



## INTRODUCTION

### General Instructions:

The completion of this Lab does NOT require a formal Lab report or write up. Instead you will present your data by completing a Lab Template LAB1: TEXTURE and POROSITY RESULTS shown below. This template is available as a separate document. **Only the completed LAB1: TEXTURE and POROSITY RESULTS needs to be turned in for credit!!!**

During this LAB you will establish several important parameters which you will also need to complete [LAB2: PERMEABILITY](#).

### Reading Assignments:

In preparation for this Lab, READ the following in your FREE Open Access Textbook(s):

- Kresic, 2024, Hydrogeology 101: Lecture 2.1 Porosity and Hydraulic Characteristics of Porous Media
- Freeze & Cherry, 1979, Groundwater: Section 2.5 Porosity and Void Ratio (Optional) and if you have it, READ the following in your *optional* Textbook:
- Hölting & Coldewey, 2019, Hydrogeology: Section 3.1 through Section 3.1.5

The following short explanations may also be helpful in your understanding of this Lab:

### Porosity

Groundwater occurs in the void spaces of earth materials: soils, unconsolidated sediments, and rock. Even rock that was formed as a solid mass will fracture as it is brought towards the surface. These fractures provide space for the storage and movement of groundwater.

**Porosity** is defined as the percentage of a volume of rock (the all purpose term hydrologists use for ‘earth materials’) that is empty space. This porosity or total porosity (n) is expressed as:

$$n = \frac{100V_{\text{voids}}}{V_{\text{total}}} \text{ Where } n \text{ is total porosity in percent; } V \text{ is equal to Volume}$$

**Effective porosity:** void spaces that are too small to admit water molecules are of little interest to hydrologists. The amount of void-space available for fluid flow is the effective porosity. Even large void-spaces that are interconnected by small pore throats are unavailable for fluid flow.

During this LAB exercise we will measure and calculate **Bulk porosity**, which can be computed from measurements of density:

$$n = 100 \left[ 1 - \left( \rho_{\text{bulk}} / \rho_{\text{pd}} \right) \right] \text{ where } \rho_{\text{bulk}} \text{ is the density of the bulk material (soil + porespace)}$$

$\rho_{\text{pd}}$  is the density of the particles that make up the soil.

(For most rock and soil, the particle density is about 2.7 g/cm<sup>3</sup>, roughly the density of quartz and clay minerals.)

Additional helpful information concerning porosity:

### Factors affecting porosity

**Grain size:** In and of itself, grain size has no effect on porosity. Well rounded sediments that are packed into the same arrangement generally have porosities from 26% to 48% depending on the packing. A room full of bowling balls and a room full of BBs would have the same porosities if the spheres were packed the same way.

**Sorting:** Well sorted sediments generally have higher porosities than poorly sorted sediments for the simple reason that if a sediment is a range of particle sizes then the smaller particles may fill in the voids between the larger particles. Sorting is measured as a ratio of the larger to smaller particle sizes in the sediment. This measure is called a uniformity coefficient.

**Grain shape:** Irregularly shaped particles tend not to pack as neatly as rounded particles, resulting in higher proportions of



voidspace.

**Clay and organic content:** Organic particles tend to be irregularly shaped and can increase voidspace. Clay particles tend to electrostatically repel one-another along the surface of the particles. This results in a relatively large proportion of voidspace.

**Primary vs secondary porosity**

**Primary porosity** is the porosity that exists between individual grains in the rock.

**Secondary porosity** is the porosity that results from fracturing, dissolution, and separation of the rock after its formation.

In our case bulk porosity approximates effective porosity, since we are working with unconsolidated sediments. In “real” life, this is not always the case. Effective porosity can be determined from hydraulic flow parameters, which we will do in subsequent Labs.

**Specific Yield:** also known as drainable porosity, is the Volume of liquid that can be drained by gravity compared to the total volume of the soil sample.

**Specific Retention:** is the amount of water retained in the soil sample after gravity drainage (Specific Yield) compared to the total volume of the soil sample.

**GENERAL INSTRUCTIONS ON COMPLETING THE LAB and GRADING:**

**For ALL assignments use a citation's database:**

ZOTERO citations database	ZOTERO is a citations database that incorporates itself into Word and your Browser.	Free open source software available at <a href="https://www.zotero.org/">https://www.zotero.org/</a>
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*Note: You may use a different citations database, if desired. But you MUST use a citations database!*

NOTE: After downloading and installing ZOTERO, take an hour or two to become familiar with the operation of the software. One of your first tasks will be to set the citation style to the United States Geologic Survey (USGS) format in ZOTERO. The USGS citation system will be required for this course and your final product.

**Loading the USGS citation format into ZOTERO:** Once Zotero Standalone is installed, click on "Preferences" under the Edit tab. Once there click on "Cite" and go to the "Styles" tab. Click on the "Get additional styles..." below the Styles Manger Box. When the Zotero Styles Repository Window opens, click on the "geology" button within the "Fields" section. A list of geology journals should now appear. Scroll down to the U.S.Geological Survey and click on it. The U.S.G.S style will now be part of your Zotero system and you can set your citations to be formatted accordingly in Zotero.

**General Writing Instruction Summary:**

- Use professional language, which means AVOID first person expressions such as “I”, “we”, “our”. Use normal prose, active voice and third party language. Do NOT use informal wording, contractions, jargon, slang terms, or superlatives. Exclude similes/metaphors (and humor!)
- Use present tense to report well accepted facts, e.g. 'Pyrite is a sulfide mineral'. Use past tense to describe specific results, e.g. 'When acid was applied, the specimen effervesced'
- Be quantitative wherever relevant (stats, numbers etc.).

Subscript & Superscript      Use appropriate subscript and superscript, especially when it comes to chemical formulas and mathematical units..  
 Acceptable examples: 2.9 g/cm<sup>3</sup>, H<sub>2</sub>O, PO<sub>4</sub><sup>3-</sup>, a<sub>g</sub>=9.8m/s<sup>2</sup>  
 Unacceptable examples: 2.9 g/cm3, H2O, PO4 3-, ag=9.8m/s^2

- Use precise concrete language, no ambiguity e.g. ‘correlated’ ≠ ‘related’. Use simple language – no unnecessary “frills” (distractions). Pay attention to sentence structure and grammar



### **COMPILING TABLES, FIGURES and EQUATIONS**

GRAPHICS are the heart of any report. Nothing is more true than in science that a picture is worth a thousand words. Always compile graphics first and then write your text focusing on your graphic. In order to create good graphics and photographs, follow the instructions below.

#### **Cameras and Photos:**

Cell phones with a 7.2MP camera are usually ok. When taking pictures, lighting and background is key. This means dark objects should be photographed with light or white backgrounds (sheet of paper) and visa versa for light objects. Having adequate lighting will also help to get sharp, crisp, in focus pictures. Blurry and out of focus pictures are not acceptable.

#### **Graphics:**

You should be able to modify, enhance, annotate or overlay graphics. Minimum resolution is 300dpi. Make sure graphics are crisp, clear and any label is easily readable. All graphics should have a caption stating the author and/or citation. Preferably use lossless graphic formats, such as .tif or .bmp. Unfortunately .jpg is NOT lossless and will degrade a little every time you open and save it again in order to manipulate picture contents.

**Graphics Editor Software:** You will need a graphics editor and learn how to use it. Windows comes with its default Windows Paint editor. It is found in the Windows Accessories Folder. For a more advanced option with many more professional features you may try GIMP: <https://www.gimp.org/> This is a FREE, open source image editor working across all computing platforms (Windows, Apple, Linux, etc.). The software comes with ample documentation and examples on how to manipulate any picture or graphic.

**Screen Capture Software:** A screen capture or snipping software is advantageous in order to only grab the part of a graphic from the screen that is important or necessary. Windows 10 comes with a default snipping tools, such as “Snip & Sketch” found in its own folder or “Snipping Tool” found in the Windows Accessories Folder. Note: When snapping a picture, make sure it is large enough on the screen to capture enough pixels to have adequate resolution for the final product.

**NOTE:** Compiling acceptable and good looking graphics and photographs is very involved and can not be rushed. These are often the heart of any report and should be compiled BEFORE writing. Last minute thrown together graphics will without doubt lower your grade.



COMPOSITION, LAYOUT, WRITING & GRAMMAR SUMMARY

Language

The following list is an example of common faults in language usage and attribution.

Errors / Mistakes / Faults	Examples with margin <i>Fault Counts &amp; Codes</i>
Spelling: incl. capitalization errors & spacing	The mineral <u>florite</u> has a <u>mohs</u> hardness of four.   Nicolas Steno <u>_</u> was trained in the classical texts on science.
Grammar: incl. punctuation, superfluous words, transpositions	Isometric crystals are also isotropic Here light propagates at the same speed.    Rocks are composed of many many <u>(minerals mixed.)</u>
Style: incl. paragraph, repetitive expressions / words, erroneous expression / words, sub- or superscription, unprofessional style, word insertion	<i>Para.</i> ... in the geologic sciences.¶Near the end of the 19 <sup>th</sup> a new theory ...    <i>rep</i> ... is a <u>light colored</u> mineral. These <u>light colored</u> minerals are often <u>light</u> ...   Stalactites hang from the <u>sealing?</u> of a limestone cave.   <i>sup</i> The density of quartz is 2.65 g/cm <sup>3</sup> .    I was investigating the outcrop with <u>my group</u> .   Sodium sulfate forms a chalky, <u>incoherent</u> precipitate. <i>amorphous?</i> ^
Sentence: incl. grammar, run-on, strings of nouns	The density of gold is greater <u>then?</u> the density of silver.   Pyrite has a symmetrical crystal <u>structure</u> , it is cubic.    <u>Skarn mineral zonation?</u> is apparent in the sample.

Content

Errors in content are spelled out. Severe infractions may count for multiple errors.

Errors / Mistakes / Faults	Examples with margin <i>Fault Counter &amp; Codes</i>
Unclear / erroneous statements	<i>unclear, units?</i> <u>Mohs hardness of the mineral in question is 16.5.</u>
False / nonsense	<i>Nonsense</i> <u>Glaciation cause severe metamorphism of the region</u>

TABLES, FIGURES & EQUATIONS SUMMARY

**Tables**

Each table must be sufficiently complete that it could stand on its own, separate from text.

**Only HORIZONTAL lines are allowed in tables. Do NOT use any VERTICAL lines.**

DO consecutively number and caption tables and refer to them accordingly within your text. Captions go ABOVE the table.

DO provide a short description of your table within the caption.

DO place your tables appropriately, closest to their mention in the text.

DO make sure tables are legible and reproduce well. Print can be smaller than text, with an 8pt size minimum.

DO appropriately label columns. Do NOT forget units for numeric values.

AVOID splitting tables across pages.



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**Figures**

Each figure must be sufficiently complete that it could stand on its own, separate from text.

DO number and caption figures consecutively and refer to them accordingly within your text. Captions go BELOW the figure.

DO provide a short description of your figure within the caption.

DO place your figures appropriately, closest to their mention in the text.

DO use appropriate citations for figures that are NOT your own. If you use a figure that has been modified by you, the phrase “modified after....” is most appropriate. Photos should show the name of the photographer.

DO make sure figures are legible and reproduce well. Print can be smaller than text, with an 8pt size minimum. Use a minimum resolution of 300dpi. This is a common publication standard.

AVOID cluttering of figures with too much detail. Simplify if necessary.

AVOID moire patterns in photos, a nuisance in copied or scanned pictures. Most scanners come with a moire pattern removal tool.

**GRAPHS**

*Understand graphs: Bar graphs and/or line graphs are used when plotting nominal vs. ratio or interval data. Scatter plot graphs are used when plotting numeric vs. numeric data.*

DO make sure that the graph axis are appropriately labeled and scaled. Axis should have titles as well as scalar units.

DO use electronic means to generated graphs. Hand drawn graphs are no longer acceptable.

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**Equations & Computations**

Equations should contain explanation of symbols used.

A reader should be able to follow where your values or numbers come from. Indicate accordingly.

WRITE DOWN UNITS!!!!

Show equations used before indicating any computation

Acceptable Example:  $F = m \times a = 0.034\text{kg} \times 9.8\text{m/s}^2 = 0.33\text{kgm/s}^2$

where  $m$  is mass of the object in kg as determined with a triple beam balance and  $a$  is the gravitational acceleration.  $F$  indicates force expressed in  $\text{kgm/s}^2$  or  $N$  (Newtons).

Unacceptable example: The answer is 0.33. This is obtained by multiplying gravity by 0.034.

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## 1 SOIL TEXTURE LAB SEGMENT

### I. COLLECTING YOUR SOIL SAMPLE

While actual soil tests for agricultural or similar purposes are interested in organic components, we are only interested in physical soil particles. Therefore, our samples should be free of organic matter or coarse lumpy aggregates as much as possible.

#### 1. Materials Needed

- a. A shovel, a garden trowel, or similar
- b. Sturdy Zip Log Bag
- c. Cell phone for pictures, possibly with collecting app (see Note below)
- d. Index card(s) & Pen Note: You may also use a phone app that can record your sample location with pictures and GPS data for later reference, such as the "Geology Sample Collector" app ("Geology Sample Collector: Amazon.Com: Appstore for Android." Android, 2012. <https://www.amazon.com/MajorForms-Geology-Sample-Collector/dp/B008AMT1X2>)

2. **Location:** Self select a location for taking your soil sample: your yard, a piece of forest, a river's edge, etc., anything without a plant cover will do. The material should be for most part preferably in the sand size range.

3. **Sampling Procedure:** Outline a circular area roughly 15 to 20 cm (6 to 8") in diameter. Remove the first 5cm (2") since this material often contains significant organics. Start sampling below this depth for approximately 15cm (6"). The depth is not as important as the amount of material recovered which should be at least 1kg (2.2 lbs).

4. **Sample Storage & Transport:** Place material in a sturdy Ziploc® bag! Place an index card inside the bag with your sample that records data, location, your name and a short description of the bag's content. You can now transport the sample to the lab for further processing.

Note: The collected sample material will be used for SEVERAL labs. Keep it stored in an accessible lab location.

### II. TEXTURAL CLASSIFICATION OF UNCONSOLIDATED MATERIAL

#### The simple Jar Method

A soil grain size analysis is usually completed in a soil lab and requires grain size sieves. A summary of a full laboratory grain size analytical procedure can be found here:

<https://www.geoengineer.org/education/laboratory-testing/step-by-step-guide-for-grain-size-analysis>

or here: <https://www.dot.ny.gov/divisions/engineering/technical-services/technical-services-repository/GTM-20b.pdf>

We will use a quick reconnaissance method to establish a rudimentary grain size analysis in your home-lab called the JAR TEST as follows (Credit: <https://hgic.clemson.edu/factsheet/soil-texture-analysis-the-jar-test/>):

#### 1. Materials Needed:

- a. Portion of your soil sample
- b. Straight-edged or ruler (cm markings preferred) you may also use a clear (glass) graduate cylinder if you can plug the top with a rubber stopper.
- c. clear jar or beaker with lid, or a clear graduated cylinder with rubber stopper.
- d. Permanent marker
- e. Watch or stopwatch or cell phone timer
- f. Clay dispersing agent: ~15g Sodium hexametaphosphate, also known as the water additive Calgon®. Otherwise an approx. tablespoon of powdered dishwashing detergent will have the same effect.
- g. Possibly a mesh sieve or old colander

#### 2. Procedure:

- a. Remove as much material from your soil sample to fill approx. 1/3 of your jar, beaker or graduated cylinder. It does not need to be 100% exact. Make sure that your selected sample does NOT have any debris, rocks, and large organic matter (leaves, sticks, roots, etc.). If lumpy, break up the soil.
- b. Fill the jar, beaker or graduated cylinder ~ 1/3 full of the soil to be tested.
- c. Fill the remainder of the vessel with clean water, but leave some space at the top to create an air cushion. It will make shaking the sample easier.
- d. Add the powdered dispersing agent to keep clay particles in the soil separated (otherwise their strong electrostatic bonds will keep them lumped together): about 15g (~1 tablespoon) of sodium hexametaphosphate,







Calgon®, or powdered dishwashing detergent for a mason jar sized vessel. With smaller vessels, you may want to reduce the amount of dispersing agent.

- e. Cap the jar and shake vigorously until the soil turns into a uniform slurry.
- f. **1 minute timer:** Set on a level surface and time for one minute.
- g. After 1 minute, place a mark on the outside of the vessel, showing the coarse sand layer settled at the bottom of the jar. If you use a graduate cylinder, read the milliliter marks and record.
- h. **2 hour timer:** Leave the vessel in a level spot for 2 hours.
- i. After 2 hours, mark the top of the next settled layer with the permanent marker. If a graduated cylinder is used, read and record the mL marks for this next layer, which is the silt layer.
- j. **48 hour timer:** Leave the vessel on a level spot for 48 hours.
- k. After 48 hours, mark the top of the next settled layer with the permanent marker (or read and record the graduated cylinder). This is the clay layer that has settled on top of the silt layer.
- l. If you didn't use a graduate cylinder, use a ruler to measure and record the height of each layer, and the total height of all three layers.

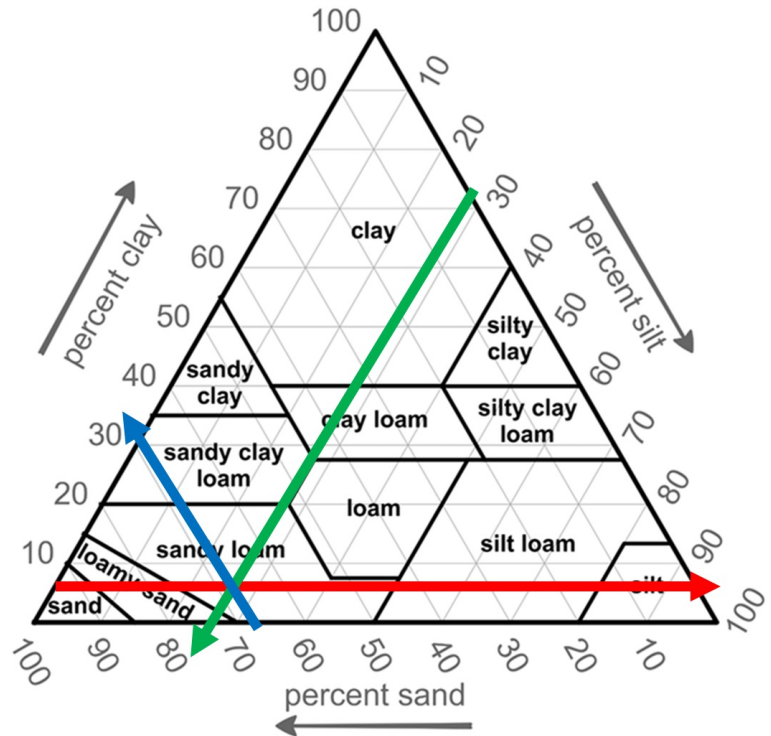


- 3. Results / Conclusion:
  - a. From your height measurements, calculate the percent of sand, silt, and clay content from the thickness of each layer.
  - b. Use these percentages to classify your soil by plotting your data on a ternary soil classification diagram.



["HOW TO" Video Lecture \(click here\)](#)

Creating Ternary Plots electronically.  
Try: <https://www.ternaryplot.com/>  
or Google Excel Solutions!





**2 MEASURING / CALCULATING BULK POROSITY (EXACT) LAB SEGMENT:**

**2.1 - Establishing  $\rho_{pd}$  or Particle Density (Average Density of Soil Particles):**

Pycnometer measurements are standard in laboratory density investigations. The Pycnometer Method is usually employed when densities of unconsolidated particles are to be measured, or when specimens are very small. A specialized bottle of known weight and volume (the pycnometer) is used with a precision balance. If the sample is very small, the temperature of the liquid filled pycnometer bottle is also measured for volume corrections.

All measurements with a pycnometer follow the general equation:

$$SG = \frac{W_{sample}}{(Pyc_{liquid} + W_{sample} - Pyc_{sample+liquid})} \times D_{liquid}$$

- Where:
- $W_{sample}(g)$  = Weight of dry sample in grams
  - $Pyc_{liquid}(g)$  = Weight of pycnometer bottle + stopper filled with liquid, usually water, in grams
  - $Pyc_{sample+liquid}(g)$  = Weight of pycnometer bottle, stopper, with sample inside and liquid in grams
  - $D_{liquid}(g/cm^3)$  = Density of testing liquid used. For water this is usually  $1.0g/cm^3$

**PROCEDURE**

**1. Dry Your sample:**

Spread your sample material loosely on some foil and put into a drying oven at  $90^{\circ}C$  for 1 - 2 hours, depending on bulk sample size and moisture content in general.



**2. For electronic load-cell balances: Scale Set-Up and Calibration**

**Note: This step is NOT needed with Laboratory Balances as these are pre-calibrated!**



Place scale on a flat, hard, level surface.

Balance is turned on and set to grams (g). Calibrate balance according to instructions. Since the electronic load cell will be influenced by temperature and vibrations, calibration is imperative when starting a measurement series, especially in field applications.



**3. Weigh Your DRY Soil Sample**

Select a representative small pile of your DRY unconsolidated soil sample. Make sure that all sample pieces will fit through the Pycnometer opening. Weigh sample in grams. Record measurement as  $W_{sample}$ .

*Note: It might be advantages to put a small piece of wax paper on the scale and "tare" the scale to zero before weighing. This way the sample can be transferred to the pycnometer without the danger of possible loss.*





#### 4. Pycnometer prep and Weighing

Fill pycnometer completely with liquid and insert capillary stopper. Liquid will squirt out through the capillary tube. Make sure that there are NO air bubbles in the pycnometer.

Dry outside of the pycnometer bottle completely with tissue. **Make sure absolutely NO liquid clings to the outside of the bottle. Make sure NO water drips on the weighing pan.**



Weigh the filled pycnometer bottle in grams (g) as shown and record as  $Pyc_{liquid}$ .



#### 5. Sample in pycnometer weighing and calculations

Unstopper the pycnometer and pour off some of the liquid. Now carefully place all of the dry weighed sample into the pycnometer and refill with liquid.

**Note: This step can be tricky as soil material is easily spilled. Take special precaution. If your sample spills you MUST start over!**

Insert the stopper, then follow the same procedure as outlined under “4. Pycnometer prep and Weighing” above.

Weigh the filled pycnometer bottle with sample inside in grams (g) as shown and record as  $Pyc_{sample+liquid}$ .

Calculate specific gravity according to the equation:

$$SG = \frac{W_{sample}}{(Pyc_{liquid} + W_{sample} - Pyc_{sample+liquid})} \times D_{liquid}$$

**Note:** If liquid other than water was used, multiply results by the density of the liquid

To establish precision and error, repeat at least three times with different sample piles of the same material. Then take the average of three measurements as the value for SG.

**Note:** For load cell balances, recheck balance with calibration weight. If the calibration has drifted, consider redoing the measurement just to be sure.

Example Calculation (see values depicted in the pictures of the balances above)

$$SG = \frac{2.68g}{(23.45g + 2.68g - 25.51g)} = 4.32 \frac{g}{cm^3}$$

If soil is used, this would be your  $\rho_{pd}$  or **Particle Density**

Record all your data in the Lab Template LAB1: TEXTURE and POROSITY RESULTS



**2.2 Establishing  $\rho_{bulk}$  (Bulk Density of the Soil):**

1. Take a 25 ml or 50 ml graduated cylinder.
2. Weigh the cylinder (unit: grams). Record answer.
3. Fill cylinder with your soil to a certain volume mark (example 25 mL) weigh again. Record answer.
4. Repeat #3 with slightly different soil volumes two more times for a total of 3 measurements.
5. Calculated as indicated below:

Material	Measurements & Calculations	$\rho_{bulk}$
	Mass Graduated Cylinder Empty $W_{cyl} = \text{_____ g}$ Sample filled to Volume $V = \text{_____ mL}$ Mass Graduated Cylinder with Sample $W_{cs} = \text{_____ g}$  $m = W_{cs} \text{_____} - W_{cyl} \text{_____} = \text{_____ g}$  From the results take the average of ALL 3 measurements!	$\rho = \frac{m(\text{grams})}{V(\text{cm}^3)}$

**2.3 Establishing BULK POROSITY:**

1. Use your previously established measurement of average bulk density:  $\rho_{bulk} = \text{_____ (g/cm}^3\text{)}$
2. Use your previously established measurement of average particle densit:  $\rho_{pd} = \text{_____ (g/cm}^3\text{)}$
3. Just plug your answers for Bulk Density and Particle Density into the Bulk Porosity Equation:

Material	Measurements & Calculations	Bulk Porosity (%)
	$n_{bulk} = 100 \left[ 1 - \left( \frac{\rho_{bulk}}{\rho_{pd}} \right) \right]$	



**3 MEASURING / CALCULATING EFFECTIVE POROSITY**

(NOTE: You must collect data from the PERMEABILITY LAB in order to complete Method 2 below!)

**3.1 Estimating EFFECTIVE POROSITY  $n_e$  from Gravitational Water Data:**

1. Weigh exactly 100.00g of dry soil sample.  $m_{soil} = 100.00g$
2. Establish the Volume of your massed soil using graduate cylinder.  $V_{soil} = \text{_____ } cm^3$
3. Put 1 hole rubber stopper with valve inserted into one end of the plastic tube. Insert a coffee filter cut-out as on top of the rubber stopper while doing so.
4. If you do the lab at home, tape the tube vertically unto a support, such as furniture or card board box with enough room for a drip catcher below the valve. Make sure your stand is sturdy. Otherwise use a lab stand!
5. Fill the lower part of the tube with your 100.00g soil. Make sure this is the same soil you will use for the hydraulic conductivity experiment. The sample surface should be level. Tapping gently on the plastic tube might help.
6. Water saturate your soil sample by filling the tube with a small amount of water, being careful the water does not stir up your soil sample. Let enough water run through your soil that ALL air in the soil pores is replaced by water. You can accelerate the process by blowing into the plastic tube to increase pressure on the water as it is trying to drip through. You should see the wetting front move through the sample. Water should drip out of the open valve at the bottom of your set up.
7. Adjust the water level in the plastic tube after saturation to the exact height of the sample by letting excess water drip through until the water line coincided with the top of your sample. Then close the valve.
8. Weigh a dry, empty beaker and record its mass in grams. Beaker mass = \_\_\_\_\_ g Place beaker under the valve exit and open the valve.
9. Collect all the water that will drain out of the saturated sample by gravity alone. This is your gravitational water which is analogous to effective porosity. *Note: It can take a very long time if you use a fine grained soil.* You can accelerate the process by applying air pressure to the top of the plastic tube (Blow in it! Hard!)
10. When completely drained (no more drips even with increased air pressure), weigh the beaker. Calculate the amount of water drained be subtracting the empty weight of the beaker. Record weight of gravitational water.  $H_2O_{grav} = \text{_____ } g = \text{_____ } cm^3$
11. Calculate the estimated effective porosity:



$$\sim n_e = \frac{H_2O_{grav} (cm^3)}{V_{soil} (cm^3)} \times 100 = \text{-----} \%$$

Note: To save time, do NOT clean up your plastic tube, but use same sample to continue with the permeability lab.



**3.2 Establishing EFFECTIVE POROSITY  $n_e$  mathematically from Permeameter Data:**

1. You will need data from [LAB2: PERMEABILITY](#) to complete this segment.
2. Use the establish Hydraulic Conductivity ( $k_f$ ) from your Permeameter experiment.
3. Use the following MAROTZ & HENNING equations to calculate PERCENT EFFECTIVE POROSITY. (Note: For the MAROTZ equation to work,  $k_f$  must be in the unit m/s!!!)

$$n_e (\%) = 46.2 + 4.5 \ln k_f \left(\frac{m}{s}\right) \quad n_e (\%) = (0.05 \times \log k_f \left(\frac{m}{s}\right) + 0.4) \times 100$$

**Only turn in the [LAB1: TEXTURE & POROSITY RESULTS](#) page for grading after completion.**