

**Physical Science Unit- Friction, Motion**

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**Notes on Unit**

I would just like to mention a few things about this unit. When I designed it I was looking for something I could use in my room full of 9-12 graders. It seems wide and encompassing and indeed it is. I spent nearly a quarter going over this material and things were included before and during these LCMs that are important to the understanding of the principles involved but are not included anywhere in this work. I think it will take teachers with some knowledge or that are a day ahead and studying to really get much use from this unit. However it is my hope that everyone will be able to take and use something from it. The unit worked well for me in that everyone got something out of it and it allowed my seniors and juniors an opportunity to develop a deeper understanding than they normally would, while still allowing the lower classes to participate and develop some understanding. It DOES take time!! Some excellent info on bow drills can be found on the web site mentioned on the Bow Drill Activity page.

## LCM Lesson Plan 1

Performance Standards- A5, A6

Science Concept- Force, Motion, Speed, Velocity, Air Resistance (Fluid Friction)

**Gear Up-** Demo of a paper airplane, start discussion of change in position over time. (motion) Decide as a group whether or not the plane traveled at the same speed throughout its flight (constant speed or Average) Discuss how we would calculate the planes speed. *Process skills- observing, communicating*

**Explore-** Give each student 2 pieces of paper, 4 paper clips, 12 inches of tape and have them design a paper airplane that they think will be able to achieve the highest speed in the group. Allow time for designing and testing different planes. *Process Skills- observing, inferring, making models*

**Generalize-** 1. How can you design your plane to achieve maximum speed and distance?  
2. Think about your flight path, what factors will ultimately determine your planes speed?  
*Process skills- inferring, predicting*

**Experiment-** After the students are comfortable with the design of their planes take them to the gym for flight trials. Each student will get three initial trials. All trials will be timed and the distance from release to impact will be measured. After all students have had 3 attempts return to the class and allow students 20 minutes to redesign to try to achieve higher speeds. Return to the gym for 2 more trials with the “new” designs again measuring time and distance. *Process skills- measuring, collecting data, hypothesizing, investigating, controlling variables*

**Interpret-** Students will use the formula  $\text{speed} = \text{distance} / \text{time}$  to calculate the speed of each of their trials. They will graph their data and compare it to given graphs of constant and average speed. They will compare their graphs/ speeds/ plane designs with their classmates and try to identify as a class things that “came together” to help achieve top speeds. Additionally they will discuss where forces were involved in the experiment (previous knowledge). *Process skills- communicating, interpreting data, making graphs*

**Apply-** Identify similarities between our planes and the bush planes. Discuss general aircraft design. Discuss why straight-line flight produced higher speeds and why a hard throw of just a few meters could be the fastest flight of the day. Bring the idea of linear and rotational motion into play. You could also discuss boat design. *Process skills- inferring, communicating, predicting*

**Extensions-** Apply to a different kind of fluid friction (design watercraft).

## LCM Lesson Plan 2

Performance Standards- A5, A6

Science Concept- Force, velocity, Acceleration, momentum, Friction, Gravity, Inertia

**Gear up-** Review force (a push or a pull), velocity (simply speed in a given direction), Acceleration (change in velocity over time) Friction (a force opposing (OPPOSITE) motion) Gravity (attraction of mass of earth 9.8m/s/s) and Momentum (mass x velocity) Inertia (resistance to a change in motion). Examples are great, we have a ton of hunters so I bring in ballistics tables for a couple of common calibers and we use them in our discussion of force (expanding gasses push), velocity (out the barrel), acceleration (0 fps to 3,000 fps in the length of a barrel), Momentum (compare bullet to 4 wheeler) and friction (down the barrel and air resistance), and Gravity (if fired horizontal to the surface of the earth it will hit the ground at the same time as a bullet dropped straight down.)

*Process skills- communicating, inferring, interpreting data*

**Explore-** Have students play catch with balls of varying weights. Do some feel like they hit your hand harder than others? Have them walk with one ball and toss it straight up and down to themselves. Repeat with a ball of a different weight, tossing different heights and walking at different speeds. *Process skills- inferring, observing*

**Generalize-** 1. What happens when you toss the ball straight up and move at a high speed? Can you catch the ball? Why or why not? Does the weight of the ball seem to matter? The height of the throw? What happens if just after you toss the ball up you make a sharp turn? Can you catch the ball? *Process skills- hypothesizing, predicting, inferring*

**Experiment-** Make several different size and weights of balls available to students. Then challenge them to answer the questions such as. If you are standing still and throw the ball up 2 or 3 meters does it land in your hand? Walk at a constant speed and repeat. Repeat but this time when you are walking at a constant speed stop instantly just after you release the ball. Where does it land? Repeat again but this time just after you toss the ball up run as fast as you can. Where does the ball land? Try again but this time make a sharp turn just after you toss the ball straight up. *Process skills- observing, collecting data, investigating, controlling variables*

**Interpret-** Explain what happened in each instance, why did it happen this way? Discuss with your classmates. Did the mass of the ball matter? Why or why not? Was Isaac Newton correct when he said that an object in motion would stay in motion unless acted upon by an outside force? What forces were at work here? *Process skills- communicating, inferring, defining operationally*

**Apply-** Identify places where knowledge of this law of motion may be beneficial (seat belts are great!) Connections can also be made to sports with a minimum of trouble. *Process skills- interpreting data, inferring*

**Extensions-** It is very simple to connect momentum with seat belts and forces. For example you can calculate the strength necessary in a bolt holding the seat belt together. This example will tie many concepts together such as force, momentum, mass velocity and Newton's laws of motion.

LCM Lesson Plan 3  
Performance Standards- A5, A6  
Science concept- Force, Friction,

**Gear Up-** Quick discussion of the types of friction (sliding, fluid, rolling). Demonstrate bow drill and talk about different types of friction (all three can be discussed in relation to the drill) *Process skills- observing, hypothesizing, communicating*

**Explore-** Have students rub their hands together quickly to produce heat, Then give them several materials to place on their hands and again have them rub them together. Materials should include something rough like sand, and a fluid (Vaseline works great). Have them vary the pressure they use when rubbing their hands together. Next have them pull a sled on the sand using a spring scale. Then a wagon of approx. equal mass and wheels. *Process skills- inferring, hypothesizing,*

**Generalize-** 1. Which type of friction is the hardest to over come? Which makes it easier for us to do work? Can we combine the effects of different types? *Process skills- inferring, hypothesizing*

**Experiment-** Students will use the friction board device (wooden under board, a block with a hook and string attached capable of having weights added attached to a spring scale) students will experiment by adding/ removing sand paper from the surfaces. They will also use Vaseline in an attempt to lessen the force (as measured by the scale) required to move the block. They will also change the weight several times to determine its effect on friction.

*Process skills- measuring, controlling variables, investigating, collecting data, interpreting data, defining operationally, observing*

**Interpret-** student groups will decide how they think mass, surface characteristics, and sliding and fluid friction affect movement. They will graph the average force required to move the block under several sets of conditions (rough, smooth surfaces, more less weight, fluid layer or not) Students will also compare and discuss their results with the class. *Process skills- making graphs, defining operationally, communicating,*

**Apply-** Connect with how have we applied this knowledge to help us in our daily lives? Engines have sliding, rolling and fluid friction. Anything that moves has to deal with fluid friction. We have used wheels (rolling friction) on many things. *Process skills- communicating, inferring*

**Extensions-** How would things be different if there was no friction? The possibilities here are endless. Examples would be ways we increase friction (studs on tires, sanding icy spots, making the road surface rough) Ways we decrease friction (wheels, bearings, Grease) and all the places we apply these concepts.

## Bow Drill Activity (Abe Horpestad)

During this activity students will apply knowledge of force and friction to successfully start a fire using a bow drill.

**NOTE-** a great resource on making and using a bow drill is on the Tracker Trail Web Site- "[Primitive Survival Skills](http://www.wmuma.com/tracker/skills/fire/bowdrill/basicbowdrill.html)" - **Basic Bow-drill** By **Peter Moc** you can find it at [www.wmuma.com/tracker/skills/fire/bowdrill/basicbowdrill.html](http://www.wmuma.com/tracker/skills/fire/bowdrill/basicbowdrill.html) It is a great starting point for those with limited experience in the actual making of the drill. I used information from it a lot during my first few days of instruction.

After 2 days of instruction on materials and techniques students will be given the opportunity to gather raw materials, fashion them into the required tools and start a fire.

The students will have to demonstrate:

1. They can gather the required materials
  - a. tinder-dry,
  - b. A spindle-straight of the proper length
  - c. A bow of the right length and slightly curved with adequate cord
  - d. A base board of the right material, composition and thickness
  - e. A hand hold that has small frictional resistance
2. They can turn their raw materials into the required tools by shaping or otherwise modifying them.
3. They must demonstrate the proper technique.
  - a. Without proper technique they cannot be successful.
  - b. Kneeling position with handhold arm braced against inside of knee.
  - c. String placed properly on the spindle
  - d. Proper stroke in relation to the spindle and bow
4. Results
  - A. Students will attempt to build a fire using as many attempts as time allows. They will need to show at least some success, either by producing a coal, smoke or hopefully a fire.
  - B. A student will have to show understanding of the science behind the bow drill; this will be done by successful completion of the drill project, especially adjustments made to their apparatus. It will also be done by completing an essay question in which they will attempt to relate as many of the related principles together as they can.

**Bow Drill Assessment Rubric** (Abe Horpestad)

	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
Tinder/ Materials Gathering	Student lacks understanding Of materials requirements,  Materials not gathered	<i>Student shows some understanding of materials requirements (50%are correct)</i>  Less than 3 required materials gathered	<i>Student has understanding of materials requirements (75%are correct)</i>  Gathers all materials but some more than 50% are poorly suited	<i>Student has excellent understanding of materials requirements (90% are correct)</i>  Student gathers all necessary materials, and all are suited to the activity
Construction Bow Base Board Spindle Hand Hold Tinder Nest	No effort Materials are not constructed	<i>Necessary materials are absent</i>  Or 50% are poorly constructed or chosen	Student has adequate tools but at least 3 are flawed	Student has great tools ready for use with 1 or fewer flaws
Technique	Student has little or no Technique,  Student lacks understanding of Principals involved	Student has some understanding of principles involved, but lacks 2 or more key techniques, and thus fire is improbable	Student has adequate technique 1 or fewer flaws and a good understanding of the principles involved	Student demonstrates no flaws in technique and has made at least 1 adjustment demonstrating understanding of principles involved
Results	No smoke, fire or coal is Evident after 10 attempts	Smoke may be evident Or a coal may be formed After 10 attempts	A coal is formed, hot or not, or smoke is evident after 5 attempts	A student can make a fire in less than 10 attempts
Understanding of principles	Student does not successfully connect any principles to bow drill operation	Student can connect 3 or fewer principles to bow drill operation	Student can connect 4 or 5 principles to bow drill operation	Student can connect more than 5 principles to bow drill operation

## Bow Drill Rubric – NOTES

This is an explanation of things covered on the rubric,

Each item under principles will count as 1 principle for grading the essay. Example, 6 items are under energy, if all six were mentioned then student would receive a 4 for PRINCIPLES.

1. Required Materials include-
  - A. Spindle
  - B. Bow
  - C. Base board
  - D. Hand hold
  - E. Tinder
  
2. Materials Requirements-
  - A. Spindle- 1. Straight and smooth enough to rotate freely, 2. tips must be pointed depending on baseboard and hand hold 3. Dry
  - B. Bow- 1. Curved enough to allow spindle to rotate on the inside of the curve, 2. Strong enough to turn spindle without breaking 3. Needs to have a place on each end to attach the rope and prevent it from slipping.
  - C. Base board- 1. One-half to 2 inches thick, 2. dry 3. flat enough to be able to hold still enough to form a coal 4. no rot. 5. Notch cut in proper size to catch shavings and form a coal
  - D. Hand hold- 1. Hard enough to hold it's shape and soft enough to form, 2. Should fit comfortably into the palm of the hand 3. Should have a deep enough socket to hold the spindle securely when it turns 4. Smooth enough to reduce friction at the top of the spindle.
  - E. Tinder- 1. Dry and flammable
  
3. Poorly suited, constructed, chosen or flawed- less than 70% of the materials requirements are met.
  
4. Technique-
  - A. Spindle turns on inside of bow
  - B. Knee used to brace hand hold hand
  - C. Weight directly above spindle
  - D. Bow moves vertically on every stroke to prevent rope burn and binding
  - E. Notch cut in base board, or base board split that works at collecting coal material
  
4. Principles involved-
  - A. Friction-
    1. Working at hand hold spindle junction should be reduced
    2. Working at spindle base board junction should be magnified
    3. Must be enough at bow spindle intersection to turn spindle with force but must not bind.

- B. Force- is transferred from the bow to the spindle,
  - 2. The spindle works as a wheel and axle
- C. Rotational velocity- at first velocity should be less until the wood shavings form a lump in the base board notch, then velocity should be increased until the coal reaches 451 degrees (temp of combustion)
- D. Energy-
  - 1. Mechanical energy put in by operator
  - 2. Mechanical energy is energy of motion (kinetic)
  - 3. Kinetic energy changed to heat energy by friction
  - 4. Chemical (potential) energy of tinder and base board changed to heat energy
  - 5. Mechanical energy can be changed to heat energy by friction
  - 6. If not enough heat energy is produced you can increase it by putting more work in (increasing speed or velocity)
- E. Gravity- can be used to increase the force and therefore the friction and in turn the heat energy

Name \_\_\_\_\_

Date \_\_\_\_\_

### Bow Drill Sheet One

1. What are the five parts of a bow drill set?
2. What should the dimensions of the baseboard, and spindle be?
3. How long should the string be on your bow?
4. How many people operate a bow drill?
5. What is burning in? Is there another way to do this (form a hand hold)?
6. What should the notch you cut in the baseboard look like?
7. How could you lubricate your handhold spindle junction if you were in the wilderness with no materials?
8. Describe the first stage in getting a coal. What is it called?
9. Describe the second stage in getting a coal, what is it called?

10. Describe a possible problem if your powder is:

A. Light brown and dusty-

B. Light brown and fuzzy-

C. Dark Brown/ black and fuzzy-

D. Dark brown/ black with little rolls-

E. Dark brown/ black and crusty-

11. Name and explain 2 things you can do to increase the spindle speed.

12. Why might you need to increase the spindle speed?

13. Describe 3 ways the principle of friction is involved in making the bow drill.

14. What three requirements for the spindle will you be graded on?

15. What three requirements for the bow will you be graded on?

16. What 5 requirements for the baseboard will you be graded on?

17. What 4 requirements for the handhold will you be graded on?

18. What is the only requirement you will be graded on for the tinder?
  
19. How will you be graded on tinder/ materials gathering if you gather only 2 on YOUR OWN materials?
  
20. How would you score a baseboard that met only 3 of the 5 requirements?
  
21. How would a student score on technique who does not get his or her weight over the spindle?

## Bow Drill Final

NAME \_\_\_\_\_

DATE \_\_\_\_\_

### THE BIG QUESTION!!

Explain why the bow drill works using and explaining the relevance of as many of the following terms as you can. Potential, chemical, kinetic, mechanical, heat, energy, friction, conversion, velocity, motion, speed, work, force, gravity. A diagram may be a good way to begin!