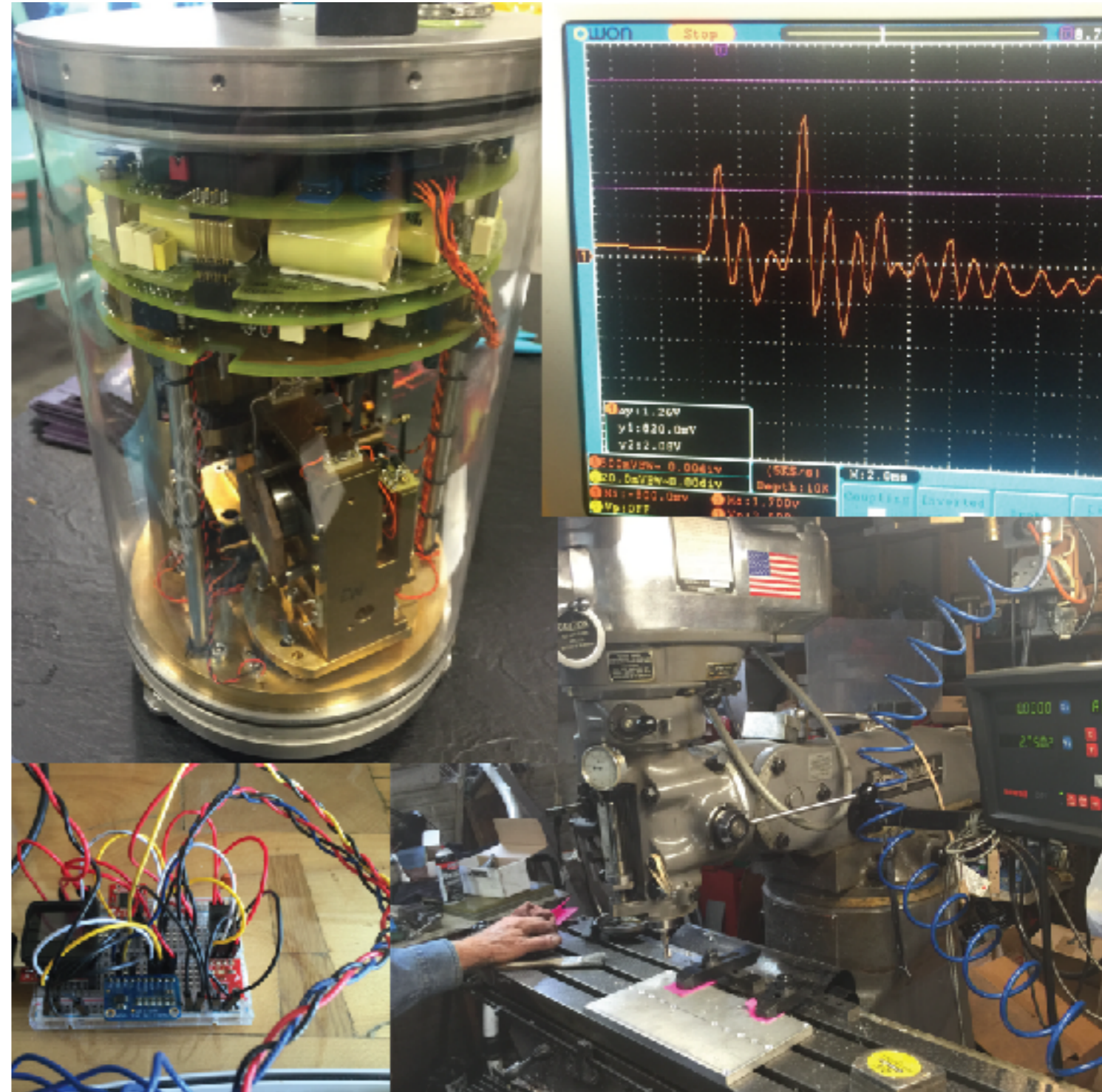


Principles of Mechanical Design

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Techniques of Geoscientific
Experimentation

September 29, 2016



Much like there are standard software design patterns, there are common and test solutions to mechanical problems



Machines are designed to deal with:

- Bending
- Twisting
- Internal Pressure
- External Pressure
- Vibration
- Static and Dynamic Loads

Bending and twisting can be calculated knowing material properties

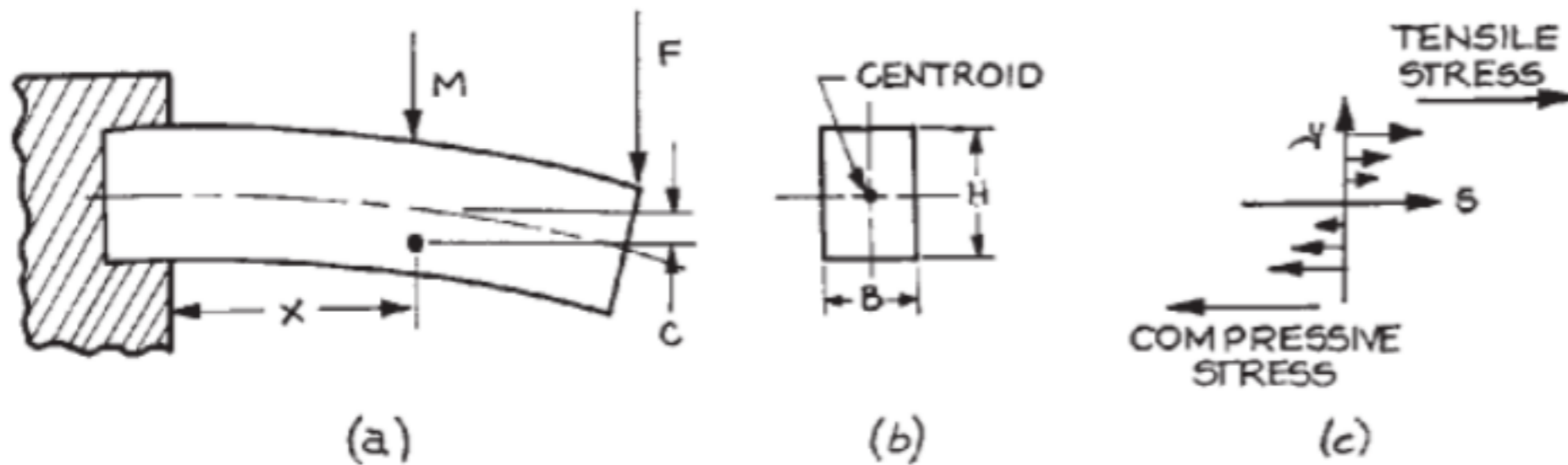
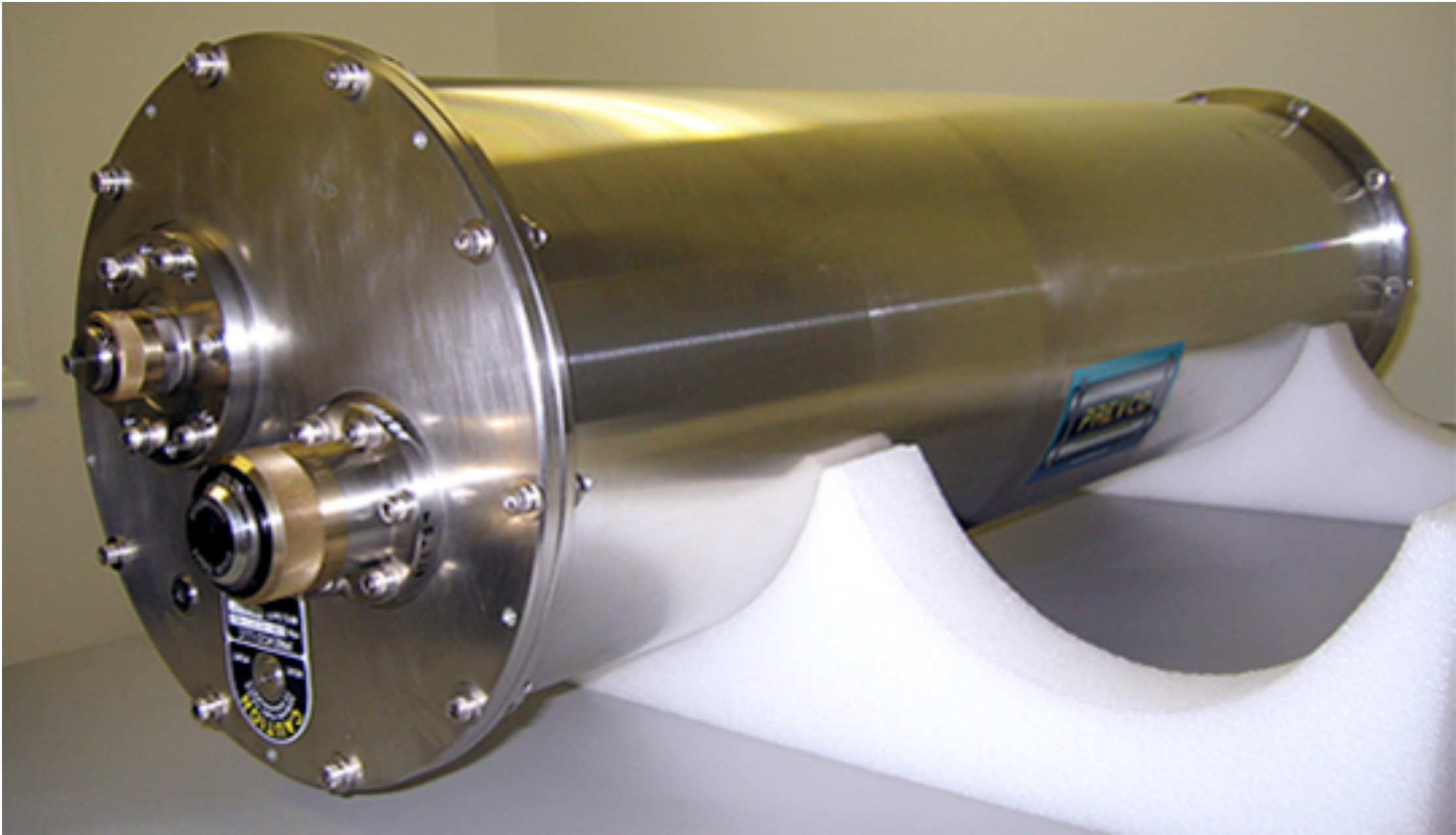


Figure 1.48 A flexed beam: (a) the beam bending under a load; (b) a cross section showing the centroid; (c) the distribution of shear forces along the long axis of the beam.

Internal pressure stresses are common in laboratory equipment



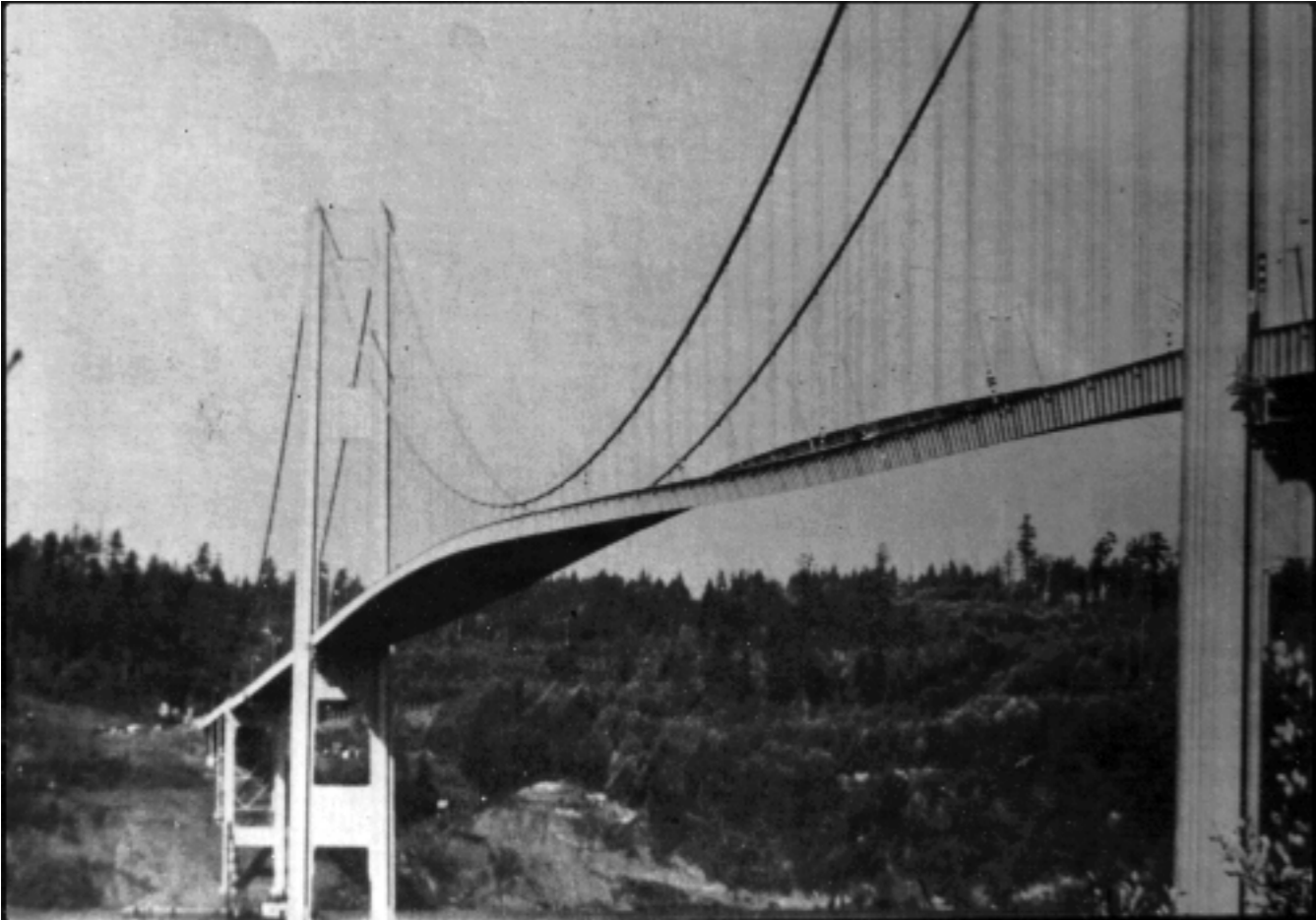
External pressure stresses are common in field equipment



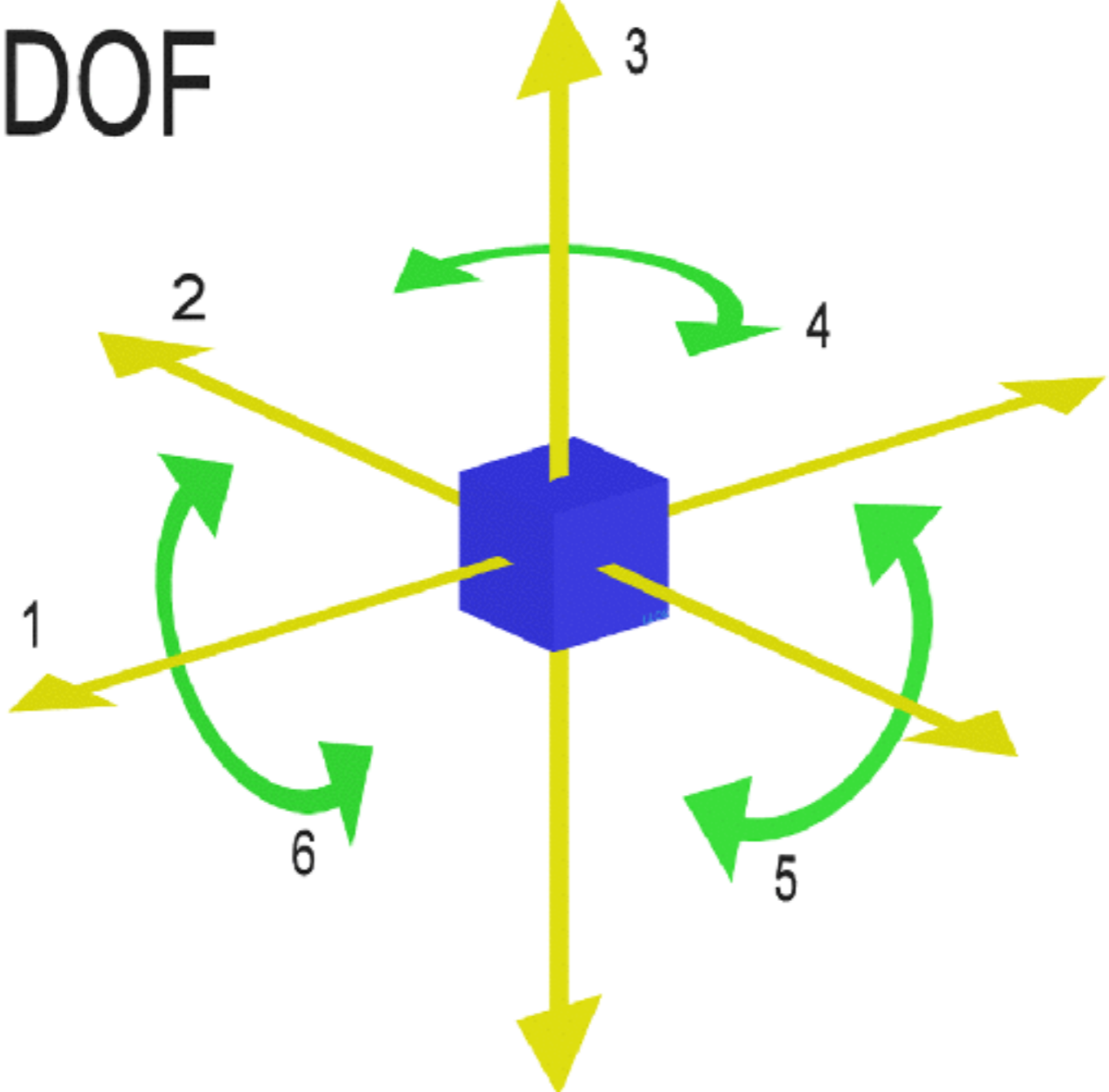
External pressure stresses are common in field equipment



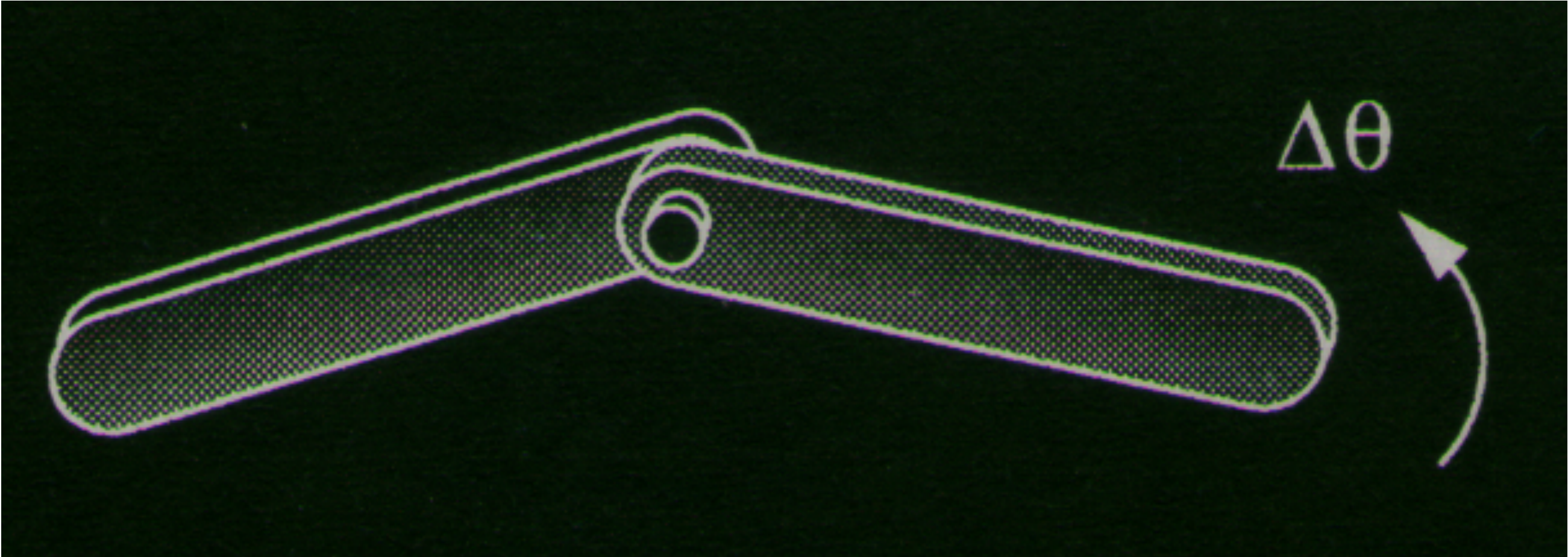
Vibration causes failure in structures of all sizes



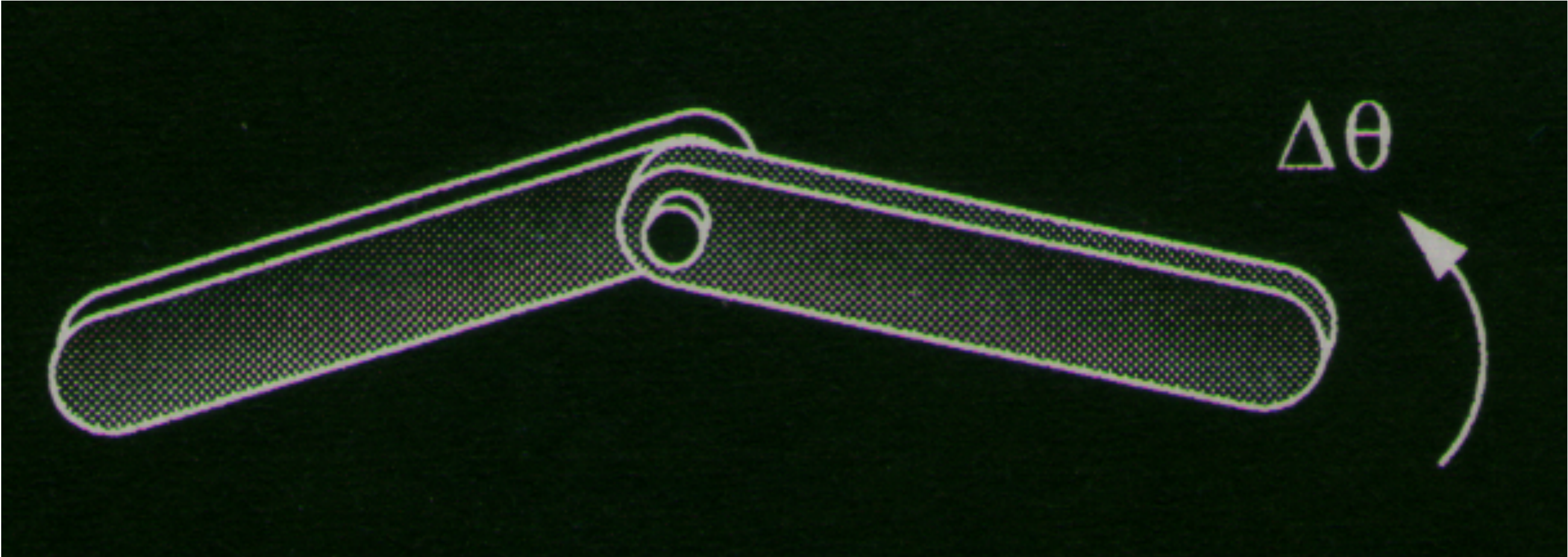
The position of an object can be described by a 6 DOF system



How many DOF?



How many DOF?



1

How many DOF?



How many DOF?



3

How many DOF?

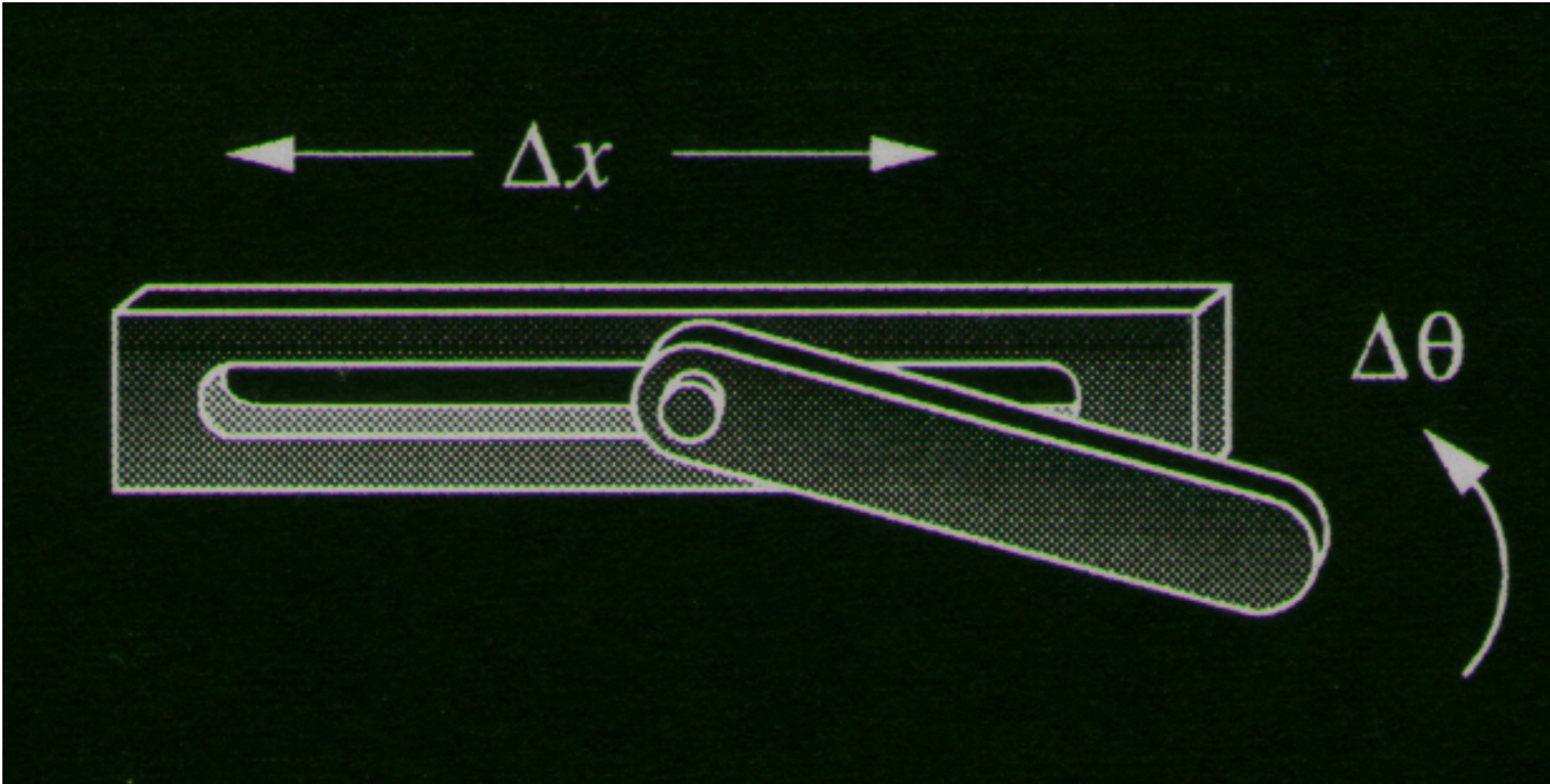


How many DOF?

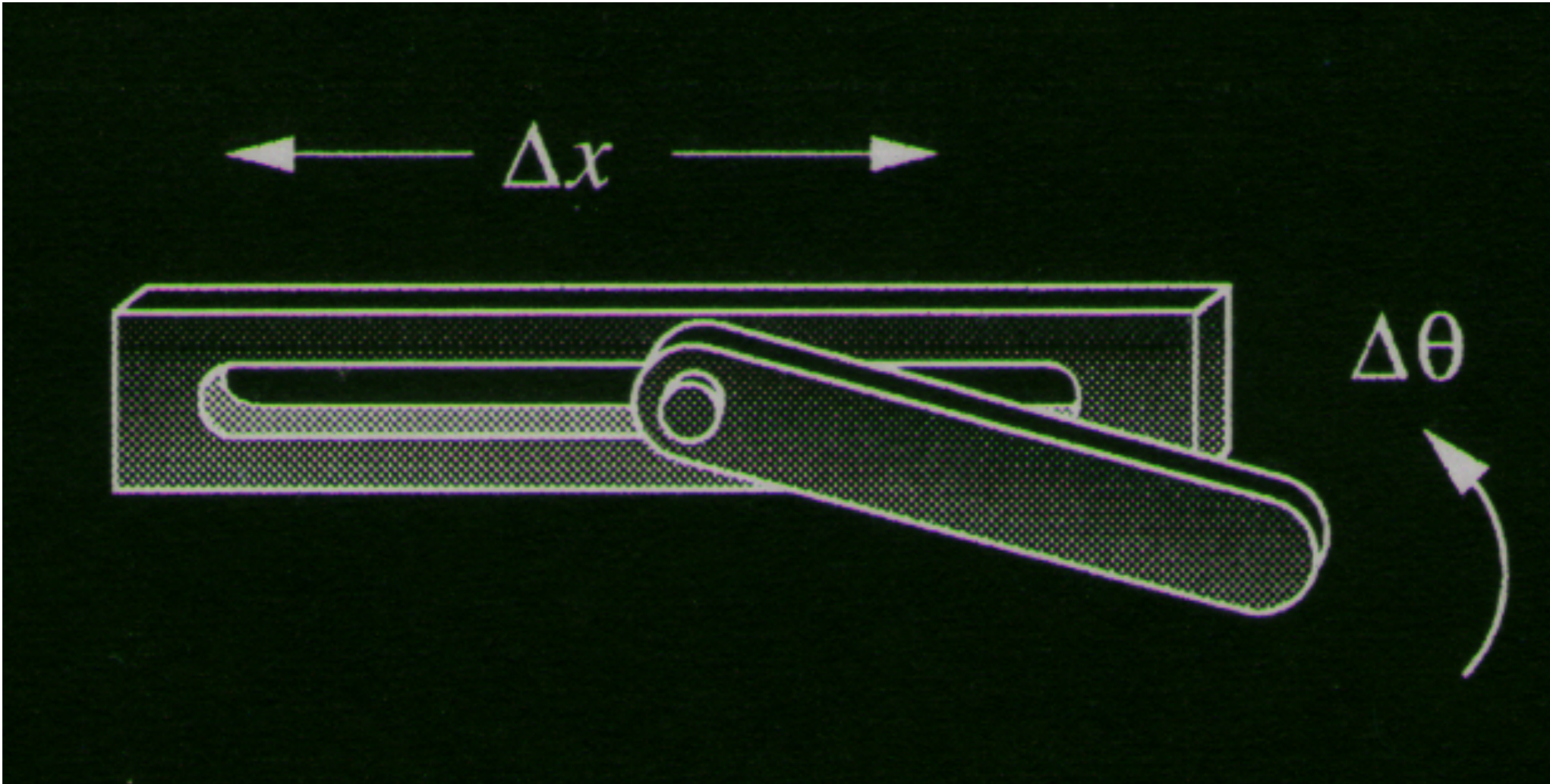


3

How many DOF?



How many DOF?



2

V-grooves are a common way to constrain motion

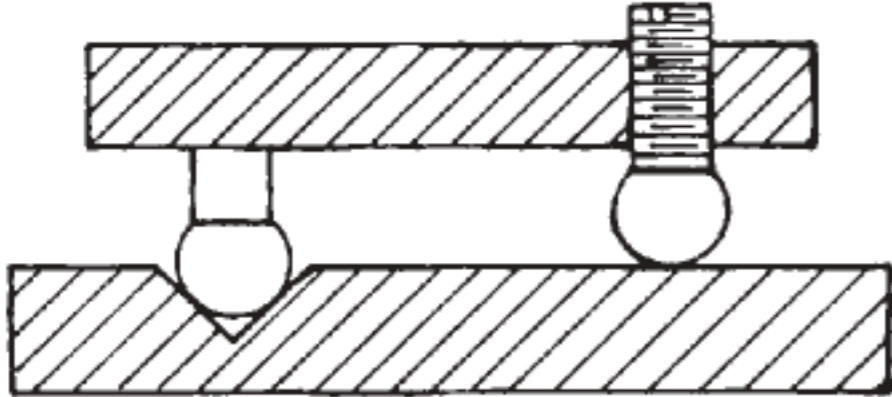
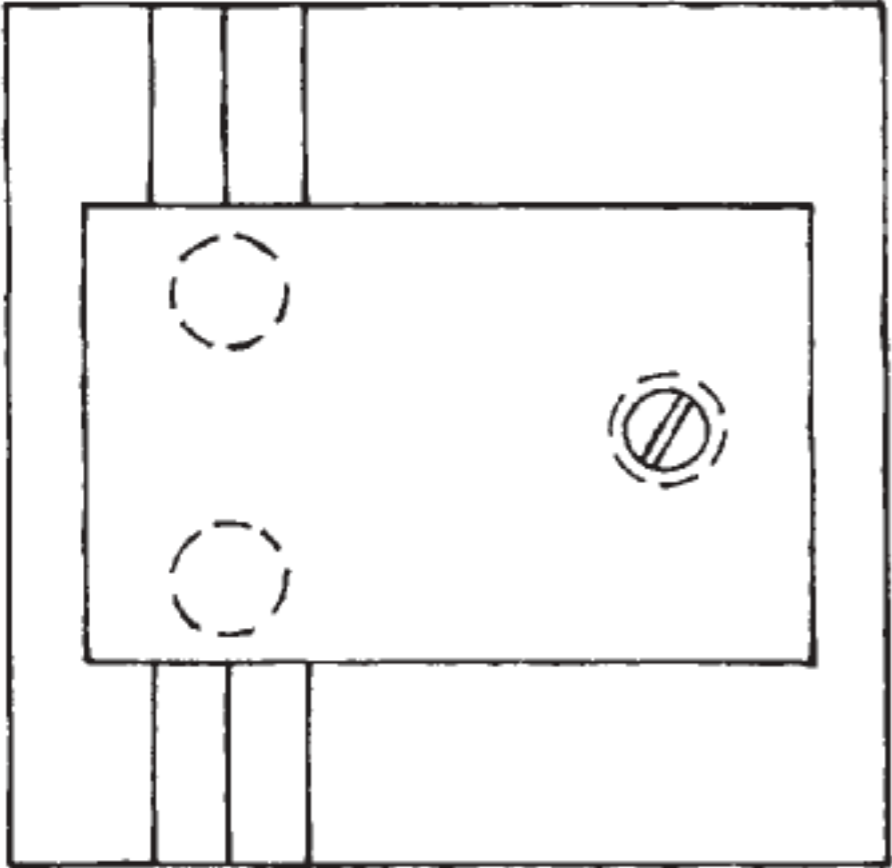


Figure 1.52 Kinematic design that constrains a carriage to move in a straight line.

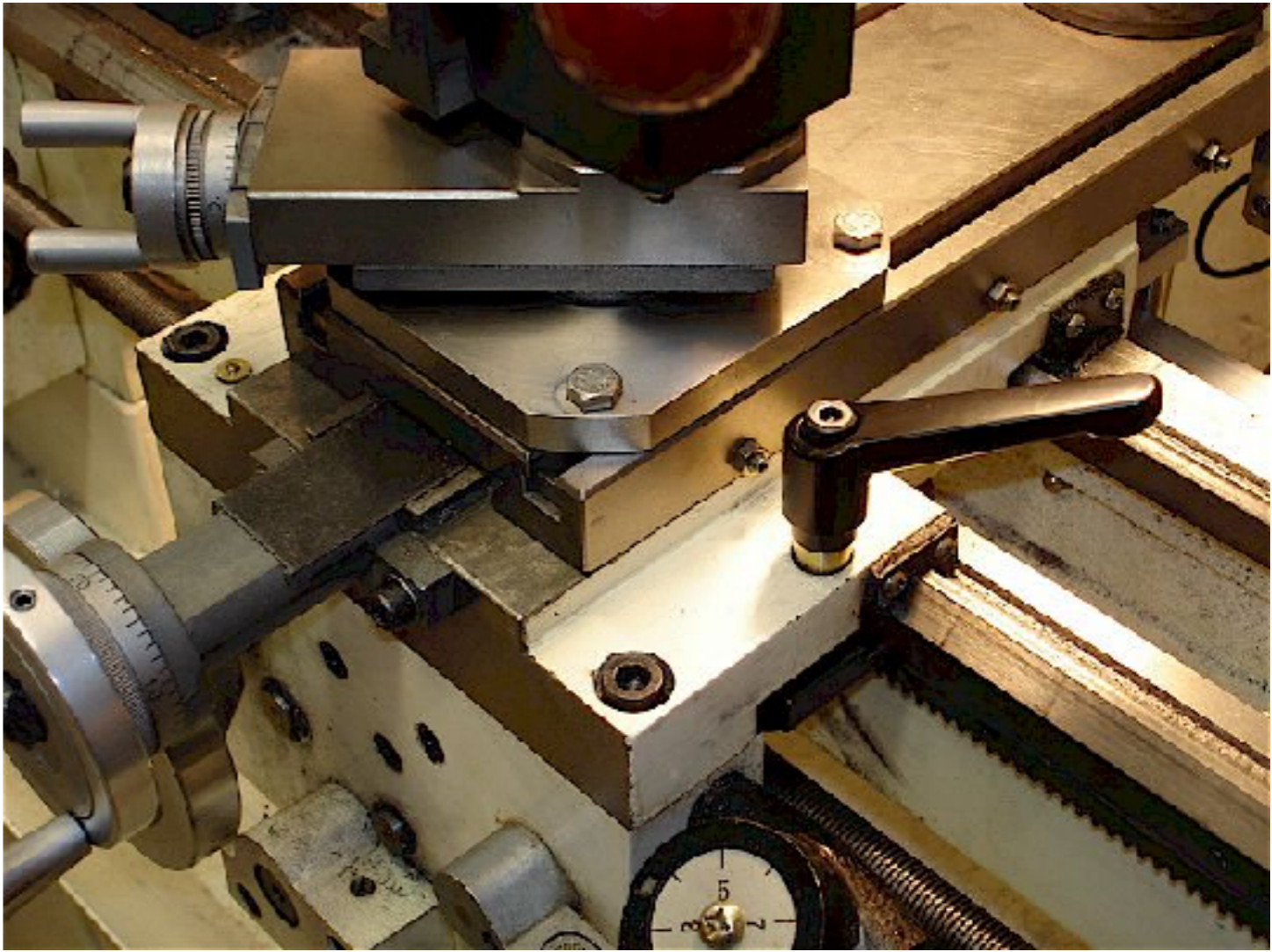


Image: mico-machine-shop.com

The design can be made more economically with a slight modification

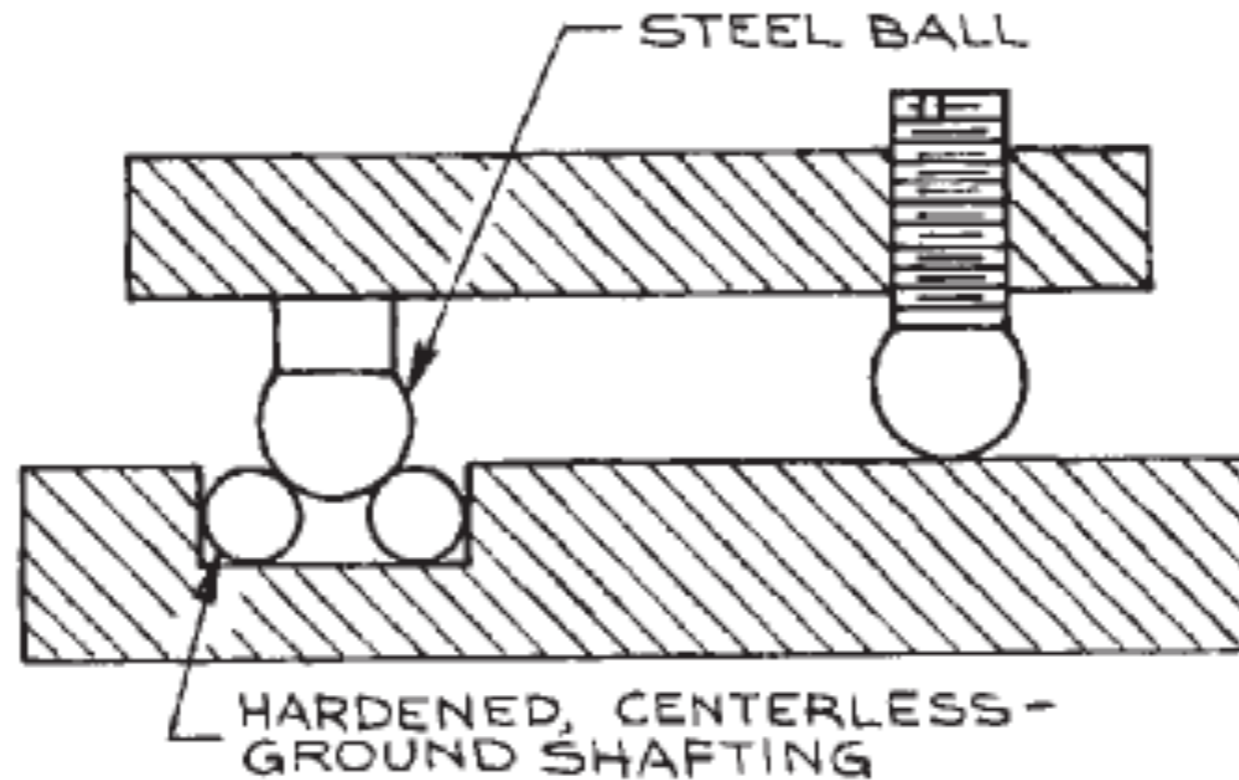
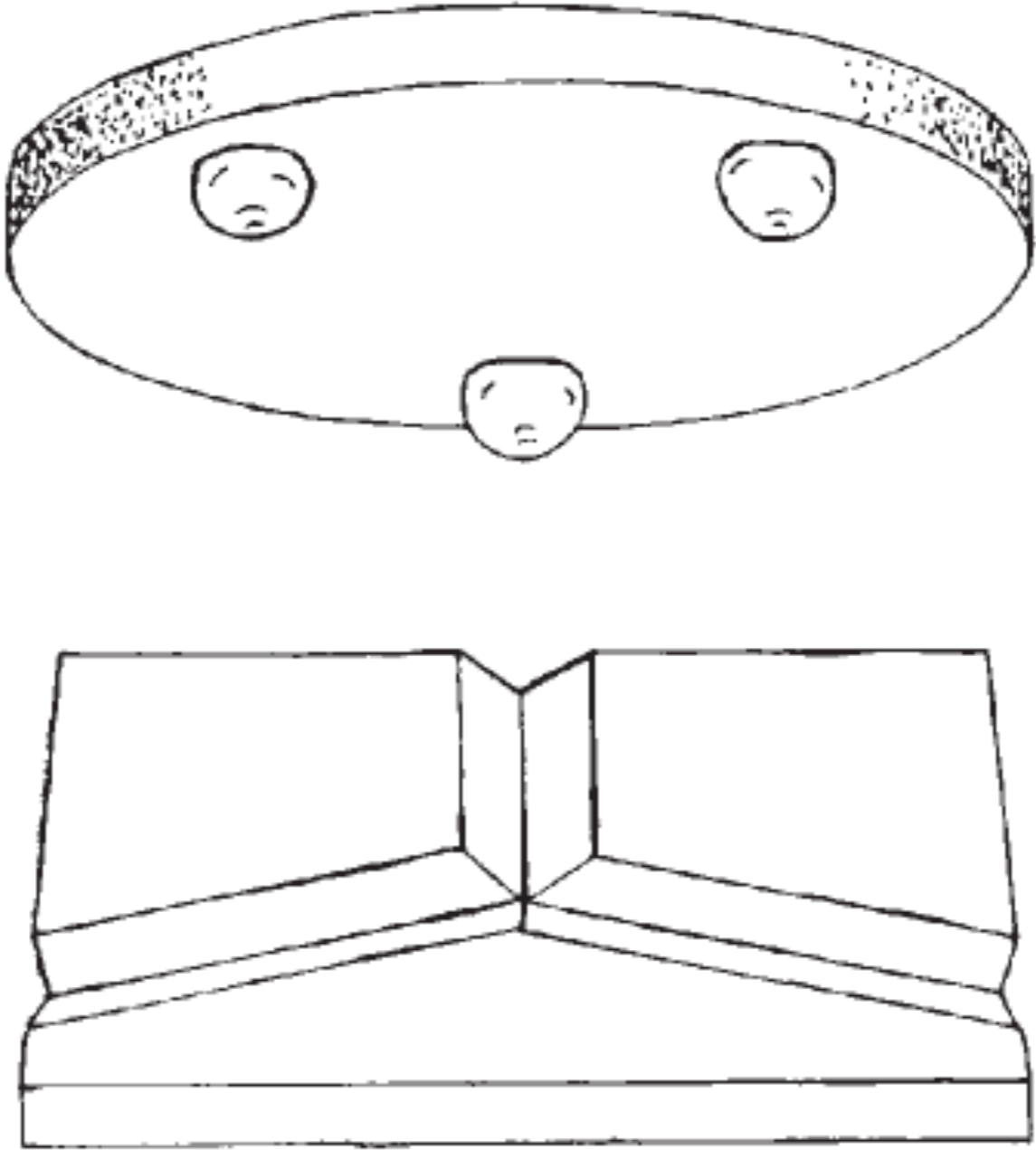


Figure 1.53 An improved version of the design shown in [Figure 1.52](#).

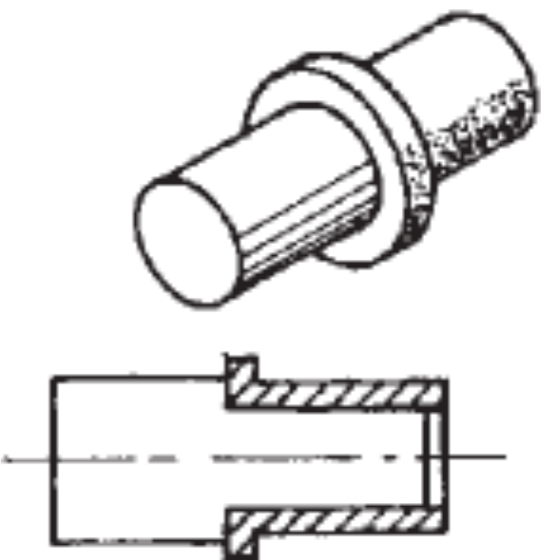
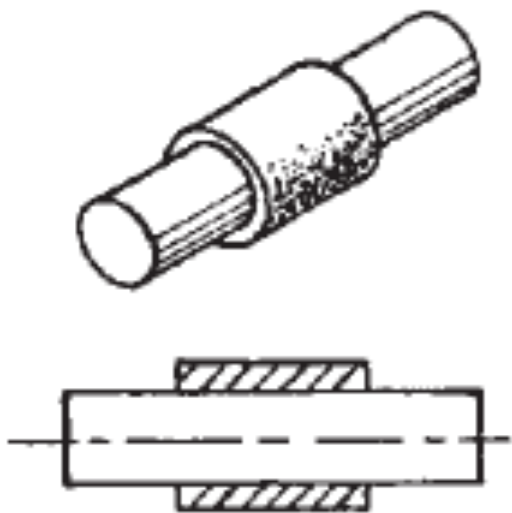
Good design practices make it possible to precisely place and locate parts



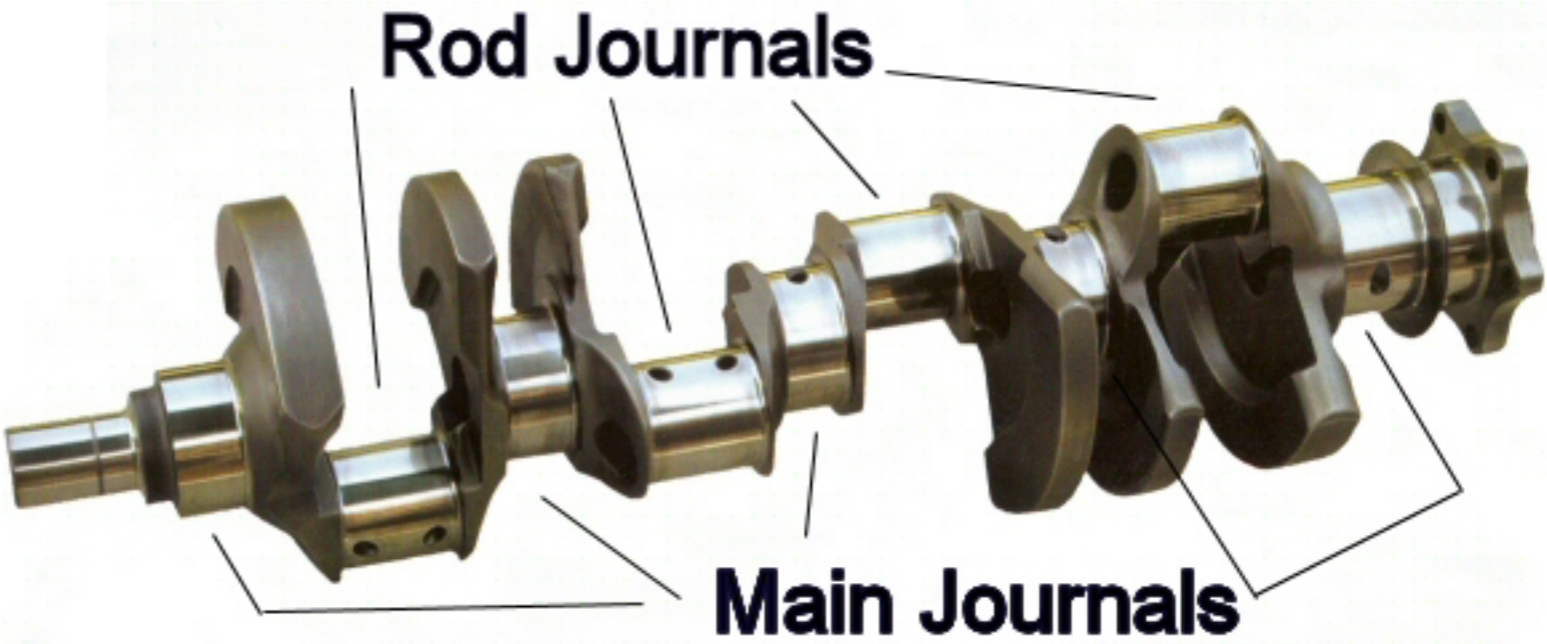
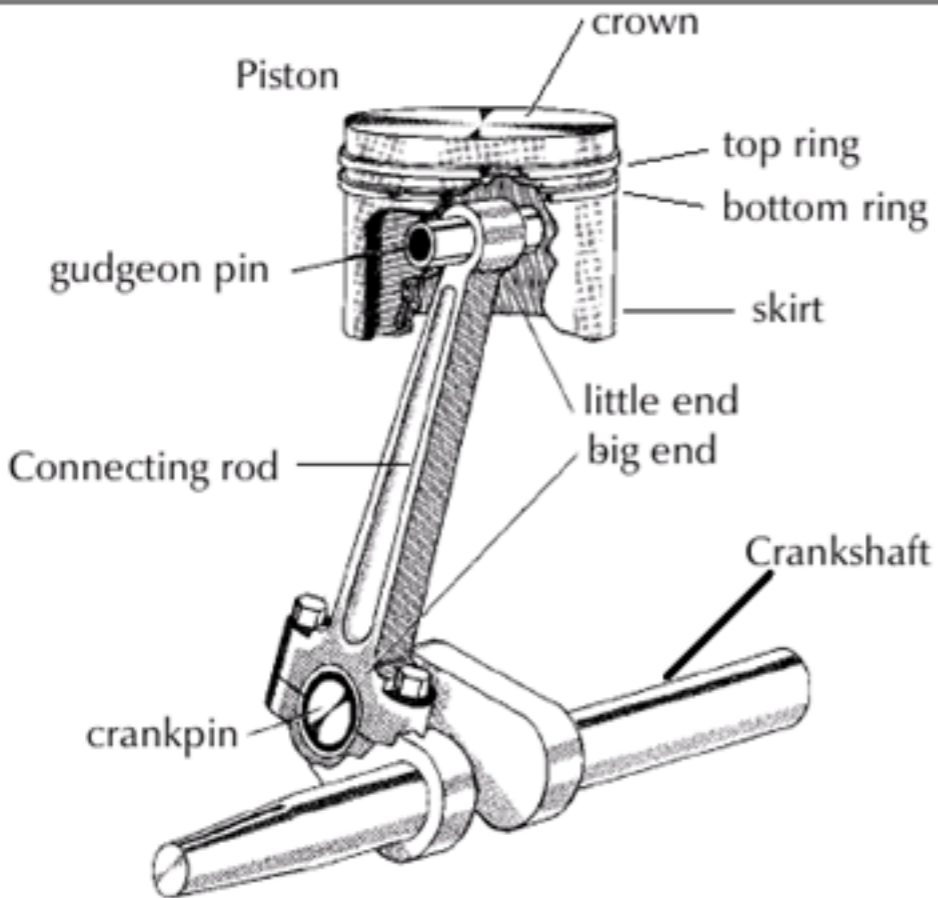
We use bearings to reduce wear and friction on moving parts



Journal bearings are good for low - high speed applications



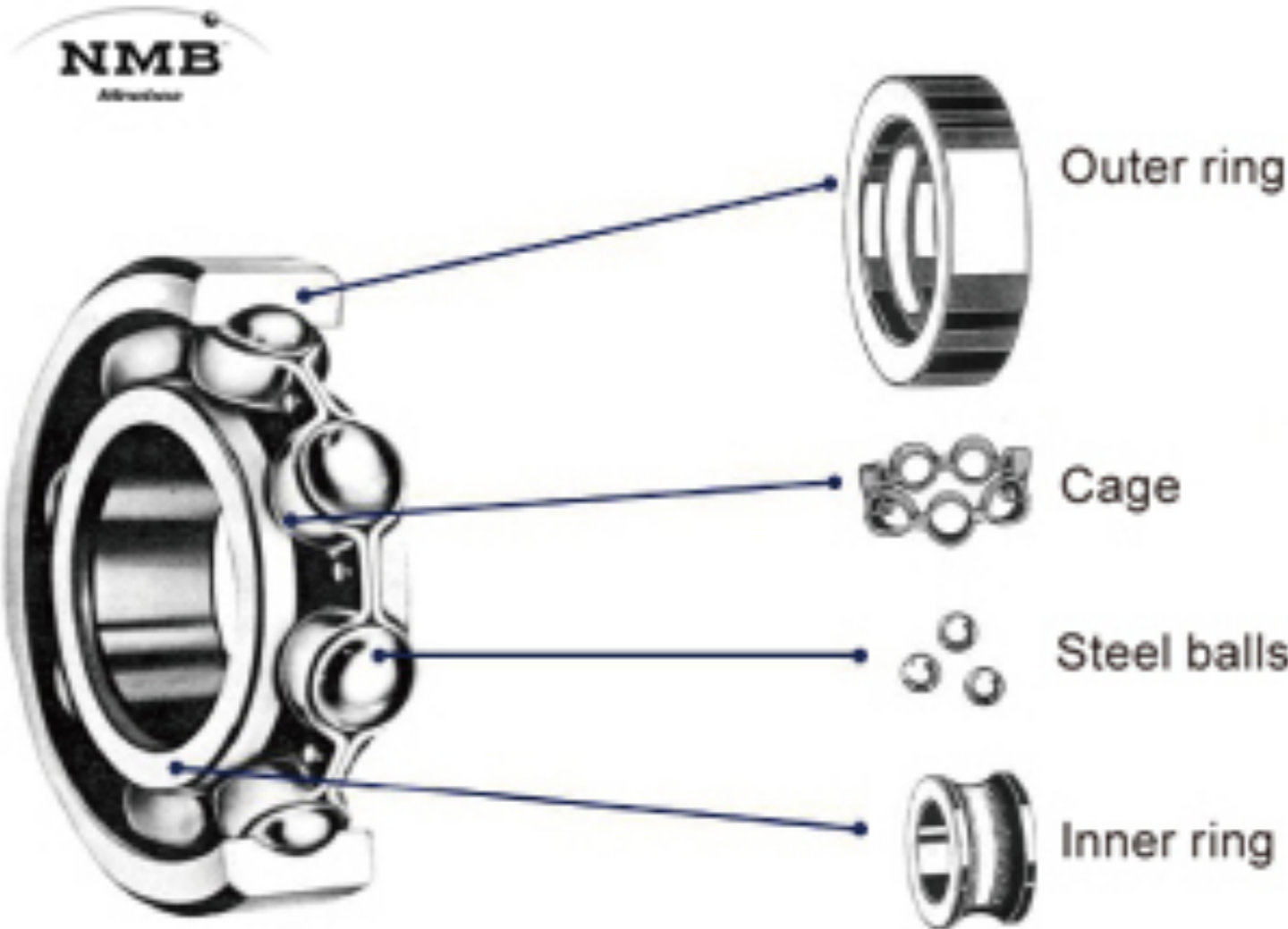
We use journal bearings every day



Rolling bearings have good speed characteristics and friction



Rolling bearings have two rings, a cage, and rolling elements



Roller bearings are common in many assemblies



Thrust bearings accommodate axial loads

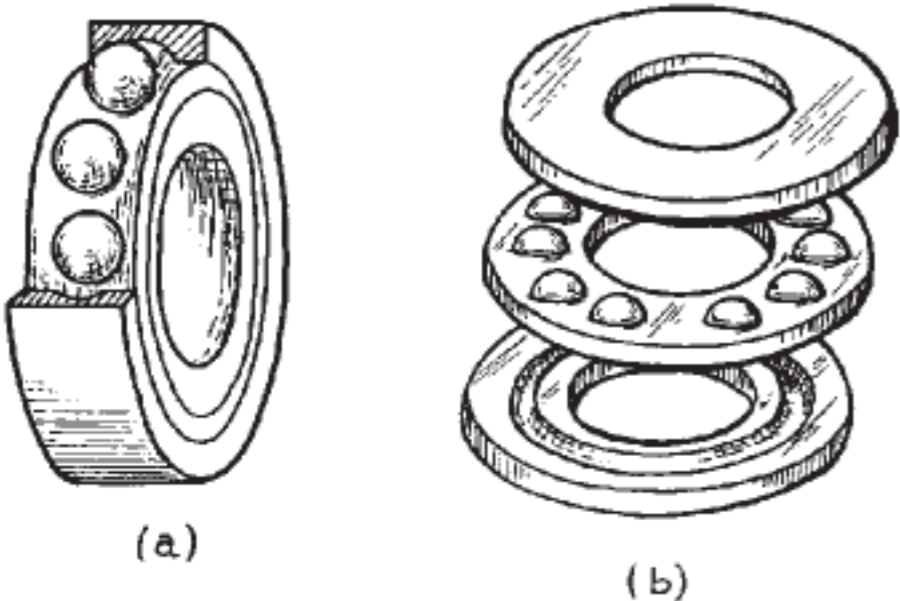


Figure 1.57 Ball bearings: (a) a radial ball bearing; (b) a thrust ball bearing.

Image: Building Scientific Apparatus

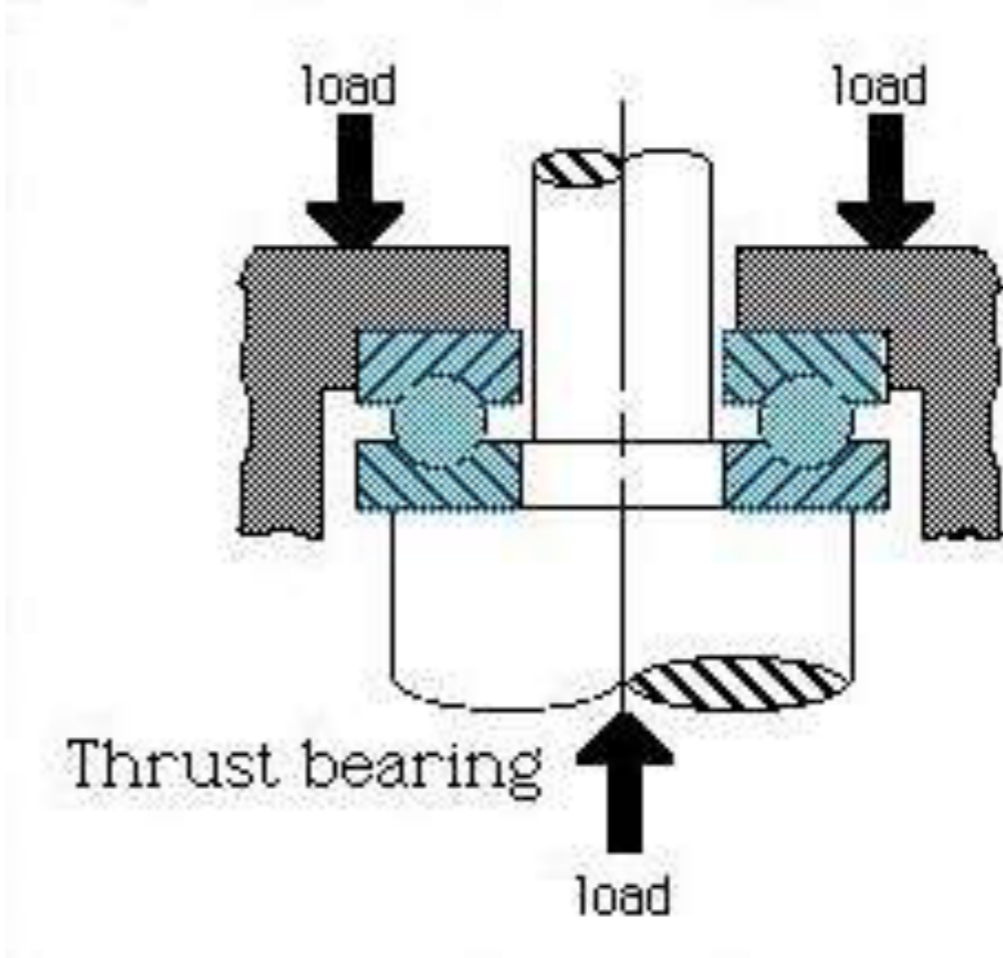
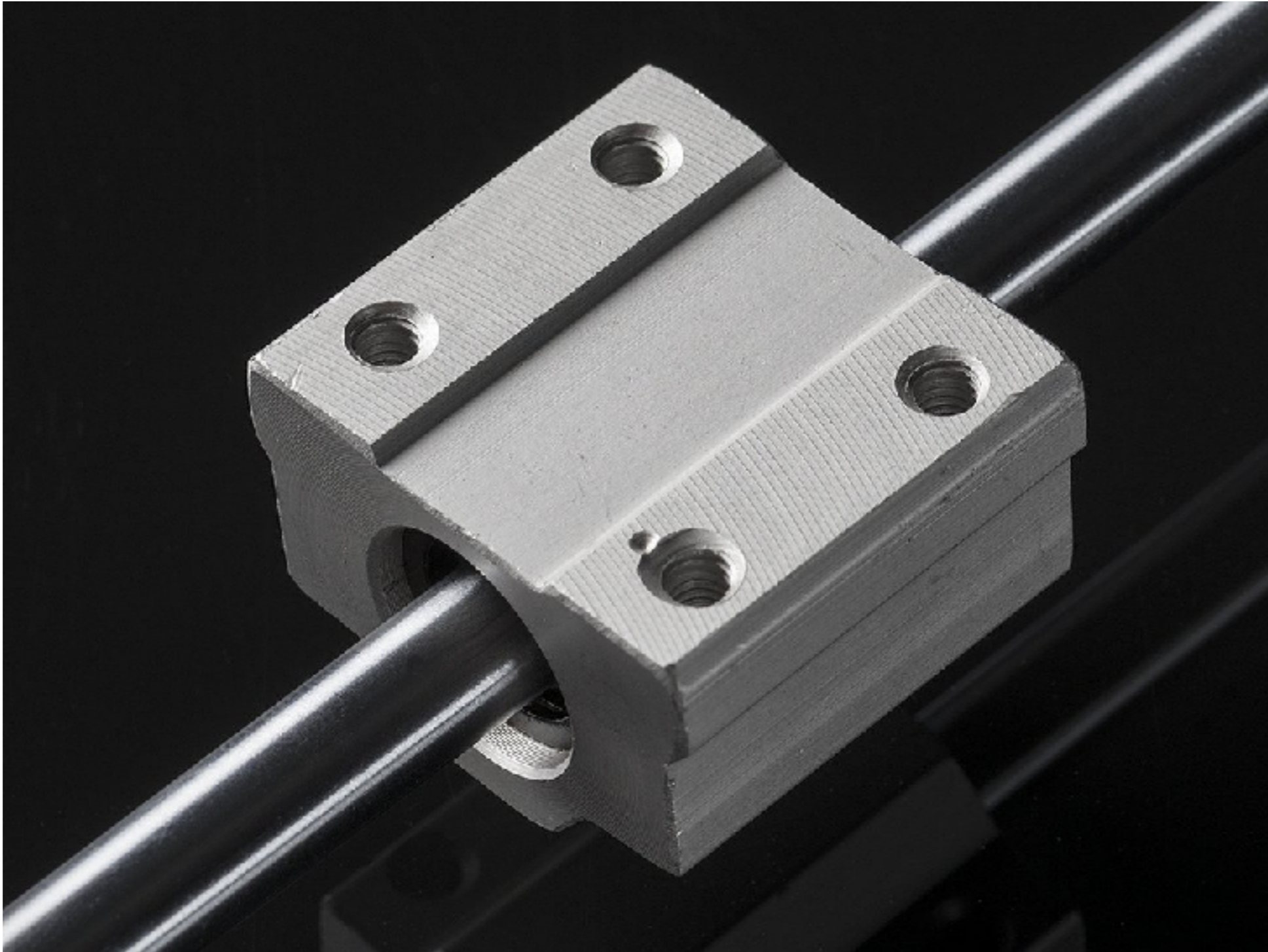


Image: <http://stemeducationreferences.pbworks.com>

Linear bearings allow translation along a fixed axis



Linear bearings allow translation along a fixed axis



Bearings can be pre-loaded to remove excess play or help share the load between multiple bearings

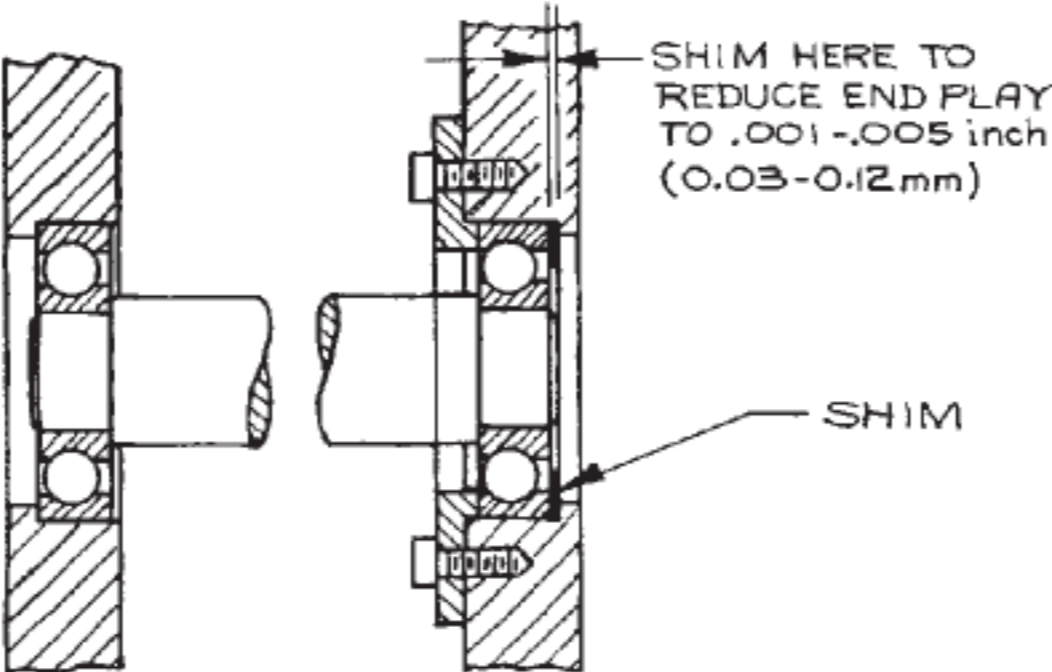
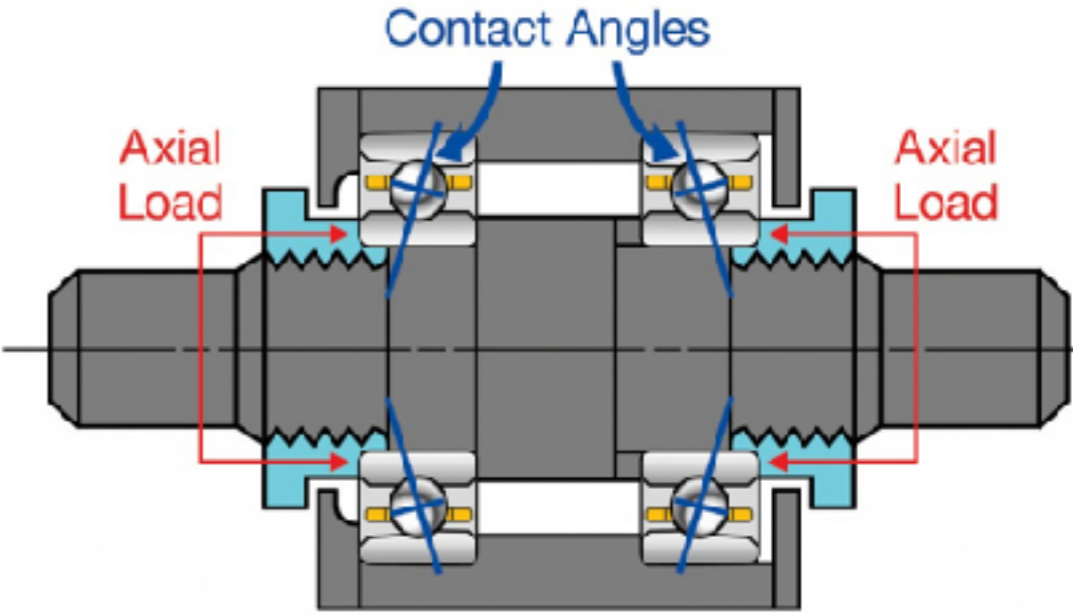
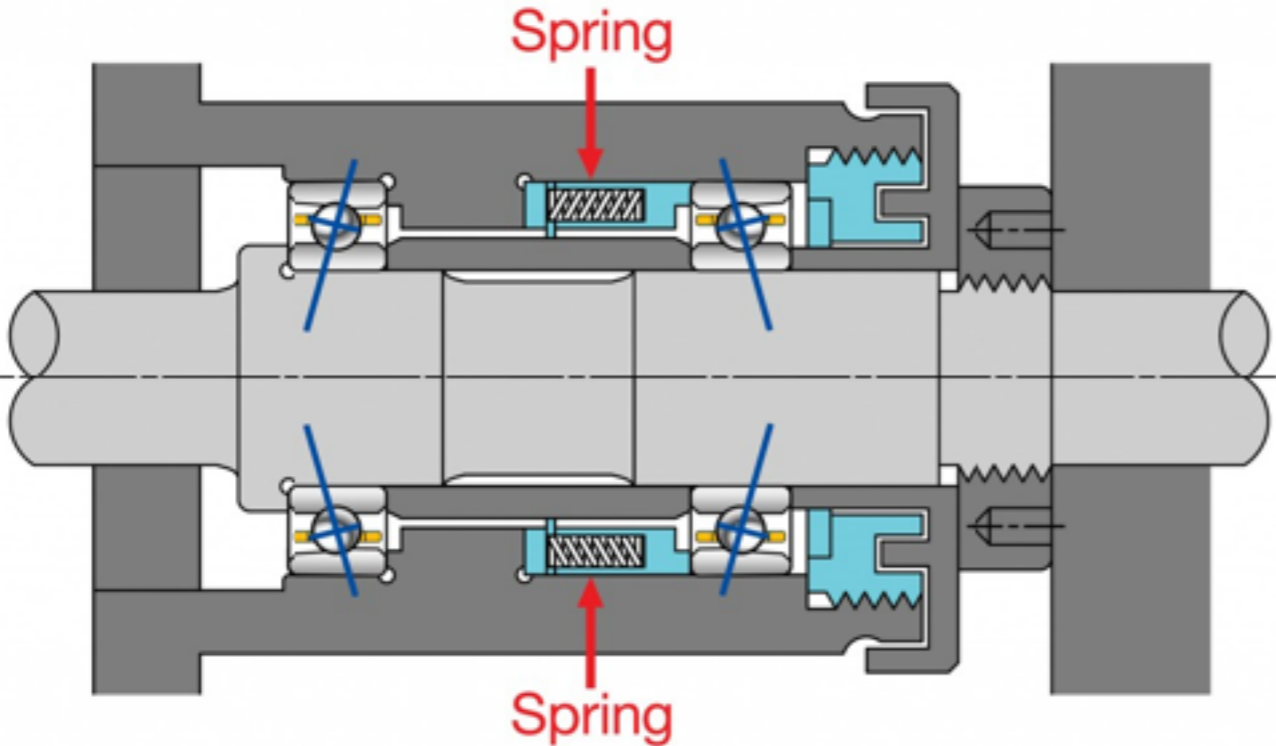


Figure 1.59 Installation of a shim to remove end play in a shaft mounted on ball bearings.



Springs can apply torsion, tension, or compression to parts

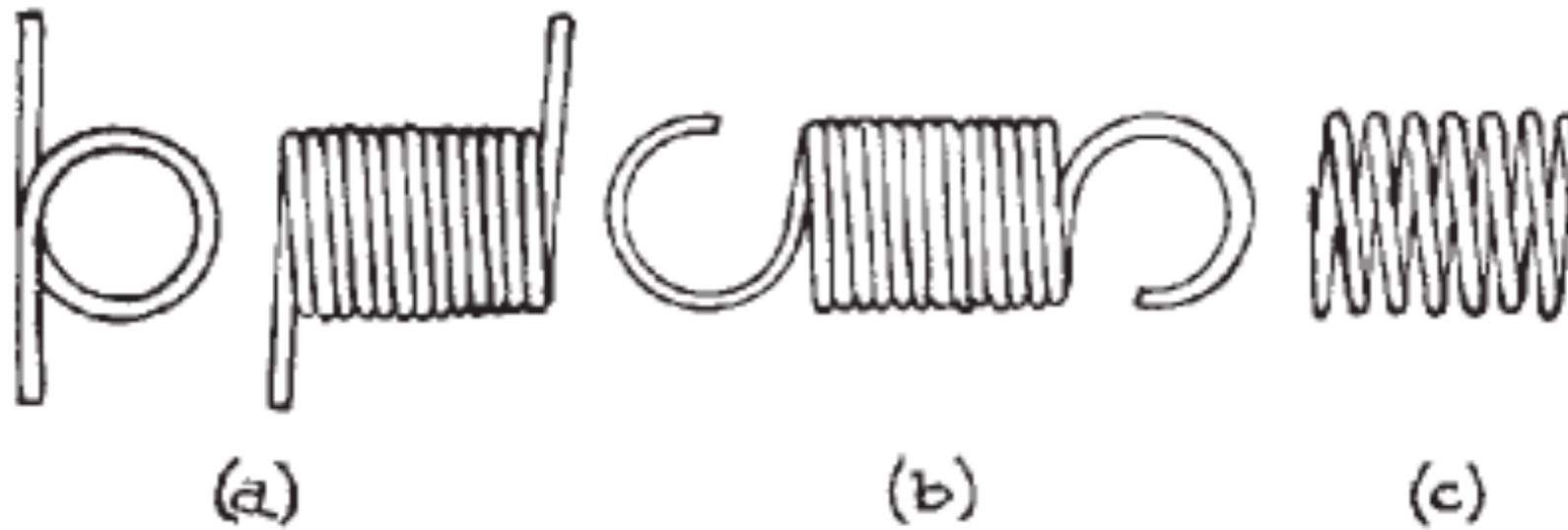


Figure 1.60 Springs: (a) helical torsion spring; (b) helical extension spring; (c) helical compression spring.

Flexures are very reliable and precise ways to constrain movement

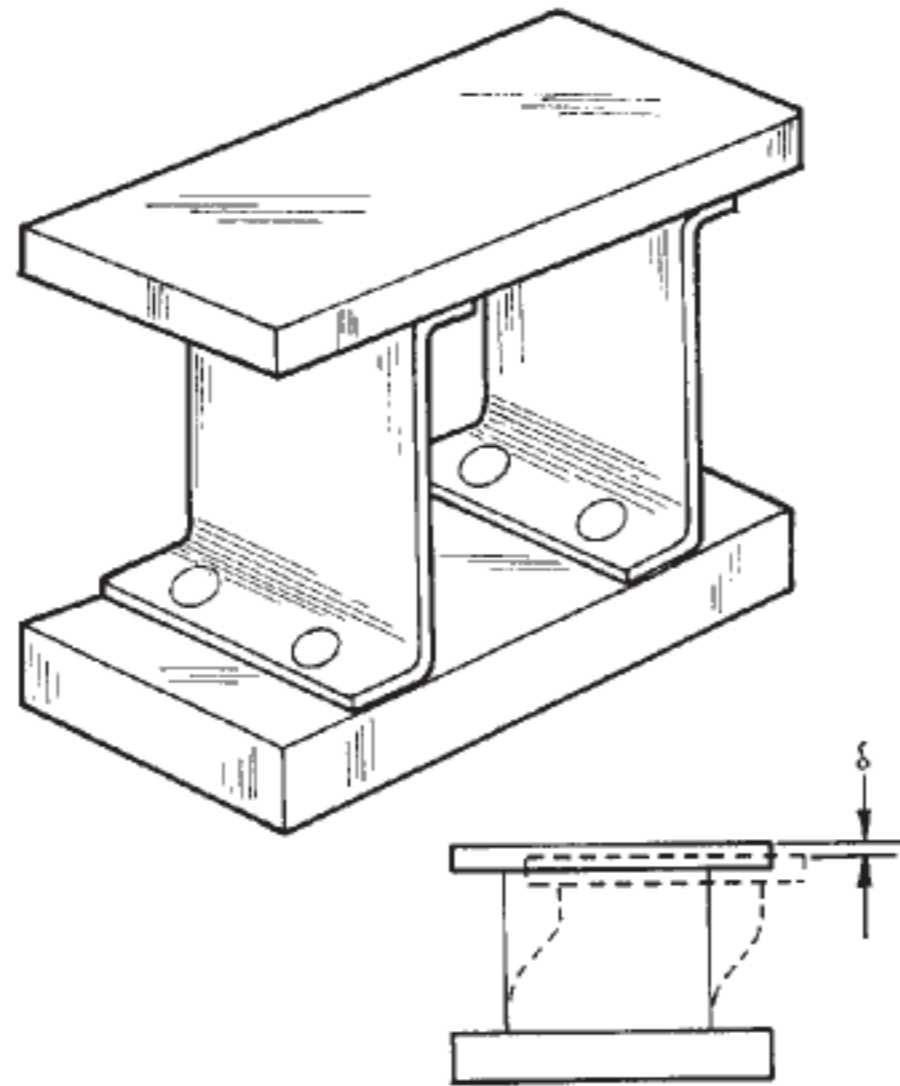


Figure 1.63 A practical design for a linear translation platform mounted on leaf springs. The inset illustrates the vertical error in the linear motion.

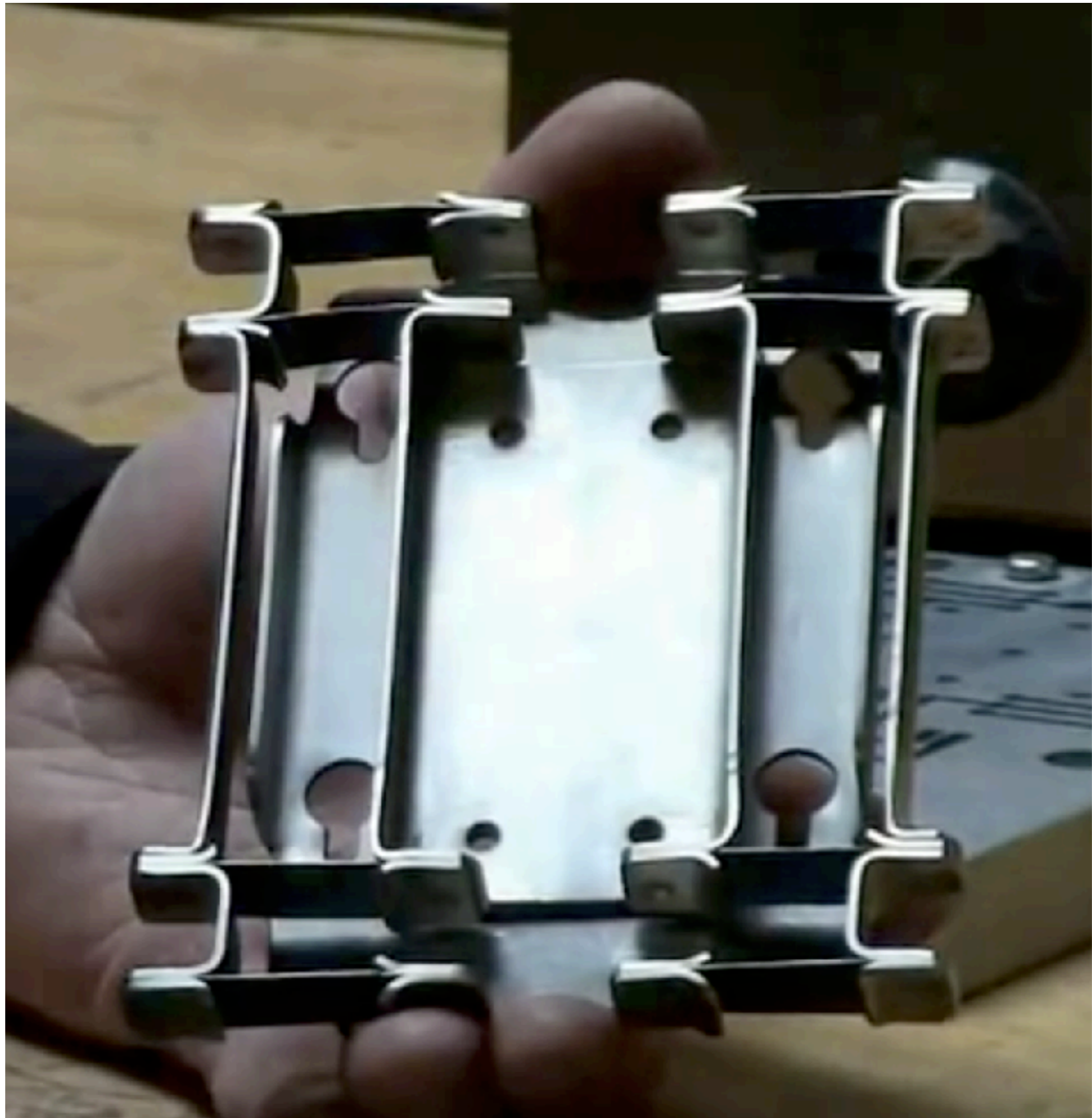
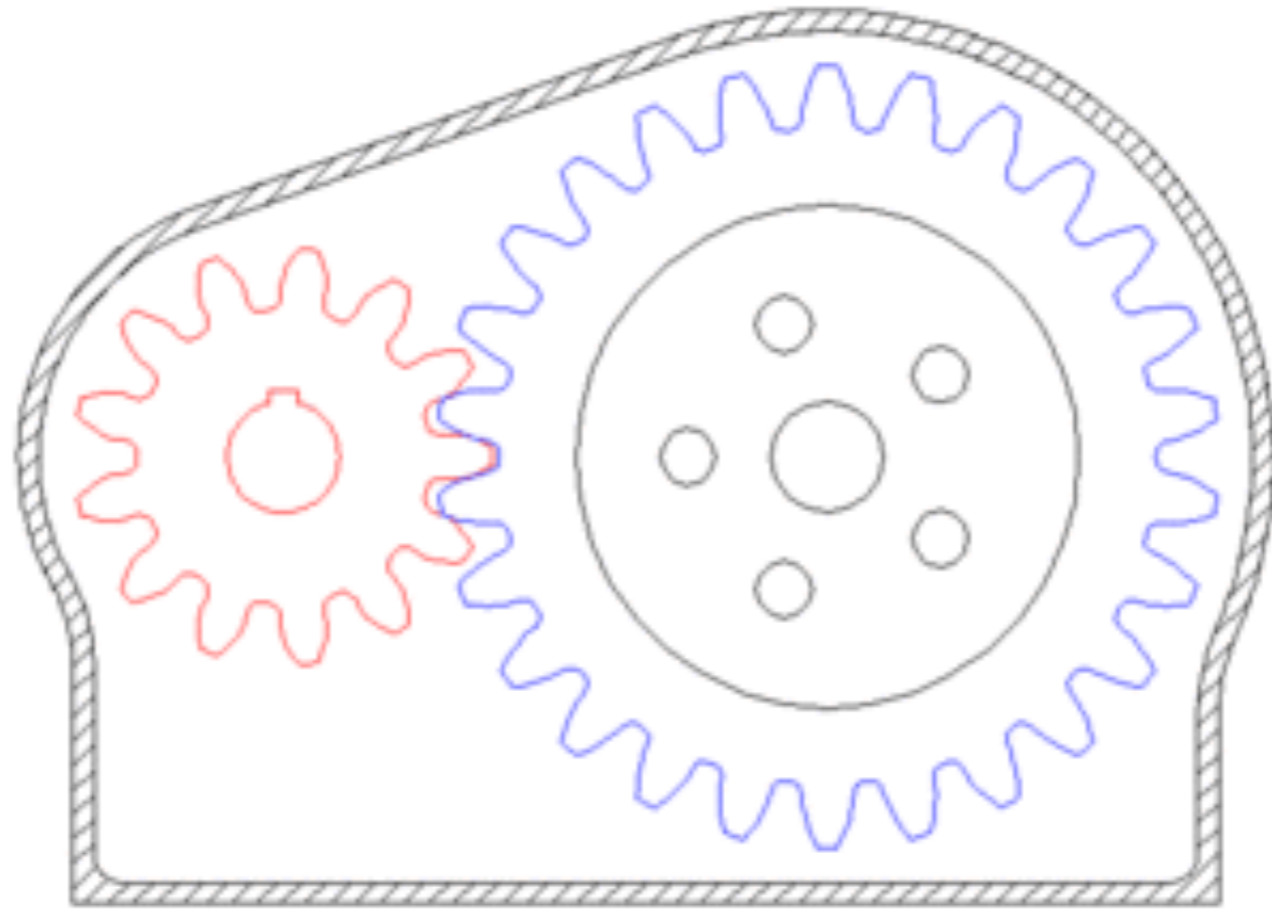


Image: YouTube Dan Gelbart

Gears are use to transfer power and modify mechanical advantage



<https://en.wikipedia.org/wiki/Gear>

Chains can be used for the same purpose, but at lower loads



Belts can be used for the same purpose, but at lower loads

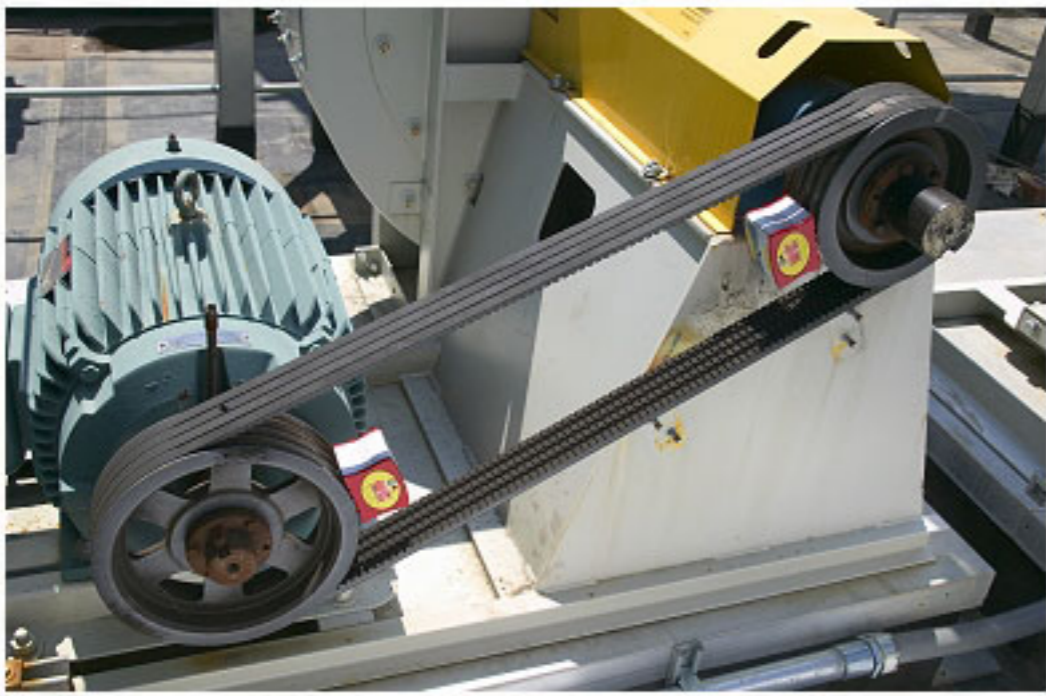


Image: petersonpredict.com



Image: pbclinear.com



Image: itp.nyu.edu

Let's look at some common prototyping and lab building materials

On organized hardware bank is a must



On organized hardware bank is a must



On organized hardware bank is a must

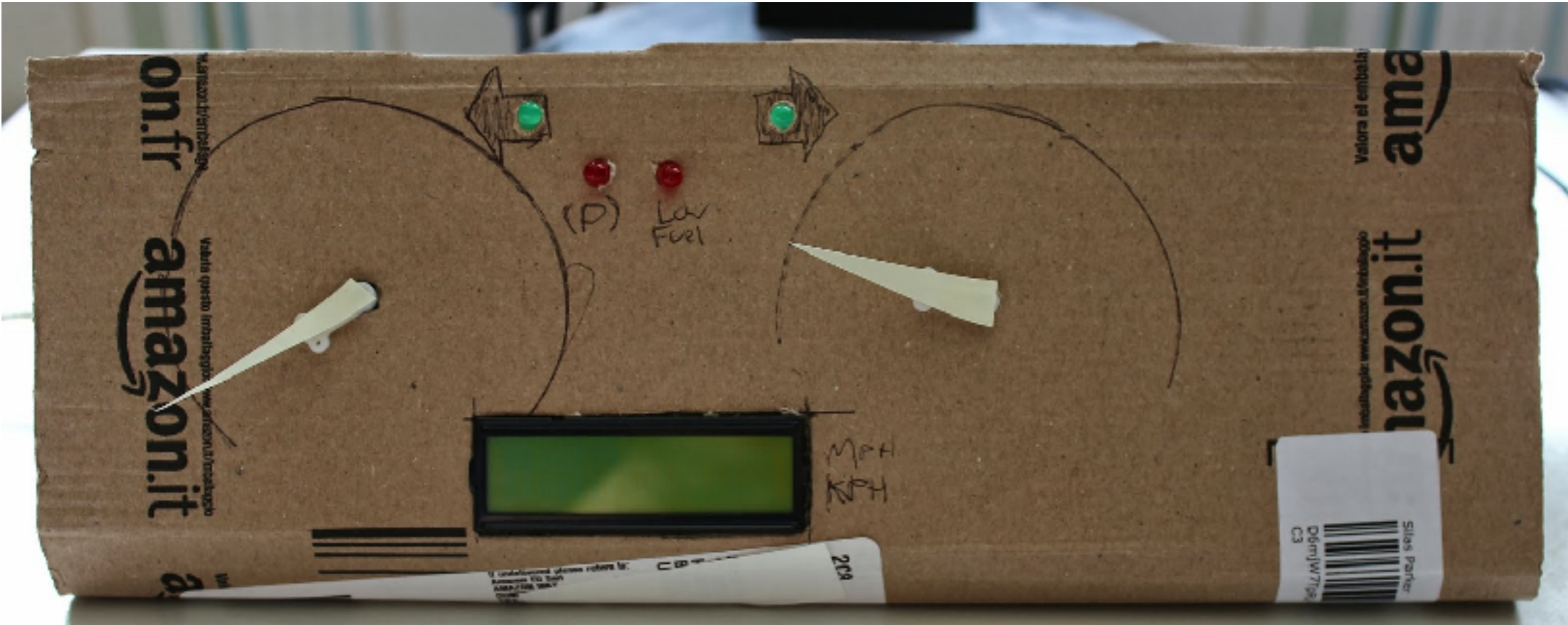


DIY Sortimo

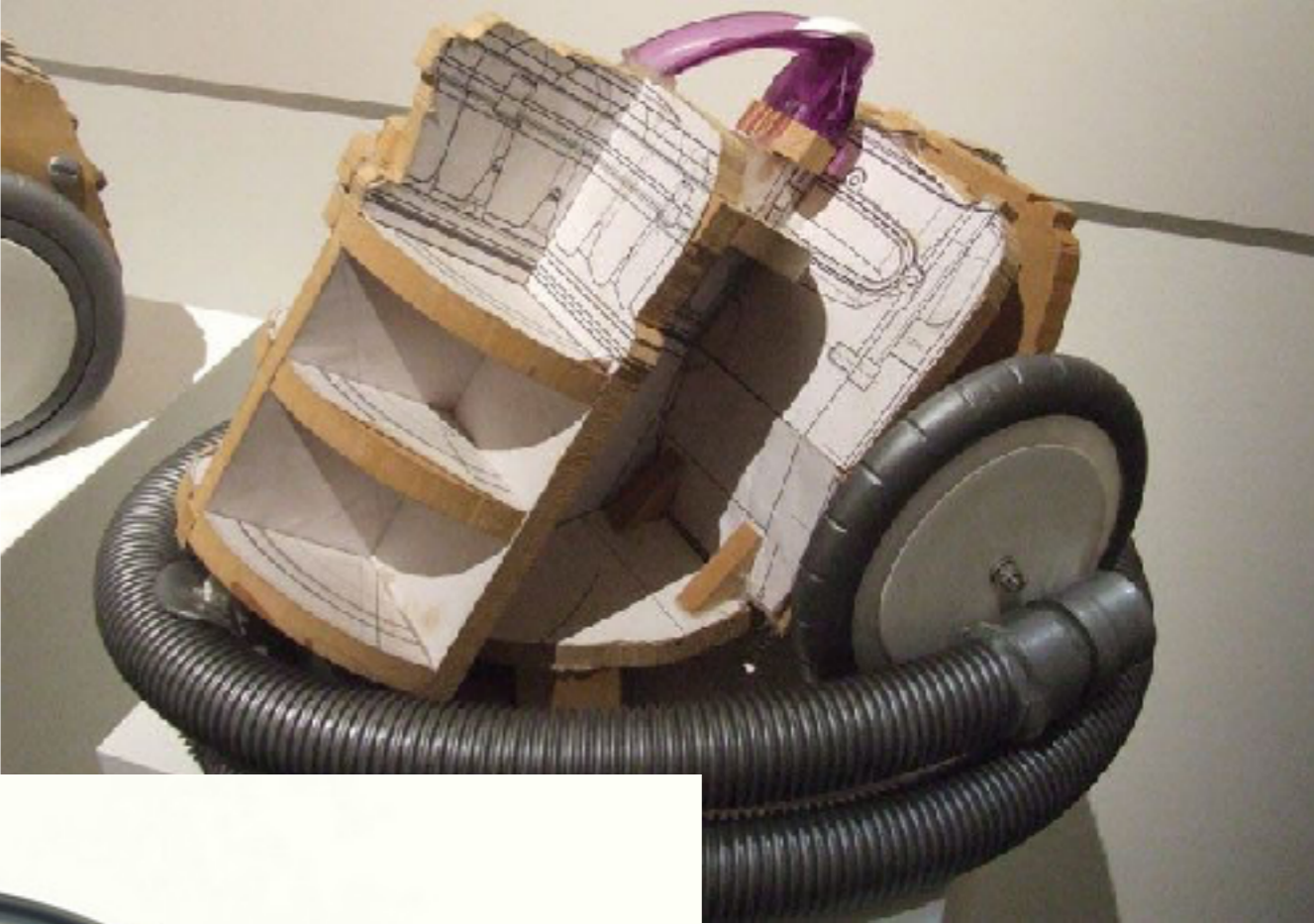
On organized hardware bank is a must



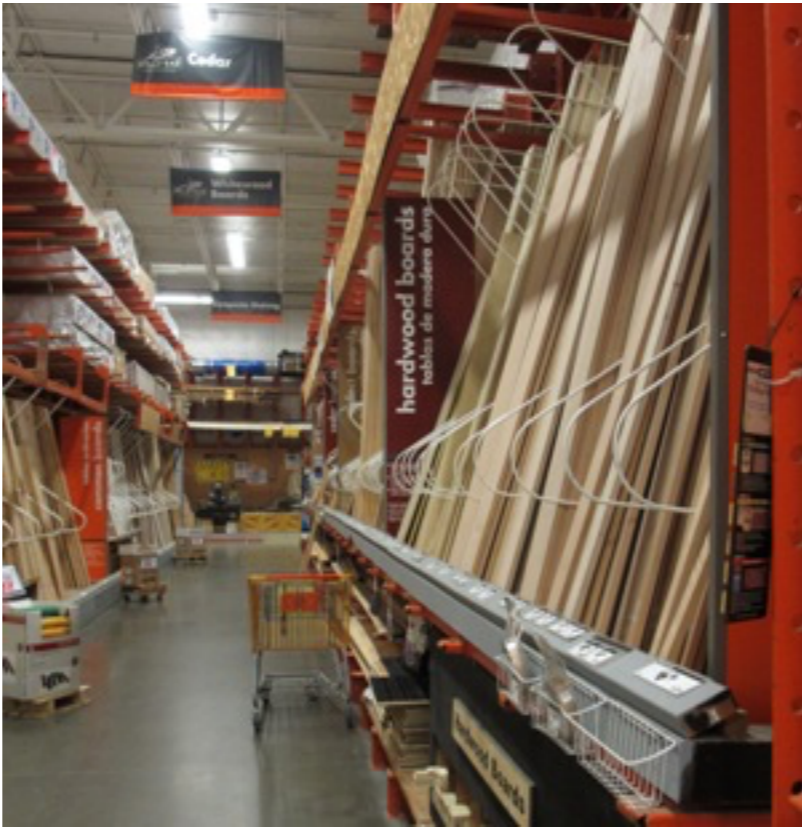
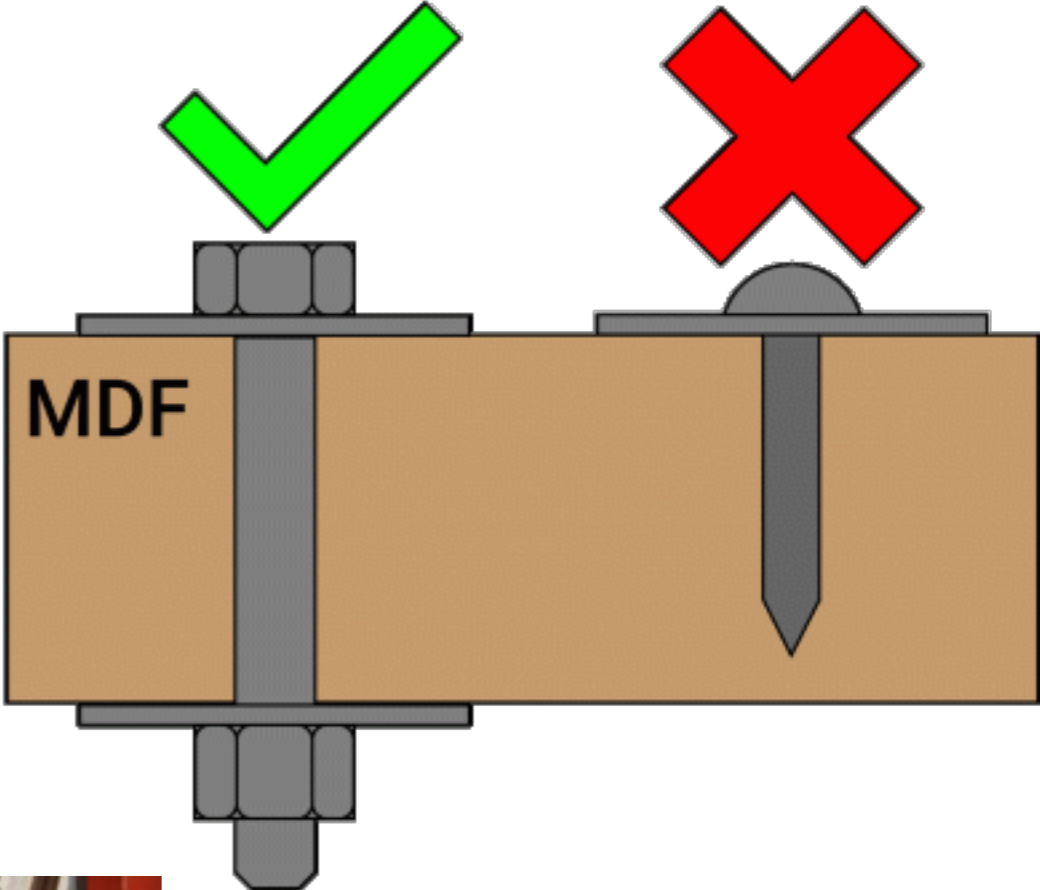
Make lots of paper prototypes



Make lots of paper prototypes



Plywood, MDF, OSB, and others are great starters



Acrylic, Delrin, and other plastics are good to have



If possible keep a selection of metals



Image: brittenstudios.com

Plastic tubing is handy for many tasks



Image: <http://steampunk.wonderhowto.com>

Tapes and glues should be kept around as well



PVC pipe and fittings are great for simple designs

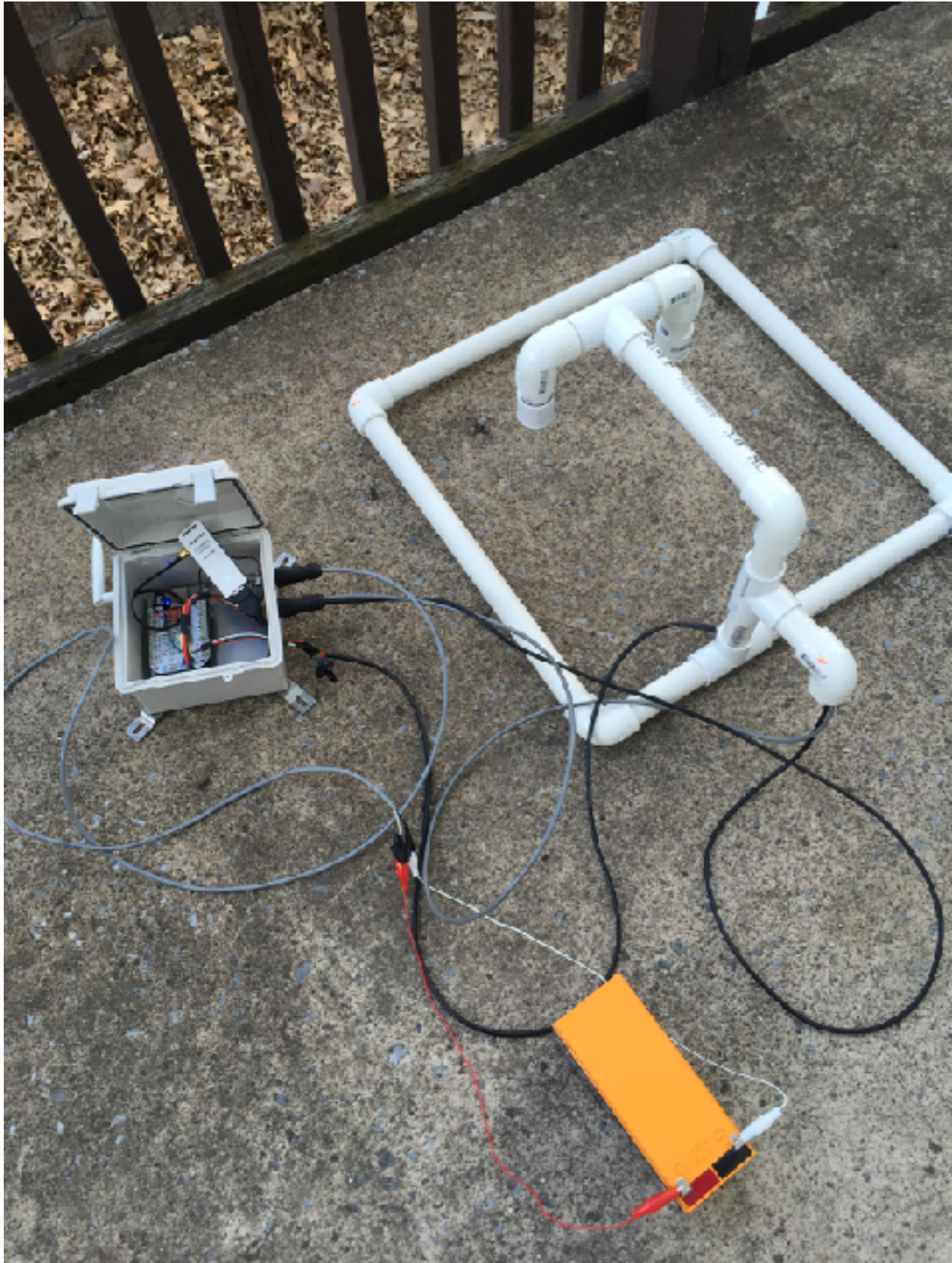


Image: [instructables.com](https://www.instructables.com)

“T-Slot” channel is great for making frames and assemblies



“T-Slot” channel is great for making frames and assemblies



Image: 8020.net

You probably recognize it



Actobotics has a variety of parts



Mounts & Hubs

These parts let you support moving components, interface various structural components, and are the basic building blocks to connecting all Actobotics products together. All hubs and mounts use a unique yet universal hole pattern which allows all the various components to connect together in a variety of configurations.



Structural

Structural parts will provide you with a strong framework for your project. Channels, brackets, beams and more keep your project rigid while also giving you multiple attachment points for expansion.

Actobotics has a variety of parts



Gears/Pulleys/Sprockets

Transferring power can be tricky, but we have all the gears, pulleys, and sprockets to get the power where you need it. Best of all, you don't have to worry about spacing or getting things lined up perfectly, the hole patterns take care of that for you.



Shafts & Tubing

Shafts and Tubing are used to either form rigid structure, or drive-shafts for wheels, servos, levers, and more. Most tubes are also wide enough to accommodate a multitude of wires to keep your Actobotics project tidy.

Actobotics has a variety of parts



Hardware

Hardware is what will keep your Actobotics project together. Here you will find a variety of screws, couplers, and collars to secure everything nice and tight.



DC Motors

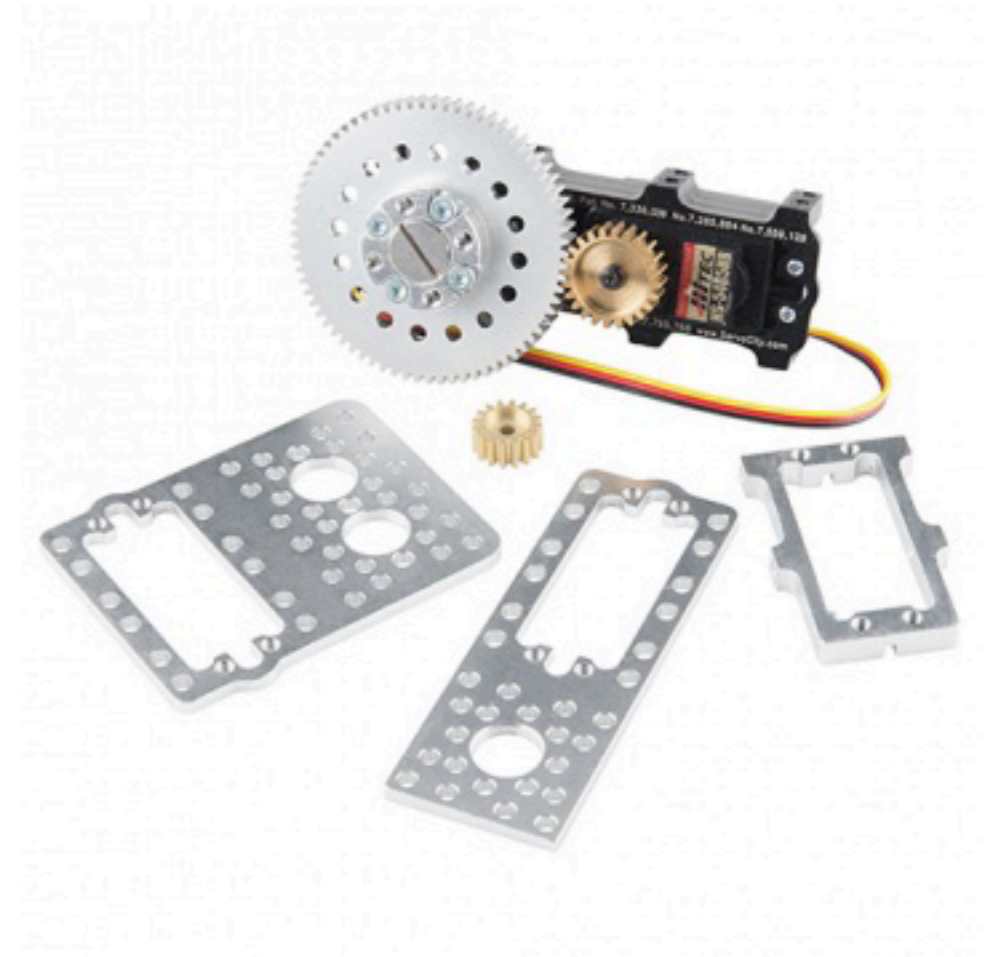
These are the perfect DC Motors for any Actobotics project that needs to get moving. Gears and sprockets would be nothing without these micro, standard, and precision gearmotors!

Actobotics has a variety of parts



Wheels

This selection of Wheels should have something for just about anyone. From the big 6" heavy duty wheel, 4.9" skate wheels, to the various sizes and colors of precision disc wheels, there's a lot to choose from.



Servo Accessories

Servo motors are essential in most robotic applications. We have a wide range of accessories from mounts, gears, and housings to make using them quicker and easier.

Where to buy materials

- Hardware store
- Amazon
- McMaster Carr
- Granger
- sidecuts.com
- tapplastics.com
- EBay
- Sparkfun, Adafruit, Pololu

Things to do

- Go walk through the hardware store
- Look at how things are made
- Start hoarding parts
- Get McMaster, MSC, Granger, etc catalogs
- Page through those catalogs when you can
- Follow Blogs



Activity: Look up and list things you can use for your project

