EML2322L – MAE Design and Manufacturing Laboratory

Motor Mount Design

This document explains how to design motor mounts (and other parts) for the course design project. The top priority for part design is function; above all else, the part must function properly without failing. Beyond that, ***good*** designers are concerned with designing parts that can be made quickly and cost effectively; this means keeping parts simple, material use low and manufacturing processes to a minimum. The following points discuss these topics.

Objectives

1. **Function.** As shown in the 3D example, the purpose of a motor mount is to attach a motor to a structure such as a robot frame.

2. **Attachment method.** Fasteners are typically used to connect the motor to the mount and the mount to the frame. Other attachment methods involve riveting, welding and adhesive bonding. Fasteners are the most suitable method for attaching the motor mount because they require moderate strength and may need removal for storage or adjustment.

3. **Mechanical properties.** The motor mount must be capable of rigidly supporting the motor (and everything attached to it) without failure during its expected life span. If the motor mount geometry and material selection are inadequate, the mount can break completely or bend so much that the motor can not effectively accomplish its task.

Motor Mount Design Tips

1. **General shape.** Use simple shapes you have experience producing using the manual machines in the lab. Stated another way, ***never design part features you don't know how to make.*** It is much easier (i.e. quicker and cheaper) to design a rectangular motor mount cut to size from a piece of longer flat bar using the bandsaw as opposed to a fancy bracket with curves that would require a CNC machine to produce (and the necessary part programming and debugging time). ***Fillets might look nice on the solid part model, but unless critical to part function, they only add time and expense to the part, with no performance benefit.***

2. **Keep it small.** A smaller or shorter motor mount has a lower material cost. A shorter mount is also stiffer (if all other geometry is identical). ***Therefore, a shorter motor mount will be cheaper and more rigid compared to a longer part, so make sure you can justify why your mounts cannot be made any shorter or smaller.***

3. **Material specification.** Most of the robots built in the course weigh around 35 pounds (including the control box). When deciding on material type and size, it's instructional to grab a piece of material off the material rack and physically apply the amount of force it will see by hand to decide if it's a prudent choice. ***Thin flat bar stock is often a good choice for motor mounts.*** Select a material possessing good manufacturability and strength. If weight is important, consider different available materials' strength-to-density ratios. Manufacturing time and thus part cost are typically proportional to material strength; knowing this, ***always select the weakest material that is strong enough for the design*** to ensure the cheapest material and lowest part cost.

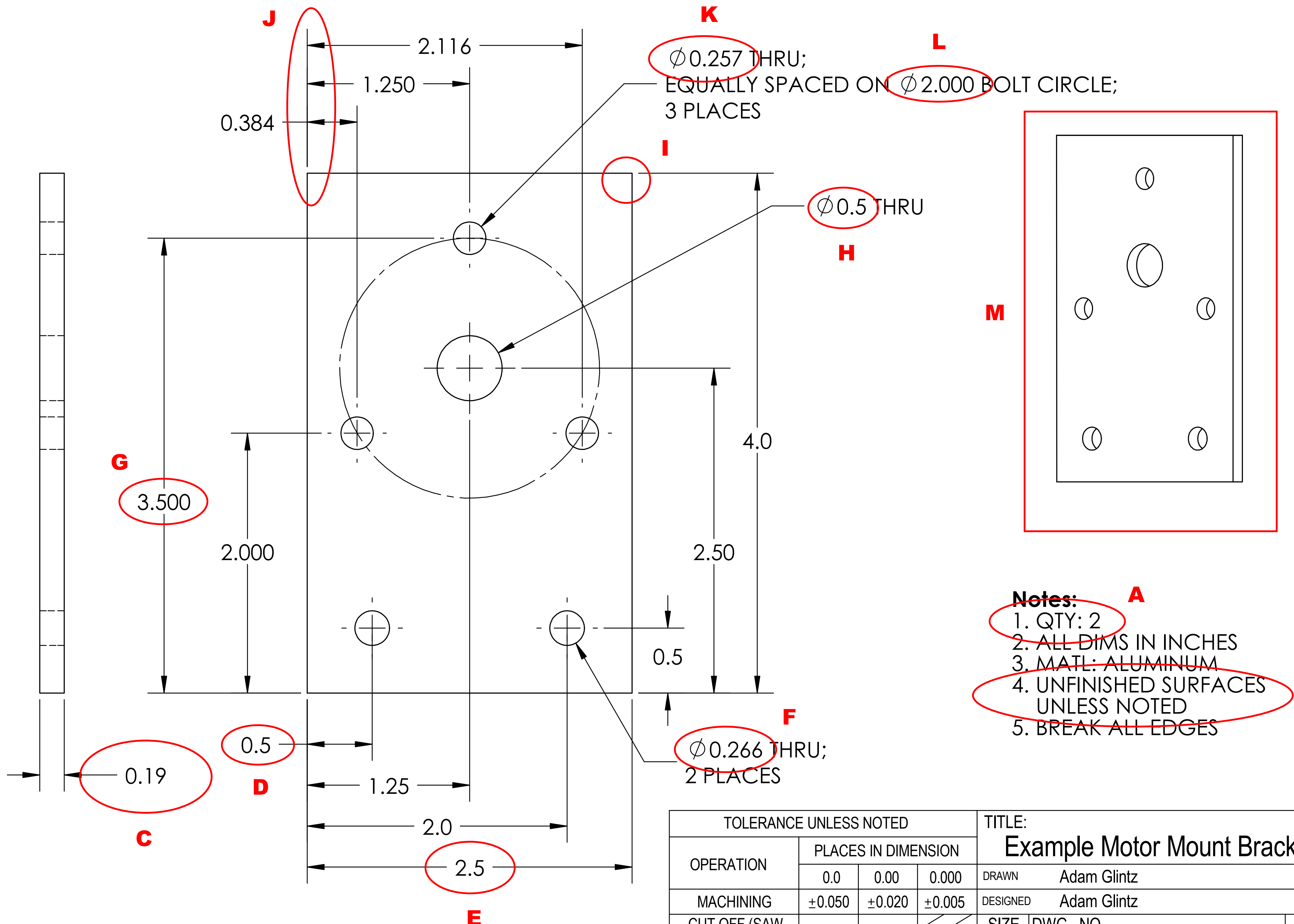
4. **Surface finish & appearance.** Based on the shaft clamp bracket previously manufactured on the milling machines in lab, raw extruded aluminum flat bar possesses approximately 0.010" flatness error right from the supplier. This is certainly flat enough for the motor or robot frame to sit securely against. ***This means the motor mount does not need nice shiny machined surfaces to function properly, so the exterior surfaces should purposely be noted as "NOT finished" on the part drawing.*** Also, notice none of the objectives listed above mention appearance of the motor mount, so the dull extruded aluminum finish is just fine for this part (as for most) to reduce manufacturing time.

5. **Clearance holes versus line fits for fasteners.** ***If ¼" fasteners are used to attach the motor mount to the frame, never use line fits (i.e. 0.250"), but rather, clearance fits.*** A fastener needs clearance to pass thru the part without threads. In this case, specify a 0.257" or 0.266" diameter hole, because these are recommended sizes in the tap and clearance drill chart for clearance holes. Always use the industry standard sizes listed on these tables.

6. **Design parts to take advantage of nominal raw material sizes.** Students entering this course cannot understand this important point, but after making parts on the mills and lathes, this tip should make sense. ***It's important to design parts around nominal raw material stock sizes*.** When a piece of 3/16" (0.1875") thick rectangular bar is ordered to make a motor mount, it will measure between 0.182" and 0.192" in "raw" stock size (which typically varies ± 0.005" for aluminum extrusions). During class it was necessary to remove as much as 0.010" off each external surface to make it "perfectly" flat and parallel. That means the thickness of our example workpiece is now between 0.162" and 0.172". If the thickness is specified as 3/16 ± 0.005" with finished surfaces, this target will never be achieved; but if the thickness is specified as 0.167 ± 0.005", it easily can be reached. ***For motor mounts manufactured in lab, the exact thickness has little effect on the function of the part, so if the designer was smart, he/she would specify it as: 0.187 ± 0.020 and place a note on the drawing that it does NOT need to be a finished surface.*** That way any 3/16" raw stock would work and the person making the part would not waste time and money finishing surfaces that don't improve the part's function. On the other hand, if the thickness of the part was important, the designer could specify the thickness as 0.167 ± 0.001" (i.e. 0.020" under nominal size). This would allow the part to be cut to final size in one pass, whereas specifying the thickness as 0.187 ± 0.001" would require the purchase of the next larger raw material stock size (~1/4"), as well as the time to cut it down to the final 0.187" size.

7. **Miscellaneous notes.** When designing parts like motor mounts, try to design parts with symmetry; this saves manufacturing time since the parts can be stacked, clamped and machined in pairs; this also saves drawing and assembly time because there's no "right" or "left" version.

The next page shows a drawing of an example motor mount bracket. The drawing provides a good example of how to apply the previous concepts to design a motor mounting bracket. The drawing is heavily commented to explain the design choices made for each portion of the part; the comments are printed on the final page of this handout. More practical tips for designing for cost and manufacturability can be found in the excellent DFM Examples handout on the course webpage.



TOLERANCE UNLESS NOTED			
OPERATION	PLACES IN DIMENSION		
	0.0	0.00	0.000
MACHINING	±0.050	±0.020	±0.005
CUT OFF (SAW, BURN, SHEAR)	±0.1	±0.060	
WELDING	±0.1	±0.060	
ANGULAR DIMS	±5	±2	±0.5

TITLE: Example Motor Mount Bracket		
DRAWN	Adam Glintz	
DESIGNED	Adam Glintz	
SIZE A	DWG. NO. EML2322L-012	REV A
SCALE: 1:1		SHEET 1 OF 1

4 3 2 1

Explanation of Design Parameters for Motor Mounting Bracket

A. This bracket is designed to fit the left and right side of the robot, which offers three advantages: first, I only need to create and proof one part model and detail drawing; second, I can cut the raw material, clamp it together and drill the holes thru both parts at the same time, which cuts my manufacturing time in half; and the third benefit is I don't have to worry about checking which part goes where on the robot, since they are now universal.

B. Finishing surfaces takes time. Unless a finished surface is required for function or appearance, clearly indicate no surface finish is required. None of the surfaces on this part affect its function, so I explicitly instruct the manufacturer to leave the surfaces unfinished. You know from your lab experience the part's 2.5 x 4.0" surfaces should be flat within 0.010" or less, which is more than adequate for mounting a motor. Also note it is NOT necessary to finish machine the sides of the part, as the part function only depends on the relative placement of the holes, not on how flat or square the sides are.

C. If you do the statics calculation or lay your hands on some material in the lab, you'll see the 3/16" thick material is ideal for motor mounts. 1/8" is a little flimsy and 1/4" is strong enough for a 200 pound robot, so 3/16" is ideal. Use a fairly large/liberal tolerance for the part thickness, since we know from lab the raw material won't be the exact size ordered from the mill (i.e. the place that processes the metal).

D. The function of these two holes is to mount the bracket to the robot's frame. Since the floor is not perfectly flat, I do not need to locate this mounting bracket to a very high tolerance, so I have selected a loose tolerance range (+/- 0.050") as a balance between function and cost. Also note nominal (i.e. fractional) hole locations are used to simplify manufacturing using the DRO.

E. Bracket width does not affect part function (unless it's WAY too small), so I specify a very large/liberal tolerance to reduce cost. In addition, I purposely keep the width of the part just large enough to support the motor and no wider so I can use less material and take up less space on the robot assembly. Always try to design for the least material use.

F. Since the locational tolerance on these holes is fairly large/liberal, I have selected free-fit clearance hole sizes to match.

G. Hole locations for attaching the motor to the mounting plate should be precisely located to match the holes in the motor assembly, thus the +/- 0.005" locational tolerance. The individual hole locations are provided on the drawing for reference, so the manufacturer does not have to waste time (and your money) punching numbers into a calculator (and possibly making a mistake that delays your part(s)).

H. The function of this hole is to provide clearance for a 3/8" motor shaft. I purposely used a loose tolerance (+/- 0.050") because it is not critical and I want to keep cost low. I could also use unilateral tolerancing and dimension this hole as 0.450" - 0.550", ensuring a clearance fit and a large range for allowable error.

I. Notice corners are intentionally left square, yet the general note to "break all edges" will ensure they are filed and not left sharp. This is quicker/cheaper than specifying large fillets which would take more time to create.

Explanation of Design Parameters for Motor Mounting Bracket (cont)

J. Whenever possible, minimize the number of part datums to make manufacturing easier and cheaper. Note there is only one X datum and one Y datum for all features on this part.

K. The motor in this example uses three 1/4-20 fasteners on a 2.0" bolt circle. Since the holes in the mounting bracket must be clearance for the 1/4" fasteners, I CANNOT specify 0.250" holes, as this would NOT ensure a clearance fit. Instead, I have specified the industry standard size for a 1/4" close-fit clearance hole: 0.257".

L. Note the tolerance on the bolt circle diameter matches the tolerances on the Cartesian coordinates listed for the individual holes. Otherwise, the manufacturer would not know which to follow.

M. Always include an isometric part view to clearly communicate the part's shape. Suppress any hidden lines and do not include any dimensions in the isometric view (ever). Always show the most complex side of the part in the isometric view.