**METALWORK INTRODUCTION**

**tAKEN directly from www.gwellwood.com/subjects/metalwork/intro/**

Let’s establish some foundation skills.

You all want to build something, I get that.

But without some foundation skills, once I unleash you onto the tools and materials, you’re likely just going to turn good material into garbage, and possibly damage the machinery in the process. Materials are not unlimited. Wasted material costs will go through the roof, and I start to question my career choice.

*(My materials costs have also quadrupled since I started teaching, while my budget has been cut in half).*

I also do this stuff for a hobby; this works.

https://www.gwellwood.com/subjects/metalwork/intro/

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| **DESIGN** |
| **SKETCHING** |
| All designs use drawings. Some people are very good at drawing, some less so. But sketching is still an important part of conveying the information you need to get across.  **DEMONSTRATION (NOT ASSIGNMENT)**    **ASSIGNMENT #1 SKETCH 5 THINGS THAT ARE IN THE ROOM**  **#NO-NUMBERS #NO-LETTERS #JUST-DRAWINGS**  All projects, concepts, and design ideas come from a set of drawings or plans. Good plans will be more than a sketch. Since you will be working with drawings to start, or creating drawings for the higher levels, you need to be able to READ a drawing.  ALL PAGES MUST HAVE A BORDER with a TITLESTRIP and YOUR FIRST AND LAST NAME on it.    NEXT UP: There are two types of  drawings that we typically use:  **Isometric**, and **Orthographic**.  They each have their purpose. |
| **ISOMETRIC SKETCHING** |
| **LESSON**  This style of drawing is best used to show what the completed object **LOOKS LIKE**.  *It sucks to****WORK FROM****.*  *Some people cannot visualize things – this drawing is best for those people to SEE what you’re going to build.*  Both the left and right sides come off at a **30°** angle to give it a more realistic appearance *(but it will look slightly distorted – no “perspective”)*. This is the ***hardest*** to draw.    You want to show the VIEW with the MOST DETAIL. You want no details “hidden.”  Notice the arrangement of each view on the sheet below. These views show the MOST information of the object.  If you were to look at the object from any other angle, you would NOT be showing useful information.  **DEMONSTRATION (NOT ASSIGNMENT)**    Assignment on next page  **ASSIGNMENT #2**  **THIS IS NOT TRACING – Kindergarten is over, move on. AT NO TIME will I EVER accept TRACED drawings. THIS IS NOT TRACING. Accept it.**   |  |  |  |  | | --- | --- | --- | --- | | **GRADE 8**  Draw any 2 (two) objects shown BELOW in **Isometric Format** | **LEVEL 1**  Draw any 6 (six) objects shown BELOW in **Isometric Format** | **LEVEL 2**  Draw any 6 (six) objects shown BELOW in Isometric Format ***BUT ROTATED SO YOU SEE THE OTHER SIDE*** | **LEVEL 3**  Draw a detailed Isometric view of the ***Major Project you want to build this year***. |   [**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/grid-paper.pdf) to print **TRIANGLE CHEATING PAPER**, which you will place *underneath* a blank piece of paper to act as a guide.  [**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/04/WORKSHEET-IsoOrtho.pdf) to print the **GEOMETRIC SHAPES** – Count the flats of the triangles.  **EVERY PAGE MUST HAVE a two-grid space BORDER (all drawings must have a border) and a two-grid TITLE STRIP (all drawings must have a title strip) at the bottom for your NAME, the DATE, and the TITLE.**  **MARKS:**  **If you pick the easy ones, I will mark you hard; if you pick the hard ones, I will mark you easy.**  **If it is not a correct Isometric Format, I won’t mark it.**  **I generally take 1 mark off for each mistake.**  **If the drawings are not done “good enough” (at least 70%) I won’t mark it at all. *But I will help you to make them better*.**  **I do not mark garbage; *don’t give me garbage.*** |
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| **ORTHOGRAPHIC SKETCHING** |
| **LESSON**  These drawings are ALWAYS used in plans and designs and blueprints.  These are **THE BEST** for **FABRICATION**. You need to be able to read these.  *They are, however, are harder for some people to visualize the finished product.*  The object is drawn with three separate views (Top, Side, End) that are “projected” off of each other.  “Projected” means that the TOP VIEW IS DIRECTLY ABOVE THE SIDE VIEW, and that the END VIEW IS DIRECTLY BESIDE THE SIDE VIEW.   * + *They are absolutely 100% directly in line*   + *The LENGTH is the same on the SIDE and TOP views*   + *The WIDTH is the same on the TOP and END views*   + *The HEIGHT is the same on the SIDE and END view*   + *Anything different is wrong; I don’t care how you feel about it*   Kind of like drawing on a box, and then unfolding the box. This is the hardest to type of drawing to understand.    **DEMONSTRATION (NOT ASSIGNMENT)**    You arrange the object sides to show the MOST DETAIL. Kind of like how a photograph shows the FRONT of your head, not the BACK. The front is useful information.  *UNIQUE TO ORTHOGRAPHIC DRAWINGS: Hidden details (like holes and edges on the opposite side or inside) are show as a DASHED LINE. Stuff that IS THERE, but you CANNOT SEE, are drawn in a dashed (hidden) line.*    **TWO OF THESE ARE DRUNK:**  **THE VIEWS MUST LINE UP!**  **THE SIZE BETWEEN VIEWS MUST BE CONSISTENT**  **ASSIGNMENT #3**  **THIS IS NOT TRACING – Kindergarten is over, move on. AT NO TIME will I EVER accept TRACED drawings. THIS IS NOT TRACING. Accept it.**   |  |  |  |  | | --- | --- | --- | --- | | **GRADE 8**  Draw any 2 (two) objects shown BELOW in **Orthographic Format** | **LEVEL 1**  Draw any 6 (six) objects shown BELOW in **Orthographic Format** | **LEVEL 2**  Draw any 3 (three) objects shown BELOW in Orthographic Format ***BUT SHOW ALL 6 SIDES*** | **LEVEL 3**  Draw a detailed Orthographic view of the ***Major Project you want to build this year***. | | [**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/grid-paper.pdf) to print **RECTANGLE CHEATING PAPER**, which you will place *underneath* a blank piece of paper to act as a guide.  [**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/04/WORKSHEET-IsoOrtho.pdf) to print the **GEOMETRIC SHAPES** – Count the flats of the triangles.  **EVERY PAGE MUST HAVE a two-grid space BORDER (all drawings must have a border) and a two-grid TITLE STRIP (all drawings must have a title strip) at the bottom for your NAME, the DATE, and the TITLE.**  **MARKS:**  **If you pick the easy ones, I will mark you hard; if you pick the hard ones, I will mark you easy.**  **If it is not a correct Orthographic Format, I won’t mark it.**  **I generally take 1 mark off for each mistake.**  **If the drawings are not done “good enough” (at least 70%) I won’t mark it at all. *But I will help you to make them better*. I do not mark garbage; *don’t give me garbage.***  *There is nothing to see here, please move along…* | | | | |
| **DIMENSIONING** |
| **LESSON**  All Manufacturing and Fabrication Industries depend on Drawings. Without Drawings, nothing can be manufactured. We’ve looked at Drawings. Now we need to look further.  The “drawings” that companies use to “Work” from are called “Working Drawings.” A Working Drawing must have enough information that someone could build the object as specified.  A Working Drawing must:   * + *Have all the views you need to explain the shape*   + *Have all the dimensions and specifications you need to build the object*   + *Have the actual materials listed*   **ASK YOURSELF: *“Can this object be built without further instructions?”***  The more things you build, the more you will be able to know what needs to be listed. You will know what you need to know, bro.  There are rules; there is a way Dimensions are given:   * + *Edges and locations of components are indicated by EXTENSION LINES that extend off (but do not touch) the object.*   + *Measurements are positioned between arrows, the arrows will extend from the actual number, TO the extension lines.*   + *Dimension lines ARE NOT ON THE OBJECT – they are a distance away.*   + *Dimension the object on the view that shows the most information*   + *Usually dimension BETWEEN the views, and to the RIGHT SIDE of the view.*   + *HOLES are measured by DIAMETER, because DRILLS are measured by DIAMETER*   + *ROUNDED CORNERS are measured by RADIUS, because you need to set your compass to the circle’s RADIUS to draw it.*   + *OVERALL Dimensions are always on the OUTSIDE*   + *NEAT AND TIDY!.*   **WORKSHEET**  In class, I usually lead you through the filling out of this worksheet:  [**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/Dimensioning-Worksheet.pdf)**to print the Dimensioning Notes Worksheet, and make each shape look like the one below:**    **ASSIGNMENT**  [**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/HANDOUT-Dimensioning.pdf)**to print the Dimensioning Assignment Worksheet, and FOLLOW THE NOTES ABOVE to dimension the shape.**  **MARKS : “COMPETENCY” – YOU WILL RECEIVE FULL MARKS WHEN THIS IS DIMENSIONED ADEQUATELY.**    Is it kicking your butt?  DO IT yourself first, then if you *have* to…. watch this [**Video Solution**](https://www.youtube.com/watch?v=8zfPFcT3BvA) (it doesn’t have to be exactly as shown, but you should show enough information).      This page intentionally blank |
| **SAFETY** |
| You might not want to watch this:    [**WORKSHEET**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/11/WORKSHEET-Safety.pdf)**TO GO WITH**[**POWERPOINT**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/11/SHOW-Safety.ppt)    This page intentionally blank |
| **MEASUREMENT** |
| **WOODWORKER LEVEL: FRACTIONS** |
| **LESSON**  The basic measurement you will need to work with can be done with simple a ruler or a tape measure. For many projects, whether wood or metal, this is fine.  While you may have learned to measure in Metric, once the US get with the freaking program of the entire freaking Globe, we’re still stuck with measuring in Imperial (feet and inches, and lovely fractions). We’ll try to make it easier for you:  If I bake a blueberry pie, and cut it into two pieces and gave you one piece, you will have received 1 of 2 pieces.  1 out of 2.  If you scored 1 out of 2 on a quiz, it would look like: 1/2.  A smart cookie would also know that scoring 1 out of 2 on a quiz is only 50%.  Half a dollar is 50 cents, or 0.50 of a dollar.  You know all that stuff they taught you in math? Yeah – this is where you use it.  Hope you were paying attention.  **ASSIGNMENT**  **Using the lesson images above as a reference,**[**CLICK HERE**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/WORKSHEET-Measurement.pdf)**to print the worksheet for Imperial Fractional Measurement.**  I don’t usually go much smaller than sixteenths when using a ruler.  If I need to be more precise, I use something better, something *easier…*  *This page also suspiciously blank* |
| **PRECISION MEASUREMENT** |  |
| **METALWORKER LEVEL: THOUSANDTHS** |  |
| Precisely fitting parts must be precisely made.  *The difference between “not fitting,” “fitting” and “way too lose,” can be as little as the thickness of your hair!*  You cannot measure this wear with a ruler, you must use more precise tools such as a Micrometer, and a Vernier Caliper, or Dial Caliper.  ***Read Inch Micrometer***  ***Read Vernier Caliper***  ***Read Dial Caliper***  **ASSIGNMENTS**  [**WORKSHEET – Micrometers**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/WORKSHEET-Micrometers.pdf)  [**WORKSHEET – Vernier Calipers**](https://www.gwellwood.com/wordpress/wp-content/uploads/2019/02/WORKSHEET-Vernier-Caliper-1.pdf)  [**WORKSHEET – Dial Calipers**](https://www.gwellwood.com/wordpress/wp-content/uploads/2019/02/WORKSHEET-Dial-Calipers-1.pdf)  *Dial Indicators, Outside Micrometers, Dial Calipers, Telescoping Gauge*  *Inside Micrometer Set (Starrett)*  *These are not the droids you are looking for*  *Move along* |  |
| **THREAD CUTTING** |  |
| **LESSON**  You will likely build a project that is assembled with threaded fasteners.  While anything could be assembled with nuts and bolts, sometimes it is super handy to have bolts that thread into the part itself. Like when you can’t actually get to the back side of the assembly, for instance.  The tool we need is a **Tap & Die Set**. These are commonly available in Metric and in Imperial (SAE). Threads cut inside a hole are done with a TAP, whilst threads cut on the outside of round stock are done with a DIE.  **INTERNAL THREADS**  In order for the TAP to work, the CORRECT SIZE hole must be drilled. If the hole is too big, the threads will be really loose; if the hole is too small, the tap may not cut, or it may jam and break off. Then you are screwed.  To make sure you drill the right size (and they are SPECIFIC), you need to have a [**TAP-DRILL CHART**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/HANDOUT-Tap-Drill-Chart.pdf) (<<< Click to print a copy)  **Handy Tips:**   * + *Make sure the cutter starts straight – if the tap isn’t inline with the hole, you may break the tap (or have crooked threads).*     - Breaking the tap off in your project is a whole world of hurt!   + *Only turn the tap and handle about half a turn (OR LESS) each time, and back it off a quarter turn to break the metal chips off. This avoids over-loading the cutter. TURN LESS, THE SMALLER THE THREADS ARE!*     - Breaking the tap off in your project is a whole world of hurt!   + *Use a high-sulfur oil. I use “Sulflo” which is a special thread-cutting oil (Red Cans in the shop)*   + *Protect the cutters: dropping, banging, or striking – they can break very easily.*   **EXTERNAL THREADS**  In order for the DIE to work, the metal diameter must be EXACT. If it is too large, the die may not cut at all; if the diameter is too small, the threads will be really loose. The material diameter MUST be that of the fastener diameter.  A 3/8″ thread can be cut in 3/8″ diameter metal.  The same handy tips apply for dies.  **A NOTE ABOUT THREADS:**  ***If you don’t have the RIGHT thread, you have the WRONG thread.***  ***Any thread other than THE RIGHT THREAD, is THE WRONG THREAD.***  **IMPERIAL (SAE) THREADS**   * + *COARSE (Unified National Coarse – UNC)*     - *Has LESS threads per inch (TPI)*     - *A 1/2″x13 thread is 1/2″ diameter, with 13 threads per inch.*   + *FINE (Unified National Fine – UNF)*     - *Has MORE threads per inch (TPI)*     - *A 1/2″x20 thread is 1/2″ diameter, with 20 threads per inch.*     - *UNF thread is STRONGER than UNC thread, if you can believe it!*       * There are MORE threads per inch       * The threads are shallower – so there is more metal left in the fastener.   **METRIC THREADS**   * + *Distance between the threads (in mm)*     - *A 12×1.25 thread is 12mm diameter, with 1.25mm between each thread.*     - *A 12×1.50 will not interchange – 1.50mm between threads.*     - *A 12×1.75 is a very coarse thread – 1.75mm between threads.*   **THREAD LAW:**   * + *Threads are unique to themselves*   + *It is either THE RIGHT THREAD, or it’s THE WRONG THREAD*   + *They do not interchange*   + *They cannot interchange*   + *“Making them fit” by brute force and ignorance ruins them*   **ASSIGNMENT**  **PRINT this**[**TAP-DRILL CHART**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/HANDOUT-Tap-Drill-Chart.pdf)**to complete this**[**WORKSHEET**](https://www.gwellwood.com/wordpress/wp-content/uploads/2020/03/WORKSHEET-Cutting-Threads.pdf)**.  You want the *FIRST COLUMN* of drill sizes (the second column is for -rolled- threads, we want -cut- threads).**  Empty, just like the mind of that one kid |  |
| **FABRICATION TIPS** |  |
| **CARDBOARD PATTERNS**  Cardboard is WAY cheaper, and WAY faster to mock something up to see that it fits, than going straight to metal.  Once you KNOW the cardboard shape will work, THEN you have a pattern to work it out of metal. Flip the pattern over for a mirrored part!  If you can’t make it out of cardboard, you won’t be able to make it out of metal.  Shock mounts for a project car I built (cardboard, steel, and welded):  Suspension Arm tube lengths and angles using tape:    Suspension 4-link bar mounts in paper, welded, drilled, then cut apart:    Transmission Tunnel in card stock, then traced onto metal: |  |