Literacy and Essential Skills in Industrial Arts

BLACKSMITH COURSE

ESSENTIAL SKILLS

Student Notes

A project of Literacy Ontario Central South

Canada
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Literacy Ontario Central South

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The Literacy and Essential Skills Project Team

Lesley Hamilton – Project Manager
David Haw – Project Coordinator
Shelley McCarrell – Project Assistant
Elise Noriega – Project Assistant
Carrie Wakeford – Project Writer
Brigid Hayes – Project Evaluator

Advisory Committee

Andrew Rothfischer – Ministry of Natural Resources
Doug Noyes – Literacy Link Eastern Ontario
Kathy Neill – John Howard Society of Peterborough
Sheila Cowan – LOCS Board of Directors
Walter Johnstone – Youth Emergency Shelter

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Steven Sykes

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DISCLAIMER:

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This manual is intended to provide an opportunity for students to learn about the Essential Skills and Blacksmith in both a real life situation and an LBS environment. This manual provides basic guidelines for safe practices inside a literacy setting. Do not assume, therefore, that all necessary warnings, precautionary measures, and legal standards are contained in this document and that other or additional measures may not be required.

The opinions and interpretations in this publication are those of the author and do not necessarily reflect those of the Government of Canada.

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ORIENTATION

WELCOME

Document Use

Welcome to introduction to Blacksmithing.

This course was designed with four primary goals.

1. To help you develop your Essential Skills; skills that will help you in your "work, learning and life"
2. To help you develop technical skills for a hobby as well as for work
3. To help you develop your artistic and creative abilities
4. To give you the opportunity to have fun, meet new people and expand your network of contacts

Call the instructor to let them know if you are unable to attend a class.

COURSE FORMAT

Reading Text, Document Use

In addition to the information in these Student Notes, this course will be presented through a mix of group instruction, demonstration and discussion, followed by independent work.

There will be times when your instructor may ask you to stop what you are working on so that they can provide information to the entire class.

It will be important that you ask other students for help. Helping each other and sharing ideas and opinions is a great way to learn.

Before you are asked to complete any step in this blacksmith course, your instructor will provide a demonstration.

Your instructor will demonstrate:

- the safe use of all of the tools and equipment you will need in this course
    - For example, using a forge to heat metal
- all of the techniques you will be using to complete your projects
    - For example, hammering techniques

You will then have the opportunity to try all of the tools, equipment and techniques while working independently on your project.

The instructor will be available to answer your questions and provide individual support and guidance as you work, so ask them questions anytime.

As you work on your own blacksmith project you will find that there are many ways of achieving the same end result. You may find that the step-by-step instructions in your Student Notes are different than the steps your instructor demonstrates in class. You may also find the same techniques are done differently in an online blacksmith video you watch. This variety will give you options to try until you find the techniques that work best for you.

STUDENT NOTES

Reading Text

Although this course will focus on oral instruction and hands-on work you will also have information and instructions to read.

In this package you will find all the Student Notes for this course. You will be asked to read a section of the notes during each class or you may read the material at home. You can also read ahead in the notes.

These Student Notes include information that will help you learn more about the topics presented and demonstrated in class. They can also be used as a reference and guide as you work on developing your blacksmith skills.

There is a Table of Contents at the front of these Student Notes to help you find the information you need.

At the end of the course you can take these notes home with you. They will be helpful as you work on future blacksmithing projects.

In your Student Notes, you will find web links. If a recommended site is no longer available, please inform your instructor.

You will be working at your own pace therefore you may find that you are ahead or behind in the notes. Talk to your instructor if you have any concerns.

Note: You can record your own notes on the pages of these Student Notes.

ICON LEGEND

Reading Text

Throughout this course you will see icons in the written material. These icons are designed to help you visually identify the content of the section you are reading.

Icons Include:

STUDENT NOTES – At the top of each page of Student Notes you will find this icon on the left side, followed by the name of the section on the top right side. This icon and the section titles will be helpful if you are looking for information listed in the Table of Contents.

ESSENTIAL SKILLS – Under each section heading you will notice this icon, bordered by two lines. The icon will be followed by a list of words. These words represent the Essential Skills you would use if you actually completed the steps outlined in the section. For example, if the text states that you need to "decide on a project" you would find Decision Making listed as an Essential Skill. This list will also identify the Essential Skills you are using as you read the information in the section. For example, Reading Text will be listed if you need to read more than two sentences in the section. Document Use will be listed if you need to read a bulleted list or complete a document.

TASK – If you see a "T" at the top of a page, you will find step-by-step directions for completing an Essential Skills task. These tasks are designed to help you develop your Essential Skills while at the same time providing information that will help you gain the skills you need as a blacksmith. In most cases the tasks will be handed out during class and you will be given time to complete them before the class ends. Some tasks are designed to be completed independently and others are designed to be done in large and small groups.

When you see this image in a box on the page there will be some additional information to consider.

ESSENTIAL SKILLS

Reading Text

We consider the Essential Skills component of this course to be very important. These skills provide the foundation that makes it possible to learn all other skills. There are nine Essential Skills; Reading Text, Document Use, Numeracy, Writing, Oral Communication, Working with Others, Thinking Skills, Continuous Learning and Computer Use.

Essential Skills are used every day at work, at home and in a blacksmith studio. While these skills are important in your personal life they are essential for success at work. Essential Skills will help you find and keep a job and manage change in the workplace.

Essential Skills are transferable. This means that the same skill can be used in different situations. For example, in this blacksmith course you will have many opportunities to develop your problem solving skills. You may find that the next time you have a problem at home, at school or at work, your problem solving skills will be stronger.

THE NINE ESSENTIAL SKILLS

Document Use

Experts have identified the nine Essential Skills required for success in the Canadian Workforce.

For more information visit:
www.hrsdc.gc.ca/eng/workplaceskills/essential_skills/general/home.shtml

Essential Skills Include:

Reading Text

Reading materials in the form of sentences or paragraphs

Document Use

Tasks that involve a variety of information displays in which words, numbers, symbols and other visual characteristics (e.g. lines, colours or shapes) are given meaning by their spatial arrangements

Numeracy

Using numbers and thinking in quantitative terms to complete tasks

Writing

Writing text and writing in documents, such as filling in forms, and non-paper-based writing such as typing on a computer

Oral Communication

Using speech to give and exchange thoughts and information

Working with Others

Employees working with others to carry out their tasks

Thinking Skills

The process of evaluating ideas or information to reach a rational decision. They include six specific skills:

Problem Solving

Addressing problems that require solutions

Decision Making

Deciding between options

Critical Thinking

Assessing, evaluating ideas or information to reach a rational judgment of value

Job Task Planning and Organizing

Planning and organizing tasks

Significant Use of Memory

Memorization of procedures, codes, numbers, remembering information, learning from an experience

Finding Information

Using text, people, databases or systems to find information

Continuous Learning

Workers participating in an ongoing process of acquiring skills and knowledge

Computer Use

Using different kinds of computer applications and other related technical tools

ESSENTIAL SKILLS CHECKLISTS

Reading Text

As you work on your blacksmith skills, read your Student Notes and complete the assigned tasks, you will be developing your Essential Skills.

There will be time at the end of each class to talk with the others in your group about the Essential Skills you used in the class.

There will also be time at the end of each class to complete your own individual Essential Skills checklist. As you complete the checklist you will have the chance to identify all of the Essential Skills you used in the class.

After you have read these introductory notes, you will be able to check off Reading Text on your Essential Skills checklist.

ESSENTIAL SKILLS IN BLACKSMITHING

Reading Text, Document Use

Blacksmiths need to draw on their Essential Skills in all nine areas; however blacksmith work demands that the Blacksmith have a higher skill level in some areas. For example, Blacksmiths need to have strong problem solving skills.

Blacksmiths:

- spot problems and solve them as they work (Thinking Skills: Problem Solving)
- decide when to start forging a piece of metal based on its colour (Decision Making)
- refer to manuals to find information about the proper set up and operation of equipment (Finding Information)
- complete precise measurements (Numeracy)
- plan projects and think in steps (Job Task Planning and Organizing)

On the other hand, writing is not an Essential Skill that would be critical to the success of a Blacksmith, even though at times they may need to record information, write notes to customers and create promotional material.

TECHNICAL SKILLS

Document Use

In addition to the Essential Skills you will develop in this class, you will also develop technical skills as you work on your blacksmith projects.

The technical skills you may develop in this course include:

- using tools such as hammers and tongs
- using power tools
- using measuring tools
- learning about metal and metal working
- using a forge

You will also develop:

- form perception
- motor coordination
- manual dexterity

In this Blacksmith course you will be completing a mix of right brain and left brain activities.

Left Brain: logical - accurate measurements, detail, precision, written instructions.

Right Brain: creative - patterns, colour, images, visual demonstrations.

CAREER EXPLORATION

Reading Text, Document Use

Thinking Skills: Critical Thinking

Although this blacksmithing course is not designed to prepare you for a specific job, you may discover that you have the skills and interests necessary for a career working with metal. If you enjoy this course, you may want to research this career path further.

For example, you may decide to look into the position of forging machine operator. In this position you would be responsible for operating machines, heating metal, monitoring metal colour and shaping metal using tools and machines.

Job titles in this field include bending machine operator, cold drawn operator, cold press operator, forging press operator, hot press operator, manipulator operator, trip hammer operator upsetter operator.

The National Occupational Classification (NOC) states:

> Forging machine operators operate forging machines to form and shape metal into various shapes and sizes and impart desired strength, hardness or other characteristics. They are employed primarily in the fabricated metal products, machinery, and transportation equipment industries.

For more information about the NOC profile visit:
http://www5.hrsdc.gc.ca/NOC/English/NOC/2006/Profile.aspx?val=7&val1=7344

You may discover that you also have skills and interests necessary for success in a field such as:

- boilermaker
- ironworker
- metalworker
- die setter
- metal fabricator
- machine operator
- industrial maintenance mechanic
- sheet metal worker
- tool & die maker

Although the jobs listed above are not directly related to work as a Blacksmith, they require some of the same skills.

There are many other jobs that will require the skills you will be developing throughout this course. If you think of one that is not on this list, share it with the others in the class.

SUMMARY

Reading Text

In addition to developing the skills needed to complete your blacksmith project, you will also develop Essential Skills and technical skills that will help you at work, school and at home.

As mentioned, there are many jobs that require skills similar to the ones you will be developing. As you work through this course, think about your interests, skills and career. At the end of each day, ask yourself, "What skills did I develop that I could add to my résumé?

WORKSHOP SAFETY

INTRODUCTION

Reading Text, Document Use

This section of your Student Notes will focus on working safely in a blacksmith shop; this includes your own safety as well as the safety of those around you.

There are risks with any hobby, sport or work environment; blacksmithing is no exception. If you don't work safely you can be exposed to the risk of serious and life threatening injury.

In this class you may be exposed to:

- Fire in a forge that could reach 1,510 degrees Celsius (2,750 degrees Fahrenheit)
- Metal that could reach 1,370 degrees Celsius (2,500 degrees Fahrenheit)

Unsafe practices will expose you to the risk of burns from metal, flames, sparks and spatter, as well as exposure to fumes and gases. You may need to chip or grind metal, which can produce sparks, flying metal, sharp edges and metal shards. Blacksmith's work with high pressure gases in cylinders that could explode if not handled properly. Hand and power tools must be handled safely. Finally, you may also work with chemicals such as varnish, which could cause a moderate risk to you and the environment if it's not handled properly.

In this class it is quite possible that you will experience minor burns and cuts and even a few blisters by the end of the day. The focus of this section of your Student Notes is to provide you with information that can help you avoid these as well as more serious injuries.

All of these risks can be greatly reduced or eliminated by following proper safety procedures. There should be no reason why you can't work safely, free from the dangers associated with the blacksmith trade. To stay safe, it is critical that you learn about and practice all safety procedures.

Note: This section is only an introduction. Your Blacksmith instructor will provide you with a detailed safety lesson before you begin your first project.

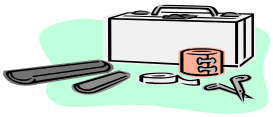
As mentioned, you are responsible for your own safety as well as the safety of those around you, so it is critical that you follow the instructions provided by your instructor, read this section of your Student Notes and apply all of the recommended safety tips whenever you are watching demonstrations or working on your own project. If you follow the safety procedures outlined, you will avoid injuries.

ACCIDENT REPORTING

Reading Text, Oral Communication

Minor injuries can be treated with items found in a First Aid Kit; however, we ask that you inform your instructor if you have an injury, even if your injury seems like a minor one.

We also ask that you immediately report any spills, accidents, and/or damage to any tools. An instructor will be able to assist you with clean up and repairs.



SAFETY TIPS

Reading Text, Document Use, Oral Communication

Thinking Skills: Critical Thinking

The safety tips in this section will focus on blacksmithing, although many of these tips are transferable to other situations. The tips in this section should be applied whether you are working on your project or watching a demonstration.

Signs of dehydration include thirst, decreased unine output, dry mouth, decreased sweating, muscle cramps, nausea and lightheadness.

Be Alert:

- Work only when you are well rested
- Do not work with tools, equipment or chemicals if you have been drinking alcohol or using drugs
- Focus on the job at hand
- Inspect each tool before you begin
- Be aware of the movement of others
- Know where the fire extinguisher and First Aid Kit are located
- Never smoke or allow anyone else to smoke near your work area

Stay Hydrated

- Keep a water bottle handy to avoid dehydration
  - Dehydration occurs when the amount of water leaving the body is greater than the amount being taken in
  - If you are working beside a fire in an enclosed area, during the summer, it will get hot!
  - Up to 78% of the body's weight is water

Follow the Rules:

- Read manuals and follow all safety procedures
- Wear the appropriate clothing and protective gear for the job you are doing
- Listen carefully to your instructors and follow their directions
- Follow all written instructions
- Read and follow labels and Material Safety Data Sheets (MSDS) for all products
- Be able to recognize symbols, for example:
    - Workplace Hazardous Materials Information System (WHMIS) symbols for:

 Compressed Gas

 Flammable and Combustible Material

    - Restricted Product Labels for:

 Explosive

 Flammable

Note: WHMIS training is not part of this course. You can sign up for a WHMIS course or wait until you have the opportunity to complete the course as part of your on-the-job training.

Organize Your Work Area:

- Have a place for your tools
- Return everything to its proper place
- Remove any hazards from your work area
    - Anything flammable, volatile or explosive
- Store gas cylinders in a separate, protected area
- Clean your work area and pick up anything on the floor
- Design your work area to be safe and efficient
- Ensure you set up your work area where there is good ventilation
    - Work outdoors whenever possible
    - Keep a window open
    - Use a portable fan to keep the air moving

Plan Ahead:

- Think through all of your steps before you begin
- Have a plan for your finished work
    - E.g. know where you will set hot metal to cool
- Never walk around with hot metal

BLACKSMITH GEAR

Reading Text, Document Use

Thinking Skills: Decision Making

This section lists the gear you will need to wear when you are blacksmithing; however some of the items can be used for other work situations. Blacksmith gear should be worn when you are working on your project or when you are watching a blacksmith demonstration.

Clothing:

- Select heat and fire resistant clothing that will protect you from high temperatures, sparks and flames
  - Choose heavy clothing made of tightly woven natural fibers
  - Leather, cotton or wool are good choices because natural fibers are flame resistant - synthetic fabric such as nylon can melt to your skin

As something falls, it will pick up speed. Imagine a hammer landing on your foot when you are selecting your footwear for this course.

- Wear long sleeved, non-flammable jackets/shop coats/coveralls
- Wear long pants that cover the tops of your shoes or boots
  - This prevents coals or hot metal from falling inside your shoes
- Wear long sleeved shirts and tuck your shirt into your pants
- Wear light weight, high top, leather, steel toed shoes or boots with rubber soles
  - Avoid synthetic shoes because they can melt

- Wear a cap and make sure your hair is tied back; you can also wear a bandana
- Remove anything flammable from your clothing
    - Check your pockets
    - Remove things such as lighters and matches
    - Check that your clothes are oil free

- Avoid wearing anything that could trap hot metal or sparks
    - For example, avoid cuffs, open neck shirts and baggy pockets
- Wear old clothes in case your clothes are damaged
    - However, don't wear anything baggy or frayed
    - Save money by shopping at secondhand stores
- Remove rings or jewellery before you begin

Safety Equipment:

- Wear approved safety glasses with clear lenses to protect your eyes from sparks and flying metal
    - Use glasses with side shields
    - Wear glasses when you are chipping, grinding, filing or using a wire brush
    - You can buy CSA approved prescription safety glasses

- Wear leather work gloves made of cotton or Kevlar to protect your hands from burns and blisters
    - Buy welders gloves
    - Check your gloves for damage before using
    - Make sure you can shake off your gloves quickly
    - Do not dunk hot gloves in water, it will create steam that can cause burns
    - Gloves give you time to drop a hot item you pick up by accident
- Wear ear protection
    - Noise can cause you to feel tired, which can increase the chance of accidents
    - Your hearing can be damaged if you are exposed to sounds over 90 decibels for extended periods of time

Decibel: the loudness of a sound is measured in decibels (dB). The sound of a hammer hitting metal can be above 85 dB, a powersaw 110 dB.

For more information visit: http://www.gcaudio.com/resources/howtos/loudness.html

Kevlar: is the registered trademark for a light, strong sythetic fiber that is heat reisstant. http://en.wikipedia.org/wiki/Kevlar

Note: We recommend that you wear gloves on both hands; gloves will help to protect you from blisters.

BLACKSMITH SAFETY

Reading Text, Document Use, Oral Communication

Thinking Skills: Critical Thinking

The following section will introduce safety tips specific to blacksmith work. Topics will include ergonomics, protecting others, the safe use of a blacksmith tools and equipment, the safe use of compressed gas, avoiding fumes, the safe use of electrical equipment and chemical safety.

ERGONOMICS

Blacksmiths need to be aware of the physical challenges of the job. Blacksmithing is demanding work so it is important to be physically fit if you plan on making blacksmithing your career or hobby.

Blacksmiths use physical force and repetitive motions. For example, hammering all day will take its toll on your muscles and joints and can cause injuries over time.

If you are a hobbyist working on small projects, you will likely have more control over your work environment; however, it is still important to be aware of the physical demands of being a Blacksmith.

Ergonomics: the study of how workspaces and equipment can be designed to be efficient, safe and productive. This includes adjusting the positions of the worker, the tools and the equipment. Matching the work to the worker will improve both comfort and safety.

Note: Physical work can cause fatigue, which can lead to mistakes and injuries.

The following list applies to blacksmiths on the job and in a home workshop.

Protect Your Muscles and Joints:

- Adjust the position of your work table/anvil so it's comfortable
    - Stand facing the anvil with your arms hanging at your sides and make a fist
    - Adjust the anvil until your knuckles line up with the face
- Have things positioned so you don't need to reach for them
- Stretch before you begin working
- Find a stable, comfortable standing position
    - If possible, lift one foot onto a stand, keep your back straight, keep your feet apart, with one foot in front of the other
- Keep your elbows close to your body and support your arms
- Place items you are working on at waist or elbow level
- Select tools that are the right weight for you
    - Remember, technique is more important than power
- Hold tools properly
- Take breaks and stretch whenever possible

It is possible that a Blacksmith will swing a hammer thousands of times a day.

- Follow these safe lifting guidelines:
    - Ask for help
        - If someone is helping you lift, it is important to communicate clearly
        - Use any available lifting aid e.g. a dolly
    - Move to the object rather than reaching for it
    - Bend your knees - don't stoop
    - Bring your chin in to force your back to stay straight
    - Tighten your stomach muscles
    - Lift with your leg muscles
        - Leg muscles are stronger than back muscles

http://healthandfitness101.com/wp-content/uploads/2008/05/lifting-pic.jpg

Workshop Design:

- Design your work area to be safe and efficient
- Keep the space between the fire (forge), anvil and other tools as short as possible while still remaining safe
- Have a place for storing tools when they are not in use
- Have a place where all scrap material is stored
- Work outside or in a well ventilated area
    - You must avoid fumes from the forge and heated metal
- Protect your lungs and the environment
- Make sure you can control the lighting in your work area

PROTECTING OTHERS

When you are working near other people, let them know when you are about to start working.

Note: If you are working at home, you may consider a rule that states: "No one is allowed in the work area when the forge is on". This rule should also include pets. That being said, it is often recommended that Blacksmiths avoid working alone. If you are working alone, ensure that others are aware of your activities. Keep a telephone handy in your work area.

Things to Consider:

- Sparks and molten metal can travel up to 10.7 metres (35 feet)
- Grinders and other tools will produce sparks
- Keep things off the floor, including cords, so others don't trip
- Let people know when metal and tools are hot
- Never walk away leaving hot metal unattended
    - Someone may not realize a piece of metal is hot and try to pick it up
- Clean up whenever you have finished working

THE SAFE USE OF BLACKSMITHING TOOLS AND EQUIPMENT

- Talk to your instructor before using tools or equipment for the first time
- Read manuals, manufacturers' guidelines, and safety guidelines before using equipment
- Check that you are wearing all necessary safety equipment before you begin
- Ensure that your work area is tidy, safe and clear of anything flammable
- Check that your tools and equipment is in good repair and properly installed
- Check power cords for damage or wear
    - Never leave cords lying across the floor or near heat
    - Never twist or tangle power cords
- Unplug tools before working on them, adjusting them or setting them up
- Turn off power and unplug any equipment you are not using
- Safely store or hang up tools when you are finished

It is possible that a blacksmith will swing a hammer thousands of times a day.

Hammer injuries are listed as one of the top five metal worker injuries. This includes eye injuries from metal shards flying off hammers.

RPM : refers to the number of times something rotates in a minute - Revolutions Per Minute.

Note: never touch a spinning grinder. The grinder spins a disk at speeds of up to 10,000 RPM's and it can cut to the bone in seconds.

Hammer Safety:

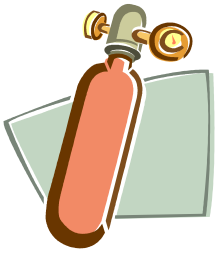
- Inspect your hammer before you begin
- Don't use any cracked, chipped or pitted hammers
- Don't use any hammers with damaged handles
- Check that the head is on the handle tightly

THE SAFE USE OF COMPRESSED GAS

Depending on the methods you are using, you may need to use high pressure fuel gasses and pressurized oxygen in cylinders. It is critical that you learn how to use these gases safely. Improper use can result in asphyxiation, fire, explosions and poisoning.

The pressure in the tanks could be more than 2000 psig, which is enough pressure to cause a very large explosion. There are many stories of damaged cylinder valves causing explosions that send tanks through concrete walls.

Note: In this course you won't need to handle pressurized cylinders, your instructor will set up the gas for the forge and make any cuts or welds you need for your project. However, if you are going to do any welding or blacksmithing at home, you will need to take a course, read the manufacturers' instructions and read labels.



General Safe Handling Guidelines – Pressurized Cylinders:

- Check that the cylinders and attachments are right for the job
- Check that everything is in good working order, including the pressure regulator, flow meter, hoses and fittings
- Check that hoses are clear and tangle free - no kinks
- Protect the cylinder from extreme temperatures and harsh weather conditions

- Protect the cylinder from contact with oil and grease
- Mark empty tanks
- Ensure that there will be space between your work and any compressed gas cylinders
    - No equipment should ever touch a cylinders
- Protect cylinders from flames
- Never attach anything to or hang anything over the cylinder
- Attach the cylinder to something stationary, away from high traffic areas
    - Chain or strap the cylinder so it can't fall over or tip
    - Never bump or drop a cylinder

Moving Cylinders:

- Ask for help moving a cylinder
    - Never drag a cylinder or lay it on its side to roll it
    - Protect cylinders from sudden movements or impacts
- Attach the cylinder to a hand cart
    - If necessary you can tip the cylinder and roll it
        - Keeping the cylinder upright, place one hand on the cylinder cap and one on the shoulder of the cylinder
        - Never lift with the valve

Note: Never weld or cut any container that has ever held flammable material.

Safe Use of a Gas or Propane Forge:

- Lift the side port (door) of the forge, using caution
    - Never slam it or let it swing freely
- Never place anything in the forge other than mild steel or approved fire brick
- Do not poke, chip or remove interior insulation
- Use tongs to place metal in the side port of the forge
- Balance your piece in the door ports to avoid damaging the interior insulation
- Shut off the gas tank valve it you hear hissing

Safe Use of a Coal Forge:

- Ensure you have good ventilation and draft
    - A chimney draft, also spelled draught, is created when the hot gasses released from the fire move up the chimney (hot air rises) and as the hot air moves up the chimney, it creates space for cooler air to be drawn into the fire

AVOIDING FUMES

The process of blacksmithing can create fumes and smoke that will rise up from the metal. Some fumes will be more harmful than others.

Fumes contain very tiny particles suspended in the gas. These particles come from heating metals and from the coatings on the metal. The gases often include ozone, nitrogen dioxide, carbon monoxide, carbon dioxide, hydrogen chloride and phosgene. You can't see or smell these particles so it is easy to forget about them.

Fumes: smoke, vapor or gas.

At a miniumum, exposure to fumes can cause burning eyes and skin, dizziness, nausea and/or fever. In the extreme they can cause long term illnesses or death. For example, carbon monoxide can be fatal.

Precautions:

- Read and follow the Material Safety Data Sheets (MSDS), labels and the manufacturers' instructions for any products you use
- Don't breath the fumes
    - Keep your face out of the "blacksmith zone"
    - Wear a respirator if necessary
    - Work in a well ventilated area
- Remove any chemicals from your work area
- Remove any dirt, coatings, paints or oils from the metal
- Know the metal you are heating
- Avoid heating any metal that has a shiny finish e.g. chrome plating
- Never heat coated metals such as galvanized, lead, or cadmium plated steel
- If you must work alone, let someone know you are working

Illness from Fumes:

- Never heat metal that contains cadmium. It can cause Cadmium Pneumonitis which is fatal. It is found in metal plating, nickel-cadmium batteries, pigments, plastics, synthetics, coatings and paint
- Metal Fume Fever is an illness caused by breathing metal fumes such as zinc oxide, (galvanized sheet metal) magnesium oxide or chromium
- Copper alloys may contain beryllium which is highly toxic
- Paint may contain lead, chromium and zinc
- Carbon monoxide from a source such as a coal fire in the forge can be fatal

SAFE USE OF ELECTRICAL EQUIPMENT

Whenever you are using electrical equipment (e.g. grinders and saws) it is important to follow safety procedures.

The human body can be up to 78% water and water is a good conductor of electricity. If your body is exposed to electricity the current will flow through you to the ground. This can result in a mild shock, serious burns, paralysis or death.

There are many factors that will affect the seriousness of an electric shock; including the area of the contact, where the current flows in your body and the environment (e.g. humidity). The key is to do whatever you can to avoid any type of shock.

If you are with someone who experiences an electric shock:

- Turn off power at the fuse box or circuit breaker
- Call 911
- Turn off and unplug the equipment
- Administer First Aid and CPR only when the victim is away from the live electrical source

<u>General Electrical Safety:</u>

- Read manuals and follow the manufacturers' instructions
- Service and repair equipment according to the manual
- Turn the power off before making any repairs or adjustments
- Never operate any equipment when the protective covers are removed
- Check equipment and insulation regularly
- Check all connections before you begin
    - Are they tight, in good repair (free from burns or cracks)

- Repair or replace damaged parts immediately
    - Never operate equipment with a wire exposed
- Keep all cables on one side of your body
- Never drape a cable over your body (e.g. across your arm or shoulder)
- Don't work next to the power source
- Never touch any live parts
- Check that your gloves and clothing are appropriate for the job and ensure that they are in good condition (no holes)
- Avoid water when working with any electrical equipment
    - Don't stand in or near water
    - Keep your hands and gloves dry
    - Change your clothes if you are sweating
- Stand on a dry floor
    - Cement is ideal or wood or rubber surfaces
    - Never stand on metal
- Turn off any piece of equipment you are not using
- Never work alone

WORKING WITH CHEMICALS

Reading Text, Document Use

Thinking Skills: Critical Thinking

Although the chemicals you will be using to finish your project are not dangerous, it is important to develop good safety habits.

Whenever you are using chemicals remember that they can be absorbed through your skin, eyes and mouth. It is important that you wear gloves, wash your hands regularly and keep your hands away from your face. Try not to rub your eyes or mouth. Before you begin, cover all cuts and scratches with a bandage. Watch for signs of skin irritation. It is important that you avoid eating and smoking while you are working with chemicals.

For years Blacksmiths have used environmentally friendly products such as linseed oil and beeswax to finish their work. However, some Blacksmiths now use products such as Instiblack 33, muriatic acid or Tremclad exterior paints. If you decide to use any of these products, please read the labels and the Material Safety Data Sheets available and remember it is important that you use these products in a well ventilated area. Follow all the safety guidelines for their use and disposal. You want to protect yourself, those around you, as well as the environment.

Note: You will find MSDS sheets in all workplaces that use chemicals.

Material Safety Data Sheets – MSDS are documents written for people who use hazardous materials. They contain information about the physical or chemical hazards associated with using the material. They outline the safe handling, storage and disposal as well as steps for dealing with emergencies, fires, spills and overexposure.

Any material covered by the Workplace Hazardous Materials Information System (WHMIS) must have an MSDS. This means that if you are working with a hazardous substance, you must have access to MSDS in your workplace and you should be trained to work with the material safely. *http://www.meridianeng.com/msds.html*

BURN SUMMARY CHART

Reading Text, Document Use, Numeracy

You will be working with a hot forge. You will also be working with metal that could reach temperatures of between 1,000° and 1,260° Celsius (1,832° and 2,300° degrees Fahrenheit). To put that into perspective, water boils at about 100° Celsius (212° Fahrenheit).

Black Heat: this term is used to describe metal that can be 426° Celsius (800° Fahrenheit) without glowing.

Conducts: transmits energy such as heat.

<u>Avoid Burns:</u>

- Assume any tool or piece of metal is hot
  - Beginners are often burned by touching black hot metal
- Metal conducts heat, so only pick up tools by the handles and assume the handles are hot
- Work safely around the forge
- Wear protective clothing

BURN SUMMARY CHART

Degree	Identification	Healing	Treatment
First Degree	Red and painful	Healed in 3-6 days	Soak area in cool water, apply antibiotic ointment and cover with gauze
Second Degree	Red or splotchy, painful, swollen with blisters	Healed in 2 to 3 weeks	Soak in cool water, see your doctor, apply an antibiotic cream, leave blisters, cover with new dressing daily, check your tetanus record, watch for infection, protect it from sunlight and do not scratch
Third Degree	White and charred, may not be painful because of nerve damage	Long healing process	**Seek Immediate Emergency Medical Attention**

- Never put anything oily on a burn, it will make it worse
- Seek medical attention if you are in doubt

CLEAN UP

Reading Text, Document Use

You will be responsible for cleaning up your work area as you go. You will also be responsible for cleaning your work area at the end of each class.

- Keep your work area clean
- Put tools and equipment away in their proper place when you are finished with them
- Store scrap metal in designated areas
- Store chemicals safely when you are finished with them
- Wipe up any chemical spills

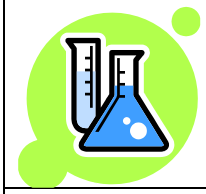
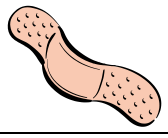
THE ENVIRONMENT

Document Use

- Plan before you start to work; this will help eliminate waste
- Save leftover pieces of metal so that others can use them on their projects
- Use small pieces of metal that others were not able to use
- Use newspaper or a cloth for clean up rather than paper towel
- Use garbage and recycle bins
- Recycle cans and glass bottles

AVOIDING INJURIES – SUMMARY CHART

Document Use

INJURY	CAUSE	AVOIDING
Burns 	Blacksmith burns are most often caused by touching hot metal or by mistakes around the fire (forge)	• Assume all metal is hot • Only pick up tools by the handles • Wear gloves • When lighting or using a forge keep your distance from flames, hot coals and sparks
Absorbing chemicals through skin, eyes, mouth. 	Touching chemicals	• Wash your hands after contact with any chemicals • Keep your hands away from your face • Do not rub your eyes or mouth • Do not eat or smoke while you are working • Use gloves if you are using chemicals
Muscle Pain 	Staying in one position for too long, repetitive movements, working in an uncomfortable position, unsafe lifting or hammering	• Stretch and move around • Pay attention to work area design • Stand straight as you work • Use correct techniques, e.g. hammering.
Blisters 	Blisters are caused by tools rubbing your skin	• Wear gloves • Use powder in the gloves • Cover any red areas to help protect against blisters developing

INTRODUCTION - BLACKSMITH

DEFINITION

Reading Text, Document Use

"A blacksmith is a person who processes iron or steel by forging the metal; i.e., by using tools to hammer, bend, cut, and otherwise shape it in its non-liquid form."
www.en.wikipedia.org/wiki/blacksmith

Blacksmiths make metal objects by hand. They do this by heating metal in a fire (forge) until it is hot enough to bend and shape. When the metal is removed from the forge, it is hit with a hammer until it takes on the shape the Blacksmith wants. The metal may need to be reheated several times during this process.

Blacksmiths produce functional products such as pot racks and tools. They also produce architectural pieces such as gates and railings. Today blacksmiths are creating artwork and sculptures. Most modern day Blacksmiths consider themselves to be artists rather than toolmakers.

The word blacksmith comes from Black, describing the colour of the metal and Smith from the word smite which means to strike.

Some of the other names for Blacksmiths included bladesmiths, locksmiths, gunsmiths and farriers (horseshoes).

Blacksmiths are considered to be the only craft that uses fire, air, earth and water.

The chart below shows three types of products produced by blacksmiths. These pieces were all produced in the Nostalgic Arts Blacksmith shop.

Architectural	
Art	
Function/Art	

Images from: http://nostalgicarts.ca/welcome

THREE STAGES

Reading Text

Society moves through stages as it develops. Archeologists studying prehistoric European and Mediterranean societies divided these stages into three separate time periods called ages. These ages were named after the materials humans were using to create the tools and weapons of the day. The names of these three stages are; Stone Age, Bronze Age and Iron Age.

Stone Age

The term Stone Age, refers to a prehistoric time starting 2.5 million years ago when humans used stone for making tools and weapons. A stone was shaped by chipping it with another harder stone until it was the right shape.

It was during the Iron Age that the role of the blacksmith grew in importance.

Alloy: the end result of mixing metals and/or non-metallic substances together.

For example, bronze is an alloy because it is a mixture of copper and tin.

Bronze Age

The Bronze Age from 3,300 to 1,200 BC followed the Stone Age. It was a time period when humans learned to melt and combine copper and tin to produce bronze. Bronze does not rust, therefore many objects from this time period can be found in museums.

Iron Age

The Iron Age dates from 1,200 to 550 BC. Iron was likely discovered accidentally when it separated from rocks that would have been placed in a very hot fire for another purpose.

Iron is a very hard substance when it's cool; however, it can be softened and shaped when it's heated. This was a significant discovery because it allowed blacksmiths to make tools and weapons that were stronger, tougher and sharper than those made of bronze.

Iron also became the metal of choice because it was easier to find than the copper and tin needed to make bronze. Additionally, because iron was plentiful it would have been less expensive.

IMPORTANCE OF THE BLACKSMITH

Reading Text

Blacksmithing is considered one of the oldest crafts, beginning about 5,000 years ago. The role of the blacksmith continued to be important in the development of our civilization up until the Industrial Revolution at the end of the 19th century.

Early blacksmiths made tools for farming, hunting and fighting. Communities with access to iron and a skilled blacksmith became more powerful than those without these resources. Better tools and weapons meant more food could be grown and people could defend themselves. It also meant they could conquer others.

There were many myths and legends surrounding the blacksmith. Although blacksmiths were often respected, there was a period of time when they were thought to be witches or wizards trained by the devil. People were mistrustful because they didn't understand the "secret ways" of the blacksmith. Because they didn't understand, they assumed it must be magic.

RECENT HISTORY

Reading Text

Villages, armies and ship crews all depended on the work of the blacksmith. In the western world, the village Blacksmith was responsible for building and repairing things such as tools, hinges, chains, knives and locks. The blacksmith shop was the hardware store, factory and repair shop.

During the Industrial Revolution, the demand for blacksmith services disappeared. At this time, machines began producing items quicker. This meant products made in factories could be sold cheaper than the same products made by the blacksmith.

Cheap factory made products also meant people replaced rather than repaired items. With no repairs coming into their shop, the blacksmiths second source of income dried up. Additionally, with the invention of the automobile, blacksmiths were no longer needed to make horseshoes. These changes resulted in a quick end to the role of the village blacksmith.

By the early 1900's most blacksmiths were out of work. While some found work fixing machinery or building tools in factories, many had no choice but to move on to other jobs.

In the 1800's, a blacksmith could make one nail a minute. One machine in a factory could produce 1,000's of nails a minute.

MODERN TIMES

Reading Text, Document Use

During the 1970's the role of the blacksmith began to reappear. There were two things that made this comeback possible:

1. People wanted to purchase high quality hand-crafted products, rather than mass produced factory made items.
2. People became interested in maintaining traditions and preserving history. People realized that blacksmithing techniques were at risk of being lost forever.

Today people become blacksmiths for a variety of reasons:

- People, including farmers, want to be able to fix things themselves
- Hobbyists and artists are choosing blacksmithing as a creative outlet
- Some people want to develop their metalworking skills for career and employment reasons
- Finally, more and more people are entering blacksmithing as a business. They are making architectural treatments as well as functional and decorative art

Today many Blacksmiths have added modern industrial equipment to their workshops. Modern equipment allows them to work faster and it removes some of the physical demands of the work. However, they continue to keep the tradition alive by using traditional methods and techniques.

By deciding to take this course you are playing a role in helping to keep the 5,000 year old blacksmithing tradition alive.

Blacksmiths have been known to say that it is important to "work smarter, not harder" when talking about their decision to use modern tools.

METAL

INTRODUCTION TO METAL

Reading Text, Document Use

Metal is a class of chemical element.

Metal:

- can be described as having ductility – (this means it can be hammered into thin sheets or drawn into wire)
- can be described as having malleability – (this means it can be shaped or bent without breaking or cracking)
- is solid at room temperature (except mercury)
- can be melted or fused
- is opaque (light can't go through it)
- can reflect light when polished
- conducts (transmits) electricity and heat
- is electropositive (loses electrons/forms positive ions)
- can be combined with other metals to create an alloy

Ferrous metals: metals that contain iron.

Nonferrous metals: all other metals and alloys that have no iron content.

Element: in chemistry, it means any substance that cannot be broken down into a simpler one by a chemical reaction.

Humans even need small quantities of metals to survive. Scan the label on your vitamin pill bottle to see if any of these are listed: calcium, magnesium, chromium, copper, iron, manganese, potassium, sodium and zinc.

IRON PRODUCTION

Reading Text, Document Use, Numeracy

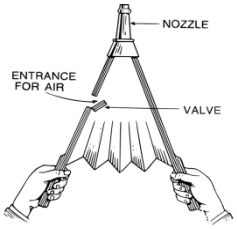
Blacksmiths have been using iron since the Iron Age (1,200 to 550 BC). Iron is naturally occurring, however, when it is taken from the ground it is not in its pure form. The iron is mixed in with ore (rock) and must be separated before it can be used.

Basically, iron is removed from ore through a process called smelting. The fuel used in a smelter usually has a high carbon content, such as charcoal or coal. Smelting uses this carbon fuel to create high temperatures which causes a chemical reaction. The carbon or carbon monoxide from the smelting process removes oxygen from the ore, leaving only the metal. The ore melts away and forms the solid waste product known as slag. http://en.wikipedia.org/wiki/Smelting

BLOOMERIES

Bronze was used before iron because it has a lower melting point. Bronze melts at approximately 950 degrees Celsius (1,742° Fahrenheit) and iron melts at approximately 1,530° Celsius (2,786° Fahrenheit). Iron could be produced only after fuel, tools and techniques were developed that made it possible to build fires that burned at very high temperatures.

If you have ever blown on a campfire, you know that fire will burn hotter when oxygen is added. The more oxygen you add, the hotter the fire will burn. It was the invention of the bellows that made it possible to increase the amount of oxygen directed at a fire so that the temperature of the fire was hot enough to separate iron from ore.



Bellows are designed with a chamber that expands when air is drawn in through an intake valve. The air can then be squeezed out of the chamber through an outlet valve. It then travels down a nozzle toward the fire. The speed that the air comes out of the chamber can be controlled by changing the amount of pressure used to force the air out of the chamber.

http://en.wikipedia.org/wiki/Bellows

During the Iron Age high temperatures were reached in a small oven like building called a bloomery. These early smelters were built using clay and rocks. They were dome shaped with a vent in the top and a door on the side. Charcoal was used for fuel and bellows were used to add oxygen to the fire.

Iron ore was placed in the bloomery for several hours with a very hot charcoal fire. The fire had to produce a temperature above 1,530° Celsius (2,786° Fahrenheit) so that the iron would separate from the ore. The piece of iron that was left at the end of the process was called a bloom.

CARBON

As mentioned, the fuel used in smelters has a high carbon content, such as coal or charcoal.

Carbon is a non-metallic chemical element. The name carbon comes from the Latin name for coal (carbo). Carbon is the fourth most plentiful element in the universe by mass, after hydrogen, helium and oxygen. Carbon is present in all known life forms including the human body, where it is second only to oxygen. (Wikipedia)

Iron is a metal with a very low percentage of carbon, usually lower than 0.05% by weight until it goes through the smelting process. Once carbon has been added to iron it is called steel or carbon steel.

As mentioned, when a metal is mixed with another metal or a non-metallic substance such as carbon the result is called an alloy. This means that carbon steel is an alloy.

Note: The percentage of carbon will affect the qualities of the iron. It changes how the steel reacts to heating, hammering, cooling and welding. For example, if the carbon content rises above 1.7%, the metal will become hard and difficult to shape. With a higher carbon content the metal will have a lower melting point.

The following chart outlines the carbon content of various metals.

Carbon Content of Iron

Type	Qualities	Carbon Content by Weight	Use
Cast Iron	Hard, difficult to shape, breakable (like glass) but easy to melt. Melts at 1,260° C (2,300° F)	2.0 – 4.0% carbon	It can be melted and poured into casts or moulds to make things like pipes, machine parts and pans. Can't be forged so it's not used by Blacksmiths.
Carbon Steel (includes mild, medium and high)	Strong and easy to shape. It can stretch without breaking or cracking. Mild carbon steel is the easiest to shape, not too hard or too soft. Melts between 1,353° C & 1,464° C (2,467° & 2,667° F)	0.07 to 2.0% carbon	Used by Blacksmiths. Can be used to make machines, tools, cars and building structures. Mild carbon steel is best for beginner Blacksmiths.
Wrought Iron	Weaker than steel but easy to shape and weld. Can be reheated and reshaped. Melts at 1,530° C (2,786° F)	Less than 0.25% carbon	Not used much now but in the past it was used for gun barrels, chains, railings, knives, nuts and bolts.
Iron	Melts at 1,530° C (2,786 ° F)	0.05%	Not many practical uses.

Note: The percentage of carbon and the melting points will vary depending on the source you use. For this course it is only important that you have a general understanding of how carbon affects the qualities of the metal.

METAL USED BY BLACKSMITHS

Reading Text

Originally Blacksmiths worked with metal called wrought iron. Wrought is an old English verb meaning "to work". Therefore, wrought iron means "worked iron".

Wrought iron was popular until the mid 1800's when it was replaced by steel. If you look back at the "**Carbon Content of Iron**" chart you will see that the carbon content of wrought iron is very low. This makes it harder to work.

Blacksmiths today work with carbon steel, although many people still use the term iron, or wrought iron. It is best to use the term steel or carbon steel to describe the metal you will be using.

Carbon steel can be found with mild, medium and high carbon content. Of the carbon steel options, mild steel is easier to heat and shape and a bit more forgiving than higher carbon steel. It can be worked even if it is not heated to the perfect temperature. Mild steel can also be cooled in water without cracking. Mild carbon steel is the best choice for people learning blacksmithing techniques; therefore, it is the steel you will be using in this course.

When you are buying steel, find out the carbon content by weight.

If you don't know what type of steel you are using, you can test it using a grinder. If grinding only makes a few sparks it is likely mild steel. High carbon steel will produce many sparks.

Carbon steel is also known as plain carbon steel.

TOOLS AND EQUIPMENT

ANVIL

Reading Text, Document Use, Numeracy, Oral Communication

Thinking Skills: Critical Thinking, Decision Making

Anvils have been used since the Bronze Age. It is the tool most people will recognize as belonging in a blacksmith shop. Anvils come in many shapes and sizes and can weigh up to 200 kilograms (440 pounds). Anvils are usually made from solid forged steel. This hard steel will stand up to years of strikes from a Blacksmith's hammer.

Ideally, you want the anvil you are using to be attached to a sturdy base or pedestal. This will allow you to walk around it rather than having to reach across. A wood base will help to absorb the blows, reduce the rebound effect and keep the anvil from vibrating and ringing, however, metal stands also work well.

It is important that the anvil you are using is positioned right for your height. If it is too low or too high it will be hard to use and you could end up with muscle strains. Ideally, you want to be able to stand up straight when you are using the anvil. Not only will this position protect your back it will make you more efficient when you swing your hammer.

Striking an anvil directly with a hammer can cause it to chip. Chipped or cracked anvils should not be used.

When buying an anvil look for quality cast or forged steel. It is best to avoid light, inexpensive models.

In class you may not have the option of changing the height of your anvil or your base. If you have any questions or concerns please talk with your instructor.

TIPS FOR ANVIL POSITIONING

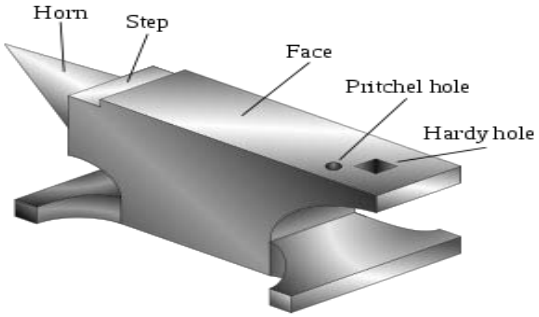
- Stand facing the anvil with your arms hanging at your sides
- Make a fist
- Adjust the anvil until your knuckles line up with the face

Note: Use this technique anytime you need to work on an elevated surface while standing. E.g. massage therapists use this technique for setting up their massage tables.

PARTS OF AN ANVIL

Face:

The flat work area at the top of the anvil body is called the face. The surface of the face should be smooth and flat. You will place the metal across the face when it is hot enough to be hammered and shaped.



http://en.wikipedia.org/wiki/Anvil

Horn/Beak:

The horn sticks out from the end of the anvil. It is usually cone shaped. You will use the horn to round, bend, fold and stretch metal. Some anvils will have a pyramid shaped horn on the other end.

Hardy Hole:

The square hole in the face of the anvil is called the hardy hole. It holds the tools you will use for forming and cutting metal. The most common tool is actually called a hardy. It is a chisel like tool used for cutting metal.

Pritchel Hole:

The round hole in the face of the anvil is called the pritchel hole. When a Blacksmith punches a hole in a piece of metal, (e.g. a nail hole in a horseshoe), they use a spike like tool called a pritchel. They place the metal over the pritchel hole so that when the pritchel breaks the surface, it is not damaged by hitting the face of the anvil.

Hardy and Pritchel Tools:

There are many tools designed to fit the hardy and pritchel holes. These tools come in all shapes and sizes. They are designed for cutting, bending, folding, twisting, moulding and punching metal.

Note: You will find additional information about anvil tools in your Student Notes.

TIPS FOR USING AN ANVIL

- Assess your anvil
- Clean off the top of your anvil before you place the heated metal on the surface
    - Use a brush or wipe the surface with the back of your gloved hand
    - Any small pieces of material left on an anvil can damage your work
- Remove any tools you are not using from the hardy hole
    - If a tool is left sticking up from the surface of your anvil, you could accidentally hit it with your hand when you start hammering the metal

ANVIL TOOLS

Cut-Off Hardy:

The cut-off hardy is one of the most commonly used tools. As mentioned, the hardy is used to cut metal. The hardy fits in the hardy hole.

- Select the correct hardy for the job
- Place the hardy in the hardy hole
    - The cutting edge will be facing up
- Heat the metal in the forge until it is an orange colour
- Place the metal across the hardy, exactly where you want the cut
- Hammer the metal
    - Rotate the bar every few strikes
- Stop when there is still about 19 millimetres (¾ inch) of metal left uncut
    - Cutting all the way through the metal can damage the hardy and the hammer and it can cause the piece of metal to fly off
- Bend the metal back and forth until it breaks
- Assess the cut and reheat if necessary

Fuller:

A fuller is used to make grooves or hollows in the metal. Fullers can also be used for finishing round corners and for stretching or spreading metal. The fuller tool comes in two pieces.

- Select the fuller that will give you the shape you need
- Fit the bottom piece of the fuller in the hardy hole

- Place the hot metal on top of the fuller
    - Place the second piece of the fuller on top of the metal (like a metal sandwich)
- Strike the top piece with your hammer
- Continue until you have the shape you need
- Assess your piece and reheat if necessary

Pritchel:

This tool is used for punching holes in metal using a technique called drifting or punching. This is done by hammering a punch into the heated metal.

- Decide on the size and shape of hole you want and select the correct pritchel size
- Heat the metal to an orange heat
- Place the tip of the pritchel on the metal where you want the hole
- Hammer the pritchel into the metal to start the hole
    - If you have trouble holding the metal, the punch and the hammer, you may need to find someone to help
- Place the metal over the pritchel hole when it starts to punch through
    - Turn the metal over and finish it on the opposite side
    - Hammer the pritchel until the hole is created
    - The metal piece will fall into the pritchel hole
- Flatten the metal if it bends
    - Assess your piece and if necessary reheat or select another pritchel size

MEASURING TOOLS

Reading Text, Document Use, Numeracy

Thinking Skills: Critical Thinking

Measurements are important if you need to make something a specific size. For example, if you are building a heavy piece to hang on a wall, it must be attached to the wall studs. Therefore, you need to know the distance between the studs and design your piece so that the hooks are in the right place.

Measurements will also be critical if you need to set a price for selling your work. Accurate measurements will help you determine material costs.

If you track your measurements it also makes it easier to create the same item again.

If you are building something specific for a customer you need to know the dimensions so you can estimate the material costs and price the job. In any business knowing your material costs is a critical piece in providing a quote for your work.

Wooden tools and rulers should not be used in a blacksmith shop.

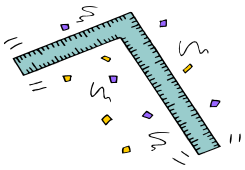
This site will help you if you need to convert between Imperial and SI (Metric): http://www.worldwidemetric.com/metcal.htm

Ruler:

Blacksmiths use metal rulers in their workshops. In most cases, you will be using a ruler that has both Imperial and SI (metric) measurements. Ideally you will want to be able to use both systems of measurement. Tape measures are also helpful. Use a flexible steel tape measure less than 5 metres (16 feet) long.

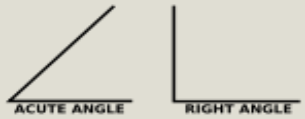
Square:

Blacksmiths often need to create bends in metal. If you need to bend a piece of metal to a right angle, you will need a square. It is not possible to assess an angle visually.



- Hold the square along one side of a bent piece of metal
- Determine how much the metal needs to be adjusted
- Heat and adjust the metal
- Evaluate and measure the bend
- Reheat the piece as necessary

Note: If the metal is placed on the anvil face with the bend at the edge, pointing toward the ground it will form a 90° angle. This can be used as a quick reference as you work.



http://en.wikipedia.org/wiki/Right_angle

The measurements you will do for your in-class project will not be complicated, but measurements are important to know for future projects.

Inset: to place a smaller thing in a larger thing.

Calipers:

Blacksmiths use steel calipers to measure the external diameter or thickness of metal. For example, if you want to measure the thickness of a metal bar or you need to measure a ball you have created at the end of a piece of metal, you would use calipers.

Calipers can also measure the internal dimensions. For example, they can be used to measure the space inside a metal pipe. They are also helpful if you need to create space for an inset.

There are many types of calipers, including ones that have digital screen displays.

Using Calipers:

- Place the two caliper arms on either side of the piece you are measuring
- Tighten the caliper
- Read the measurement on the caliper
    - It will measure the distance between the tip of each arm
- For an inside measurement: Place the two caliper arms on either side of the metal, inside the piece you are measuring

TONGS

Reading Text, Document Use

Thinking Skills: Decision making

Tongs are another important tool in a blacksmith shop. Tongs are made up of two pieces of metal that are exactly the same. They are held together by a rivet at the pivot/fulcrum point. The parts above the rivet are called the handles. The part below the rivet are called the jaws.

Tongs come in all shapes and sizes and have different jaw styles. Some blacksmiths make their own tongs, customizing them for the type of work they do most often.

You will use tongs to keep your hands away from the heat as you add and remove metal from the fire. You may also use them to hold shorter pieces of metal on the anvil as you work. If you are using water to cool the metal, tongs are used to dunk the metal into the water bath.

Note: Only use tongs when necessary. If the piece of steel you are using is long enough, you can hold it with your hand. Assess the job and ensure you are using the right sized tongs. This is a very important safety consideration. You do not want to lose your grip on hot steel when you are hammering.

Pivot / Fulcrum: the point or join where the lever turns. Increases the force you can apply on an object.

TIPS FOR USING TONGS

- Assess the work that needs to be done
- Consider the size of the metal piece
- Select the tongs with the right handle length
- Test the jaws of the tongs by picking up and holding the metal
- Assess your grip
    - You should be able to hold the metal comfortably
    - If the size is not right, try another pair of tongs
- Turn the metal by moving your wrist back and forth
    - Use this technique whether you are using your hands or tongs
    - If you roll the metal with your fingers your hands will quickly become tired

VISE

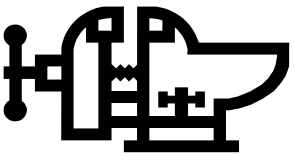
Reading Text, Document Use

Thinking Skills: Decision Making, Critical Thinking

A vise allows you to hold metal in one place while leaving your hands free. It is helpful if you need to twist the metal, hit the end of the metal, or ensure that it doesn't move as you work.

There are several types of vises you could use, including a vise that attaches to the leg of the workbench and the kind that is mounted on the top of a workbench. A vise that is made of forged steel is a good choice for a blacksmith.

TIPS FOR USING A VISE



- Assess the work that needs to be done
- Consider the size of the metal piece
- Select the correct vise for the job
    - Avoid jaws that have a texture, it could mark your metal
- Heat the metal
- Place the metal in the jaws of the vise, with the heated end out
    - Ensure no one brushes against the hot metal
- Screw the jaws together
    - Continue tightening them until the metal is secure
- Test the vise to ensure the metal is secure before you begin working

HAMMERS

Reading Text, Document Use, Numeracy

Thinking Skills: Decision Making, Critical Thinking

Blacksmiths use a variety of hammers that can weigh anywhere from 0.45 kilograms (1 pound) to 7.25 kilograms (16 pounds). However, most blacksmiths use hammers that weigh between 0.90 and 1.36 kilograms (2-3 pounds).

Ball-peen hammers and cross-peen hammers are the most common in blacksmithing. You will have a chance to use both in this course. The ball-peen hammer is used by blacksmiths, engineers, machinists and mechanics. It is ideal for shaping, riveting or thinning metal.

The cross-peen hammer is flat on one end and pointed on the other. It is an excellent forging hammer.

Search hammers on the internet for images of the different styles.

TIPS FOR USING HAMMERS

Selecting a Hammer:

- Assess the weight of various hammers
- Select a hammer that feels light
    - You will be swinging your hammer hundreds of times a day during this course. The hammer will feel like it is getting heavier as the day goes on
- Assess the balance of the various hammers
- Select the one that feels balanced in your hand

- Select a cross-peen and/or ball-peen hammer
    - Don't use a carpenter's hammer or any hammer with a textured surface that could mark the metal
- Assess the condition of the hammer and only use it if it has not been damaged

If you are driving a long distance and you have a tight grip on the steering wheel, your arms and shoulders will tire quickly. Think about this when you are holding a hammer.

Swinging a Hammer:

- Hold the hammer with a light but firm grip near the end of the handle
    - The end of the hammer should stick out less than 25 millimetres (1 inch) past your little finger
- Swing your hammer in a controlled fashion
    - The control you have over the hammer stroke is more important than strength
- Use your whole arm
- Keep your elbow close to your body
    - You will often want to hit the metal on an angle
- Assess how each hammer strike lands
    - Was it straight or on an angle?
    - Did the strike leave a mark in the metal?
- Hold the hammer tight enough so that you have control but not so tight that your forearm gets tired

- Keep your grip loose until it is about to strike the metal
- Use gravity and the weight of the hammer to gain momentum rather than using muscle
- Assess the feel of the metal as you strike it
    - Did it move?
    - How did it move?
- Check that you are in a comfortable position
    - Stand straight with your feet apart comfortably with one foot ahead of the other
    - Keep your shoulders square to the anvil
    - Bend your knees slightly
- Make adjustments in your grip, the angle of the hammer, the speed of your strikes and your body position, based on your assessment

POWER TOOLS

Reading Text, Document Use

Thinking Skills: Critical Thinking

Most blacksmiths today use both traditional and modern equipment. For example, shops with mechanical forging equipment such as a power hammer still use hand held hammers.

Power Hammers:

Power tools make it possible for blacksmiths to produce more in less time. It also removes the muscle strain that is common with traditional blacksmithing. When you are not swinging a hammer all day, you can work longer and faster. You can also work on larger pieces of metal.

Since the late 1800's blacksmiths have had access to power hammers. These hammers were water powered but evolved to steam, electric, hydraulic and compressed air.

Reminder: Whenever you are using any type of power equipment, assess it before you begin.

Check that it is in good working order and ensure all guards and shields are in place.

Pneumatic: a term that describes tools that are powered by compressed air.

Power hammers are tall, narrow machines that have a built-in hammer and anvil. They have a motor that provides the power for the hammer and a lever that allows you to control the speed of the hammer strikes.

Using a power hammer does not mean that the machine creates the piece for you. You still need to heat the metal, place it on the anvil and position it to get the shape you want.

Even with a power hammer the blacksmith still needs creativity and technical blacksmithing skills. Without the knowledge of how to shape metal on an anvil, a power hammer is of little value.

Grinders:

An angle grinder is a handheld power tool. The motor, (either electric or pneumatic) spins a sandpaper disk at a high RPM.

Once the disk is spinning you press the grinder firmly against the metal surface. It is important to hold the grinder with two hands and keep your grip firm as you apply pressure. You can also use a vise to keep the metal from moving as you work.

You can use a grinder to:

- grind, buff, sharpen, shape and polish metal
- remove metal flakes and rust
- smooth an area that has been welded
- sharpen the edges of metal tools

The grinder spins a disk at speeds of up to 10,000 RPM's. Follow all safety precautions outlined in the manual that comes with the machine.

RPM : refers to the number of times something rotates in a minute - Rotations Per Minute.

If the metal you are grinding gets hot, you may need to dip it in water.

A bench grinder is similar to an angle grinder; however a bench grinder is a table top machine that uses interchangeable grinding wheels or brushes rather than disks.

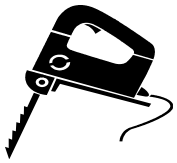
Rather than moving the grinder into the metal you stand in front of the bench grinder and move the metal into the spinning wheel. You need a firm grip on the metal.

Like sandpaper, there are different grades depending on the disk or wheel you are using. You will need to assess the job and select the right disk or wheel.

In addition to metal workers, grinders are also used by woodworkers, tilesetters and construction workers. They are also used in auto body repair.

Saws:

A jigsaw is a hand held saw used to make straight or detailed cuts, including angles, bevels, miters or curves. The interchangeable blades allow you to cut metal as well as wood, plastic or tile. The electric motor moves a blade up and down at a high RPM.



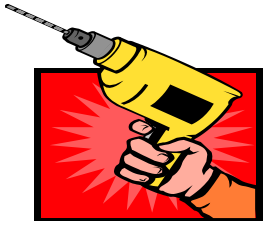
There are specific blades for cutting metal. When you are using a jigsaw to cut metal select a blade designed for the job. Jigsaws work best when cutting smaller pieces of mild steel. You can use cutting oil to keep the saw lubricated.

Band saws are table mounted. The blade is similar to the blade used in a jig saw. With a band saw you can cut larger pieces of metal.

Drills:

Drill bits are used to create round holes. They are thin pieces of metal that have grooves that spiral. Each bit has a piece of metal that sticks out at the bottom. This is designed to grip the material being cut.

Bits are interchangeable so you can make different sized holes. You can also choose drill bits designed to create smooth or threaded holes.



The bits are put in a drill. The motor of the drill spins the bit so when it is pressed against the metal it spins through the metal making a hole.

Blacksmiths may use either a drill press or a hand held drill for creating holes in metal. With a hand held drill, you apply pressure manually. With a drill press, the metal is clamped on the machine and a lever lowers the spinning bit into the metal.

Follow all safety precautions outlined in the manual that comes with the machine.

Remember, when you are using tools of any kind:

- inspect them to ensure that they are in good condition
- ensure you and those around you are safe
- safely store tools when you are finished
- wear all recommended safety equipment
- follow all safety guidelines

When you have time, search the internet for the different types of tools listed in this section of your Student Notes.

THE FORGE

INTRODUCTION

Reading Text

Iron is too hard to work unless it has been heated. The Blacksmith places metal in a forge which is a very hot environment. They then watch the metal closely, moving and rotating it until it is the right temperature.

When the metal is removed from the forge it is placed on an anvil and shaped using hammer strikes. If the metal cools before it has reached the right shape, it must be placed back into the forge and reheated.

The blacksmith shop may also be called a forge or a smithy.

Note: When the word forge is used as a noun, it refers to the piece of equipment used by a Blacksmith to heat metal.

Traditionally, a forge was a coal fire in a hearth, vented with a chimney. Bellows were used to direct oxygen to the fire. You will find that many Blacksmiths today use a gas forge and a fan powered by electric motors.

In the past a forge was made of stone and the walls were lined with clay or brick. Today, gas forges are usually made of cast iron or steel and lined with fire brick.

A forge needs to be vented outside and your work area needs a source of fresh air. With a traditional forge, a chimney with a good draft is needed to remove smoke and fumes from the work area.

This image shows a traditional blacksmith shop.

TRADITIONAL FUEL

Reading Text, Document Use, Numeracy

Thinking Skills: Critical Thinking

The fuel used to heat the forge has changed over the years. Traditionally, a forge was heated with solid fuel such as:

Peat:

- Created by removing water from partially decayed vegetable matter

Charcoal:

- Created by heating wood, with a limited amount of oxygen. What remained is charcoal, which is almost pure carbon
  - Charcoal for blacksmithing is sold as natural or natural lump charcoal
  - It is important to note that this is not the same as the charcoal sold for barbeques

Coal:

- Coal is a naturally occurring fuel source
- Coal is sold as blacksmith or farriers coal and may also be called bituminous coal
  - Only use sulfur free coal because sulfur causes steel to crumble

Coke:

- Created by baking coal at a high temperatures while limiting the amount of oxygen, leaving mostly carbon

Blacksmiths who want to stick with tradition continue to use solid fuel. They also prefer solid fuel because it gives them more control over the size of the fire.

In the past a blacksmith apprenticeship would last 10 years. An apprentice would start learning the trade when they were only 7 or 8 years old. These young apprentices would spend the first few years learning to build and maintain the forge fire.

Drawbacks of Traditional Fuel:

- Part of your day is spent building the fire and waiting for it to reach the right temperature
- Temperatures can drop too low if you are not paying attention
- Finding the right fuel can be challenging
- A traditional forge will take up a lot of space in your shop

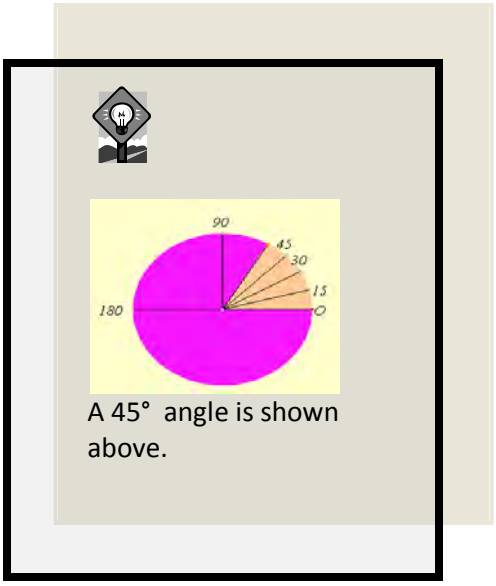
TIPS FOR USING A TRADITIONAL FORGE

- Clean out the fire area first
- Light several sheets of balled up newspaper
- Add fuel and oxygen
- Continue to add fuel until you create a mound in the centre
    - Use a poker and a rake to move the fuel
- Place fresh fuel around the outside of the fire
- Rake the fuel from the edges into the mound in the centre of the forge as needed
- Continue adding fuel around the edge of the fire
- Continue moving the fuel around in the forge

- Build up the temperature by using oxygen (bellows/fan)
    - Have a watering can available to cool the fire if necessary
- Assess the fire before you begin working
    - Is it hot enough and deep enough to begin?

<u>Adding Steel:</u>

- Place the steel you want to work into the coals on a horizontal angle
    - Placed the steel into the coals on an angle that is less than a 45°
- Place it under 5 centimetres (2 inches) of coals
    - Don't lay steel on top of the coals, it won't get hot enough
- Work on one piece of metal at a time
    - Remember the old saying "don't get too many irons in the fire"



A 45° angle is shown above.

CURRENT DAY FUEL

Reading Text, Document Use

Many blacksmiths today use propane or natural gas to fuel their forge. For beginners and hobbyists, this is often the best option. If you are going to try blacksmithing at home, you may want to consider researching gas forge options.

As mentioned, a gas burning forge is a box lined with firebrick. It is fueled with either propane or natural gas. They have one or two burners and a motorized blower for adding oxygen. It looks more like a gas oven than a fireplace.

There are many advantages to using a gas forge.

- The fuel:
  - is easier to find
  - is cheaper than the solid fuels
  - burns cleaner
- The ideal temperature can be reach quickly, maintained easily and adjusted as needed
  - A gas forge can easily maintain temperatures high enough for most blacksmith projects
- There are very few parts to a gas forge so they don't need a lot of maintenance
- They are portable, which means you can take them outside
  - Your yard becomes your workshop
  - You don't need a large indoor workshop

http://www.chileforge.com/forges_tabasco_details.html

TIPS FOR USING A GAS FORGE

- Follow the manual for lighting your gas forge
- Turn off the gas and any electric blowers when you don't need to maintain a high temperature
    - This will save you money
- Follow all safety procedures for using gas or propane
- Ensure that there are no flames shooting out of the door
    - If a gas forge is not operating correctly, it will create deadly carbon monoxide
    - Operate in a well ventilated area
    - Work outside whenever possible

Note: If you are using a gas forge, your instructor will set it up for you.

If you are working in an enclosed area with a gas forge, and you get a headache, leave the area immediately. It could be a sign of carbon monoxide poisioning.

FORGING

HOT FORGING

Reading Text, Document Use, Numeracy, Oral Communication

Thinking Skills: Critical Thinking, Decision Making

As mentioned earlier when the term forge is used as a noun it refers to the piece of equipment a blacksmith uses to heat metal. When the term forging is used as a verb, it describes the steps used to shape metal.

For example, hot forging is the term used to describe hammering heated metal on an anvil until it's the shape you want. It is the heat that makes metal soft enough to be worked without cracking.

COLOUR AND TEMPERATURE

If you look closely at images of blacksmiths at work you will notice that they are often working in a dimly lit workshop. Blacksmiths need to keep the light in their work area low so that they can see the temperature of the metal. This can be a challenge if you are working outside in bright light.

It may sound odd to talk about seeing temperature, but remember blacksmiths were around long before thermometers. Lucky for early blacksmiths, they had colour to tell them when the metal was the right temperature to be worked. Even today, experienced blacksmiths rely on colour changes to guide them.

Hot metal becomes soft like clay.

The work a Blacksmith does is also referred to as hand forging.

Cold forging refers to forging metal that is not heated. This only works with very soft metals.

You have likely heard the expression “red hot”. Well “red hot” is not hot enough for a blacksmith. To work metal it needs to turn orange or yellow. At this colour the metal will be somewhere between 1,000° and 1,260° Celsius (1,832° and 2,300° Fahrenheit).

Note: The maximum temperature a piece of steel should reach is 1,316° Celsius (2,400° Fahrenheit). The metal will turn white at this temperature.

As you work on your projects you will need to watch the metal in the forge carefully. It is hard to be patient; however, if you remove the metal and place it on the anvil before it turns orange or yellow, the metal will be difficult or even impossible to work. Remember, you want to work smarter, not harder.

As metal is worked it will begin to cool. You will need to keep a close eye on the colour while it is on the anvil. When it turns a light red colour, it’s time to return it to the forge to be reheated.

Heating metal causes a temporary colour change. It will go from black to blue to purple to red to orange to yellow and finally to white. The colour changes reverse as the metal cools.

Remember most burns happen with black heat.

Metal will cool quicker when it touches a cool surface, such as the anvil or vise.

COLOUR AND TEMPERATURE CHART

Note: This chart has been included as a reference point only. The colours and temperature ratings will vary depending on the source you use. You will also find that the colour will vary depending on the metal you are using. For more information please talk to your instructor or search "metal colour and temperature" on the internet.

	°C	°F
black	426	>800
red	500	932
brown red	550	1022
dark red	680	1256
cherry	*800*	*1472*
light red	*900*	*1652*
orange	*1000*	*1832*
yellow	*1100*	*2012*
pale yellow	*1200*	*2192*
white	*1400*	*2552*

TIPS FOR HEATING METAL

- Track the time the metal is in the forge
    - This will be a helpful reference point as you learn and will be helpful if you want to make the same piece again
- Watch metal when it's in the forge and monitor the colour changes
    - Overheating the metal could ruin your hard work
    - Thinner pieces and pieces with a large surface area will heat faster
    - Forge temperatures will vary

The metal will be cooling as you work, therefore you need to work quickly. However, always put safety first.

- Ensure that the metal heats evenly
- Assess the metal colour before removing it from the forge
    - A bright orange-yellow colour is ideal for most projects
- Remove metal from the forge and place it on your anvil
- Assess the movement of the metal as you strike it
    - If the metal is not changing shape easily you may need to return it to the forge
- Assess the colour of the metal as you work
- Return the metal to the forge when it has cooled to the light red colour

The colour the metal needs to reach will depend on the metal and the techniques you are using; however, there are a few general guidelines you can follow.

Red: In most cases, when the metal is red it is time to return it to the forge.
Orange: In most cases, this is a good temperature to work steel.
Yellow: Depending on your project, this is also a good temperature to work steel.

Note: Two common mistakes made by new blacksmiths:

1. They remove the metal from the forge before it is ready
2. They continue hammering when the metal should be returned to the fire

FORGING TECHNIQUES

INTRODUCTION

Document Use, Oral Communication

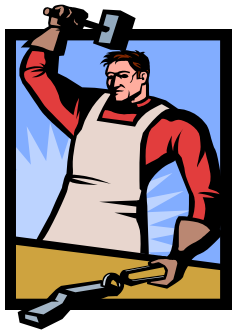
Blacksmiths have had many years to develop forging techniques and tools. The basic techniques will be covered in this section.

Note:

- You may find that the same technique has many different names. As a beginner it is more important that you understand the steps and the outcome of using a technique
- There is usually more than one way to get the same end result
- Blacksmiths have a variety of tools and techniques to choose from
- For more information about blacksmithing techniques you can read a resource book on blacksmithing or search the internet
- Ask your instructor for assistance

Depending on your project you:

- may need to use a combination of techniques to make one piece
- may not have the opportunity to use all of the techniques outlined in this section



It is important to remember that forging will change the size and shape of a piece of metal; however, unless you cut a piece off, the volume will stay the same.

Therefore:

- if you shorten a piece of metal, it will become thicker
- if you flatten a piece of metal, it will become wider and/or longer

UPSETTING

Reading Text, Document Use

Thinking Skills: Decision Making, Critical Thinking

You can use a technique called upsetting to decrease the length and increase the diameter of a piece of metal. The volume of the metal will not change so when you shorten a piece of metal, it must become thicker. You would use this technique to create a flat end (e.g. a nail head) or a round ball on the end of a metal piece.

TIPS FOR UPSETTING

- Heat the metal until it is yellow-white (very hot)
    - Upsetting requires hotter than normal temperatures
- Heat only the section of metal you want to change
    - The temperature and the force used in this technique can cause the metal to bend in the wrong place
    - Apply water on the metal just below the area you want to work to keep it cooler
- Place the metal on the anvil with the hot end sticking out beyond the edge
- Hold it tight - you never want hot metal to fly loose
- Hit the hot end squarely with your hammer
    - Continue hitting the end, rotating the metal bar a quarter turn after each blow
- Assess your progress and reheat metal as needed
- Continue until you have reached the shape you want
- Straighten metal if it bends in the wrong place

An Alternative:

- Place the metal in a vise
    - Have the hot end sticking out of the vise
- Check that the metal is secured in the jaws before you strike it
    - You can also place the heated end of the metal vertically on the anvil and hammer down

DRAWING OUT

Reading Text, Document Use, Numeracy

Thinking Skills: Critical Thinking

You can use this technique to increase the length and decrease the diameter of the metal. The volume of the metal will not change so when you make a piece of metal longer it must become thinner.

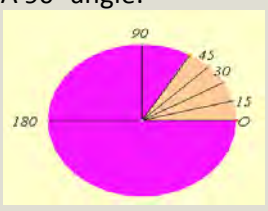
TIPS FOR DRAWING OUT

- Heat the metal until it is an orange colour
- Place the metal flat on the anvil face
- Strike the surface of the metal squarely using the peen side of the hammer
- Rotate the metal 90° every few strikes
    - If you don't rotate the metal it will become wide and flat

Use light but controlled strikes. Too much force often means your strikes will not be accurate. As a gauge, you should see the metal changing shape by your sixth strike.

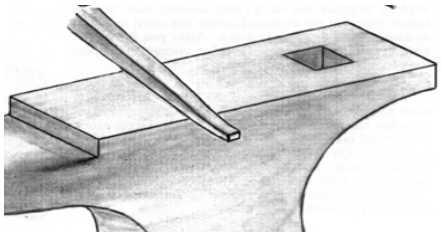
Diameter: the width or thickness of something.

A 90° angle:



- Start at the end of the metal piece
- Push the metal toward the hammer as you work
- Work your way down the length of the metal until you have the shape and thickness you want
- Assess the piece and continue if needed

Note: When you return the metal to the forge to be reheated, watch it carefully; thin metal can overheat and melt away



http://www.artist-blacksmith.org/education/drawout.jpg

TAPERING/SHARPENING

Reading Text, Document Use, Numeracy

Thinking Skills: Decision Making

This is a technique similar to drawing out because you increase the length and decrease the diameter of the metal. However, with this technique you continue until you have created a tapered or pointed end.

TIPS FOR TAPERING/SHARPENING

- Start with a squared piece of metal
- Heat the metal until it is an orange colour
- Place the metal on the anvil face on a 45° angle
- Strike the metal squarely using the flat face of the hammer
- Rotate the metal 90° every few strikes
- Assess the piece, returning it to the forge as needed

BENDING AND TWISTING

Reading Text, Document Use, Numeracy

Thinking Skills: Decision Making

There are a number of techniques you can use to bend and twist metal. For example, you could hammer the metal around a form such as an anvil horn, twist it while it's in a vise or twist it using a bending tool held in the hardy hole.

TIPS FOR BENDING AND TWISTING

Remember to use your measuring tools. For example, a square will come in handy when you need to create a right angle bend.

Use tools such as tongs to apply pressure to the end of the bar when bending and twisting.

Bending Using a Bending Tool:

- Place the two pronged bending tool in the hardy hole
    - Prongs are facing up
- Place the hot metal between the two prongs
- Apply pressure to bend the metal

Twisting - Using a Vise:

- Heat the section of metal you want to twist
- Place the cool end of the metal in a vise
- Use a tool to provide leverage and twist the metal
- Continue to twist until you have the look you want

Bending - Using a Form:

- Heat the section of metal you want to bend
- Place the heated metal over a form, such as the horn on the anvil
- Hammer until the metal bends around the form

Right Angle Bend:

- Place the metal across the anvil with the hot end extended past the edge
    - The edge should line up with the area on the metal where you want the bend to happen
- Hammer the metal down over the edge of the anvil face

SCROLLING

Document Use

You can use this technique to roll the metal around itself, creating a tight or loose scroll.

TIPS FOR SCROLLING

- Heat metal to an orange heat
- Place it on the horn of the anvil and hammer until it starts to bend around the horn making a small curve
    - You may want to taper the end first

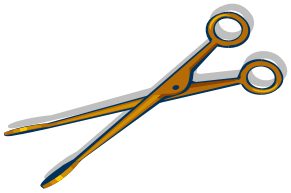
- Place the metal on the face of the anvil, with the open end of the curve facing up
- Hammer the curve in the direction of the roll
- Continue until the metal bends in on itself
- Reheat as needed

RIVETING

Reading Text, Document Use

A rivet is used to hold two or more pieces of metal together. For example, it holds together the two pieces that make up a set of tongs.

A rivet looks like a metal pin or peg, similar to a thick nail without the pointed end.



TIPS FOR RIVETING

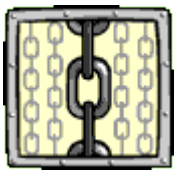
- Take two pieces of metal
- Create identical sized holes in each piece
- Line up the holes
- Find the right sized rivet
- Heat the rivet
- Insert the heated rivet through both holes using tongs
- Create a head on the flat end of the rivet using the upsetting technique
    - You will no longer be able to slide the rivet out
    - As the rivet cools it contracts pulling the two pieces of metal together

FORGE WELDING

Reading Text, Document Use

It is unlikely that you will need this technique for your class project; however, it is good to know there is a way to attach two pieces of metal permanently using a forge.

Forge welding causes the molecules of the metal to align. The end result is one solid, very strong piece of metal with no joints or seams. E.g. a chain made by a blacksmith is one continuous piece of metal.



TIPS FOR FORGE WELDING

- Use medium or high carbon steel
- Heat the metal to a pale yellow or white colour
    - You may see sparks
- Place the metal on the anvil
- Apply flux such as borax to the heated metal
    - This step removes any oxides
- Bring the two pieces together until they stick
- Hammer the pieces together

Flux: a substance that helps metal to fuse. It removes any impurities and prevents oxidation.

Borax: a white crystalline solid that is an ore of boron. It is used as a cleaning agent, water softener and preservative.

PROBLEM SOLVING FORGING TECHNIQUES

Document Use

Thinking Skills: Problem Solving, Critical Thinking

- The metal bends in the wrong place
    - Causes: Uneven strikes, poor metal quality or uneven cooling
- There are gouge marks in the metal
    - Causes: Striking metal on an angle or striking too hard causing the edge of the hammer to dig in
- The metal bows out
    - Cause: Striking too hard when working on a narrow piece

Problem Solving:

- It is difficult to fix problems in blacksmithing
- You can try hammering the metal to correct the problems
    - For example, you can try to hammer out gouges

Preventing Problems:

Ideally you want to work carefully, so that you prevent these problems

- To prevent problems sprinkle water to cool the area below where you want the change to occur
- Assess your work as you go correcting minor problems as soon as you see them
    - Problems will grow if left unchecked

FINISHING

HEAT TREATING

Reading Text, Document Use, Oral Communication

Thinking Skills: Decision Making

If you were to look at a piece of metal under a microscope, you would see that it is made up of a series of crystal structures. When metal is heated and melted, the arrangement of these crystals will change. When the metal cools the crystals won't line up in the same orderly fashion. This change in structure will cause the metal to become harder.

Heat treating takes a lot of practice. It is a precise and complex process.

Additionally, each time the metal is worked (stretched, flattened, hammered and shaped) the crystals are compressed. This also causes the metal to become harder and less flexible, which makes it difficult to work.

Heat treatment involves heating metal to a specific temperature then cooling it in a controlled way. This will alter the structure and features of the metal without changing its shape. Steel responds well to heat treatments.

Depending on what you want from your metal, you can use different heat treating methods to make it either harder or softer.

- Softening will reduce strength and hardness, remove stresses, increase toughness and restore ductility - tempering is used to soften metal
- Hardening is done to increase strength and make the metal wear resistant

Note: It is very important that you apply the correct process (temperature and cooling method), for the metal you are using and the results you need. Ask your instructor for assistance.

Heat Treating:

- Heat metal to a specific temperature
    - The temperature the metal reaches will affect the end result
- Keep the temperature steady for a period of time
    - The length of time is important to the end result
- Cool the metal
    - Cooling the metal quickly (e.g. in water) will make it hard and brittle
    - Cooling the metal slowly (e.g. air cooled) will make it softer

HEAT TREATING – HARDENING

Reading Text, Document Use, Oral Communication

Hardening is a heat treatment. This step takes place after you have finished creating your piece.

It involves cooling heated metal quickly by quenching it in water. Quenching involves dunking the entire piece into a bath of room temperature water.

If you use this heat treatment, your piece will be very hard and tough but it will also be brittle and breakable.

You can use liquids such as oil in place of water for quenching; however, for your class projects you will use water.

TIPS FOR HARDENING METAL

- Place your finished piece in the forge until it is the right temperature
    - For your project you will want the metal to reach a dull cherry red
    - Heat the metal at a slow and even pace
    - Watch it carefully so it does not overheat
- Continue turning the piece in the forge
- Remove the piece from the forge after it has been held at the correct temperature for a period of time
    - Ask your instructor for assistance

- Dunk the piece into a large tub of water; this step is called quenching
    - Use room temperature water
- Place the metal in the water vertically
- Work quickly - stir the piece around in the water

HEAT TREATMENTS - TEMPERING

Reading Text, Document Use, Oral Communication

Thinking Skills: Decision Making

Tempering is a heat treatment used after the metal has been through the hardening process (heating/quenching). Tempering is used to lessen the tension created during the hardening process.

Tempering softens brittle metal. The end result is a piece that is more ductile, malleable, resilient and tough. It will still be hard, but it will be soft enough to handle pressure and strikes without breaking, cracking or shattering. It is also easier to cut, shape and file a tempered piece of metal.

Note: In most cases, metal that has been through the hardening process will be harder than it needs to be, so tempering will not ruin your piece.

As mentioned, this takes practice. You need to find the right time and temperature combination.

Perlite: light weight, natural volcanic glass with a high water content.

TIPS FOR TEMPERING

- Remove your piece from the bucket of water
- Return it to the forge and reheat it slowly to a dull cherry red
    - Ask your instructor how long it needs to be heated
    - Remove it from the forge and place it on your anvil
    - Allow the metal to cool to black
- Place your piece in an insulated container of Perlite to cool overnight or leave the metal sitting out at room temperature so that it cools slowly
    - Do not use a fan

TIPS FOR HEAT TREATING, DECISION MAKING

You will need to make many decisions before you use a heat treatment. The decisions you make will depend on the outcome you want.

Work with your instructor to answer the following questions:

- What combination of qualities do you need in your finished piece?
    - Does your piece need to be hard, soft, resilient or ductile?
    - Which is more important, ductile or durable?
    - Does it need to be resilient and resistant to cracking?
    - Will there be pressure applied to the finished piece?
    - Will you need the metal to hold a sharp edge?
    - Does it need to be soft enough to cut, shape and file?
    - Does the whole piece need to be the same?
        - E.g. a hammer needs a combination of hard and soft parts

Note: You can use both heat treatments and you can repeat either the hardening or tempering process.

If you are going to make this piece again, record the times so you can repeat the steps or make any necessary adjustments.

PREVENTING CORROSION

Reading Text, Document Use

Thinking Skills: Decision Making

Iron ore must be removed from the ground through mining operations. It is unlikely that you would ever find iron on the surface of the earth because it breaks down quickly when it is exposed to water and air. A piece of iron left exposed would eventually disappear.

You have worked hard on your piece; you don't want to have it corrode. There are steps you can take to help protect your finished piece. Even if you are keeping it inside, you will need to protect it from humidity in the air.

PROTECTING METAL

Before you select a method for protecting your finished piece you need to make a few decisions.

- Where will you display your final piece?
  - Inside or outside?
- Will you be using it for food?
  - If yes, use only non-toxic finishes
- What colour do you want your piece to be?
- Do you want it to have a matte or shiny finish?

There are more bronze than iron artifacts because iron will rust away.

Corrosion: a process by which something is destroyed progressively by chemical action, as iron does when it rusts. It is a result of two chemical processes, oxidation and reduction.

Stainless steel is non-corrosive and won't rust but cannot be used by Blacksmiths.

PREPARING THE METAL

Before you begin:

- Use a strong steel wire brush or grinder to remove any flakes on your finished piece
    - These are usually carbon flakes
- Clean off your anvil face with the brush
- Decide on a finishing method

Beeswax

Beeswax will prevent rust but it is not weather proof. It will leave a black shiny finish.

- Heat the metal to black heat
- Apply beeswax
- Use a rag to rub the melted wax into your finished piece
    - Work carefully, the metal will be hot and the wax will melt and drip
    - Buff the piece with a cotton cloth if you want to increase the shine

Linseed Oil

Linseed oil will help to prevent rust. It will leave a black matte finish.

- Heat the metal a black heat
- Use a brush or rag to rub the linseed oil over your finished piece
    - Work carefully, the metal will be hot

Paint

You will want to select a clear or coloured rust proof metal paint.

- Spray the paint onto room temperature metal
- Work in a well ventilated area and/or wear a mask

Varnishes

Varnish will rustproof your piece. It will leave a transparent and shiny finish.

- Use a brush to add varnish to room temperature metal
- Work in a well ventilated area and/or wear a mask

STARTING TO WORK

PRACTICING

Reading Text, Document Use

Before you begin your first project take some time to practice your blacksmithing skills.

For example, you will want to:

- heat metal in a forge
    - Apply all safety procedures
- watch metal for colour changes
    - Practice rotating metal
- hammer heated metal
- use several different forging techniques
    - Tapering and upsetting are good places to start

For your in-class projects you will be using mild carbon steel.

PROJECT SELECTION

Document Use

Thinking Skills: Critical Thinking

To help select a project, ask yourself:

- What techniques will I need to use?
- What skill level will be required?
- Am I confident in my ability to do this project?
- Will it challenge me?
- How much time should this project take?

PROJECT DESIGN

Reading Text, Document Use

Thinking Skills: Critical Thinking

Before you begin, outline all of the steps you will need to take to complete the project. This will provide a guide for your work.

For example:

- List the tools you will need
- List the materials you will need
    - Type, length and the diameter of the metal
- If you are copying a finished piece, measure the example and record the dimensions

- If you are designing your own piece, sketch out the design on paper and record the dimensions
- List the steps from start to finish in the order you will complete them
- List the techniques you will use
    - List them in the order you will complete them

TEMPLATES

In your future work you may need to create templates. Templates are forms. They can be made from cardboard, wood or metal. They provide a pattern that will guide your project.

Templates are necessary if you need to:

- repeat a project
- make several identical pieces for the same project
    - e.g. if you are making tongs, both pieces are exactly the same
- have a guide for shaping a piece of metal
- have a guide for producing a complex piece
- check and compare shapes before starting
- make a prototype that you continue to improve

Templates are also helpful if you are working with others on a team project. They open up discussions about materials and techniques.

Blacksmith Resources Used Throughout Students Notes

www.hrsdc.gc.ca/eng/workplaceskills/essential_skills/general/home.shtml

http://www.meridianeng.com/msds.html

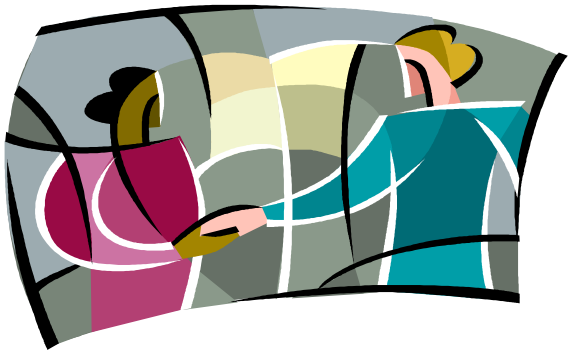
http://healthandfitness101.com/wp-content/uploads/2008/05/lifting-pic.jpg

http://en.wikipedia.org/wiki/Tiffany_lamp

store@thestorefinder.com

http://www.clarku.edu/~djoyce/trig/angle.html

http://en.wikipedia.org/wiki/Right_angle



We hope you have enjoyed this Blacksmith Course.

On behalf of Literacy Ontario Central South, Literacy and Essential Skills in Industrial Arts (L.E.S.I.A.) project, we would like to thank you for your participation.

Best of luck with your future endeavours.