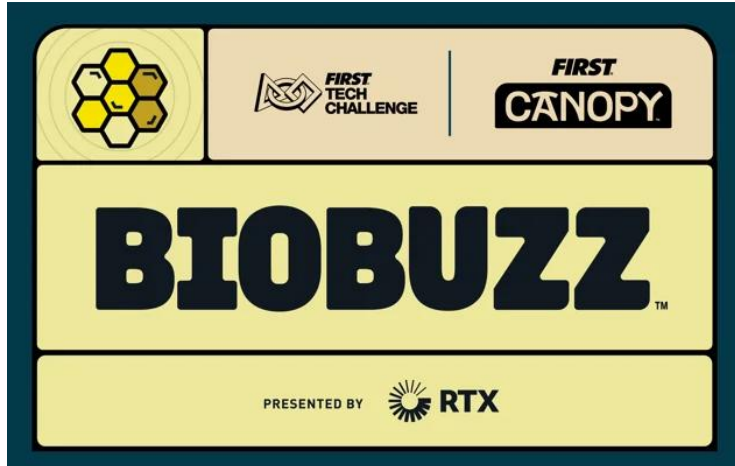


Fasteners and Hardware in FTC

9/12/2026 Canton FTC Season Kick Off



Brought to you by:

20511





Today's Plan (40 Minutes)

- Bolted joints, torque & washers
- Fastener length & robot failure modes
- Lock nuts, lock washers, jam nuts & Loctite
- Drive types & bolt head styles
- Good habits + quick quiz

Think like a mechanic: every bolt on your robot has a job to do!



What Is a Bolted Joint?

- A reusable way to connect two or more parts
- Uses a bolt and a nut (and often a washer)
- Works like a super-strong clamp

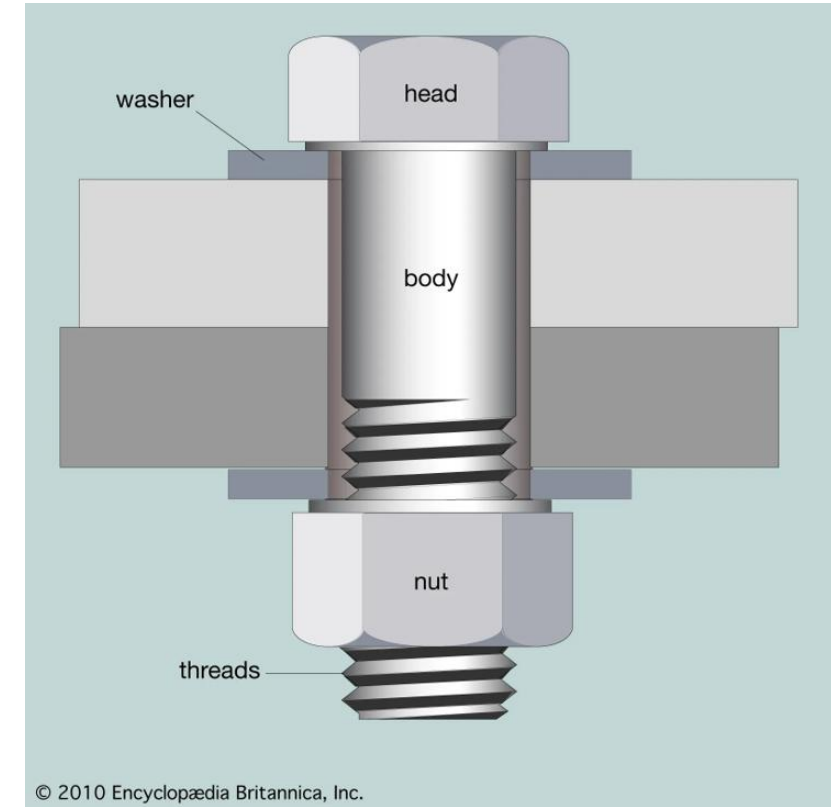
Think of it like a C-clamp you can tighten by hand — but way stronger.

Meet the Parts

- **Bolt:** metal rod with a head and spiral grooves (threads)
- **Nut:** block with matching threads inside
- **Washer:** flat ring that protects surfaces and helps keep things tight

How It Holds Things Together

- Tightening the nut stretches the bolt a tiny bit
- This creates clamping force (a steady squeeze)
- The squeeze makes friction so parts don't slide





What Is Torque?

- Torque = twisting force from a wrench
- More torque (to a point) = more clamping force
- We aim for “just right,” not too little or too much

Like tightening a jar lid: too loose and it leaks, too tight and it cracks.

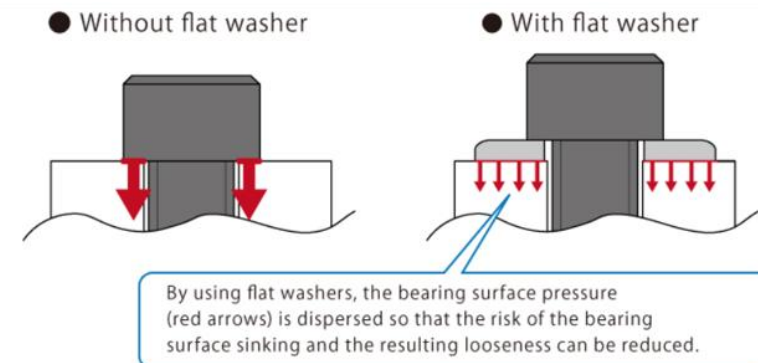
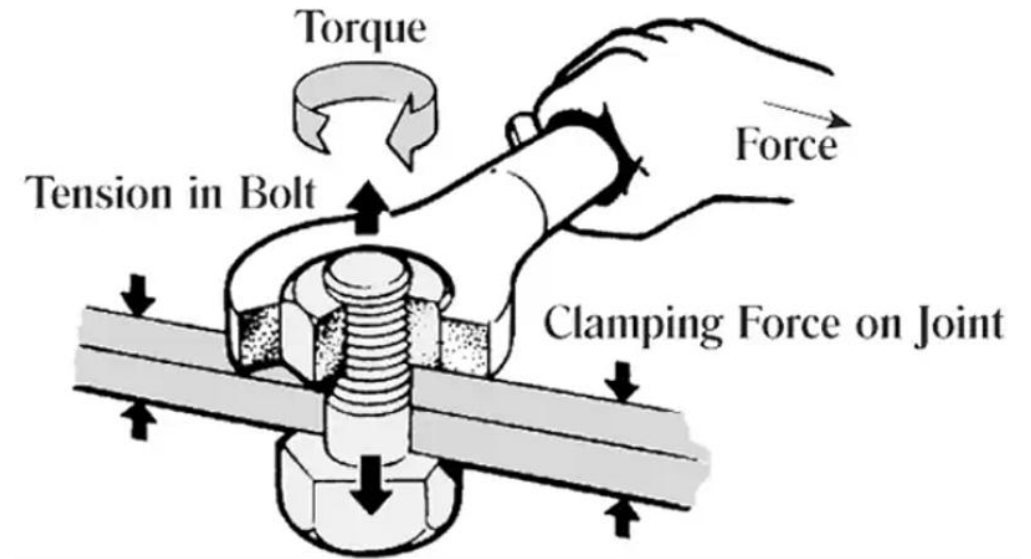
Why Torque Matters

- **Too loose:** not enough squeeze, parts can slip or fall apart
- **Too tight:** bolt can stretch too far, strip threads, break, or crack parts
- **Just right:** safe, strong, and stays tight

The Role of Washers

- Spread out the pressure so parts don't get damaged
- Help the nut or bolt head turn smoothly
- Some special washers help resist loosening

A washer is like a snowshoe — it spreads out the load so nothing sinks in.

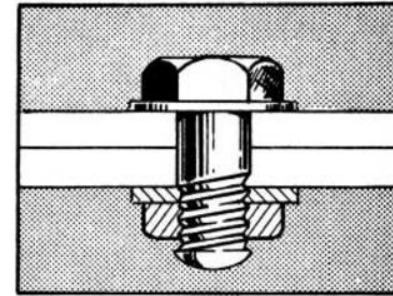




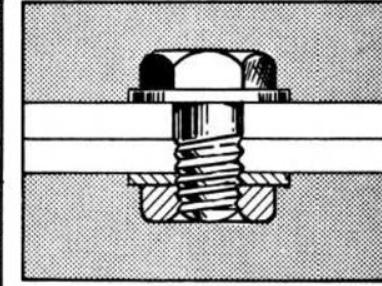
Why Fastener Length Matters

- Bolt must be long enough for the nut to grab enough threads
- Too short: nut barely holds, joint can fail
- Too long: sticks out, might hit other parts, adds weight
- Length also affects how well the bolt can stretch to make clamping force

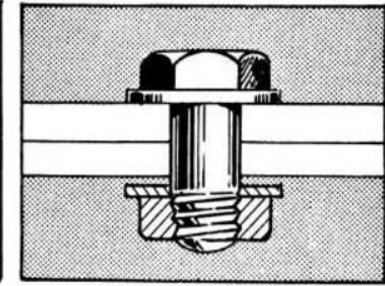
Like picking a shelf screw: too short and the shelf falls, too long and it pokes through.



BOLT GRIP LENGTH CORRECT



BOLT GRIP LENGTH TOO SHORT

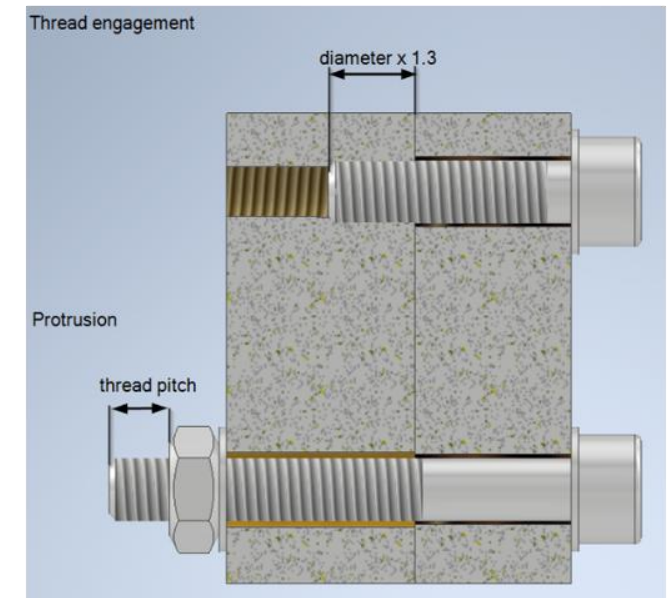


BOLT GRIP LENGTH TOO LONG

ANF0502

Simple Rules for Choosing Length

- **Through a nut:** aim for 1–3 threads sticking out past the nut when tight
 - Make sure the nut is fully on the threaded section, not the smooth shank
- **Into a threaded hole:** engage threads about as deep as the bolt's diameter
 - Example: a 6 mm bolt $\approx$ 6 mm of thread engagement





Common Failure Modes in Robotics

- Motors spin, drivetrains crash, arms slam — fasteners take a beating

Lack of Tightening

- Bolt was never torqued enough when built — joint has slop and wears fast

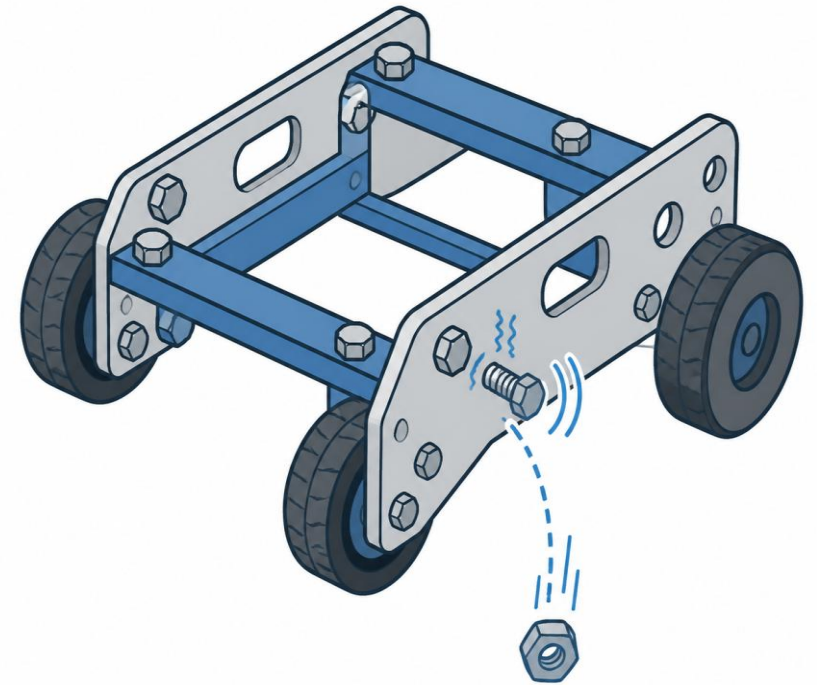
Fasteners Too Short

- Not enough threads engaged; looks fine at first, then strips or pops after a hit

Vibration

- Motors, gears, and impacts shake joints again and again
- Without help, nuts can slowly back off — check bolts before every match!

Vibration is like a tiny jackhammer working 24/7 to loosen every joint.

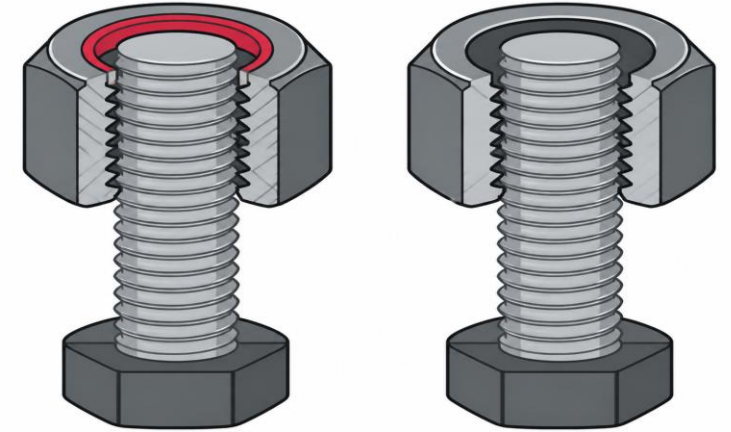




How Does a Lock Nut Work?

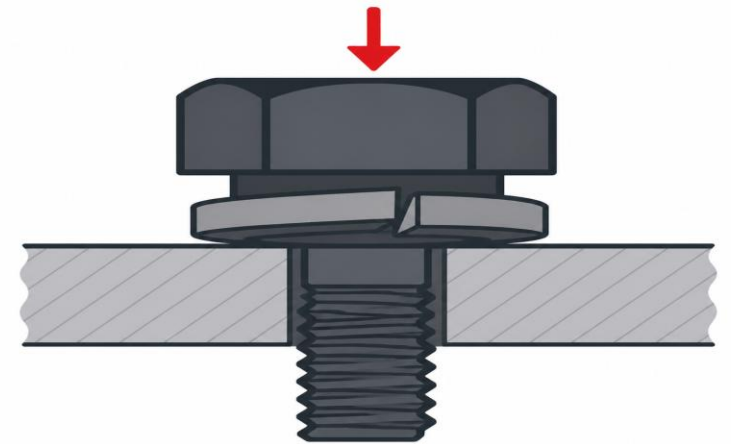
- Nylon-insert lock nut (“Nyloc”): a plastic ring sits inside the top of the nut
- Metal threads bite into the soft nylon, creating extra friction
- That friction resists loosening from vibration, even if torque isn’t perfect

Like a shoe that's a size too small — it takes real effort to get on or off.



How Does a Lock Washer Work?

- Split-ring (spring) washer: acts like a spring, pushing back on the bolt head
- All-metal star/serrated washer: teeth dig into both surfaces to resist turning
- Handy on softer materials or when a locknut isn’t practical

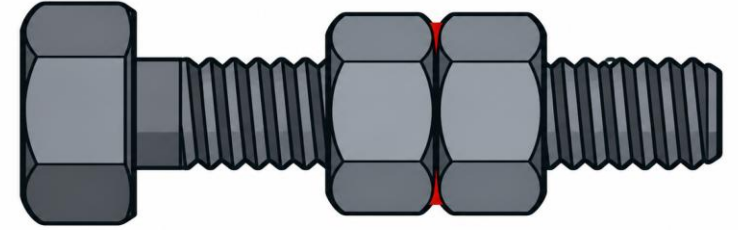




Jam Nut

- Two nuts threaded onto the same bolt, tightened against each other
- Bottom nut is torqued down; a thinner “jam nut” tightens on top against it
- Friction between the two nuts locks them both in place

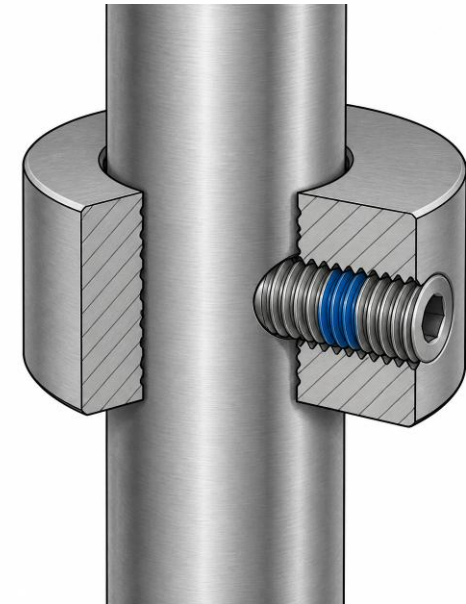
Picture two people pushing against each other's backs — neither one can slide.



Thread Locker (Loctite) & Set Screws

- A liquid adhesive on threads that cures (hardens) after installation
- Blue = removable: strong, but can still be undone with hand tools
- Red = permanent: very strong, usually needs heat to remove
- Great for set screws (locking a gear or wheel hub to a shaft)

Think of Loctite as glue made just for screws — blue peels apart, red is forever.



Common Bolt Drive Types



Phillips (cross-shaped)

- Use a Phillips screwdriver (sizes like #1, #2).
- Very common in household items.
- Tip: Press firmly to avoid slipping (“cam-out”).



Allen (hexagon recess)

- Use an Allen/hex key (metric or inch sizes).
- Tip: Pick the exact size; keep the key straight.



Hex Head (external hex/wrench drive)

- Bolt head itself is a six-sided (hex) shape — no recess needed.
- Use an open-end, box-end, or socket wrench (metric or inch sizes).
- Tip: A socket + ratchet grips all six sides for the most torque with less slipping.



Quick Tips

- Match the tool exactly (metric vs inch, T-size, Phillips size).
- Seat the tool fully, keep it straight, and push in while turning.
- If it slips, stop and try the correct size.



Socket Head

- Pros: Less Likely to Strip!
- Cons: sticks up higher, can snag on other parts or wires

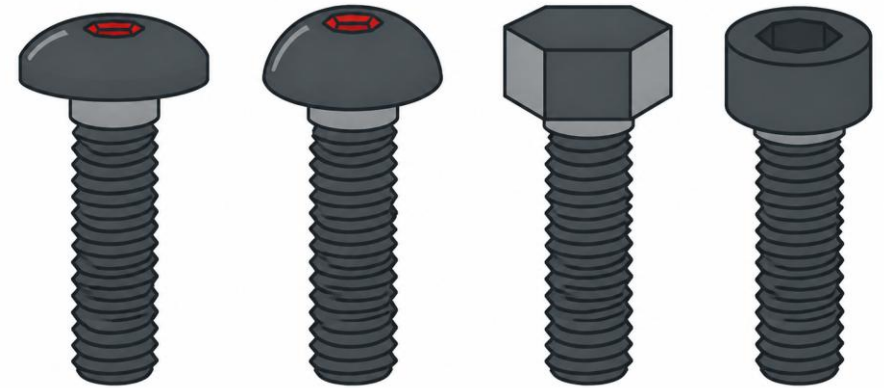
Button/Pan Head

Pros: low rounded profile, wide bearing surface spreads out the load less likely to snag

- Cons: Smaller Drive, Less depth for Allen wrench. More likely to strip.

“Cheap” vs. Quality Bolts

- Cheap bolts: inexpensive, fine for low-stress spots, but softer metal
 - Can strip or bend easily, unknown strength
- Quality bolts (Grade 8, Class 10.9): marked head, consistent strength
 - Best for FTC



Typical Fasteners: goBILDA, Studica & REV DUO

Popular FTC build systems — and the hardware that holds them together

goBILDA

- Primarily M4 socket head cap screws for channel and structural connections
- Set screws secure gears, sprockets, and hubs onto hex or REX shafts
- Nyloc (nylon-insert) lock nuts throughout to resist vibration

Studica Robotics

- M3 socket head and button head cap screws are the standard fastener
- T-Slot Nuts ("Hammer Head") drop directly into extrusion channels
- Kep nuts and Nyloc nuts secure joints; split washers add extra grip

REV DUO System

- M3 hardware throughout: low-profile socket screws, hex cap screws, and T-slot screws
- T-slot screws drop into extrusion / C-channel slots for fast, tool-free assembly
- M3 Nyloc nuts and washers complete most structural joints

Screws

From drive size, to surface area, to clearance, the different styles of screws each have their strong suits.





Good Tightening Habits

- Start by hand to avoid cross-threading
- Keep threads clean; use washers when needed
- Tighten several bolts in a cross/star pattern
- Use a torque wrench and follow recommended torque

Avoid Stripping the Bolt

- **Stripping:** the tool chews up the bolt head shape so it won't turn
- Causes: wrong-size tool, not fully seated, turning at an angle, too much torque
- Prevent it: correct-size driver, seat fully, keep tool straight, torque wrench for final tightening
- If it slips: stop, try a better tool, add penetrating oil, or ask an adult for help





Steel into Steel (High-load joints): 2.5 to 3.0 Nm (approx. 22 to 26 in-lbs).

- goBILDA high-tensile steel fasteners can handle up to **4.5 to 5.0 Nm** if clamped into premium alloy steel components, but the context of robotics often limits this.

Steel into Aluminum (goBILDA Channels/Hubs): 1.2 to 1.5 Nm (approx. 11 to 13 in-lbs).

- Because aluminum threads strip much easier than steel, it is standard practice to roughly **halve the maximum steel torque** when fastening into structural aluminum parts like goBILDA channels.

Steel into Plastic / 3D-Printed Parts: 0.4 to 0.6 Nm (approx. 4 to 5 in-lbs).

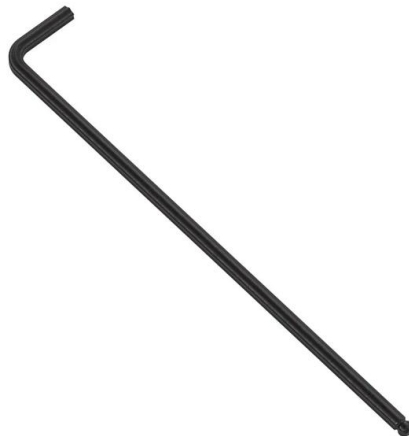
- Tighten strictly by hand until the screw is flush and firmly snug.





Recommended Tools:

- Basic Allen Wrench (A)
 - T- Style Allen Wrench (B)
 - Open Ended Wrench (C)
 - Tap (D)
 - “Pipe” Wrench (E)
-
- Nicer T-Handle wrenches are easier for the kids to use and last longer.
 - Taps are great to repair minor cross threading.
 - **All 5 are used often!**





Quick Check: You Be the Mechanic

- What happens if a bolt is too short for the nut?
- Name one thing that can loosen a bolt over time on a robot.
- What's inside a nylon lock nut that helps it grip?
- Why might you pick blue Loctite instead of red on a set screw?

Key Takeaway

- Right length + right torque + the right “extra help” (locknut, lock washer, or Loctite) = a joint that survives competition
- When in doubt, ask a mentor and check the torque spec!

