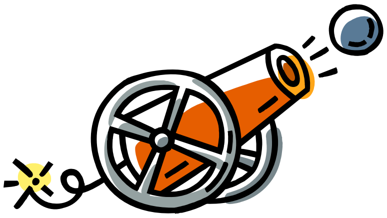
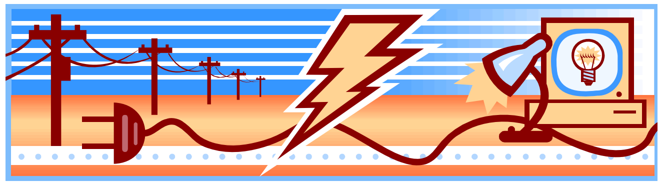
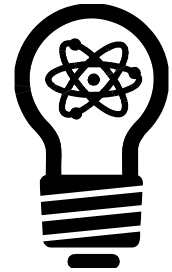

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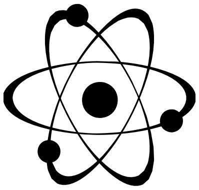

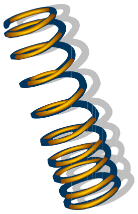


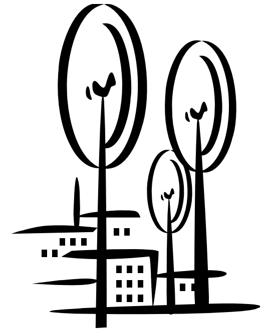
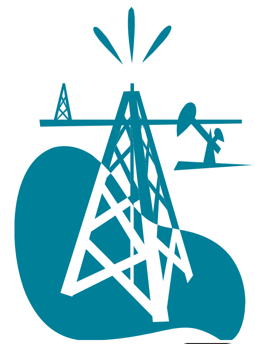

2015-2016

Updated December 2014


Earth Science 105

2015-2016 Academic Year

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Laboratory Manual

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ES 105 Laboratory # 1
ENERGY AND ENERGY TRANSFORMATIONS

Introduction

Energy is an integral and fundamental part of our lives, and we often do not realize how dependent we and our society are on energy. Our bodies, in order to perform their most basic biological functions, consume large amounts of energy. This lab is designed to give you examples of different types of energy, and to demonstrate some of the ways energy can be transformed from one type to another.

One of the main concepts you will be introduced to is the concept of ***conservation of energy***. **This important concept tells us that energy is never created or destroyed; it can, however, be transformed into different types of energy (like motion or heat)**. During any given energy conversion, an equal amount of energy exists before and after the conversion process. There will be several stations that explain and demonstrate the conservation and conversion of energy. You will see that energy can *seem* to disappear. No process of transforming one type of energy to another is perfectly efficient, and some energy will always be converted into forms that are inaccessible to us. As you tour each station, refer to the various sections in this manual that will lead you through this exploration of energy.

Goals and Objectives

- Investigate the concept of *conservation of energy*
- Explain transformation of energy
- Convert energy from one type to another

Forms of Energy (a few examples)

- Mechanical (Kinetic)
- Mechanical (Potential)
- Electromagnetic (Light)
- Electromagnetic (other)
- Heat
- Chemical
- Electrical
- Magnetic
- Nuclear

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Pre Lab Activity: Fill in the blanks below with appropriate Energy Forms and Transformations and complete Table 1 (next page)

Please fill in the blanks below. The energy types you learned about are Potential, Kinetic, Chemical, Electrical, Nuclear, Thermal, Sound and Light.

1. A battery in a flashlight is an example of __________ energy being converted into __________ energy.

4. A baseball being hit by a baseball bat is an example of __________ energy being converted into __________ energy.

3. A match being lit is an example of ___________ energy being converted into ___________ energy.

2. Turning on the TV at your house is an example of ________ energy being converted into both ________ and __________energy.

5. The sunlight shinging on solar panels is an example of ______ energy being converted into _______ energy. This energy is then transferred into ___________ energy when we turn on a lamp.

Pre-Lab Activity (continued) – **Start Table 1 before coming to lab**.

Instructions: Complete Table 1 before class and compare and contrast answers with your lab group when you arrive in class..

Table 1 is provided for you to complete. In the left-hand column list as many forms of energy as you can. In the right-hand column, identify an example. To get you started, you might recall that electromagnetic waves are one form of energy, and an example might be the microwaves in your microwave oven.

Table 1:

Form of Energy	Example
Electromagnetic Waves (light)	Microwaves (in your microwave oven)

Part A - Conversion of Mechanical Energy into Heat Energy

Conservation of energy is a very important concept. The term simply means that energy cannot be created or destroyed - it is conserved. There is a finite and unchanging amount of energy in the universe. There is, however, no restriction on converting one form of energy into another (except as per the Second Law of Thermodynamics). There are many devices (or processes) that transform one type of energy to a different type of energy. Sometimes it is said that energy is "lost" in transforming one kind of energy into another but in reality the "lost" energy is only converted into a form that is unavailable to use conveniently. Often the "lost" energy is in the form of heat that 'escapes' into the surrounding environment.

Activity 1. Use the table below extend the list by adding your own entries to the table. Then share your list with the others in your group and compile a 'master list'.

Table 2: Shows some possible ways that energy can be 'lost' during a conversion

To Convert	Into	You Might Use	Ways Energy Might Be Lost
Electrical	Light	A light bulb	The lamp heats up and the heat escapes into the air.
Mechanical (Kinetic)	Electricity	An electrical generator	
Light	Heat	A solar collector (that sits in the sun and uses black pipes filled with water)	The water that absorbs the light and converts it to heat begins to boil and this requires a form of chemical energy.
Heat	Mechanical	A steam engine	
Chemical	Light	A chemical reaction	
Ultraviolet (UV) Waves	Visible Light Waves		

Activity 2: Moving hands (Mechanical energy transformed into heat energy)

Instructions: Press your hands together and rub them back and forth twenty times. As you do this, press as hard as you can but still allow them to rub together. Try to apply the same force throughout this activity. As soon as you stop rubbing, feel the temperature of your hands.

1. What did you observe? Explain in terms of energy conservation and conversion.

2. Change the amount of *frictional force* between your two hands by pressing your hands together very lightly (reducing friction). Rub them back and forth twenty times. As before, feel the temperature of your hands where they touched. Were they warmer or cooler than before?

3. Compare this observation to the one above. Explain in terms of energy conservation and conversion.

4. Does reducing the frictional force affect how much mechanical energy is transformed into heat energy?

5. Explain why you put grease (a lubricant) on parts of your bicycle that rub together (e.g. wheel bearings). Explain your answer to this question in terms of energy conservation and 'lost' energy.

6. Make a short list of things (five things) you encounter every day that convert **mechanical energy** (of moving objects) **into heat**.

Part B - Conversion of Mechanical and Chemical Energy into Electrical Energy

A generator converts mechanical energy into electrical energy. Electrical energy can flow through a wire in the form of an electrical voltage and commonly is used to light a bulb to produce light. The light bulb converts the electrical energy into light energy that our eyes can easily detect.

Activity 1: Hand crank generator to electric light (Mechanical to Electrical)

This consists of a hand-crank generator to convert mechanical energy to electrical energy and wires to carry the electrical energy (voltage) to a light bulb.

Instructions:

1. Connect one wire-lead from hand generator to light bulb leaving the other wire-lead unconnected (**open circuit**). Gentle turn the generator and "feel" (gauge) the degree of difficulty. Was it (easy, moderate or difficult) to turn the crank?

2. While turning the crank at the same speed as above connect the other wire-lead to the light (**closed circuit)** and "feel" (gauge) the degree of difficulty to turn the crank. Was it (easy, moderate or difficult) to turn the crank?

Questions:

1. What do you notice about how hard the hand crank turns with respect to a closed circuit (light bulb on) verses an open circuit (light bulb off)? Explain why there is a difference.

Activity 2: Measuring actual voltage in a closed circuit

Instructions:

- For Multimeter **black wire-lead connects to COM terminal** and **red wire-lead connects to theVmA terminal** (check with instructor)
- Connect hand generator wires to each wire of the Multimeter (at direct voltage (DCV) setting of 20) and slowly turn the handle and record the voltage in the table below. Repeat for a faster turn.

Slow Turn Voltage (volts) =
Fast Turn Voltage (volts) =

Thought Question:

1. (Think about and Discuss) How hard (fast) and how long you would need to turn the hand generator to produce enough energy to light a 60 watt light bulb for an hour? Or brew a cup of coffee in the morning?

Activity 3: Comparing chemical (battery) energy to mechanical energy

Instructions:

- Connect the battery pack to the Multimeter and record the voltage (in table below) using same settings (Multimeter at direct voltage (DCV) setting of 20) as activity 2 above.
- Disconnect the battery pack and connect the hand generator to the Multimeter and try to maintain a constant turn that replicates the same voltage as the battery pack. **Now you can FEEL the energy associated with 3-volts.**

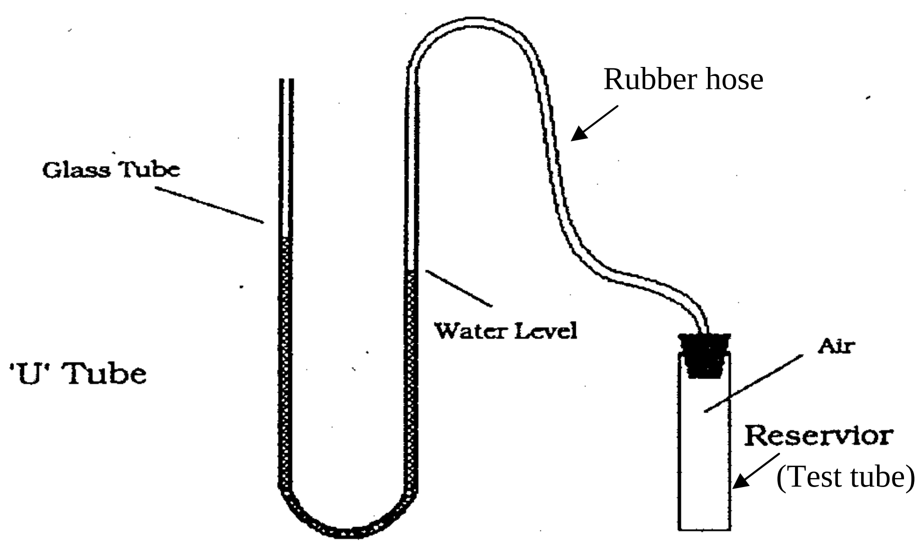
Voltage (volts) with 3-volt (2-battery) pack =
Speed of hand generator (slow, medium or fast) associated with 3-volts (2-batteries) =

Questions:

1. (Think about and Discuss) How hard (fast) and how long you would need to turn the hand generator to produce enough energy to recharge your cell phone? (Typical cell phone batteries are 3.7 volt and 800 mA/hour).

Part C - Conversion of Heat into Mechanical Energy

Figure 1: Apparatus to investigate conversion of heat energy to mechanical energy



At this station you will convert heat energy into mechanical potential energy. To understand how the potential energy is observed, consider the 'U' shaped tube in Figure 1. One side of the U-shaped tube is connected to a small reservoir (a test tube); the other end of the U-shaped tube is open to the atmosphere. If the pressure in the reservoir is the same as the atmosphere, the water level in both sides of the tube will be the same. However, if the pressure inside the reservoir is larger than the atmospheric pressure, the water levels will be different; the pressure inside the reservoir tends to push the water out of the tube. In lifting the water in the tube, the gas in the reservoir does work; holding the water up (that is holding it in a non-equilibrium position) requires energy -- **mechanical potential energy**. To make the gas expand (and increase the pressure in the reservoir), we rely on the **ideal gas law**. The **Ideal Gas Law** states that if you increase the temperature of a gas, the pressure will increase. To increase the temperature, you must transfer heat (energy) into the system.

Activity 1: Hot and Cold (thermal energy) converted into Mechanical Energy

Instruction:

- Record the location of the water level on the scale. (Measure the level of water on the open end of the glass 'U' tube)
- Place the air-**test tube (reservoir) into the warm water beaker** and record the new level of the water in the table below.
- Now place the air-**test tube (reservoir)** into a beaker of cold water. What happens to the water level in the tube when the reservoir is cooled? Record your observations in the table.

Observations:

Initial water level on open side of the glass 'U' tube	**Water level** on open side of the glass 'U' tube **in warm water reservoir** for 30 sec.	**Water level** on open side of the glass ‘U’ tube after immersing in **beaker of cold water**
Describe change of water level from previous level:		

Questions:

1. 1. Explain your observations recorded in the table in terms of energy conservation and energy conversion.

2. What happens when you leave a blown-up balloon in the sun? Give a detailed explanation as to what happens to such a balloon in terms of energy transfer and conservation of energy.

Part D — Conversion of Light Energy into Electricity

Light energy conversion to other types of energy (e.g. electricity) is never 100% efficient. This station contains a solar cell which directly converts light to electricity with approximately 5% efficiency. That is: 5% of the light that reaches the panel surface is converted to electricity.

Activity 1: Solar to electrical to mechanical.

Instructions: The small motor connected to the solar cell converts light to electricity and then to mechanical energy.

1. Turn 40-watt lamp on and observe if motor (Fan) turns. Record how fast fan is turning.

2. Turn 75-watt lamp on and observe if motor (Fan) turns. Record how fast fan is turning.

Questions:

1. Which wattage (light bulb) produced the most electricity (turned the fan fastest)?

2. Most (95%) of the light energy was lost in the process of conversion. Where do you suppose the other 95% of the light energy is going if only 5% is converted to electrical energy?

Refer to Table 5 below to answer the post-lab question about energy conservation.

Table 5: Estimates and comparisons of energy usages in your daily lives.

Energy Using Activity	Is Comparable With
Take a hot bath (full tub)	Burning a 100 Watt lamp for a day.
Using a 250 watt hair dryer for 8 minutes	Riding your bike 30 miles (under ideal conditions).
Heating a pot of water for tea or coffee on the stove	Bench lifting a 50 lb. weight 40,000 times
Watch TV for an hour	Eating a dessert with 250,000 calories
Driving your car 45 miles to Portland	Playing 13,400 games of racquetball
Leaving a 100 watt light burning all night (10 hours)	Dancing the Tango for 4.5 days nonstop

Name____________________________________

Lab Day _____ Lab Time_____________________

POST-LAB ASSESSMENT:

Comparison of Energy Sources

Questions:

1. It is part of our common language to use the term ‘conserve energy’ to mean ‘try to consume less energy’. Contrast this meaning of ‘conserve energy’ with the physics law of ‘conservation of energy’.

2. All methods of generating electricity have adverse impacts on the environment. Try to list at least two ways that each of the following energy sources used to generate electricity negatively impact the environment:
   a) Burning fossil fuels:

   b) Hydroelectric (dams):

   c) Solar:

(Hint: you might consider what impact building such plants may have on the environment.)

3. Which is you favorite energy source? Why?

4. Try to stump your lab partner by thinking of a situation where energy is apparently lost for good. Write down the ideas you come up with and give your lab partner’s explanation of where the "lost" energy went.

Consider the idea that energy is always conserved and discuss whether people will ever be able to generate power without affecting the planet. Record your discussion.

ES 105 Laboratory # 2
EXPLORING WORK, MOTION AND GRAVITY

Introduction

Work: Work is a word used in many different ways. It is used to describe our jobs and careers. It is used to describe what we do when we study for an exam. However, with regards to science that is not what work is. The scientific definition of work is a force acting through a distance (Work = Force x Distance). A force is just a “push or a pull” that gives energy to an object sometimes causing a change in motion of the object. (Recall from last lab that Energy is the property of a system that enables it to do work.) Work is done only when a force moves an object. When you push, lift, or throw an object, you are doing work. Your force is acting on the object, causing it to move a certain distance. One important aspect of work to note is the direction of the applied FORCE must be in the same direction of the DISPLACEMENT (movement) for it to be considered WORK.

Friction: Friction is a resistive force that opposes the motion or attempted motion of an object with which it is in contact. In a sense friction is a force that resists (or limits) the work being done as objects are moved. Friction always acts in a direction to oppose motion. So when an object falls downward through the air, the force of friction (referred to as **Air Resistance**) acts upward. There are different types of friction including rolling friction and fluid friction, but for the purpose of sliding solid objects across a floor or tabletop, the two important types of friction are **static and sliding friction**. The strength of these forces of friction depends upon two factors: 1) the types of surfaces involved and 2) how hard the surfaces push together. Static friction occurs when you first try to move the object before it is in motion and is a little stronger of a friction force than sliding (or moving) friction once the object is in motion.

Gravity and Free Fall: “Free-falling objects” refer to objects that are allowed to fall straight down accelerated ONLY by the force of gravity. An object in free fall accelerates as it falls due to the force of gravity (acting as an unbalanced force). Other than the force of gravity, what other affects might there be on a falling object? The dreaded **air resistance** is one effect. However, the effects of air resistance can be ignored as long as the (maximum) velocity of the object is relatively modest**. For most objects beginning at rest, air resistance is negligible throughout the first seconds of fall.**

In this week’s lab, there will be a series of stations that will allow you to explore the motion of objects and how friction affects the motion of both sliding and free-falling objects. You will also learn how to calculate the work needed to move objects. Your instructor will help you gather data to measure the acceleration of free falling objects due to gravity.

There are a few basic measurements and calculations that are necessary to understand the motion of objects and the work needed to move objects. These measurements and calculations include:

Distance or Displacement (d)	the distance over which an object moves under the influence of gravity (units of measurement: e.g., centimeters, meters, kilometers)
Time of Travel (t)	the time during which an object completes its travel (units of measurement: e.g., seconds, minutes, hours).
Velocity v = d/t	the rate of change or displacement (units of measurement: e.g., miles/hour, meters/sec)
Acceleration a = change in velocity / time	the rate of change of velocity of an object over time (units of measurement for acceleration are d/t^2, such as: meters/sec/sec = meters/second^2)
Force (F)	is a push or a pull units generally measured in (Newtons)
Work (w)	is the change in an object's state of motion that results from the application of a Force.
Work (joules)	**= Force (Newtons) x Displacement (meters)**
Power (P)	Is the time rate of work Units generally measured in (watts)
Power (watts)	**= Work (joules)/Time (seconds)**

Goals and Objectives

- Students will be able to perform measurements using a spring scale to determine the force associated with lifting and pulling weight.
- Students will be able to be able to calculate the average work.
- Describe what is meant by accelerated motion
- Determine the acceleration of gravity

Useful Websites

- http://www.pbs.org/wgbh/nova/galileo/

Name____________________________________

Lab Day _____ Lab Time_____________________

Pre-Lab Activity: Complete the following calculations prior to arrive in lab. Show all of your math work and unit conversions. **(**HINT: 1 hour = 60 minutes, 1 min = 60 seconds, 1 km = 1000 m**)** and (1 kilogram = 1000 grams)

1. If you drive a car for a distance of 35 km and it takes you 45 minutes to do so, what is your average velocity in units of km/hr? What is your average velocity in m/sec?

2. Phil has a very messy office and wants rearrange some furniture. He needs to move a desk 10 meters. If Phil exerts a force of 20 Newtons, how much work is he doing?

3. What is the Force (in Newtons) associated with a 500 gram weight in free fall near the Earth's surface? (assume acceleration due to Earth's gravity is ~ 10 meters/second^2)
(note the 2nd Law of Motion is F(Newtons) = mass(kilograms) x acceleration(meters/seconds^2)

4. You will be using a Spring-scale to determine the Force associated with moving objects in the lab. Go to Wikepidia.org (http://en.wikipedia.org/wiki/Spring_scale) and write a brief definition of what a Spring scale is. (Be careful to discuss difference between Mass and Force readings)

5. A spring scale measuring the force associated with lifting a 500 gram weight on Earth (#3 above) is now used on the Moon. What will the Spring scale readings be for Mass and Force associated with the Spring scale reading on the Moon?
(assume acceleration due to Moon's gravity is ~1.6 meters/second^2)

MASS (in grams) FORCE (in Newtons)

Part A — Work

Activity 1: Let's Talk Work!

Instructions:

- Tape a meter stick to an object to keep it vertical.
- Use a force spring scale to lift weights of different sizes to the 30 cm mark.
- Record your data in the table below.
- Use a force spring scale to lift weights of different sizes to the 60 cm mark.
- Record your data in the table below.

Data Table One

Weights (Grams)	**Height (Centimeters)**	**Distance (Meters)**	**Force (Newtons)**	**Work (joules)**
100	30			

Predict

What will happen to ***force*** if weight is raised to 60 cm? ______________________

____

What will happen to ***work*** if weight is raised to 60 cm? _______________________

____

Now try it and see if your prediction was correct.

100	60			
200	30			

Predict

What will happen to ***force*** if weight is raised to 60 cm? ______________________

____

What will happen to ***work*** if weight is raised to 60 cm? _______________________

____

Now try it and see if your prediction was correct.

200	60			
Try 500	30			

Questions

1. What does doubling the height (distance moved) do to total work?

2. What does doubling the force do to total work?

Solving Problems!
*Remember to include your **units of measurement!** Some measurements are required to solve.*

1. Kelsey is a very strong! She lifted a 200-gram weight to 50 cm. How much work did she do?

2. Mario wants to be a super hero. He has been practicing for his super hero test by lifting cars. If Mario exerts a force of 12,000 Newtons to lift a car 2 meters, how much works is being done on the car?

Part B — Friction

Use the spring scale to measure the pulling force (associated with Static and Sliding friction) necessary to move at constant velocity a wood block across different surfaces. Add a 200 gram weight to block and measure the pulling force again. Record your measurements in Table below.

Friction Surfaces: Static vs. Moving

Type of Surface	Static Friction (Newton's)	Moving (Newton's)	Static with weight	Moving with weight
Smooth-smooth				
Smooth-rough				
Rough-rough				

1. What surface(s) and weight had highest amount of friction ? Explain your answer. Which was greater Static or sliding friction?

Part C — Gravity and the Physics of Free-Falling Bodies

Activity 1: Free Fall of Objects with Similar Size but Different Mass

Collect two balls of the **same size but different weight** such as a heavy solid steel ball and a light hollow plastic ball. With your lab partners, hold both balls simultaneously at a height of one (1) meter above the floor.

As a group, make a hypothesis (predict) as to which ball will hit the ground first:

As a group, test your hypothesis by releasing the balls at the same time. Repeat the experiment several times and describe your results.

1. How did the actual results compare to your initial hypothesis? What can you conclude about the effects of the Earth's gravity on the heavy and light ball, respectively?

Activity 2: Free Fall of Unlike Objects

In your group, repeat activity 1, only this time using a rock and a feather (or piece of paper if you can't find a feather). Hold the rock and feather at a height of 1 m above the floor.

As a group, make a hypothesis (predict) as to which object will hit the ground first, the rock or the feather:

As a group, test your hypothesis by releasing the rock and feather at the same time. Repeat the experiment several times and describe your results.

2. How did the actual results compare to your initial hypothesis? What can you conclude about the effects of the Earth's gravity on the rock and feather, respectively?

3. How does this activity compare to Activity 1 with two balls of the same size but different weight? Explain the differences and/or similarities.

Activity 3: Free Fall in a Vacuum

NOTE: Do NOT run the vacuum pump unless it is connected to the 'Rock and the Feather' tube.

As a lab group, visit the station that consists of a glass vacuum tube and vacuum pump. The apparatus consists of a long tube containing a rock and a bit of paper (or feather, depending which tube is available). Air in this tube can be evacuated using the vacuum pump, thus creating a vacuum (similar to space). Hold the tube vertically with the valve-end up. Hook up the hose to the tube, open the valve, and turn on the pump. After 60-80 seconds, all air should be evacuated from the tube. **Shut the valve**, turn off the pump, and remove the hose.

With all of the air out of the tube, quickly turn the tube end up, and hold it vertically while the feather and rock experience free fall. Repeat the process several times and note your observations.

4. Which object hits first in the vacuum tube, the rock or the feather (or piece of paper as the case may be)?

5. How do the vacuum tube results compare with the results from Free Fall Activity 2 (above)?

6. Explain processes that influence free-fall of objects under the influence of Earth's gravity.
   a. What are the controlling factors?

   b. How does the Earth's atmosphere affect the free fall of objects under the influence of gravity?

   c. What other force(s) besides gravity is operating on the objects?

Part D — Measuring the Earth's Gravitational Acceleration

Activity 1: Using the photogate apparatus to Measure Gravitational Acceleration

Using a "PHOTOGATE" (a light beam with a sensor for light), and a "PICKET FENCE" (a clear plastic strip with uniformly spaced opaque bands), the acceleration due to gravity can be determined. The photogate head, emits an infrared beam from one side of its 'U' shape to the other. A light-emitting diode (LED) on the top of the Photogate Head blinks to show when an object blocks the beam. Timing begins when an object interrupts the infrared beam. We will drop our "picket fence" through the photogate head. **The software calculates the average velocity of the picket fence from one band to the next, because the distance from one band to another was programmed into the calculation.** Before recording data, experiment with the photogate and picket fence.

Procedure

1. Hold the picket fence at one end between your thumb and forefinger so the bottom edge of the picket fence is just above the photogate beam (see diagram below). Have your partner click START, then drop the picket fence through the photogate. The computer will begin recording data when the photogate beam is first blocked.
2. Click STOP once the entire 'picket fence' has passed completely through the photogate,
3. Make sure the graph shows a diagonal line before moving on. If data looks erratic, make sure you are dropping the picket fence vertically, not at an angle: data will be skewed.
4. After your practice runs, open the EXPERIMENT menu; select DELETE ALL DATA RUNS.
5. Using the techniques from above, conduct five runs and record them in Table 1.
6. Click on GRAPH from the left hand data menu and examine the plot of Velocity versus Time in the Graph display. Determine the slope of the 'best fit' line for velocity versus time for each run. Record these values in your data table and find the average. Include units!!

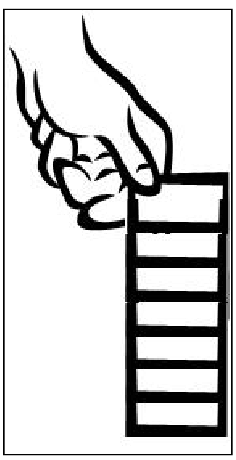


Table 1:

Run Number	Slope of Best Fit Line (acceleration due to gravity)
1	
2	
3	
4	
5	
AVERAGE	

Name___________________________________

Lab Day _____ Lab Time_____________________

Post-Lab Questions on Acceleration Due to Gravity

1. What can you say about the values for acceleration from Table 1? Is it constant, or does it vary in some consistent manner?

2. Compare your values (from Table 1 above) for the acceleration due to gravity, g, (with the accepted value for g at sea level at the equator of g = 9.81 m/s^2?

3. What factors may have contributed to the value you determined experimentally being different from the accepted value? List and briefly describe several of these.

ES 105 Laboratory # 3
ENERGY OF OBJECTS IN MOTION and PHYSICS OF LANDSLIDES

Introduction

In this lab, we will work with two important aspects of the physics of objects in motion. From lab 1, you should recall that energy can be transformed from one type to another and that energy is never created or destroyed; it can, however, be transformed into different types of energy (like motion or heat). This is known as the concept of *conservation of energy*. This very important concept tells us that an equal amount of energy exists before and after the conversion process. Today in lab, you will work with converting gravitational potential energy to kinetic. In doing so, it will seem that energy can disappear. No process of transforming one type of energy to another is perfectly efficient, and some energy will always be converted into forms that are inaccessible to us.

The second key aspect of today's lab will focus on the physics of landslides. Landslides are part of a spectrum of gravity-driven geomorphic processes collectively known as "mass wasting". Mass wasting processes include rock fall, rock avalanche, landslide, earth flow, debris flow, and soil creep. The prerequisite conditions for landslides typically include: (1) the Earth's gravitational field (a fundamental driving force), (2) the occurrence of loose rock and sediment at the Earth's surface, (3) heavy rainfall, and (4) steep slopes. To understand the occurrence of landslides, geologists and engineers must first understand the physics of gravity ("Newtonian physics", "Newton's Laws of Gravity") and how it interacts with materials (rock and sediment) at the Earth's surface. This lab provides an introduction to Newtonian physics, gravity, and the forces that cause landslides.

Goals and Objectives

- Further investigate the concept of *conservation of energy*
- Investigate the conversion of gravitational potential energy to kinetic energy
- Formulate explanations for energy that can *seem* to disappear
- Calculate effect of angle of influence on the acceleration of gravity
- Investigate frictional effect on motion

Useful Websites

- http://landslides.usgs.gov/
- http://www.fema.gov/hazard/landslide/index.shtm
- http://www.physicsclassroom.com/Class/newtlaws/U2L3a.html
- http://www.grc.nasa.gov/WWW/K-12/airplane/newton2.html
- http://en.wikipedia.org/wiki/Sine#Computation

Name____________________________________

Lab Day _____ Lab Time_____________________

Pre-lab Questions:

1. Define the following terms and/or provide the correct formula prior to attending your lab

   A. **GRAVITATIONAL POTENTIAL ENERGY**

   B. **KINETIC ENERGY**

   C. **MASS WASTING/LANDSLIDE**

   D. **FORCE**

   E. **NEWTON (unit of force)**

   F. **NEWTON'S SECOND LAW OF MOTION**

2. **Calculate the following values:**

	0°	**10°**	**20°**	**30°**	**40°**	**50°**	**60°**
Sine of angle							
Cosine of angle							

(If any of your values are negative, set your calculator on degrees instead of radians.)

Part A — Energy Transformation and Conservation

In closed systems the *Law of Conservation of Energy* is obeyed. It states the total energy remains constant. Another way to say this is that the initial total energy in a closed system is equal to the final total energy. In this part of the lab, we will examine two types of energy:

1—*Translational Kinetic Energy* **=** $E_K = \frac{1}{2} mv^2$

where **m = mass** (kilograms) and **v = velocity** (m/sec). Kinetic energy is the energy associated with motion along a line. It is measured in Joules [J] which is the same as

$$\text{kilograms} \times \frac{\text{meters}^2}{\text{second}^2}$$

2—*Gravitational Potential Energy* **=** $E_P = mgh$

where **m = mass** (kilograms), **g = acceleration** due to gravity (9.8 m/sec^2) and **h = height** above surface (m).

Gravitational potential energy is the energy associated with the gravitational pull on an object that is some elevation (h) above a surface (usually Earth's surface). Think of skiing down a slope; at the top of the hill you have a large potential energy – your elevation, h, is large. As you travel down the hill your elevation decreases; so does your potential energy: $E_P = mgh$. At the bottom of the hill (at an altitude of h = 0), your potential energy is zero. Does this mean your energy went to zero? No. Your potential has been converted into translational kinetic energy, and you're zipping along.

Instead of skis, we will roll a ball down a ramp, converting potential energy into kinetic energy. At the bottom of the ramp the ball can roll, with some friction, along a horizontal track. We measure the final velocity as the ball traverses one meter along this track. By comparing the initial potential energy to the final kinetic energy, we will determine if energy is conserved.

Activity 1: Investigating gravitational potential energy and translational kinetic energy
Go to the ramp-track station in the lab. It should look like this:

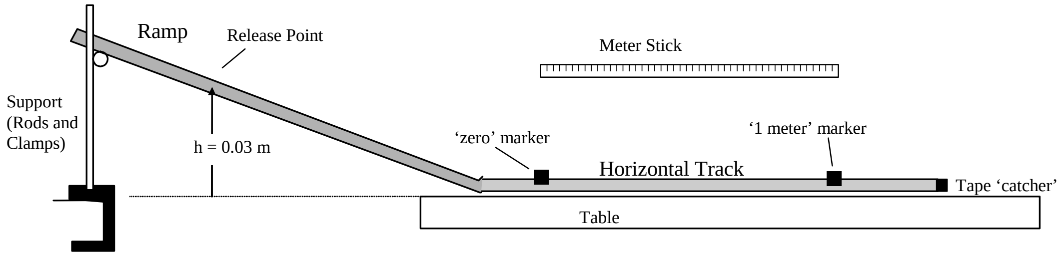


Figure 1: Apparatus to investigate the conservation of energy

Procedures:

1. Determine the mass of the ball in grams using one of the balances in the lab. Record below.

   The ball's mass is __________________ g

   and convert this mass to kilograms: record below.

   __________________ kg.
2. Carefully measure a starting point on the ramp that is **3 centimeters** above the base of the horizontal track (H= 0.03 m). Make sure you are measuring the VERTICAL HEIGHT of the starting point, NOT the diagonal length from the base of the ramp!!!
3. One person will release the ball from the previously determined release point. Another person in the group will click START to begin recording. The program will record the value of position versus time. One person **must** catch the ball **before** it **hits** the motion sensor.

   DO NOT LET THE BALL HIT THE MOTION DETECTOR!
4. Repeat this measurement for a total of five trials. After each trial, use the best fit line tool to determine the slope of the graph following directions provide below. The slope of the position versus time graph is equal to the average velocity of the ball rolling along the horizontal surface. Record the velocity for each trial in the data table below (Table 1). Repeat your experiment 5 times and find the average.
5. **Follow these directions to determine the best fit line**.
   a. Click the DATA tool button. Select NO DATA.
   b. Click the DATA tool button again. This time choose Run #1.
   c. Click on the SCALE TO FIT button.
   d. Using your mouse, select data: click and hold the left mouse button to draw a box around the part of the graph that is a smooth diagonal line. This part of the graph corresponds to the ball rolling along the horizontal surface. The line should be highlighted in yellow.
   e. Now click on the FIT button and select LINEAR. Record the slope (m) in Table 1 as the velocity.
   f. Repeat steps a through e for all five trials. Be sure to select part of the line for each trial. Do not rely on it having yellow highlight. Tabulate your data in Table 1.
6. Run the experiment again, starting the ball at **6 centimeters** above the table top, and calculate the velocity on the horizontal track in meters/second. Repeat your experiment 5 times and find the average. Tabulate your data in Table 2.

Table 1: Data table for experiment with ball starting at **3 centimeters** above the table top.

H = ___0.03__________ meters

In the last column, record the velocity from the computer table if you used it to collect your data. **It is not necessary to record the time if you used the computer to collect your data.**

Trial	Time (seconds)*	Velocity (m/sec)
1		
2		
3		
4		
5		
AVERAGE:		

***If you are using meter stick and manual timer, you will need to calculate your velocity.**

Table 2: Data table for experiment with ball starting at **6 centimeters** above the table top.

H = ____0.06_________ meters

In the last column, record the velocity from the computer table if you used it to collect your data. **It is not necessary to record the time if you used the computer to collect your data.**

Trial	Time (seconds)*	Velocity (m/sec)
1		
2		
3		
4		
5		
AVERAGE:		

***If you are using meter stick and manual timer, you will need to calculate your velocity.**

Activity 2: Computational Questions. Show your calculations; be sure to include **units** in all of the equations on the next three pages.

1. Calculate the **initial potential energy** in the system: E_p = mgh (mass x acceleration of gravity x height) for the ball starting at **3 cm**. (g = 9.8 m/sec^2; use units of kg, m, seconds).

2. What is the **final potential** energy?
   (Hint: write the equation with values inserted for the variables, and remember: h = 0 meters)

3. Calculate the **final kinetic energy** in the system: $E_K = \frac{1}{2}mv^2$ (That is: square of velocity times the mass divided by 2. Use average velocity from **3 cm** height, and units of kg, m, s).

4. What is the **initial kinetic energy** (when the ball is at the top of the ramp)?
   (Hint: write the equation with the values inserted for the variables).

5. Compare the initial potential energy (from Q. 1) and final kinetic energy (from Q. 3). Are they equal (to within your uncertainty), or are they quite a bit different? By what factor?

6. Law of Conservation of Energy suggests that E_P and E_K should be equal; explain how the concept of conservation of energy is supported or rejected by the track experiment. If rejected, what might be the possible reasons?

7. **Surprise!** The potential and kinetic energy are not equal because we haven't accounted for the energy 'lost' during the rolling (rotational energy) motion of the ball

Part B — Newton's Second Law, Force, and Landslide Analysis

Landslides are driven by the Earth's force of gravity acting on a mass of rock or sediment on an inclined hillslope.

The critical analytical parameters include:

Symbol	Name	Description	Units
F	**Force of Gravity**	The pulling action on an object due to Earth's gravity	Newton N = 1 kg-m/sec^2
g	**Acceleration due to gravity**	Constant on the Earth: g = 9.83 m/sec^2	m/sec^2
m	**Mass**	Amount of material measured in kilograms	kg
θ	**Angle of Slope**	Angle of hill-slope inclination (90 degrees = sheer cliff face, 0 degrees = flat surface)	degrees

Newton's second law of gravity states that the force operating on an object in space is directly proportional to the product of its mass and acceleration.

Newton's second law translates into the following equation:

$$F = ma$$

where F = force (Newton), m = mass (kg), and a = acceleration (m/sec^2)

When **Earth's gravity is considered, "F" is equivalent to "weight"** (e.g., your weight on a scale is a measure of the Earth's gravitational pull on your body mass; the more mass you have, the more you weigh), and "a" is equivalent to "g" which is the acceleration due to gravity (a constant = 9.8 m/sec^2).

In terms of Earth's gravitational pull, Newton's second law is translated as:

$$Wt. = mg$$

where Wt. = weight of an object (Newtons), m = mass of object (kg), and g = acceleration due to gravity (g = 9.8 m/sec^2).

This part of the lab is particularly relevant, because the Willamette Valley represents one of the most dynamic and spectacular geologic environments in the United States. Intense seasonal rainfall patterns, steep mountain slopes, and expansive valleys provide for an active geomorphic setting associated with seasonal flooding and landslides. Annual cost of damage to public and private lands in western Oregon ranks among the top 20% of the most severe in the United

States. Damage to public infrastructure from storm events during the mid-1990's alone totaled hundreds of millions of dollars. Landslides accounted for a large portion of this damage. Slope failure and erosion in the Coast Range are further exacerbated by sustained timber harvesting, and the Willamette Valley is experiencing unprecedented population growth and development, invading the foothills. Understanding of the spatial and temporal distribution of landslides is critical for the appropriate design of land-use regulations, hazards mitigation, and conservation planning (read this as: "Your house could be next! How do you know if you are at risk for landslide and what can you do about it?").

Application of Newton's Second Law:

With your lab group, visit the inclined plane station and examine the apparatus. A mass of rock is sitting on an inclined plane; this is analogous to a mass of rock on a hill-slope in the Coast Range or western Cascades. The figure below illustrates the forces acting on the slope material.

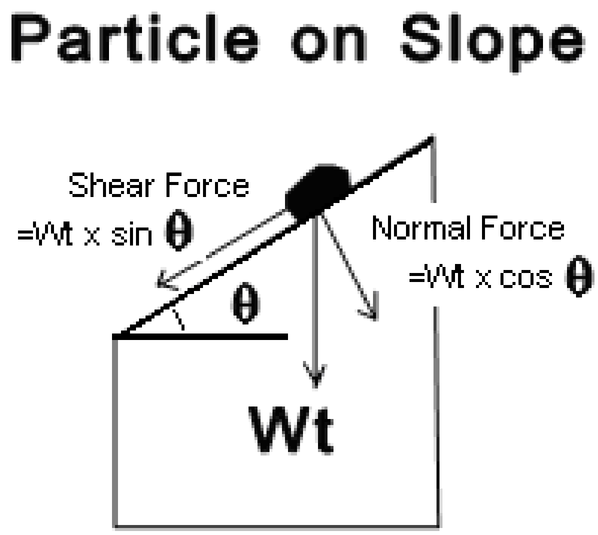


Figure 2: Diagram of forces of weight

Definitions for Particle on Slope:

θ = slope angle relative to horizontal plane (units in degrees)

Wt = weight of particle or mass of material (units in N) = mass x gravity

Shear force: parallel to slope = Wt x sin θ (units in N)

Normal force: perpendicular to slope = Wt x cos θ (units in N)

Equations for Particle on Slope:

Wt (weight of particle in Newtons) = mg (= mass times acceleration of gravity)

SHEAR force (in N) = Wt (sin θ)

NORMAL force (in N) = Wt (cos θ)

Activity 1: Force Analysis of a Rock Mass on a Slope (Inclined Plane)

Questions:
Given that **shear** force is oriented down slope and **normal** force is oriented perpendicular to slope, answer the following questions (refer to the inclined plane drawing above):

1. Which of the two forces (shear or normal) will drive the rock-block down slope when it fails?

2. Which of the two forces will tend to resist down-slope movement of the rock mass?

3. When do you think the block will begin sliding down the slope? (Circle one comparison)

shear = normal **shear < normal** **shear > normal**

Instructions:

1. Determine the mass of our block-of-rock sample by using the balance in the room.

    a. **Mass of Rock Block___________________ kg** (HINT: 1 kg = 1000 g)

    b. **Weight of Rock Block___________________N (Newtons)** Show Calculations:

2. Place the rock on the inclined plane and slowly lift the board to **determine the critical angle** at which it slides down the slope (tilt the plane until the rock begins to slide). **Record the angle in Table 3.**
3. Now repeat the experiment with various types of surfaces. **Record the angles in Table 3.**
    Reduced friction: Tape wax paper to the rock (place it between rock and wood)
    Increased friction: Tape a piece of sand paper (place it between rock and wood).

Figure 3: Critical Angle apparatus

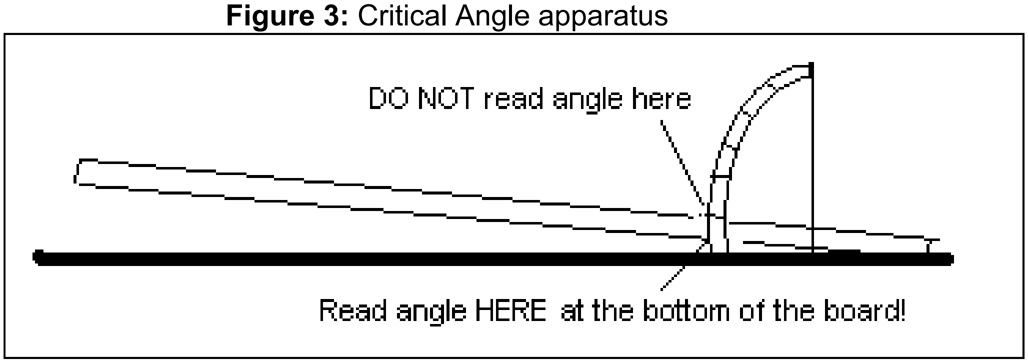


Table 3: Critical Angle of sliding for various surfaces.

Condition of Inclined plane	Critical Angle of sliding (degrees)	Normal Force at Critical Angle Wt. x (cos θ)	Shear Force at Critical Angle Wt. x (sin θ)
Rock on Wood			
Rock on Wax Paper			
Rock on Sandpaper			

4. Calculate the normal force and shear force of the critical angles—be sure your calculator is using degrees, not radians to calculate the sine and cosine of angle θ. **Record in Table 3**

5. How do inclined-plane results (Table 3) compare to your prediction in question 3 above?

6. List some ideas as to what other physical factors may be important to slope failure that are not part of the above equations for slope analysis?

7. Based on your experiments above, discuss the effects of surface friction on the critical hill slope angle at which landslides occur.

8. In the absence of wax paper and sand paper on hill slopes in the natural environment, what types of factors will influence the frictional conditions and critical angles at which hill slopes fail?

Name____________________________________

Lab Day _____ Lab Time_____________________

Post-Lab Assessment
Calculations

1. Imagine you have placed yourself on a balance and determined that your body mass is 100 kg. Calculate your weight in units of Newton's (hint: 1 N = 1 kgm/sec^2). Show all of your math work; keep units with numbers.

2. A car has a mass of 1000 kg and the net force exerted on the car is 0 N. Use Newton's 2nd Law to calculate the acceleration of the car in m/sec^2. Show all of your math work; keep units with numbers.

3. A rocket has a mass of 1000 kg and the net force exerted by the rocket engine is 2000 N. Use Newton's 2nd Law to calculate the acceleration of the rocket in m/sec^2. Show all of your math work.

Questions

1. What effect will clear-cut logging of trees have on slope stability in the Coast Range? Explain your answer in the context of today's lab experiments.

2. Write a 5-10 sentence summary of the critical factors that affect landslide susceptibility in western Oregon. Think about the conditions necessary for landslides to occur, and the factors that affect the critical thresholds at which they begin.

ES 105 Laboratory # 4
UNDERSTANDING GEOLOGIC TIME
Relative Dating and Fossils,
Radioactivity and Numerical Age Determination

Introduction

The Geologic Time Scale was developed using two approaches. In the first, rock units were studied and correlated between geographically distant areas using the principle of faunal succession. With the discovery of radioactivity in the early 20th century, numerical (or "absolute") ages could be applied to the Geologic Time Scale. In this week's lab, you will explore both of these aspects of geologic time.

First, you will investigate the Geologic Time Scale and examine how features of the geological record – species of fossils, and other features – can be used to correlate geological events. In this approach, geologic events are placed in a correct sequence, and the **relative age** (which layer/strata is older and which is younger) of the events is determined.

You will then explore the **concept of half-life**. **One half-life represents the time it takes for half of the radioactive parent isotopes to decay into stable daughter isotopes**. Numeric ages are calculated from rock samples by comparing the amount of **daughter isotope** in the rock to the amount of remaining **parent isotope**, because different radiometric isotopes decay at known statistically constant rates. Radiometric dating thus provides Earth scientists with a powerful tool to investigate Earth history.

Goals and Objectives

- Construct a geologic time scale to gain an understanding of the timing of major events in Earth's history.
- Use fossils to constrain the ages of sedimentary strata and to correlate strata of different thicknesses.
- Develop a conceptual understanding of half-life
- Calculate half-life from counts of decay to daughter atoms.
- Determine ages of materials using half-life radioactive decay techniques.

Useful websites

- http://www.geosociety.org/science/timescale/timescl.htm
- http://pubs.usgs.gov/gip/fossils/succession.html
- http://pubs.usgs.gov/gip/geotime/radiometric.html
- http://evolution.berkeley.edu/evolibrary/article//history_23

Name_____________________________________

Lab Day _____ Lab Time_____________________

Pre-lab Questions – Complete these questions before coming to lab.

1. Define the following terms prior to arriving at your lab section.
   A. Geologic period

   B. Stratigraphic correlation

   C. Parent atom

   D. Daughter atom

   E. Isotope

2. Your lab period lasts 110 minutes. If your lab instructor spends 20 minutes introducing the lab and giving instructions, what percentage of the lab will you have spent listening to your instructor talk? Show your calculations.

3. The oldest known crustal rock is 3.8 billion years old. Give this age in millions of years. Show your calculations. Include units with the numbers.

4. Briefly **describe** and **graphically** represent (draw a diagram) the concept of half-life in the space here.

Part A — Scale Modeling of Geologic Time and Earth History

As an introduction to the duration and extent of Earth history, you will work in lab groups to build a scale model of significant geologic events.

Activity:

Table 1 is a summary of the significant events in Earth history. The geologic time interval of the events is given in the last column of the table. Use this table as a reference to construct a model of geologic time.

Using the note cards provided, build a physical model of geologic history in the hallway, outside the classroom, using the floor tiles as a scale for time. You must decide the scale to use for your model (for example, given the length of the hallway and total number of floor tiles available, how many tiles will represent 1 billion years of Earth history? or 1 million years?). Determine an appropriate model scale and lay out your note cards in the appropriate order and at the appropriate scaled distance along the hallway. Your scale should be such that all of the note cards are not piled on top of one another!

Questions:

1. What scale did your group use for the physical model of geologic time? (answer in number of floor tiles / billion years)

2. Examine your scale model, noting how the spacing of events changes. Sketch your model of the geologic time line below, with spacing generally to scale.

Table 1: Summary of Significant Events in Geologic Time (from oldest to youngest).

Years Before Present	Event in Earth History		Event occurred during this Geologic Time Interval
4.6 billion	**Estimated origin of Earth**	Precambrian Time	Beginning of Hadean Eon
3.8 billion	**Oldest known crustal rocks**		Beginning of Archean Eon
3.0 billion	**Oldest known fossil life** (stromatolites = fossil mats of bacteria/blue-green algae)		Archean Eon
2.5 billion	Evidence of glaciations / climate impact preserved in the rock record (ancient glacial deposits)		Start of Proterozoic Eon
1.8 billion	Multicellular algae preserved in the fossil record		Proterozoic Eon
700 million	Oldest well-documented worm burrows preserved in rock record		Late Proterozoic Eon
540 million	**Invertebrate marine organisms abundant** (trilobites, brachiopods)	**Paleozoic Era**	**Start of the Paleozoic Era** Cambrian Period
430 million	First jawed fish / vertebrates evolve, first early land plants		Silurian Period
370 million	Amphibians evolve (water-land animals), fish abundant		Devonian Period
300 million	Reptiles evolve, amphibians abundant, coniferous land forests abundant		Carboniferous Period
245 million	**Mass extinction event**, many invertebrates become extinct		**End of Permian Period**
220 million	Dinosaurs evolve, first mammals evolve	Mesozoic Era	Triassic Period (Mesozoic Era)
200 million	First birds evolve, dinosaur city		Jurassic Period (Mesozoic Era)
100 million	Flowering plants evolve, mammals become very diverse, dinosaurs still around		Cretaceous Period (Mesozoic Era)
66 million	**Mass extinction event**, dinosaurs become extinct (global asteroid impact event?)		**End of Cretaceous Period** (Beginning of Cenozoic Era)
55 million	Global greenhouse climate, warm and toasty on the planet, mammals diversify	Cenozoic Era	Eocene Epoch (Tertiary Period)
35 million	Global cooling of climate, start of the glacial climate cycles, glaciers develop on Antarctica		Oligocene Epoch (Tertiary Period)
3 million	Hominids (man) evolve from hominoids		Pliocene Epoch
2 million	Massive ice sheets in North America		Start of the Pleistocene Epoch
1.8 million	Homo erectus evolves (precursor to modern)		Pleistocene
300,000	**Homo sapiens evolve**		Pleistocene Epoch
10,000	**Modern humans take over**		Holocene Epoch
0 years	You and I sit here thinking about it.		Late Holocene

Part B – Time and Stratigraphy

For this part of the lab you will use a beaker, sediment, and fossils to explore the relationship of time and correlation in geology. Obtain the materials for this activity. Follow the instructions, record your observations, and answer the questions in the spaces provided.

Procedure:

1. Pour a few centimeters of sand into the beaker. Level the sand by gently shaking the jar from side to side.
2. Place an Ordovician fossil on top of the sand layer.
3. Pour a few centimeters of gravel on top of the sand and shell.
4. Place a Devonian fossil on top of the gravel layer.
5. Cover the gravel layer and shell with a few more centimeters of sand.
6. On the left side of the diagram below, sketch the contents of your beaker **actual thickness**. Label the two sand layers, the gravel layer, and the two fossils along with the geologic ages of the fossils.
7. Trade beakers with another group, or set your beaker by the fossil and sediment supplies.
8. Measure the size of an individual grain of sand in millimeters and record the grain size in the data table (Table 2). Estimate the average size of the gravel in millimeters and record the grain size in the data table (Table 2).
9. Measure the thickness of your layers in millimeters and record in the data table (Table 2).

Your Group:

Other Group (see pg 4.9, q. 8):

Table 2: Data table for Time and Stratigraphy activity.

Layer	Grain size (mm)	Thickness (mm)	Time to deposit layer (years) – calculated in Questions 1 & 2 below
Upper sand			
Gravel			
Lower sand			

Answer the following questions:

1. If a bed of sand a single grain in thickness was deposited once each year, how long would it take to form beds with the thickness of the sand layers in your beaker? Determine for both lower and upper sand layers. Show calculations below and record answers in Table 2 above.

2. If the minimum thickness of a gravel bed were a single grain of gravel in thickness, how long would it take to form your gravel layer if one grain-thickness was deposited each year? Show calculation below, and record answer in Table 2 above.

3. Compare the relative age of the lower sand bed to the Ordovician fossil. Is the sand younger or older than the fossil? What about the gravel?

For the following questions, refer to the Geologic Time Scale. Answer in terms of **PERIOD** listed on Geologic Time Scale, not absolute age in millions of years.

4. Assuming that the lower fossil in your beaker was deposited in the Ordovician Period, what is the OLDEST that the gravel bed could be? (Answer in terms of **Period listed on Geologic Time Scale.**)

5. What is the YOUNGEST that the lower sand bed could be? (Answer in terms **of Period listed on Geologic Time Scale**.)

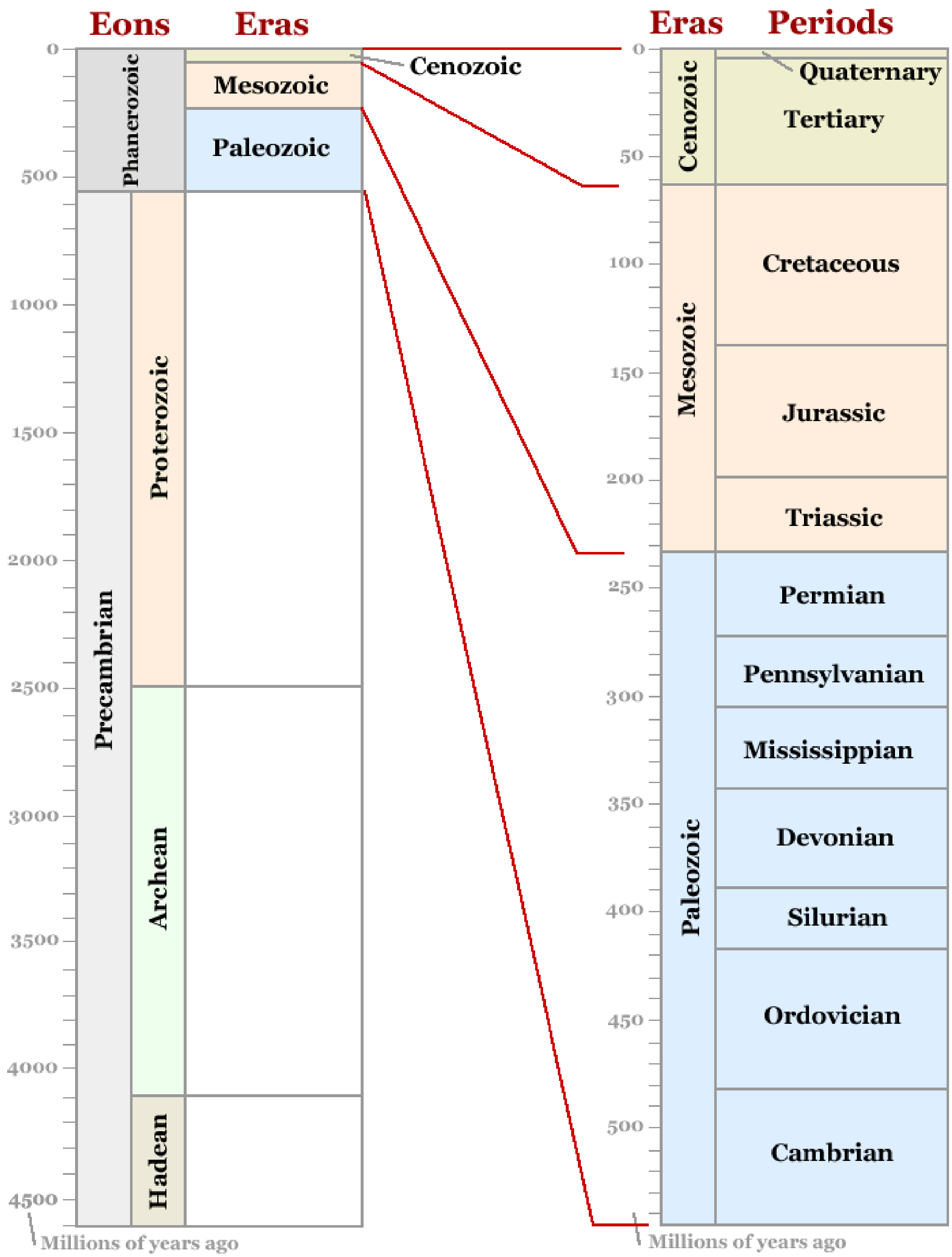
6. Assuming that the upper fossil was deposited during the Devonian Period, what is the YOUNGEST possible age of the gravel layer? (Answer in terms of **Period listed on Geologic Time Scale**.)

7. What is the OLDEST possible age of the upper sand layer? (Answer in terms **of Period listed on Geologic Time Scale.**)

8. Borrow a jar from another group. On the right side of the diagram on page 6, sketch and label the sediment layering in the other group's jar. Draw lines between the columns to CORRELATE (match) the layers, fossils, and geological ages. You have just demonstrated how geologists relate rocks in one area to those in another area.

9. Do you think fossil or the type of sediment is more important in correlating of rock units between different areas? Explain your answer.

Geologic Time Scale



http://geology.com/time.htm

Part C – Exploring the Concept of Half-Life

The determination of Earth history by numerical ages is achieved from measurements of radiometric isotopes found in some rocks and other Earth materials. The PARENT/DAUGHTER ratio may be used to calculate the absolute age of a rock sample. Recall from lecture that **numerical** (or absolute) **ages** for geological events are derived from the measurement of certain radioactive isotopes in Earth materials. **Isotopes** are atoms of an element that have differing numbers of neutrons in their nuclei. Various isotopes of the chemical elements are radioactive, meaning that the nucleus is unstable and decays (disintegrates) by emitting one or more particles, which are designated as alpha (α), beta (β), and gamma (γ). This decay usually changes the original radioactive isotope (**PARENT**) into a different isotope (**DAUGHTER**). For example: $^{238}U \rightarrow {}^{234}Th + \alpha$

While the time interval before each individual nuclide disintegrates is random, each known isotope has a determined **half-life** value, which represents the rate of isotope decay. A second half-life is reached when half of the <u>remaining</u> radioactive parent decays, and so on. Hence, half-life is the time during which each nucleus has a 50% chance of disintegrating.

In this activity, you will explore the basic concept behind radioactive decay and half-life. You will need a cup, 100 pennies, and a calculator for this activity. **You will treat these pennies as if they were radioactive isotopes that are decaying. A penny that lands heads up is a parent isotope and a penny that lands tails up has "decayed" into a daughter isotope.**

Procedure:

1. Count your set of pennies to make sure you have 100. For Trial #1, put the pennies into the cup and shake vigorously. Pour the pennies out on the table, count how many pennies are **heads** up, record result in Table 3, and calculate the **percentage** of heads up pennies [(#heads up)/(total # of pennies poured out on that trial)], and record in table.

2. For Trial #2, **put the heads-up pennies back into the cup, and set the tails-up pennies aside.** Repeat step 1, making the same calculation as above, and record results in Table 3.

3. For Trial #3, put the heads-up pennies back into the cup, and set the tails-up pennies aside. Repeat step 2, making the same calculations as above. Record results in Table 3.

4. Continue this process until the pennies are gone, recording the results in Table 3.

Table 3: Results of penny experiment.

Trial #	Number of Heads	% of Heads Up in Trial
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Instructions: Plot the results of this experiment on the graphs below (Figures 1 and 2).
On Figure 1, graph the **total number** of heads-up pennies for each trial.
On Figure 2, graph the **percentage** of heads-up pennies for each trial.

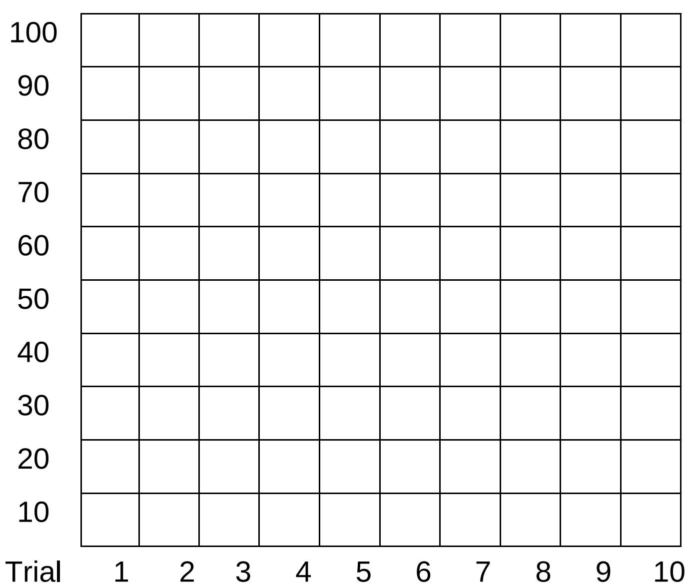


Figure 1: Graph showing the **total number** of heads up pennies for each trial

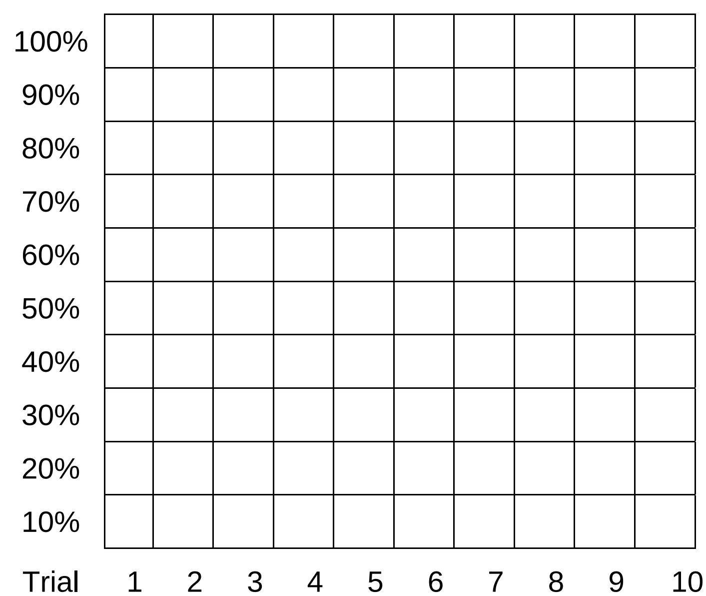


Figure 2: Graph showing the **percent** of heads up pennies in each trial.

Questions:

1. Is your graph of the total number of heads up pennies per trial (Figure 1) a linear or exponential (curved) relationship? Explain why you think the graph has this shape.

2. What would be the predicted ratio of heads to tails in each trial? Is this prediction verified by the results of this experiment displayed in Figure 2?

3. The number of radiometric parent and daughter isotopes in even a small sample of rock is huge; however statistical errors still must be accounted for. This is one source of uncertainty in radiometric dating methodology. Make a generalized statement about the statistical <u>reliability</u> of the heads/tails experiment. That is: how does the number of pennies used in the experiment increase or decrease the reliability of the results? (Notice your results as the number of pennies decreases, as you have graphed in figures 1 and 2.)

4. How reliable would the results be from an experiment starting with billions of pennies? Explain.

Part D – Determining the Half-Life of ^{137}Ba*

The isotope ^{137}Cs has a half-life of 30 years and decays by the reaction:

$$^{137}\mathbf{Cs} \rightarrow {}^{137}\mathbf{Ba}^* + \beta$$

where β is a beta particle (an electron from a nucleus) and ^{137}Ba* is an isotope of barium in the excited state. The * symbol denotes the excess energy that the barium nucleus has after it has formed through beta decay from cesium. The barium nucleus loses the excess energy by releasing a gamma particle (high-energy electromagnetic particle) given by the following reaction:

$$^{137}\mathbf{Ba}^* \rightarrow {}^{137}\mathbf{Ba} + \gamma$$

The half-life of this nuclear reaction is a few minutes. To measure the half-life, it is enough to measure the activity of a sample of ^{137}Ba* starting from the time it is formed until a significant amount has decayed. The ^{137}Ba* source is produced by passing an eluting solution (slightly acidic saline solution) through a sample of ^{137}Ba*. The ^{137}Ba* is dissolved into the eluting solution but the ^{137}Cs is not dissolved. So the solution contains only ^{137}Ba*.

Procedure: Your instructor will provide the solution to you and assist with the experiment.

1. Place 3 drops of eluting solution containing the ^{137}Ba* on a watch glass.
2. Place the watch glass under the Geiger counter.
3. Start recording data by clicking START. Record data until the decay rate shown on the graph stops changing. This should take about 10 minutes.
4. Click STOP. Print enough copies of the graph so that all of your group members have one.
5. **Draw (by hand) a <u>best-fit curve</u> through the data points on your graph**, extrapolating the curve back to where it intersects with the y-axis of the graph. Remember, a best-fit curve does not connect the data points on the graph. Instead, a best-fit curve is a smooth curve that comes as close as possible to all of the data points without necessarily going through most of them. You will use the graph to analyze the data and answer the questions on the following pages.

Data Analysis and Questions:

Follow the directions and complete the table provided below to estimate three independent values for the half-life of ^{137}Ba* from your graph of the activity.

1. Using your best-fit curve, find the count rate at time zero of the data collection run and record this as the **starting count rate** value in **1** of Table 2, below. Next, using the best-fit curve, find the count rate that is approximately **<u>one-half</u>** of the original value and record this as the **ending count rate** in line 1 of the data table. Also record the time at which one-half the original count rate is reached as the time at the end of the interval.
2. Enter the ending time and final count rate from 1 as the **starting time and count rate** for **2** on the data table. Use the best-fit curve; find the count rate that is approximately **<u>one-half</u>** of the starting count rate. Record this final count rate value as well as the time at which the value is reached.
3. **For line 3, do not use the ending count of line 2**. Instead, pick a point near the higher end of the count data along the best-fit curve that is easily divisible by two, and record the starting time and this starting count rate in **3** of the data table. Find the point on the best-fit curve where the count rate drops to approximately **<u>one-half</u>** your original count value. Record the ending count rate and ending time as before.
4. Calculate the half-life of ^{137}Ba* for 1, 2, and 3 and record in Table 2.

Table 2: Table for data analysis and estimation of half-life values

	Time at starting count rate (start of interval)	Starting Count Rate (at the start of interval)	Ending Count Rate (half of starting count rate)	Time at ending count rate	Half-life for ^{137}Ba* (end time minus start time)
1	0.0				
2					
3					

1. Do the half-life values agree? Explain why or why not.

2. Determine the **average** value for the half-life of ^{137}Ba*.______________________________

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POST-LAB ASSESSMENT

1. Based on your physical and quantitative models of Earth history, assess the importance of modern humans in the relative framework of biologic and physical evolution of the planet.

2. Convert the following decimal values to percents and reduced fractions.

Decimal	Percent	Fraction
0.50		
0.25		
0.125		
0.0625		
0.03125		

Your prelab diagram of half life may help you visualize the following questions:

3. You have 1.224 mg of freshly prepared gold-189, half-life 30 min. How much of the gold-189 sample remains after five half-lives?

4. A piece of fossilized wood has carbon-14 activity one-eighth that of new wood. How old is the artifact? The half-life of carbon-14 is 5730 years.

5. A sample of a particular radioisotope is placed near a Geiger counter, which is observed to register 160 counts per minute. Eight hours later the detector counts at a rate or 10 counts per minute. What is the half-life of the material.

ES 105 Laboratory # 5
INTRODUCTION TO CHEMICAL REACTIONS

Introduction

By definition, a **physical change** is one in which only the physical characteristics such as state (gas, liquid, or solid), size, density, or color of a substance is changed without changing its composition. Ice melting is an example of a physical change (solid to liquid change of state). A **chemical change** results in the formation of one or more NEW substances with different composition and properties from the original substances. When a match burns, the ashes and smoke are very different than the original match. In today's lab you will observe a number of different chemical changes.

A chemical change is accomplished by rearranging atoms through breaking and reforming of chemical bonds in a **chemical reaction**. The actual rearrangement of atoms – bond breaking and reforming – is not directly observable. Because we cannot see this process, we have to use indirect evidence to infer that a chemical change has occurred. These indirect lines of evidence include: production of gas, production of a solid (precipitate), release of heat (exothermic reaction), absorption of heat (endothermic reaction), change in pH, and/or change of color (unless using indicators to check for acids or bases).

Goals and Objectives

- To acquaint students with the nature chemical changes.
- To identify whether a chemical change has occurred based on a series of observations.
- To study and explore basic types of chemical reactions.
- To perform a series of experiments, make observations, and determine whether a chemical reaction has occurred.

Useful Websites

- http://www.ric.edu/faculty/ptiskus/reactions/
- http://www.chemtutor.com/react.htm
- http://www.mcwdn.org/chemist/pcchange.html

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Pre-Lab Activities: Answer the following questions. Use the material presented in the lab, your lecture materials, and text, to assist in answering these questions.

1. How is a chemical change different from a physical change? How can you determine whether a chemical change has occurred? List at least three observations that may indicate a chemical change has occurred.

2. In chemistry, what is a ‘reactant’?

3. Define endothermic:

4. Define exothermic:

5. If a reaction container feels warmer after the reaction has occurred, was the reaction endothermic or exothermic?

SAFETY NOTES: Be sure to read and understand before proceeding!

- ✓ For safety reasons, before you begin this laboratory, all books, packs, and coats must be stored at the front of the room.

- ✓ Be sure that all of the equipment that should be in your kit is there and that it is clean and ready to use. For some of the reactions, it is very important to have clean equipment and not to introduce contaminants. Contamination can produce incorrect results. If you are unable to clean a piece of equipment, ask your instructor if you need to replace it at this time.

- ✓ Be sure to follow instructions carefully. Use the proper measurements as indicated in the instructions. Be observant.

- ✓ In some of the experiments, you will be mixing acids and water. The rule is: ALWAYS ADD ACIDS TO WATER. NEVER ADD WATER TO ACIDS.

- ✓ When you are through with the lab, be sure that you leave the equipment as you would like to find it. Remember, there are many other students using the same equipment over the course of the quarter.

The Golden Rule of Chemistry Labs:

LEAVE THE LAB FOR OTHERS AS YOU WOULD HAVE THEM LEAVE IT FOR YOU!

WEAR YOUR GOGGLES

Part A – Indicators

Chemical fluids are often acidic or alkaline (basic). **The pH of a solution describes its acidic or alkaline character. Neutral pH is 7; acidic solutions range from pH 0 to 7; alkaline solutions range from pH 7 to 14**. The number comes from the negative log of the hydrogen ion concentration (or pH = —log [H^+]). Solutions are characterized as acidic or alkaline, according to their pH.

Indicators are particular substances added to solutions that change color according to the pH (acidity or alkalinity) of the solution. They are highly useful in measuring the pH of a solution quickly and quite accurately. Indicators are used in a wide range of fields (environmental, forensics, petroleum) to determine the concentration of a chemical of interest with great accuracy. There are many pH indicators used in chemistry; each with their own color changes and active pH range. One of the most common pH indicators is phenolphthalein. Phenolphthalein is an ionic substance that changes color in solutions that have a particular pH range.

Activity 1: Pour 1-2 mL of 0.1 M **Sulfuric Acid**, H_2SO_4, into a test tube. Add 3-4 drops of phenolphthalein solution. Place a stopper on the tube and shake gently. Record result in Table 1. **Do not throw out solution as you will need it for Activity 3.**

Activity 2: Place 5 mL of distilled water in a **large test tube**. Using your forceps (tweezers) put a small pellet of sodium hydroxide, NaOH, into your test tube. Gently tap the tube in the counter if the pellet is stuck to the side of the tube. NEVER HANDLE NaOH WITH YOUR FINGERS! It is **strongly alkaline**, and will burn your skin. Place a rubber stopper on the test tube and shake gently. Remove the stopper and add 3-4 drops of the phenolphthalein solution to the tube. Place the stopper back on the test tube and shake it gently. Observe the tube for a few minutes. Record result in Table 1 below. **Do not throw out solution as you will need it for Activity 3.**

Activity 3: Use pH paper (measures the specific range from pH 1 – 14) and determine the pH number associated with each solution in Activity 1 and 2. Record results in Table 1 below. **You are done with the solutions so discard solutions and rinse out test tubes.**

Table 1: pH of solutions

Fluid	**Character (acid/alkaline)**	**Response of phenolphthalein indicator**	**pH number**
Dilute H_2SO_4			
Dilute NaOH			

Question 1. Phenolphthalein is an indicator for what pH character?

Part B – Studying Chemical Reactions

In this part of the lab, you will work through a sequence of experiments, make observations, and determine whether a chemical reaction has occurred. **Follow the instructions to do the experiments in the containers specified, not in the small tubes containing the reactants.** As you progress through this portion of the lab, complete 'Table 2: Observations', on the following page. Allow cloudy solutions to sit in the test tube rack to see if a precipitate settles out. Include this information in your observations.

Experiments:

1. Add 5 mL of tap water to a large test tube. Grasp the tube by wrapping your hand around it. Notice the temperature of the tube. Add ammonium chloride crystals, NH_4Cl, to this test tube. Close the tube with a rubber stopper and shake gently. Notice the change in temperature of the tube as the crystals dissolve. Record your observations in Table 2.

2. Pour 1 mL of 0.1 M potassium bromide, KBr, into a large clean test tube. Add 1 mL of 0.1 M sodium chloride, NaCl, to the KBr. Record your observations in Table 2.

For reactions 3 and 4: take two clean test tubes

3. place:1 mL of 0.1 M sodium chloride, NaCl, in one test tube;

4. and place 1 mL of 0.1 M Potassium Chromate, K_2CrO_4, in the other test tube.
Add a few drops of 0.1 M silver nitrate, $AgNO_3$, to each.
Record your observations for each in Table 2.

5. Pour 5 mL of 1 M hydrochloric acid, HCl, into a clean test tube. Carefully add a small chip of calcium carbonate, $CaCO_3$, to the acid. Record your observations in Table 2.

6. Take the test tube containing sodium bicarbonate (baking soda), $NaHCO_3$ from your kit. Add several drops of acetic acid (vinegar), $HC_2H_3O_2$. Record your observations in Table 2.

Complete Table 2 by determining whether a reaction took place for each of the experiments you performed and describe the evidence in support of a reaction taking place.

Table 2: Observations from chemical reaction experiments.

Experi-ment #	Write chemical names of reactants (eg. Ammonium chloride + water)	Observations (Fizzes) (Precipitate forms) (color change) (Temperature Change) or (?)	Has a chemical reaction occurred?
1			
2			
3			
4			
5			
6			

Questions:

1. Which chemical reactions produced a new phase?
   List by experiment number, in the proper column in the table below. Some of the reactions may have not created a new phase; some may have created more than one new phase.

CREATED SOLID PHASE	CREATED LIQUID PHASE	CREATED GAS PHASE

2. Is a new phase always an indication of a chemical change? Explain.

3. Which reactions were exothermic (gave off heat)? How could you tell?

4. Which were endothermic (absorbed heat)? How could you tell?

5. Is a color change a reliable indicator of a chemical reaction? Explain.

6. What gas was released in Experiment 5? How might you test for the type of gas released during a chemical reaction?

Part C – Endothermic and Exothermic Reactions

In this part of the lab, **you will use a TEMPERATURE SENSOR interfaced with a computer to study one exothermic reaction and one endothermic reaction.**

Procedures: (wear your googles!)

Activity 1. Citric acid solution and baking soda

The equation for this reaction is:

$$\underset{\text{citric acid}}{H_3C_6H_5O_7\,(aq)} + \underset{\text{baking soda}}{3\,NaHCO_3\,(s)} \rightarrow 3\,CO_2\,(g) + 3\,H_2O\,(l) + Na_3C_6H_5O_7\,(aq)$$

1. Place a Styrofoam cup into the 250 mL beaker as shown in the diagram provided by your instructor. Put 30 mL of 1.5 molar citric acid into the cup. Place the temperature sensor into the citric acid solution.
2. Weigh out 5.0 g of solid baking soda on a piece of weighing paper.
3. Start recording data by clicking START.
4. Wait 20 seconds and then add the baking soda to the citric acid solution. Stir gently and continuously with the temperature sensor to ensure good mixing.
5. Use the DataStudio program to record data until the reaction is complete. After the data has been recorded, dispose of your reaction products as directed by your instructor. Rinse the Temperature sensor with distilled water.

Activity 2. Magnesium and hydrochloric acid

The equation for this reaction is:

$$\underset{\text{magnesium}}{Mg\,(s)} + \underset{\text{hydrochloric acid}}{2\,HCl\,(aq)} \rightarrow H_2\,(g) + MgCl_2\,(aq)$$

1. Measure out 30 mL of 0.5 molar HCl solution into a second Styrofoam cup and place the Temperature Sensor into the HCl solution.
2. Obtain a 2.0 cm piece of shiny magnesium metal from your instructor.
3. Start recording data by clicking START. After 20 seconds, add the magnesium ribbon to the acid solution. Stir gently and continuously with the temperature sensor to ensure good mixing.
4. Use the DataStudio program to record data until the reaction is complete. After the data has been recorded, dispose of your reaction products as directed by your instructor. Rinse the Temperature Sensor with distilled water.
5. Click TABLE from the left hand menu. Set up your Table display so it shows both experiments.
6. Find the minimum and maximum values for temperature for the citric acid/baking soda and the Mg/HCl experiments. Record the initial temperatures in your data table. Then record the minimum or maximum value as the final temperature.

Results: Calculate the temperature change for each reaction by subtracting the initial temperature from the final temperature.

	Citric Acid-Baking Soda	Hydrochloric Acid-Magnesium
Final Temperature (^oC)		
Initial Temperature (^oC)		
Temperature Change (^oC) (Use correct sign!)		
Was reaction Endothermic or Exothermic?		

Questions about endothermic and exothermic reactions:

1. Which reaction had a negative temperature change? Is the reaction endothermic or exothermic? Explain.

2. For each reaction, describe three ways you could tell a chemical reaction was taking place.

3. Which reaction took place at a greater rate (produced a temperature change Faster or Slower)? Explain your answer.

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POST-LAB ASSESSMENT

1. What type of change (physical, chemical or both) occurs when ice becomes water?

2. When you apply rubbing alcohol to your skin, you feel a cooling effect. Is a chemical reaction taking place? Explain.

3. When you apply hydrogen peroxide to a cut, there are bubbles released. Is a chemical reaction taking place? Explain.

4. What factors affect the rate of a chemical reaction?

5. List some chemical reactions that are useful or annoying in your daily life.

ES 105 Laboratory # 6
STUDY OF SEDIMENTS AND SEDIMENTARY ROCKS

Introduction

Rocks are the materials of Earth, and understanding their origin and how they change enables us to begin to understand Earth and its processes. **Rocks** are aggregates of minerals and are classified into three groups based on the processes that formed them: **Igneous**, **Sedimentary**, and **Metamorphic**. This lab focuses on some of the common sedimentary rocks, which are formed at the surface of Earth.

Sedimentary rocks can form from the consolidation and lithification of particles called **sediment**. Sediment is created either by physical processes breaking pre-existing rocks into smaller particles, or by inorganic or organic chemical processes, where mineral material is precipitated from solution. Sedimentary rocks can also form by the precipitation of mineral material from solutions containing dissolved mineral materials.

Sedimentary rocks form at or near Earth's surface in many different environments, including oceans (marine), streams (fluvial), lakes (lacustrine), deserts (eolian (wind)), and alpine (glacial),. Some sedimentary rocks have features that reveal a great deal about the environment in which they formed. For example, the degree of rounding of the particles, the presence and nature of fossils, and the mineral composition may help decipher the conditions in ancient environments. These observations provide clues about ancient Earth history and also aid in finding potential fossil fuel deposits.

A handful of minerals are commonly found in association with sedimentary rocks, including **quartz**, **potassium feldspar**, **plagioclase feldspar**, **mica** (**muscovite** and **biotite**), **calcite**, **halite**, **gypsum, clay minerals,** and **hematite**. You will examine most of these minerals at the beginning of this lab activity.

Goals and Objectives

- To become familiar with minerals commonly associated with sedimentary rocks
- Investigate the characteristics of sediment grains
- Recognize the classes of sedimentary rocks (**Clastic** and **Chemical**), and be able to distinguish samples of each type
- Classify and name samples of sedimentary rocks by their composition and texture

Useful Websites

- http://www.physicalgeography.net/fundamentals/10f.html
- http://www.windows.ucar.edu/tour/link=/earth/geology/sed_clastic.html
- http://www.windows.ucar.edu/tour/link=/earth/geology/sed_chemical.html
- http://reynolds.asu.edu/glg103/sed_env_start.htm

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Prelab questions: Complete prior to arriving at your lab section.

Define TERMS that are in CAPITAL LETTERS, and answer the questions below:

1. **CLASTIC SEDIMENTARY ROCK** (also called detrital sedimentary rock)

2. What is the most common **clastic sedimentary** rock?

3. **CHEMICAL SEDIMENTARY ROCK**

4. What is the most common **chemical sedimentary** rock?

5. **CEMENTATION** (of clastic rocks)

6. List common sedimentary rock cements:

Part A – Observing Sediment Grains

In this part of the lab, you will examine examples of common sediment grains with a magnifying glass, record your observations, and provide sketches of the grains. **When you look at each sample of grains, notice the shapes, sizes, distribution of sizes, and variety of composition of the grains.**

- **Grain Shape**: can be **well rounded, subrounded, subangular, and angular**.
- **Grain Size**: size becomes **smaller and more rounded** with more time in the transportation system. It is a clue to the environment of deposition. Use millimeters (mm) to record the grain sizes.
- **Grain Sorting: is a term to describe the range of sizes present**:
  Well Sorted = grains are all about the same size
  Moderately Sorted = largest grains are 4 to 5 times the size of the smallest
  Poorly Sorted = largest grains are 5 to ten times the size of the smallest
- **Grain mineral types**: Often noting the colors of grains can be useful
  Include quartz (the most common), feldspar, mica, and rock fragments
  Fossils may indicate an adjective (fossiliferous) be added to sedimentary name
- **Cements**: are the “glue” that hold together the grains.
  Include calcite, silica, iron oxide, gypsum and halite.

Activity 1: Loose Sediment Grains

Study the samples of sediment grains that have been provided. Complete the tables on the following page. **For each sample, describe the general shape of the grains, record the average grain size and the range of grain sizes, describe the sorting, list the grain types (or colors of individual grains).** Use Table 1, to suggest (name) what the likely sedimentary rock would be formed from the sediment. Also, make a simplified sketch of the sediment grains, showing the sorting and grain shape.

Table 1: Grain sizes of clastic sedimentary rocks

Size descriptions		Sediment	Particle size	Rocks formed from it
Coarse ↑	Gravel	Boulder	>256 mm (10 in.)	Conglomerate (rounded grains), Breccia (angular grains)
		Cobble	64-256 mm	
		Pebble	2 to 64 mm	
		Sand	0.0625 ($½^{4}$) to 2 mm	Sandstone
	Mud	Silt	0.0039 ($½^{8}$) to 0.0625 mm	Siltstone
↓ Fine		Clay	<0.0039 mm	Mudstone (massive), Shale (bedded)

Sample 1	Observations	Sketch of the sediment
General shape of grains		
Average grain size		
Range of grain sizes		
Description of sorting		
List of grain types		
Probable rock type formed		

Sample 2	Observations	Sketch of the sediment
General shape of grains		
Average grain size		
Range of grain sizes		
Description of sorting		
List of grain types		
Probable rock type formed		

Sample 3	Observations	Sketch of the sediment
General shape of grains		
Average grain size		
Range of grain sizes		
Description of sorting		
List of grain types		
Probable rock type formed		

Sample 4	Observations	Sketch of the sediment
General shape of grains		
Average grain size		
Range of grain sizes		
Description of sorting		
List of grain types		
Probable rock type formed		

Part B – Introduction to Classifying Sedimentary Rocks

Examine the sedimentary rock study sets provided and answer the following questions.

1. Study the set of sedimentary rocks provided**. Place those that are made of pieces or fragments of mineral and/or rock material (but not the rocks that have shells or shell fragments) on one tray, and the rocks made of organic material (like shells or coal) or of crystals on the other tray.** One group of samples is the **CLASTIC SEDIMENTARY ROCKS**. The other group is the **CHEMICAL SEDIMENTARY ROCKS**.

DO NOT CONTINUE TO (#2) BEFORE YOUR INSTRUCTOR CHECKS YOUR WORK.

2. In the spaces below, list the sample numbers that occur in each group.

Clastic Sedimentary Rocks	Chemical Sedimentary Rocks

Keep the rocks on these trays. You will be asked to use one tray or the other for Part B.

3. **Use the clastic rock tray.** Pick up each specimen and look at the size of the grains (the fragments of which it is composed). Use a magnifying lens and ruler to measure size of the grains. Separate the clastic specimens into two groups based on the grain size: those that have large grains (big enough to distinguish without a magnifying lens) from those that have small grains (too small to see individual grains without a magnifying lens). **In the spaces below, list the sample numbers that occur in each grain-size group.**

Coarse-grained Clastic Rocks	Fine-grained Clastic Rocks

4. Study one of the coarse-grained clastic rock samples. Indicate which one you chose. **Describe** and **sketch** this specimen, showing the grains and the surrounding material.

5. **Use the chemical sedimentary rocks**. Because they form from a wide variety of processes, some chemical sedimentary rocks are **Inorganic or crystalline** (appear homogeneous), while others consist of **Organic** material, including plant material, shells and shell fragments. **Separate the chemical sedimentary rocks that are crystalline from the ones that are organic, and write the specimen number in the table below.**

Inorganic (or crystalline) Chemical Sedimentary Rocks	**Organic Chemical Sedimentary Rocks**

Limestone is the most abundant chemical sedimentary rock. It is made of the mineral calcite. Calcite reacts with hydrochloric acid (HCl,). **When a drop of dilute HCl is placed on calcite, it fizzes vigorously**. This is a good test for limestone. Limestone comes in many different varieties, which form by numerous processes. The calcite can precipitate directly from seawater, form as dripstone in cave formations, or be incorporated into shells by marine organisms. After an organism dies, its shell can become calcite sediment. Calcite also sometimes precipitates in the spaces between clastic grains as cement to hold the rock together.

6. **Test all of the sedimentary rocks with HCl and briefly describe your results**. List the samples that react to HCl, and describe the nature of the fizzing (vigorous or minimal) **SAFETY NOTE: Although dilute HCl is not dangerous it can irritate skin and occasionally cause damage (small holes) to fabric/clothes. Be careful when using it.** Please rinse your table top off if any spilt on it.

HCl tests on **chemical rocks**	HCl tests on **clastic rocks**

Part C – Classification of Sedimentary Rocks

(NOTE: you do not have specimens of every rock included in the classification tables.)

Activity 1.

1. Classification of sedimentary rocks starts with determining if the rock is clastic or chemical.
2. Begin your identification by describing the texture (grain size and shape) and composition (color of sediments) of the rocks listed in Table 6.
3. Identify the rocks in the study set using the classification charts (Table 2 and 3) and your description.
4. **Complete Table 4 with the correct rock names, including terms that describe special features of note about a rock is appropriate.**

Clastic Sedimentary Rocks are made from deposits of broken and/or weathered rock. **Clastic rocks are first classified by the size and shape of the particles, and secondly by the composition of the particles within the rock.**

Table 2: Clastic Sedimentary Rock Classification

Particle Size	Characteristics	Rock Name
> 2mm (bb size)	Grains are angular	**Breccia** (say brech-chia)
	Grains are rounded	**Conglomerate**
2 mm to nearly microscopic	Sand grains consisting of pure quartz	**Quartzose Sandstone**
	Sand grains consisting of dark fragments and quartz	**Lithic Sandstone**
microscopic	Typically layered and soft	**Mudstone/Shale**

<u>Chemical Sedimentary Rocks</u> are derived from material that had been dissolved in water**. They are composed of crystals that precipitated from water by physical or organic processes.** They may have formed when water evaporated in shallow lakes leaving chemicals behind to form evaporite deposits**. They are also are formed by organisms extracting dissolved material to create their hard parts.** For this reason, deposits of shell debris or plant material are considered chemical sedimentary rocks. In some cases, the shell material is easily observable, but in other cases, the shells cannot be seen without a microscope. <u>Note that *fossil-rich* is used as a descriptor for any rock containing visible fossils.</u>

Table 3: Chemical Sedimentary Rock Classification

Mineral Composition	Characteristics	Rock Name
calcite	Fizzes in HCl; massive is fine grained, oolitic contains small concentric balls	**Limestone (use descriptors like massive, fossil-rich, oolitic)**
calcite	Dull appearance, soft, fizzes in HCl	**Chalk** (not included in lab set)
calcite	Composed mostly of visible shell fragments; has large pore spaces; fizzes in HCl	**Coquina**
quartz group	Dense porcelain like, sometimes sharp edges, hardness = 7	**Chert**
gypsum	Soft, hardness = 2	**Rock Gypsum** (not included in lab set)
halite	Translucent, cubic cleavage, salty taste (do not taste lab samples!)	**Rock Salt** (not included in lab set)
opal	Dull appearance, soft, does not fizz	**Diatomaceous Earth** (not included in lab set)
carbon/plant material	Glassy, black, brittle, low density	**Coal**

Table 4: Sedimentary Rock Description Table.

Rock #	Clastic or Chemical	Composition (light or dark grains)	"Texture" Grain Size: Grain Shape: Grain Sorting	Rock Name
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				

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POST LAB ASSESSMENT QUESTIONS

1. List three sedimentary rocks (from table 2 and/or 3) that are the most likely to contain fossils. Explain why this is so, in terms of composition and environment of formation.

2. What is a good test to determine if a sedimentary rock is limestone? Does this test cause a physical change or chemical reaction? Explain how you can tell.

3. Why is the study of sedimentary rocks important for understanding how and where fossil fuels such as oil, natural gas, and coal (hydrocarbons) are likely to be found?

ES 105: Laboratory # 7
INTRODUCTION TO TOPOGRAPHIC MAPS

Introduction

Topographic maps contain a wealth of information, which can be valuable to those who learn how to use them. Topographic maps, also called contour maps, represent the three-dimensional the surface of Earth on a two-dimensional piece of paper. Unlike other maps, topographic maps show natural features with a fair degree of accuracy in terms of width, length, and thickness (height or depth). Geologists make use of topographic maps as a means of studying features in three dimensions. By examining the features and symbols of a topographic map, a geologist can become familiar with Earth features and draw conclusions about the geologic processes that led to their formation.

Goals and Objectives

- Become familiar the information available on topographic maps
- Learn to use map scales to find distances
- Visualize the shape of the Earth's surface using contour lines and topographic profiles
- Depict the third dimension of Earth's surface from the various elements of topographic maps

Useful Websites

- http://www.topozone.com/
- http://topomaps.usgs.gov/
- http://erg.usgs.gov/isb/pubs/booklets/symbols/

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Pre-lab Activities: Complete these before coming to lab

Find the following unit equivalents:

1 mile =	________________ feet	1 km =	________________ meters
1 foot =	________________ inches	1 meter =	________________ centimeters
1 mile =	________________ kilometers	1 km =	________________ miles
1 inch =	________________ centimeters	1 cm =	________________ inches

1. Convert 7920 feet to miles. (Hint: see following page is you don't know how to do this.) Show each step, or combined steps, needed to complete the conversion.

2. If a map has a scale of 1:24,000, how many miles does 7.5 inches on the map represent? Show your calculations with units.

3. If a stream channel is 50 feet lower elevation at one location than at a point 25 miles upstream of that location, what is the gradient of the stream between those two sites? Show your calculations with units.

4. Define the following terms, with respect to stream systems:
   a. Velocity

   b. Discharge

   c. Gradient

Activity 1. Compare this list of steps to convert 15 inches into feet to the table below.

1. Write 15 inches as a fraction using a horizontal fraction bar (see **1** in table).
2. Put a multiplication sign after the fraction, aligned with the fraction bar. Write another fraction bar after the multiplication sign, using a horizontal line (see **2** in table).
3. Choose the unit equivalent needed to convert from the information above (see **3**).
4. Write the 'inches' part of the unit equivalent on the opposite side of the second fraction bar as 'inches' is in relation to the first fraction bar. Write the 'feet' part of the unit equivalent on the opposite side of the second fraction bar as its equivalent inches has been written (see **4** in table).
5. Put an equal sign after the expression, multiply as indicated, and cross out any things found both above and below the fraction bar as a matching pair (both units and factors). Be sure to put the units remaining (feet, in this example) after the final product (see **5**).

Table 1

1	**2**	**3**	**4**	**5**
$\frac{15\,\text{in}}{1}$	$\frac{15\,\text{in}}{1} \times ---$	1 foot = 12 inches	$\frac{15\,\text{in}}{1} \times \frac{1\,\text{ft}}{12\,\text{in}}$	$\frac{15\,\text{in}}{1} \times \frac{1\,\text{ft}}{12\,\text{in}} = 1.25\,\text{ft}$

Problems:

1. Now use this method to convert 7920 feet to miles. You can show each step, or combine steps, to complete the conversion as show in number 5 of the above table:

Use this method to do unit conversions throughout this lab. Remember to include units.

Part A — Scale

A topographic map is a smaller representation of a larger area. The map scale is the relationship between distance on the map and the corresponding distance on the ground. The two types of map scales that are useful to the geologist are <u>ratio</u> and <u>bar scales</u>. The **ratio scale**, written 1:12,000 for example, means that one inch on the map equals 12,000 inches (1,000 feet) on the ground. A **bar scale** is a line with units of distance (feet, miles, kilometers) marked on it. The bar scale allows easy conversion of map distances to true ground distance. On a topographic map, both the ratio scale and the bar scale are provided in the center of the bottom margin. Show your calculations and include units with numbers for these questions.

1. A ratio scale of 1:24,000 means 1 inch on the map is equal to ______________ inches on the ground.

2. Convert ratio scale of 1:24,000 to a verbal scale: with 1" =(how many feet)?.

3. Complete the table below. Show calculations **with units** on the right side of the table.

Ratio Scale	**Verbal Scale**	Math work
1:24,000	1inch = feet	
A ratio scale of 1:62,500 means 1 inch on the map is equal to __________inches on the ground. Convert to 1 inch = how many feet. Record below in and show calculations with units.		
1:62,500	1 inch = feet	
Convert a map scale of 1 inch = 1 mile to a ratio scale. Record below and show calculations with units.		
1:	1 inch = 1 mile	

1. In the space below, draw a six inch long line. <u>**Use a ruler!**</u> Make this line into a **bar scale** using **2 inches = 1 mile**. Subdivide <u>**the entire scale into quarter mile sections**</u> and label the origin, the <u>divisions of the first mile</u>, and the <u>whole miles for the rest of the scale</u>.

2. On the bar scale above, one quarter <u>inch</u> equals _________ miles. Convert this to feet. Record this in the table below. Also determine: what is the ratio scale for this bar scale. (Hint: convert to inches) Show your calculations with units

Verbal Scale	Ratio Scale	Math work
¼ inch =	1:	

Part B—Topographic Maps

Topographic maps use <u>contour lines</u> to depict three-dimensional features on a flat piece of paper. **Contour lines** connect points of **equal elevation** on the ground surface, which means, for example, that every point on a 60 foot contour line is 60 feet above sea level. Therefore, a single contour line on the map shows how and imaginary horizontal plane would intersect the Earth's surface are that particular elevation. The **contour interval** is the difference in elevation between two contour lines. The contour interval on a given map is constant for the entire map. The contour interval chosen depends on roughness of the terrain or **relief**, which is defined as the difference in elevation between the highest and the lowest points on a map.

THE FOLLOWING ARE IMPORTANT RULES ABOUT CONTOUR LINES:

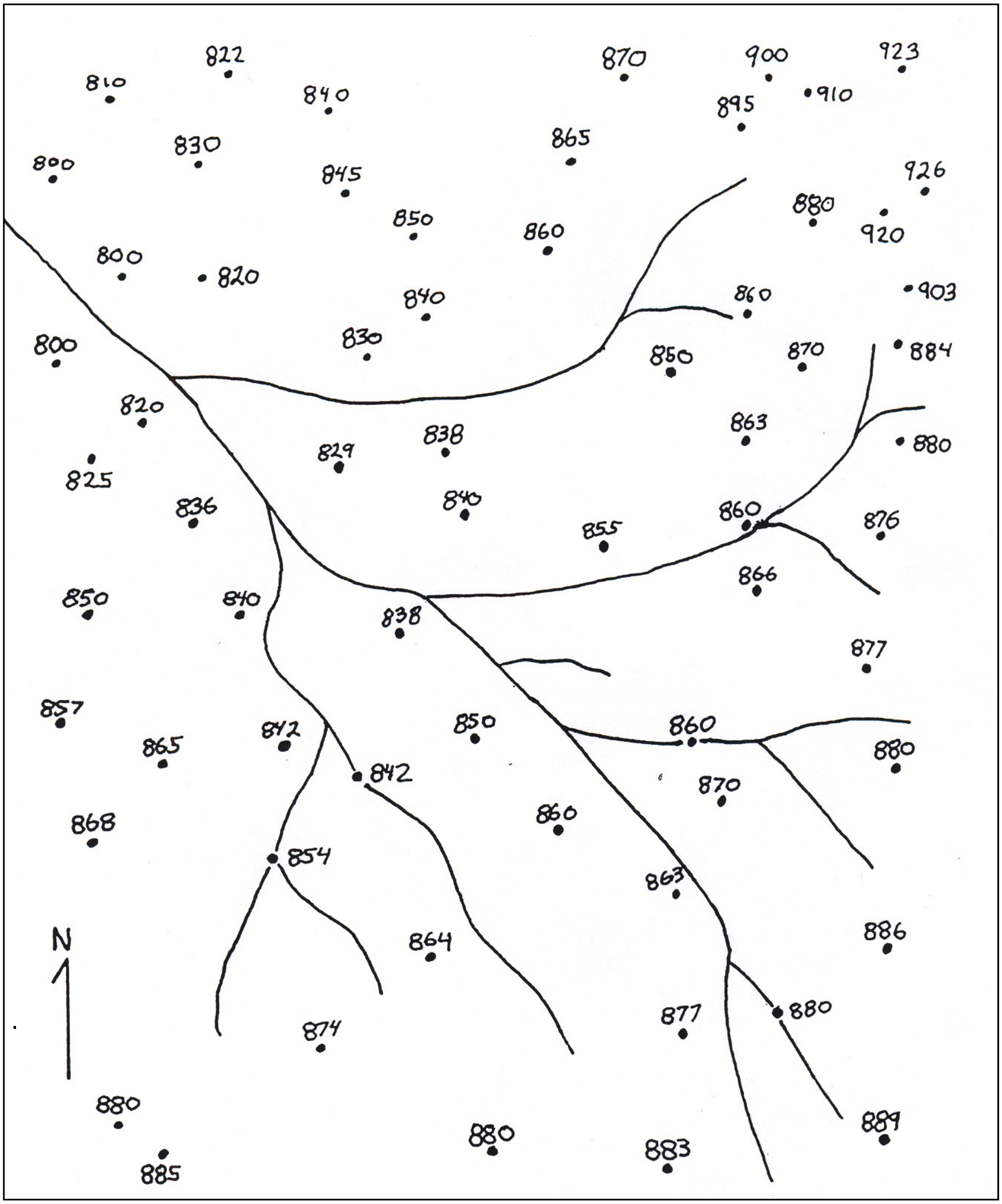
1. Every point on a single contour line connects points on the map that are **exactly the same elevation** on the ground.
2. Contour lines separate areas of higher elevation from areas of lower elevation. You can determine direction of slope of a hill by checking the values of the adjacent contour lines.
3. The **contour interval** (the elevation between two adjacent contour lines of different elevation) **is constant** for the topographic map. The contour interval is chosen by the map-maker based upon the relief of the map (the difference in elevation from the highest point to the lowest point on the map).
4. Contour lines must be counted consecutively (none can be skipped). Heavier contour lines speed up counting of contour lines: **usually every fifth contour line is drawn heavier**.
5. Contour lines **never cross** each other (except in the very rare case where the mapped area contains an overhanging cliff). Contour lines will merge into a single contour line where mapping a vertical cliff (also a rare occurrence).
6. The **spacing of contour lines reflects the steepness of slopes**. Widely spaced contour lines represent a gentle slope; closely spaced contour lines reflect a steeper slope. Evenly spaced contour lines represent a uniform slope.
7. Contour lines **make a <u>V pointing upstream</u>** where they cross a channel or valley.
8. Depressions (lower elevation areas enclosed within higher elevation areas) are marked by hachures on the inside of contour lines. 
9. Contour lines either enclose an area (as a hill top or a depression) or they end at the map edge. On a large enough map, they would all make closed forms.

Activity 1. Locate areas on the Monmouth quadrangle that shows what is described in Contour Rules # (4, 6, 7, 8, and 9) above. Discuss locations with lab partners and if you are not able to locate an example of rule PLEASE CHECK WITH LAB INSTRUCTOR.

Activity 2—Construct a Topographic Map from surveyed data points.

On Figure 1, draw all the contour lines **in pencil** using a contour interval of 20 feet. If you have a pen, put it away, and **get a pencil**. ("Only one who is perfect in every way contours with a pen.") Study the map and locate the higher and lower areas. Refer to the rules on the previous page to assist you. If you are having trouble, see the sample exercises for the last website listed in the introduction to Lab 4. *Lightly* draw in contour lines, starting either at the high elevations or the low elevations. Make changes where you realize you missed a feature: Use an eraser.
When you are finished (and satisfied), darken and label the contour values neatly.

Figure 1: Topographic map construction



Activity 3—Construct a Profile from a Topographic Map

Profiles are made to illustrate the shape of the surface of the earth between two designated points. These two points are at the ends of the line of profile, which is drawn and labeled on the map. The line is used in the construction of the profile. To construct the profile, use each intersection of a contour and the line of profile on the map. Project a perpendicular line from this intersection to the horizontal line having the same elevation as that contour line. Make a dot on the profile for each intersection of a contour line and the line of the profile as drawn on the contour map. Remember to include information implied by the map. NOTE: where the profile crosses a stream channel, the elevation is between two contour lines. (The stream channels are shown by dot-dash lines.) Hilltops and the ends of the profile also have implied information. After all the dots are made on the profile, connect the dots by a smooth line which represents the profile of Earth's surface. **On Figure 3, draw a profile for the dashed line A to A' in Figure 2. Be sure to label both ends of the profile, and the elevations at the side of the profile.**

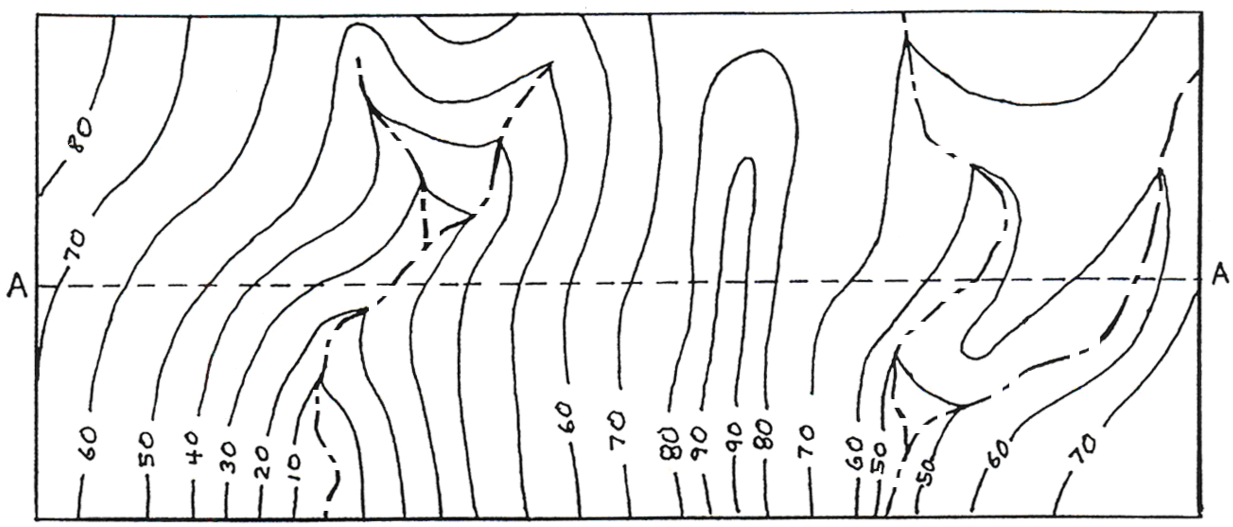


Figure 2: Topographic map with profile line drawn and labeled.

100	
90	
80	
70	
60	
50	
40	
30	
20	
10	

Figure 3: Topographic profile A—A' from Figure 2.

Part C — Additional Information on Topographic Maps

Topographic maps are produced at various scales (1:24,000; 1:63,360; etc.) that represent different areas of coverage. Common sizes are 7.5 minute and 15 minute (Discontinued) describing latitude and longitude dimensions, and are given locality names (such as "Monmouth") usually for some prominent town or geographic feature in the mapped area. In this part of the lab, you will study a U.S. Geological Survey quadrangle that illustrates the kind of information available on these maps.

Map study and use requires an understanding of latitude and longitude. Lines of latitude and longitude form an imaginary grid system with lines that are measured in degrees of arc from a reference. Any point on Earth may be pinpointed to its exact location by its latitude and longitude. **Latitude lines** are oriented in an east-west direction. They are parallel to one another, with the equator designated 0 degrees, and increasing in degree measurement to the poles at 90 degrees. Those in the northern hemisphere are north latitude, and those in the southern hemisphere are south latitude. **Longitude lines** are oriented in a north-south direction and start from 0 degrees at Greenwich, England and increase in measurement both east and west up to 180 degrees on the other side of the Earth near the International Date Line. Those to the east are called east longitude, and those to the west are called west longitude. For more exact locations, degrees (^{o}) are further broken down into minutes (') and seconds ("); one degree has 60 minutes (1^o=60') and one minute has 60 seconds (1'=60").

If you plan to use a compass with a map for navigation, is necessary to understand the concept of magnetic declination. The compass needle, when pointing north, actually points to **magnetic north**, the magnetic pole of Earth, not to **true** north, or **geographic north**, which is Earth's axis of rotation. These two "norths" are not located at the same place, and magnetic north moves over time. The **declination** is the angle of correction needed because topographic maps are drawn aligned to geographic north, which is toward the top and parallel to the left and right margins of the map. Because magnetic north moves, knowing the date the declination is accurate is important also.

Study the Monmouth, Oregon Quadrangle and answer the following questions:

1. ____________________ 1. Who published this map?

2. ____________________ 2. What year was it published?

3. ____________________ 3. What is the latitude of the northern boundary of this map?

4. ____________________ 4. What is the latitude of the southern boundary of this map?

5. ____________________ 5. How many degrees of latitude are along the eastern edge? (HINT: subtract southern edge latitude from northern edge latitude.)

6. ____________________ 6. What is the longitude of the west side of this map?

7. ____________________ 7. What is the longitude of the east side of this map?

8. ____________________ 8. How many degrees of longitude are along the southern edge?

9. ____________________ 9. What is the contour interval?

10. __________________ 10. How much vertical distance separates the lighter contour lines?

11. __________________ 11. How much vertical distance separates heavier contour lines?

12. __________________ 12. What is the highest elevation shown on the map? (Look in NE)

13. __________________ 13. What is the lowest elevation? (Follow river downstream)

14. __________________ 14. What is the relief of this map?
(subtract lowest elevation from the highest elevation.)

15. __________________ 15. What is the **value of the declination (in degrees)** shown?

In the area to the left, sketch how declination is indicated on the map.

.

16. What is the map scale in: (Show math work with units here)

16a. __________________ a. inches to inches?

16b. __________________ b. feet to feet?

16c. __________________ c. inches to feet?

16d. __________________ d. inches to miles?

17a. __________________ 17. What is the name of the quadrangle to the: a. south?

17b. __________________ b. east?

17c. __________________ c. northwest?

17d. __________________ d. west?

18. __________________ 18. What is the approximate elevation of the town of Monmouth?

19. __________________ 19. What is the elevation of the benchmark located at the intersection of Main St and Monmouth St. **in Independence**?

20. __________________ 20. How many miles is it along Hwy 99W from Main St. **in Monmouth** to where 99W crosses the Luckiamute River?

21a. __________________ 21. What is the distance (**21a. in miles)** and (**21b. in Kilometers**)

21b. __________________ between the top of Cupids Knoll and Fircrest Cemetery?

22. __________________ 22. What is the elevation of Cupids Knoll?

23. __________________ 23. Which side would be easiest to climb? Explain why.

Part D — Learning about rivers from topographic maps

Note: Chucksney Mountain, Salem, and Sauvie Island Quadrangles are 1:24,000 scale maps.

1. On the **Chucksney Mountain Quadrangle** look at the tributaries that drain into the North Fork of the Middle Fork of the Willamette River (in the Southwest corner of the map). Then look at the width of the Willamette River channel in the **Salem** and **Sauvie Island** Quadrangles. **Does the width of the river channel increase or decrease when going downstream towards the mouth of the Willamette?**

2. Use the contour lines on the **Chucksney Mountain Quadrangle** to determine the elevation change from the top to the bottom of one of the tributaries that you observed in the previous question and record the elevation change below. **(Be sure to look up the contour interval on the map)**

3. On the **Salem Quadrangle**, locate Beardsley Bar and Doves Bar along the Willamette River. **What is the difference in elevation between these two points along the river? In what direction is the river flowing?**

4. **Does the gradient of the Willamette River increase or decrease as you go from its upper tributaries downstream towards its mouth?**

5. What type of stream channel do the tributaries in the **Chucksney Mountain Quadrangle** have? Circle the correct choice below.

   a. Braided stream channel
   b. Steep gradient bedrock channel
   c. Low gradient meandering stream channel

6. What type of channel does the Willamette River have in the **Monmouth** and **Salem** Quadrangles? Circle the correct choice below.

   a. Braided stream channel
   b. Steep gradient bedrock channel
   c. Low gradient meandering stream channel

Name___________________________________

Lab Day _____ Lab Time_____________________

7a Post-Lab Assessment

1. Imagine you were hiking with friends, and became separated from your hiking companions. If you had a topographic map of the area, what clues on the topographic map would you use to arrive somewhere where you could be found?

2. Would a GPS receiver be able to assist you in finding your location on the map? What information would be helpful?

3. What large city is located near 40^{o}N, 116^{o}E? (Use globe, atlas, world map, *GoogleEarth.)*

4. In what area is 40^{o}N, 116^{o}W?

5. What coast are you near at 34^{o}N, 119^{o}W? (Name continent, side of it, and ocean)

6. What coast are you near at 34^{o}S, 119^{o}E? (Name continent, side of it, and ocean)

7. Is it important to include N or S, and E or W with latitude and longitude information? Why?

APPENDIX – Additional Laboratory Activities

Lab 2: Calculation of Acceleration due to Earth's Gravity

In this activity, you will study the motion of a free-falling body. Using a special timer, the position of the object will be recorded at even intervals of time. Let's call the time interval Δt (read as "delta t" or "change in time"). We will use the letter y to indicate the position of the object. The position at a chosen time will be called y_0. After one time interval passes, we refer to the object's position as y_1, after two intervals, y_2, and so forth. From the changes in positions, we can compute the velocity. The average velocity is determined by the change in position per change in time, Δt. For instance, the (average) velocity after four intervals of time have passed, v_4, is:

$$v_4 = \frac{y_4 - y_3}{\Delta t}$$

This equation could be read as 'the velocity (after fourth time interval) is the change in position (between the third and fourth time interval) over the change in time'.

Once the average velocities have been calculated, these values can be used to determine the average acceleration. The slope of the graph of average speed versus time gives the acceleration of the falling object. Mathematically, the average acceleration after the fourth time interval, a_4, is described by the following equation:

$$a_4 = \frac{v_4 - v_3}{\Delta t}$$

In this part of the lab, you will measure the acceleration of a free-falling body using two different methods and devices – a spark-tape apparatus and a picket-fence/photogate system.

Activity 1: Using the spark-tape apparatus to Measure Gravitational Acceleration

Procedure

We will drop our object, a carbon-coated tape, approximately 2 meters. As the tape falls, a spark generator produces sparks at even time intervals. These produce marks on the tape representing equal times between each spark. The result is pictured below Figure 1. The distance between two successive marks indicates the distance fallen in a particular time interval. The time interval, Δt, is given on the knob on the spark timer. It is a fixed time interval (typically Δt = 1/30 sec = 0.033 seconds). Ask your instructor to verify the value for Δt. Your instructor will help you drop the tape and produce the marks. You should have *at least* 9 marks on your tape.

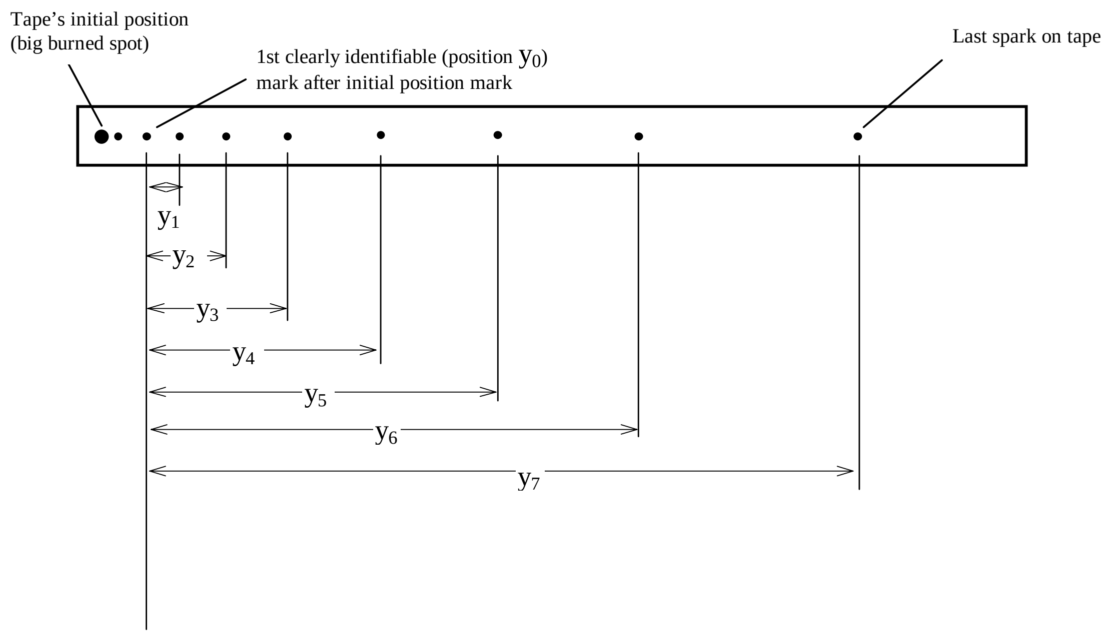


Figure 1: Schematic representation of spark tape resulting from free-fall apparatus.

Note: The first mark (the prominent burned one) gives the tape's initial position. However, the weight was released at a random time. Furthermore, the second mark may be covered up by the first mark. (What you think is the 2nd mark may actually be the 3rd mark!) Hence you can't rely on total elapsed time *or* the position of the next mark after the first mark. However, you *can* rely the on time intervals □t and distances *between* successive marks.

Analysis

Lay the tape flat on the table. You may wish to secure it with masking tape. Locate the initial mark. Now find the next clearly identifiable mark -- probably the 2nd or 3rd mark after the first (prominent) mark. This will be position y_o—label it accordingly. Place a meter stick along the tape in preparation to measure the y-distances (as shown above) from y_o to other mark locations. See the diagram above.

Complete Table 1, for at least seven data points. (Hopefully, you will have more data points than seven.) Measure the distances **very** carefully, enter them into your table. Be sure to record all your distances in **meters**.

NOTICE:Δt is always the same value (probably 0.0333 sec -- but check with your instructor). NOTICE that all the distances in column 2—the 'y (meters)' column—must be in **meters**!

Fill out the rest of the table: Δt is the same number of seconds for every point.

Table 1:

Δt (sec)	y (meters)	Δy	$v=\Delta y/\Delta t$ (meters/sec)	Δv	$a=\Delta v/\Delta t$ (meters/sec^2)
$\frac{1}{30}$	$y_0 = 0$	No Data	No Data	No Data	No Data
$\frac{1}{30}$	$y_1 =$	$y_1 - y_0 =$	$v_1 =$	No Data	No Data
$\frac{1}{30}$	$y_2 =$	$y_2 - y_1 =$	$v_2 =$	$v_2 - v_1 =$	
$\frac{1}{30}$	$y_3 =$	$y_3 - y_2 =$	v_3	$v_3 - v_2 =$	
$\frac{1}{30}$	$y_4 =$	$y_4 - y_3 =$	$v_4 =$	$v_4 - v_3 =$	
$\frac{1}{30}$	$y_5 =$	$y_5 - y_4 =$	$v_5 =$	$v_5 - v_4 =$	
$\frac{1}{30}$	$y_6 =$	$y_6 - y_5 =$	$v_6 =$	$v_6 - v_5 =$	
$\frac{1}{30}$	$y_7 =$	$y_7 - y_6 =$	$v_7 =$	$v_7 - v_6 =$	
$\frac{1}{30}$	$y_8 =$	$y_8 - y_7 =$	$v_8 =$	$v_8 - v_7 =$	
$\frac{1}{30}$	$y_9 =$	$y_9 - y_8 =$	$v_9 =$	$v_9 - v_8 =$	
$\frac{1}{30}$	$y_{10} =$	$y_{10} - y_9 =$	$v_{10} =$	$v_{10} - v_9 =$	

Note about calculations: $\div \frac{1}{30}$ is the same as x 30

Compute an average of the accelerations in your table. Let's call this number the acceleration due to gravity.

The acceleration due to gravity is ________________________ in units of ________________.

There! You did it! *You* measured the acceleration due to gravity.

Lab 3: Rotational Kinetic Energy Determination

1. **Surprise!** The potential and kinetic energy are not equal because we haven't accounted for the energy 'lost' during motion of the ball. Let's calculate the rotational kinetic energy of the system by using the formula below. Show your calculations; be sure to include units!

   $E_R = \frac{1}{5} mv^2$ E_R = _______________ in units of __________________.

Now add *all* of the kinetic energy (E_K + E_R) ___________________ in units of ____________.

2. How does the sum of kinetic energy (E_K + E_R) compare to the initial potential energy? Is the total energy conserved? What other energy factor(s) haven't we accounted for yet? (HINT: why does the ball slow down as it is rolling?)

3. What would be the potential energy in the system if the ball were positioned at a height of 0.1 meters? Show your calculations; be sure to include units! (Your answer should be in Joules).

Predicting the Final Velocity of the Ball

Because the total energy is conserved, you know that at the beginning the total energy is only gravitational potential energy. At the end of the experiment, the ball has no altitude (h = 0 above the horizontal table), so all the energy is in the form of kinetic energy. Since the total energy at the beginning must be equal to the total energy at the end, we can say

Potential energy (E_P) at beginning = Kinetic energy at end (both rolling + translation)

Or **mgh =** $E_R + E_K = \frac{1}{2} mv^2 + = \frac{1}{5} mv^2$. This simplifies to **mgh =** $\frac{7}{10} mv^2$

Solving the above for the final velocity of the ball along the horizontal ramp, we find

$$v = \sqrt{\frac{10}{7} gh}$$

Questions:

4. Using the equation $v = \sqrt{\frac{10}{7}gh}$, calculate the ideal velocity on the horizontal track when the ball is released on the ramp at h = 0.03 meters? What are the units of the velocity?

5. In reality, will the velocity be higher or lower than the ideal calculation above? Why?

6. How did your average velocity (from table 1, pg.6) compare with the ideal velocity (as calculated in question 10 above)? Comment on why it is the same or different. (HINT: there is more than one reason the velocity is not ideal!)

7. Without calculating, PREDICT what happens to the final velocity if we double the initial height (h = 0.06 m)? Will the final velocity increase or decrease? About how much: double, one-half, or some other value compared to when it is released from h = 0.03 meters?

8. Support your above answer by employing the equation $v = \sqrt{\frac{10}{7}gh}$ for h = 0.06 m.

   That is, calculate the final velocity of the ball when it is released from 6 centimeters. Be sure show your calculations, and report your answer, with the appropriate units.

Lab 3: Energy of Motion and Landslides

PART C — Landslide Prediction

Examine the cross-sectional sketch below. Label in Figure 4, with numbers, the positions where you might expect to find the following mass wasting processes:

(1) rock fall (i.e. free-falling rock material),
(2) soil creep (slowly moving sediment under the influence of gravity),
(3) catastrophic landsliding, and
(4) zone of little to no chance of mass wasting processes.

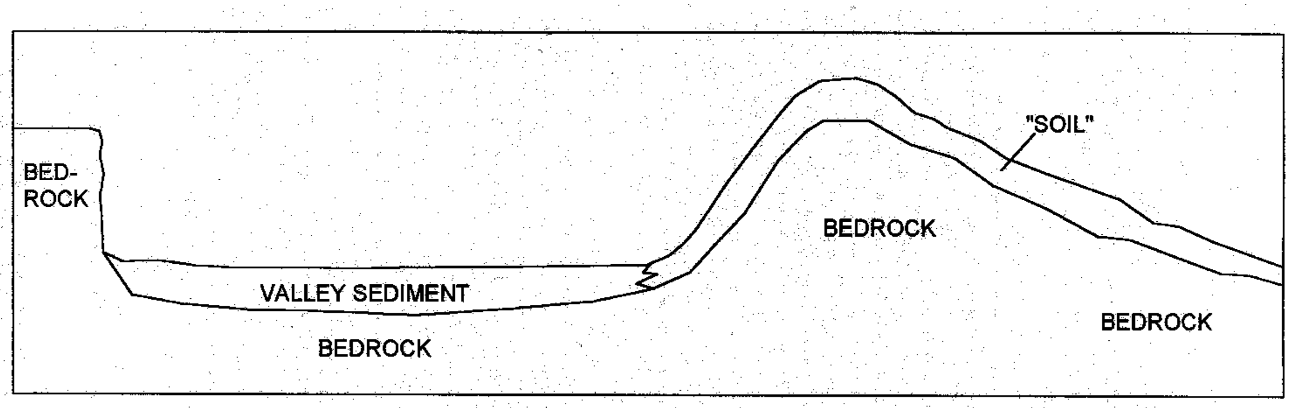


Figure 4: Landslide prediction diagram

Questions:

1. What are the chances of your property experiencing a landslide if you live in the Coast Range of Oregon (for example somewhere between Dallas and Lincoln City)? List the critical factors that apply (or don't apply as the case may be) to why you think these are your chances.

2. What are the chances of your property experiencing a landslide if you live in the middle of the Willamette Valley (for example in Salem or Albany)? List the critical factors that apply (or don't apply as the case may be) to why you think these are your chances.

Acceleration of a Cart

If a cart moves on a plane that is inclined at an angle θ, the component of force acting on the cart in a direction that is parallel to the surface of the plane is the shear force. The acceleration of the cart should be given by:

$$\mathbf{a = g \sin} \theta$$

Procedures:

1. Before recording any data, make sure the Motion Sensor can "see" the cart as it moves.
2. Measure the angle the track makes with the table top. Record in Table 4 below.
3. Place the cart on the low end of the track and have one person start recording. Have the other group member give the cart a gentle push up the inclined plane track so the cart will move toward the Motion Sensor. Keep recording as the cart moves away from the sensor
4. Stop recording when the cart returns to the bottom of the track.
5. If the plot of data is not smooth, check with your instructor to realign the Motion Sensor. The repeat the above procedure until the plot is smooth for the run up and then down the track.
6. Erase your practice runs by clicking on the EXPERIMENT menu and selecting DELETE ALL DATA RUNS. Do NOT use the FILE menu and delete the activity!!
7. You are now ready to collect data. Place the cart at the low end of the track. Start recording data. Give the cart a gentle push toward the Motion Sensor. Continue collecting data until the cart has returned to the bottom of the track. This is 'Run #1'.
8. Set the track to a steeper angle and measure the angle. Repeat data recording (Run #2).
9. Open the GRAPH from the left hand menu. Select Data Run #1. Choose the plot of velocity vs. time. Use the cursor to select the region of the plot that shows the cart's motion after the push and before it stopped at the bottom of the track. Determine the slope of the best fit line. This slope is the acceleration of the cart. (Note: Units are m/s^2)
10. Repeat for Data Run #2.

Record all data in Table 1 and answer the questions on the following page.

Table 1: Acceleration of cart on Inclined plane

	Run #1	Run #2
Angle of track (θ)		
Experimental Acceleration (slope of velocity/ time)		
Theoretical Acceleration (calculate from **a = g sin** θ)		

Questions:

1. What happens to the velocity of the cart as it moves up the inclined plane?

2. What happens to the velocity of the cart as it moves down the inclined plane?

3. What happens to the acceleration of the cart as it moves up the inclined plane?

4. What happens to the acceleration of the cart as it moves down the inclined plane?

5. How did the acceleration change when the track became steeper?

6. Calculate the theoretical value for the acceleration of the cart based on the track's angle and record it in Table 1.

7. What is the percent difference between the acceleration determined in the activity and the theoretical value for acceleration? $\left(\frac{\text{theoretical - experimental}}{\text{theoretical}} \times 100 = \text{percent difference}\right)$

(Show calculations here.)

8. What is a possible explanation for the difference in these two values?

Lab 4: Relative Age Dating

Pre-lab Questions for Determining Relative Ages of Geologic Events

Define the following terms prior to arriving at your lab section.

Stratigraphic correlation

Principle of original horizontality

Principle of stratigraphic superposition

Principle of lateral continuity

Unconformity

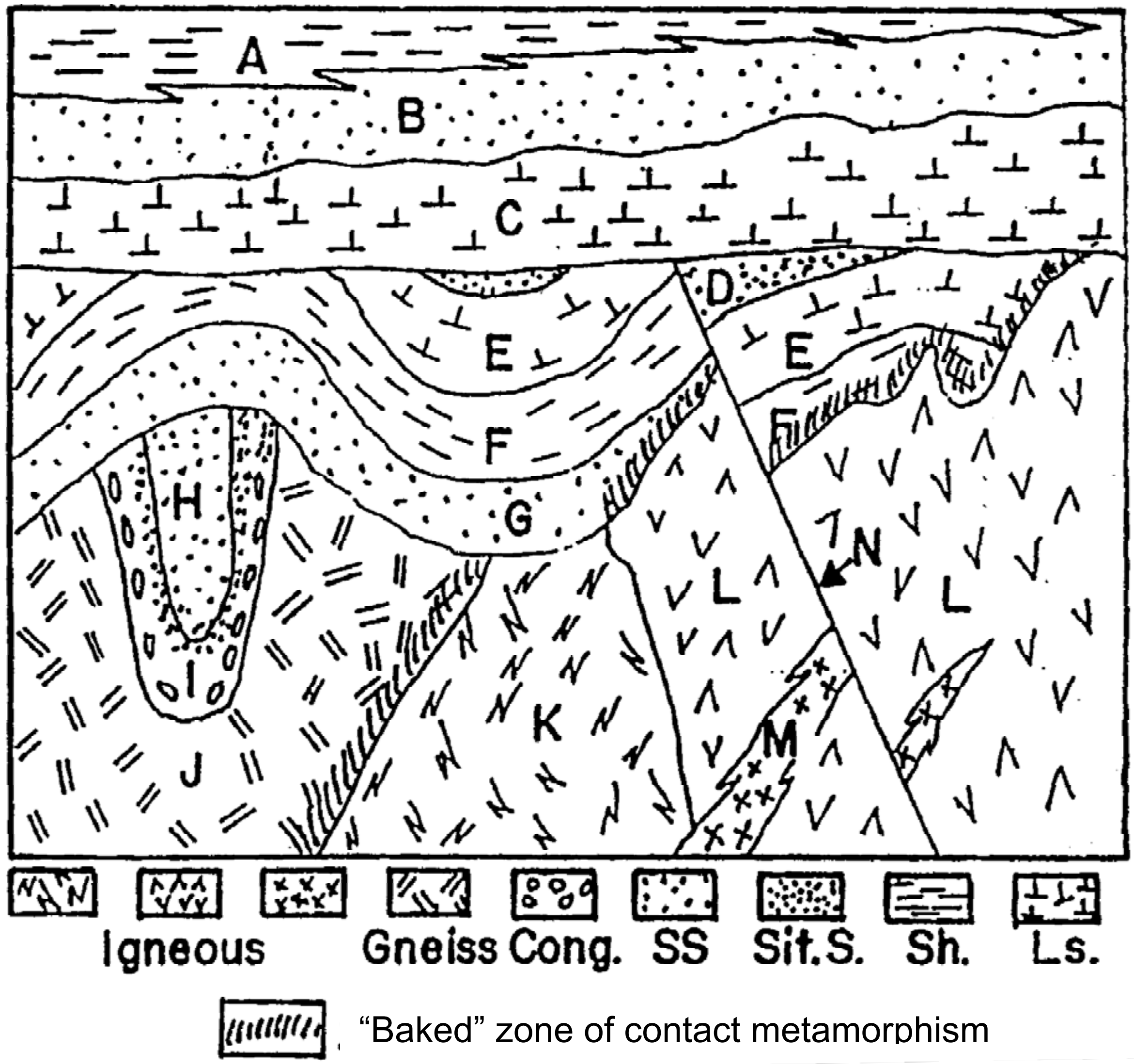
Law of cross-cutting relationships

Determining Relative Ages of Geologic Events

Another technique to determine the relative ages of geological events is the Principle of Cross-Cutting relationships, which states that any geological feature, which cuts another geological feature, must be younger than the cross-cut feature. Stated in simple terms, a loaf of bread must be older than the bread slices which transect the loaf.

Activity:
Study the sketch on the following page. LIST the sequence of geological events, **oldest** at the **bottom** and **youngest** at the **top**, on the table below, and cite reasons for this order of events. Close ups of significant relationships are shown on the following page (8.4).

Event	Older than	Because	Younger than	Because



HINTS:

- "I" contains inclusions of "J" and "K"
- "I" changes from conglomerate at the bottom to sandstone at the top
- "I" does not include pieces of H

Rock Types

Igneous – Intrusive

Metamorphic

Gneiss

Sedimentary

Cong. – Conglomerate

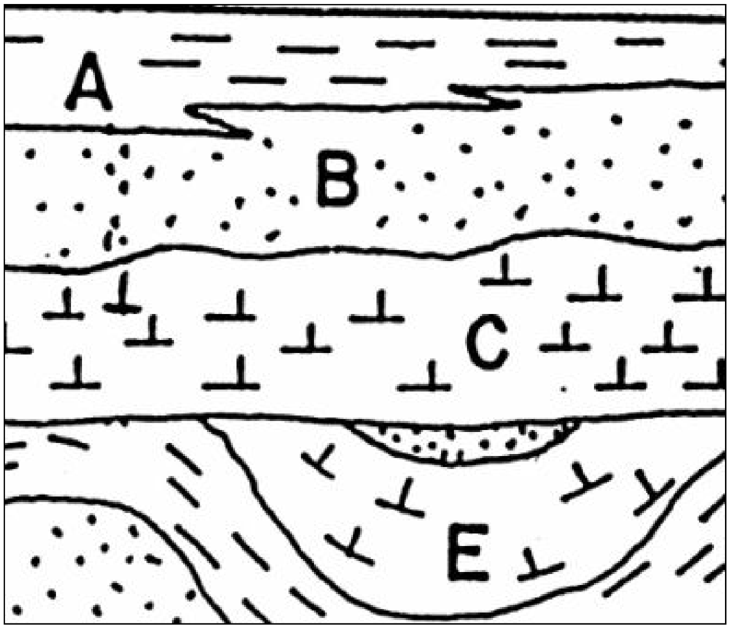
SS – Sandstone

Sit. S. – Siltstone

Sh. – Shale

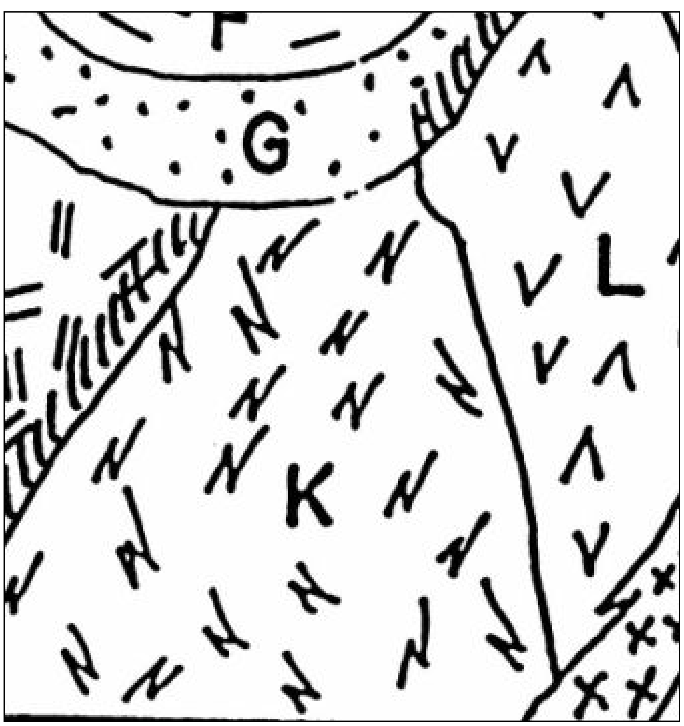
Ls. – Limestone

There are details of this cross section on the following page. Working on the geologic history of smaller portions first can help you unravel the geologic history of a complicated section like the one above.

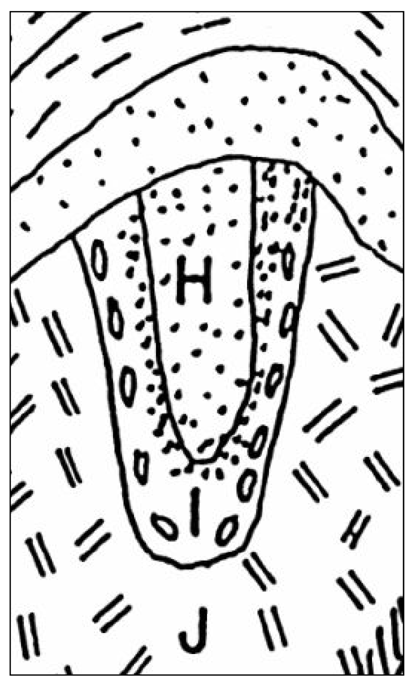


Angular Unconformity

Fault



Intrusions



Refolded area

Questions: Quantify some basic observations on geologic time in the spaces provided (Use dates shown in the "Geologic Time Scale".) Show all of your math work.

____________ Based on the data given, how old is the Earth (i.e. what is the total known time encompassed by geologic history?). Answer in billions of years.

____________ What is the total duration of the Precambrian Eons? (in millions of years)

____________ What is the total duration of the Paleozoic Era? (in millions of years)

____________ What is the total duration of the Mesozoic Era? (in millions of years)

____________ What is the total duration of the Cenozoic Era? (in millions of years)

____________ What percentage of total Earth history is comprised by the Precambrian Eons?

____________ What total percentage of Earth history is marked by the presence of life in the fossil record? Show all of your math work.

____________ What total percentage of Earth history is marked by the absence of life in the fossil record? Show all of your math work.

____________ Homo habilis is considered by many anthropologists to be the first true human, and lived ~ 2 million years ago. What total percentage of Earth history is marked by the presence of human-like species in the fossil record? Show all of your math work.

____________ What total percentage of Earth history is marked by the presence of "modern man"? Show all of your math work, write the answer in **scientific notation**.

____________ Assuming that you live to the ripe old age of 82, what total percentage of Earth history will be marked by your presence on this planet? Show all of your math work, write the answer in **scientific notation**.

Lab 5 Chemical and Physical Changes

Exploring the Differences between Chemical and Physical Changes

In this part of the lab, you will work through a sequence of experiments, make observations, and determine whether a chemical or physical change has occurred. As you progress through this portion of the lab, complete Table 1: Observations, on the following page.

Procedure:

1. Take a test tube labeled *iron filings* and a test tube labeled *sulfur* from your kit. These have already been pre-weighed for you with 3.5 grams of the iron filings and 2.0 grams of sulfur. Mix the two completely by grinding them together with a mortar and pestle.

2. Divide the mixtures into two piles (i.e., aliquots) and place each on wax paper.

3. Observe one of the aliquots under a magnifying glass and record your observations in table 1.

4. Test the same aliquot for magnetism by passing a magnet under the paper. **(Please do not remove the magnet from the Ziploc bag!)** Does the material appear to be magnetic? Record your observations in Table 1.

5. Now pour each aliquot into a test tube: one aliquot into a small Pyrex test tube from your kit, the other aliquot into the soft glass test tube from your kit that is labeled **"breakable".** (Set this one aside for a few minutes.)

6. Add a small amount of water to the first test tube (Pyrex tube, not breakable one), cover the end of the tube with your thumb, and shake vigorously. Record your observations in Table 1.

7. <u>Clean out</u> the mortar bowl and put some cold tap water into the bowl. Take the mortar bowl with water, your **breakable** test tube containing the dry iron/sulfur mixture, and a test tube clamp to one of the hoods. Be sure to wear goggles!

8. **This step is performed under the hood!** Gently heat your mixture using the hottest part of the flame (the inner blue tip). Heat your mixture until the mixture itself (not just the glass of the test tube) is producing a bright orange-red glow throughout the mixture. Be patient, it may take 5 or more minutes for the mixture to reach this stage. Confirm with your instructor when it has reached this stage (to be sure the reaction has proceeded). Immerse the hot end of the tube into the bowl of water before it has a chance to cool. This will break the end of the tube, and there will be a small but exciting steam explosion!

9. Carefully throw the broken glass of the test tube (but not the new compound you just created!) into one of the white glass disposal bins in the lab. Using the cooled material that was in the test tube, repeat the tests you performed on the original iron and sulfur mixture (examining with a magnifying lens, checking the magnetic properties, and mixing with distilled water in a large clean test tube). Record your observations in Table 1.

Clean all the permanent glassware and return all the materials to your kit in a neat and tidy manner. Leave the laboratory counter neat and in a condition that you could walk in and begin work immediately if you were in the next lab section. Thank you!

Table 1: Observations of iron/sulfur mixture.

Material	Viewed with magnifying glass	Tested with magnet	Properties in water
Before Heating			
After Heating			

Questions:

1. At what point did a chemical change occur? How could you tell?

2. Based on what you have observed in this laboratory exercise, write a conclusion to the experiment that summarizes how a chemical change differs from a physical change.

Lab 5: Balancing Chemical Equations

Balanced **chemical equations** are used to describe chemical reactions. This equation tells what substances are involved as reactants and what substances are formed as products. In addition, the relative proportions of molecules of each of the substances are specified. The coefficients in the balanced equation give the **mole ratios**(comparing the number of molecules) of the various substances. From these mole ratios, the quantities of reactants required to produce a certain quantity of product can be determined as well as how much product can be expected when given quantities of reactants are utilized.

1. Balance the chemical equations listed below, by placing the correct coefficient in the space provided in front of each substance.

____ Mg	+	____ O_2	→	____ MgO			
magnesium		oxygen		magnesium oxide			
____ KIO_3	→	____ KIO_2	+	____ O_2			
potassium iodate		potassium iodide		oxygen			
____ $AgNO_3$	+	____ Cu	→	____ $CuNO_3$	+	____ Ag	
silver nitrate		copper		copper nitrate		silver	
___ $AgNO_3$	+	___ $NaCl$	→	___ $AgCl$	+	___ $NaNO_3$	
silver nitrate		sodium chloride		silver chloride		sodium nitrate	

Part A – Cooking with Chemistry

Although you probably have never thought about it, you carry out chemical reactions frequently in your kitchen—otherwise called cooking. In many chemical reactions, one reactant is present in a quantity that will limit the amount of products that can be formed. This reactant is called the **limiting reactant**. The concept of a limiting reactant will be explored by preparing a confection called S'MORES which is a well-known camper's delight. S'mores (Sm) are a concoction of graham crackers (Gc), marshmallows (M), and chocolate pieces (Cp). The recipe can be written in the form of a chemical equation:

$$\mathbf{2\ Gc + 1\ M + 3\ Cp \rightarrow 1\ Gc_2MCp_3}$$

Where the reactants (ingredients) are: Gc = graham cracker
M = marshmallow
Cp = chocolate piece

And the product is: Gc_2MCp_3 = a s'more

If you were camping, you would make a s'more by toasting a marshmallow on a stick over the campfire and then putting it between two graham cracker halves with three chocolate pieces. When the graham cracker pieces are pressed together, the hot marshmallow melts the chocolate and a gooey treat results. (*You will not be allowed to eat any of your s'mores due to OSHA regulations and standard laboratory safety procedures.)* This part of the lab explores the results of adding proportions which differ from those specified by the balanced equation for a chemical reaction. From different combinations of reactants, you will predict the maximum numbers of s'mores which can be prepared and test your prediction.

Procedure:

There are six different s'more stations labeled "A" through "F". Be sure that *all* the reactants for each bag at each station are put back into the bag before proceeding to the next station. Recall, the proportions of reactants which follow the balanced equation above. Record your results in Table 1 on pg 5.5

1. First use to s'more station A. From the above proportions, determine how many s'mores you can make from the reactants provided. Write a balanced equation for the reactants in this bag, including leftovers. Test your prediction by assembling the reactants into s'mores.
2. Using the reactants in station B, predict the maximum number of s'mores which you will be able to prepare. Again, write the equation and test.
3. Repeat Step 2 using the reactants in the stations C, D, and E.

Table 1: S'mores reactions

	Reactants present	predicted yield	actual yield
A			
B			
C			
D			
E			
F			

4. Write a unit conversion $\frac{\text{S' mores}}{\text{Reactant}}$ for each reactant:

5. Predict the maximum number of s'mores which can be prepared using the reactants in station F. Unit conversion calculations for Station F:

Identify the limiting reactant in station F.

Lab 6: Sedimentary Rock Identification

Part A – Overview of Minerals in Sedimentary Rocks

As noted in the introduction, a small number of minerals are commonly associated with sedimentary rocks, including **quartz** (SiO_2), **potassium feldspar** ($KAlSi_3O_8$), **plagioclase feldspar** ($NaAlSi_3O_8$, $CaAl_2Si_2O_8$), **mica** (**muscovite** and **biotite**), **calcite** ($CaCO_3$), **halite** (NaCl), and **gypsum** ($CaSO_4 \cdot H_2O$). Table 2 is a summary of the diagnostic (i.e. distinguishing) physical properties that are used to identify these minerals. Use the set of mineral identification tools (Table 2, nails, pennies, dilute HCl, your eyes and intellect) and identify the names of the set of unknown mineral samples provided. List your results in Table 1.
(NOTE: There is one example of each mineral, so use the process of elimination to your advantage!)

Table 1: Identification of minerals commonly associated with sedimentary rocks.

Sample Number	List of Diagnostic Properties (Used to Identify Each Mineral)	Mineral Name
#3		
#5		
#6		
#8		
#10		
#13		
#14		
#15		

Table 2: Common sedimentary minerals and their diagnostic physical properties

Mineral Name	Diagnostic Physical Properties
Quartz	Harder than glass (specimen will scratch glass)
SiO_2	Glassy to waxy surface appearance (luster)
	Various colors of milky white, clear, smoky gray, rose
Potassium Feldspar	Harder than glass (specimen will scratch glass)
$KAlSi_3O_8$	Breaks into blocky, angular pieces
	(two directions of cleavage at 90^o)
	Common varieties are salmon pink or white in color
Plagioclase Feldspar	Harder than glass (specimen will scratch glass)
$NaAlSi_3O_8$,$CaAl_2Si_2O_8$	Breaks into blocky, angular pieces
	(two directions of cleavage at 90^o)
	Whitish to medium gray in color
	Parallel striations (lines) commonly visible
Mica	Softer than fingernail (fingernail will scratch specimen)
$K[Al_2/(Mg_3, Fe_3)]_,(AlSi_3O_{10})(OH)_2$	Breaks into thin sheets/flakes, book-like occurrence
Muscovite Mica:	Clear to silvery in color. Breaks into thin silvery flakes
Biotite Mica:	Brown to black in color. Breaks into thin, dark flakes
Calcite	Softer than a penny, harder than fingernail
$CaCO_3$	Breaks into rhombohedra (three directions of cleavage)
	Whitish in color
	Fizzes in dilute hydrochloricacid
	(the "fizzing" is the result of CO_2 release)
Halite	Softer than a penny, harder than fingernail
NaCl	Breaks into cubes (three directions of cleavage)
	Clear in color, tastes salty (Don't lick lab samples!)
Gypsum	Very soft, scratches easily with fingernail
$CaSO_4{\cdot}H_2O$	Clear to white to pink in color
	May show three directions of cleavage

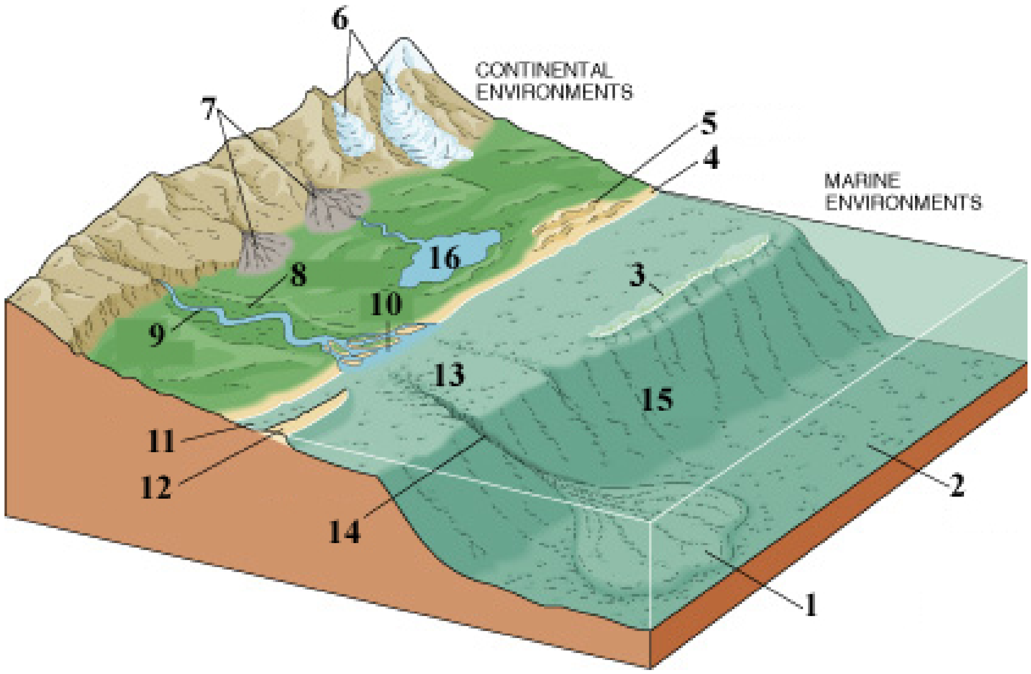


Figure 1: Environments in which sediments are deposited. The diagram is not to scale.

1	Abyssal Fan	9	River Channel
2	Deep Sea Floor	10	Delta
3	Reef	11	Lagoon
4	Beach	12	Barrier Island
5	Sand Dunes	13	Continental Shelf
6	Glaciers	14	Submarine Canyon
7	Alluvial Fans	15	Continental Slope
8	Flood Plain	16	Lake

You will refer to this diagram in the post-lab exercise. Concentrate on the energy of the environment, and the characteristics of the rocks that would form there. Think about the way the environment would transport sediment grains, the size, sorting and shape of the grains, the surface features that may be preserved, etc. You may want to look up some of the terms listed in the diagram in your textbook or from other sources.

1. Study Figure 1 (previous page) and list at least two environments where the following sedimentary rocks would be deposited. Think about the energy necessary to transport the grains. Describe the overall characteristic of the depositional environment for each rock type.

a. **SANDSTONE**

b. **SHALE**

c. **LIMESTONE**

d. **Lab 7:Rivers and Topographic Maps**

Acitivity 1: The Willamette River

1. Describe stream gradient in your own words.

2. How can you determine the stream gradient from a topographic map? What information do you need to know? Express stream gradient mathematically.

3. On the **Chucksney Mountain, OR Quadrangle**, determine the gradient of <u>a tributary</u> of the North Fork of the Middle Fork of the Willamette River. Look in the southwest corner of the map, and find a stream that drains into the fork of the Willamette. Show your calculations. Also, state the type of channel (see previous page for channel descriptions).

4. Determine the gradient of the Willamette River on the **Salem, OR Quadrangle**, between Beardsley Bar and Doves Bar. Show your calculations and describe the channel type.

5. Use information on the **Sauvie Island, OR Quadrangle** to determine the gradient of the Columbia River between the mouth of the Willamette River and the point where it enters the Pacific Ocean. Assume the distance between these locations is 100 hundred miles. (Hint: what is the elevation of the mouth of the Columbia River?) Show your calculations.

6. Study the gradient, channel type, and channel size of the three segments of the Willamette/Columbia River system. Write a brief paragraph summarizing how these variables change as you move downstream in a river system.

Activity 2: River Features

Examine the **Monmouth, Oregon Quadrangle**, which shows many features associated with a moderately large river, and answer the following questions.

1. Locate the area along the Willamette River east of Independence. What is name given to this river-formed feature? (HINT: Refer to the discussion of channel features earlier in lab.)

2. Is this feature likely to change its shape/position in the future? In which direction will it migrate and how can you tell? Should folks in Independence be worried?

3. Where would you expect an oxbow lake to form on the Luckiamute River in the near future? Describe location with direction and distance from landmarks. Why did you pick this location?

4. Several stream terraces are located along the course of the Willamette River associated with periods of deposition and incision of the valley floor during the Quaternary. Using the Monmouth quadrangle, try to locate at least two (there are more) of these terraces by stating their general location and an approximate elevation.

5. Sketch a **topographic profile** (cross section) from the top of Davidson Hill southwest across the valley of the Luckiamute River (south central portion of map). Indicate the type of materials (solid bedrock and alluvial sediment) you would expect to find underlying various portions of your cross section, based on their relative elevation, slope, and position with respect to the Luckiamute River.

Lab 8: Stream Table Experiment on Sediment Transport

Determine Effect of Flow Velocity on Mode of Sediment Transport and Stream Competence
Visible sediment grains move through a channel as either bed load (rolling, sliding, or saltation (i.e., bouncing like a jumping bean)) or suspended load. Reduce the discharge to a minimum by pinching the tube so the current is moving only a few grains.

In the table below, record how the **sand-sized sediment** is being transported under **Low** flow conditions. Use some chalk dust to observe suspended load transport under **Low** flow conditions.

Increase the discharge to a **Medium** flow by squeezing the tube about half way. Again record your observations for how the **sand-sized sediment** moving.

Increase the discharge to **High** flow by releasing the tube completely. Once again, record on the table how the sand-sized grains are moving.

Table 1: Sediment Transport. Record how the sand-sized sediment is being transport for each condition.

Discharge Condition	**Sand-Sized Bed Load**		
	Sliding	**Rolling**	**Saltation**
LOW			
MEDIUM			
HIGH			

Question:

1. Describe how the transport mode and behavior of sand changed under each new flow condition. Consider the amount of grains moving and how the transport mode changed with increasing discharge.