



# Village Science

Teacher's Edition

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# To The Teacher

This book is written after the first edition worked it's way across Alaska and parts of Canada for over fifteen years.

The first edition was primitive, written after my first year teaching. However, I had lived a subsistence lifestyle in the Alaskan bush for fifteen years before that. I have rewritten almost every word, but the concepts and applications remain the same.

While this new effort reflects the best that I can currently offer, I hope many people receive it as inspiration and go on to surpass me in all regards.

## **Text**

The textual materials are straightforward. I could have embellished more, explained more, included more verbage, but instead I chose to be concise. In that regard, I have sometimes oversimplified. My goal at this time is to inspire students to find science in their local environment. It is not to be the last step on the way to Harvard. You will find much information in the text that is nowhere else in print. Please feel free to validate or invalidate that information in your community as you interact with the knowledge base of that community.

## **Activities**

My intention was to drive the students into the community with the questions that will prompt meaningful discussion with the local experts and elders, stirring memories. This is where most of the learning will take place in each lesson.

All of the activities have a specific purpose, a fact, a concept or principle behind the directive. I have included in this teacher's edition some tips and hints for the activities, but hopefully your local situation will create greater insights than I have to offer.

Caution: There are few activities that do not have potential danger. They reflect village life which is full of hazards. Rather than avoid them, this book provides the teacher with the opportunity to stress safety. I haven't identified all the hazardous activities or this book would be quite a bit longer. Use caution in every regard, particularly with gasoline.

## Student Responses

These questions are basic recall and comprehension, straight out of the text. The teachers' answers are printed in a separate booklet. If you did not receive the booklet with this publication, contact the Alaska Native Knowledge Network, P.O. Box 756730, Fairbanks, Alaska 99775-6730.

## Math

Some of these questions are quite hard. They are real-life questions that might have to be modeled on the board. Many will require higher-level math skills than the students have. Some might require higher level math skills than the teacher has.

Most of these are real life problems I wrestled with in thirty-three years of living in the Alaskan bush.

## How to use this book

It is possible to read a chapter and do the questions at the end just like any other text. However, I think the essence of this book lies in the activities.

There is no particular order in which these lessons need to be done. However, I would recommend that you consider the seasons, saving outboard motors for the spring, and doing winter trails at the appropriate time. It would be good to do all the components of engine lessons at the same time, as they make up a whole. They aren't vod ed lessons. Each one is embedded with science concepts and locally relevant knowledge.

## Physical vs. Life science

Physical sciences are not more important than the life sciences, but are a healthy prerequisite. It is easy to understand the burser in a caribou joint after studying friction on a larger scale. It is easy to understand why rabbits have long intestines when the concept of surface area is part of one's reality. Knowing physical science concepts takes life science efforts out of the realm of memorization and places it in the realm of understanding and application.

## Thematic teaching

Science can be the core of a fun-filled day, month, or school year. Writing, math, social studies, art, and other subjects are easily woven in and through the life process that is known as discovery, or more formally, science.

Thank you for using this book. My hope is that your life and the lives of the students will be changed by it, opening up further the realm of using the local environment to explore science.

Sincerely,

Alan Dick

## Part I

# Skill, Tools, & Craftsmanship

## Cutting & Drying Fish

### Activities

1. Look at and discuss the smokehouse locations in and around the village. What do they have in common? In what ways are they different? Find some of the older fishcamp sites in your area. Why were they located there?

*Nowadays many people have smokehouses located close to their homes where the fire can be tended easily. Smokehouses double as storage sheds in other seasons. Older fishcamp sites are located in dry windy locations with close access to the fish net or wheel.*

2. What are the common materials for smokehouse roofing and siding? Are the roofs relatively flat or do they have a steep pitch?

*People now use steel, although it gets hot. Steel is durable and sheds snow. Bark is cool, but doesn't last long at all. Most smokehouse roofs are still rather flat pitch.*

3. Ask what local wood is used for smudge fire. What is that fire called in your village?

*Smudge wood is usually whatever is local and plentiful. Only in Kodiak have I seen spruce used. Other places use birch, willow, alder etc.*

4. Ask people in your village what changes they make in their drying process when the weather turns bad.

*Cut the fish thinner so they can dry faster.*

5. Do people in your village usually bring the fish right into the smokehouse after cutting or do they leave them on poles outside for a few days to get a dry crust?

*Usually dogfeed is hung outside for several days to get a dry crust before being brought into the smokehouse. Eating fish is brought straight into the smokehouse, but this varies from area to area.*

6. Make a trap for blowflies like a fishtrap. Use a jar with a screen for the funnel. Use a piece of sour fish for bait. Can you reduce the number of blowflies in your area?

*A large jar with a screen funnel works well. It is hard to reduce the number of blowflies. They keep coming and coming...*



7. Cut a fish into three pieces. Put one in the freezer. Score the other and hang it to dry. Leave the third one, as it is, in a warm place. In a day or two, compare the three. What can you say about preserving fish?

*The frozen fish will not rot because the bacteria can't multiply when the temperature is so low. The dried fish will not rot because the water content of the fish is reduced so bacteria cannot multiply. The other fish will rot in a short time.*

8. Leave a fish outside where blowflies can lay their eggs. Once the maggots start to crawl around, bring the fish into the smokehouse and put the fish directly into the smoke. Does the smoke get rid of the maggots? Does the fish ever dry properly? What can you say about prevention being better than a cure?

*Once the maggots are on the fish, smoke will not get rid of them. The fish will not dry properly. The maggots seem to make their own moist pockets. Prevention of maggot infestation is the only solution. Some oldtimers used to scrape the maggots out with a spoon, but no one seems to have that kind of patience any more.*

9. Get samples of different people's fish throughout the village. Being careful not to insult someone's cutting style, compare them. Compare dog fish and eating fish.

*Be careful no family is insulted.*

10. Why do people cut king salmon in strips rather than flat like red salmon or other eating fish?

*King salmon are too big to cut like blanket fish. The each side would be too thick and would spoil, or too much meat would have to be left on the backbone.*

11. Try to find some dry dog fish that has the evidence of maggots. Can you see and smell the difference from that part and other unspoiled parts?

*The place looks like it was once infected. It has a foul smell even after it is dry.*

12. Ask someone how to cut whitefish in the fall. How is this different from salmon in the summer? Why do you think there are differences? Distinguish between cutting whitefish for dogs and for people.

*Whitefish cut in the fall don't need as much surface area exposed as the temperature is much cooler. In cutting for dogs it is actually better to have the fish sour a little.*

13. Hang fish on a spruce, birch, or willow pole. Can you tell the difference in terms of friction between the pole and fish?

*Spruce is much rougher. Birch and willow are quite slippery. The fish are apt to fall.*

14. How are salmon bundled and stored in your village. If this is a thing of the past, ask how it used to be done.

*A few people still bundle fish. We used to buy and sell dogfeed in bundles of forty. Now most people put them loose in the cache or leave them hanging in the smokehouse.*

15. Why do people make and use fishrafts? In your village, what do they use on top of the cutting table to keep the fish from slipping around?

*Fishrafts make cleaning fish much easier, and they keep the fish from spoiling until they are cut. Fish exposed to the sun spoil within a few hours.*

16. Find out about the fermenting methods used in your village for preparing fish heads. Have you ever tried "smelly heads?"

*People still eat "smelly heads," although they are careful not to eat too many. Most often they are buried in a pit lined with birchbark. Some people put fireweed leaves in with the heads. The fish can be dug up much later and used as food, although other means of preserving food have replaced this method.*

## Student Response

1. What are the two oppositions of those trying to dry fish?

*Blowflies and bacteria that causes rotting*

2. What keeps blowflies away?

*Smoke*

3. What requirements are there for fish to rot?

*Moisture and heat.*

Which of these is the easiest to remove?

*Easier to remove moisture. Some coastal villages are dry enough with sufficient wind that smokehouses aren't necessary.*

4. What are the factors that determine how we cut and prepare fish?

*The weather is the main thing. Location of smokehouse is also important*

5. Why is a good roof so important for a smokehouse?

*If the roof leaks, the fish can become damp again, allowing blowflies a second chance and rotting to occur.*

6. What are some of the better materials for smokehouse sides? Why is sheet iron not the best?

*Boards, slabs, spruce bark, brush, solid color plastic tarps. Sheet iron is too hot and promotes rotting.*

7. Describe what makes a location good for a smokehouse.

*Cool dry air, not much moisture in the ground. Clear the area of brush. This allows fresh air to circulate around the smokehouse.*

8. What is the secret of drying fish?

*Cool dry surroundings with enough smoke to keep flies out*

9. \_\_\_\_\_ is increased when we cut fish. This speeds the drying process.

*Surface area. There is more surface from which the fish can allow moisture to evaporate*

10. What changes need to be made in the way fish are cut during wet weather?

*Less meat on the fish to be hung. Leave more on the backbone. The thinner fish will dry before rotting*

11. What changes might be made in the smudge wood during rainy weather?

*More heat to dry the fish. While heat is normally avoided, some is necessary in rainy weather.*

12. What type of tree makes the best fishpole? Why?

*Spruce. The bark is rough enough to hold the fish on the pole.*

13. Describe one way of bundling and storing fish.

*There are lots of ways. The main idea is to bundle dogfeed tightly in bundles that are easy to count—20, 40, etc. All fish should be stored in a well-vented cache with a good roof. The fish will stay dry and will not mold.*

## Math

1. Nick has 7 dogs. He figures that he needs 1 fish per day for each dog from freezeup to breakup, from October 1 through May 7. How many fish does he need to dry for the winter? (He can feed them fresh fish from his net during the summer.)

*1561*

2. Nick manages to get 1,400 fish. He gives away 2 dogs on January 1. Will he have enough fish to get through breakup on May 7?

*Yes. He will need 1561 minus  $(31 \times 4 + 7)2$  or 1299 fish*

3. Marjory has 5 dogs to feed from October 1 through May 7. She plans to cook for her dogs, supplementing with oatmeal. She will only need a half a fish per day for each dog. She has 600 fish. Will she have enough fish to make it to breakup?

*Yes. She needs 540 fish and has 600.*

4. Nick (from problem #1) has a chance to go to work instead of fishing. He figures that he can make \$1,800 (after taxes) in the time he might be fishing. It costs 50 cents per day to feed a dog. Financially, is he better off fishing or going to work?

*Yes. If he buys fish it will cost \$108 per dog  $\times 7$  or \$756 to buy dogfeed. However, there are other considerations besides money. Family, what he enjoys the most, taxes etc.*

5. At 50 cents per day for commercial dog feed, how much does it cost to feed a dog from October 1 through May 7 for the life of the dog (12 years)?

*$\$108 \times 12 = \$1296$*

6. Henry's smokehouse has poles that are 6 feet long. Each pole can hold 9 fish on average. He counts the poles and finds that he has 127 poles full of fish. He needs 1400 fish to get his dogs through the winter. Can he stop fishing or should he fish more?

*Fish more. He only has 1143 fish.*

7. In Ed's village an average king salmon dries out to 5 pounds of strips. He has 90 pounds of strips, but he needs a total of 150 pounds to get through the winter if he will have enough to give away at Christmas. How many more king salmon does he need?

*12 kings*

# Sharpening

## Activities

**Note: In the following activities you are asked to use tools and blades. There is obvious danger. Be careful!**

1. Collect as many blades as you can. Identify tools for cutting wood, dirt, metal and food. Are they sharpened on one side or both? Look at the above edges with a strong magnifying glass. Draw several of them.

*Answers will vary.*

2. How thick are the edges? Can you find a relationship between the materials they cut and the thickness?

*Materials that cut dirt and metal will have a thicker edge than those that cut wood and meat.*

3. Try to sharpen all of the above tools with a file. Are some of the edges harder than others? What do people use to shape and sharpen the harder steel tools?

*Some steel is quite hard, like the carbide blade tip on a drill that drills concrete. Steel that cannot be filed can often be sharpened with a stone, but some metals are too hard for stones, and must be sharpened commercially.*

4. Carefully test the blade of a hand plane with a file. Are both sides equally hard?

*No the cutting edge is much harder than the back side.*

5. Tap the above blades with a piece of hard steel. Do any of them ring? (Small blades are hard to test.) What can you say about the steel that rings?

*Steel that rings is high carbon steel, and makes a good edge, although it isn't necessarily hard.*

6. Carefully test a dull knife in cutting wood. Bring that same knife to someone who knows how to sharpen. Ask that person to sharpen the knife for you. Try it again. Is the difference noticeable?

*Like night and day.*

7. Try cutting wood with a steak knife. What happens and why?

*Very difficult. The serrations on the steak knife are too rough to penetrate the wood.*

8. Try shaving a piece of wood with a razor designed for a man's face. Use gloves. What happens and why?

*The razor breaks because it is too thin.*

9. Try digging with a dull shovel, particularly in a place with grass or small roots. Sharpen the shovel. Do you notice any difference?

*Night and day.*

10. Look at a dull edge under a magnifying glass. How is it different from what you expected? Can you understand why pushing such a rough surface into your work is difficult? Now look at a sharp edge with the glass. Even this looks crude. Compare both blades in ten words or less.

*It is thick and quite rough. The sharp edge is much thinner, although the marks from the file or stone are obvious. It's a different world down there.*

11. Scissors don't cut the same way as a knife. Study scissors and describe how they cut.

*Scissors cut by shearing the material. They don't penetrate like a knife. They tear one half of the material from the other.*

12. Cut fish with a dull knife. Sharpen it and cut fish again. Estimate what percent of effort was saved by sharpening it.

*Night and day.*

13. Sharpen the chain and cut the same block, again timing the cut. What is the difference?

*A sharp saw could be two or three times faster. But time isn't the only consideration. Wear on the saw, bar, chain and operator are greatly reduced by a sharp saw.*

14. Ask in the village if anyone knows how to sharpen a Swede saw. Ask the person for instructions.

*There might be someone left who knows how. Inquire in other villages.*

15. Collect different files. What are the differences other than size? Put a piece of paper over the file and with a crayon or lead pencil do a "rubbing" of the file. Compare the imprints from the different files.

*There are many kinds of files. Some are rough. Some are smooth. Some are double and some are single cut.*

16. With an old file, file aluminum (like an old prop). What problem arises?

*Aluminum is soft and files easily, but the aluminum plugs the file.*

17. Compare the two sides of a sharpening stone. Which one is for faster and which one for finer sharpening?

*The difference is obvious. One side is rough and the other smooth. The main thing is to keep the file clean of dirt that plugs the pores and glazes the surface so it can't cut anything.*

18. Sharpen a knife for meat and finish the edge with a butcher's steel. Cut a little meat. Now try the same edge on wood. What do you notice? Strop the edge back and forth on a piece of leather for a while and then try again on both meat and wood. What do you notice? Which edge is better for meat, the rough or smooth one? Which is better for wood?

*The knife that is sharpened with the butcher steel will cut meat well, but will be too rough for wood. The edge that is stropped will be good for wood, but not quite as good on meat. Rough is better for meat, smooth better for wood.*

19. Students should each share a story of a time they cut themselves being careless with a tool.
20. Draw or trace a Swede saw blade identifying the two kinds of teeth. Describe to someone else how each of these relates to a modern chainsaw tooth.

*The V shaped teeth are like the side plate of the chainsaw tooth. The other teeth are like the top plate.*

21. Picture in your mind what would happen if a Swede saw blade had only this kind of teeth.



22. Picture what would happen if it had only this kind of teeth.



23. If you can get some beaver or muskrat teeth, test the front and back for hardness. Explain how they are self-sharpening.

*The front of the tooth is very hard. The back of the tooth is softer. The back wears faster than the front, therefore leaving the thin hard edge. As they are used they are self-sharpening.*

24. Picture in your mind what is happening when the rakers on a chainsaw chain aren't filed evenly. Can you imagine the jerking of the chain as some teeth bite deeper into the wood than others?

25. Put pressure on a bathroom scale with a fish cutting knife. Record how many pounds you can assert. Now put pressure with an ulu. How many times more pressure is possible with the ulu? Test the whole class. First let students estimate the test. How many times more pressure can the ulu put than the knife? Average the results. How does the knife serve as a lever?

*The ulu can usually put 4–5 times more pressure than the knife. If you think of the knife as a lever and your thumb on top as the fulcrum, you will see that the fish actually has a mechanical advantage over your hand.*

## Student Response

1. What happens when an edge is too thick?  
*It pushes the work away rather than penetrating the material*
2. What happens when an edge is too thin?  
*It cuts well, but breaks easily*
3. What are the three considerations in sharpening a tool?  
*At what angle is the edge formed?*  
*How thick or thin is the actual edge?*  
*How rough or smooth is the edge and sides of the blade?*
4. What two things determine how thick or thin an edge can be?  
*Hardness of the steel and the material being cut*
5. Draw a shovel blade sharpened for rocky ground. Draw one sharpened for ground with no rocks, but lots of roots.  
*The one for rocky soil will be thicker*
6. What is the difference between cutting meat and wood in terms of the friction of the blade?  
*A blade for cutting meat has a rougher edge. A blade for cutting wood has a smoother edge to reduce friction*
7. Draw a Swede saw blade. Which teeth are for cutting fibers and which for chiseling the severed fibers out of the cut?
8. Which is harder: a file or a sharpening \*stone?  
*A stone*
9. An axe of fairly soft steel has a hard spot. What might cause this?  
*Someone hit a rock with the axe and hardened the steel at that point.*
10. Why do people put oil or saliva on a sharpening stone?  
*To float the particles out of the stone so it does not plug and glaze over.*
11. Why do we put pressure only on the forward stroke of a file?  
*The teeth are strong when filing in a forward direction. If pressure is put on the file during the backstroke, it will fold the teeth over and damage them.*

12. Draw a chainsaw tooth. Label which part severs fibers. Which part chisels the fibers from the cut?

13. What do the rakers do on a chainsaw tooth? What happens if they are too high? Too low?

*The rakers determine how much each tooth bites into the wood. If they are too high, the teeth can't bite enough. If they are too low, each tooth will bite too much.*

14. Why should the height of the rakers be the same on all teeth?

*If they are irregular, they will bite unevenly, jerking and stressing the chain. Uneven rakers will also cause the saw to kick back.*

## Math

1. When Sal cuts fish she puts about 15 lbs pressure on her knife. She finds that sharpening reduces the surface area of her cutting edge by 30%. How much pressure will she apply to do the same work?

*10.5*

2. Hank can cut a block of wood in 30 seconds when his chainsaw is sharp. It takes 1.5 minutes when it is dull. If he can cut a tree into blocks in 25 minutes with a sharp saw, how long will it take with a dull saw?

*75 minutes (1 hour, fifteen minutes)*

3. Hank also discovered that he could increase the speed of ripping by 35% by filing the rakers on his saw from .025 to .040. If he could cut 350 board feet before, how much lumber can he cut with the rakers filed properly?

*472.5 board feet*

4. Hank estimated that it would take him 5 days to cut the lumber he needed. Once he filed the rakers, he cut 35% faster than expected. How long will it take him to cut the lumber now?  $[(x + .35x) = 5]$

*$x = 3.7$  days. Not  $5 - (.35 \times 5) = 3.25$*

## Nails, Pegs, & Lashings

### Activities

1. Make a nail collection. How many different kinds can you find?

2. Try to identify the different purposes of each of the above nails.

Try filing each nail. Are they harder or softer than the file?

*Some are harder than others.*

File or grind a galvanized nail in one place, exposing the metal underneath. Leave the nail in a warm, damp place with a galvanized nail that hasn't been filed. Does rust appear where the galvanize was removed?

*It should. The galvanize is just a coating.*

3. Find a building in town where the siding was nailed on with nails that weren't galvanized. Can you see the rust "bleeding" through the paint or down the side of the building?

*There should be many examples of nail heads rusting and "bleeding" down the side of a building.*

4. Experiment with different nails: long, short, smooth and rough. Can you determine why they are different? Drive each one into a board with the head slightly above the surface of the board. Pull them one by one. Do the ring nails or galvanized pull out easier or harder? Can you tell the difference?

*Ring nails should be a little harder than the galvanized, but the both of them are harder than smooth or sinker nails.*

5. Draw a nail that would hold two inches of foam to a wood surface? Imagine in your mind what would happen when the head of the nail pressed against the surface of the foam. How would you design a nail for this purpose?

*It would need a very large head, perhaps two inches in diameter.*

6. Drive nails into the end grain of a board. Do they hold as well, better or worse than cross grain?

*They don't hold as well in the end grain as they do cross grain.*

7. Look at the point of a spike (end view). Can you see how one side is tapered more than the other? Draw what you see.

8. Try the tricks mentioned in this chapter to prevent splitting at the end of a board. Do they help to keep the wood from splitting? Use green frozen lumber.

*They should.*

9. Listen to a good carpenter drive nails on a surface like a floor or roof. How is his nailing different from that of an inexperienced person (apart from speed)?

*A good carpenter nails with rhythm. An inexperienced carpenter bangs away irrationally.*

10. Research how nails are now made. Find a case of nails. Where were they made? How were nails made before modern machinery?

11. How much does a pound of nails cost in the village? How much does this come out to for each 6d, 8d, and 16d nail?

12. Pull some old nails from a board. Does driving them first to loosen them seem to help?

*It defies reason to drive a nail in so you can pull it out, but the technique works. Breaking the nail loose from the place it has been for a long time allows it to come out much easier.*

13. If there is a nailgun in the village, have an experienced person demonstrate. Can ten students drive ten nails as fast as one person with a nail gun? What are the safety features of a nailgun so someone can't be shot with a nail? What are some of the hazards of nailguns? What can you learn about the pressure of the compressor, specifically the difference between a framing gun and a finish gun?

*A nail gun can easily out-nail ten students. A framing gun operates over 90 lbs./square inch of pressure. A finishing gun operates around 60. Finish nails are smaller, and require less force.*

14. Ask a good carpenter about hammers. What weight hammers are used for different applications? Waffle and smooth faces? What are the differences between steel, wood, and fiberglass handles? Why do people prefer one over another? Which hammers are better in different situations? Why do you think there is such a variety of hammers?

Waffle face



Smooth face

*Most framers use a 20-24 oz hammer with a rough waffle face to grip the nails and drive them quickly. A finish hammer is usually 16 oz, and has a smooth face. A sheet-rock hammer is waffle-faced to create a rough surface for the sheet-rock mud to adhere to.*

15. Ask an oldtimer in the village to demonstrate lashing a fishtrap. What lashing material was commonly used? Videotape if possible.

*Spruce roots were used.*

16. Ask a local sled builder to demonstrate how to lash a sled—crosspieces and stanchion—to the runner. Videotape to show others.

17. If there is a log cabin in the village, inspect the corners and inspect the pins used. Are they spikes or wooden pins? What kind of wood was used for pins? Ask a local person where the pins were placed in the wall and why. If spikes were used, ask them how the holes were drilled to allow for settling of the logs.

## Student Response

1. What will happen if a nail is too short? Too thick? Too smooth? Too thin?

*Too short: it will pull out. Too thick: it will split the wood. Too smooth: it will also pull out. Too thin: it will bend going in or break under stress*

2. Draw the type of nail that is used on tar paper and roofing shingles.

*Big head.*

3. What kind of nail would you use on a boat?

*Ring nails. They have such high friction they hold well when the boat is working in rough water*

4. Draw the end view of a nail. Show how it should be driven if it is close to the end of a board.

5. Draw a nail that would have high friction in wood. Draw one that would have low friction.

6. Draw a scaffold nail.

7. Why are galvanized nails used?

*They don't rust. An ungalvanized nail will rust and bleed through paint and stain. Galvanized nails also hold well because they have rough surfaces.*

8. What is the name given to describe the sizes of nails?

*Penny symbol "d"*

9. Why were pegs used in log cabins?

*To keep the logs in line above one another, particularly around the windows and doors.*

10. Why are spruce roots superior to all other materials for a fishtrap?

*They don't stretch, are easily cleaned, don't rot easily and are available to anyone with ambition in country that has spruce trees.*

11. What is the best lashing for a sled and why?

*Braided halibut twine. It doesn't stretch and it wears well. Rawhide stretches when it is wet and dogs like to eat it.*

## Math

1. If a 50 lb case of 8d galvanized nails cost \$57, what is the cost of 27 lbs at the same rate? 150 lbs?

*\$30.78. \$171*

2. Matt wants to use spikes on his cabin rather than wooden pegs. Spikes are \$.50 each. He figures that each log will average 3 spikes. There are 56 logs in the house. How much would wooden pegs save him?

*\$84*

3. If Matt's time is worth \$10 an hour and he can make 12 pegs an hour, which is cheaper?

*14 hours = \$140. Spikes are cheaper, but he might want to use wooden pegs for other reasons*

4. Which is stronger: 4 larger nails with a shear strength of 65 lbs each, or 9 smaller nails with a shear strength of 52 lbs each?

*9 smaller nails.*

5. Two carpenters frame a whole house. The total time of both workers is 80 hours using a nail gun (40 hours each.) They both make \$18 per hour. Without a nail gun, they will take 98 hours. The special nails for the nailguns cost \$100 more than regular nails. Nailgun rental is \$20 per day for 5 days. Are they saving money?

*\$1440 wages, plus \$200 for nails and gun rental totals \$3080.*

*\$1764 if they don't use the nailgun.*

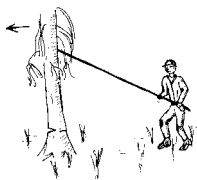
6. A 50 lb case of 16d galvanized nails costs \$57 delivered to the jobsite. A case of 16d sinker nails cost \$42 delivered, but Al figures that he has to use 20% more nails if he uses sinkers because they don't hold as well. Which is cheaper: sinkers or galvanized?

*The sinkers will cost \$50.40 which is cheaper. What we didn't consider however is the added time to drive them.*

7. Sinker nails are \$1 a pound delivered to the jobsite. Scaffold nails are \$1.50 delivered. Building scaffolding takes 30 lbs of nails. Scaffold nails save 3 man-hours working at \$12 per hour. Are scaffold nails worth purchasing and using?

*Sinker nails are \$30. Scaffold nails are \$45, but they save \$36 in man hours, so they are cheaper.*

## Falling Trees & Small-Scale Logging



### Activities

1. Cut a small tree. Have a person push the tree with a pole held ten to twelve feet up the trunk. Does the pole help to push the tree over with enough inertia that it doesn't get hung up?

*It should help greatly. Don't push the tree by hand. There isn't enough leverage, and the person pushing is too close to the chainsaw.*

2. Purchase a couple of plastic wedges. Use them to tip trees that are leaning the wrong way. Make wooden wedges out of dry wood. Compare the results. One person should run the saw and another person drive the wedges.

*Wedges are absolutely amazing. They can lift and fall a tree in the complete opposite direction than it is leaning.*

3. Before falling a tree, stand back and hang an axe head down from your hand at arm's length. It will hang straight down according to gravity. Line the axe handle in your sight against the tree. Can you see any leaning of the tree? Does this help determine how you fall the tree? Some people say this isn't worth doing on flat ground, but helps greatly on a slight hillside. What do you think?

*A good eye on flat ground can tell which direction a tree will go, but on a hillside it is tough without some kind of plumb bob. The axe serves this purpose.*

4. Ask local people how they release trees that are hung up.

*This is very dangerous. Don't follow any advise, just get opinions.*

5. Have a contest. Let several people put a stick in the ground twenty-five feet away from a tree. See who can fall their tree the closest to the stake. Make good use of the trees.

*This is a good test of ability to fall a tree. Use constant caution. There is no aspect of falling trees that isn't dangerous.*

6. Ask local people if they can tell the difference between falling trees in summer and winter. Do they snap more noticeably in the winter?

*They should notice that trees snap a little quicker in the winter. In the summer they groan and slowly go over.*

7. Ask local people what happens if you fall a tree and don't first make a notch in the front of the tree. Do their comments agree with the above text?

*I tried this once. It sent me and my saw at least 15'. Believe it, but don't demonstrate! The idea of this conversation is to keep students from ever making this mistake on their own.*

8. Try skidding a log on the ground. Put skids underneath as described in the text above. What are the differences?

*It should be very noticeable.*

9. Ask the oldtimers in the village if there are any pictures of the old winches that were used to pull logs up the bank.

10. Ask them how they skidded the logs. Did any of them do it in the manner described in the above text?

### Student Response

1. Draw a tree whose center of gravity is leaning to the right.
2. Why would a living tree be more effected by the wind than a dead one?

*The branches have needles to catch the wind.*

3. Draw what will happen if there is no notch in the front of the tree.

*The tree will split up the trunk and endanger the logger and saw.*

4. Draw what will happen if the notch on the front of the tree is not V cut, but only as wide as the saw blade.

*It will fall until the cut is closed and then will stop. The tree will not fall unless the whole hinge is cut, which is dangerous.*

5. Draw the top view of the stump of a tree that was made to pull to the left.

6. Why is it dangerous to completely cut the hinge when falling a tree?

*The tree can fall in any direction. The butt of the tree can jump in any direction.*

7. Why is falling trees more dangerous in the winter than in the summer?

*The frozen trees snap and fall quickly rather than leaning and stretching the way they do in the summer.*

8. Why does the logger want the tree to fall fast once it starts to go down?

*Its inertia will carry it through branches of other trees that might hang it up.*

9. When skidding logs out of the woods, what is the most important thing to avoid? Name one technique for doing this.

*Avoid friction. Peel some small blocks and skid the tree on the smooth rounded surface of the blocks.*

10. From the whole lesson, list four things that are dangerous when logging.

*Cutting the hinge. Logging against the wind, not cutting a notch on the side the tree is to fall. Trees that have fallen and are wedged between other trees.*

## Math

1. Matt can fall and limb 25 trees a day. He can cut an average of 36' of 6"  $\times$  6" houselogs from each tree. His house is going to be 24'  $\times$  32' with 8' high walls (each linear foot of houselog = .5 square foot). Approximately how many days must he log in order to get enough logs to make his house out of three-sided logs?

*He needs 1792 linear feet of house logs. This is 49.7 or 50 logs. It will take him 2 days to fall and limb the logs and 2 days to mill the logs. Total 4 days.*

2. Matt is done with his house. He figures that he needs 5 cords of wood to get through the winter. A cord of wood is 4'  $\times$  4'  $\times$  8'. He can cut and split approximately 100 cubic feet of wood a day. How long will it take him to cut and split enough wood for all winter?

*5 cords is 640 cu. ft. This is approximately 6.4–6.5 days*

3. Harold can fall and raft 100 logs in 7 days. Two men can do the same job in 3 days. He has to take time off his job making \$100 a day to do this. He can pay his nephew \$80 a day to help him. Which is cheaper for Harold: to work alone or hire help?

*If he works alone it costs him \$700 in lost wages.*

*If he hires his nephew, it costs him \$300 in lost wages for himself and \$240 to hire his nephew. He saves \$160 by hiring his nephew. In addition, he is teaching his nephew and he is being more responsible to his job. None of this takes the IRS into account.*

## Guns

### Activities

1. Ask the people in your village what kinds of guns they have. Is there a favorite manufacturer? Favorite caliber? Favorite action (bolt, lever, semi-auto)? If people don't want to answer, be sensitive. Some people in the bush feel that the government is threatening their rights to have guns and they are reluctant to let people know what they have.
2. Does anyone in your village reload? Ask them about the best bullets and calibers for hunting in your area. Ask them to demonstrate reloading a few cartridges.

*Reloading by an experienced person is quite safe. Reloading by an inexperienced person is quite dangerous. Monitor students activities in this regard.*

3. Start a collection of different cartridges. Do not take them from live ammunition! This is very dangerous. Get them from reloaders in your village, hunters, or from gunshops when you go to town. Research the history of each cartridge. They all have a story.

*This is fascinating. There are many gun books and magazines that have history woven all through them.*

4. Usually someone has saved a bullet that has been cut out of a moose or caribou. Ask around the village for one. Can you see the grooves imprinted in the bullet from the rifling in the barrel? Draw the mushroomed bullet. Do you think it hit a bone?

5. Try filing the different parts of the bullet. Is it hard or soft?

*The lead is quite soft. The copper jacket is a bit harder.*

6. Ask your local reloading expert to put a primer in a cartridge and omit the bullet and powder. Let him shoot the primer outside. Do you now have a sense of how little power is in the primer?

7. Ask your reloading expert to put a little powder on a flat surface and light it with a match. Does it explode or burn quickly? Smell the burned powder.

*Do not let students do this! Demonstrate only.*

8. Scrape the lead on a .22 cartridge with your fingernail. Can you detect the wax to lubricate the bullet?

*You should.*

9. Handle lead and steel shot from a shotgun. Can you feel the difference in weight?

*You should.*

10. If a bullet came out of a rifle without spin it would wander. The best way to observe this is to hit a volleyball underhanded in the gym. If you hit it with no spin, people on the receiving end will see it wander, and will have a hard time hitting it. Research what a "knuckle ball" is in baseball and how it is thrown. What is the relationship of this phenomenon to shotgun pellets?

*Shotgun pellets are like a floater in basketball or a knuckle ball in baseball. Without spin they tend to wander.*

11. With the bolt removed from a bolt action rifle (to remove all danger) look down the barrel. Can you see the rifling? How do you think police verify that a certain bullet was shot from a certain gun?

*They claim to be able to match the rifling in the barrel with the grooves in the bullet. I don't see how they can with so many guns made in assembly line manner.*

12. Feel the recoil pad on some of the rifles and shotguns in the village. Do you think they would help reduce the kick of the gun? Do you find recoil pads on .22s? Why?

*Recoil pads do help, but a .22 kicks so little a recoil pad is unnecessary.*

13. Bore sight a bolt-action rifle according to the directions given in the text. Are the sights or scope on target?

*If they are not, align them.*

14. Ask people in your village which they prefer: open sights or a scope. What are their reasons for their preference? Does it vary with the animal hunted?

15. From a ballistics chart, compare the three top favorite rifles in your village for velocity of bullet, drop of bullet, and foot pounds of energy at 100, 200, and 300 yards. Note the differences for different weight bullets. What are the favorites in your village?

*This will vary depending on the animal. A round that is good for moose in the brush will drop too much for seal on the ocean.*

16. Draw the trajectory of those three favorite rifles and three favorite bullet weights.

17. Ask the oldtimers what the favorite rifles were long ago and why.

18. Drop two balls of the same size but different weights at the same time from a given height. Does the heavier one fall faster? Why or why not?

*It defies our thinking, but two balls of the same size will drop at the same rate even if their weight isn't the same. The light one will drop at the same speed as the heavy one.*

19. Ask the good hunters in your village whether they shoot with one or both eyes open.

20. Test the students in your class. Which eye is dominant? Do they shoot right handed or left handed? Does anyone shoot right handed with a left eye dominant or vice versa?

## Student Response

1. What are the three types of guns?

*Rifles, handguns, and shotguns*

2. Draw a loaded cartridge and label the parts cartridge, powder, primer, bullet.

3. What are the four differences that must be considered when choosing a bullet?

*Size, shape, jacket, and hardness*

4. What is the material most often used in making bullets? What is the jacket material?

*Lead with a copper jacket*

5. What are primers and what do they do?

*Primers are like caps in a cap gun. They explode lightly when struck by the firing pin. Their explosion ignites the gun powder.*

6. What energy conversions take place as we squeeze the trigger? What kind of energy is stored in a cartridge?

*Kinetic energy of the firing pin creates heat that releases the chemical energy of the primer, that releases heat energy, that releases the chemical energy of the powder, which is converted to kinetic energy of the bullet.*

7. What is the difference between handgun and rifle powder?

*Handgun powder burns faster so it can be completely consumed before it gets out of the short barrel.*

8. What element is used in the chemical reaction in a cartridge that replaces oxygen in the burning process?

*Sulfur*

9. Draw the rifling in the barrel of a rifle.

10. What are four kinds of actions of rifles? Name one advantage of each.

*Single shot is simple and doesn't often misfire. Bolt action is reliable and tends to be more accurate. Pump action is fast and doesn't require the shooter to remove his eye from the sight while loading another cartridge. Semiautomatic is very fast.*

11. What are the two kinds of actions of handguns? Name one advantage of each.

*Revolvers are reliable. Semiautomatics are fast. (not in text, but there are a few single shot handguns.)*

12. In your own words, what is recoil?

*The gun kicking back. As the bullet is pushed out of the barrel, the gun is pushed back against the shooter's hands. (This is Newton's third law  $A = R$ )*

13. Draw the side view of the process of bore sighting a rifle.

14. List three advantages of open sights.

*They are reliable*

*They are inexpensive*

*They are easy to fix*

*They don't get out of adjustment easily.*

15. List three advantages of scopes.

*They allow the hunter to see the target clearly*

*The hunter's eye can focus in one place*

*They gather light*

16. Draw the trajectory of a fast bullet.

17. Draw the trajectory of a slow bullet.

## Math

1. Phil reloads his own shells for \$.30 each. A box of 20 shells costs \$19.95 in the store. His reloading equipment cost \$65. Approximately how long does he have to reload (if he uses an average of 3 boxes a year) in order to pay for his reloading equipment?

*A box cost him \$6 to reload. The first year his expenses are  $\$65 + \$18 = \$83$ . The store shells would have cost him \$60. By the middle of the second year, his reloading will have paid for itself.*

# Chainsaw Clutch & Chain

## Activities



1. Put a weight on a string. Attach a strong rubber band or soft bungee cord to the string. Hold the loose end of the rubber band and spin the weight around the head. (The dangers of this should be fairly obvious.) Try this with different weights and different strengths of rubber bands. Can the students feel the difference?

*The heavier weight will stretch the bungee more than the lighter one. The greater the speed, the greater the stretching of the bungee.*

2. If students haven't tried the old water-bucket-around-the-head activity, let them try it. This illustrates inertia quite well.

*Fill a bucket about 1/4 full with water. Swing the bucket. Why doesn't the water come out of the bucket when it is upside down? The inertia of the water in a straight line is greater than gravity.*

3. There are two types of chainsaw clutches: those with the sprocket on the outside of the clutch and those with the sprocket on the inside. Find one of each kind in the village and draw a top view of each.
4. Do this outside. Get an experienced person to run a saw that has the sprocket on the inside and clutch on the outside. Take the cover off and observe the operation of the clutch. Increase and decrease rpm. Can you see the shoes go in and out? Describe what you see to someone who didn't see the demonstration.

*Be careful. One teacher did this and a student touched the moving clutch and broke a finger.*

5. Look on the chainsaw in the above activity for the oil flow adjustment. Observe the oil coming out of the saw to supply the bar. Adjust the oil flow. Is the difference obvious? Find the hole in the bar that allows the oil to flow to the chain. Is there a similar hole if the bar is turned over?
6. Get a chainsaw clutch from an old chainsaw. Look at the drum. Does it look blue from being overheated? Look at the shoes. Test them for friction with other materials. Do they look like they are made of high friction material? What do you think that material is? To get the clutch off you will probably have to follow these directions:
  - Remove the sparkplug.
  - Put a screwdriver in the sparkplug hole and turn the engine until you feel the piston is at the bottom of the cylinder. Remove the screwdriver.
  - Cram the cylinder full of nylon or other plastic rope.

Now you can put a wrench on the nut holding the clutch and the rope will hold the crankshaft from turning.

7. Test the clutch spring for tension. Is it a strong spring? Does it also look blue from overheating? Does it stretch evenly or is it dysfunctional?

*It is a very strong spring.*

8. Imagine what would happen if oil got into the clutch. What problems do you think would occur if this happened when the saw was operating?

*The oil would reduce the friction between the drum and shoes. The clutch would slip.*

9. Get some 30w oil. Heat it by putting the plastic container in very hot water. How thin does it get? Do you think it would stay on the bar well when it is that thin? Cool it in a freezer. Feel it. Do you think it would pump well at this temperature?

*At cold temperatures oil has a hard time to flow.*

10. Get some commercial bar oil. Put a little on your fingers. How is it different from regular 30w oil? Why do you think this is so?

*Commercial bar oil is actually sticky. It is intentionally so to allow it to stick to the chain and bar, and not floy off the end of the bar.*

11. Get some crankcase oil. Wrap a magnet in thin plastic wrap. Immerse the tip of the magnet in the old oil and see if you can pick up the iron filings that are supposedly in the crankcase oil.

12. Get a chainsaw bar with a roller nose. Does it have a hole to grease, or is it permanently lubricated?

*Some do, some don't. if it has a hole to lubricate and you ignore it, the nose will spoil in a short time.*

13. Get several bars and chains, new and old. Test them for side motion and wear. How sloppy is the chain in the bar? Does it tend more towards one side than another? Which part of the bar is worn the most? Does it look like the owners turned the bar over often, or is one side worn more than the other?

*The comparison between new and old bars should be obvious.*

14. Draw or trace a side view of a chainsaw chain.

15. Ask people in your village what is the best saw they ever owned and why. What is the favorite bar length?

*This varies from town to town.*

16. Ask people in the village how they cut wood before chainsaws. If you can, fall and buck a tree using that method.

*We used swede or two man saws. This was quite slow and tedious.*

17. Ask people in the village the names of the chainsaws they know or remember. Make a class list. Find on the map the locations where they were manufactured.(You will need a world map.)

*A good chance to slip a little geography into the scienc class.*

18. Ask in the village if someone can demonstrate how to splice a broken chainsaw chain.

*You will need to order extra links ahead of time. The links should match the chain, 3/8 or .404 pitch.*

19. Gently file the materials of the bar, clutch drum, clutch shoes, sprocket, chain dogs, and teeth. Which are hard and which are softer than a file?

20. Have a contest to see who can untangle a chainsaw chain the fastest. (This is often a challenge!) Let students tangle a chain, and pass it to the next person to untangle.

21. Get an owner's manual. Draw a picture of two dangerous activities that should be avoided.

*There is nothing safe about chainsaw operation, yet young Alaskans handle them all the time. This lesson is a good opportunity to teach safety that will prevent future accidents.*

## Student Response

1. What might happen if the chain and engine of a chainsaw were always connected?

*It would be dangerous and hard to start*

2. What are the two main parts of the clutch?

*The drum and the shoes wrapped with a spring*

3. How does inertia work in a chainsaw clutch? The shoes are held in tightly to the driveshaft by a strong spring. When the speed of the engine gets high enough, the shoes spread out against the tension of the spring. The law of inertia says a body in motion will stay in motion in a straight line. The shoes, in response to this, expand out tight against the drum that drives the chain. ( Exact wording is not necessary or likely.)

4. What is around the shoes that keeps them from flying outward at low rpm? What would result if it were too loose? Too tight?

*A spring. If it is too loose, the clutch engages at too low an rpm. If it is too tight, the engine has to turn very fast to allow the shoes to overpower the spring and engage the drum.*

5. Draw a chainsaw clutch where the engine is turning at low rpm and the chain isn't turning.

6. Draw a chainsaw clutch where the engine is turning at high rpm and the chain is turning.

7. If there were low friction between the shoes and drum, what would happen when there was a load on the chain?

*The clutch would slip. The chain would stop even if the engine were turning.*

8. What happens to the shoes when the engine is slowed down after running at high speed?

*They retract back to the center, pulled in by the spring.*

9. What is happening when the chain is stuck in the tree and the saw is being run at high rpm?

*The shoes are slipping against the drum. The heat from the friction can warp the drum.*

10. What happens when chain oil is too thin? Explain or draw it.  
*The oil flies off the end of the bar and doesn't make it around to the pressure/contact points where the cutting is being done.*
11. What happens if the chain oil is too thick?  
*It can't get through the oil pump and a shortage of oil on the bar results.*
12. How is professional bar oil different from 30w oil?  
*It is sticky*
13. Why is the use of old crankcase oil discouraged?  
*It has iron filings that can greatly wear the bar and chain.*
14. What is a roller nose on a chainsaw bar? What is the purpose?  
*A roller nose on the end of the bar has bearings that reduce friction on the nose of the bar.*
15. Draw a chainsaw bar and chain as they are cutting a block. Identify the place on the bar where the chain is loose. Identify where it is tight.

## Math

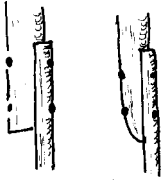
1. Commercial bar oil is \$3 per quart. Henry bought eight quarts and figured that his bar lasted two times longer than if he used free crankcase oil. A new bar is \$30. Did he save money?  
*Yes. The bar oil cost \$24, a new bar would cost \$30.*
2. Would it be cheaper if he ordered an extra bar from a discount place for \$22 or commercial bar oil for \$2.25?  
*Yes, it is still cheaper. The bar oil would be \$18 and the bar \$22.*
3. Henry can get bar oil for \$3 a quart, or order in bulk, 5 gallons for \$32, plus \$13 shipping. Is he saving money, and if so, how much? The answer can refer to quarts or 5-gallon buckets.  
*The cost by quarts is \$60. The total cost for bulk is \$45. The savings is \$15 per 5-gallon bucket or \$.75 per quart.*
4. Jesse wants to sell cordwood. He figures that each cord for his chainsaw takes 1 quart of bar oil at \$2.75,  $\frac{3}{4}$  gallon of gas at \$3.50 per gallon including two-cycle oil. Snowmachine costs are about \$21 per cord, including wear and tear. It takes 5 hours to cut and haul a cord. How much should he charge to make the equivalent of \$10 per hour? \$12 per hour?  
*His overhead per cord is \$26.37 if he makes \$10 per hour, his labor costs are \$50. He must charge at least \$77 per cord to make \$10 per hour. If he wants to make \$12 per hour he has to charge \$87.*

# Ice Pick

## Activities

1. Make an ice pick out of a wrecking bar or other good steel. Before putting a slight bend in the tip, make a few holes in the ice. Then put the slight bend. Observe the difference. Does it widen the hole better with the bend? Can you hear the difference between the two picks?

*Putting the slight bend in the tip should cause the ice pick to quiver and shatter the ice. It will be easier to widen the sides too. There is a distinctive "buck, buck" sound of a well made ickpick. With your back turned you can hear whether an ice pick is well designed or not.*



2. Before rounding the nose of the wood on the handle, leave the wood square. Does it splash once there is water in the hole? Round the nose of the wood and try it again. Does it splash as much?

*Rounding helps a lot. Once the hole is full of water splashing becomes a real concern.*

3. Strap a five to six pound weight to the ice pick you have made. Pick a hole. What differences do you observe? (Ankle or wrist weights might work well.)

4. Try to make a hole in the ice with an axe. What is your experience once the hole fills with water? Can you widen the bottom of the hole?

*An axe is almost worthless. Once there is water in the hole, the axe splashes so much it is impossible to make a decent hole.*

5. If there is an ice auger in the village, compare the time and effort required to make a hole with the auger to the time it takes to make a similar hole with an ice pick. Which is faster and easier for you? What are the advantages of each?

*An auger is faster and cleans the hole by itself. It is necessary to shovel the chips out of a hole made by icepick. However, an icepick can make a hole big enough for beaver, but an auger can't widen a hole.*

6. Observe how icy your gloves get when using the ice pick. What will you do to increase friction so you don't lose the ice pick down the hole?

*Put a rope on the icepick or you will lose it!*

7. Listen closely. Can you hear the difference in the sound of the ice just before you punch through and water comes into the hole?

*There is a distinct sound the ice makes just before breaking through. Before punching through, widen the hole on the bottom as it is hard to do with water in the hole.*

8. Make an ice pick out of a snowmachine spring over 2" wide. What differences do you see between this ice pick and the first one.  
*It is too wide to penetrate deeply, but it cuts brush in a beaver feedpile very well.*
9. Compare the ice pick you have made with a commercially designed ice pick if there is one available. If they are both sharp, which one works better for you?
10. Are there any homemade ice picks in the village? Look at them. What do the tips look like? How wide are they? How heavy are they? What is the average weight? What kind of steel are they made of? Do they ring when struck with another piece of steel? (The wooden handle will deaden the sound to some degree.)
11. What kind of wood is used for the homemade ice pick handles?
12. Talk with the local beaver trappers and, if possible, go out trapping with them. When you get back, describe to someone else what you learned.
13. By inquiry in the village, discover the difference between an ice pick used for walking after freeze-up and one used for beaver trapping.  
*An icepick used for walking and testing thin ice is much lighter than one used for making a waterhole or setting snares for beaver.*

## Student Response

1. Why is it important to have an ice pick that has enough mass?  
*If the ice pick doesn't have enough mass, the force to drive it will have to come from the individual's arms. With enough mass, the force will come from the ice pick.*
2. Draw an edge that is too thick. Draw one that is too thin.
3. Why is a slight bend put in the tip of some ice picks?  
*To make them quiver and shatter the ice.*
4. Why is friction important on the handle?  
*Good grip. It might slip and be lost down the waterhole. A frequent occurrence.*
5. What is the most common material for an ice pick handle and why?  
*Spruce. It is strong and doesn't rot easily.*
6. What happens if the bottom of a water hole isn't widened?  
*The hole will freeze over quickly if the current isn't available to warm the surface*

7. Draw a perfect ice pick, including handle.

### **Math**

1. Mike has a chance to go beaver trapping with his uncle. A gasoline-driven ice auger costs \$209. He can make his own ice pick for \$12. If the average price of a beaver pelt is \$25, how many beaver does he have to catch to break even with the cost of the gasoline auger?

*Eight beaver. However, he might consider that the motorized auger might break down. If it does and they are very remote, he might not catch any. There is more to consider besides money.*

2. Mike can pick 14 holes a day when the ice is 3' thick. The next year he traps, he finds that the ice is 4' thick. Approximately how many holes will he make if he picks at the same rate?

*Approximately 10–11*

## Part 2

# Shelters

## Wood Stoves

### Activities

1. To demonstrate that water is a byproduct of combustion, hold a very cold piece of metal over a small flame. Can you get the water in the smoke to condense on the plate?

*It should.*

2. Hold your hand a safe distance over a candle flame. Can you feel the warm air rising. Can you devise a way to demonstrate this to others, like a pinwheel? (My last pinwheel burst into flames.)

*A strip of tissue held above the flame will flutter indicating the hot air rising.*

3. Look at the wood stoves in your village. (Does everyone burn oil? Check the steambaths.) Note the controls for air intake. How many different kinds are there? Are most of the doors airtight? What kind of dampers do the stoves have? Do all the stoves have either mud or bricks inside?

*A steam bath stove doesn't need an airtight door.*

4. Find a wood stove with a bimetal helix coil. Heat it with a blow drier or other safe heat source. Watch it close. Cool it with a fan or cold water. Watch it open. Gently file both sides of the coil. Which is harder? Can you guess what kind of metals are used?

*One side is harder than the other. I haven't a clue what different types of metal are used.*

5. Put a very green stick of wood on a burning fire (a block from the top of the tree will illustrate well). After ten to fifteen minutes, open the stove door and observe the steam coming from the wood. Can you hear it hiss?

*It should be obvious.*

6. Get an old stovepipe that has been used on a wood stove. Scrape the inside. What does the material smell like? Put the material you have scraped on a metal plate and heat it. What happens. Try to burn the material. Does it burn? Was the stove losing heat by not completely burning the wood?

*The condensation on the inside of the stovepipe should at least glow when heat is applied. The stove lost the heat that could have been released by the burning of the gasses that went up the stovepipe.*

7. Make a campfire. Fan the flame. Does this increase burning? If so, why? Put more wood on the fire. Does the fire burn stronger? Why? Pour water on the fire. What happens and why?

*Fanning a campfire increases burning because it is providing more oxygen. If you fan too much it slows the fire by cooling it off. More wood will temporarily slow the fire by cooling, but will soon add to the fire as more fuel is being consumed. Water slows the fire for two reasons. It cools the fire, and the resulting steam blocks oxygen from getting to the fire.*

8. Put a candle in a jar. Light it. Put a metal cover on the jar. What happens and why?

*It eventually goes out when all the available oxygen is consumed.*

9. Discuss the difference between the convenience of burning green wood versus the efficiency of burning dry wood. Ask the oldtimers in the village about the advantages of each.

*Greenwood is more plentiful, but it is heavy to haul. Drywood is harder to find, but is lighter and more efficient.*

10. Send for information on modern commercial wood stoves. Discuss the advantages of the different features.

Talk to some of the oldtimers in your village about stoves they used to use for travel, for cabins, and homes. Is the information consistent in your area with what I have presented here? If there are differences, why do you think they exist?

## Student Response

1. What things go together to make wood?

*Carbon, heat, and water*

2. When your house or tent is heated by a wood fire, where did the energy originally come from?

*The sun*

3. What three things does it take to make a fire?  
*Heat, fuel, oxygen*
4. What happens if a fire doesn't get enough air?  
*It goes out or slows down*
5. With a given amount of air, how can you cause wood to burn faster?  
*Increase the heat around the fire*
6. What does mud in the bottom of the stove do, or firebricks in the modern stoves?  
*It holds the heat in the stove and keeps the rate of burning more constant.*
7. Comment about the size of a stove, surface, size of stovepipe, and air intake.  
*If the stove is too big, the fire will be too far from the surface of the stove to conduct heat. If the stove is too small, it can't hold enough wood to burn long. Small stoves require splitting wood very small.  
If the top of the stove isn't flat, it will be difficult to heat water or cook on it. If the top is too high, it will take a long time to heat water. If it is too low, the stove cannot hold enough wood. Black stoves radiate more heat. If the stovepipe is too big, all the heat will go up the stovepipe. If it is too small, the fire cannot get enough air. If it is too short, it cannot get enough draft.*
8. In an oil stove we control the flow of fuel. In a wood stove we control the flow of what?  
*Air*
9. What are the disadvantages of burning green wood?  
*Heat is used to boil the water out of the wood. Additionally, the steam interferes with the oxygen uniting with the wood.*

## Math

1. How many cubic feet in a cord of wood? ( $4' \times 4' \times 8'$ )  
*128 cu. ft.*
2. How many cords in a pile  $8' \times 5' \times 13'$ ?  
*4.06 or 4 cords*
3. If green wood has  $\frac{2}{3}$  the available heat as dry wood, and dry wood is \$125 a cord, what is the fair price for green wood if the same value is to be obtained?  
*\$83.25*

4. What is the area of four stovepipes, 4", 5", 6" and 8". Is the area of the 4" pipe  $\frac{2}{3}$  the area of the 6" pipe? (When pi is 3.14)  
 12.56, 19.62, 28.26, 50.24. No, it is less than  $\frac{1}{2}$

5. Look at a block of wood. Measure the diameter from the ages of fifteen and sixteen years. Be kind to yourself; use metric measurement. If the block were a perfect circle, what is the area for each year? How much did it increase in one year? Do the same operation between thirty-three and thirty-four years. How much did it increase? How much greater or less was the growth in **area** of the tree when it was younger than when it was older? Figure the difference in volume if the block is .5 meters long.

*The answer will be determined by the block of wood chosen. A ring .25" in a young tree adds less volume to the tree than a ring .25" in an older, larger tree.*

6. Compute the volume of the inside of three stoves. Compute the area of the stovepipe of each stove. Is there a relationship (bigger stoves have bigger pipes)?

*The answer will be determined by the three stoves selected.*

## Wall Tents

### Activities

1. Ask the oldtimers in your village what they use for tent floor. If they use spruce bark, get someone to show you how to peel one, although this only works from late May to mid July.
2. Pitch a wall tent. Make the roof nice and tight. How big is it? 10'  $\times$  12', 8'  $\times$  10'? How high are the walls? When you put the tent away, ask an experienced person to teach you the right way to fold it.
3. Touch the inside of the tent when it is raining. Does it leak down your finger?

*It probably will. Rain water runs through a tent not over it.*

4. Make a bed for the tent. Is it warmer on the bed than on the floor?

*It should be much warmer on the bed.*

5. Make a stove for a tent. Make a half-a-drum stove or a five-gallon can stove. We used to use Blazo cans, but square cans are now available from hotels and restaurants where they buy coffee in square five gallon cans. Take your time and make a stove to be proud of.

6. Ask the experienced people in your village about tent stoves and sparks. How do they keep from burning their tent down?
7. What kinds of tents are used in your village now? Many people still use wall tents for hunting camps. How many of the tents are wall tents? How many of them are white? How many of another color? Of the canvas wall tents, do any have evidence of mildew? Why or why not?
8. Ask in the village why some people use nylon dome tents?  
*They are light and easy to set up.*

### Student Response

1. What are four kinds of flooring for a tent? Which is best in the winter on the snow?  
*Spruce bark, boards, gravel, spruce boughs. Spruce boughs are best in winter.*
2. What wood burns with the most sparks? With the least?  
*Tamarack. Cottonwood or willows*
3. What are two techniques to reduce sparks on a tent?  
*Make holes in the top pipe to cool the sparks or put a screen over the top of the pipe*
4. Why is a white tent warmer than a dark one?  
*It reflects the radiant heat of the stove much better*
5. Does water run off or through canvas tent fabric?  
*Through*
6. What are two advantages of having a bed?  
*Warm air rises, so it is warmer on the bed than on the ground. It also allows room under the bed for storage*

### Math

1. What is the difference in floor space between a  $10' \times 12'$  tent and an  $8' \times 10'$ ?  
*40 sq. ft.*
2. Frank's tent weighs 72 lbs. His stove and pipes weigh another 27 lbs. He can haul 200 lbs in his sled to his trapline. How many pounds of groceries and gas can he haul on the same trip?  
*101 lbs*

3. Ed spent \$225 for a 10'  $\times$  12' wall tent with 4' walls. He used it for two seasons, but put it away wet and it rotted. The tent could have lasted eight years if well cared for. How much did the tent cost him per year? How much should it have cost him per year? Can you put a price tag on his laziness?

*\$112.50 per year. If it lasted eight years it would have cost \$28.13 per year. His laziness cost \$168.75*

## STeambaths

### Activities

1. Pour rubbing alcohol into your hand. Blow on it. Does it feel cold? Why? Try the same thing with a small amount of gasoline. Try now with water. Which cools your hand the most? What causes the cooling?

*It should feel cold from evaporation. Be careful with the gasoline, but it should feel cold too as it evaporates. Water will evaporate, but not as fast.*

2. Did/do people in your village whip themselves with brush in the steambath? If so, identify the type of brush used in your area.

3. Bring a thermometer into the steambath. What is the temperature on the floor? At shoulder height? At ceiling height?

4. Pour water onto the rocks. Does the temperature actually rise, or does it just feel hotter?

*The temperature rises, but most of the heat is released when the steam is condensed back to water, releasing it's latent heat.*

5. Ask the people in your village about the best rocks for a steambath. Where do they get them? Ask them which rocks are not good, and why. Ask someone who knows about welding and cutting with an acetylene torch what they can tell you about cutting on concrete. Do you see any similarities?

*Concrete will explode if you heat it with a cutting torch. The water of hydration in the concrete is released, and turns to steam, causing the concrete to shoot in many directions.*

6. Try to clean grease from your hand with water. Try to remove it with soap. Soak the soap in water. Does it dissolve? Put the soap in a little stove oil, or vegetable oil. Does it dissolve? What can you say about soap dissolving in both oil and water?

*Soap is slightly soluble in both water and oil.*

7. Ask the oldtimers how they used to make steambaths when they were away from the village. They made a little hut from canvas or skins.

*They made a campfire and heated the rocks in the campfire, then shoveled the rocks into the steambath, removing them when they got cold, replacing them with hot rocks.*

8. Ask the oldtimers if there were other reasons for taking steambaths besides cleanliness.

*Steambaths were spiritual and social gatherings.*

9. Look up “igneous” and “sedimentary”. What is the difference in their formation?

*Igneous comes from fire, or volcanoes. Igneous rocks are generally ok for steambaths. Sedimentary rocks are formed when silt and gravel are deposited and pressed together. Sedimentary rocks often have a high water content, thus making them dangerous for steambaths.*

## Student Response

1. How does perspiring help to cool us off in a steambath?

*Evaporation takes heat. When we perspire, the heat comes from our bodies*

2. Why do people whip themselves with brush?

*To increase circulation in the skin*

3. Why are rocks important in a steambath?

*They have enough mass to hold the temperature steady*

4. Why are white rocks desirable rather than black ones?

*White rocks have less moisture. They don't explode like black ones*

5. Why is the bath hotter at the ceiling than on the floor?

*Warm air rises*

6. Why does soap work well to remove grease and oily dirt?

*It is partially soluble in both polar and nonpolar liquids*

7. What are polar and nonpolar substances?

*Polar substances have molecules that are out of balance electronically, like little magnets. Nonpolar substances are balanced*

## Math

1. My friend Joe takes a steambath every night of the week. From the time he makes the bath to the time he gets done it takes him about  $2\frac{1}{2}$  hours. What fraction of his life is spent at the steambath.

10.4%

## Insulation & Vapor Barriers

### Activities

1. While in a warm house, close the cover on a jar. Bring the jar outside or put it in a freezer. Is there condensation inside the jar when it is cooled? Bring the jar into the warm house again. What happens?

*Condensation will form when the jar is cooled (if there was enough moisture in the air in the warm place before it was sealed.) When the cold jar is brought into a warm place, condensation will form on the outside of the jar for a while. Any condensation on the inside of the jar will evaporate when it is fully warmed.*

2. Breathe on a plate or piece of metal that has been cooled outside in sub zero temperatures. What happens. Bring it inside and watch what happens. Where does the frost go?

*It frosts on the cold plate, but evaporates in the warm building.*

3. The next time it gets  $-40^{\circ}$  or  $-50^{\circ}\text{F}$ , scuff your feet on a rug and touch a doorknob (or your brother's ear). Is there a spark? Why do you think this doesn't happen when it is warm?

*There is much static electricity during cold outside temperatures as there is very little moisture in the air. During warm outside temperatures, there is more moisture in the air, which "wicks off" the static electricity buildup, so there is less evidence.*

4. The next time it gets very cold, put a blanket against the bottom of a cold window and leave it overnight. What happens? Why?

*The blanket freezes to the window. It insulates the cold widow from the inside temperatures, and moisture from the room freezes on the blanket.*

5. During cold weather, observe windows that are single, double, and triple pane. What difference do you see?

*Single pane frost terribly. Double pane frost a little. Triple pane seldom frost.*

6. How are winter shoe packs with felt liners like a wall without a vapor barrier? What happens in very cold weather when you try to take the liners out of the boots after wearing them all day? Why does this happen? Can you think of a way of preventing this?

*The moisture from the person's foot goes to the outside of the felt liner and freezes against the inside of the rubber shoe pack. They are frozen in. If you put your foot in a plastic bag, and put that in the shoe pack, the moisture from your foot couldn't reach the liner. Your foot would be warm, but wouldn't*

7. Compare shoe packs with felt liners to the white "bunny" boots or VB (vapor barrier) boots as they are called. What are the similarities and differences?

*They are similar in that they both have felt liners, and rubber on the outside. They are different in that the VB boots have the felt liner sealed off with a rubber vapor barrier on the inside. The felt liner in the VB boots never gets wet because the moisture of the foot cannot reach it. The felt liner in the shoe pack constantly gets damp from the individual's feet.*

8. Check the houses in the village. Ask what kind of insulation is in the walls and ceiling. Is there a vapor barrier?

9. Check the roof of an old abandoned cabin in your area. What kind of insulation was in the walls and ceiling?

10. Try to find an old abandoned log cabin with a sod roof. Study the roofing materials.

11. Test wet and dry insulation (wet & dry socks?) for their conductivity of heat.

*Damp socks transmit heat much faster than dry ones.*

12. Ask the oldtimers how they could detect a bear hole during winter months. Does one of these signs relate to condensation?

*The grass and branches around a bear hole will have condensation from the moisture in the hibernating bear's breath. This condensation is slight enough to be hard to detect.*

13. Put a glass tube or other piece of glass in a hot flame. Does it conduct heat well? Compare this with a metal coat hanger or other piece of long metal. Compare these with wood.

*Wood and glass do not conduct heat well at all. Metal is a good conductor.*

14. Visit a house under construction or talk to local carpenters. Do you see the vapor barrier? What do the carpenters say about vapor barriers?

15. Ask oldtimers about sod roofs. Were they warm? Did they leak?

*Sod roofs were very warm and cozy. They didn't leak if they were constructed properly. They had no vapor barrier, and the moisture from the house passed through the sod. The sod roof breathed the same way caribou mukluks breathe.*

16. Submerge a piece of closed cell foam (usually blue or pink) after weighing it. Leave it under water for a few days. Weigh it again. Did it absorb any water? What is the R factor of two inches of foam?

*Closed cell foam will not absorb water at all. It is excellent for underground insulating. 2' of foam has an R factor of 10.*

### Student Response

1. What four things do the bacteria require that cause wood to rot?

*Wood, heat, moisture, air*

2. What is vapor?

*Water in the air*

3. What would happen if there were no vapor in the air of our homes?

*We would have bloody noses and have a hard time breathing. Wood would crack. There would be a great deal of static electricity.*

4. Which can hold more water vapor: warm or cold air?

*Warm air*

5. What happens to the vapor in warm air when the air is cooled?

*It will release the moisture that is held as a vapor*

6. What happens when vapor gets into the walls of our homes?

*The air is cooled and it releases its moisture. This ruins the insulation's ability to retain heat. The moisture also promotes rotting*

7. Draw a cross section of a wall that has insulation and a vapor barrier.

8. What things in our homes naturally put water vapor into the air?

*People's breath, boiling water, and cooking.*

9. If you tried to explain the use of a vapor barrier simply to someone who didn't know, what simple rules would you give them?

*The vapor barrier must go between the living space and the insulation. There should be no holes in the vapor barrier. The vapor barrier and insulation work together. They should never be used apart from each other in the north.*

10. What two things make fiberglass good insulation?  
*It doesn't conduct heat and it traps dead air*
11. What are the three disadvantages of fiberglass insulation?  
*It is unpleasant to install. It is destroyed by floods and little animals if they can remove it.*
12. What are two disadvantages of foam insulation?  
*High cost and it emits poisonous gasses when it burns.*
13. Draw a cross section of a sod roof. Did the oldtimers use a vapor barrier?  
*No. The oldtimers didn't use a vapor barrier. The sod roof "breathed" allowing the vapor to pass through the sod.*

## Math

1. A roll of visquene is  $8 \times 100$  feet. Assuming there are no overlaps (in reality there are). How many rolls of visquene are necessary to put a vapor barrier in a house  $24' \times 36'$ , with walls 8' high. The outside walls and ceiling need a vapor barrier. How many square feet will be left over for overlap and other purposes?  
*Three rolls. 72 linear. ft. or 624 square feet left over.*
2. The above house needs \_\_\_\_\_ square feet of visquene. It comes in rolls of  $12' \times 100$  for \$47.21 or rolls of  $8' \times 100'$  for \$29.52. What is the best combination of rolls that can be purchased and what is the total cost?  
*The best combination is 1 roll of 12' wide and 1 roll of 8' wide. Total cost is \$76.73.*
3. Two inches of foam has an R factor of 10. Six inches of fiberglass has an R factor of 19 (round off to 20). A piece of foam is  $2' \times 8'$  and costs \$14. Fiberglass costs \$37 for a roll that contains 78 square feet. Which is the better insulation buy for a square foot?  
*Foam is \$.857 per square foot, giving an insulating value of R10 or \$1.75 per square foot of R 20 (2' thick). Fiberglass insulation is \$.47 per square foot giving R 19. Fiberglass is by far the cheaper insulation.*
4. A building has 1276 square feet to insulate with six inches of fiberglass. The price of fiberglass landed on the jobsite is \$.47 per square foot. What is the cost of insulating the house?  
*\$599.72*
5. Hank was building a  $40' \times 56'$  shop. He wanted to pour the concrete floor over 4" of foam. Each piece of foam is  $2'' \times 2' \times 8'$ . How much

would this cost if he could get the foam for \$10.99 each? (Round off if you like.)

\$3077.20

## Gas Lamps & Gas Stoves

### Activities

1. Put a little (room temperature) gas lamp fuel in your hand. Blow on it. Does it feel cold? Why? Put a little room temperature stoveoil in your hand. Blow on it. Does it feel as cold? Why? Can you explain why we don't use stoveoil in a gas lamp?

*Be careful. The fuel is volatile. Yes it feels cold. The fuel is evaporating. Stove oil doesn't feel as cold as it doesn't evaporate easily.*

2. Cut two identical blocks of wood. Split one into four parts. Split the other into small kindling. Make two campfires of the same size. Put the split pieces of the first block on one and the split pieces of the second on the other. Which burns faster? How much faster? What can you say about increasing the surface area of fuel?

*The fire made of the finely split pieces will burn much faster.*

3. First light an old gas lamp. Let it cool down, then take the generator out. If you are careful you can do it without breaking the mantle. Is it black with soot? Scrape it clean with a pocket knife or sandpaper. Re-install it, and light the lamp again. Can you tell the difference between before and after? What is the difference and why?

*The clean generator will burn much brighter than the dirty one. The soot on the dirty one insulated the fuel from the flame.*

4. Observe. What do you suppose the little needle is for on the end of the generator you just removed?

*It cleans the tiny hole through which the fuel passes. If the hole is plugged, fuel cannot get through to the flame.*

5. Get someone with the necessary knowledge to show you how to replace a mantle. While the old mantle is off, inspect the screen. Does it have any holes?

6. If possible, research what kind of material is used in the mantle of a gas lamp. How is the material unique?

*I used to know the answer to this, but they have changed the material. The uniqueness comes in that the remaining ash which is the mantle,*

*glows when heated. It's electrons jump to higher orbits when excited by the heat, but when they collapse to their natural electron orbits, the emit photons of light.*

7. Pump the tank full of pressure. Release the pressure. Lubricate the pump with a few drops of oil, and pump the tank again. Is there a difference? Why?

*A lubricated pump is better because it has less friction, but the oil also serves to seal the plunger in the pump.*

8. Ask people in your village if they use gas lamps outdoors in the past. Do they still use them in hunting, whaling, or fishcamps?
9. Light a gas stove. Identify the parts of the flame that are producing carbon dioxide. Identify the parts of the flame that are producing carbon monoxide.

*Yellow flame is carbon monoxide, blue is carbon dioxide.*

10. With the same amount of water at the same temperature in the same teapot, time how long it takes to boil water on the gas stove, on a propane stove, and on an electric stove. Which is faster? Which do you think is more convenient? Which do you think is safer in the house?

*The gas stove gives the most intense heat, but it is messy to fill and inconvenient to use.*

11. With pliers, hold a piece of a broken mantle in the flame of a candle or gas stove. Does it glow?

*Yes it does. Even the string glows.*

## Student Response

1. What are the three main parts of a gas lamp?

*Tank, generator, and mantle*

2. What is the main purpose of the generator?

*Heating the fuel and air*

3. What happens to fuel in the generator?

*It turns to a vapor*

4. Draw a picture of fuel as a liquid and the same amount of fuel as a vapor.

*Drops of liquid are big, drops of vapor are small but more numerous*

5. Why does the generator pass over the flame in both the gas lamp and gas stove?

*When the fuel is heated, it turns to a vapor. If this didn't occur, the fuel wouldn't burn well at all*

6. The screen in a gas lamp does two things. What are they?

*Spreads the fuel and air mixture. Retains heat*

7. Why do whitefish hunters have a hard time with their gas lamps in cold temperatures and what is the cure?

*The cold air cools the generator too much and the fuel isn't vaporized. The cure is to put the glass on the lamp. This keeps the heat in and allows the fuel to do its job.*

8. What color is the flame when carbon monoxide is produced? What color is the flame when carbon dioxide is produced?

*Yellow. Blue*

9. Which is more efficient in the production of heat, combustion to carbon monoxide or combustion to carbon dioxide? By what ratio?

*Carbon dioxide is more efficient. 1 to 3*

## Math

1. If a blue propane flame gives off 1500BTU<sup>2</sup> how many BTU are given off if the air adjustment is wrong and the flame is completely yellow?

*500*

2. A 5-gallon can of Blazo fuel costs \$38. It lasts Mark 3 months in his trapping cabin. A bottle of propane lasts him 7 months at home. Propane is \$105. Which is cheaper per month?

*Blazo is \$12.66 per month; propane is \$15 per month*

3. Gas lamps don't work well with leaded gas. But Blazo fuel is \$8 a gallon, and leaded gas is \$2.25 a gallon. New generators are \$1.98 apiece. Mark is wondering if it is cheaper to burn cheaper fuel and change generators once a week or whether it is cheaper to burn the correct fuel. Which method is cheaper if a gallon of fuel lasts three weeks?

*Blazo is \$8. Gas plus new generators is \$8.19. It isn't worth the bother. Burn blazo.*

## Part 3

# Travel

## Piloting A Boat

### Activities

1. Watch a video about a swift river or go to a swift section of a local river. Discuss the route you would go to take advantage of all the areas with slack current. Draw a map of a section of that river. Ask one of the elders in your village which way he would travel if he was piloting a boat on that stretch of river.
2. Imagine that you are a salmon going upstream in that river. Color the path you would swim during the day in blue. Color the path you would swim at night in black.
3. Draw a typical stretch of river in your location, or where you go to hunt. In your imagination, estimate the current in different parts of the river.
4. If it is possible, measure the current in a cross section of that river. If you have no way to accurately measure, release a stick on the sandbar side, timing how long it takes to pass a certain point downstream. Do this again, releasing the same stick in several points across the river from the original release point. Measure the time it takes to reach the same downstream point. Compare their results.

One way I have done this is to tie a weight on one end of a 120' rope. Tie a good float (5 gallon can) at the 20' mark and another float on the other end. When this is thrown in the river, the weight holds the floats in the river, and the floats are always 100' apart. An object can be released by the upper float and the time to the bottom float is recorded. Divide the seconds necessary to travel the 100' into 68.2, and you will have the speed in miles per hour.

5. At each of the above points measure the depth of the river. The easiest way might be to put a weight on a string, putting a knot at every foot in

a string. Counting the knots as they slip through the fingers will give the depth in feet.

6. Observe islands in your river. Do you think the river widened, depositing the islands, or did the island occur because the river cut a new channel? Either might be the case.

7. The next time there are waves on your river caused by wind, note the bends they occur on, the direction of the wind, and the relationship of the wind to the current. Where are the biggest waves? Are the waves as large by the shore?

*The biggest waves are in the middle, and the waves by the lee shore are the smallest.*

8. If possible, drive the boat from a river where there are choppy waves into a creek where the water is flat. Can you feel the difference in the speed of the boat?

*It is measurable.*

9. While piloting a boat in deep water, set the throttle so the boat is barely on step. Cruise to the sandbar side of the river and notice the increase in speed of the boat and motor. Be careful not to hit bottom!

10. Listen and watch closely the next time you are in a boat. Hum in tune with the motor. Does the pitch of the motor get higher when you pass through shallow water? In and out of eddies? Do you think this effect is more noticeable with a planing or displacement boat?

*It is more noticeable with a planing boat.*

11. Ask the people in your village about the dangerous places on your local rivers. What stories can they tell about close encounters?

12. Pour water out of a teapot that has a spout. Observe. Where is the strongest flow of water? Which is stronger, gravity or momentum?

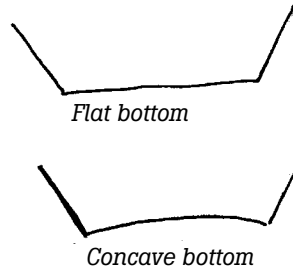
*The strongest flow of water is at the bottom. Gravity is stronger than the momentum of the water coming out of the spout.*

13. Put a piece of plywood on a slant. Pour water from the teapot across the top end. Observe and mark where most of the water flows. Tilt the plywood up and down changing the angle, again observing and marking the greater flow of water. At what angle does gravity exert the greater force, pulling the flow of water downward instead of yielding to momentum? Try to keep the water flow and pressure the same while changing the angle.

*This will help you understand what is happening in the different bends of a river, particularly the smaller, swifter ones.*

14. Design a boat that would trap air under the boat so it will travel on a cushion of air.

*I built a boat with a concave bottom. It got on step instantly, and trapped air, causing the boat to skim wonderfully. However, it didn't corner well at all, and it pounded terribly in waves.*



### Student Response

- What are the three main forces working on the water in a river?  
*Gravity, friction, and inertia*
- Draw a typical bend in a local river. Identify the deep and shallow places. Estimate what the current will be in 5 places on the river.
- Why is the current next to a river bank slower than the current in the middle?  
*Friction with the bank.*
- In the picture to the right, tell how fast you think the water might be going in the different places circled if the current in the middle is 6 mph.
- What are the three priorities a pilot operates by when traveling upstream?  
*Water deep enough*  
*Shortest distance*  
*Least current*
- Draw a picture of a typical bend in a river. Draw a big rock in the middle of the river. Draw the path a boat might take.
- Draw a picture showing a boat in ground effect and another in deep water.  
*The boat in ground effect should be traveling higher than the one in deep water.*
- Why are the waves caused by wind larger in the middle of the river than on the sides of the river?

*Waves are caused by friction between the water and the air. The current is less next to the bank. So the combined velocity of the current and wind are less against the bank than they are in the middle of the river.*

9. Draw a picture of a boat that is traveling at the best angle for waves.

*Bow down*

10. Draw a picture of a boat that is traveling at the best angle for calm water.

*Bow slightly up to keep some of the boat's surface out of contact with the water.*

11. Why do small choppy waves help a boat travel a little faster?

*Air is trapped under the boat. Friction with air is less than with water.*

12. What are three things to remember or do when traveling at dusk?

*Don't spoil your night vision. Have running lights. Don't travel in the dark, even if you know the river.*

## Math

1. Pete can travel from the store to his cabin in 3.5 hours. His son can make the same trip in 4 hours. If gas is \$3 per gallon and the motor uses 4 gallons per hour, how much more does it cost his son to make the same trip?

*\$6*

2. A boat travels at 16 mph relative to the water. The river's current averages 9 mph. How long will it take to make a round trip of 22 miles each way? What is the total time of the 44 mile trip?

*3.14 against the current and .88 with the current. Total 4.02 hours*

3. A boat travels at 16 mph. How long will it take to make a round trip of 22 miles each way across a lake? What is the total time of the 44 mile trip?

*2.75 total*

4. Compare the trip in current and the trip on the lake. Why do you think there is a difference?

*You would think that the round trip would be the same in the current and on the lake, but the fact is, the boat is in the negative force of the river longer than it is in the positive force, so it takes longer to make a 22 mile round trip in a river than on a lake.*

5. An outboard motor uses 4 gallons per hour. It can go 21 miles per hour. How many miles per gallon does it use?

*5.25 mpg*

6. Another outboard uses 3.2 gallons per hour, and goes 18 miles per hour. Which outboard is more economical?

*5.625 mpg*

7. Which of the above outboards is more economical going upstream for 72 miles on a river with an average current of 12 miles per hour?

*The one using 4 gal per hour and going 21 mph because the speed relative to the current of the faster boat is greater.*

*21 mph - 12 mph = 9 mph ground speed*

*18 mph - 12 mph = 6 mph ground speed*

*The slower boat is slightly more efficient in calm water, but is far less efficient against a current.*

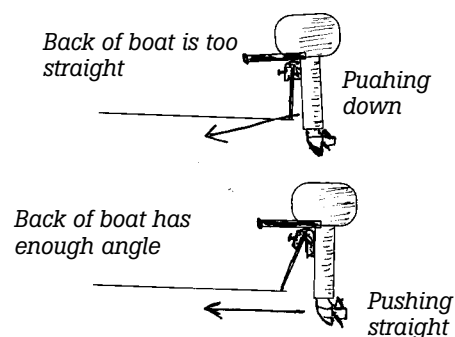
## Boat Design

### Activities

1. Look at the different boats in the village. Identify the planing boats and displacement boats. Some fishing boats are a compromise between the two.
2. What is the average length and width of the boats in your village? What is the average height of the sides in the middle of the boat? What is the average angle outward of the sides, in both the middle and back? What is the average angle backward of the transom?

3. Ask a local boat builder what happens if the transom doesn't have enough angle.

*The motor can't get far enough under the boat. It is tilted out, and thus pushes the back end down and the front of the boat up. If the transom has too much angle, the motor can always be tilted out with the tilt pins.*



4. What are the different materials used in boat construction in your village?
5. How does the style of boat in your village compare with those in the description in the above text? Are they "downriver boats," "upriver boats," "ocean boats" or a combination, or something different?
6. Talk with a local boat builder about boat design. Does he agree or disagree with some of the thoughts in the above text?
7. Look at a canoe if one is available. Are the turns and curves gradual? Compare this with a planing boat. Which would you rather paddle or pole upstream?
8. Ask the oldtimers about shooting out of a canoe. What precautions must be taken?
9. Try poling a planing boat upstream in swift water. Paddle or pole a canoe in the same place. Compare the effort.
10. Compare the bottoms of the boats in your village. Feel them if you can. How rough or smooth are they? If they are rough, how did they get that way? How would you reduce the friction on each one? Do boats in your area need paints with copper compounds to prevent organic growth?
11. Students should slap the surface of a small body of water with their hand, a board or paddle. Increase the speed with which it is slapped. Notice that it seems to become "solid" the faster it is slapped. How does this apply to a planing boat.
12. Carve a displacement or planing boat from soap or cottonwood bark.
13. Ask oldtimers how they hauled big loads long ago. How is that different from today?  
*They had long slim displacement boats with much smaller motors.*
14. Draw an upriver boat. Draw a downriver boat. Which do you prefer?
15. Ask oldtimers how they built canoes or kayaks. What are the effects of changing width? Length? Did they put a rocker<sup>1</sup> in the bottom? How high were the sides? What were the problems they had with materials? Today we weld and use synthetic caulking. How did they fix leaks long ago?
16. Ask around the village to find out the gas consumption of the new four-cycle outboards. How many gallons per hour for each horsepower rating? Divide the horsepower by the gallons to find the ratio. Compare this with the gas consumption of newer two-cycle motors.

17. Compare the difference in purchase price of a two-cycle and a four-cycle outboard. The four-cycles are more expensive. What is the price of gas in your community? Can you figure how many gallons of gas a four-cycle would have to burn to pay for the difference in purchase price? This isn't a simple problem. You will probably have to do it as a class, but it is one everyone must take into account when buying a motor.

*My calculations say that by the time the four cycle engine has paid for itself in the gas it has saved, it will be worn out. I don't think there is much difference in the long run, but that is for this area.*

18. Ask in your village how much the boats cost. Compare the cost of the different kinds of boats with each other. Ask people how long each kind of boat lasts (plywood, fiberglass, aluminum etc). In the long run, what is the cheapest kind of boat? Is it also the most useful kind of boat? Do people still make their own boats? Why? Is it because commercial boats aren't designed properly for your location?

## Student Response

1. What are the two different kinds of boats?

*Planing and displacement*

2. Which of these two kinds of boats is better for carrying a big load with a small motor?

*Displacement*

3. Which of these two kinds of boats is better for running around with a light load?

*Planing*

4. What is the most important thing to remember in designing a displacement boat?

*Gentle, gradual curves to push the water out of the way gradually.*

5. A planing boat is better when it is wide or slim?

*Wide*

6. Which planing boat will get on step faster, one with a flat bottom or one with a V bottom?

*Flat*

7. Which planing boat will give a smoother ride in rough water, one with a flat bottom or one with a V bottom?

*V bottom*

8. Which is better for your location? Why?

*Answers will vary.*

9. What are the advantages of high sides on a boat? What are the disadvantages?

*Advantages: safer in waves, water can't come in the boat. Disadvantages: high sides tend to blow around in the wind. It is harder to get in and out of a boat with high sides.*

10. What is the force called that slows a boat with a rough bottom? How is this remedied with a wooden boat?

*Friction. Sand or burn the rough material off with a blow torch and paint it.*

11. There are four common materials used in boat construction. List them and one advantage and one disadvantage of each.

*Wood: Inexpensive, strong, repairable. Heavy, not durable in the ice, knots fall out, rot.*

*Plywood: Same advantages and disadvantages as wood, but leak less. Marine plywood is expensive.*

*Aluminum: Doesn't rot or rust, light, unharmed by ice, easy to drag over ice, lasts a long time. Owner can't design and build his own, noisy for hunting, owner can't repair it, some have leaky rivets. Eventually they crack in the transom and in the front where the boat touches the beach.*

*Fiberglass: Unharmed by running in the ice. Slides well on ice, low friction with water, strong and low maintenance. Owners can do repairs. Owner can't design his own, heavy, age in sunlight, shipping cost is high.*

## Math

- One boat travels 20 miles upstream in a swift river where the average current is 10 mph. The boat's speed relative to the water is 20 mph. The boat makes a round trip. Another identical boat and motor travels 40 miles on a lake where there is no current. There is no wind acting on either boat. Question: Do they both make the trip in the same time, or is there a difference? If there is a difference, why?
- Plywood costs \$35 a sheet landed in the village. Screws to build a boat are \$4.50 a pound. Paint is \$22.5 a gallon. The lumber to build the ribs and other parts is \$1.25 a board foot. Five gallons of fiberglass resin flown into the village is \$89. The fiberglass cloth is \$3.00 a linear foot. How much would it cost to build a boat 24' long? The boat is 4' wide and will take six sheets of plywood. It will require 4 pounds of screws and three and a half gallons of paint (only available in gallons.) Add

10% for incidental expenses like calking, glue, paint brushes etc. An aluminum boat is \$3,200 landed in the village. Which is cheaper? Considering that an aluminum boat lasts twice as long, which is cheaper?

## MagneTos & Spark Plugs

### Activities

1. Collect as many different kinds of spark plugs as you can find in the village. How many different kinds do you find? How many different companies are represented by the plugs? What differences do you notice among them? How many different kinds of engines do these plugs represent?

*The differences are numerous. The diameter and length of the threads that go into the cylinder head, the diameter and length of the porcelain, the electrodes etc. A collection of 10-15 different ones is small.*

2. Compare the length of the plugs, the length exposed within the cylinder, the length of the threads, and the diameters. Why do you think there are such differences? Can you find some plugs that are golden brown, some black, and some that burned too hot? (You may not, as the golden and white ones might be still in machines.)
3. What are the differences in the identification numbers of hot and cold plugs from the same manufacturer. If you can't tell by looking, a manual will tell the difference.

*Snowmachine plugs will best illustrate this.*

4. Find old flywheels. Test the magnets for strength. Are they strong or weak magnets?

*Fairly strong.*

5. Get an old and a new spark plug of the same kind. Put the plug wire of an engine (chainsaw is easiest) on each plug. Hold the base of the plug against the cylinder of the engine, and crank the engine over. Do you see a difference in the color of spark in the new and old plug? (It is hard to see the spark in a bright location.)

*If the old plug sparks at all it will probably be yellow or red. The new one should be blue or white. As stated above, do this in a dark room, not in direct sunlight. Be careful. You can get a good shock from this. The person holding the plug to the cylinder head should not touch any other part of the engine.*

6. Find a plug that will not fire in the above manner because of carbon and dirt. Carefully clean the center post with a hairpin, or other slim object. Can you clean it well enough to give a hot blue or white spark?

*Now is the time to learn. In the middle of a snow or rainstorm is not the time to experiment.*

7. Close the gap on an old plug, and test it against the cylinder. Did the color of the spark change when the gap was made smaller?

*It should improve a little, but this doesn't always work.*

8. Look up the recommended spark plug gap for three or four different engines. The recommended gap should be in the manual for the machine. Pick some high and some low compression engines. Why do you think there are some differences in the recommended gaps?

*High compression engines have more resistance to the spark jumping the gap. However, the manufacturers know this, and make the coil stronger. The gaps should all be about .0020-.0025*

9. Find out about sandblasting spark plugs. Ask how long a sandblasted plug will stay clean and why.

*Sandblasting works for a short while, but the rough surface created will accumulate carbon fairly soon.*

10. Put the end of a fouled spark plug in the flame of a propane or Coleman stove until it turns red hot. Carefully let it cool. Test the spark before and after this. What difference do you see in the spark? Why do you think this is so?

*This cleans the plugs, as it burns the carbon from them. They won't work as long as a new plug, but will get you home if you are stuck out in the woods.*

11. Find a coil that people say is bad. Is there anything visible to indicate that it doesn't work well?

*The sad answer is... "no". There is nothing visible about a coil that would indicate it's functioning.*

12. On a working engine, pull the wire that goes from the magneto to the coil. While holding the wire, ground your hand against the cylinder and pull the starter rope. Put that wire back and pull the wire from the spark plug. Put a screwdriver handle up the spark plug cap and again ground your hand against the cylinder. Pull the starter rope again. Do it slowly! Can you feel the difference in voltage? (You should!) This will be uncomfortable, but shouldn't hurt unless you pull very fast.

*The voltage coming from the magneto to the secondary coil is hardly noticeable. The voltage from the secondary coil to the sparkplug is strong. If you don't pull the engine fast at all, it will give you a little jolt,*

*but won't hurt. Don't touch the engine with any other part of your body other than the hand held against the cylinder. The spark will go through your hand, and not thru your body. This might sound a little dangerous, but when you are stuck out in the woods, this is one of the ways to tell if the spark is strong enough. It is better to learn how to do it safely.*

13. Ask around the village to see if anyone knows the difference between a generator and an alternator. What is the difference?

*A generator has a permanent magnet in the armature. An alternator has an induced magnet in the armature. An alternator can generate more electricity, particularly at low rpm's, but it needs some electricity in the battery to induce the magnetic force. That is why a car with a completely dead battery cannot be jump started by pushing. All new cars have alternators, and they need a little electricity to activate the magnet.*

14. Draw a cylinder whose timing is too advanced. Draw one whose timing is too slow. Look in an owner's manual of a four-cycle engine and find how many degrees before top dead center (BTDC) the timing should be set.

*The drawing is in the text.*

## Student Response

1. Make a simple drawing of the parts of the spark system of an outboard motor from magneto to spark plug.

2. Where is the electricity generated in an engine?

*In the magneto*

3. Where is the voltage increased?

*In the secondary coil*

4. What does the spark plug do in an engine?

*Ignites the fuel*

5. Draw and label three cylinders, one firing too soon, one firing too late, and another firing at the proper time.

6. Explain why a spark might jump the gap in open air, and not in the cylinder.

*There is more resistance in the cylinder. There are more air molecules in the way.*

7. What colors indicate the hottest sparks?

*Blue and white*

8. What colors indicate the weakest sparks?  
*Red and orange*
9. What two things could keep a sparkplug from firing well?  
*The gap is not set properly*  
*There is carbon on the plug, shorting it out.*
10. List five things that could make the sparkplug black with carbon?  
*Fuel mixture too rich*  
*Spark is too weak*  
*Wrong kind of 2 cycle oil*  
*Too much oil in the gasoline*  
*The plug doesn't retain enough heat*
11. Draw a picture showing how a dirty plug allows the spark to ground out, not jumping the gap.
12. What kind of plug should be used in an air cooled engine during cold weather? Why?  
*A hot plug. It can thoroughly burn the fuel on it's surface. A cold plug will carbon.*
13. Why would an outboard be able to use one type of plug all the time, and a snow machine need different plugs in different seasons?  
*An outboard is cooled by water that is a fairly constant temperature. A snowmachine is cooled by air that might be from -50° to +40°F.*
14. List five things that could cause the voltage to a sparkplug to be weak.  
*Dirty or worn magneto coil*  
*Improper distance between the magnet on the flywheel and magneto coil.*  
*Broken or dirty wire connections.*  
*From the magneto to the secondary coil*  
*From the secondary coil to the ground*  
*From the coil to the ground.*  
*Secondary coil shorting out*  
*Dirty or cracked spark plug.*

## Math

1. The voltage generated by a magneto is 50 volts. The coil increases this to 15,000 volts. If the magneto is fixed so that it now generates 75 volts. How many volts will the coil produce?  
*22,500 volts*

# Carburetors

## Activities

1. Find an old carburetor from any machine that utilizes a float. Identify the parts. Identify how the float controls the amount of gas in the bowl. Is there an artificial rubber seal to shut off the flow of fuel? Take the needle valves out. Draw the shape of the tip. Don't touch the tip with a file, but touch the side of the needle valve. Is it hard or soft? Can you find a screen in the fuel line within the carburetor? What do you think would happen if this became plugged?

*The needle valves are made of soft material. There should be a screen in there somewhere. If dirt gets in the little holes in the carburetor, it will stop the whole operation.*

2. Look at the aircleaner on several chainsaws. Can you see how the air flow might be slowed down by a dirty aircleaner? How does the owner's manual say to clean it?

*The owners manual often says to use compressed air, but lacking that we usually use a toothbrush lightly.*

3. Look in the owner's manual of a chainsaw. What is the standard setting for the needle valves? (If no chainsaw is available, try to find another engine that has a carb with a high and low speed needle valves.)  
*3/4 to 1 turn open on both the high and low speed needle valves.*

4. Take the bar and chain off a chainsaw. Replace the clutch cover (for safety reasons). Remove the cover from the carburetor. Start the engine. Find the idle set screw. Adjust it when the engine is idling. What happens?

*The engine speeds up or slows down. The idle set screw is like fine tuning the throttle. It determines the lowest speed the engine can run. Watch the throttle move back and forth as you adjust the idle set screw.*

5. Set the high-speed needle valve too rich and then speed the engine up. Can you hear the sound when it is getting too much gas. Now shut the high-speed needle valve down. Speed the engine again. Can you hear the weak sound it makes? These two sounds will help you tune engines in the future. Remember them.

*A good mechanic uses his/her ear to tune an engine. It takes practice, but the sounds of a rich or lean engine are distinct.*

6. We usually set the needle valve halfway between the points where we can hear the lean weak sounds and the rich sounds. Then we open the needle valve 1/4 turn. This insures that the engine isn't too lean. Why

do you think there are springs on the needle valves if they aren't moving parts?

*The springs keep tension on the needle valves so they can't vibrate open or closed.*

7. While the chainsaw is running without a bar and chain, remove the air cleaner. Pull the choke lever. Can you see the choke butterfly? Why do you think choking a warm engine kills it?

*It gets too much gas.*

8. While the chainsaw is running, pull the throttle. Look in the carburetor. Can you see the throttle butterfly moving?

9. Put a little gasoline in your hand, and blow on it. Does it feel hot or cold? Why? Can you understand carb icing now?

*It feels cold because it is evaporating. In the carburetor evaporation is constantly taking place. The temperature of the carburetor is reduced far below that of the outside air.*

10. The next time you are in a small plane, ask the pilot to show you the carb heat knob. Ask him why the engine loses a little power when it is applied. Does this explain why pilots don't run with carb heat all the time?

*With the carb heat on, the air that is pulled into the carburetor comes off the heated exhaust manifold. This warm air melts any ice in the carburetor, but warm air is thinner than cold air. Therefore, the engine isn't getting enough oxygen to efficiently burn the fuel. If the engine ran with carb heat on all the time, it would be inefficient for lack of air.*

11. Cut two identical blocks of wood. Split one into four parts, and the other into kindling. Make two separate campfires and burn them at the same time. Which one burns faster? Explain to someone else why fuel is sprayed into the carburetor in a fine mist.

*The block that is split into thin pieces will burn faster. When fuel is sprayed into the cylinder in a mist, it burns faster and more completely.*

12. Ask people in the village about the carburetors that came with the first snowmachines. Are the ones available now better?

*The first carburetors on many snowmachines were Tillotson carburetors that could operate in any direction. They didn't have a float. But they did have lots of tiny holes and parts that plugged with frost. They were terrible. Most carburetors now are Mikuni type, with a bowl, float, and simple parts.*

## Student Response

1. A carburetor mixes what and what?

*Air and fuel*

2. What happens if there is too much fuel? Not enough fuel?

*Too Much: If there is too much fuel (rich), combustion will not be complete, power will diminish, and carbon will quickly build up in the cylinder.*

*Not Enough: Lose power fade under load, overheat. A lean engine, running too hot, is self-destructing. Parts warp, wear, and break.*

3. Why is a carburetor that isn't getting enough gas particularly harmful in a two-cycle engine?

*A lean engine runs hot and when a two-cycle engine is lean on gas it is also lean on oil.*

4. Draw a carburetor and identify the parts.

5. What is the purpose of the air cleaner and what happens when it is dirty?

*It filters dirt, dust, and sawdust from the engine. When it is dirty the air is constricted and more fuel is drawn into the engine than normal.*

6. Describe Bernouli's principle in your own words.

*When air (or other fluid) speeds up, the pressure decreases*

7. What does the throttle do?

*It speeds up the air that is passing through the carburetor, decreasing the pressure*

8. What do the needle valves do?

*It controls the amount of fuel that can get to the fuel jet.*

9. What does the choke do?

*It reduces the area through which the air can flow, therefore increasing the velocity of the air and decreasing the pressure. As the air pressure is reduced, the amount of gasoline taken into the carburetor is increased.*

10. What does the float do?

*It controls the amount of fuel that gets to the bowl of the carburetor. It shuts off the fuel if there is enough available.*

11. Why is it important to increase the surface area of fuel?

*When the surface area is high, combustion is more complete. There is greater power and efficiency.*

## 12. What is carb icing?

*It is ice that has formed in a carburetor. The evaporation of fuel takes heat. That reduction of heat cools the air coming into the carburetor. As the air is cooled, the moisture in it is condensed and cooled to freezing.*

**Math**

1. A carburetor is set too rich. It uses 7% more gas than it should. The operator spends \$127 on gas in one month. How much could he save by tuning his carburetor?  $1.07x = 127$

*\$8.31*

2. The pressure in an airplane carburetor throat is 12.9 psi. Atmospheric pressure is 14.7 psi. What is the difference in pressure? The plane climbs; the atmospheric pressure is now 14.2 psi. What is the pressure difference now?

*1.8 psi, 1.3 psi*

## Compression

**Activities**

1. Get an old piston that still has rings. How many rings does this piston have? Compress the rings. Can you see how they would seal the piston in the cylinder. Is the groove in the piston a tight fit for the rings? Is there a post in the groove that keeps the piston ring from turning around in the groove? Why do you think this is so?

*Most pistons have at least two rings. The rings are split so they can expand and seal against the cylinder walls. Note that there is a post that keeps each ring from turning. Note that the split in one ring is no directly above/below that of another. This is to keep the gasses from escaping past them.*

2. Ask some of the local mechanics why cylinders are honed before installing new rings. Ask them to demonstrate how to get the piston and rings in a cylinder. What caution must be exercised?

*Cylinders are honed before putting new rings in because the cylinder walls are glazed to the shape of the old rings. Honing removes the glaze and gives the new rings a chance to fit themselves to the cylinder wall. Exercise caution putting the piston in the cylinder or the rings can be broken if they aren't aligned correctly.*

3. File a old piston ring. Is it hard or soft? File the piston. Is it hard or soft?  
*The rings are very hard, much harder than the file. The piston is probably soft aluminum.*

4. Pull the sparkplug from an engine (like a chainsaw). Put your finger over the sparkplug hole, and pull the starter rope. Can you feel the compression? If you can get a compression tester, test the pressure in the cylinder. Some compression gauges give pressure but don't indicate the ratio. If a cylinder has 105.8 psi, what is the compression ratio?

*Atmospheric pressure is approximately 14.7 psi. Round it off to 15 psi. 105.8 divided by 15 is about 7.*

5. Make a campfire with good dry wood. Push the sticks close together. Pull them apart. Does the fire burn faster if the wood is closer?

*The fire burns much faster when the wood is closer.*

6. Draw a piston in a cylinder at the bottom of the stroke and the top of the stroke. Measure the volume in each position. What is the compression ratio? Now draw a piston in a cylinder that has a high compression ratio.

7. Get a hand pump and pump a bicycle tire. Is it hot? Where does the heat come from?

*All air pumps get hot in operation. The heat comes from compressing the air. This understanding is preparing students for Boyle's and Charles law.*

8. If you can get a simple compression tester, test the compression in a snowmachine, outboard, four-wheel ATV, and chainsaw. What is the difference between them?

9. Some engines have a head gasket and others do not. Ask a local person who does mechanics which local machines do and which don't. How can he tell if the head gasket is damaged? Where is it most often damaged? Can you use any gasket material for a head gasket? Why?

*Head gasket material is special because it must withstand heat and pressure. A blown headgasket will reduce the compression in a cylinder, and cause the engine to run poorly or stop.*

10. Talk to the local power plant operator about the compression in a diesel engine. How does the fuel get into the engine if the pressure is so great? Does a diesel engine have a carburetor? Why?

*Diesel engines don't have a carburetor. Each cylinder has a fuel injector that sprays the fuel in at the proper time under great pressure.*

11. Research how compression is achieved in a jet turbine engine.

## Student Response

1. What three things are necessary for something to burn?  
*Air (oxygen), fuel, heat*
2. If a campfire is burning too slowly, what can you do to make it burn faster besides adding more wood?  
*Move the sticks of wood closer together.*
3. Why is compression necessary?  
*To move the fuel droplets close together so they can ignite each other easily.*
4. What is the purpose of piston rings?  
*To seal the pressure in the cylinder. They keep gasses from escaping.*
5. Draw a cylinder where the fuel is not compressed.  
*The fuel drops are far apart.*
6. Draw a cylinder with the fuel compressed.  
*The fuel drops are close together.*
7. What is the approximate compression ratio of a gasoline engine?  
*7:1 to 11:1*
8. What does psi mean?  
*Pounds per square inch*
9. What can cause compression loss?  
*Worn piston rings.*

## Math

1. If the compression ratio is 9:1 and atmospheric pressure is 14.7 psi, how many psi is there in the cylinder when the piston is at the top of the cylinder?  
*132.3*
2. If the compression ratio is 16:1 in a diesel engine, what is the pressure in psi?  
*235.2*
3. The compression ratio in a chainsaw is supposed to be 7:1, but the rings are bad and there is a 15% compression loss. What is the psi in the cylinder?  
*87.5*

4. The compression in a diesel engine is 17:1. How much pressure must the fuel pump generate if the fuel is injected when compression is at its greatest? Greater than \_\_\_\_\_.

*250 psi*

## OUTboard MoTor Lower UniT

### Activities

1. Find a complete lower unit. Identify the parts, prop shaft, drive shaft, anti-cavitation plate, skeg, water intake and engine exhaust.
2. Look at the motors in the village, new ones and old ones. In what ways are they similar? In what ways are they different? Trace the changes in outboards through time. Ask oldtimers about inboard engines. How were they better? How are outboards better?

*Inboards were slow but powerful. Outboards are easy to steer, are lighter, quieter, and can be removed to work on them. They travel much faster than inboards.*

3. Compare the lower units made today and those of years ago. Ask the oldtimers about the advantages of the shear pin type lower units. Is there one in a cache somewhere? Why did the outboard manufacturers change from shear pins to slip props?

*Shear pins were inconvenient and sometimes dangerous to change, but the lower units lasted for a very long time. The modern lower units are terribly expensive to change. Sometimes I wish for the inconvenience of the shear pins.*

4. What kind of metal do you think the gears are made of? Try to file them. Are they hard or soft? Try to file the drive and prop shafts. Are they hard or soft?

*Gears are made of very hard steel.*

5. Feel the seals. Are they soft? Are they worn? What holds the seals tight against the shaft?

*Many seals have a small spring that holds the seal to the shaft.*

6. Find the intake for the water pump. Why do you think the holes aren't bigger?

*If the holes were bigger grass and small rocks would enter and plug the cooling system.*

7. On a complete lower unit, turn the prop as if the boat were going forward. One side of the prop has low pressure coming from the top; the other side has low pressure coming from the bottom. Identify each. If the prop were to cavitate, which side will it cavitate on?

*The prop will only cavitate on the side that is on the downstroke.*

8. Look at a prop shaft with the gears attached. Explain to someone else how the motor shifts from forward to neutral to reverse. Try to draw this so someone else can understand by your picture.

*This will jiggle your brain for a little while, but is worth understanding.*

9. Change grease in a lower unit. Make sure the bolts are tight once you are done. Did you see the new grease pushing the old grease out of the upper hole? Did bubbles come out too? Are you confident that the lower unit is full of grease? Was there any water in the lower unit when you first drained it?

10. Stir a clean magnet in the grease that has just been drained from a lower unit. Are there any metal chips? (Cover the magnet with thin plastic wrap before doing this to facilitate cleaning.) Rub some of this grease between your fingers. Rub some new grease between your fingers. Can you feel a difference in friction? In thickness (ability to keep metal parts from touching each other)?

11. Tap an old drive shaft with another piece of metal. Does it ring, indicating high carbon steel? How was it attached to the end of the crankshaft so it wouldn't spin? Ask someone what these are called.

*It should ring as most of them are good quality high carbon steel. There are splines on the end that fit into the splines on the crankshaft.*

12. Roll an old prop shaft on the table. Look closely. Does it wobble, indicating that it is bent? What do you think happened to the seals if the shaft was bent?

*If it was bent, the seals were worn.*

13. Try paddling a boat with the motor up, out of the water, and then lower the motor. Paddle again. Note the resistance of the lower unit. Can you now see why design and size are so important? Imagine the resistance at high speeds.

14. Imagine that the prop has just hit a big rock. What parts absorb the stress and shock?

*The blade of the prop transmits the impact to the gears through the prop shaft. Something has to give between the pressure in the cylinders and the blade of the prop. Something has to break or slip.*

15. Where does the exhaust leave the engine? Why doesn't it exhaust into the air?

*Much of the exhaust goes out the back of the prop. It is much quieter this way.*

16. Check five to ten props in the village. What is the average pitch? Are these mostly working boats or speed boats? Do you see any relationship between the prop diameter and the horsepower?

*Bigger motors usually have bigger diameter props.*

17. Does anyone in your location have a jet boat? Talk with them about the advantages and disadvantages of jet units. Why don't more people have a jet unit?

*Jet units are very expensive. They don't carry a big load well, and they plug with gravel, leaves, and even pieces of plastic in the water.*

### Student Response

1. What gear is at the end of the driveshaft that turns both the forward and reverse gears?

*Pinion*

2. Why is lower unit grease important?

*It lubricates the gears and bearings.*

3. Should you fill the lower unit with grease from the bottom or the top hole?

*From the bottom hole or there will be too many air bubbles.*

4. What do seals do?

*Keep the grease in and water out.*

5. Why are the thin shims important in a lower unit. Explain or draw.

*They determine how loose or tightly the gears fit together.*

6. What are the two shafts that turn in a lower unit?

*Drive shaft and prop shaft*

7. Draw a picture of cavitation.

*This should show air bubbles going down to the prop.*

8. What does the skeg do?

*Protects the prop from hitting the bottom*

9. What does the trim tab do that is behind the prop?

*It corrects for torque that might cause the engine to want to turn to one side.*

10. A prop is marked  $11 \times 13$ . What do each of these two numbers mean?  
*11 = the diameter. 13 = the amount the prop would move forward if it were auguring through a solid.*
11. One prop is marked  $13 \times 13$  the other is  $11 \times 13$ . Which is the speed prop? Which is the work prop?
12. Why is it important to balance the load and the rpm?  
*Too much load or too many rpm both put stress on the engine parts.*
13. Describe or draw a prop that has a shear pin.
14. Describe or draw a slip prop from the rear view.
15. What happens when a prop gets out of balance?  
*It vibrates because the forces aren't balanced. If this is allowed to continue, bearings and seals will be damaged.*

## Math

1. Consider that an outboard usually turns 5,500 rpm. How many revolutions per second is this? Can you even imagine something moving up and down that fast? How many times a minute can you clap your hands? How many times faster is a piston? (Time and count yourself for a minute.)  
*91.7. Answers will vary*
2. Find some old forward, pinion, and reverse gears in the village. Count the teeth on each. How many are there on the pinion gear? On the forward gear? If the forward gear turns one time, how many times has the pinion gear turned?  
*Answers will vary*
3. Using the information you discovered from the above question, if the engine is turning 5,000 rpm, how many rpm is the prop turning?  
*Answers will vary*
4. The pinion gear in my motor turns  $2 \frac{1}{2}$  times for every turn of the forward gear. The engine is turning 5,000 rpm. How fast in rpm is the prop turning?  
*2,000*
5. Find the cost of a new outboard motor? Find the cost of a new lower unit for the same motor. What percentage of the cost of the whole motor is the lower unit? (A 30-horsepower Mariner costs \$3,200 and a whole new lower unit costs \$1,356. Use this example if you can't find your own figures.)  
*Answers will vary. 42.37%*

6. Pat has to buy parts for his lower unit. Pinion gear \$32, forward gear \$45, seals \$5.75, reverse gear \$45, new prop shaft \$37, new prop \$127, and grease \$3.75. How much did it cost him to hit the rock?  
*\$295.50*
7. A new stainless steel prop is \$250. An aluminum prop is only \$105. The stainless prop lasts two times longer than the aluminum. Which is more economical?  
*Stainless*
8. A speed prop supposedly goes forward 13" for every revolution, but in reality it only goes 6.5". What percentage of efficiency is this?  
*50%*
9. Frank can get a second hand lower unit for \$675 or a new one for \$1,172. The used one will last two seasons and the new one will last four. Which is more economical?  
*The new one is cheaper*
10. Aluminum props used to cost \$15 each in 1972. Now they are \$120. What percent increase does this represent?  
*800%*

## OUTboard MoTor Cooling System

### Activities

1. Take a water pump apart. Identify the three main parts. What causes the impeller to turn as the shaft turns?  
*The drive shaft has an indentation that holds a key. The key also fits into the impeller in the pump. As the shaft turns, the water pump also turns.*
2. Touch the bottom plate of the water pump with a file. Is it harder or softer than the file? Why do you think this is so?  
*It is hard. It must be durable to withstand the abrasion from silt.*
3. There are two types of metal that water pumps are made of. Find examples of each. Why do you think there is a difference?  
*Aluminum housings are cheaper, but less durable. Chrome housings are very durable but more expensive.*

4. Put an impeller in a pump housing. With a stick in place of the drive shaft, turn the impeller. Watch the impeller blades extend and compress. Imagine the water coming in the side where the blades are extending and leaving the side where it is compressing.
5. Find the intake for the water on the lower unit. Is there a screen of any kind? Why do you think the screen is there? Ask people in the village what it is for and what would happen if it were missing.  
*There is usually a screen to keep rocks and grass out. The cooling system, particularly the thermostat would plug up if it were not there.*
6. Check the copper tubing that carries the water from the pump to the upper unit. Are there seals where it connects to each?  
*Yes, there is pressure in the cooling system from the pump, and the seals hold the pressure.*
7. Can you find the thermostat? They are in different places on different motors. If possible, remove it. Alternately, pour hot and cold water on it. Can you see it move in response to the temperature difference?  
*The response is visible.*
8. If you live near a silty river, collect some water and let it settle overnight. Is there sediment on the bottom of the container? Pour most of the water off and rub your hand on the bottom of the container. Can you see why silt will wear the impeller inside the pump housing?

## Student Response

1. What would happen to an outboard if water didn't circulate around the cylinders? Is this change permanent?  
*Parts would warp because of overheating. Yes*
2. What are the three parts of a water pump?  
*Impeller, housing, bottom plate*
3. With a drawing of the top view, show how a water pump works.  
*It should show the impeller off center.*
4. What is the purpose of the screen on the lower unit?  
*Keep rocks and grass out*
5. What is the purpose of a thermostat? How can it malfunction?  
*Control the waterflow so the engine can work at the best temperature. If a rock gets stuck, it can refuse to open or close.*
6. What does the indicator do? If it is plugged, does that mean the water pump isn't working?

*The indicator shows if there is water coming out of the cooling system of the engine. If the indicator is not showing water, the water pump may or may not be working.*

7. Why should an outboard motor be tilted up when not in use? During what season is this not so?

*Silt settles in the waterpump if the engine isn't tilted up. This isn't true in late fall when the water is no longer silty.*

8. A water pump doesn't work. The operator improvises a way to get home. What are the consequences if the improvised water cooling system doesn't work?

*If his improvised method doesn't work well, the engine might still run, but parts will be warped and damaged from the heat.*

## Math

1. A cheap aluminum impeller housing costs \$12. An expensive stainless steel one costs \$37. However, a housing made from stainless steel lasts 4 times longer. Which is cheaper in the long run?

*The stainless one.*

# Dogsleds

## Activities

1. If there are any dog teams in your area, study the sleds. What is the length? Is there rocker in the runners? What are the sleds used for: racing, cross country, hauling loads, or what?
2. Study the snowmachine sleds and hitches in your area. What are the features people look for? What materials are best?
3. What did people there use for runners before plastic became available? Before that what did they use? Ask about different weather conditions. Does their experience compare with the above text?
4. Ask the oldtimers how they determined where to put the bridle of the sled and why they did it that way.
5. What is the load most often hauled now by sleds in your village? What used to be the main load?

6. Ask people in your area why they switched from dogs to snowmachines. What are the advantages and disadvantages of each?
7. Watch dogs as they train. What rhythms do you see? Do all the dogs in the team go from a walk to a trot to a full run at the same speed? Watch the team on uneven ground. Why is the musher pushing?
8. Try pushing the different sleds in your village. Which runners are best and why?
9. Rough-lock the runners of a sled. Try to push or pull it.
10. Try roughlocking a sled's runners and going down a small hill. Roughlock only one side. Try again.
11. Ask the oldtimers in your area how they traveled in the mountains with dogs.
12. Push an empty sled. Load it and push it again. Is there a difference in getting it going? Is there a difference once it is going?
13. Put most of the load in the sled on the front. Try to pull it around corners. Now put the same load in the back of the sled. Pull it around the same course. What is the difference?
14. Put a temporary bridle on a sled. Move it from center. Pull the sled. Is the difference obvious?
15. If possible, try a long, short, and medium sled (eight, ten, and twelve foot) on a rough trail. What differences do you observe?  
*The longer sled should glide over the bumps better.*
16. Get a big load in a sled and hook up a few dogs. Let them try to get the load going. Stop. Pull slack in the towline, and command the dogs to pull. When they hit the end of the slack, there is a jerk. ( as in the section "Moving a Big Load" Is there an easier way you know of to get the sled going with a big load?
17. Put a fisherman's scale on the end of a line from a small sled. How many pounds do you have to pull to break the sled free from static friction? How many pounds is the sled pulling once it is moving? Of course, some of the resistance while the sled is stopped is from inertia, but much is static friction.
18. Look at the sled brakes in the village or ask the oldtimers what they used for a brake. Were the conditions mostly powder snow, or clear ice?

## Student Response

1. What five things are dogs pulling against when they pull a sled?

*Friction*

*Lifting the sled up banks and hills*

*Inertia*

*Keeping the sled on the trail*

*Very small effect of wind resistance*

2. What kind of runners did the oldtimers have for warm and cold weather?

*For warm weather they used steel.*

*For cold weather they used ironwood*

3. What were some of the local alternatives to ironwood runners imported from the lower 48?

*Split green spruce or the hardwood from the downhill side of a spruce tree.*

4. Why have we changed to plastic?

*It has less friction, and is good in all weather conditions.*

5. Draw a picture of roughlocking.

6. Describe inertia as it relates to driving a dog sled.

*It takes energy to overcome inertia and regain speed as a sled either gets going or hits bumps and is slowed down.*

7. Why is rhythm important?

*When a musher allows the dogs to keep a rhythm they aren't spending too much energy overcoming inertia as the sled speeds up and slows down.*

8. What happens if a long sled doesn't have any rocker in the runners?

*It will be very hard to steer*

9. What happens if the sled has too much rocker?

*It will shift from side to side and will require constant steering.*

10. What happens if the bridle on the sled isn't centered? Explain, or draw the result.

*It will pull to one side. If one side is longer, the shorter side will pull harder and the sled will pull to the opposite side.*

11. Draw a picture that illustrates the advantages of a long sled on a rough trail.

12. Thinking of the five things that a dog is working against, tell as much as you can about making the dog's job easier and increasing the miles traveled in a day.

*Plastic and other low friction runners will greatly reduce the resistance to forward motion.*

*The musher can push the sled over bumps and hills*

*The musher can push, kick or drag to keep the sled going at a constant pace and therefore maintain the dog's rhythm.*

*As the musher steers to keep the sled on the trail, he/she avoids the energy drain of getting stuck or slowed down by deep snow.*

*A musher can try to minimize wind resistance.*

13. Draw the top view of a sled that would be pulled by a man and two dogs. Include the method by which he would steer.

14. Why is traveling in March or April difficult?

*The trail becomes high and the sled tends to slide off to the side.*

15. What two forces have to be overcome to get a sled moving?

*Inertia and static friction*

16. Draw a picture showing the disadvantage of a sled with a bend in the runner that is too abrupt.

17. What is the purpose of a sled brake?

*To stop or slow the sled.*

## Math

1. A sled has a runner that is in contact with the snow for 8.5 feet. Each runner is 2" wide. (remember, there are two runners.) The sled, including driver and load, weigh 275 lbs. What is the psi of the runners? What would it be if the runners were 1.75" wide? 3" wide?

*2" wide = .674 psi*

*1.75" wide = .77 psi*

*3" wide = .44 psi*

# Snowmachine Tracks

## Activities

1. Put gasoline on a rubber band. What happens? Put a rubber band out-

side in the cold. How flexible is it below zero? Why aren't tracks made of real rubber?

*Gasoline will quickly dissolve the rubber in a rubber band.*

2. Look at the different snowmachine tracks in the village. How do they compare in length and width? Do some have metal cleats? Do any have racing stars? Of all the different kinds, which is the most popular in your village?
3. Measure the surface area of the tracks plus surface area of the skis of different machines. Compare the surface area to the weights given in the snowmachine specifications. How many pounds per square inch does each one represent? Are there relationships between the psi of trail machines contrasted with racing machines?
4. Draw the patterns of the bottom of the tracks. Compare them. Compare them with four-wheeler tire patterns. Are there any similarities?
5. Find old tracks around the village. Compare their thickness. Diagnose why each one broke (cracking, wear in certain places). Try bending a piece of track that has been out in the cold. Try bending the same piece of track once it has been inside for a while. How much difference is there? Speculate how much more power it takes to turn a cold track than a warm one.
6. Carefully try to cut a piece of snowmachine track. Can you appreciate the technology that made it this tough?
7. Ask the people in the village what they do when a track breaks far away from home.
8. What uses have people found for discarded snowmachine tracks in your village?

*They make great walkways before the porch on a house. They aren't slippery, and people clean their feet on them.*

9. Compare the suspension systems of the machines in your village. Do some still have bogie wheels? Talk to people that own the two different kinds. What are the advantages of each? Find a discarded slide rail. Does it look like it wore out because of snow or gravel? Try to cut it with a knife. Is it hard? What uses have people discovered for used slide rails? Inquire how much new slide rails cost and how hard they are to install. Identify the part of the track that slide rails run against. How is this different from the rest of the track? Are the bearings on the bogie wheels sealed bearings? What do you think happens when the seals go bad? What can you learn about increasing the life of bearing seals?

*Slide rail material is quite hard for a plastic. They are fairly inexpensive and are easy to change once the track is removed.*

*Bearing seals? Stay out of water and dirt.*

10. Look at the skis on different machines in your village. Talk with people who use the plastic skins that fit under the skis. What do they say? What is the surface area of the average ski? Compare skegs on the different skis.
11. Measure the distance between the skis on different machines. Is there a difference? If so, why do you think this is so? What do snowmachine owners say about skis being close together or farther apart? Is it important? If so, under what conditions?  
*Wider skis are more stable, especially at high speeds.*
12. Talk to several people who have installed the sheets of plastic under the belly of the snowmachine. Do they notice a significant difference? Why did they install the plastic in the first place?
13. When did snowmachines first come to your village? Ask the older people how they have changed over the years. What about them has improved? What about them has not improved? Why do they think machines are better than dogs?

## Student Response

1. Why wouldn't a track made out of natural rubber last on a snowmachine in Alaska?  
*It would stretch too much and be dissolved by gasoline and oil.*
2. Why are there nylon cords in the track as well as Kevlar?  
*To keep the Kevlar from tearing*
3. What is the problem with a very large track?  
*It takes a lot of energy just to turn it.*
4. What is the problem with a small track?  
*It sinks deeply into the snow.*
5. What is the problem with a track that is too smooth? Too rough?  
*Too smooth doesn't have enough friction to pull a load or climb a hill.  
Too rough will dig in when traveling on powder snow.*
6. What kind of track would you want to operate in deep powder snow?  
*High surface area*
7. What kind of track would you want for racing? For pulling big loads on hard trails?

*Racing: smaller track with cleats and stars.*

*Big loads on hard trails: wider track with cleats.*

8. Skis are designed to have very little friction in a \_\_\_\_\_ direction, and considerable friction in a \_\_\_\_\_ direction.

*Forward, sideways*

9. What is the purpose of skis besides steering?

*Provide surface area to keep the machine on top of the snow as much as possible.*

10. Why do some people put plastic skins on skis?

*They greatly reduce friction and increase flotation.*

11. Why do some people have belly plastic installed?

*Reduce friction in deep powder and protect the belly.*

## Math

1. A machine weighs 375 lbs. The track is 15"  $\times$  47" in contact with the trail. The skis are 5"  $\times$  30" each with plastic shoes. What is the average psi of this machine on the surface of the snow?

*.373 psi*

2. A racing machine weighs 489 lbs. The track is 15"  $\times$  40" in contact with the snow. The skis are 5"  $\times$  24" each. What is the average psi on the surface of the snow?

*.582 psi*

3. A long track uses 25% more energy to turn than a short one. Turning a short track represents 9% of a machine's effort. If Pete usually spends \$350 a year on gasoline approximately how much is he paying for the convenience of having a long track?

*\$7.87 not expensive at all.*

4. Having plastic ski skins and plastic on the belly of a machine saved 12% of a machine's effort. They cost \$75 to purchase. If Moxie usually spends \$425 for gas on his trapline, will the plastic on the skis and belly pay for themselves in the first year?

*No. \$51 is less than the original \$75. But they will pay for themselves the next year. However the difference is in performance and handling, not just in gas savings.*

# Snowmachine Clutch

## Activities

1. Remove the clutch guard from a machine and identify the parts.
2. Block the back of the machine up or suspend it so the track is free from the ground. With students at a safe distance, start the engine. Accelerate and decelerate the engine. Can you see the clutch responding automatically to the throttle changes?

*Make sure no one is in front of the machine, and no one has loose clothing of any kind.*

3. Watch the drive clutch. Is it bigger at low or high rpm?

*It is bigger at low rpms.*

4. Watch the driven clutch. Is it bigger at low or high rpm?

*It is lower at high rpms.*

5. Is clutch movement smooth or erratic? If it is not smooth, what does this indicate?

*If it isn't smooth, it indicates poor lubrication.*

6. At below zero temperatures, put polar grease between your fingers on one hand and regular grease between the fingers of the other hand. Can you feel the difference?

7. What would slip if the track were frozen down and the engine accelerated? Do you see evidence of this around the clutch?

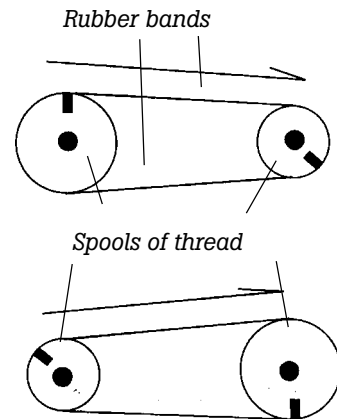
*The belt burns. Fine pieces of belt are all around the clutch.*

8. Remove and replace a drive belt. Compare a worn and a new belt for width. Find the price of a new belt.

9. Can you see the weights in the drive clutch? If this isn't possible, try to find an old one that has been taken apart. Describe how inertia causes the drive clutch to close together. Draw what you imagine happening.

10. Compress the spring from both the drive and driven pulleys. Are they stronger or weaker than you thought? Is there a way to tighten the spring on the driven pulley on the machine you are looking at?

*The spring on the driven pulley should be much stronger than the one*



*on the drive pulley. Most driven clutches have a way to tighten or loosen the spring.*

11. Improvise some pulleys, even if you have to use a rubber band as a drive belt. Use different size thread spools as pulleys if you can't find anything else. Predict how many turns the driven spool will turn when the drive spool turns once.
12. Drive a four-wheel ATV, accelerating through the gears. While doing this, try to imagine what would be happening to the drive and driven pulleys if it had a snowmachine clutch. (Actually, Polaris six-wheelers have a clutch like a snowmachine.)
13. Do you think this kind of clutch would work on an outboard motor, giving better performance?  
*I have always wondered this. It might help, but it would be heavy and bulky.*

## Student Response

1. How do each of the following attempt to balance the engine speed with the load?
  - Trucks, cars & four-wheel ATVs:  
*Transmission*
  - Outboard motors:  
*Changing props*
  - Airplanes:  
*Variable speed props*
2. What are the three main parts of a snowmachine clutch?  
*Drive clutch, belt, and driven clutch*
3. Which clutch is on the end of the engine's driveshaft?  
*Drive clutch*
4. Draw a picture of a big pulley driving a smaller one. If the big pulley turns once, will the little one turn more or less than one turn?  
*More than one turn*
5. Draw a picture of a smaller pulley driving a bigger one.
6. Draw a picture of two pulleys of the same size.
7. Which of the above pictures illustrates an engine starting to move?  
*Smaller driving the larger*

8. Which one of the above illustrates an engine at cruise speed?

*Same size pulleys*

9. What is the main advantage of a snowmachine clutch over a truck transmission?

*It is constantly sensitive to the load.*

10. Why couldn't a snowmachine clutch be used on a truck or car?

*A belt cannot drive the power required to move a car.*

11. What is the advantage of a snowmachine clutch over a chainsaw clutch?

*A chainsaw clutch is like a one-speed transmission.*

12. What is the governor on an engine? What happens if there isn't enough load on an engine? What happens if there is too much load on an engine?

*The load is the governor. If there isn't enough load, the rpm are too high and the machine is stressed by the inertia of the piston. If there is too much load on the engine, it is again stressed, but this time from the pressure on the parts.*

13. What two things does the snowmachine clutch balance?

*Centrifugal force in the drive clutch and the spring pressure on the driven clutch*

14. Why is good lubrication important in a snowmachine clutch?

*So the centrifugal force and pressure of the spring can be in balance and friction between parts will not interfere with that balance*

## Math

1. A pulley 3" in diameter turns a pulley 2" in diameter. If the first one turns 50 complete revolutions, how many revolutions does the second one turn?

*75 revolutions*

# Snowshoes

## Activities

1. Time someone walking a given distance in deep snow without snowshoes. Then time the same person with snowshoes.

2. Try different kinds of available snowshoes (trail, bear paw) on different snow conditions. Which is easier and why? Which is easier in the brush? On a snowmachine trail? On windswept snow? In powder?
3. Try different kinds of bindings. Which seem better to you? This test is invalid unless you walk under many different conditions: packed trail, in the brush, up hills, in deep powder, etc. Which bindings and snowshoes are the quietest?
4. Compute the psi of individuals wearing winter boots and again with a pair of snowshoes (their weight divided by the area of the boots or snowshoes).
5. Ask some of the oldtimers in your village what kinds of snowshoes they used and why. What did they do to the rawhide (oil, varnish, etc) to make it waterproof?
6. Ask an oldtimer how to pick a good birch tree for snowshoes. How could they tell the grain of the wood and the toughness of the fiber?
7. Take two pieces of birch from the same tree. They should be carved about the same size, similar to the frame of a snowshoe. Cut them two to three feet long for this test. Steam one. Bend them both. Which bends easier? Which breaks first? (An easy steamer is made from a coffee can with two inches of water in the bottom with stovepipes extending to the desired length.)
8. How did they make rawhide in your village? How was the skin cleaned and how was it split into thin strips? Does anyone still know how to do this? Try to learn if there is a skin available.
9. If a pair of homemade snowshoes is available, try to discover the pattern followed to lash the webbing. What did oldtimers do to protect it from wearing?  
*A glancing blow with an axe or abrasion on the outside of the frame can sever the webbing, so many oldtimers made an effort to embed the webbing into the frame for protection.*
10. Study the different kinds of snowshoes described in catalogs and resource materials. What kinds of traditional snowshoes were used in other regions of the North? Can you guess their winter weather by the design? Look at the following picture. What kind of snow conditions do you think this snowshoe was designed for?  
*Deep powder. It is a trail model snowshoe with fine webbing.*
11. What kind of snowshoes do you think are best for walking home on a snowmachine trail? Time someone walking with these snowshoes for a mile. Time someone without snowshoes. Who walks faster?

*Bearpaw snowshoes are good because they are light and easy to carry, and there is a little bounce in the step.*

12. Some oldtimers knew how to make emergency snowshoes. Ask the old people in your village if they ever used that kind.

## Student Response

1. What is the idea behind snowshoes? Use the term "psi".  
*To increase the surface area so the psi is decreased and the individual doesn't penetrate the snow too deeply.*
2. With the same snowshoes, who will sink more deeply into the snow: a person eighty pounds or someone one hundred and ten pounds?  
*Someone 110 lbs. The psi is greater*
3. Which is better for hard packed snow: bear paw or trail snowshoes?  
*Bear paws*
4. Which is better for powder snow: bear paw or trail snowshoes?  
*Trail*
5. Why would someone want smaller snowshoes even if the snow is soft, deep powder?  
*Break trail for dogs or other people following.*
6. What purpose does the tail of the snowshoe have?  
*It acts like a keel keeping the snowshoe from swinging from side to side.*
7. Why aren't commercially-made snowshoe frames strong?  
*There is little quality ash and hickory left in the country and most commercially-made frames are sawed from a tree rather than split.*
8. What kind of skin was the toughest to use for traditional lashing? What is the disadvantage of this kind of lashing?  
*Spring cow. It is illegal.*
9. Why did oldtimers oil their snowshoes?  
*Quiet walking, keep dogs from eating the webbing, and keeping the frames from rotting.*

## Math

1. What is the psi of a person weighing 175 lbs on snowshoes that have 400 square inches.  
*.437*

2. What is the psi of the same person wearing boots with 48 square inches? Snowshoes increase the surface area the person is exerting force upon by how many times?

*3.64, 8.34 times*

3. On a trail snowshoe, measure the surface area in front of the individual's toe. Measure the surface area behind the individual's heel. Which is greater?

*In the front.*

4. Compute the psi of the smallest person in the class if they have a standard pair of 10"  $\times$  56" snowshoes. How big would the snowshoes have to be for the largest person in the class to have the same psi therefore sinking the same distance into the snow? You will have to figure the area of the snowshoes out in several different parts, circles, squares and triangles.

*Answers will vary*

5. A homemade snowshoe weighs 2.2 lbs. Another one made by the Army is 3.0 lbs. If someone's step is 2' and there are 5,280 feet in a mile, how many extra pounds are lifted in a mile? How many extra pounds are lifted on a hunting trip where the person walks 7.4 miles?

*2,112 pounds in one mile. 15,628.8 pounds*

## Winter Trails

### Activities

1. Break trail with snowshoes in powder snow. Walk back along the same trail within an hour. Walk the same trail the next day if it has been cold. What differences do you notice?

*In an hour the trail is still soft. The trail sets up and gets hard overnight.*

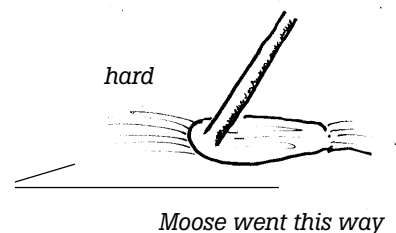
2. Ask oldtimers in the village how they used the fact that trails set up overnight in planning their travels.

3. Ask old people in the village how they can tell which way a moose or caribou has gone even after the track is blown over. How does this relate to the above activities?

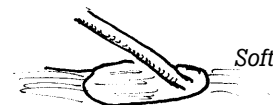
*Snow that is compressed sets up hard. Poke both sides of a moose track in the snow. The direction the moose is going will be hard. The direction it came from is soft.*

4. Observe trails as they emerge "high centered" in March. Ask oldtimers if this was as big a problem with dog teams as it is with snowmachines.

*I think it was harder with dog teams.*



5. Stand on a packed trail. With your eyes closed and a long stick in your hand, can you feel the trail and walk for 200 yards? Do you think you could find a trail that is blown over on a lake or the river by this method?



6. Design a rig that could be pulled behind a snowmachine that would smooth out the bumps in the snowmachine trail. Think about hidden stumps and the need to adjust height.
7. Ask the experienced snowmachine operators in your village for stories about overflow. How do they get out when they get stuck? What months does overflow start in your area?
8. Find out if there are people in your village who fell through the ice and how they survived.
9. How do people get snowmachines out that fall through the ice? Do the machines usually run after they have been underwater for a while? How do people know where to look for the machine in the open water?
- Some times there is a small oil slick above the machine as gasoline leaks out of the tank.*
10. After breakup, check the ice chunks on the sides of the river. Break them with a stick. Can you see how different it is from the fall ice? Do you think two feet of that kind of ice is strong?
- Not at all. The crystals don't hold well together at all.*
11. From the oldtimers, ask about five places that usually have bad ice in your area. How do they tell bad ice right after freeze-up? During the winter after snow covers the ice? In the spring?
- In the fall, test with an icepick. In the winter, look for indentations to indicate that the ice has melted out from under the trail. In the spring, bad ice tends to be darker. Stong ice is whiter.*
12. Draw a picture of overflow as you imag e it under the snow on the river.

## Student Response

1. Why did people with dog teams break trail one day and haul a load on the next day?

*The trail will set up overnight.*

2. Which is harder, breaking trail with an empty sled or hauling a load on a firm trail?

*Breaking trail with an empty sled.*

3. How did oldtimers find a trail that was blown over?

*With a stick, feeling through the drifted snow for the hardpacked trail beneath.*

4. Draw the process that causes a trail to become high centered in March and April.

5. Why doesn't overflow freeze under the snow?

*Snow is an excellent insulator.*

6. What did dog mushers do when traveling on bad ice?

*Spread the dogs out.*

7. What is the difference between fall and spring ice?

*Fall ice tends to be much stronger than the crystallized spring ice.*

## Math

1. Force = mass  $\times$  acceleration. A snowmachine has  $\frac{1}{3}$  of its weight on the front skis. It weighs 357 lbs. Another machine has  $\frac{1}{4}$  of its weight on the front skis. It weighs 402 lbs. Which machine impacts the trail harder when going over a bump?

*The 357 lb machine*

2. Fall ice is 12 times stronger than spring ice. If Aaron can walk on ice  $2\frac{1}{2}$ " thick in the fall, how thick must ice be in the spring to be safe?

*17.5". The figure 7 times stronger is an approximation. There are many variables.*

