Weekly Laboratory Assignments

ESC 115 Physical Geology

Offered Each Semester

Contents

1 Travel Guide for Dubuque

THis assignment is not required. Instead, it is offered for extra credit in place of any lab you may fail to turn in later during the semester (though you are still responsible for any material you miss, as you will see it on the midterm or final.). My reasoning is that students are still adding and dropping courses during the first week of the semester, so rather than trying to catch them up, this opportunity keeps them from falling behind.

Your task is to prepare a guide for the City of Dubuque that addresses the following:

- Why someone would want to visit Dubuque;
- How to get to Dubuque from Chicago, Minneapolis, Davenport, and Des Moines;
- Where to stay while here;
- What the geologic and human history of the area is; and
- What geologic sites to see.

You may include as many figures as you wish plus links to web sites. However, if you use someone else's figure, it must be clearly labeled with its source. Print out your guide and hand it in at the beginning of the next lab.

2 Mineral Identification

The following terms will help with mineral identification. We'll watch a video together, so keep these terms in mind.

On the following page are tables to complete for mineral identification. Generally, the process follows these steps:

Luster: metallic or non-metallic?

Hardness: Greater or less than 5.5?

Streak: What color?

Special identifying characteristics: magnetic, tastes salty, heavy, layering, crystal form, cleavage?

Mineral Identification Sheet								
Item Number	Luster	Hardness	Mineral Color	Streak	Cleavage/ Fracture	Diagnostic Property	Key Chemical Elements	Mineral Name
1								
2								
3								
4								
5								
6								
7								
8								
9								

Mineral Identification Sheet (continued)								
Item Number	Luster	Hardness	Mineral Color	Streak	Cleavage/ Fracture	Diagnostic Property	Key Chemical Elements	Mineral Name
10								
11								
12								
13								
14								
15								
16								
17								
33								

Out-of-Class Assignment

By the end of lab, you should know the answers to the following questions. Print this page, answer the questions, and turn it in at the beginning of next week's lab.

Physical Properties: Define the following:

Luster:

Streak:

Cleavage/Fracture:

Relative hardness ranked 1 (softest) to 5 (hardest)

fingernail _____

calcite _____

gypsum _____

quartz _____

glass _____

Special ways of distinguishing the following minerals:

calcite:

galena:

graphite:

gypsum:

halite:

hematite:

magnetite:

malachite:

mica:

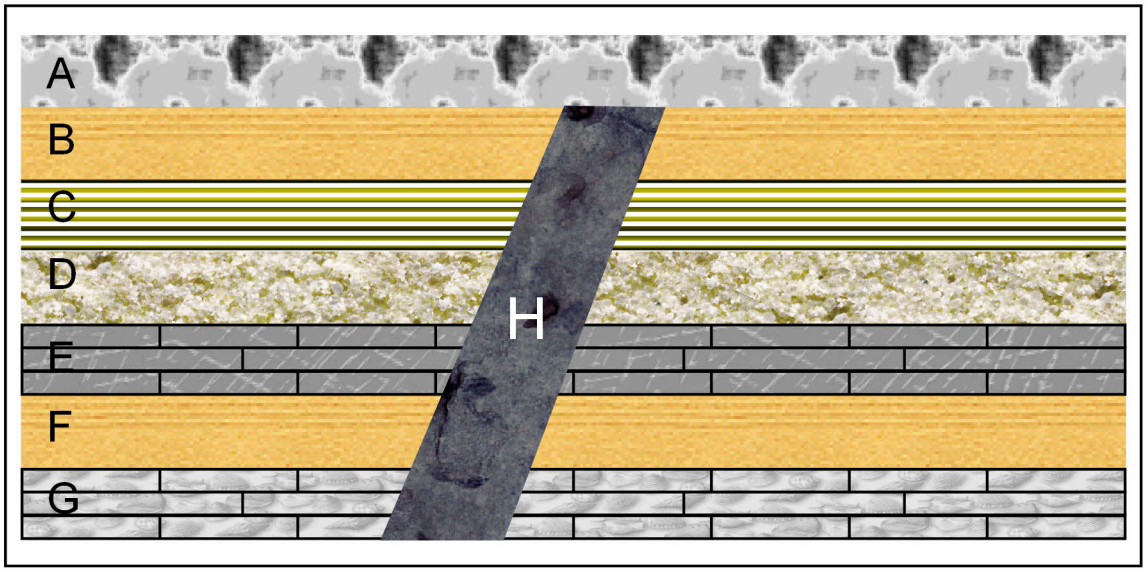
pyrite:

quartz versus feldspar:

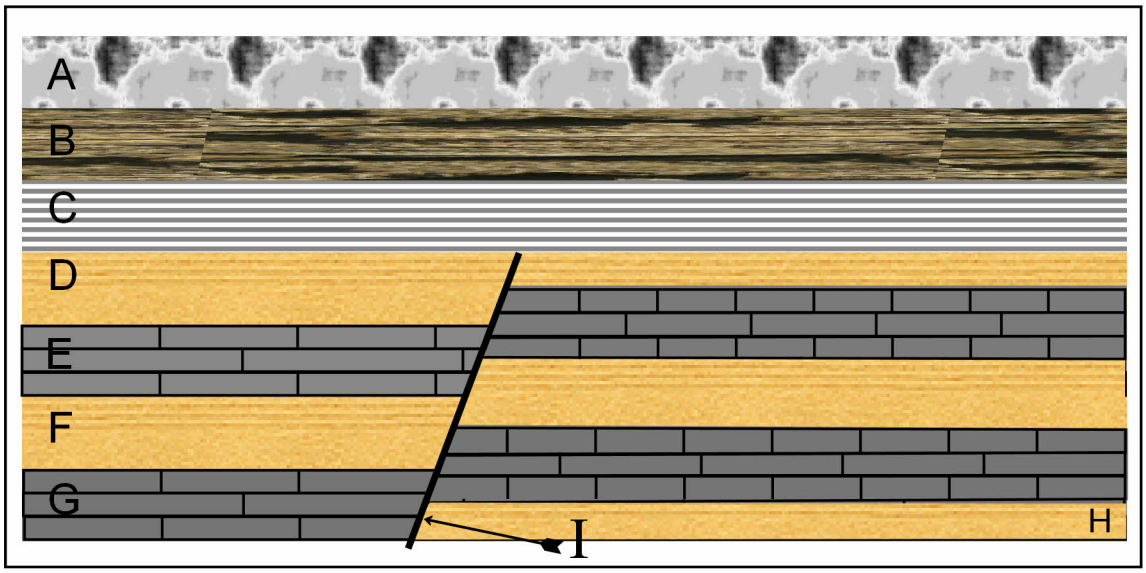
3 Geologic Time

For the following figures, determine the ordering for youngest to oldest for the layers identified with letters:

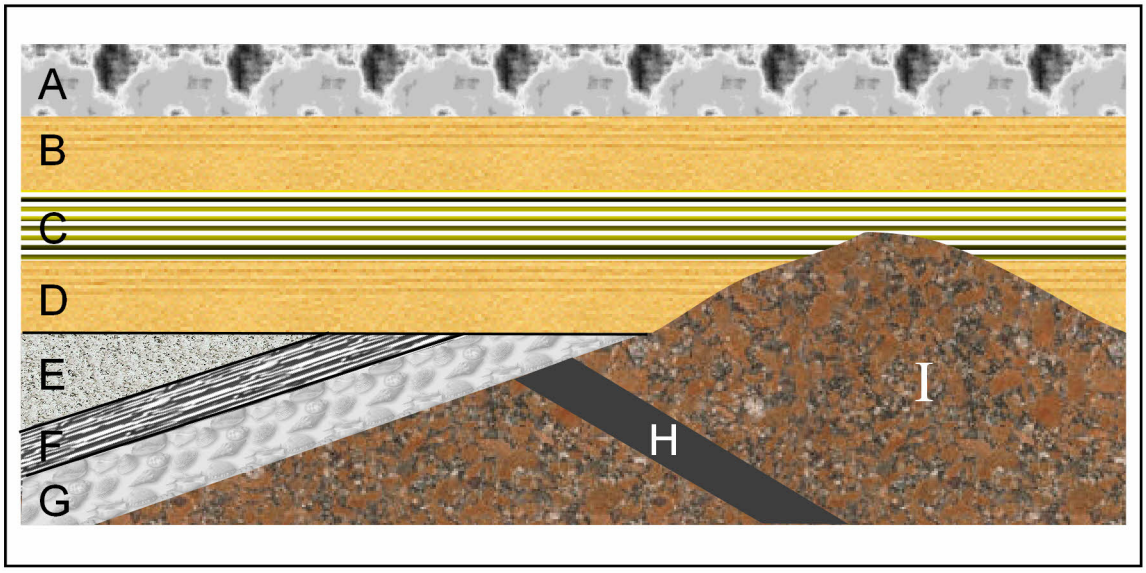
1. _____



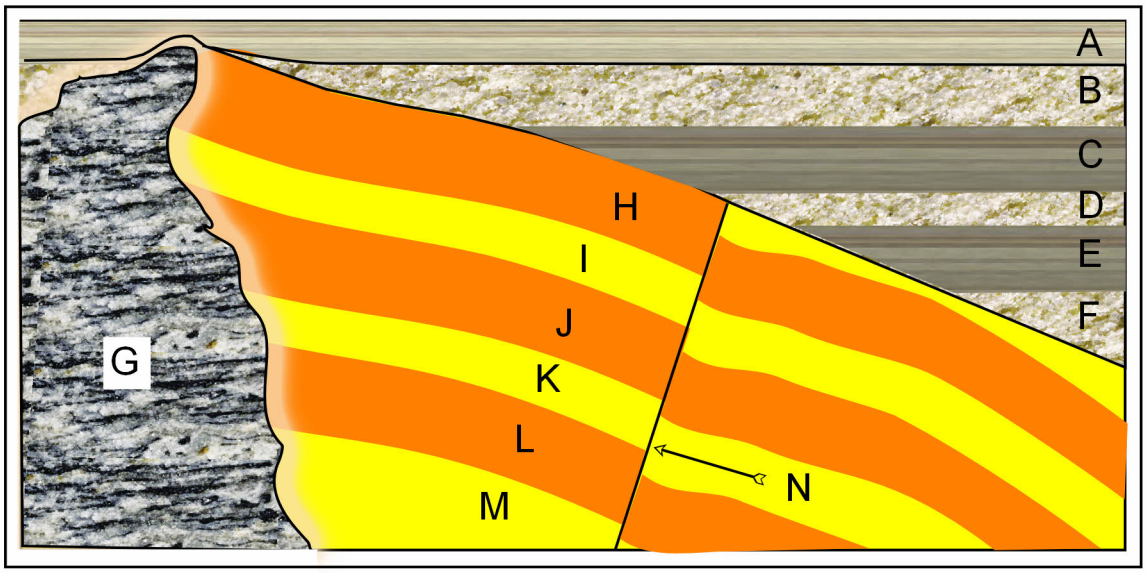
2. _____



3. _____

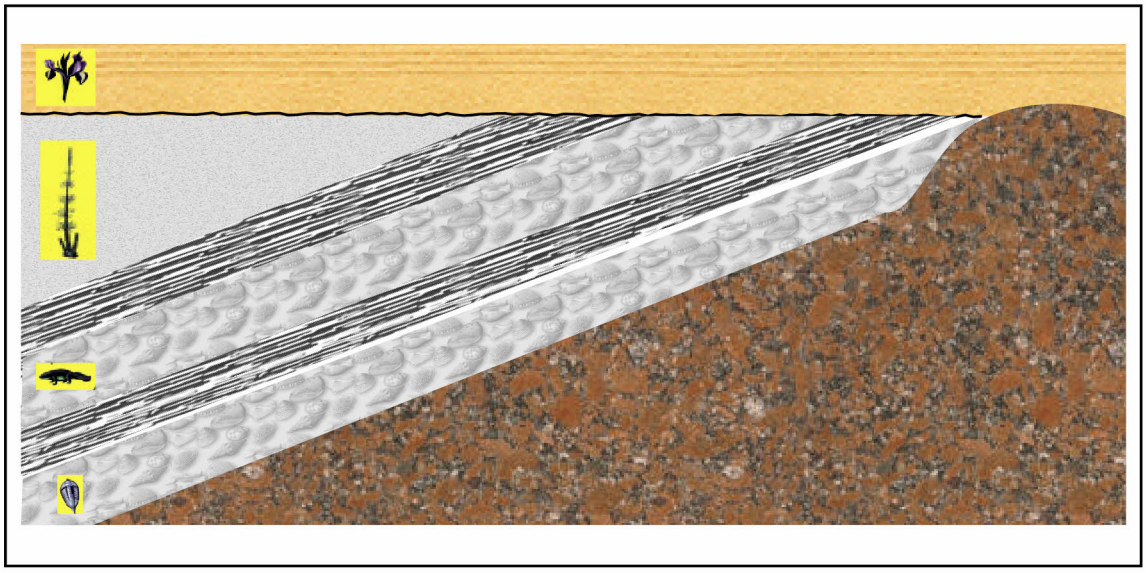


4. _____



5. The following figure shows rocks similar to the distribution of rocks underlying Iowa. It includes fossils to represent the age of the rocks. I'll project a figure to help you with this. What happened during the Mesozoic time period at the location of this figure?

_____



6. Examine the geologic map of the area south of Dubuque, shown below.

   (a) What is the age of the rocks upon which UD sits. Use your book to determine a fossil that is common to that time period. _____

   _____

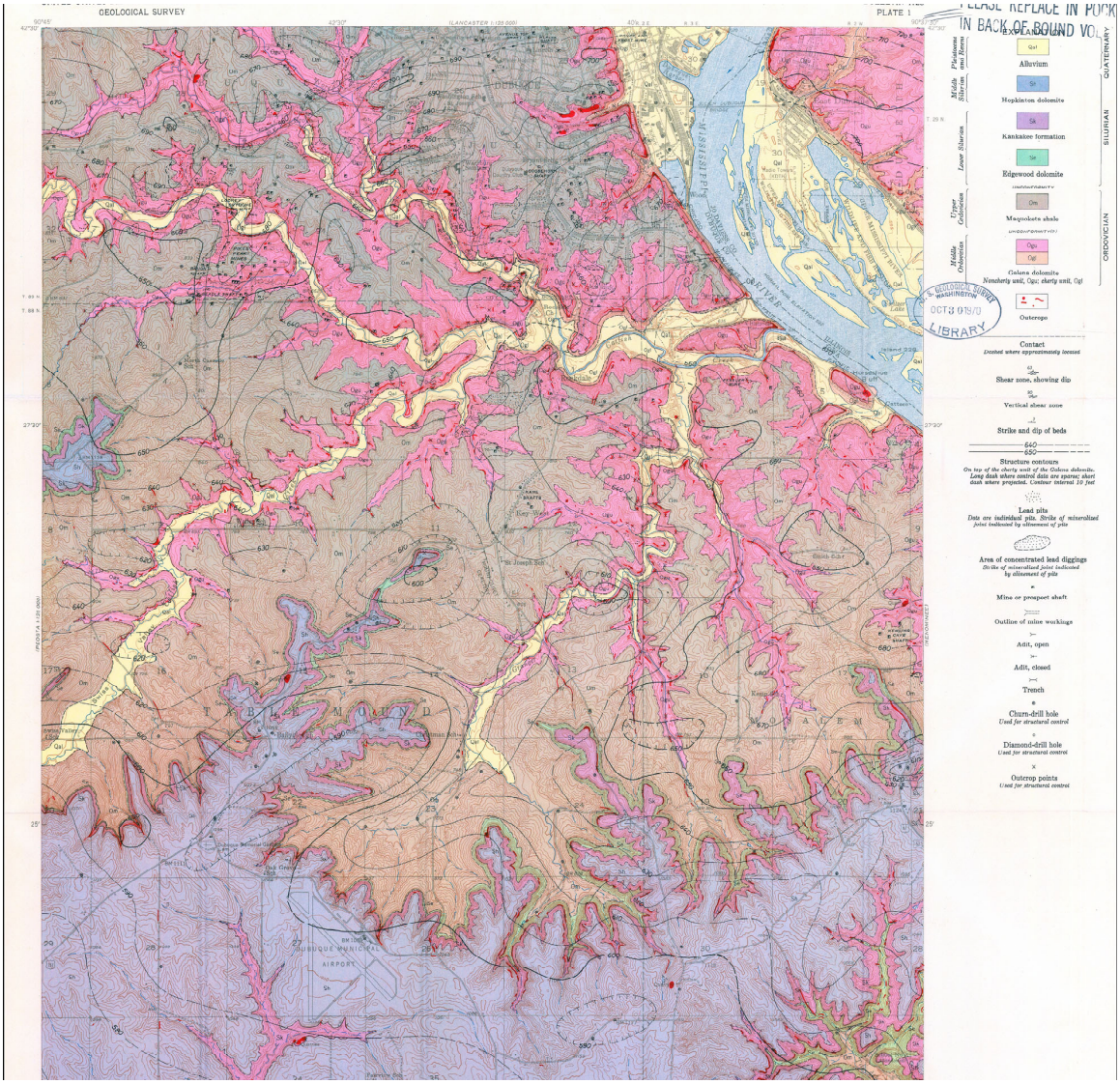
   (b) What is the geologic age of the blue formation covering much of the south of the area? _____

   (c) How can you recognize it when you drive south from Dubuque?

   _____

   (d) What is the geologic age of the yellow formation on the map? What does it represent?

   _____



Out-of-Class Assignment

Familiarize yourself with the following terms, providing a brief definition and an example of their use::

- relative dating versus absolute dating
- parent isotope versus daughter isotope
- half-life
- unconformity

Define in your own words the following laws and principles:

- Law of Original Horizontality
- Law of Superposition
- Law of Inclusions
- Law of Cross-Cutting Relationships
- Principle of Fossil Succession

4 Rocks

4.1 Igneous Rocks

Igneous rocks form when melted material, magma, cools and crystalizes. The rate at which it cools affects its texture (crystal size). Magma that cools quickly has small crystals —fine texture. Quick cooling occurs whe magma is ejected onto the surface of continents or under the oceans, forming *extrusive* rocks. Magma that crystallizes more slowly inside the earth—an *intrusive* rock—has time for larger crystals to grow into a coarse-grained rock.

To classify an igneous rock, follow these steps:

1. Determine its texture. Is it coarse-grained or fine-grained? (Rocks are called *porphyritic* if they have some coarse grains surrounded by fine grains.) We'll also look at a glassy rock and a vesicular (foamy) rock.

2. Determine if it's felsic, intermediate, or mafic, based mainly on light-to-dark color.

3. We will construct a chart together as we learn the rock names.

Igneous Rock Identification Sheet			
Item Number Number	Texture Texture	Color Index	Name Name
18			
22			
27			
28			
29			
30			
32			
53			

4.2 Metamorphic Rocks

Metamorphic rocks are formed by high temperature and pressure but no melting. The previous rock that is transformed affects the composition, as does the conversion of clays to micas. We will construct a table together in class.

Item Number	Description	Distinctive Features	Rock Name
20			
23			
24			
26			
51			

4.3 Sedimentary Rocks

Sedimentary rocks reflect the distance thesediments forming them have travelled plus the sediment size, itself a reflection of the water velocity transporting the sediments. Fast-moving water transports larger sediments.

Carbonate rocks (limestone) is a special case, because much of it is formed in place from once-living creatures.

Item Number	Composition	Texture/ Distinctive properties	Rock Name
19			
21			
25			
30			
31			

Out-of-Class Assignment

In class, I referred to rocks as the words that we use to construct the story of the Earth. What are three things we can learn from a rock that tell us about the past?

1.

2.

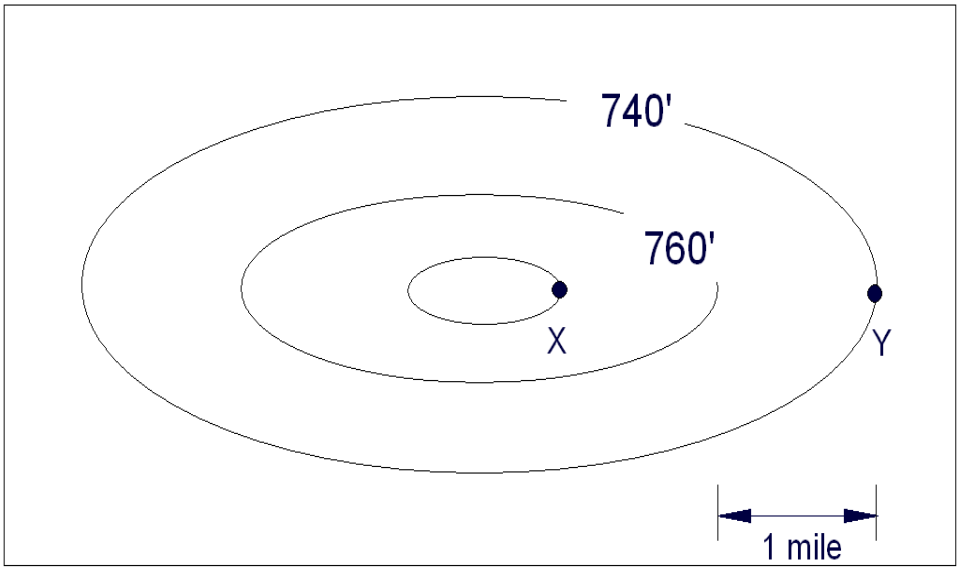
3.

5 Topographic Maps

To begin the process of three-dimensional visualization, we will look at an anaglyph map of the Dubuque area. This map was created by superimposing digital elevation data upon the USGS topographic maps. The anaglyph gives you a strong visual sense of the landform in the Dubuque area. Note the escarpment to the south, near the airport, and the abandoned channel through the northern part of town. This is the beginning of exploring the topography of Dubuque.

Topography is the study of the elevation of the Earth's surface—the hills and valleys, the mountains and plains. A *topographic map* shows elevation of the surface by means of *contours*. Contours are lines of equal elevation. In other words, if you walked along a hillside without going either up nor down, you would be tracing a contour line. Contours are created with a regular *contour interval*. That is, the elevation difference between any two contours is always the same for any given map. Topographic maps give you a quantitative measure of landforms.

An example of a measurement we might want to make is the gradient. Gradient equals rise over run, as we learned years ago. We measure rise by looking at the difference in elevation represented by contour lines, and we measure run by using the scale on the map. Look at the following figure, and then answer the questions below it.



1. What is the scale? 1 inch = _____

2. What is the contour interval? _____

3. What is the contour level at point X? _____

4. What is the shape the contours represent? _____

5. What is the gradient from point X to point Y? Show your calculations.

The following questions refer to the Dubuque South Quadrangle unless stated otherwise.

1. What is the contour interval? _____

2. What is the scale? 1 inch = _____

3. What is the northernmost latitude? _____

4. What is the easternmost longitude? _____

5. Locate Horseshoe Bluff along the Mississippi River.

   - What is its Township? _____
   - What is its Range? _____
   - What is its section number? _____

6. Locate Dubuque Municipal Airport.

   - What is its Township? _____
   - What is its Range? _____
   - What are its section numbers? _____

7. What is the approximate elevation of Chalmers Field? _____

8. What is the approximate elevation of Mt. Carmel Convent? _____

9. Note the average elevation of the Mississippi River. What is the average gradient from Mt. Carmel Convent to the Mississippi River? Show your calculations.

Out-of-Class Assignment

Turn in at the beginning of lab next week your own map of the geology of Iowa. Use the U.S. Geological Survey's online map tool, available at
http://ngmdb.usgs.gov/maps/mapview/

- Use the zoom tool to focus into the Dubuque area until you see the geologic map like I showed in the Geologic Time lab.
- Take a screen capture of the map, print it, and turn it in at the beginning of next week's lab.

6 Writing Assignment

Next week, we have a lab exam. This week, in lab, we will have an informal and optional review session. I'll bring in maps, rocks, and minerals, and we will go over the material for the lab. Please see the Midterm Lab Exam Review Guide.

Out-of-Class Assignment

Because we don't have a regular lab this week, I'm asking you to do a bit more outside of lab. Write an essay about your favorite or earliest experience of nature. Why is it your favorite? How did it impact you?

For full credit, your essay should be at least five paragraphs of at least five sentences each, with a clear introduction and thesis statement, good topic sentences for each body paragraph, and a clear conclusion.

7 Midterm Lab Exam Review Guide

1. Identify the main geologic influences on Dubuque, including minerals, glaciation, and the river.
2. Read a topographic map, determining latitude, longitude, contour interval, and main features,
3. Determine relative age of sedimentary rocks,
4. Calculate a topographic gradient, given a contour map, and
5. Identify the following minerals without a key, giving your reasoning:
   - calcite
   - feldspar
   - galena
   - graphite
   - gypsum
   - halite
   - hematite
   - magnetite
   - malachite
   - mica
   - pyrite
   - quartz
6. Identify the following igneous rocks:
   - pumice
   - obsidian
   - rhyolite
   - granite
   - andesite
   - diorite
   - basalt
   - gabbro
7. Identify the following sedimentary rocks:
   - shale
   - sandstone
   - conglomerate
   - breccia
   - limestone
8. Identify the following metamorphic rocks:
   - gneiss
   - schist
   - slate
   - marble
   - quartzite

8 Earthquakes

This week's lab is to be completed on your own outside of class.

1. Examine earthquake photos, such as those at

http://www.johnmartin.com/earthquakes/eqshow/index.htm

Find two different countries that have been hit by earthquakes within 5 years of each other. Find a photo from each that shows the importance of building methods. Put them into a Word document, annotate them to show why you chose them.

2. Next, complete the online lab at

https://www.newpathonline.com/api_player/enus_54_6304/LXX/index.html

At the end of the exercise, you will be shown a summary of your findings. Take a screenshot and paste it into the Word document that you started above. Print the entire document, and turn it in at the beginning of next-week's lab.

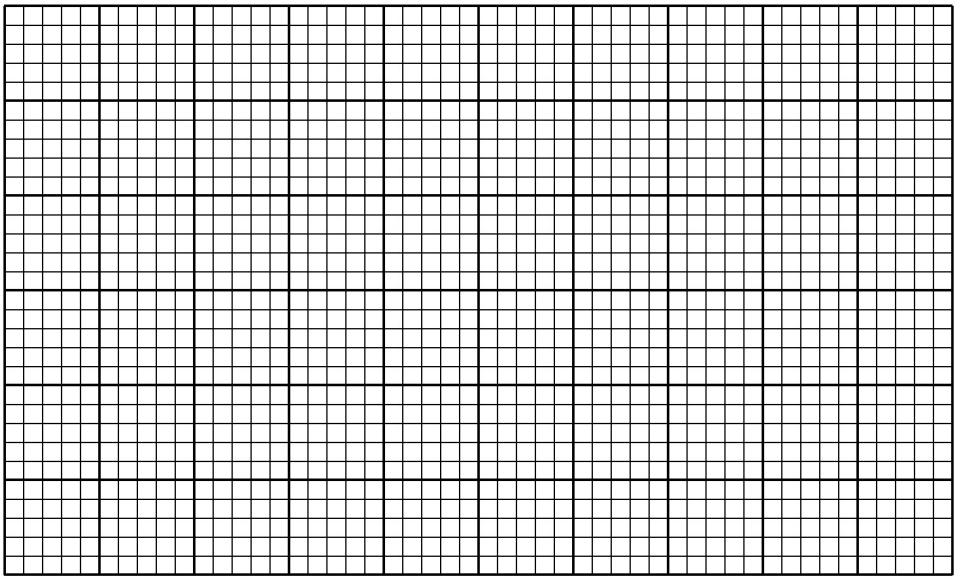
9 Glaciers

We will be working in class with a map of the Grinnell Glacier, originally from *Johnson, Arthur (1980). Grinnell and Sperry glaciers, Glacier National Park, Montana, a record of vanishing ice, USGS Professional Paper 1180,* and annotated at

`http://serc.carleton.edu/quantskills/activities/glacial_retreat.html`

- On the map that I will provide you, note the outline of the extent of the Grinnell Glacier in 1850. This is the first part of approximating the area of the glacier.
- Count the number of squares on partially covered by the glacier.
- Repeat this for 1937, 1968, and 1993.
- On the graph below plot the number of squares versus the year of the measurement.
- Based on the trend you observe, approximately when will the glacier melt

  completely (area= 0)? _____



Out-of-Class Assignment

The purpose of this section of the lab is to familiarize you with the local impact of glaciation. Read about Iowa's glaciers at [here.]

Then answer these questions and submit them at the beginning of next week's lab.:

1. What is the Des Moines lobe?

2. What is a kettlehole? Name one in Iowa.

3. What is a kame? Name one in Iowa.

4. What is an esker? Name one in Iowa.

10 Streams and Runoff

Stream Gradient

1. The figure below is from a small tributary to the South Fork of Catfish Creek. Answer the following questions about the figure:

   (a) The map is contoured in feet. What is the contour interval? _____

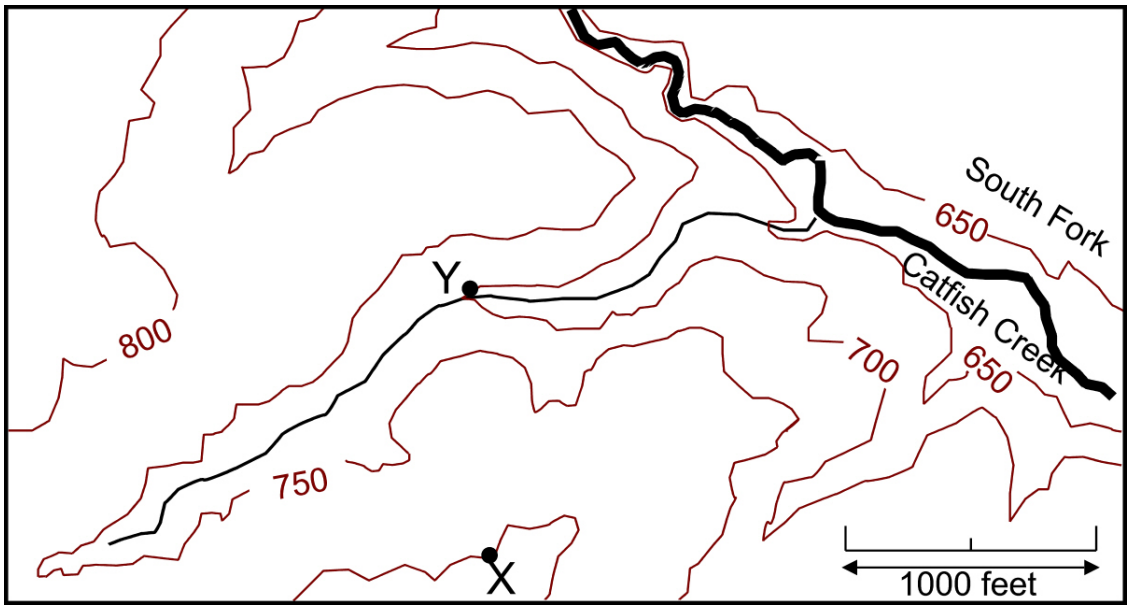
   (b) What is the elevation at point X? _____

   (c) What is the elevation at point Y? _____

   (d) What is the distance from point X to Y? _____

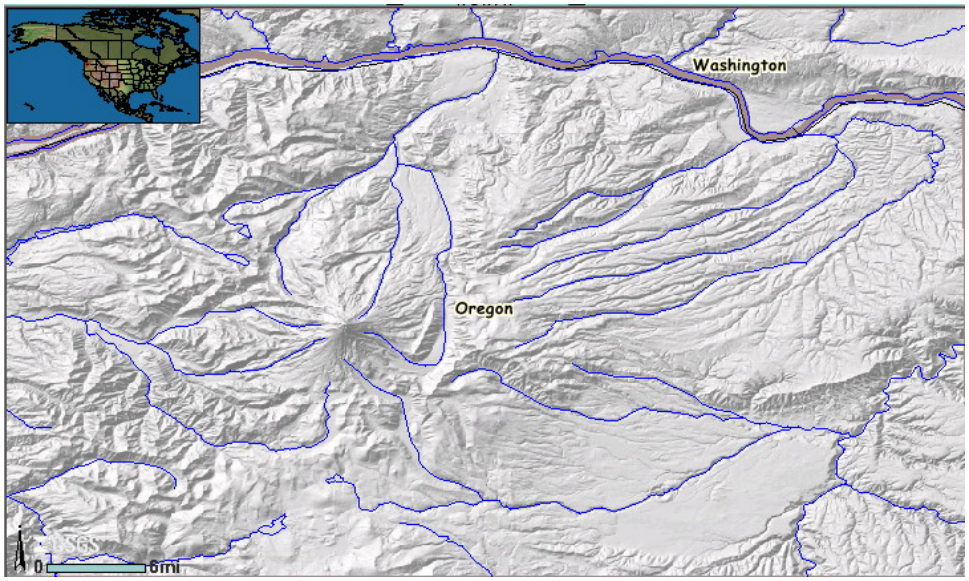
   (e) What is the gradient from point X to Y? _____

   (f) Which direction does the tributary flow? _____

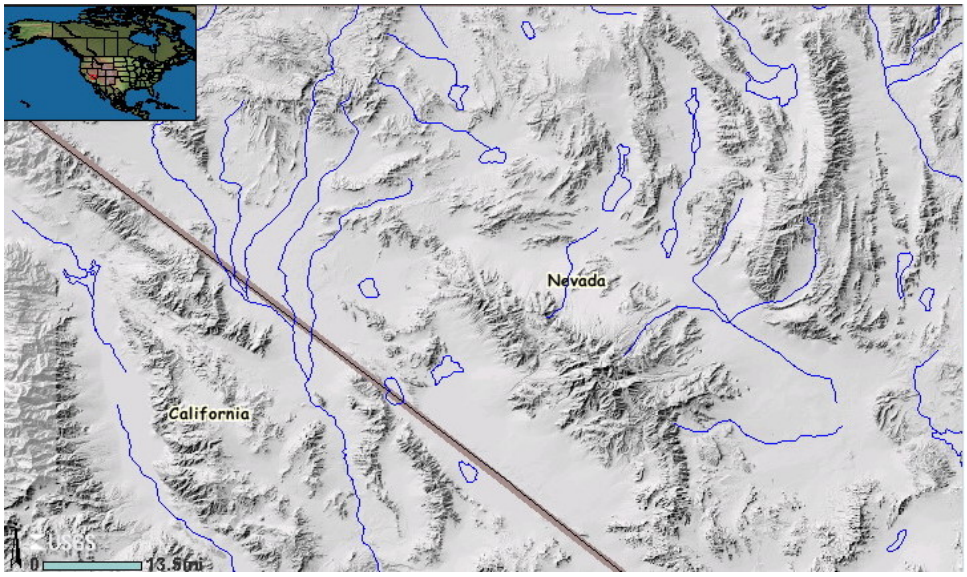


Stream patterns

2. What type of drainage pattern do you so in the figure below? What is controlling the formation of those patterns?



3. What type of drainage pattern do you so in the figure below? What are the little enclosed areas? Why do they form?

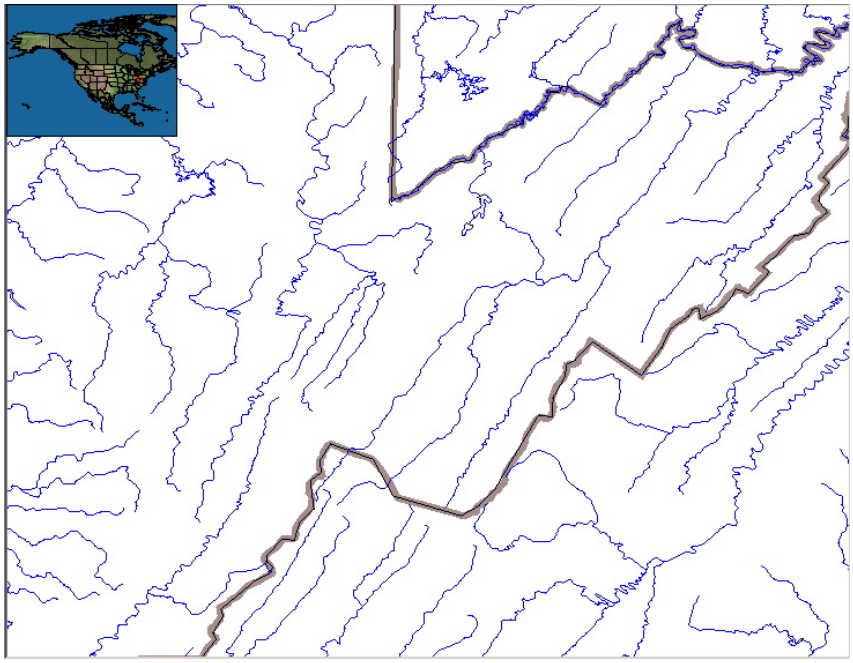


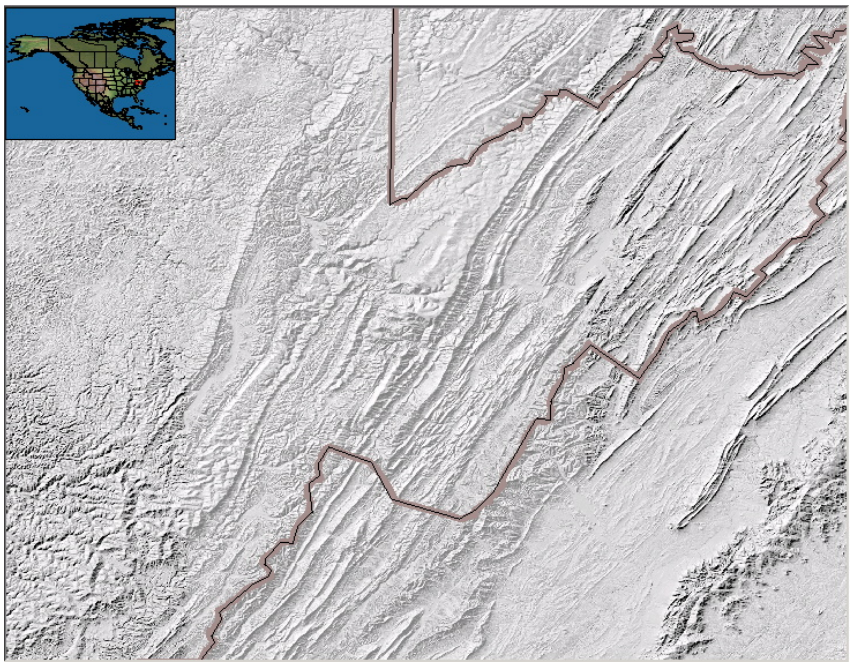
4. The following two maps are from the area where Virginia, West Virginia, and Maryland meet. Use these two maps to answer the following questions.

   What is the primary drainage pattern in this the northeast section of West Virginia? Mark on the map a clear example.

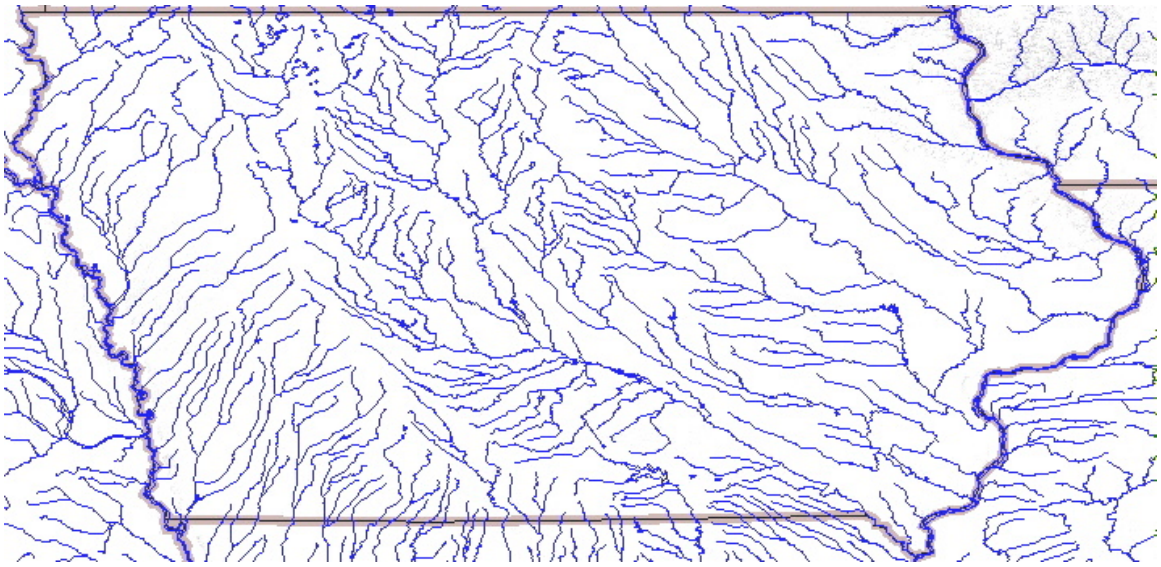
   What is the topographic pattern in the same area? What do you think might be causing it?

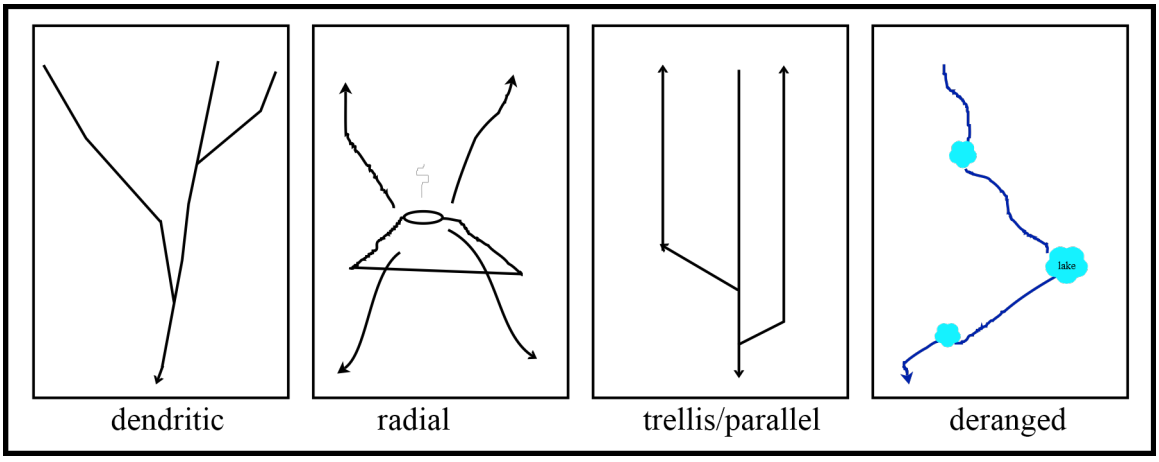
   In the west and northwest portion of the map, the drainage and topography look different. Explain how and why.





5. The map below shows the streams of Iowa. On the map, sketch the drainage divide between the Missouri River and the Mississippi River. Why is it not in the center of the state?





Reference figure for drainage patterns.

Rainfall and Urbanization

A new housing development called *Easley Estates* (figure below) is being considered near a tributary to Catfish Creek. One of the concerns is about the amount of runoff generated during rainstorms. For this portion of the exercise, you'll need the following information about the development:

- Each house is 50 feet by 50 feet.
- Each house sites on a lot 200 feet by 200 feet.
- Roads into and out of the development are 20 feet wide.
- Driveways are 10 feet wide and average 75 feet in length.
- Sidewalks are 5 feet wide.

At the top of the next page is a diagram of the proposed development. Use it to answer the following questions, including those on the next page.

1. What is the total area of the development? _____

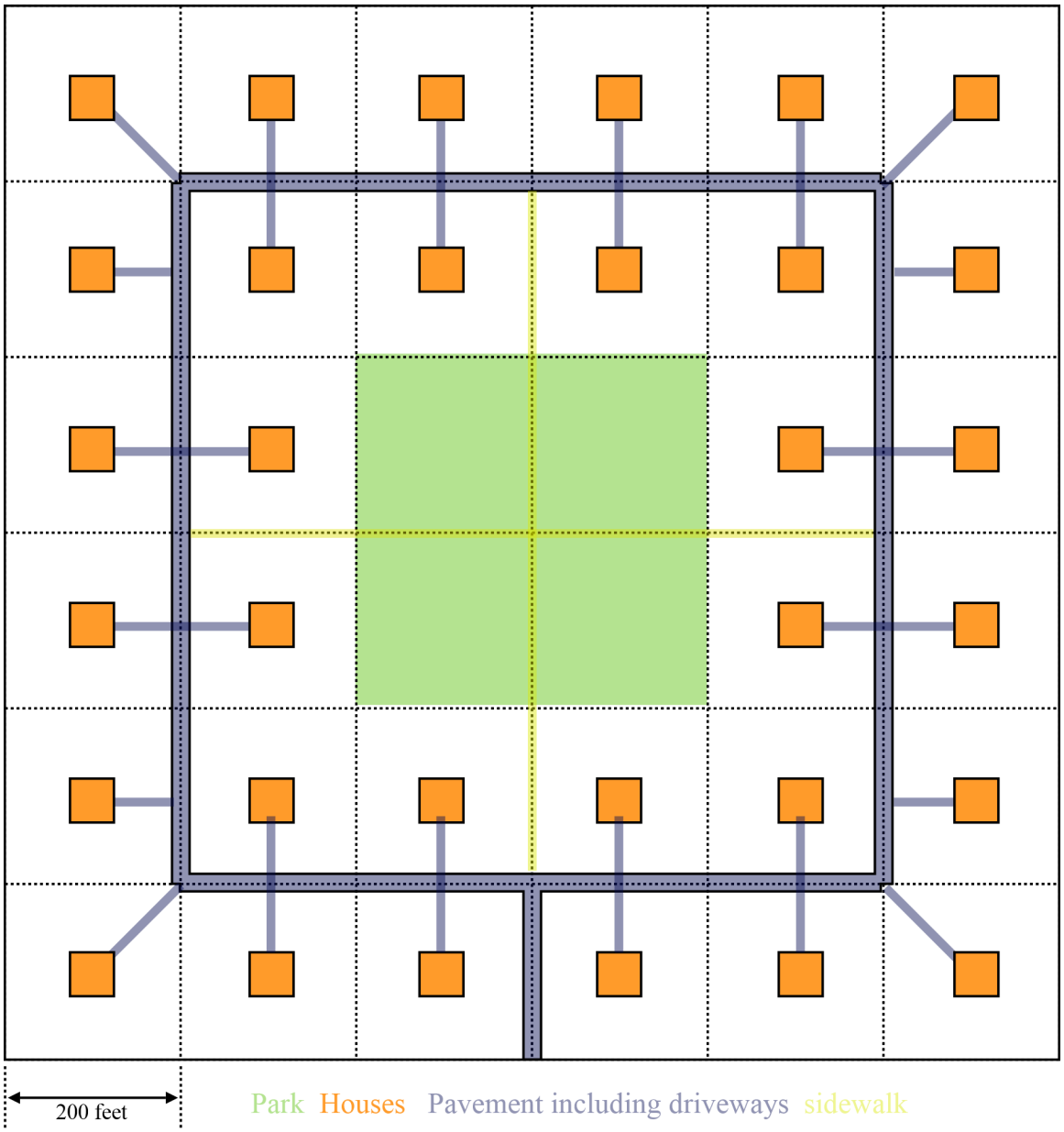
2. What is the total impervious area?

   - roads _____
   - rooftops _____
   - driveways _____
   - sidewalks _____
   - **Total impervious area:** _____

3. What is the impervious area as percentage of total area: _____
4. If it rains two inches in an hour, what is the total runoff from the impervious area?_____

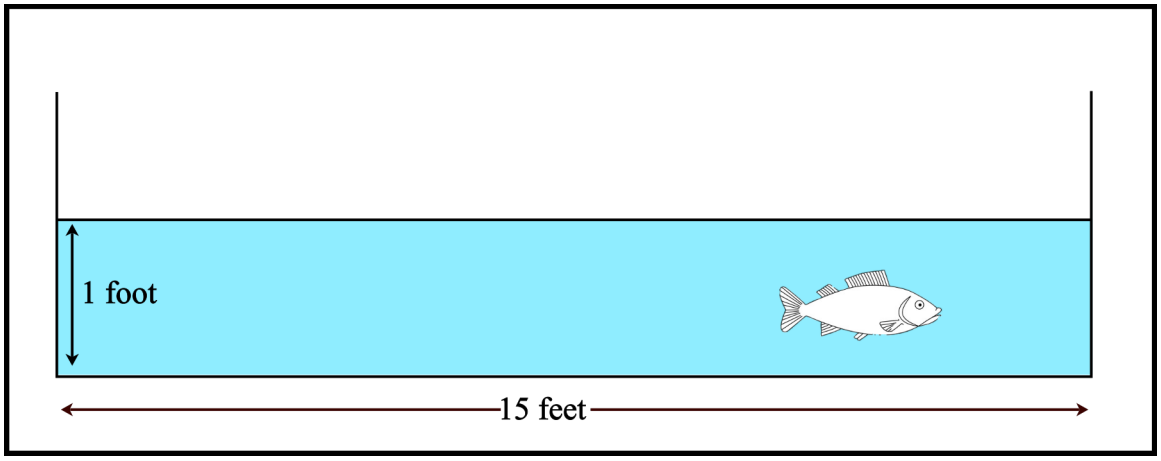
Easley Estates

Fine Living in a Planned Community

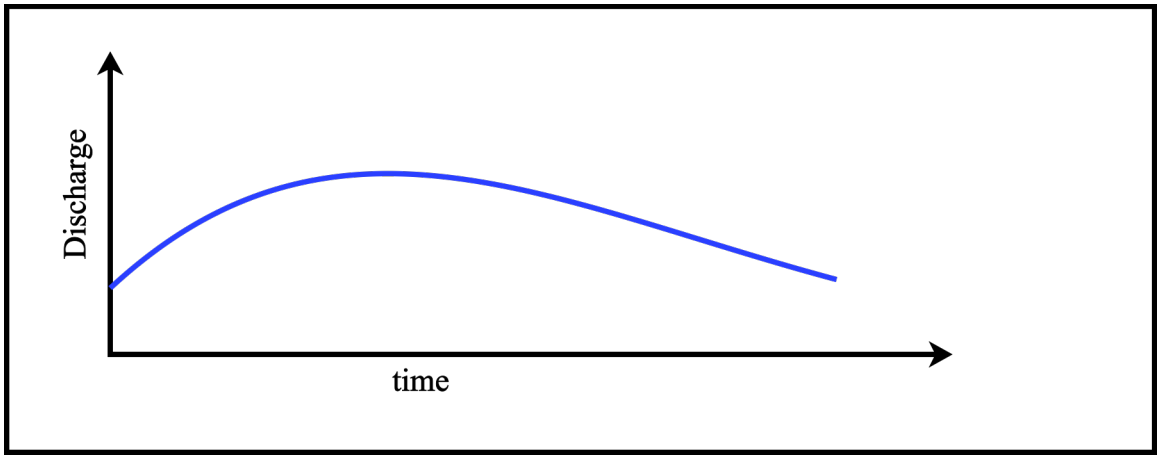


5. If a retention basin was built 100 feet by 100feet, how deep would it need to be to held the water from a 2-inch storm? _____

6. Below is a cross-section of Catfish Creek before a storm. What is its discharge if its velocity is 30 feet/minute? _____



7. If the hydrograph below is created prior to the development's construction, how is it likely to change afterward? Sketch on the figure.



Out-of-Class Assignment

Answer the following questions and submit a print by the beginning of lab next week.

1. If the rainfall event described in the lab had been a 3-inch storm instead of 2 inches, how deep would the retention basin need to be to hold the water? Show your work.

2. Identify a stream where you'd like to go tubing, canoeing, or rafting. How would you arrange the trip?

content...

11 Groundwater

The objective of this assignment is to use Darcy's Law and flownets to estimate the path and traveltime of a contaminant. In order to complete the lab, you need to remember a few points:

- Water flows downhill. This means that the flowpath of ground water is perpendicular to contours of the water table.
- The gradient (slope) of the water table is one of the factors controlling the rate at which ground water flows. We determine the gradient just like we did in our other topographic labs. This gradient is usually denoted $\frac{\Delta h}{\Delta l}$.
- The two other important factors that control the rate of flow are permeability and porosity. Permeability is a measure of how easily water passes through a rock or sediment—gravel has a high permeability while clay's permeability is low. Porosity is a measure of the amount of void space in a rock or sediment, usually expressed as a percentage. A typical number for a sand is 30%.
- Darcy's Law summarizes the relationship between these factors:

$$\overline{v} = \frac{-K}{n}\frac{\Delta h}{\Delta l}. \tag{1}$$

  where $\overline{v}$ is the average velocity, K is the permeability, n is the porosity, and $\frac{\Delta h}{\Delta l}$ is the gradient of the water table.

In the attached figure is shown a contour map of the water table elevation for an unconfined aquifer from which the town of Easleyville draws its water. The water supply is obtained from two wells, W-1 and W-2. A nearby town recently lost use of its wells due to benzene contamination from leaking underground storage tanks. Concerned citizens have requested that the town devise a Wellhead Protection Plan (WHPP). A first step in the process is to identify potential sources of ground-water contamination. Among the sources identified are four gasoline stations, marked A-D on the map. In continuing work on the WHPP, your tasks are the following:

1. Determine if a leak from each gasoline station is likely to reach the wells by constructing flowlines from each station.
2. Determine the travel times from each station to a well, if appropriate. Assume that the porosity of the aquifer is 25% and the hydraulic conductivity is 200ft/day. Furthermore, assume that the gasoline moves at the same velocity as the water.

(a)

(b)

(c)

(d)

3. Gasoline in fact travels much slower than the ground water, perhaps at half the rate. How does this affect your calculations?

4. If a spill (any contaminant, not just gasoline) took place at the road intersection shown on the map and the contaminant entered Hampton Creek, then

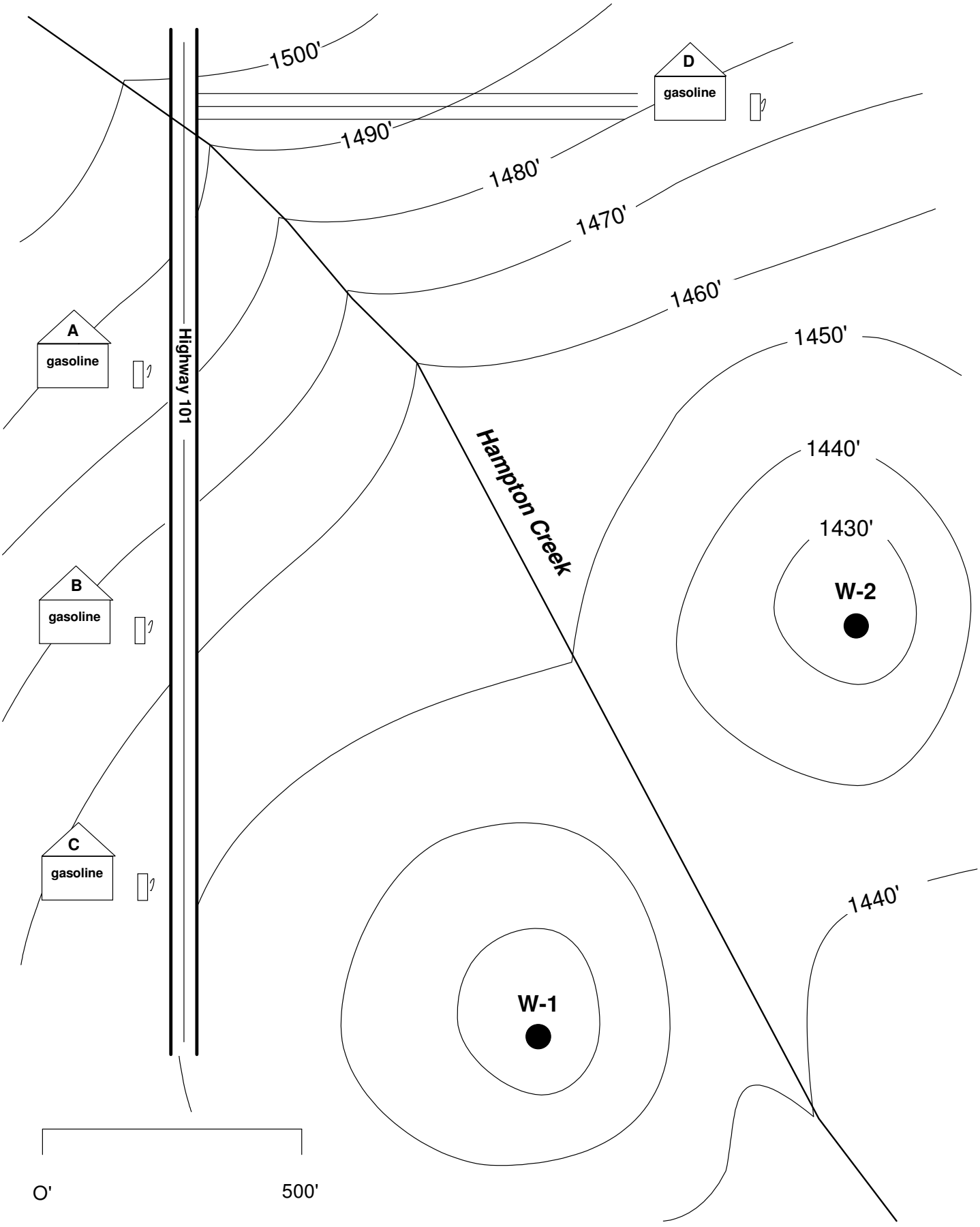
   - What is a property of the contaminant that might be important to consider?

   - Would that contaminant enter the ground water? Why or why not?

   - Label the parts of the stream gaining water from the ground water and the parts losing water to the ground water.

5. Consider how a groundwater well is constructed, open or screened at the bottom. Gasoline is less dense than water and not very soluble. How does this affect the likelihood of gasoline contaminating the wells? Think of at least two effects.

6. If you discover that well W-1 is already contaminated, what would you suggest as a management scheme for supplying Easleyville with water. What additional information might you want?


1500'
1490'
1480'
1470'
1460'
1450'
1440'
1430'
1440'
D
gasoline
A
gasoline
B
gasoline
C
gasoline
Highway 101
Hampton Creek
W-2
W-1
O'
500'

Out-of-Class Assignment

Write up your management plan for the last question. Be sure to include a list of priority users, emergency plans, and recovery plans. Submit it at the beginning of lab next week.

12 Unit Conversions

Unit conversions are a fact of life for Americans. We buy lumber in feet and inches, take a 50 cc shot, drink milk from a gallon jug but softdrinks from a 2-liter bottle, gain pounds of weight, and take 250 mg of aspirin for the resulting headach. Because of a units conversion error, NASA lost the $125-million Mars Climate Orbiter. Units matter. See [here.]

Most scientists use the metric system. Most American engineers use the British system. Most of the rest of us need to be somewhat comfortable with both. This lab is intended to brush the dust off our skills in performing such conversions. A table of common conversions is attached, and more are available on the web, such as at http://www.onlineconversion.com/.

Technique

There are many ways to convert between metric and British numbers, but a method that always works is the old *multiplication by one* method. The idea behind this is simple:

- Always put equal measures one above the other, and
- Make sure all units cancel out except the one you are converting *to.*

For example, to convert from 3 feet to centimeters, we can use the fact that 1 foot = 12 inches and 1 inch equals 2.54 centimeters. We write it like this

$$\frac{3ft}{}\frac{12in}{1ft}\frac{2.54cm}{1in} = 91.44cm \tag{2}$$

The feet and inches cancel out, leaving only centimeters. In the process, we avoid getting confused about whether to multiply or divide.

When converting areas or volumes, remember the the conversion factor must be squared or cubed, too:

$$\frac{3ft^2}{}\frac{12in}{1ft}\frac{12in}{1ft}\frac{2.54cm}{1in}\frac{2.54cm}{1in} = 2787cm^2 \tag{3}$$

Note that $3ft^2$ is not the same as $(3ft)^2$

Useful Conversions

1m = 1000 mm	1m =100cm	1cm= 10 mm
1 km=1000 m	1 km= 0.62 mile	1 mile= 5280ft
7.48 gal = 1 ft^3	1 mL=1 cm^3	1000 mL=1 L
1 kg=1000 g	1 g=1000 mg	1 kg= 2.20 lb
1 oz (weight) = 28.35 g	1 oz (liquid) = 29.57 cm^3	1 newton = 0.225 lb-force
1 acre = 43,560 ft^2	1 $mile^2$ = 640 acres	1 hectare = 10,000 m^2

Note: Does a 16oz soft drink weigh a pound?

Assigned Problems

Perform the following conversions or answer the questions. Show how you calculate your answers.

1. $10ft \longrightarrow cm$

2. $20cm \longrightarrow mm$

3. $20cm \longrightarrow m$

4. $25km \longrightarrow miles$

5. $15gal \longrightarrow ft^3$

6. $2kg \longrightarrow lbs$

7. $12oz(liquid) \longrightarrow cm^3$

8. $12oz(solid) \longrightarrow g$

9. If a parking lot is 100 feet by 100 feet, how many acres does it cover?

10. If a circle has a radius of 2in, what is its area in cm^2 ($A = \pi r^2$) ?

11. If a square has sides of length 7ft, what is its area in m^2? ($A = s^2$)

12. When you buy 2×6 lumber, the actual size is 1.5in by 5.5in. If you are building a deck that is 16ft by 16ft, how many 8-foot-long 2×6 boards would you need to buy?

13. Carpet used top be sold by the square yard. If your bedroom is 14ft × 14ft, how many square yards of carpet would you buy?

Out-of-Class Assignment

Extra Credit: As we'll see next week, the density of granite is approximately $2.75 g/cm^3$. How big would a ton of solid granite be? Give your answer in cubic meters. For credit, show your work. Submit your answer at the beginning of next week's lab.

13 Density and Isostasy

Measuring Density

Mass is basically the amount of matter in a substance. Weight is the measurement of the force of gravity on a mass. Density is the mass per volume of a substance.

Provided for your lab are two different rocks, granite (light-colored) and basalt (dark-colored). Use the scale provided to determine the weight (in grams) of four samples of each rock. Use a graduated cylinder with water to find the volume (in ml) of each one of those same samples. Remember, $1ml = 1cm^3$. Fill the cylinder to a known level, add the rock (gently), and note the new water level. The change in water level gives you the volume of your rock. (My daughter did this in second grade!)

Granite			
	Mass (g)	Volume (cm^3)	Density (g/cm^3)
1.			
2.			
3.			
4.			
Average			

Basalt			
	Mass (g)	Volume (cm^3)	Density (g/cm^3)
1.			
2.			
3.			
4.			
Average			

How did you do?

Granite: Most granite has a density of around $2.75 g/cm^3$.

Basalt: Most basalt has a density of $3.3 g/cm^3$.

Why do you think your values are different? In other words, what were your sources of errors?

Understanding Isostasy

Using the wood blocks provided, show your work in determining the following:

	Red Blocks	Brown Blocks
Mass	g	g
Volume	cm^3	cm^3
Density	g/cm^3	g/cm^3
Convert to percentage (water has a density of 1 g/cm^3)	%	%

Float the blocks in water. Mark the waterline. Perform the following measurements to the nearest millimeter:

	Red Blocks	Brown Blocks
Total height of block (H_{total}):	mm	mm
Height below the waterline (H_{below}):	mm	mm
Percentage below waterline (H_{below}/H_{total})	%	%

Compare your results from the two tables. The percentages for each set of blocks should be roughly the same for density as percentage of water and the percentage of the block below the waterline. Assume they would be equal if the experiment was repeated several times with more precision. What equations could you write that would allow you to calculate the portion of a wooden block below the waterline, given the density of the block?

Generalize your answer for the preceding question to determine isostatic equilibrium for any solid of density ρ_{solid} and liquid of density ρ_{liquid}.

If the density of ice is $0.917 g/cm^3$ and of ocean water is $1.027 g/cm^3$, then what percentage of an iceberg is beneath the waterline?

Out-of-Class Assignment

1. If the density of liquid mercury (Hg) is 13.56 g/cm^3 and the density of granite is 2.75 g/cm^3, then what percentage of a block of granite is below the surface of the mercury? Show your work.

2. Both temperature and salinity affect density of water. At what temperature does water have its maximum density? How does this compare to the density of ocean water? If ice melts from Greenland's glaciers and the resulting water flows into the oceans, will it sink or stay on top?

14 Final Laboratory Exam Review

1. Be able to convert between common units, including lengths, areas and volumes.
2. Be able to identify p and s waves from a seismogram reading and interpret them.
3. Be able to describe using p and s wave traveltime to determine the location of an earthquake epicenter.
4. Distinguish between density and isostasy and calculate density from mass and volume.
5. Be able to identify major glacial features in Iowa.
6. Be able to identify major drainage patterns and drainage divides.
7. Be able to calculate a stream discharge.
8. Be able to calculate runoff from impervious surfaces due to rainfall.
9. Be able to use Darcy's law and a water-table map to indicate groundwater direction and velocity.