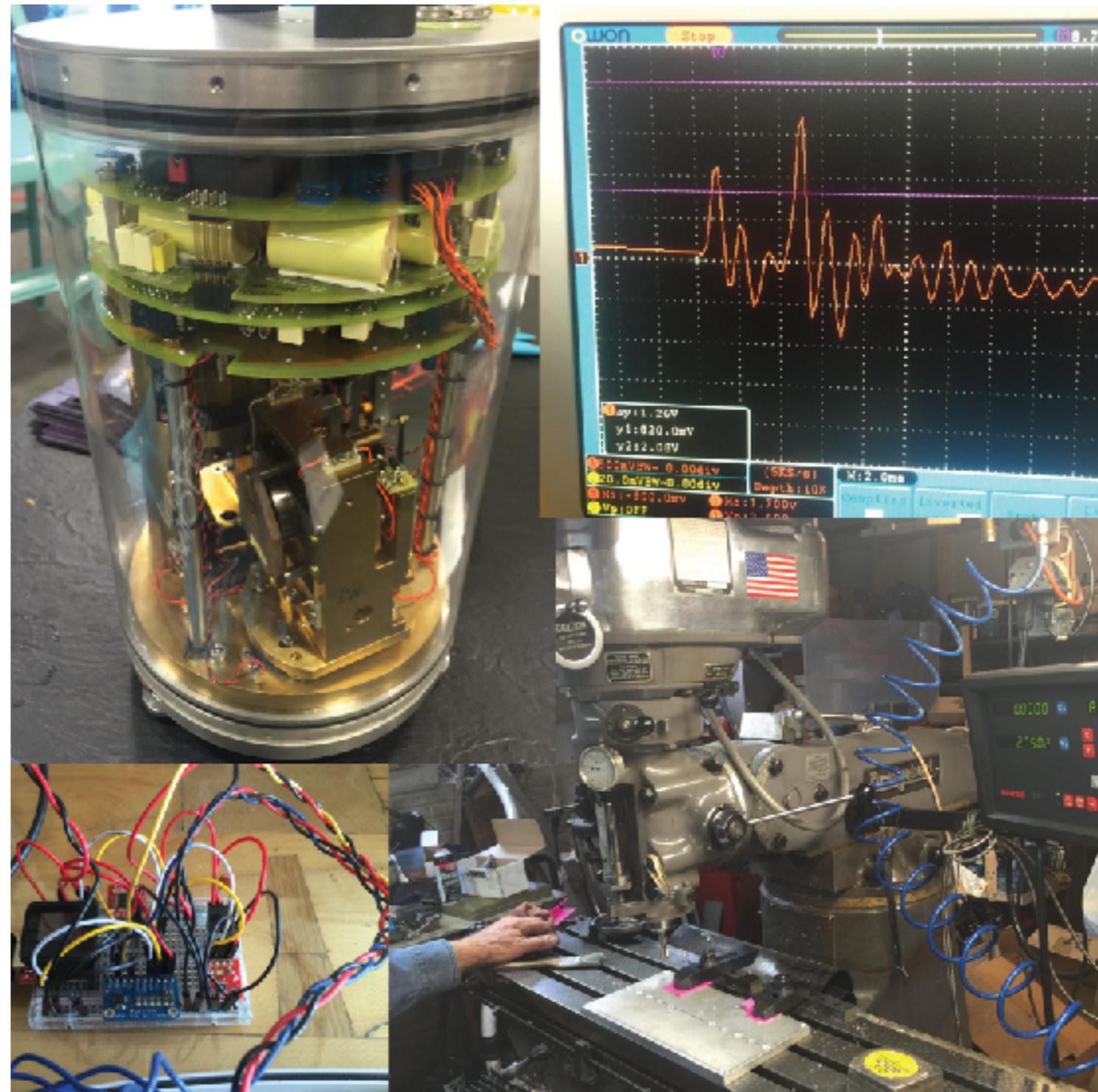


# Principles of Mechanical Design

J.R. Leeman and C. Marone

Techniques of Geoscientific  
Experimentation

September 29, 2016



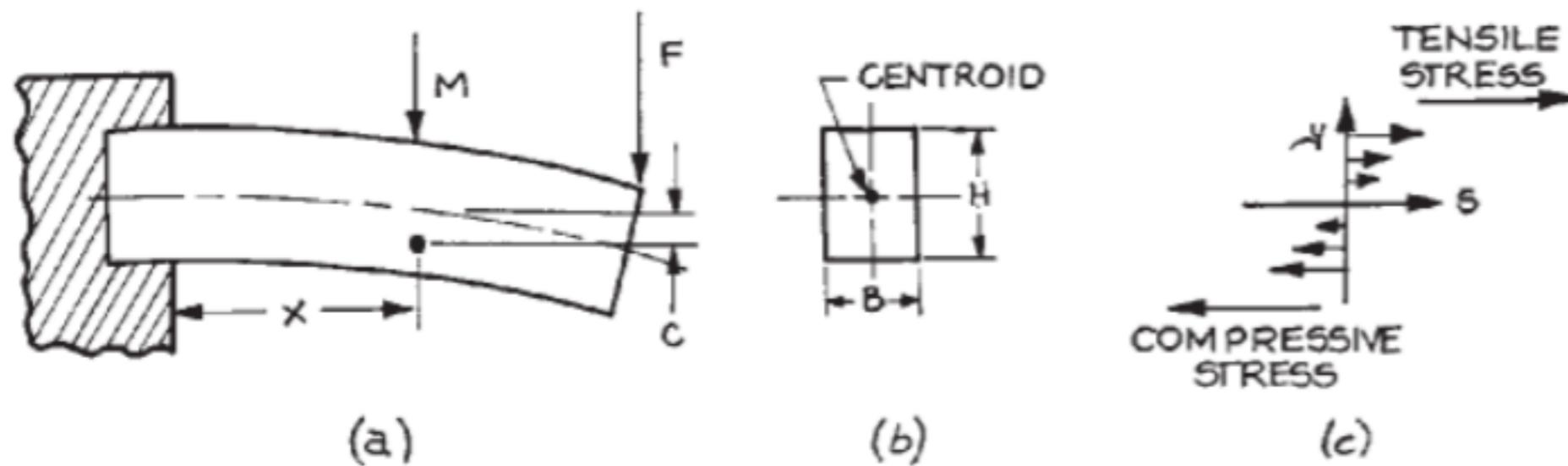
Much like there are standard software design patterns, there are common and test solutions to mechanical problems



# 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

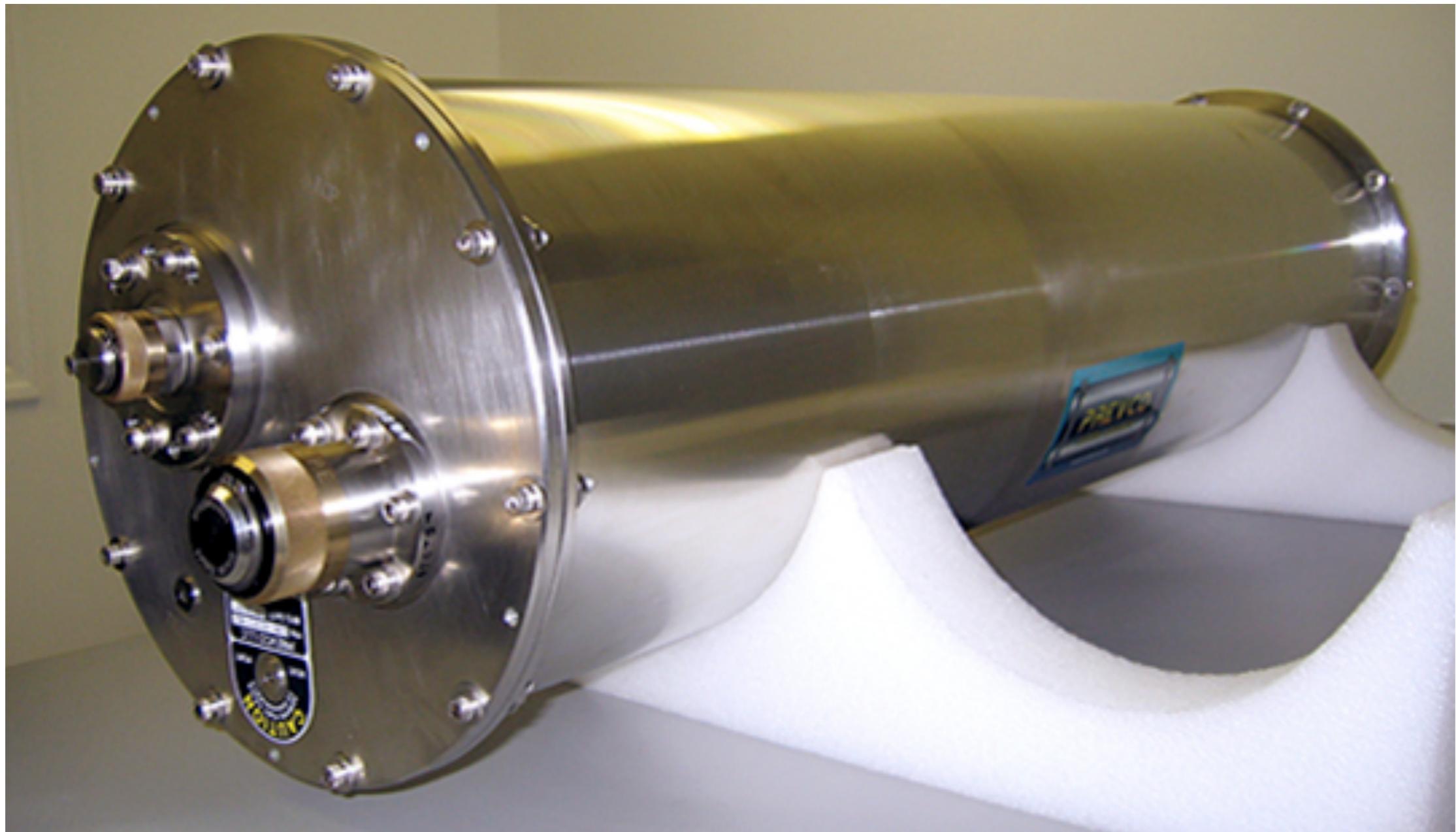


**Figure 1.48** A flexed beam: (a) the beam bending under a load; (b) a cross section showing the centroid; (c) the distribution of shear forces along the long axis of the beam.

# Internal pressure stresses are common in laboratory equipment



# External pressure stresses are common in field equipment



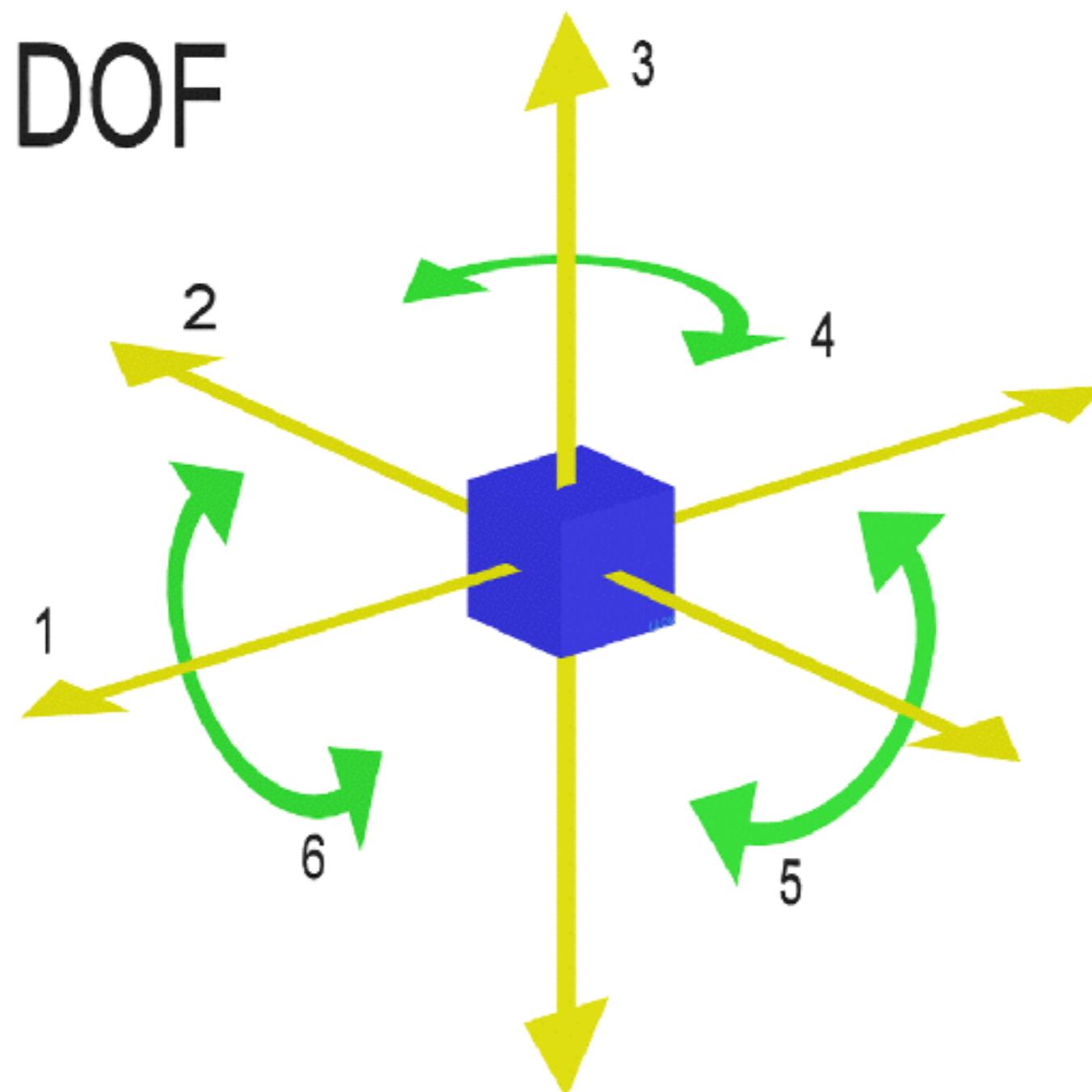
# External pressure stresses are common in field equipment



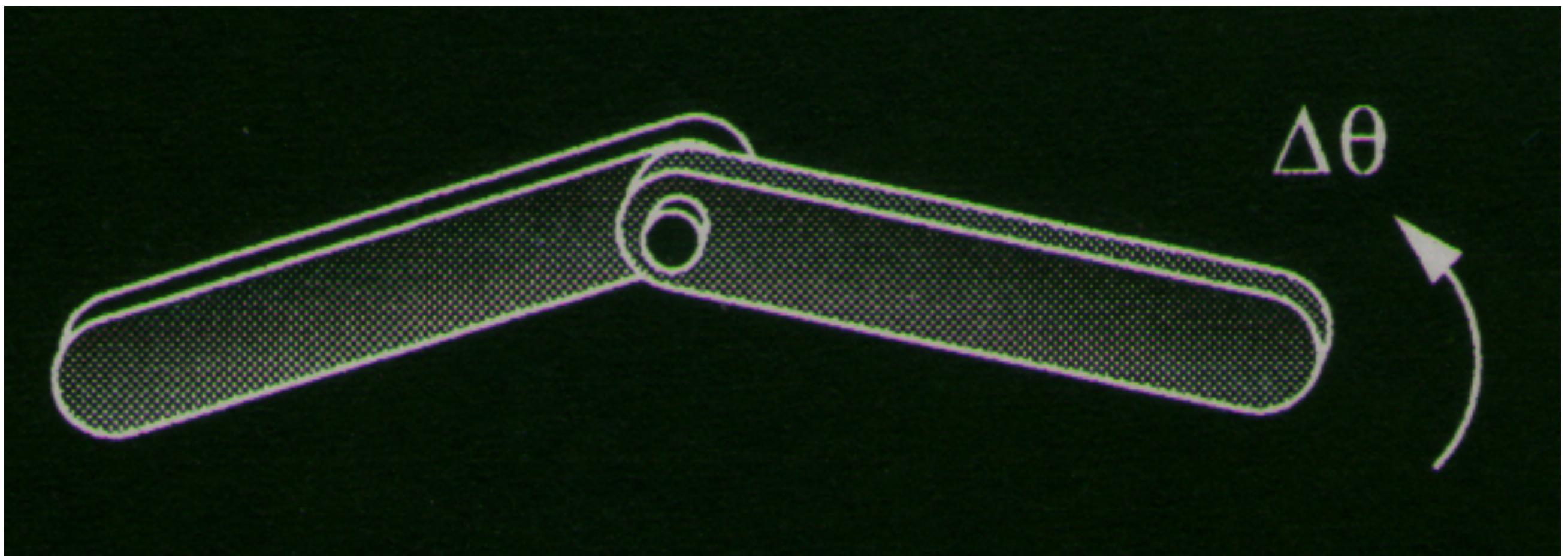
# Vibration causes failure in structures of all sizes



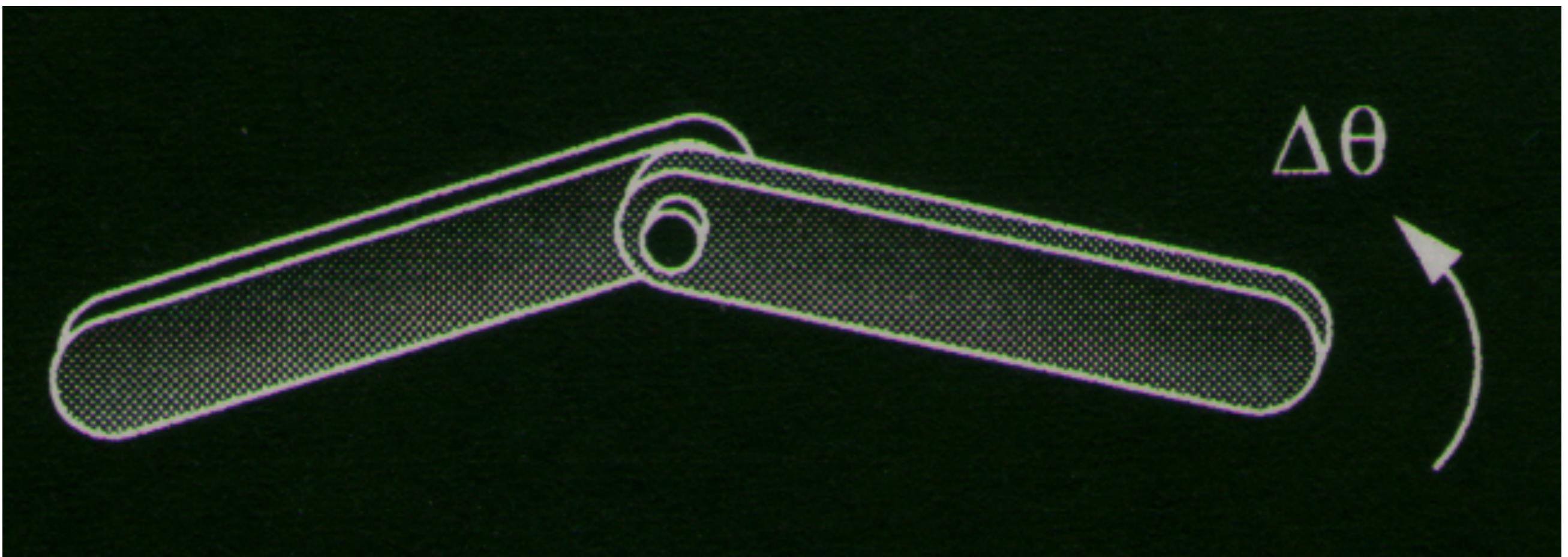
The position of an object can be described by a 6 DOF system



# How many DOF?



# How many DOF?



1

How many DOF?



How many DOF?



3

# How many DOF?

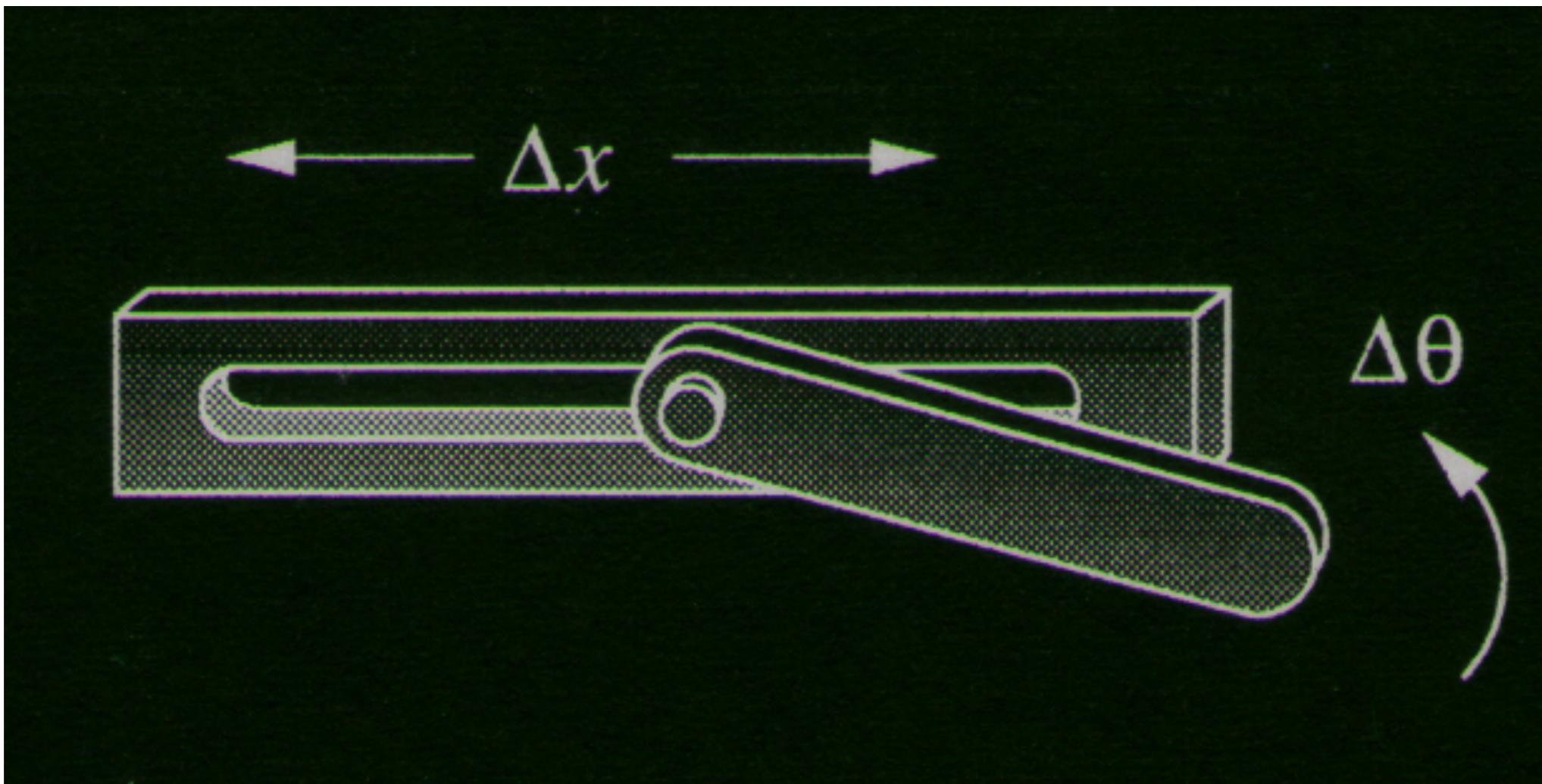


# How many DOF?

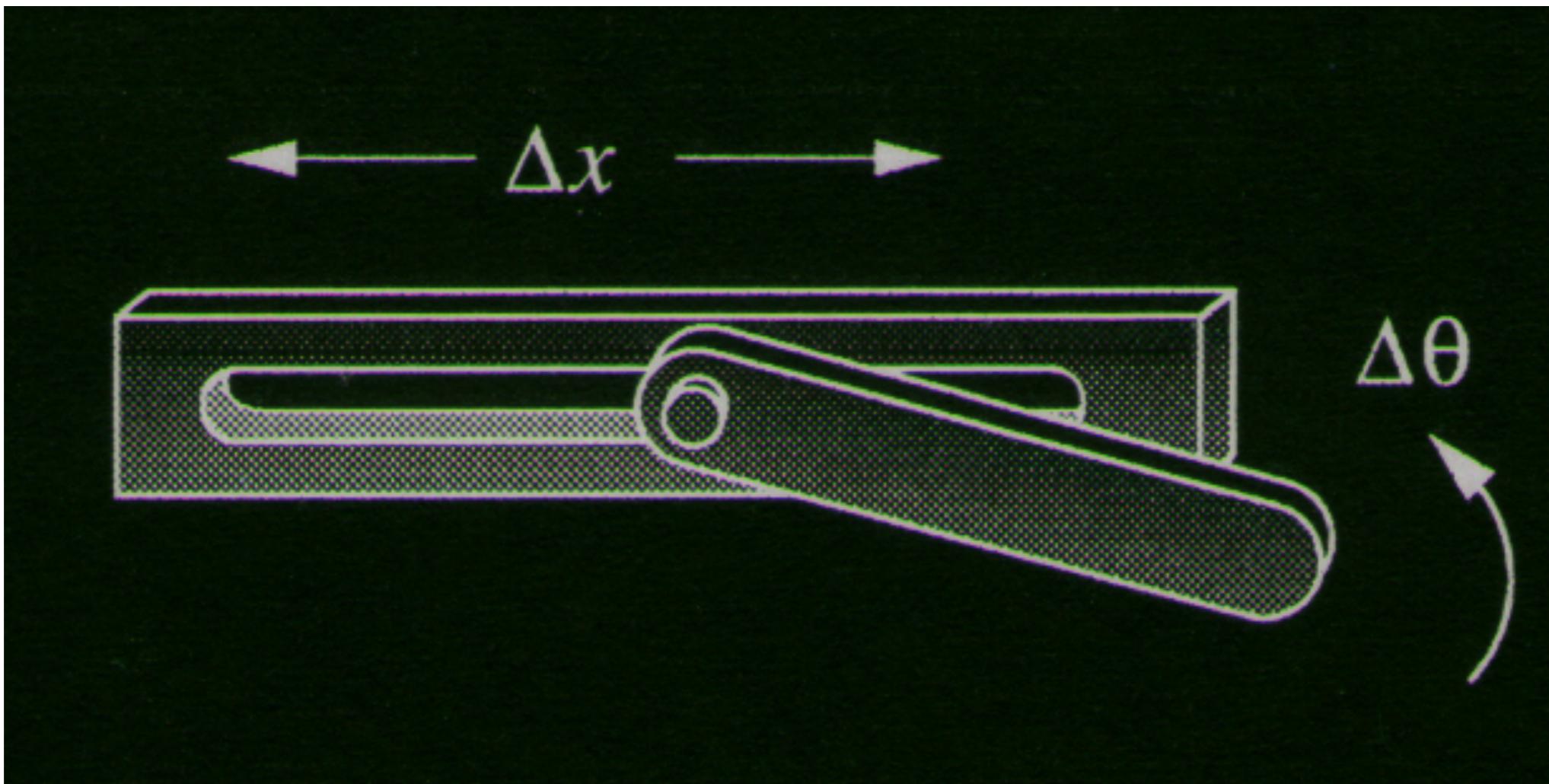


3

# How many DOF?

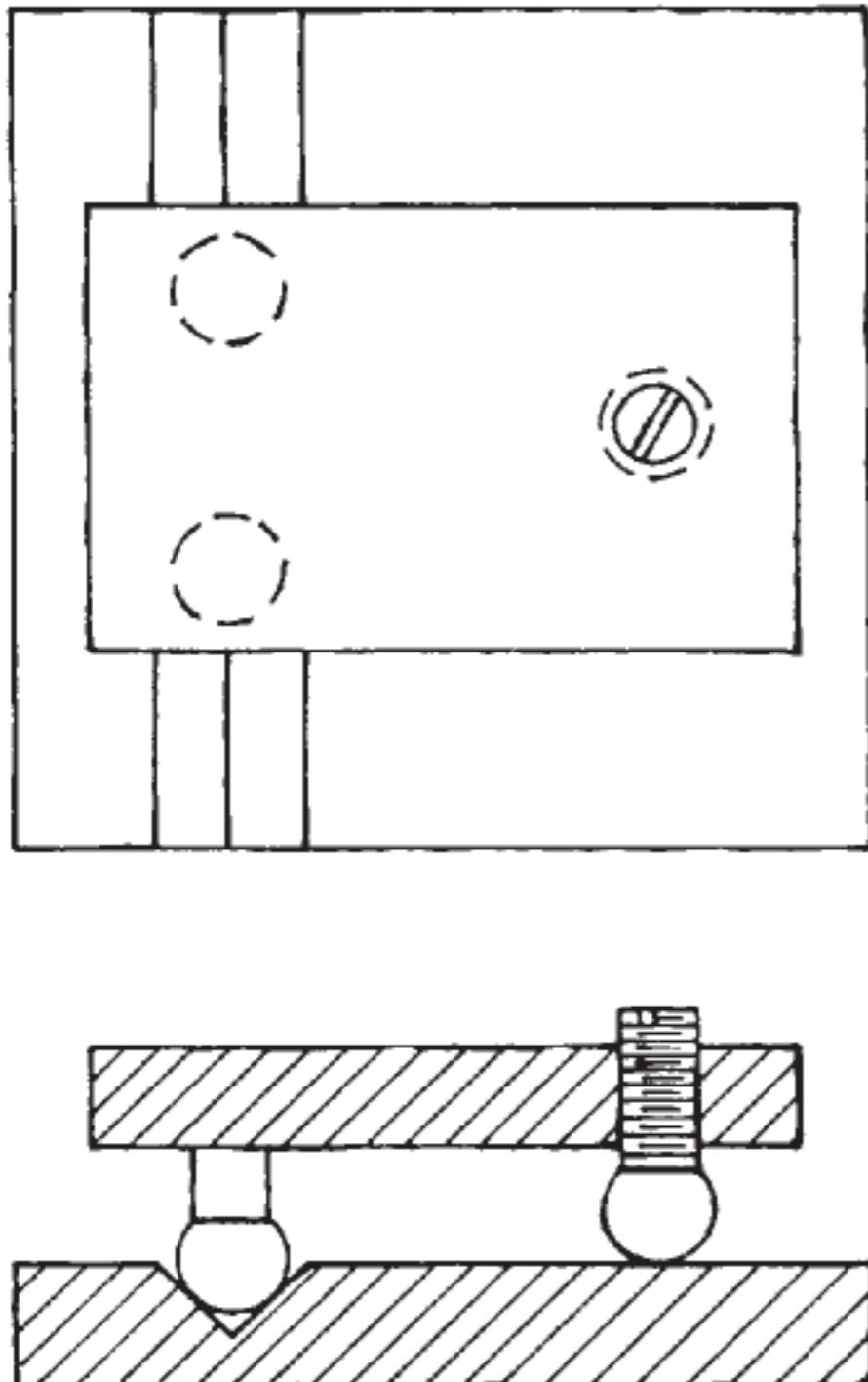


# How many DOF?



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.

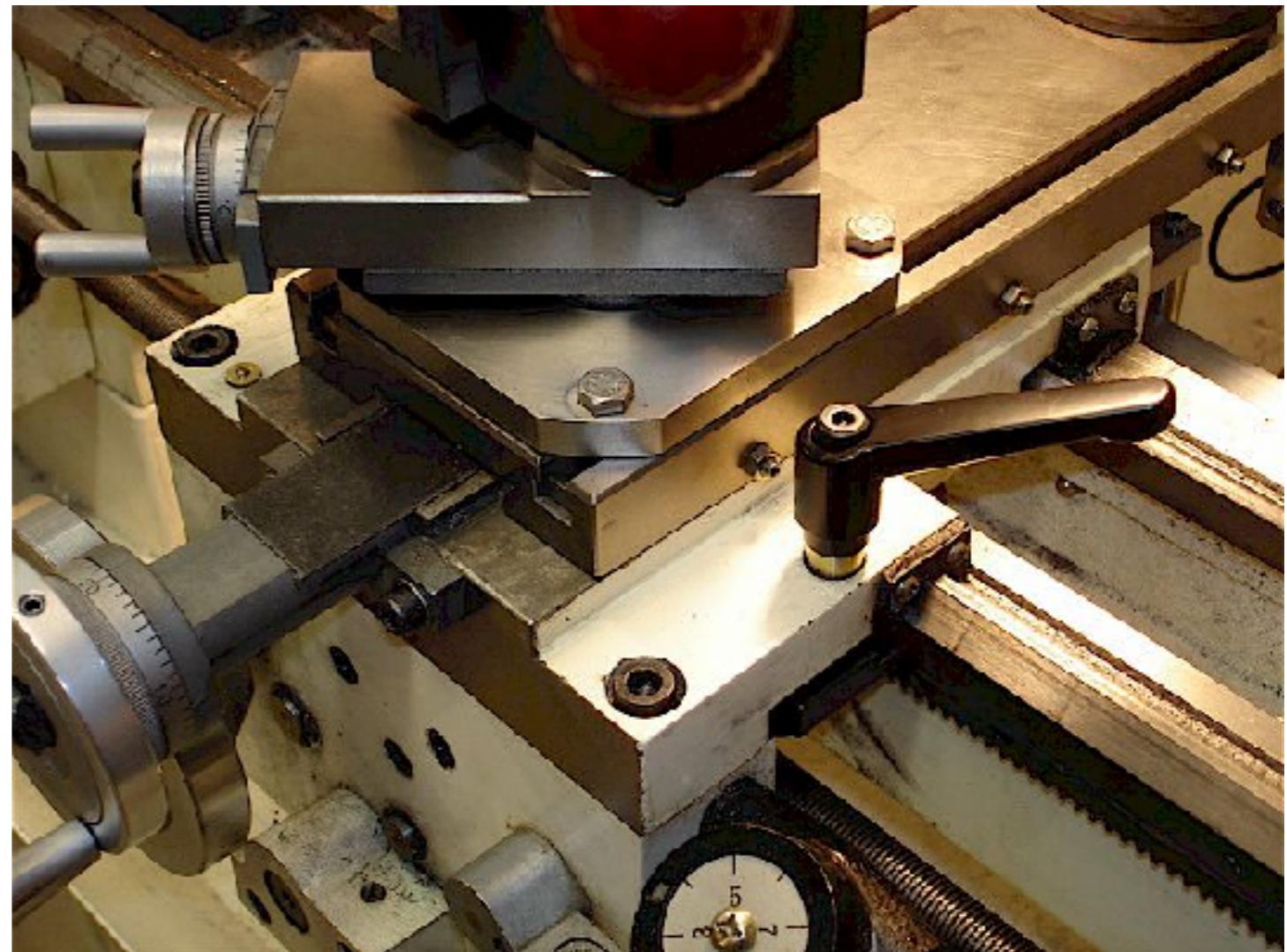
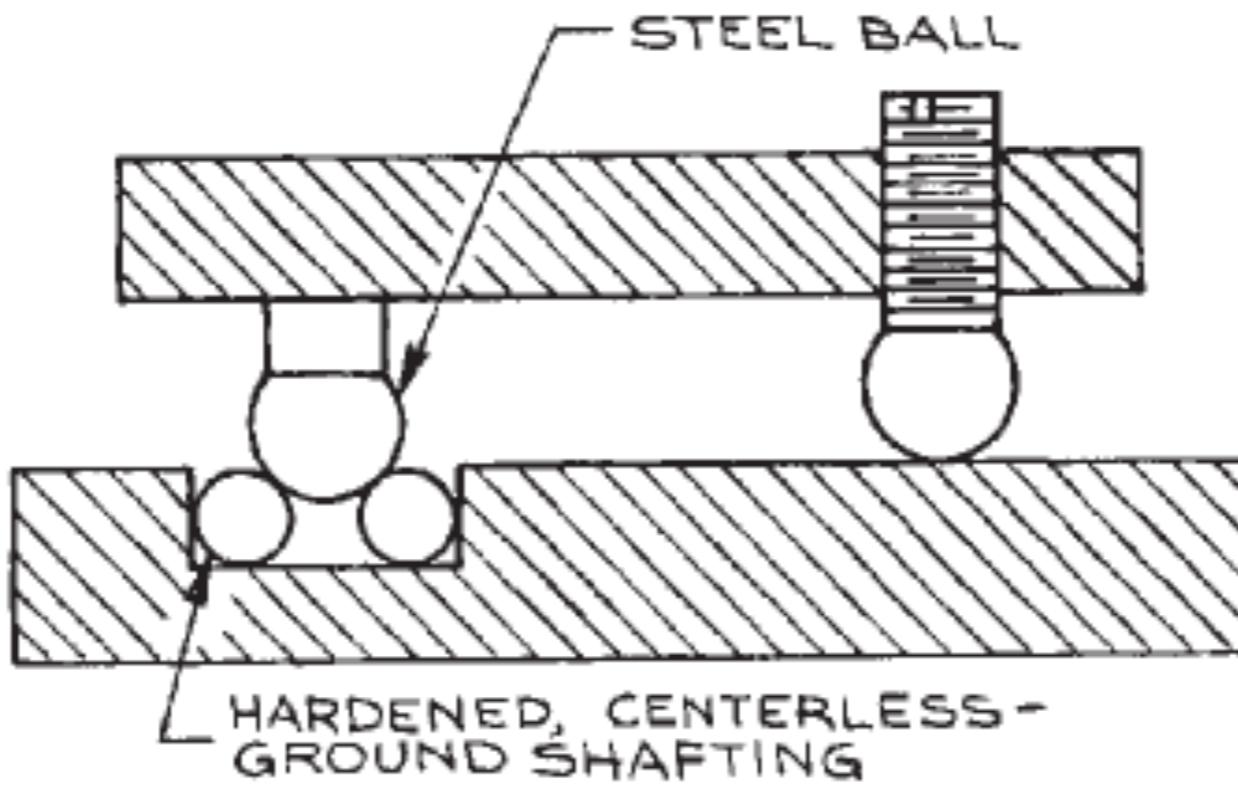


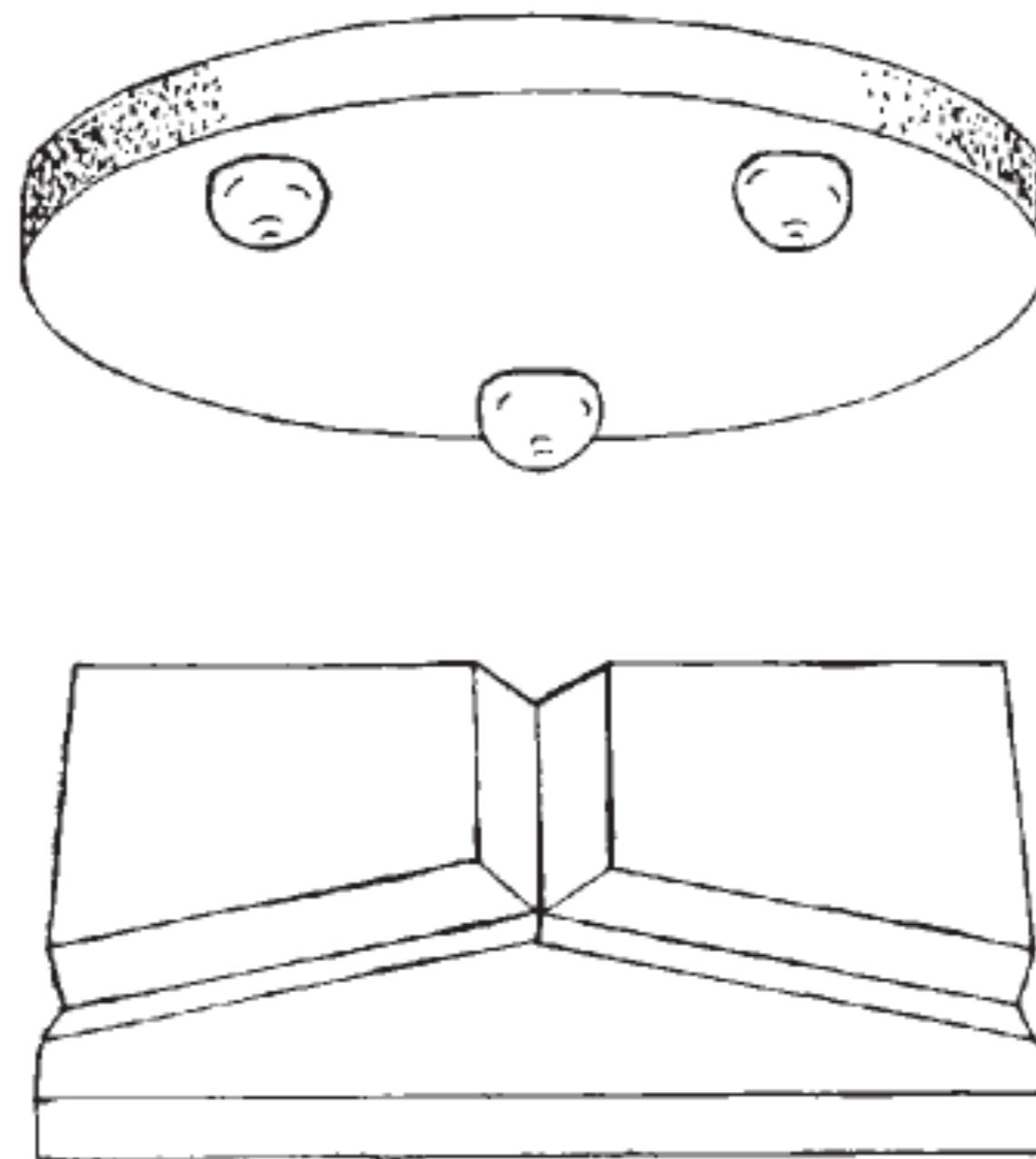
Image: [mico-machine-shop.com](http://mico-machine-shop.com)

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](#).

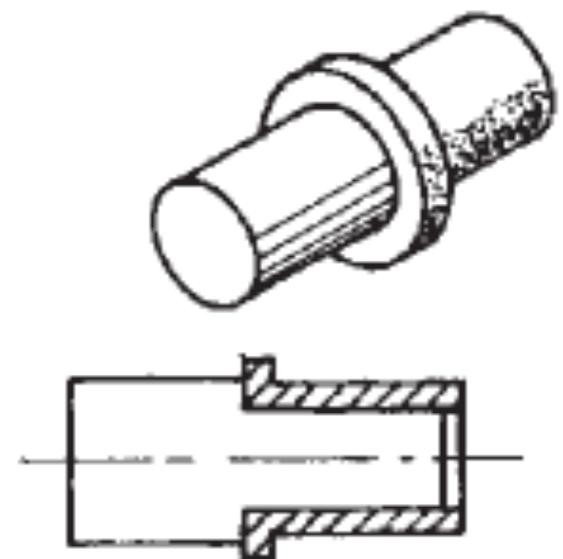
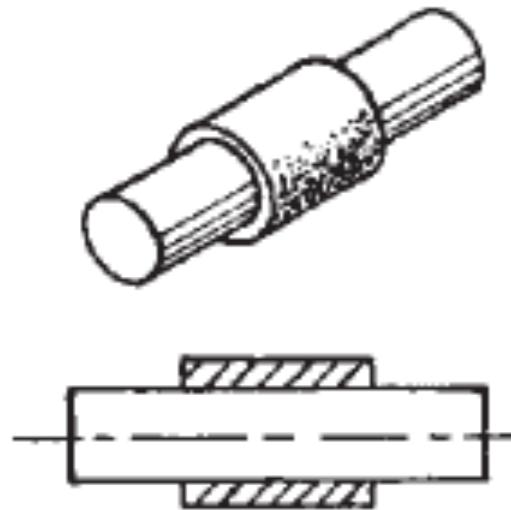
**Good design practices make it possible to precisely place and locate parts**



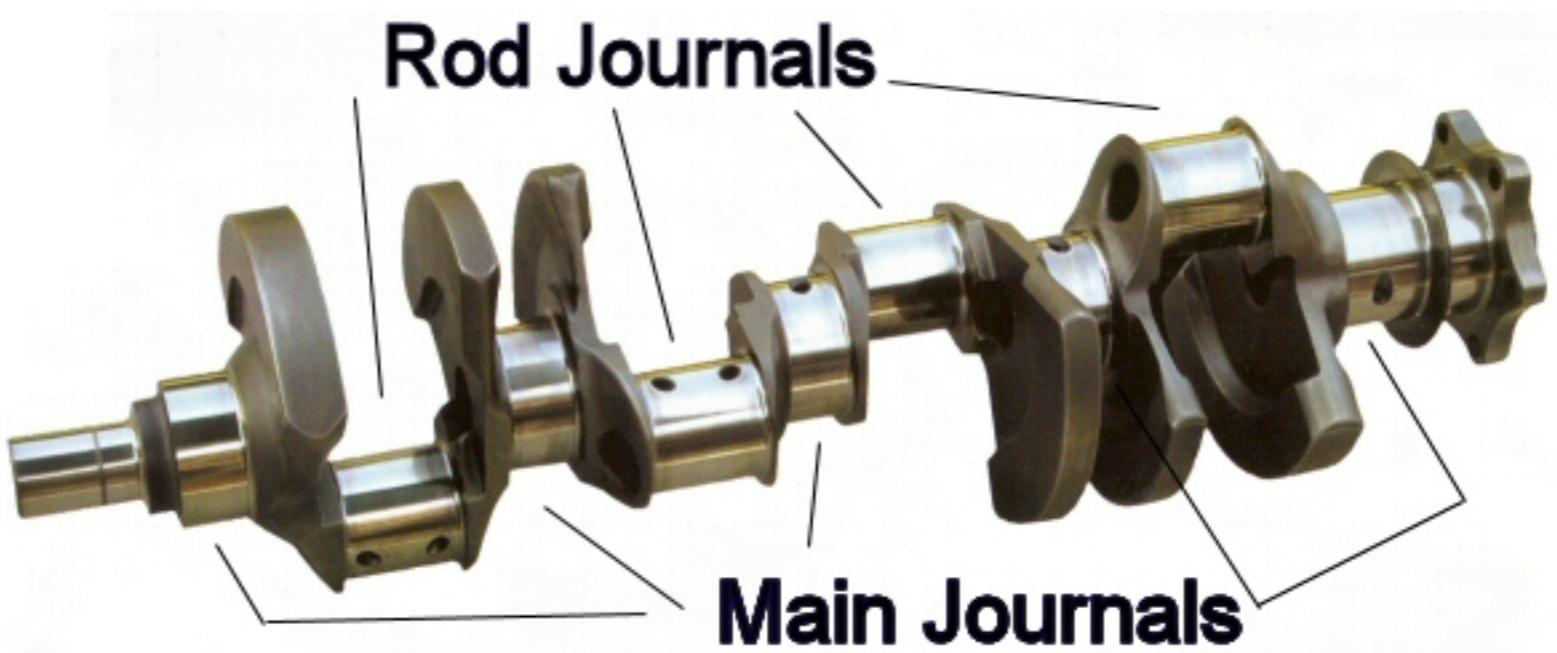
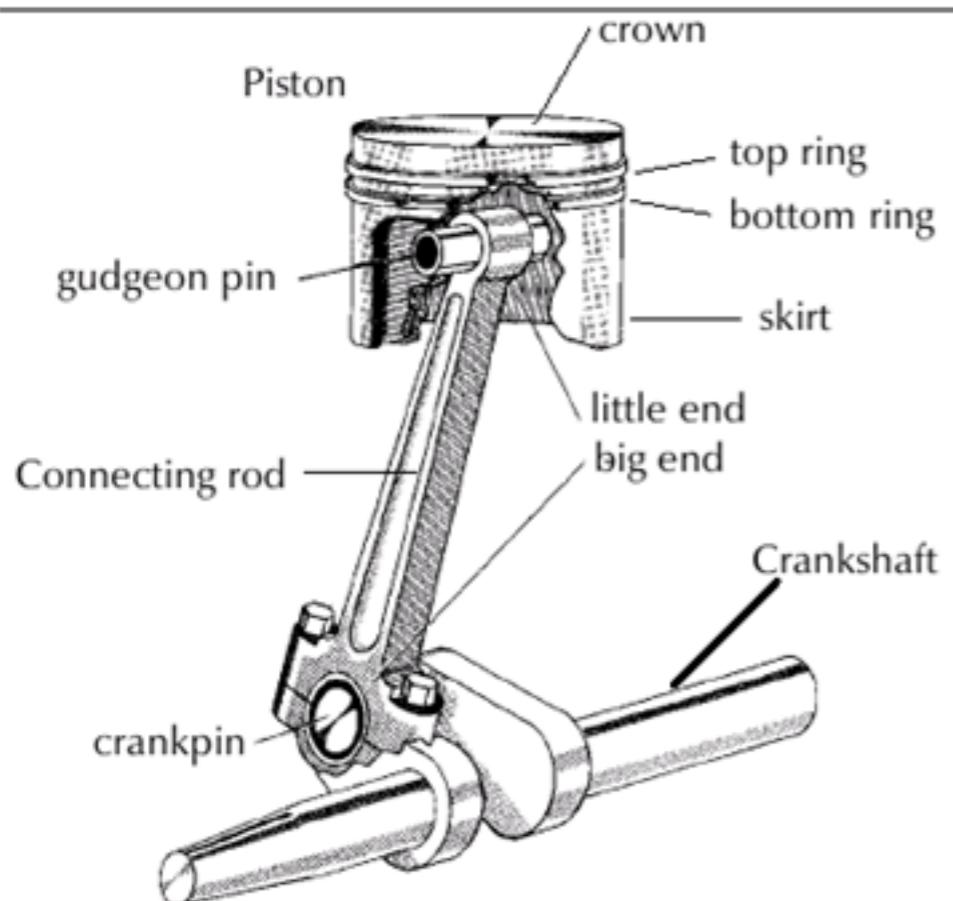
We use bearings to reduce wear and friction on moving parts



# Journal bearings are good for low - high speed applications



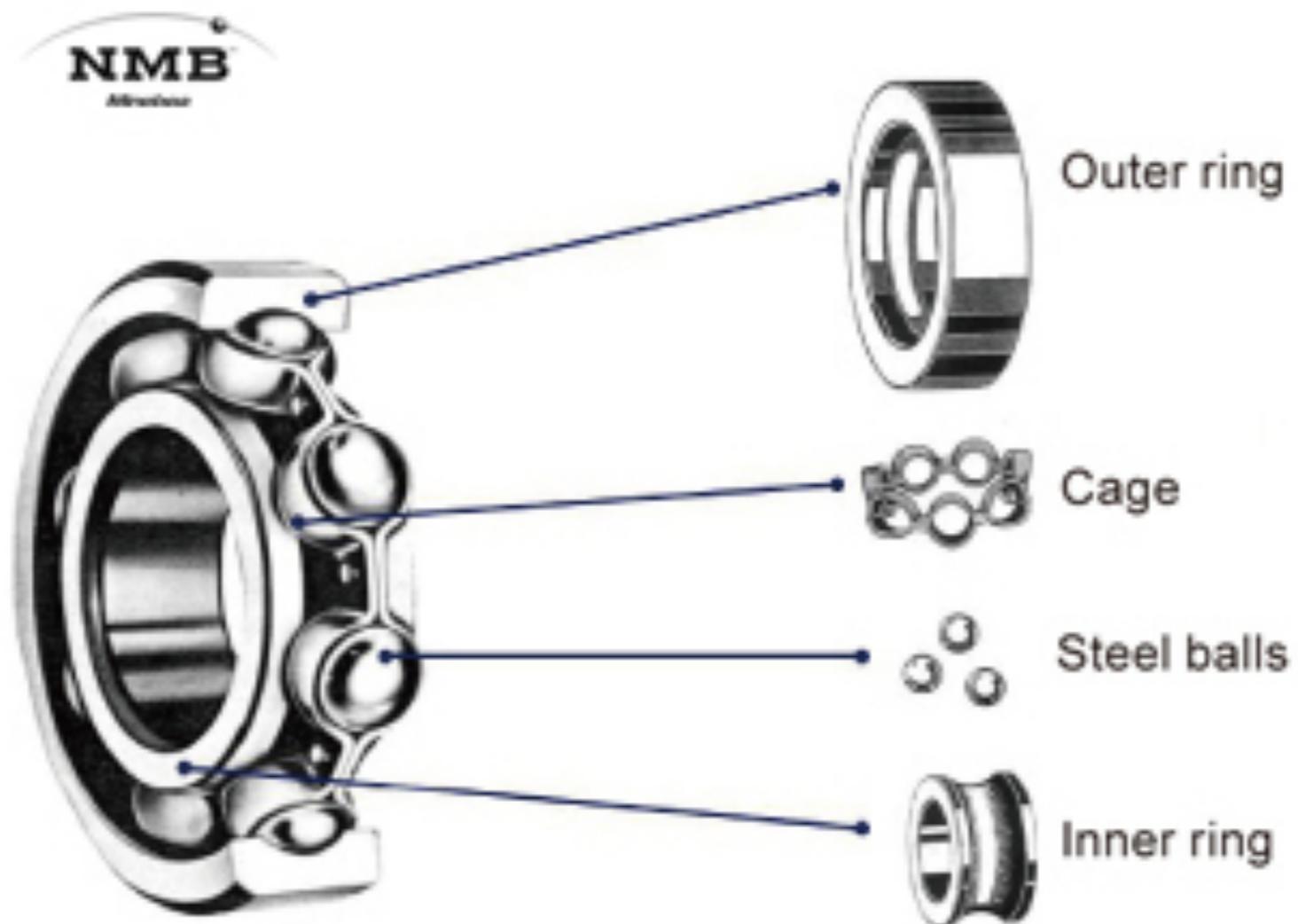
# We use journal bearings every day



# Rolling bearings have good speed characteristics and friction



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

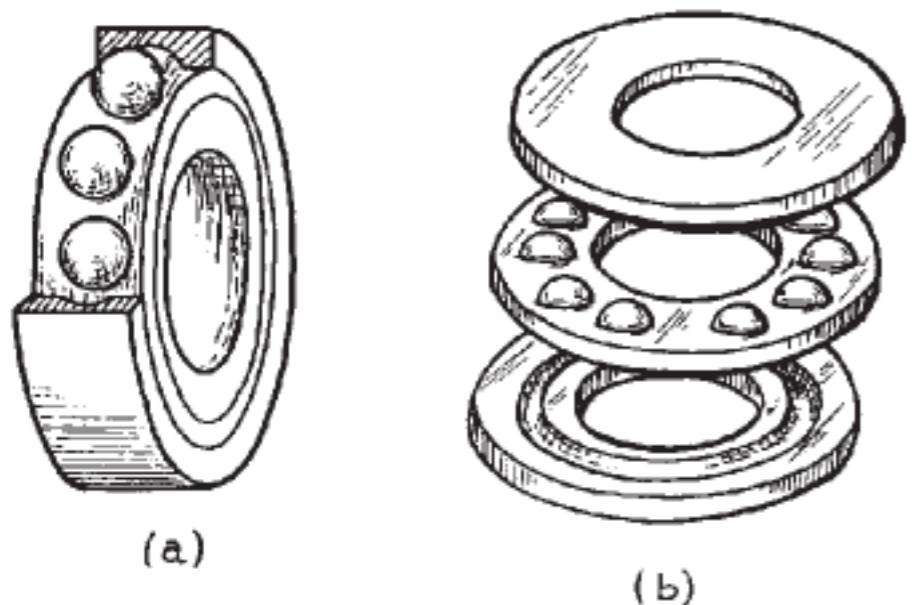


**Roller bearings are common in many assemblies**



wiseGEEK

# Thrust bearings accommodate axial loads



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

Image: Building Scientific Apparatus

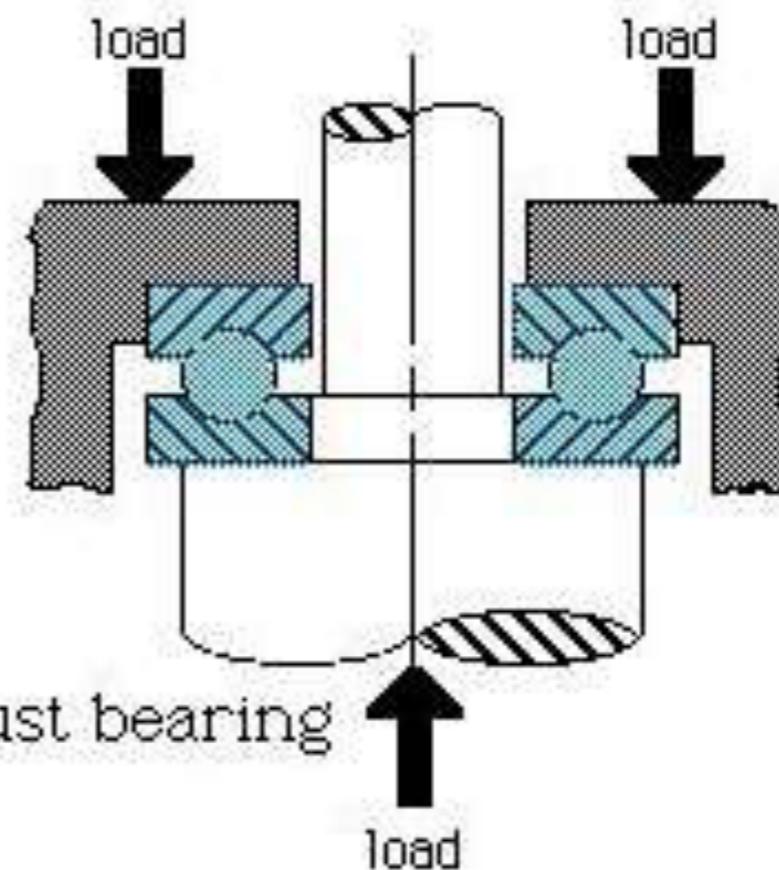
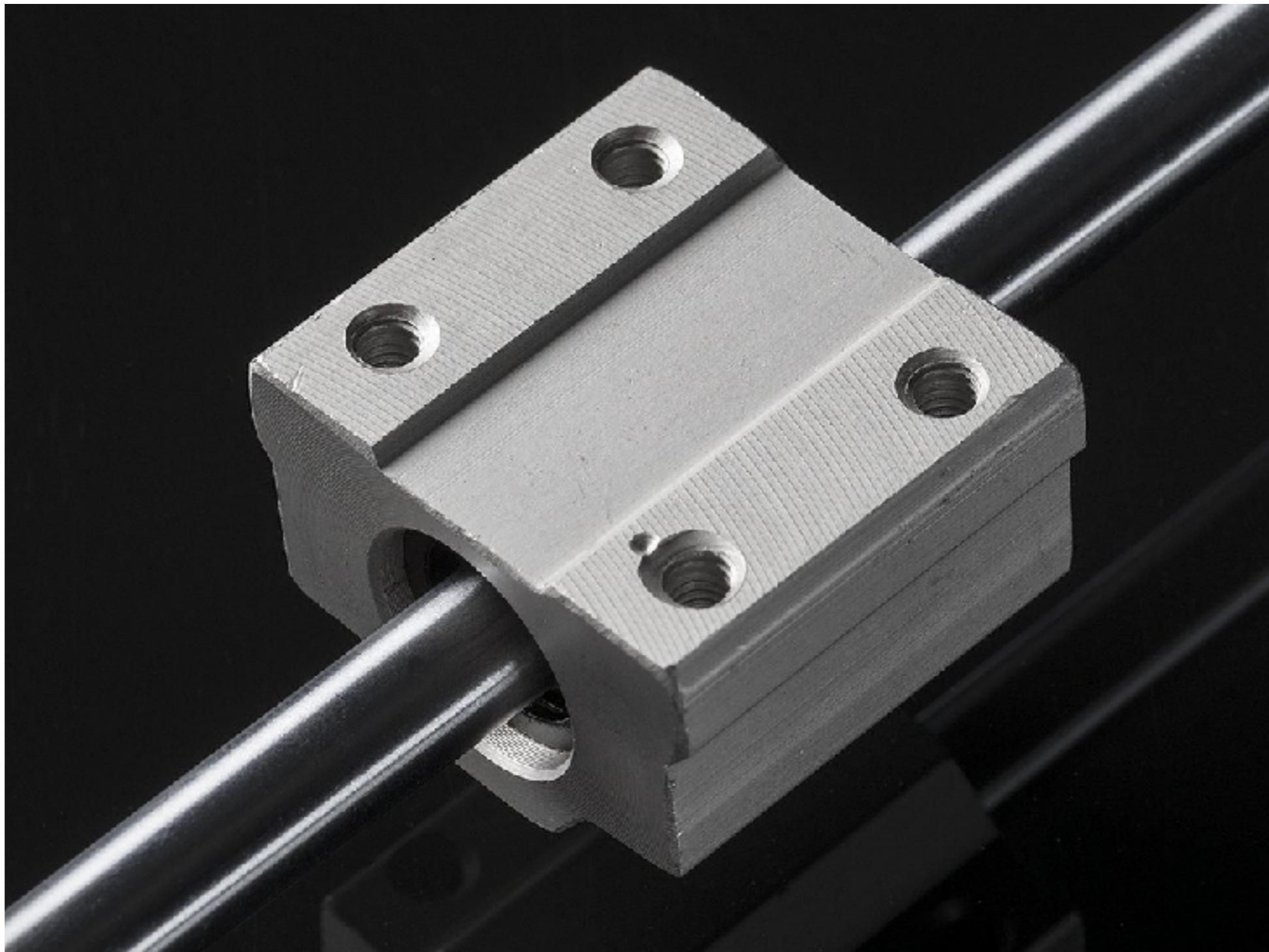


Image: <http://stemeducationreferences.pbworks.com>

**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

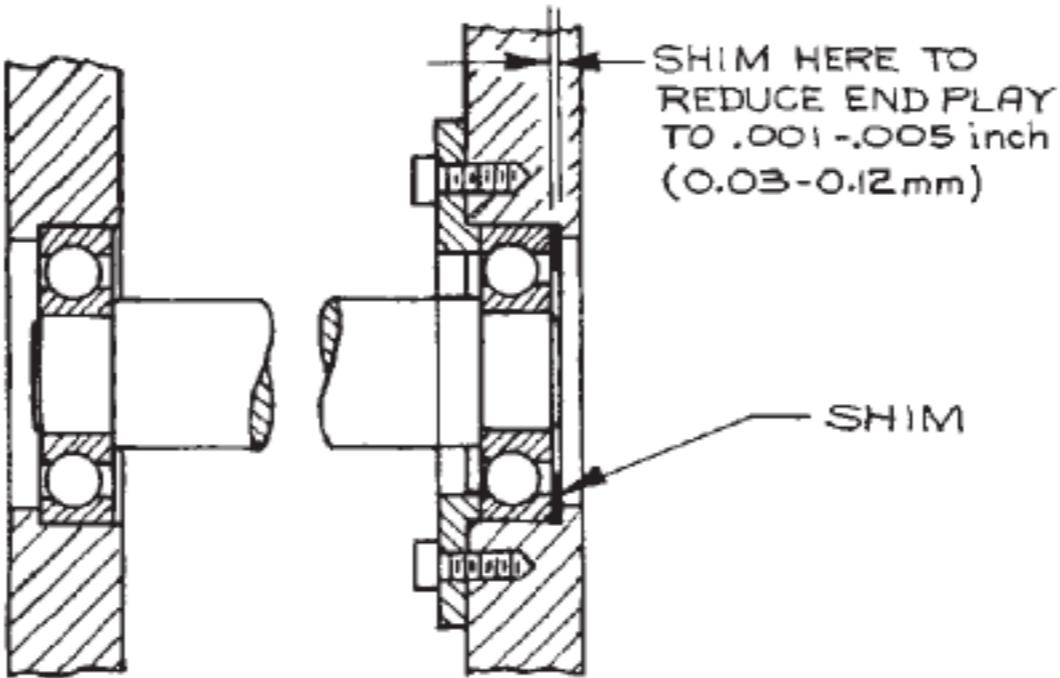
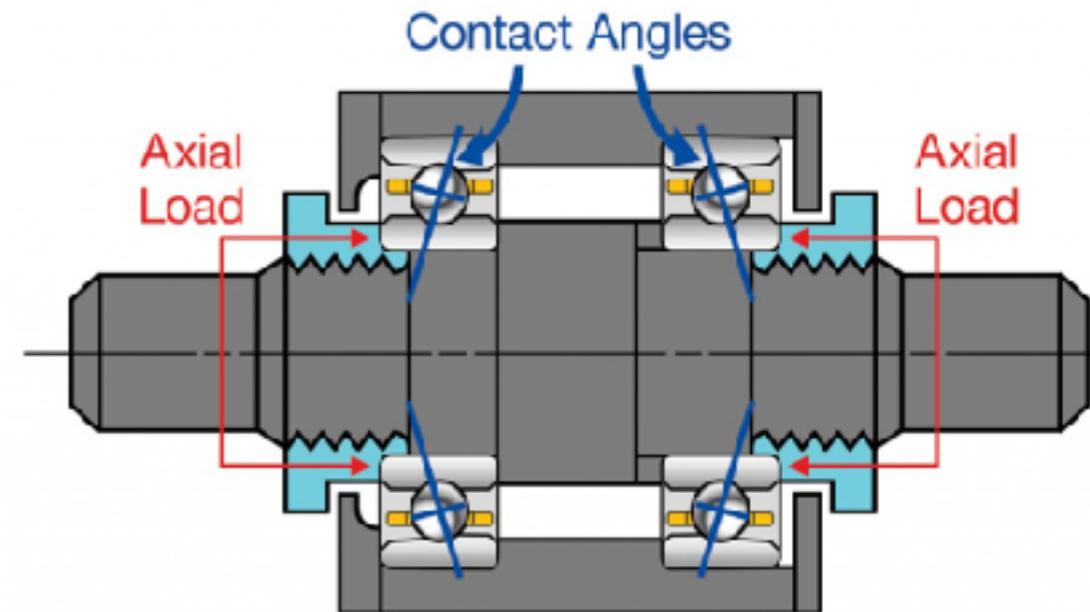
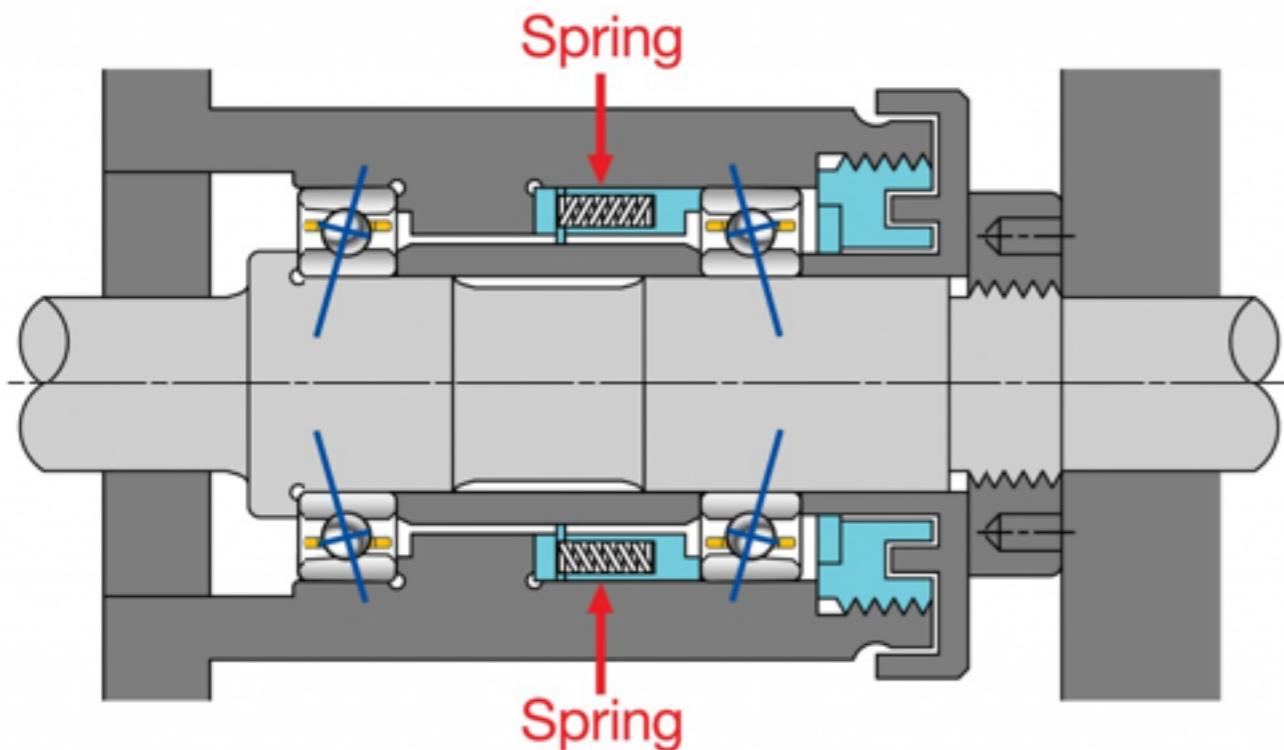
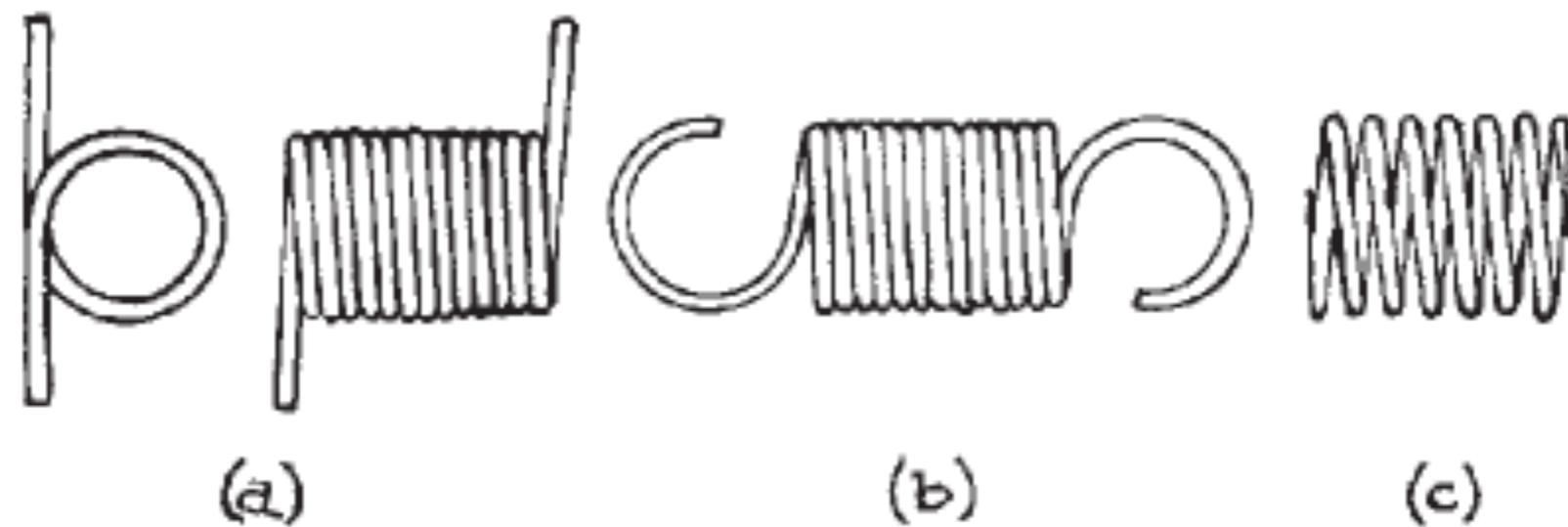


Figure 1.59 Installation of a shim to remove end play in a shaft mounted on ball bearings.

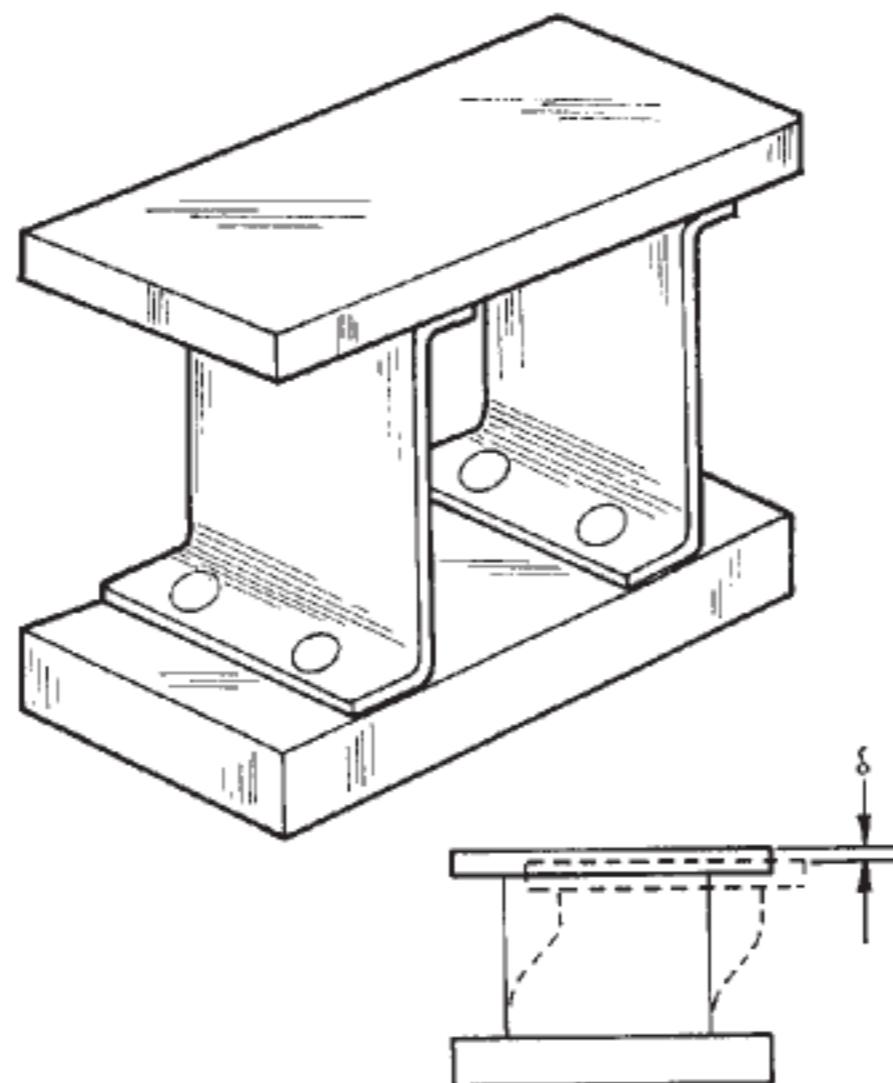


# Springs can apply torsion, tension, or compression to parts



**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.

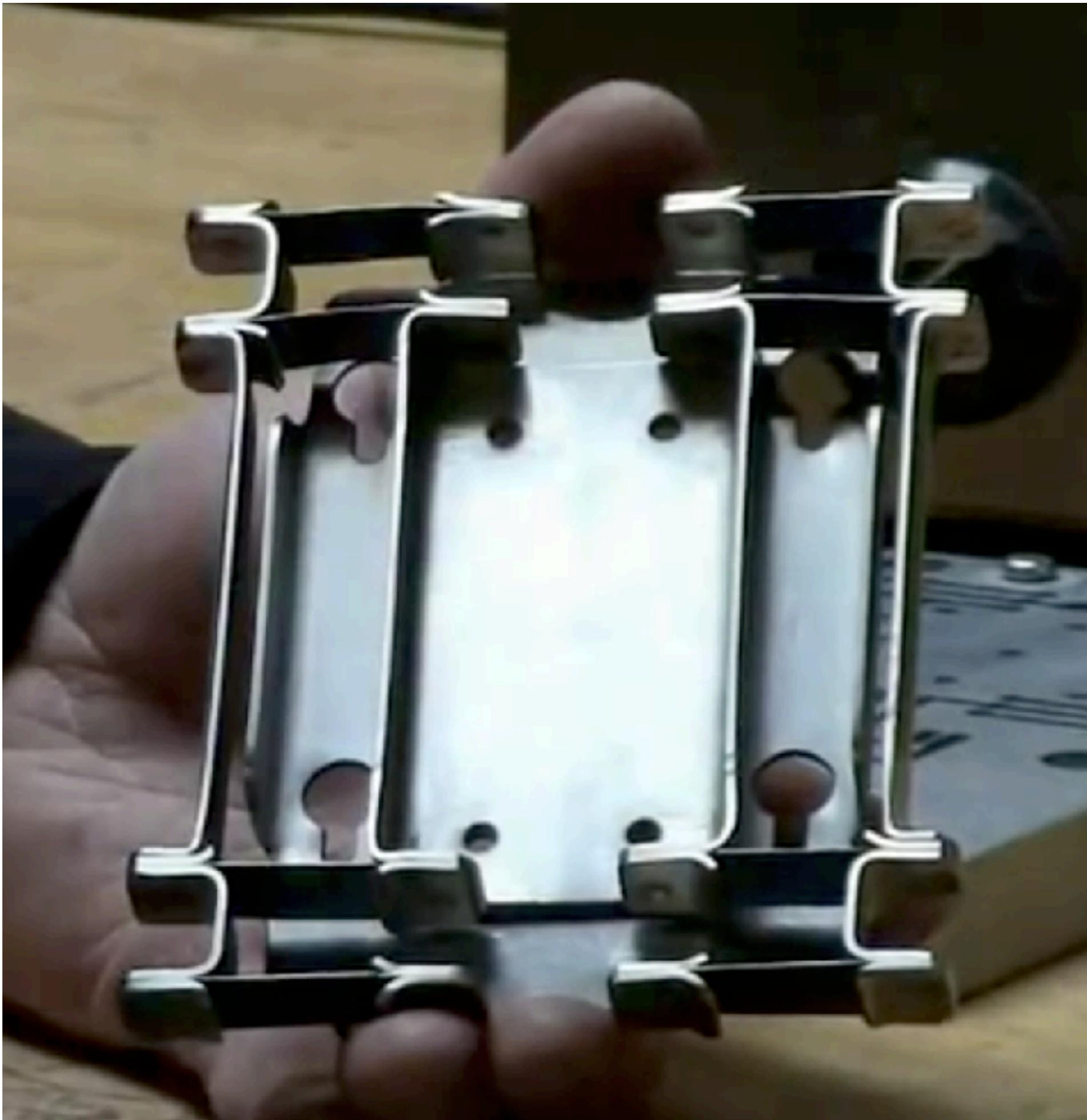
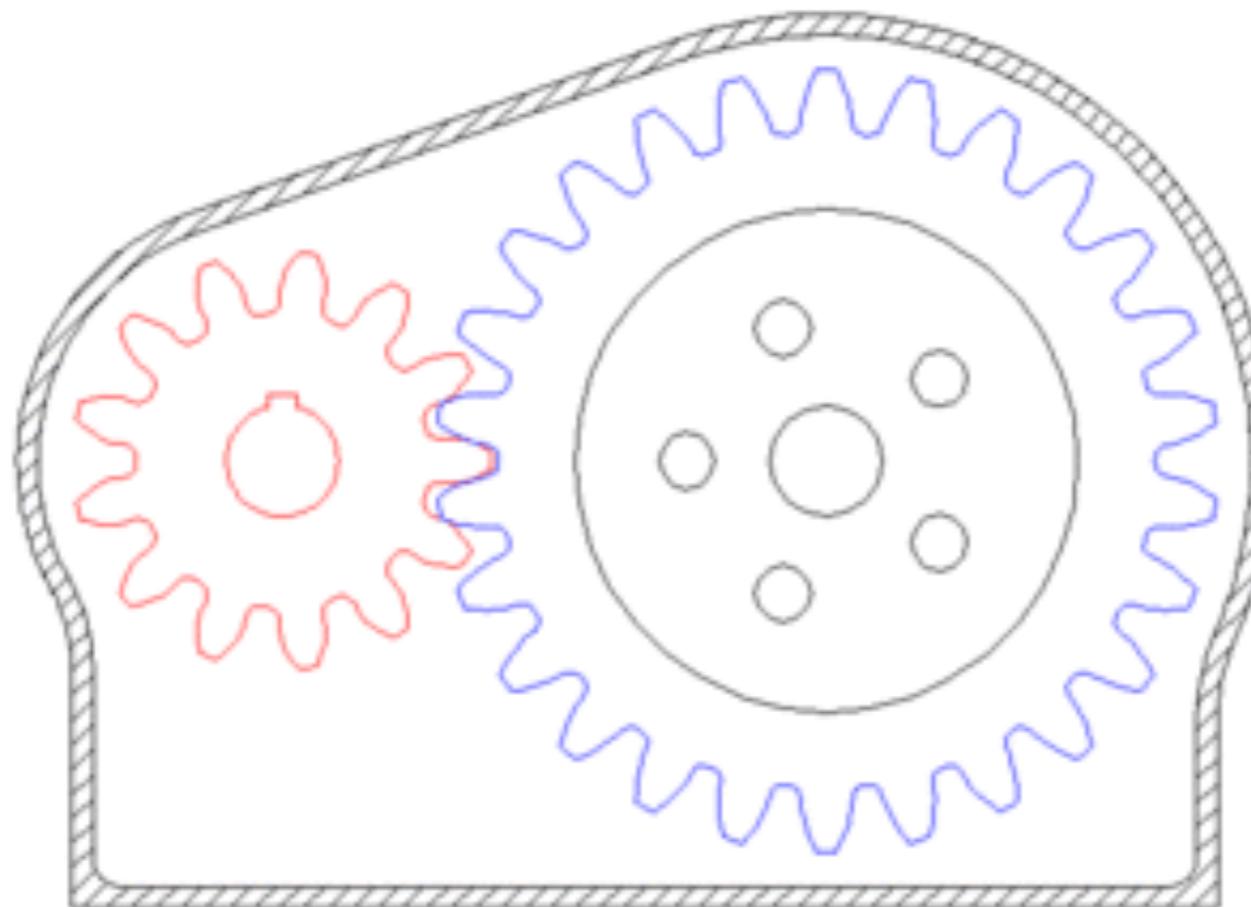


Image: YouTube Dan Gelbart

# Gears are used 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](http://petersonpredict.com)



Image: [pbclinear.com](http://pbclinear.com)



Image: [itp.nyu.edu](http://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**

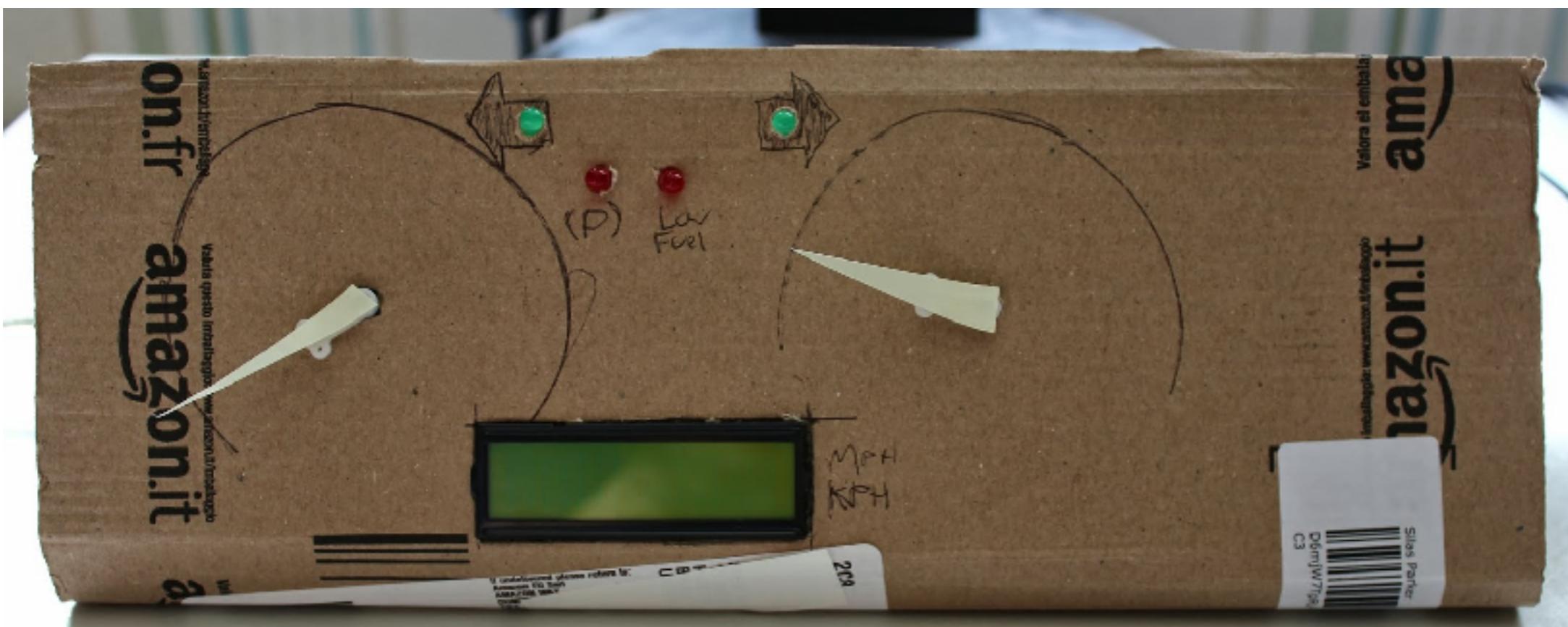
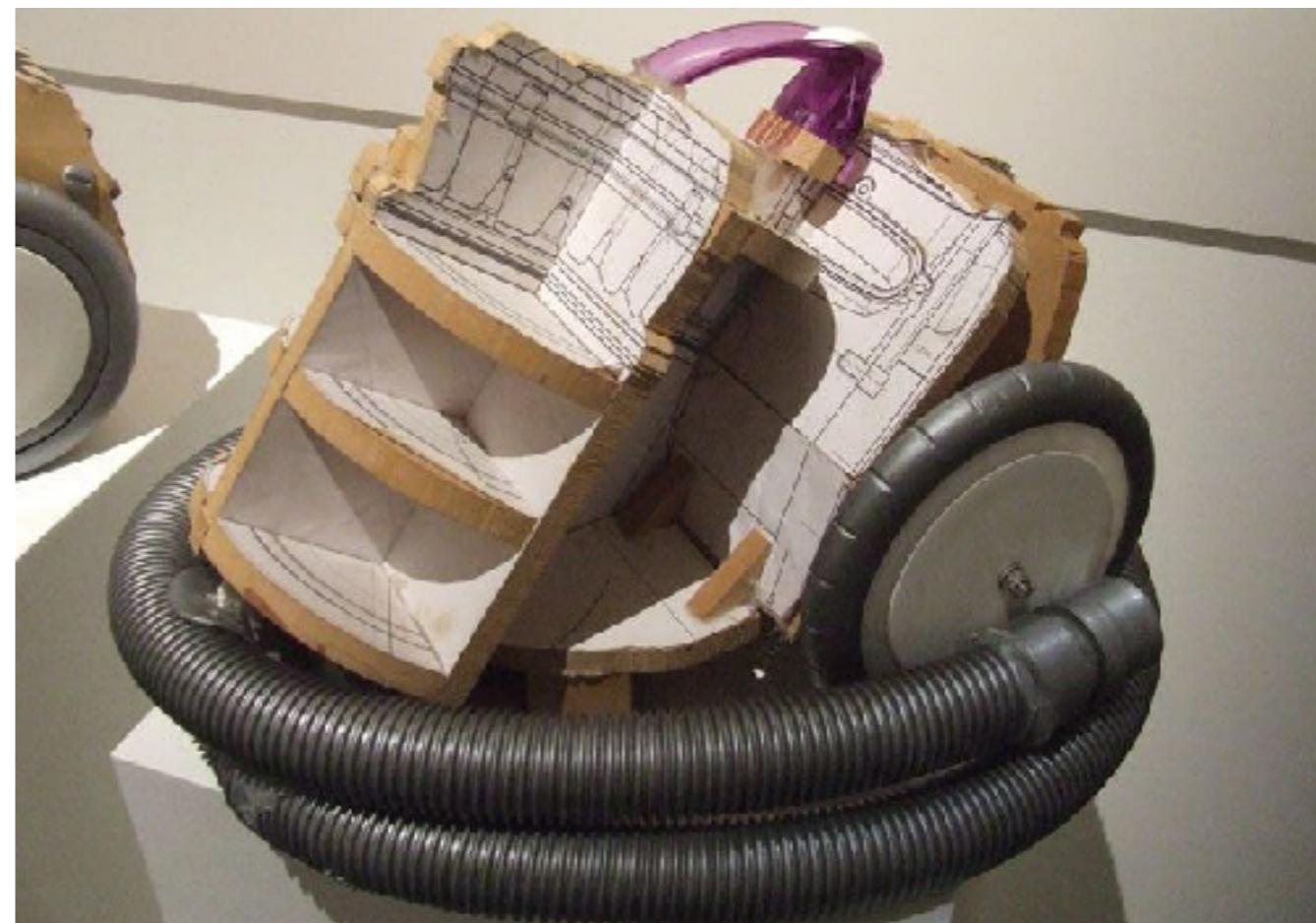


**DIY  
Sortimo**

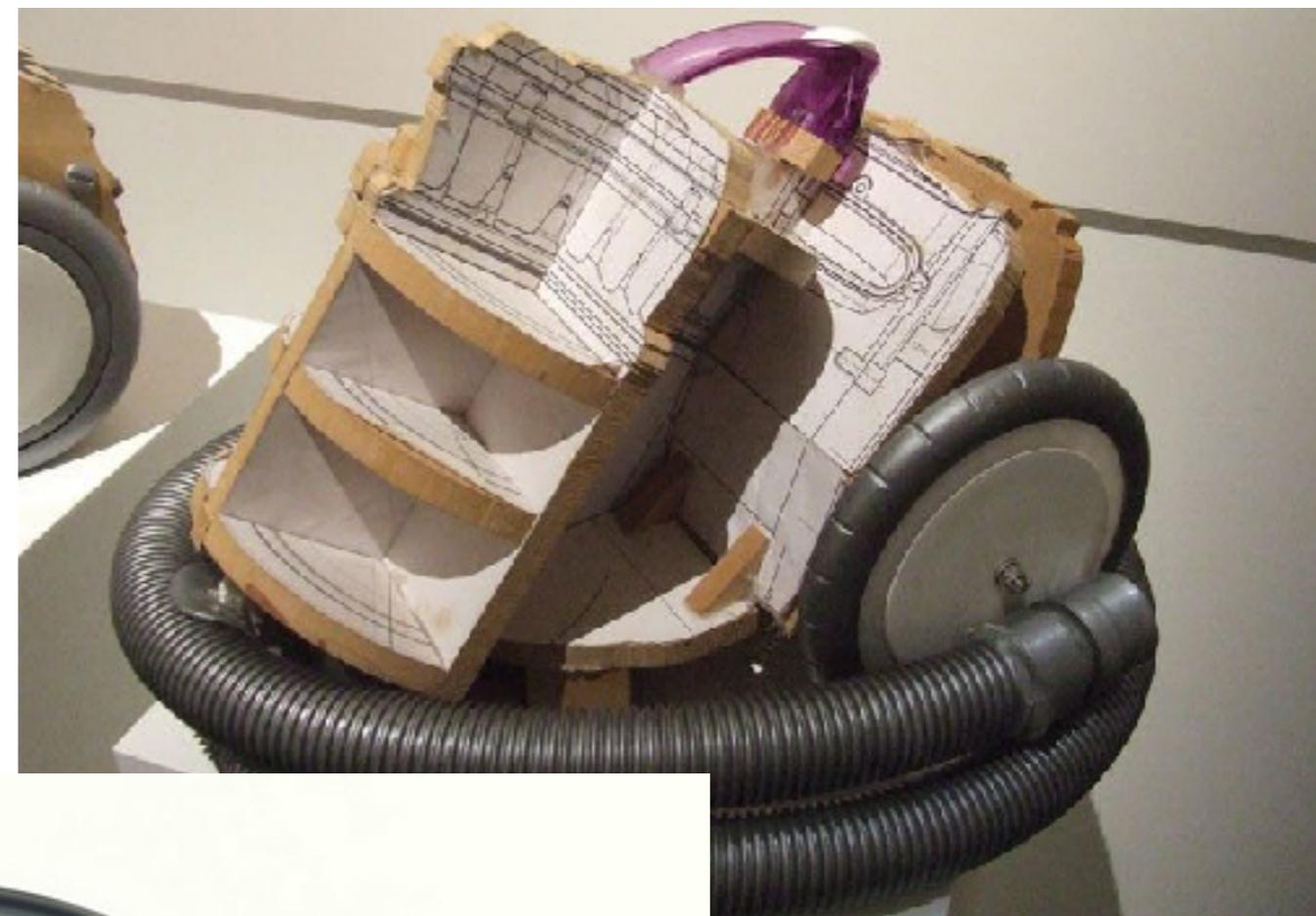
# On organized hardware bank is a must



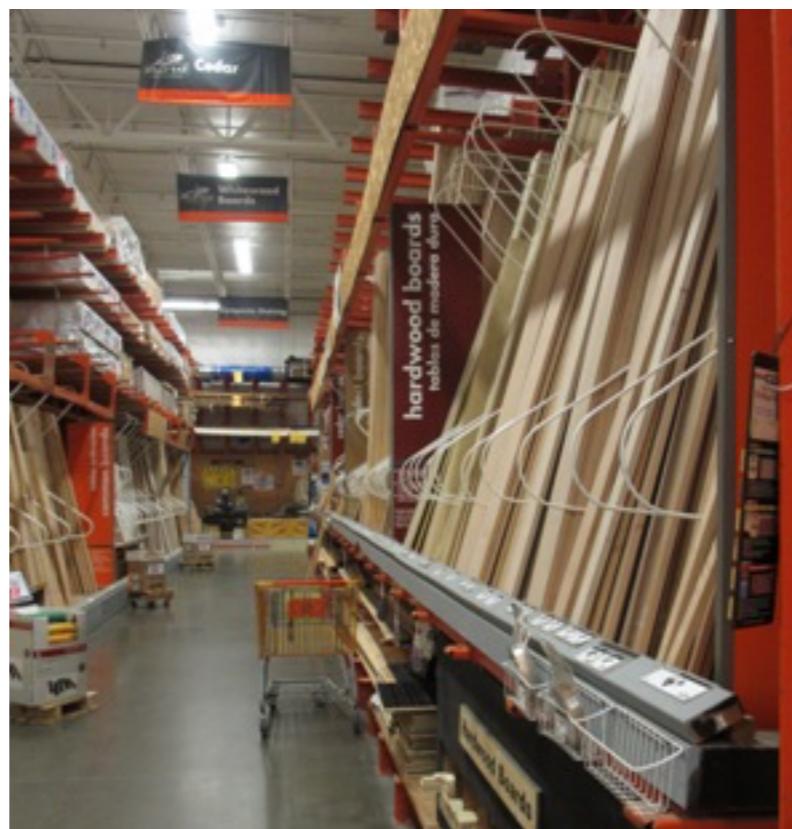
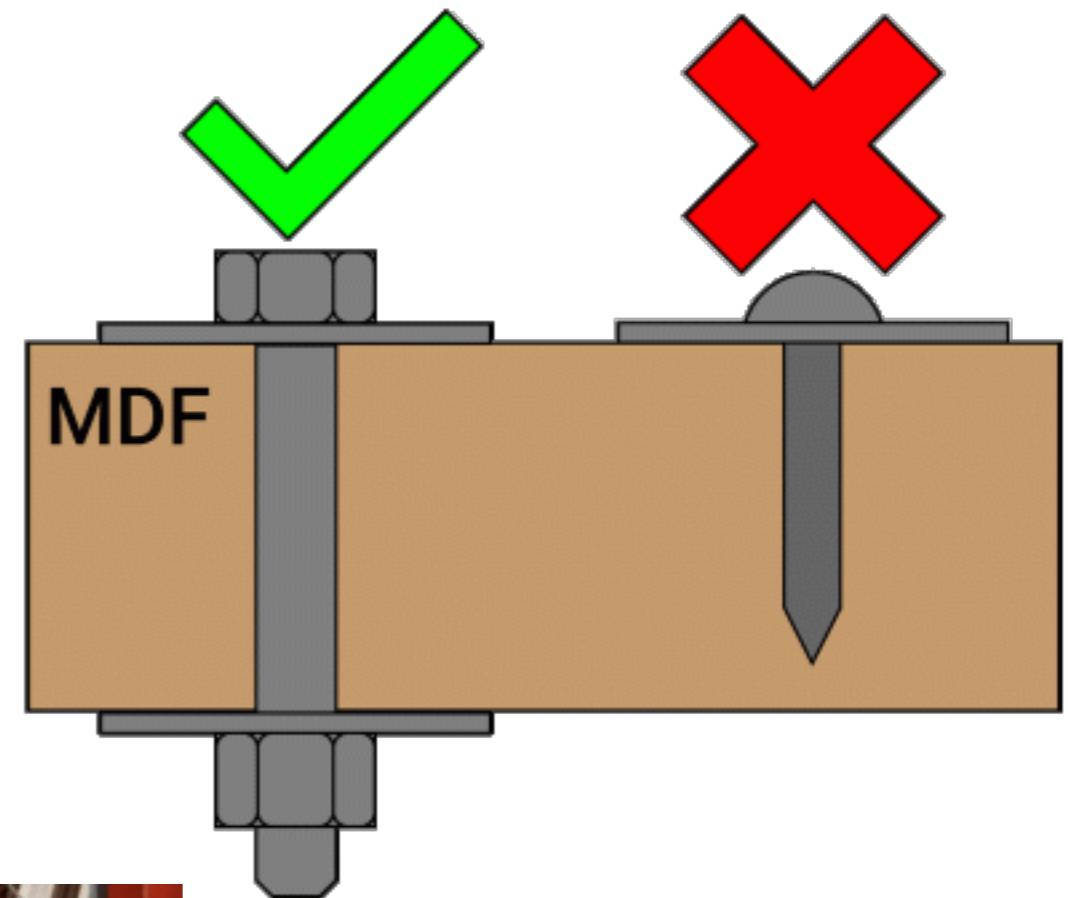
# Make lots of paper prototypes



# Make lots of paper prototypes



# Plywood, MDF, OSB, and others are great starters



# Acrylic, Delrin, and other plastics are good to have



<http://www.polycarbonateplasticsheets.com>

# If possible keep a selection of metals



Image: [brittenstudios.com](http://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

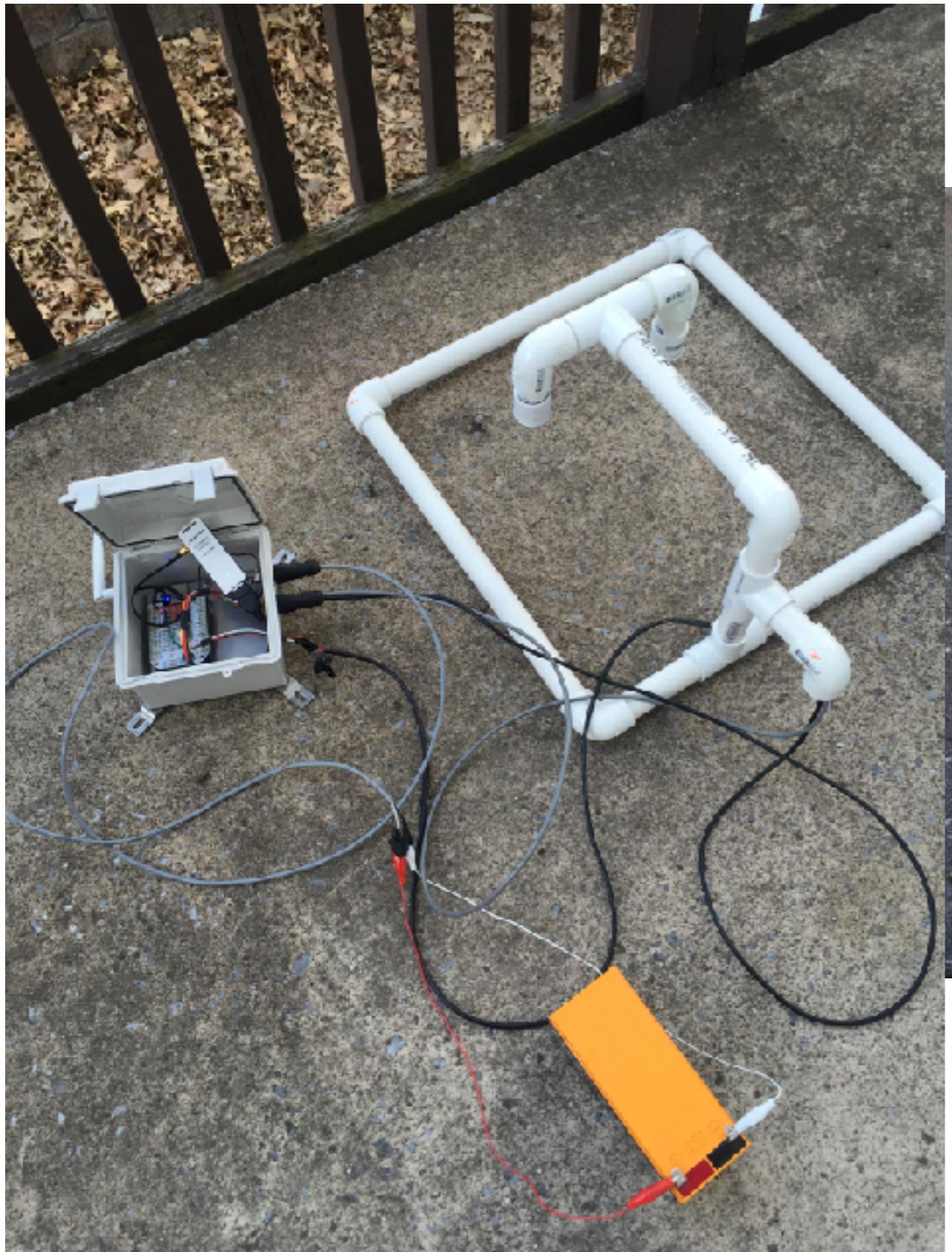


Image: [instructables.com](https://www.instructables.com)

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



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



Image: [8020.net](http://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

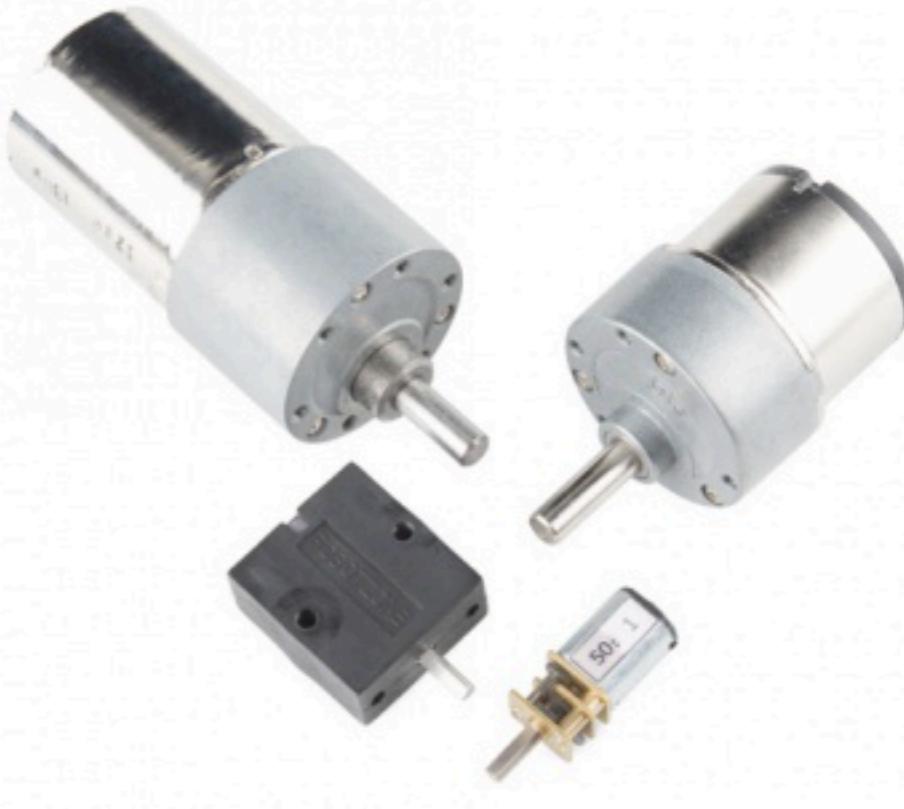
Shafts and Tubing are used to either form rigid structure, or drive-shafts for wheels, servos, levers, and more. Most tubes are also wide enough to accommodate a multitude of wires to keep your Actobotics project tidy.

# 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

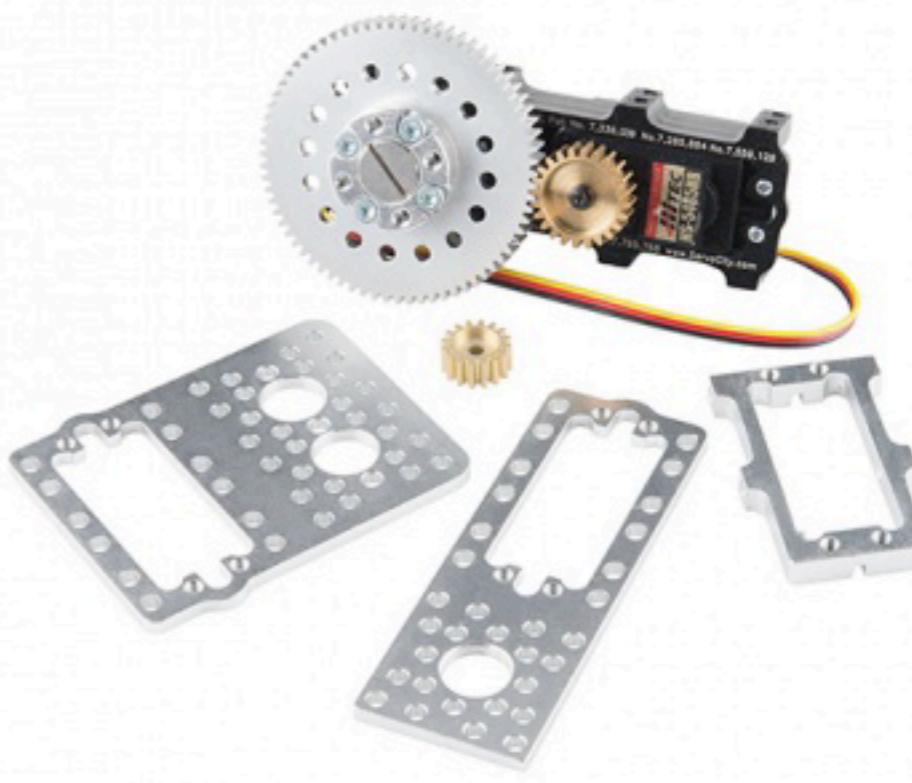
These are the perfect DC Motors for any Actobotics project that needs to get moving. Gears and sprockets would be nothing without these micro, standard, and precision gearmotors!

# 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

