of the town is shaded in orange.) Locate the two depressions that are closest to city hall. Click on the yellow push-pin icon in Google Earth (GE) to add a placemark and drag the maker onto the first depression. Repeat for the second one. Find the entries for your new placemarks in the left panel of GE. Add a new folder there. Give it a name (your name). Move the placemark entries into that folder. Save the folder as a KML file, and turn in a copy of the file by e-mail.