

Training L2

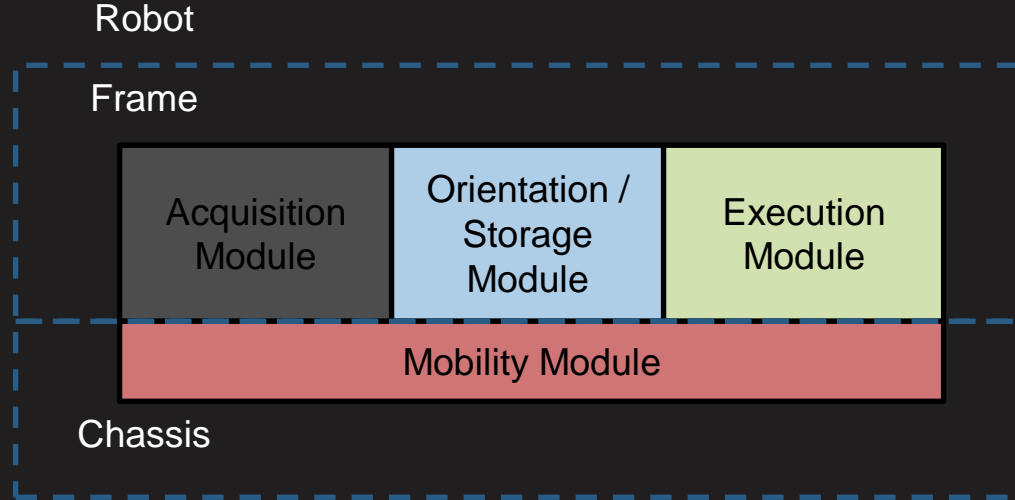
FIRST Robot Framing and Fasteners

Objectives

Understand:

- ❑ Understand robot structure materials
- ❑ Understand robot structure material rigidity
- ❑ Understand fasteners used in building structures
- ❑ Understand robot structure rigidity

Robot Frame



Robot construction is like a car – the frame provides structure and protection for the robot modules

Robot frame needs to be:

- Lightweight
- Strong and rigid
- Allow for access to robot modules
- Manufacturable and affordable

Framing Materials

- Aluminum Stock
 - Plate, Bar, Angle
- Aluminum Extrusion
 - Square /Channel / Round Tube
 - T-Slot
- Other:
 - Polycarbonate(LEXAN), wood, PVC tubing, steel tubing



Forces on a Rigid Body

- **Tension:** a force which causes an object to stretch
- **Compression:** a force which causes an object to be squashed or to buckle
- **Bending:** a force which causes an object to bend
- **Shear:** a force which acts across a object in a way that causes one part of the structure to slide over an other
- **Torsion:** a turning force which causes an object to twist

Aluminum Plate and Bar Stock



Bar Stock



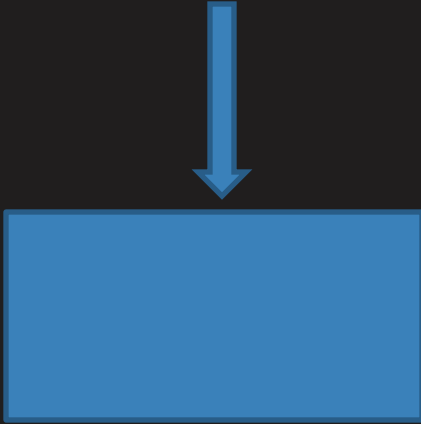
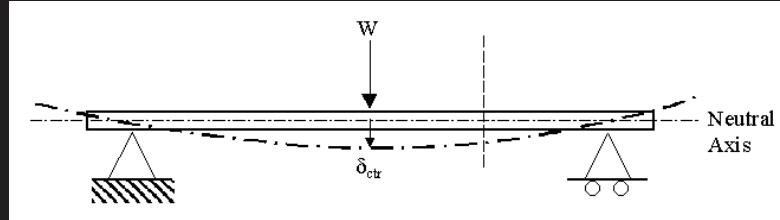
Plate Stock

Typical Aluminum Thicknesses:

- 1/16in (0.0625)
- 1/8in (0.125)
- 3/16in (0.1875)
- 1/4in (0.125)

Aluminum Plate and Bar Stock Strength

Long thin bar/plate stock material will bend



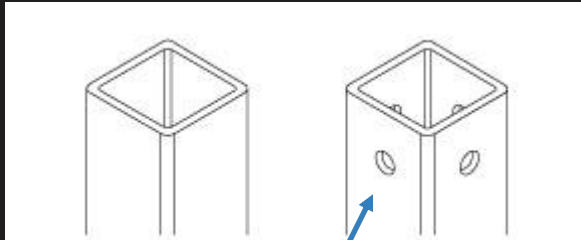
Is better than



Extruded Aluminum Tubing Framing



Box

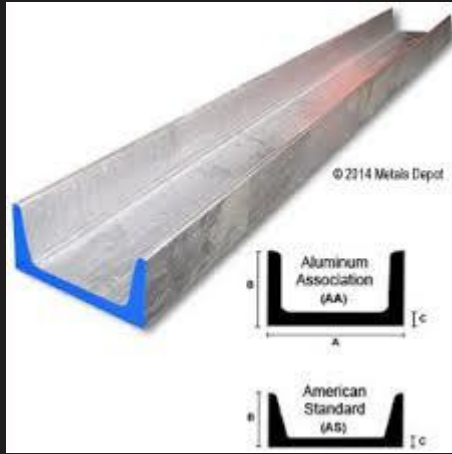


Can purchase with Holes on 1inch centers

Typically (1/2in, 1in, 2in etc.)
Wall thickness 1/16in (0.0625) or 1/8in(0.125)

U / L Channel Framing

U Channel



L Channel

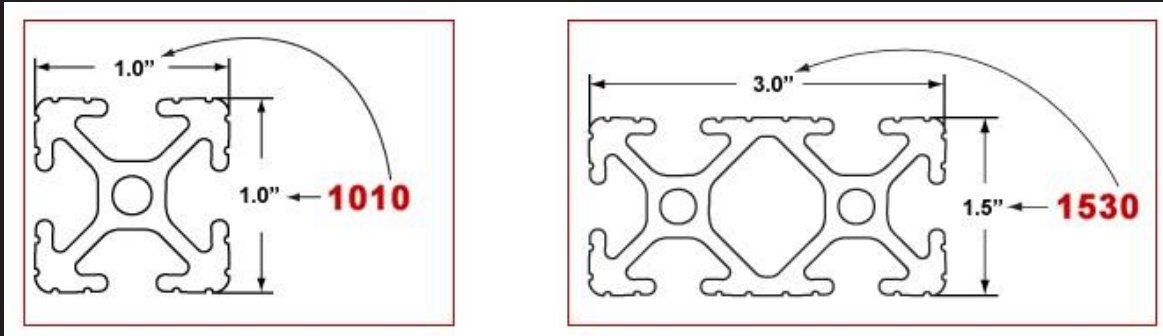


Typically (0.5inx0.5in to 4inx4in.)
Wall thickness 1/16in (0.0625) or 1/8in(0.125)

T-Slot framing



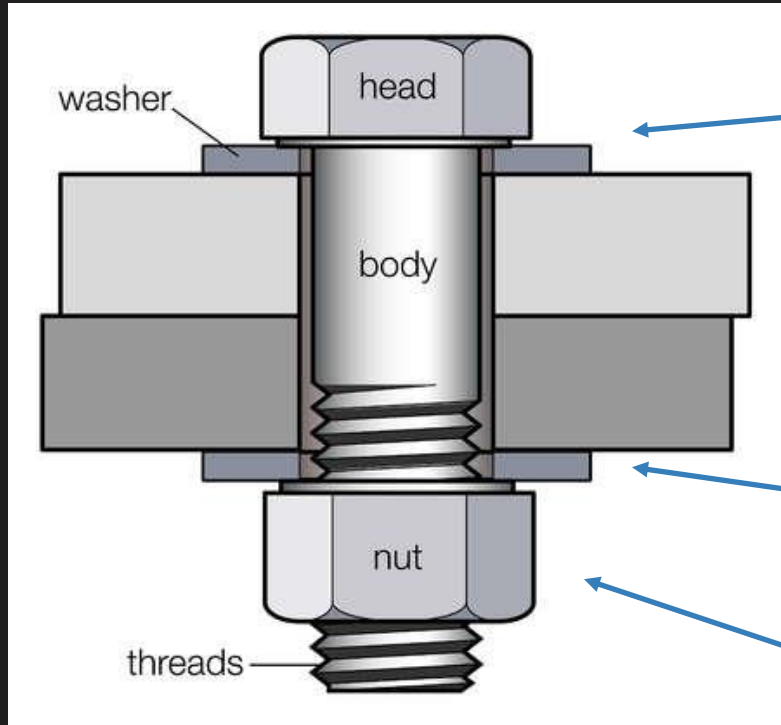
Uses a slot nut with screw



Metric:
Single: 40mm x 40mm
Double: 25mm x 50mm

Fastener Construction

Fastener Construction



Washer(Spreads force over a wider area)



Lock washers

(Locks nut from unscrewing due to vibration)



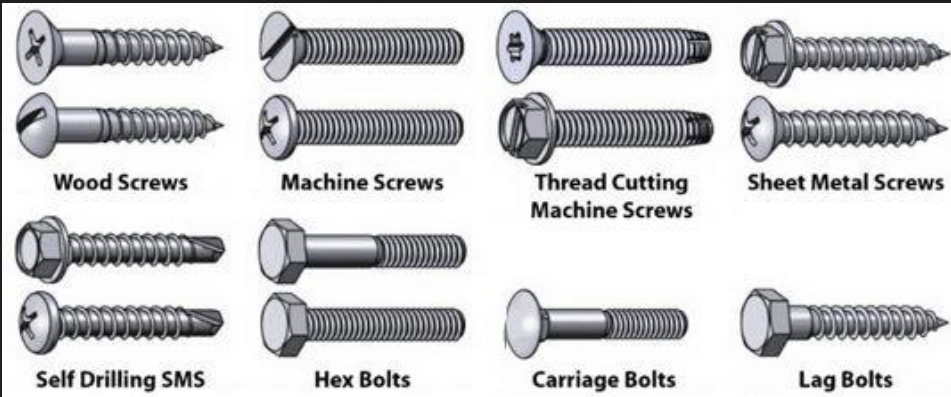
Locknut

(Plastic insert acts as a lock washer)

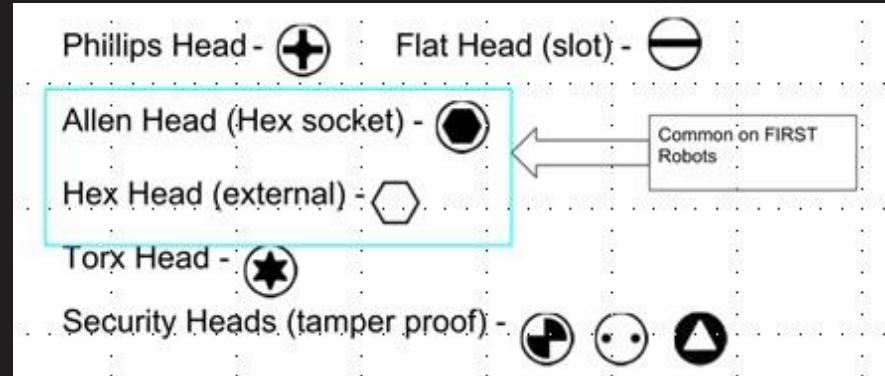


Screws / Bolts

Screw / Bolt Types



Screw Head Types



Standard Sizes

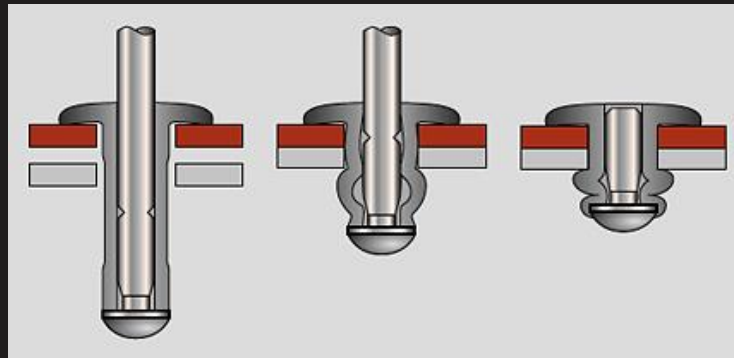
- #screw size-Threads/in
- #4-40 (0.112) – Low stress-panels, covers (rarely used)
- #6-32 (0.138) – Good for tapping
- #8-32 (0.164) – Good for tapping, mounting smaller FRC components
- #10-24 (0.190) – Good for mounting larger FRC components
- #10-32 (0.190)
- #1/4-20 (0.250) – High Load

Rivets



- Only for thin walled material
- Rivets are generally weak – you need many of them.

They come in sizes such as $1/8'$, $3/16'$, and $1/4'$.



Brazing - Welding

Welding: Process of melting both material and filler to join metal. Requires a lot of training and special equipment.

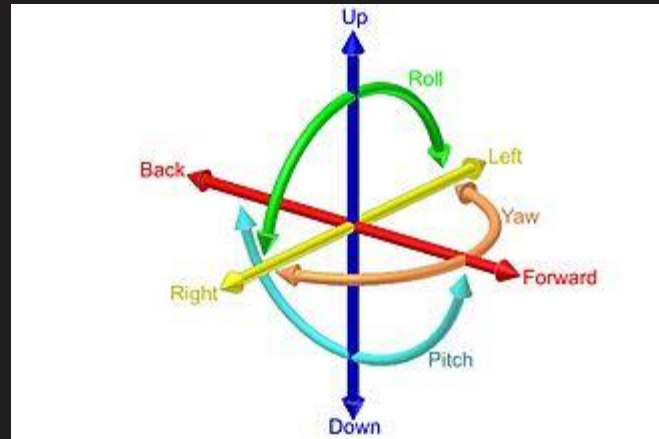
Brazing: Process of melting a low melting point metal as filler to join base materials by capillary action (like soldering). Easy to do and would be used in conjunction with rivets and joining plates.

Aluminum

Joining Method	Joint Strength	Temperature	Distortion	Aesthetics
Brazing	Good	700-900°F	Minimal	Excellent
Welding	Excellent	Above 1200°F	Likely	Fair

Degrees of freedom of a Rigid Body

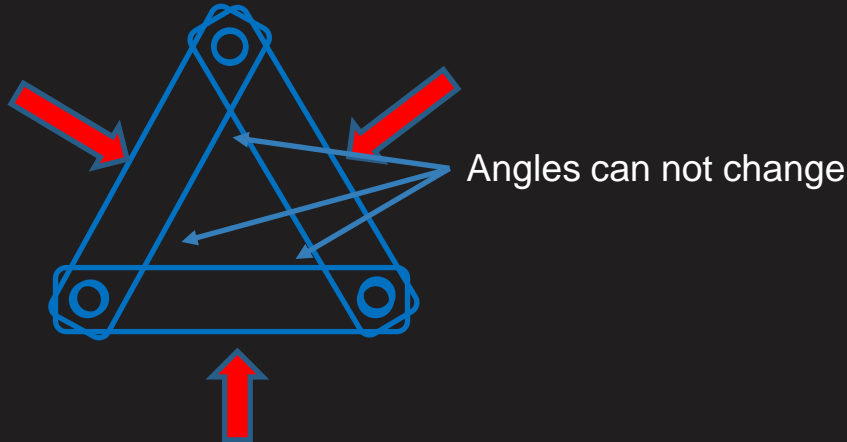
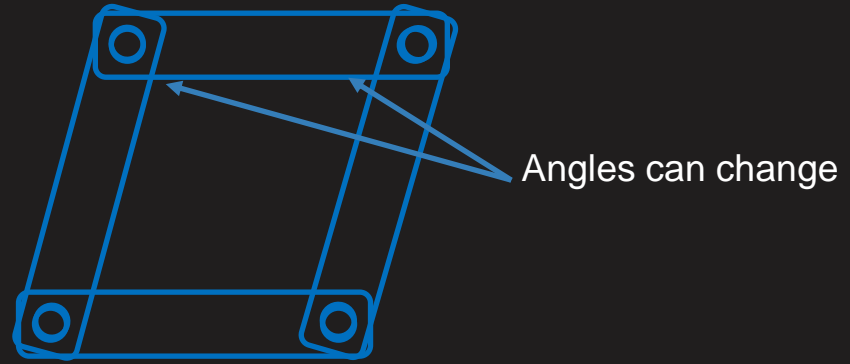
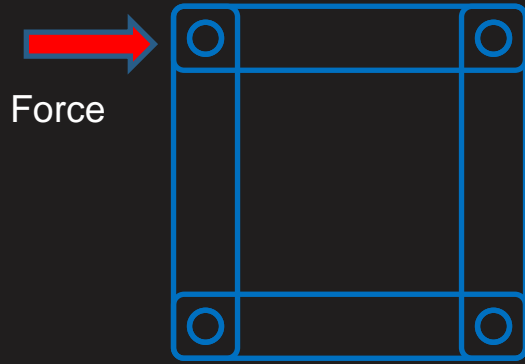
- There are six degrees of freedom (movement) of a rigid body in three-dimensional space
- Position movement on three perpendicular axis's (x,y,z): Up-down, Left-Right, Forward-Back
 - Rotational movement on the three positional axis's: Pitch, Yaw, Roll respectively



Increase rigidity by restricting movement on position and rotation axis's

Rigidity

- Rigidity is the property of a structure that it does not bend or flex under an applied force

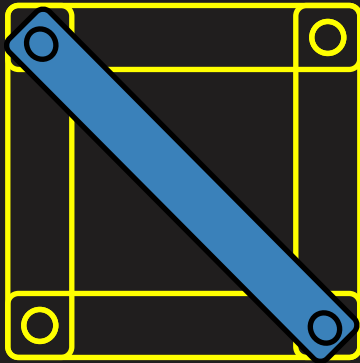


Rigidity Methods

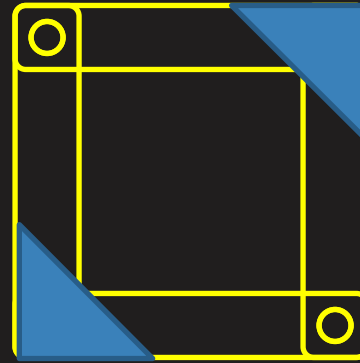
There are two common methods to make structures rigid, these are:

- Using cross member bracing
- Using gusset plates

Cross Member



Gusset Plate



When components or structures need to be stiff, create triangles.

Rigidity Components

Gusset



“T” Joining plate



Corner bracket



Tee Joining plate



“L” Joining plate



Rigidity Components on Framing

Gusset



Gusset



Corner bracket



Tee joining plate



90 degree joining plate



Rotary Shaft Components



Hex Shaft



Hub



Pulley



Sprocket



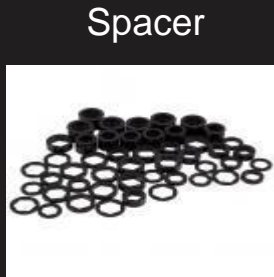
Bearing



Collar



Vex Thunderhex shaft:
fits in round bearing



Spacer

Framing Best Practices

- Use T-Slot framing members for the base of the frame (It should be level – it is the interface to the chassis module)
- Minimize use of T-slot framing because of weight
- Part of the preliminary design should consider the weight of the framing
- Use tube or channel members for framing (strong and light weight)
- All corners should have gussets or triangle joining plates for rigidity
- Check for square corners: Use corner clamps before riveting or drilling when adding joining plates
- All rotating shafts should have bearings at each end of the shaft

Revisions

V160612 – RJV – Updated to Team 2228 format
V150926 - Original