**Lecture Tutorials for**

**Introductory Physical Geology**

**with Quantitative Reasoning**

Original and adapted activities by

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**Context**

* The audience for these activities is an introductory physical geology or quantitative reasoning course for non-majors.
* The skills and concepts that students must have mastered involve creating and interpreting graphs (including triangle plots), explaining diagrams, and reading maps.
* These activities are designed to reinforce specific lecture topics and are scattered throughout the course.

**Goals**

* The content and concept goals for these activities follow those of the lecture topics: earthquakes, plate tectonics, minerals and rocks, volcanoes, geologic time, petroleum, rivers, groundwater, glaciers, and climate change.
* The higher order thinking skills goals for these activities involve making traditional lectures more interactive, holding students’ attention throughout a class and deepening their comprehension and retention of lecture topics.
* Other goals for these activities are to increase attendance in a traditional lecture class and to prepare students for laboratory exercises.

**References**

* Kortz, K.M., and J.J. Smay, 2012, *Lecture Tutorials for Introductory Geoscience*, W.H. Freeman & Co., New York.
* The definition of a lecture tutorial, according to Kortz and Smay, is “a short worksheet that students complete in class.”
* Note that the second edition is now available.
* The same authors have also published *Lecture Tutorials in Earth Science* (2014).
* See the SERC activity “A Lecture Tutorial on the Mahomet Aquifer in Central Illinois” <<https://serc.carleton.edu/earth_rendezvous/2016/program/demos/tuesdayB/136698.htm>> for further information on a specific tutorial.

**Usage**

* These activities involve pen-and-paper or clicker questions related to the lecture topics. The accompanying Power Point slides may be incorporated into the lecture.
* If the paper option is chosen:
	+ The date may be entered on the first page of each activity.
	+ The two pages for each activity may be copied double-sided and cut in half. That is, students would receive a half sheet of paper with questions on both sides.
* If the clicker option is chosen:
	+ Clickers or smart phone apps may be utilized to submit answers.
	+ A device or clicker icon may be placed in the lower right corner of each question slide (see first slide for an example).
* Note that the atmospheric carbon dioxide concentration tutorial should be updated yearly with new data.
* Students may consult with classmates, but each person submits individual answers.
* Tutorial content is not graded because the answers are discussed in class. However, each tutorial is assigned 1 or 0 points for completion or omission of the work.
* Tutorials typically account for 3-7% of the total course grade, depending on the number of tutorials and the other elements of the course.
* This file contains 26 tutorials, one for each lecture in a specific course. However, not every tutorial is used in every semester; they are rotated from year to year. Some tutorials are used but not collected for grading.

**Results**

* The goals for adding tutorials to lectures have largely been met.
* For the goal of making lectures more interactive:
	+ Students refer to information on the front screen and respond with clicker answers or on tutorial sheets.
	+ Tutorials apply the lecture topics directly.
	+ Less material is covered, but the coverage is deeper than before tutorials were added to the course.
	+ In the process, the number of content slides per lecture decreased by ~25%.
* For the goal of improving student understanding:
	+ The numbers of students who did not complete the corresponding laboratory exercise, i.e., who received a score of 0, were compared before and after the introduction of tutorials.
	+ These proportions were ~17% for six semesters without tutorials and ~7% for six semesters with tutorials.
	+ This decrease of 10% in 0 scores implies that more students were able to complete the laboratory exercises, which did not change substantially over the twelve semesters.
* For the goal of increasing student attendance:
	+ No formal roll call was taken, but before tutorials were added to the course, attendance was typically less than 50% based on occasional counts.
	+ Tutorials are not announced in advance, and not every lecture contains a tutorial; thus, students are encouraged to attend.
	+ Attendance after tutorials were introduced increased to ~70% based on activities submitted.