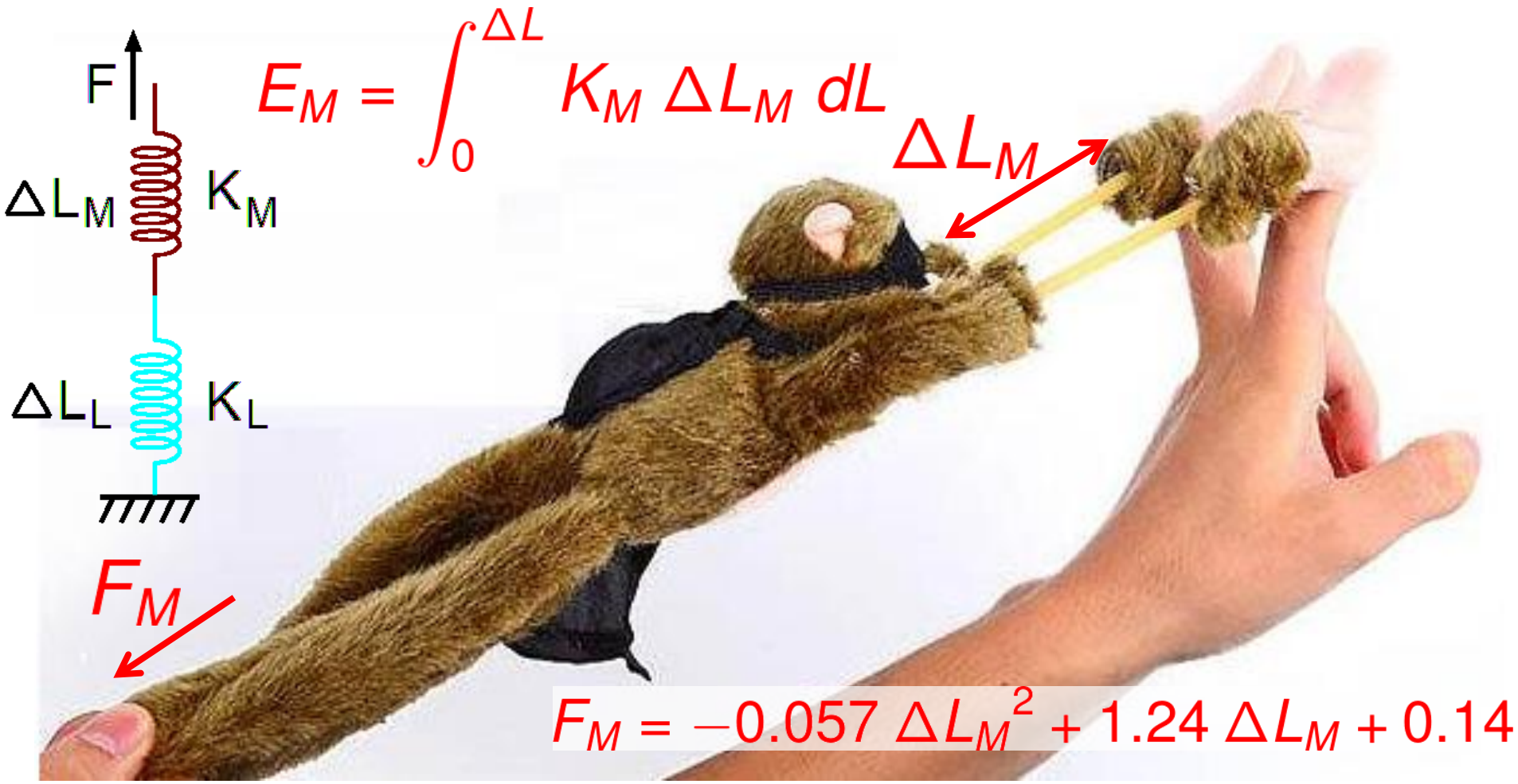
Designing a flying screaming monkey launcher



Using Fusion 360 you will design a device that will hold a stretched flying screaming monkey and release it when an integrated gear motor is energized. The device will be about 22 inches long and at one end will have protruding elements to take the place of the two fingers and at the other a release mechanism powered by a gear motor. A CAD model of a monkey and gear motor with cam will be provided. One will note that the CAD monkey model has a loop attached to its feet that the release mechanism will hold. The design will be comprised of **custom 3D printed elements and off-the-shelf parts**.

Learning objectives:

- **using one's creativity** to invent the structure and release mechanism
- integrating **custom designed** elements with **off-the-shelf** parts
- hand drawing **initial design concepts**
- designing the launcher in **CAD** (monkey and motor models supplied)
- **optimizing 3D printability** (limiting the need for supports)
- (advanced) performing an **equivalent circuit analysis** for force vs deflection
- (advanced) performing a **FEA (Finite Element Analysis) simulation**
- (advanced) optimizing the **design for manufacturability** (DFM)

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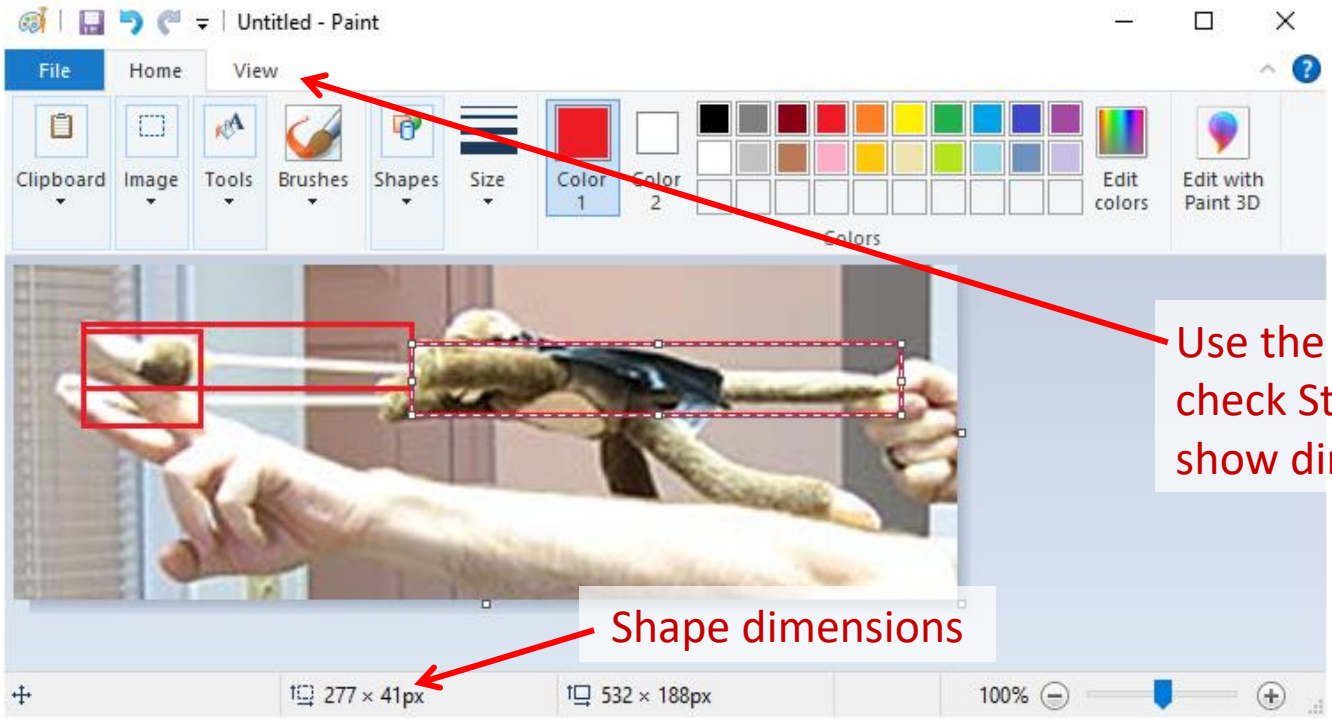
Estimating Dimensions from Photos (You can skip this because a monkey CAD model is provided.)

We are excited to get going with our design and we don't yet have an actual monkey yet to measure. We can find a photo on the Internet and paste it into a graphics program to **determine estimates of dimensions**. Ideally a photo should include an item we know the size of, such as a coin, but here we can use the length of a finger.



Here a photo is pasted into Microsoft Paint showing shapes drawn. As a shape is drawn its dimensions will be shown in the box at the bottom as 274 x 41px is for the body rectangle. One may have to use the View tab and check Status bar to view dimensions. A circle was drawn so that its diameter equals the finger length and two rectangles were drawn for the stretched arm length and body length. Microsoft Paint is included with Windows. For Macs one can use its included Preview software.

mid finger length = $\sqrt{67^2 + 54^2}$ = 86px we want the diagonal of the 67 x 54px box

my finger = 3.1" 3.1"/86px = **0.036 (inches per pixel)**

monkey arm length = 186px 186 x 0.036 = **6.7"**

monkey body length = 277px 277 x 0.036 = **10.0"**

Monkey Stretch Testing and Analysis

Mr. Barbetta's Flying Screaming Animal Testing Lab

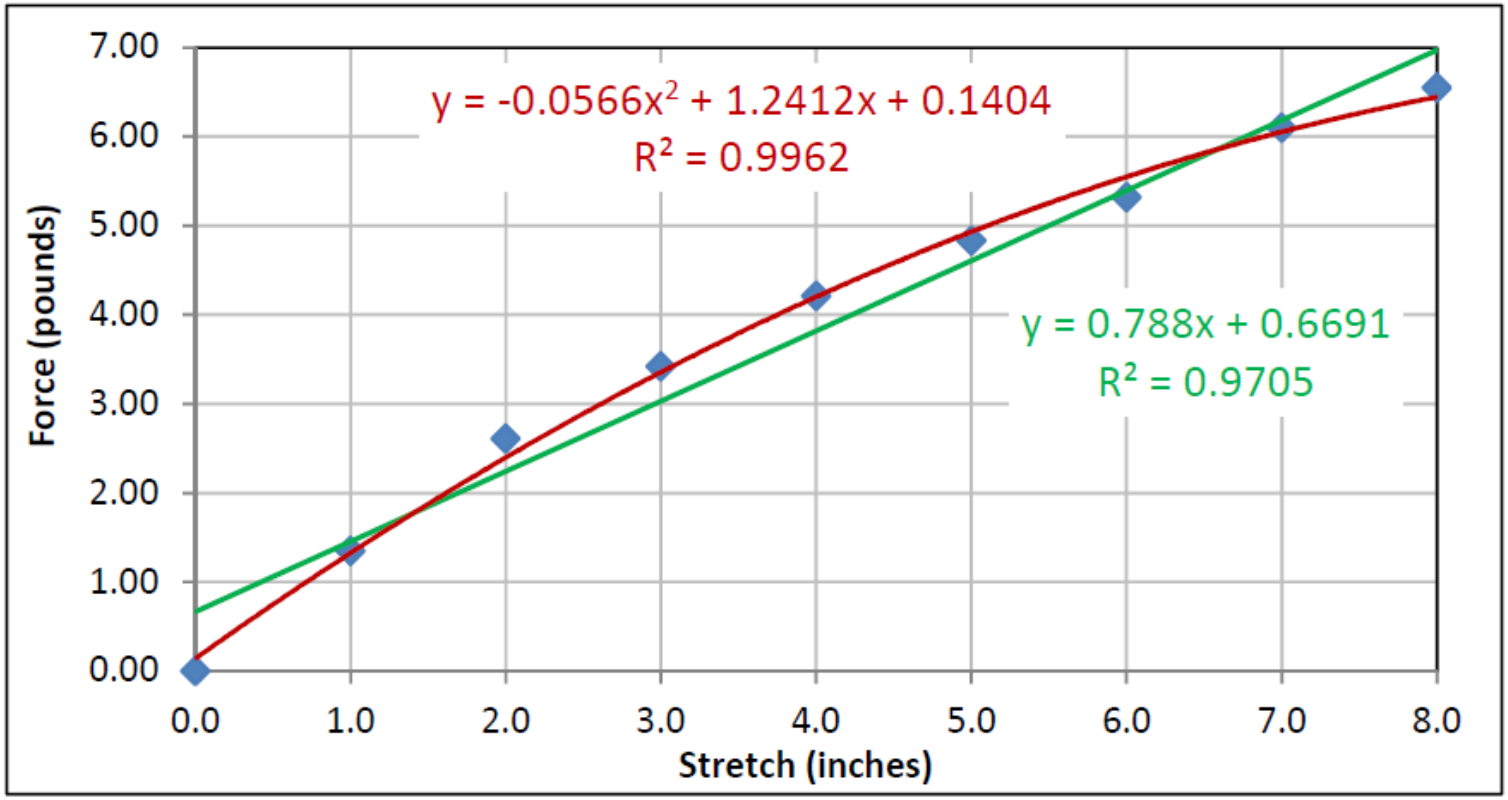
No flying screaming animals are ever harmed in this lab.

Unstretched monkey with 18" ruler

Stretched monkey with 18" ruler

Monkey Stretch Data Analysis (This can be skipped, but it does show the force needed to stretch the monkey.)

Stretch (in.)	Force (lbs)
0.0	0.00
1.0	1.35
2.0	2.61
3.0	3.42
4.0	4.21
5.0	4.83
6.0	5.32
7.0	6.10
8.0	6.55



As the monkey was stretched, the force was recorded and the data was entered into Excel. It can be helpful to create a mathematical model of a flying screaming animal characteristic.

First a straight line fit was performed using the Excel "Trendline" feature and enabling the showing of the equation. The R^2 option was also enabled to quantify the fit of the line or curve. One would think a straight line would provide the best fit for the stretching to act as a spring with its spring constant (k) equaling the slope of the line. It's interesting that a parabolic curve with a decreasing slope offers a better fit, however, the linear fit with a slope of **0.788 lbs/in** will suffice. For each inch of stretch the force should increase by 0.788 pounds.

We can see that as long as the monkey stretch doesn't exceed 8 inches our stretching force should remain under **7 pounds**. **For a good safety margin we should insure our launcher can withstand 10 pounds of force.**

It would be interesting to test several flying screaming monkeys to investigate **manufacturing variablilities**.

Is there an ISO or ASME standard for flying screaming monkey characteristics?

Monkey Stretch Energy Analysis using Calculus

$$E_M = \int_0^{\Delta L} K_M \, \Delta L_M \, dL$$

To determine our monkey's potential energy when stretched we can integrate over the monkey's change in length. K_M is the spring constant of the monkey.

$$E_M = \frac{1}{2} K_M \Delta {L_M}^2$$

If the force to stretch relationship were linear, as with an ideal spring, the integration would evaluate to this equation.

In Mr. Barbetta's Flying Screaming Animal Testing Lab it was found that the relationship had a non-linear relationship and a 2nd order polynomial provided a nice fit. We have to follow through with integration.

$$E_M = \int_0^{\Delta L} -0.0566 \Delta {L_M}^2 + 1.2412 \Delta L_M + 0.1404 \, dL$$

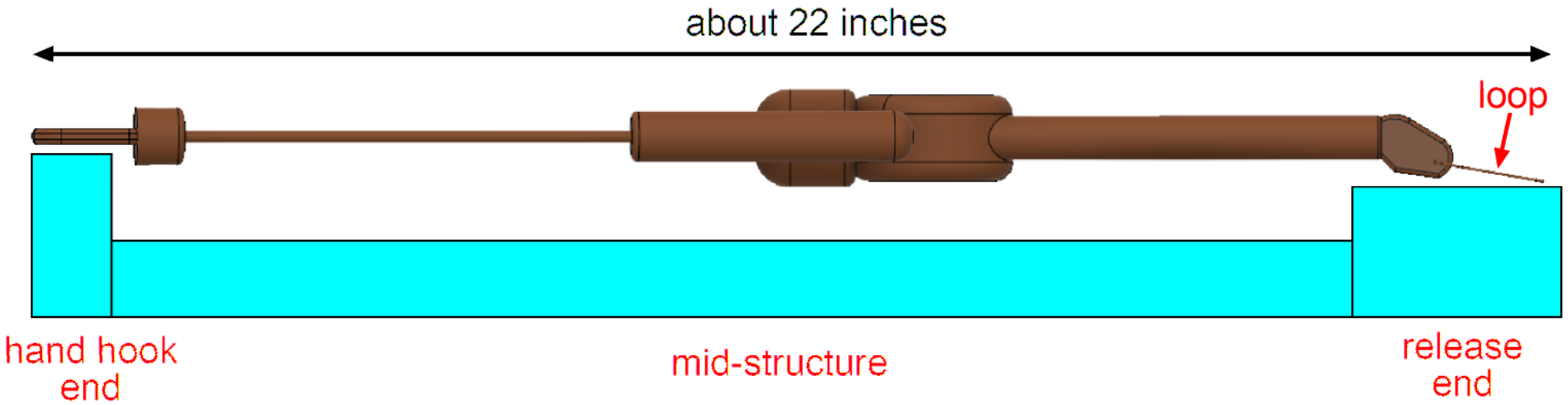
It's not that bad. We can split this into three integrations and then play with the exponents. It's nice that onelimit of integration is 0 so we only have to evaluate for our stretch amount of 8 in.

$$E_M = \int_0^{\Delta L} -0.0566 \Delta {L_M}^2 \, dL \; + \int_0^{\Delta L} 1.2412 \Delta L_M \, dL \; + \int_0^{\Delta L} 0.1404 \, dL$$

$$E_M = \left[\frac{-0.0566 \Delta {L_M}^3}{3} + \frac{1.2412 \Delta {L_M}^2}{2} + 0.1404 \Delta L_M \right]_0^{\Delta L_M}$$

$$E_M = \frac{-0.0566(8)^3}{3} + \frac{1.2412(8)^2}{2} + 0.1404(8) = 31.1819 \text{ lb in} = 3.6 \text{ J}$$

Incorporating Off-The-Shelf Components



Here is a simplified side-view diagram of the monkey and its launcher. At one end is a structure that takes the place of ones fingers that would fit into pockets on the hands of the monkey. The hands of the monkey are first hooked onto this structure.

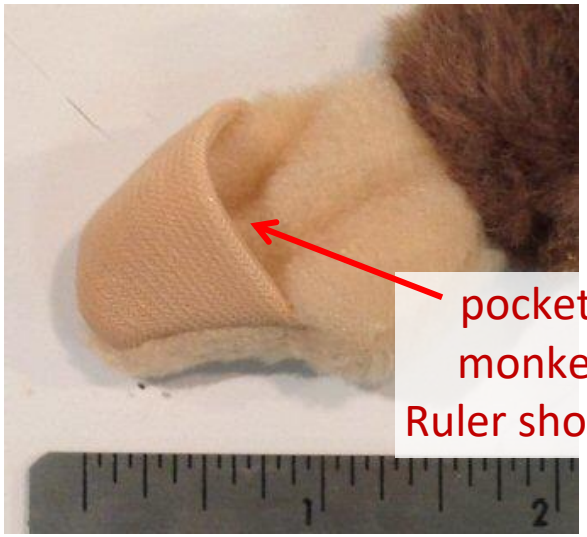
The monkey is then stretched manually and the loop is attched to the monkey's feet is attached to a "release mechanism". The gear motor is part of the release end. When the gear motor is powered and its shaft turns, the loop is released and the monkey's stretched arms propels the monkey forward and away from the launcher. The gear motor is only used to release the monkey and not stretch it.

Designing the launcher, represented by the blue blocks, so that the entire launcher will be 3D printed, will require a great deal of 3D printing. The printing will take many hours and will use a lot of filiment. The launcher must be at least 22 inches long and withstand over 7 pounds of force. A fully 3D printed plastic structure will bend easily.

In order to make manufacturing feasible, the amount of 3D printing must be minimized. A cheap and easily obtainable "off-the'shelf" part or parts could be used for the majority of the launcher's length with the 3D printed parts attached at each end. Examples of "off-the-shelf" parts can include a length of wood, wooden dowel, pipe, metal bar or rod, threaded metal rod, etc. The latter pages of this document show such materials that can be purchased from an industrial supplier or Home Depot.

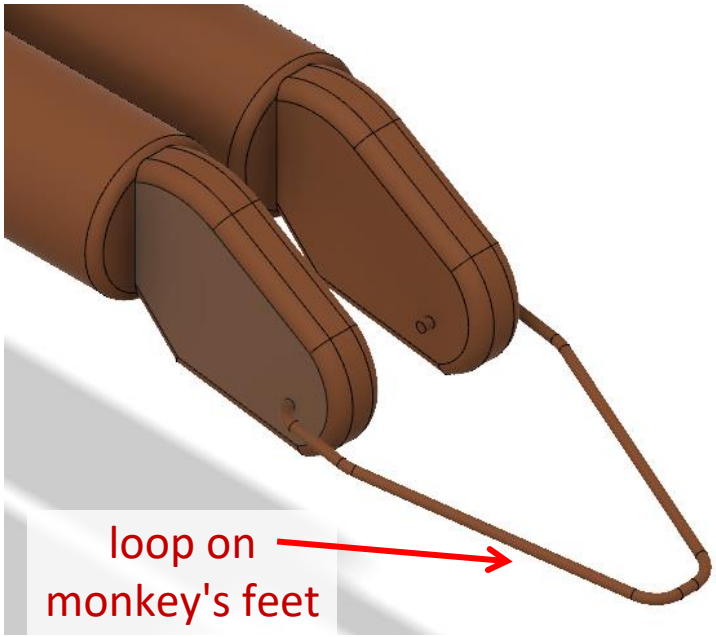
You will be drawing these off-the-shelf parts in CAD as part of your design, but they will be very simple.

Design Breakdown



Monkey hand supports

One task is to design the **stationary structure that the monkey hands will slip on to**, which will take the place of the two human fingures that would be inserted into these pockets.



Release mechanism

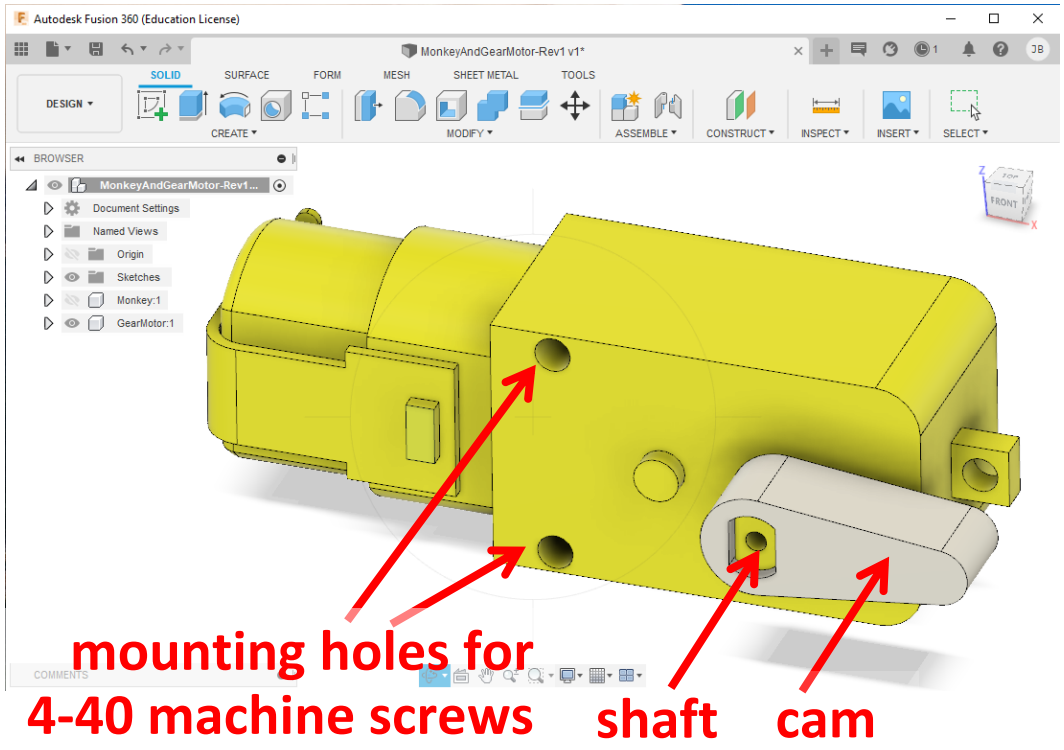
This task will require the most creativity and concerns the design of a movable **release element**, its linkage to the gear motor shaft**,** perhaps with **additional movable elements,** and the associated **support structure** . The following pages show details for the gear motor.

When the gear motor is powered the release element will move in such a way that the loop will be released.

It's best to brainstorm and start hand sketching some ideas. There are many methods to design this mechanism.

To get some ideas one can perform a Google image search on **rotational to linear motion** or **mechanical linkage** or **mechanical cam.**

Gear Motor Information



Tulead DC 3-6V Gear Motors TT Motor Strong Magnetic Interference Pack of 6 for Robot Smart Car Toys

Brand: Tulead

4.4 out of 5 stars 10 ratings

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- Strong magnetic,with anti-interference ability
- Voltage:3V; No-Load Current:≤150mA; No-Load Speed:90±10% rpm
- Voltage:6V; No-Load Current:≤200mA; No-Load Speed:200±10% rpm

Here is a close up view of the gear motor (yellow) with a Cam (white) on its shaft (yellow). When the motor is powered the shaft will turn and the cam will turn with it. The extended section of the cam is called a lobe and it can push on or move a part in your design.

This cam will be a 3D printed part and you can use it as is, modify it, or create your own.

When powered with 5V the shaft will spin at 180 RPM (3 rotations per second), but it will slow down "under load". This means that it will spin more slowly when the cam is pushing against something. The term "gear motor" is used because inside the yellow box are gears to slow down the high rotational speed of the motor. More importantly this provides greater "torque" (rotational force) from the shaft. However, as torque is increased the speed will slow down until the motor "stalls". This is a cheap and fairly weak gear motor. You would be able to stop the cam by holding it. When the motor isn't powered you can also turn the cam by hand. One may do this to set an initial cam position.

There are two mounting holes with an inner diameter of 0.120". Two 4-40 1" long machine screws can pass through the gear motor and a part you design to hold the gear motor in place. Two 4-40 nuts on the screws will allow them to be tightened.

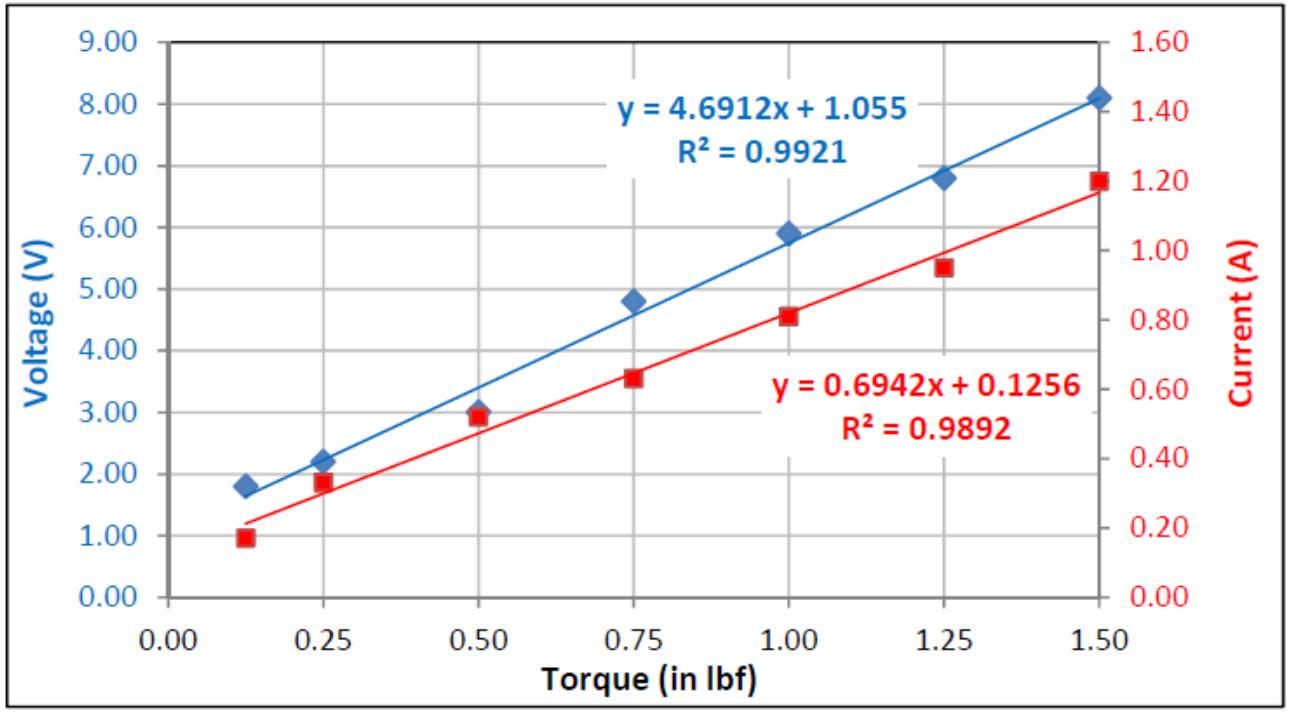
These are nice cheap gear motors for projects. They are available from many sellers. Here's a listing to buy these gear motors for $2 a piece. If you need more powerful gear motors there are more expensive ones on Amazon.

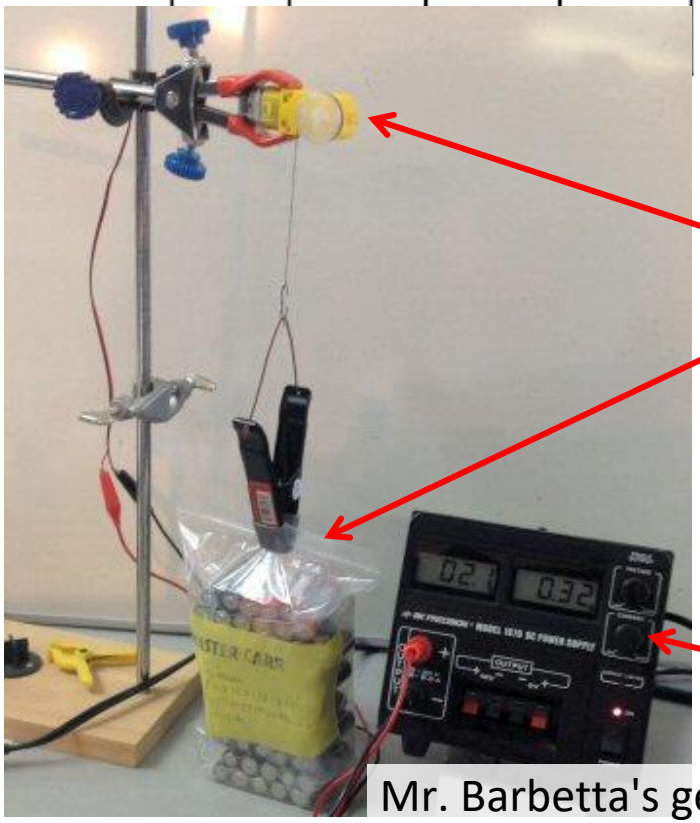
Gear Motor Torque Analysis

Stall testing of 3-6V, 48:1 gear motor (dual shaft, yellow body, black motor cap)

Pully Radius (in)	0.50

Force (lbf)	Torque (in lbf)	Voltage (V)	Current (A)
0.25	0.13	1.80	0.17
0.50	0.25	2.20	0.33
1.00	0.50	3.00	0.52
1.50	0.75	4.80	0.63
2.00	1.00	5.90	0.81
2.50	1.25	6.80	0.95
3.00	1.50	8.10	1.20



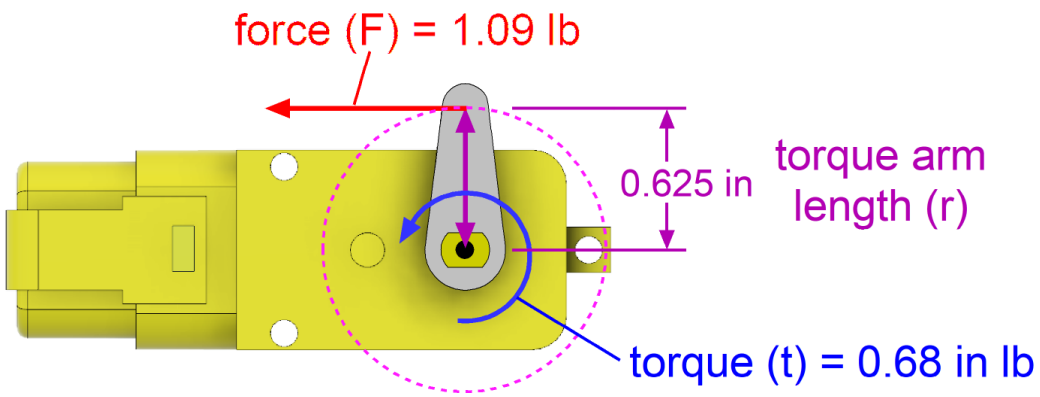


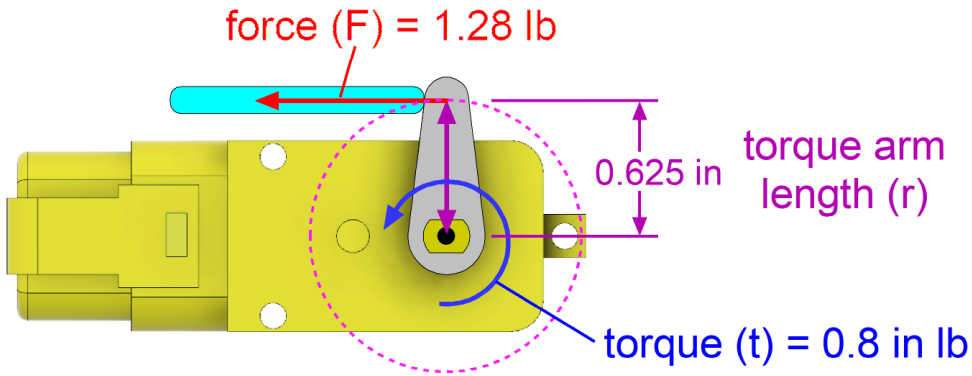
Gear motor with 3d printed 1" diameter pulley

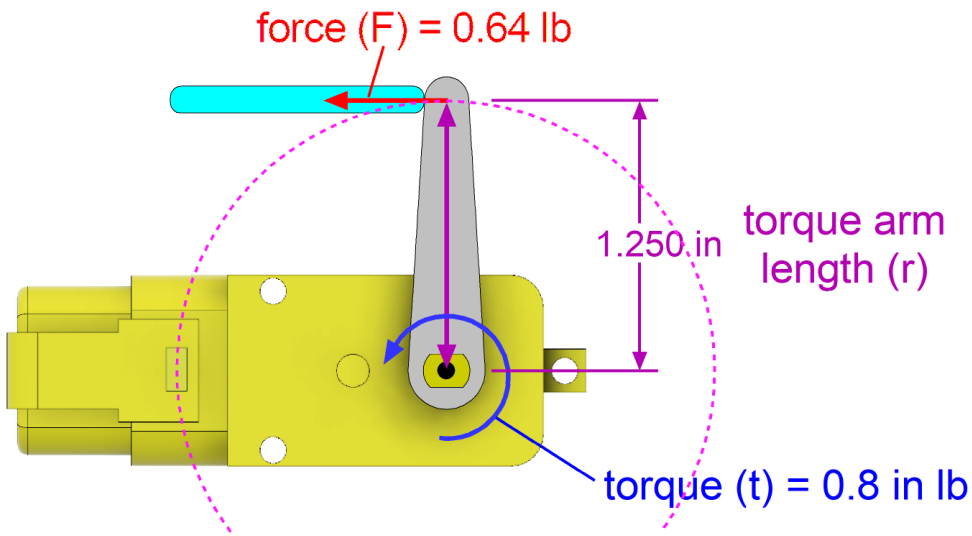
Bag of AA batteries
Batteries are added or removed
to achieve various weights

Variable power supply

Mr. Barbetta's gear motor testing lab







Unpowered Hold Torque and Force

One test determined the amount of torque needed to overcome any static friction to cause the shaft to turn. This demonstrates that one can't simply have to cam hold the loop and then release it upon powering the motor. The shaft would turn too easily.

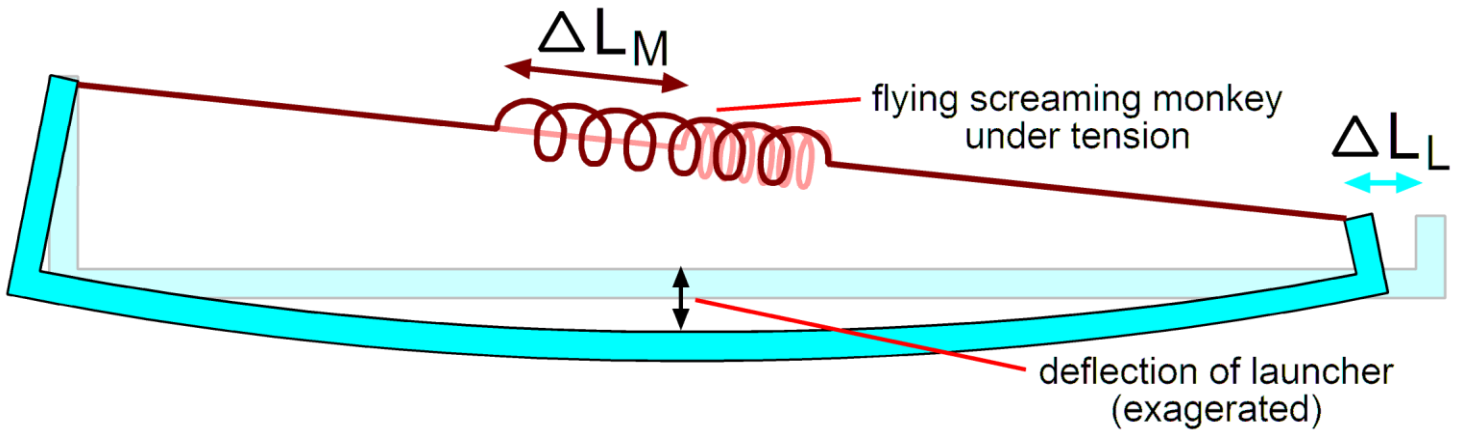
Powered Starting Torque and Force

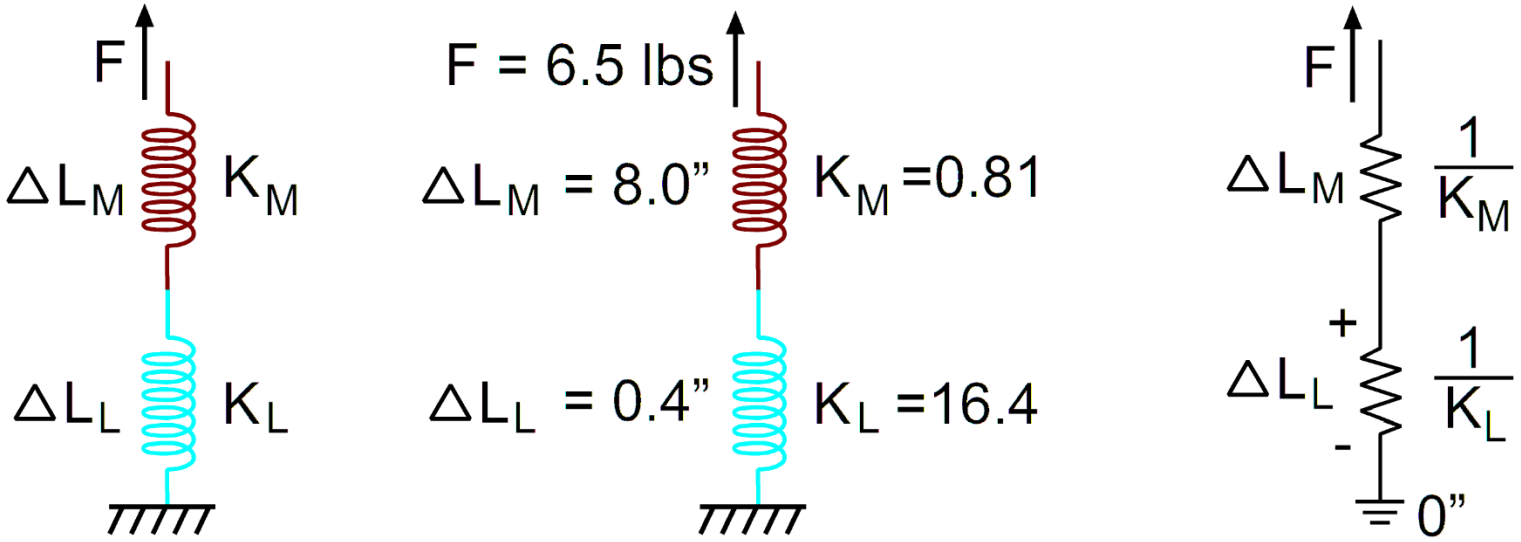
The tests reveal a torque of about **0.8 in lb** when the gear motor is powered with **5V**.

The **blue element represents a movable part that the cam is pushing** and on it is **a red arrow representing the force** imparted on it by the cam. The cam can also pull on a movable part with the same force.

The two pictures illustrate how the force is related to the length of the cam.

System Circuit Model (Advanced)



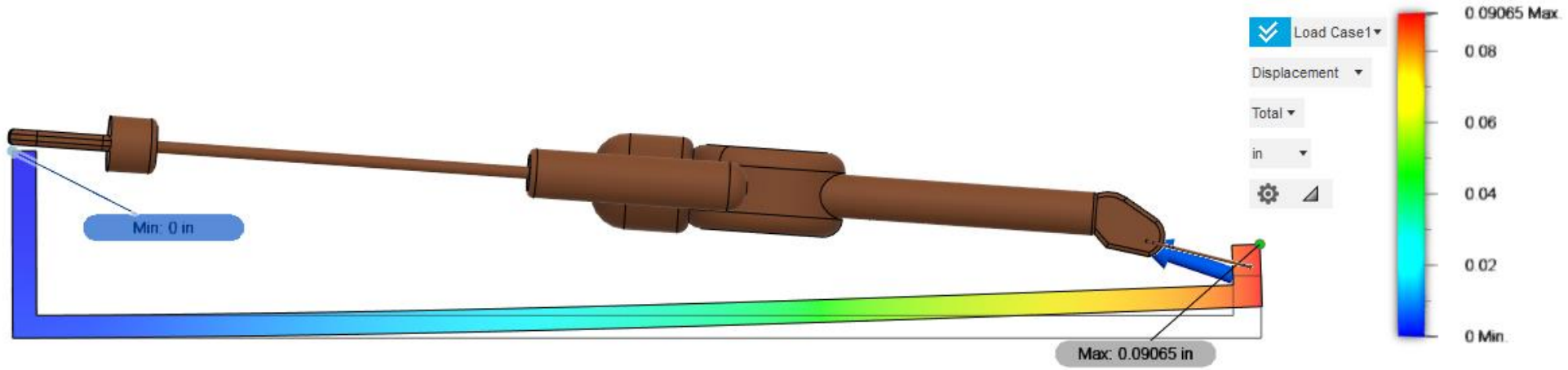


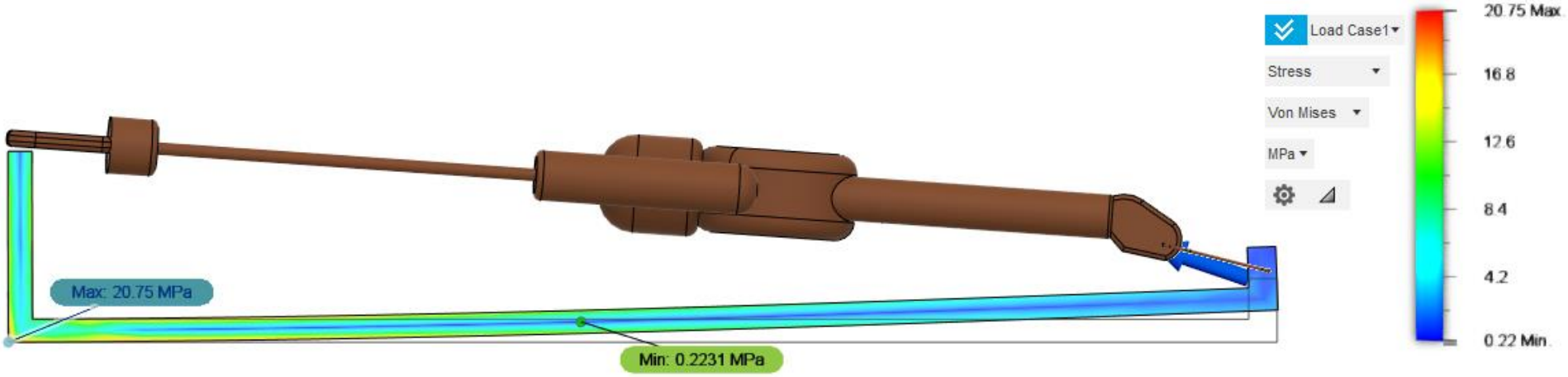
The top diagram represents how the force to stretch the monkey will cause a deformation of the launcher, which we wish to minimize. We can create a simplified spring model and an **equivalent electrical circuit model** to calculate the deformation of the launcher.

FEA (Finite Element Analysis) of the Launcher (Advanced)

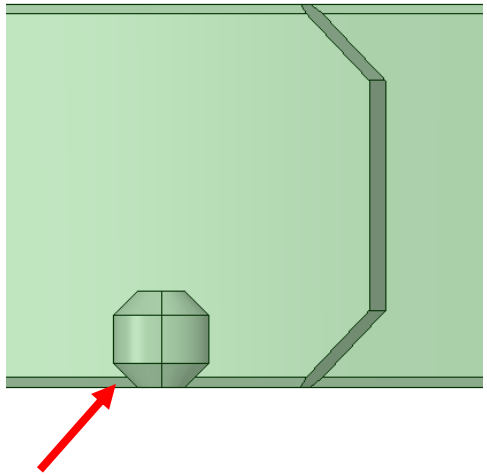
We can extend our simple equivalent circuit analysis to a **static stress simulation** in Fusion 360 or Inventor. Below are screen shots from Fusion 360 for doing so with a simplified launcher structure. You will be using the elements you designed including any off-the-shelf parts. **You need not include movable elements of your design**. For example, the force from the loop at the monkey's feet can be applied to an equivalent stationary point.

In the below simulation a constraint is set on the structure at the monkey's hands. The results for both **displacement** and **stress** are shown.

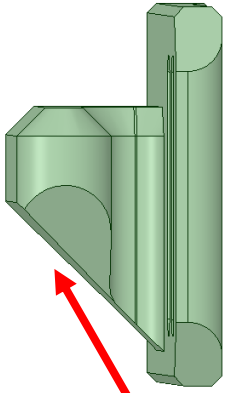




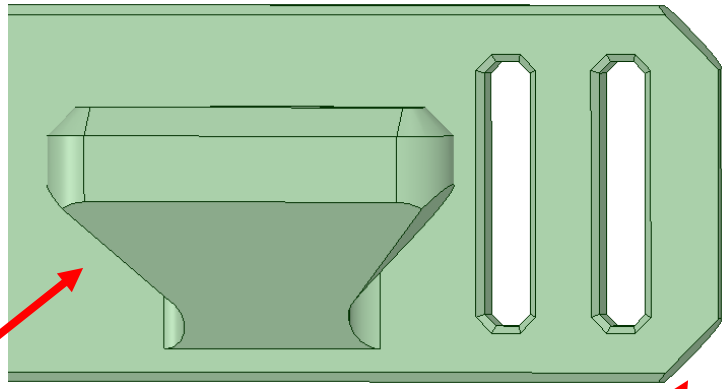
Optimizing 3D Printability (eliminating the need for supports)



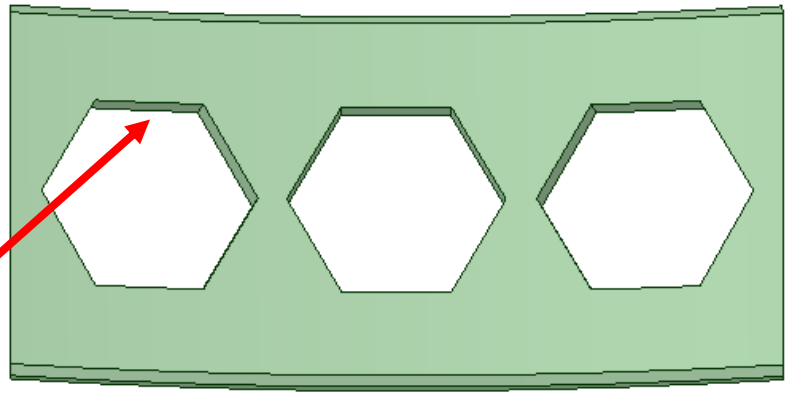
This protrusion supports the thin (0.015") plastic (polycarbonate) shield. It is **at the bottom of the frame so that it sits on the build plate** and is thus not an overhang. To approximate a rounded form chamfers are added to the bottom. The **chamfer angles are 45 degrees to avoid the need for supports.**



This protrusion supports the rubber strap. It 's **chamfer angles are 45 degrees to avoid the need for supports.**



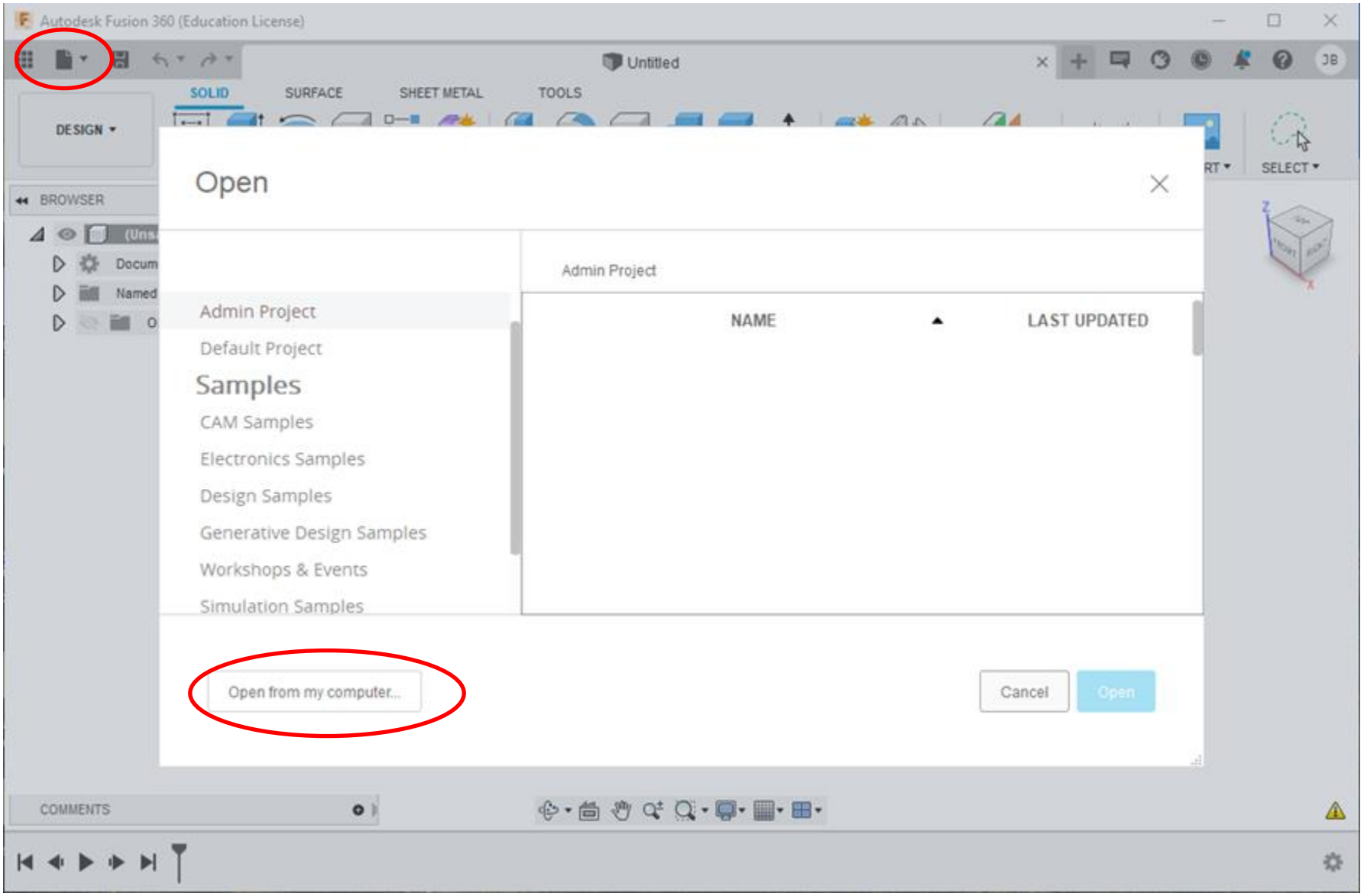
There are other **bottom chamfer angles of 45 degrees to avoid the need for supports.**



The tops of these holes are only 0.230" wide and thus, **this "bridge" doesn't need supports**.

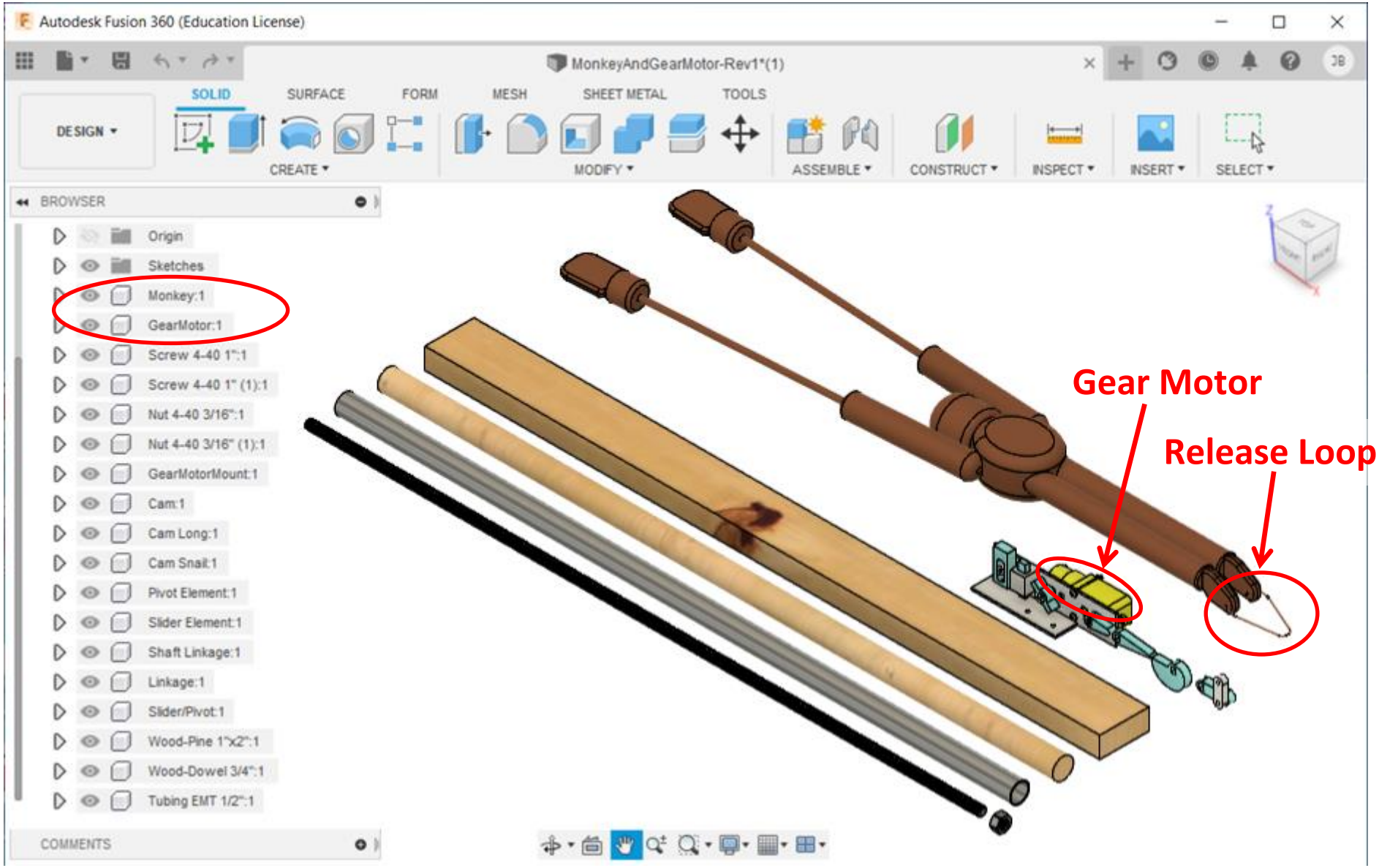
"Overhang Rule": If an overhang is 45 degrees or steeper, supports are not needed.

Opening the CAD Fusion Starting Project



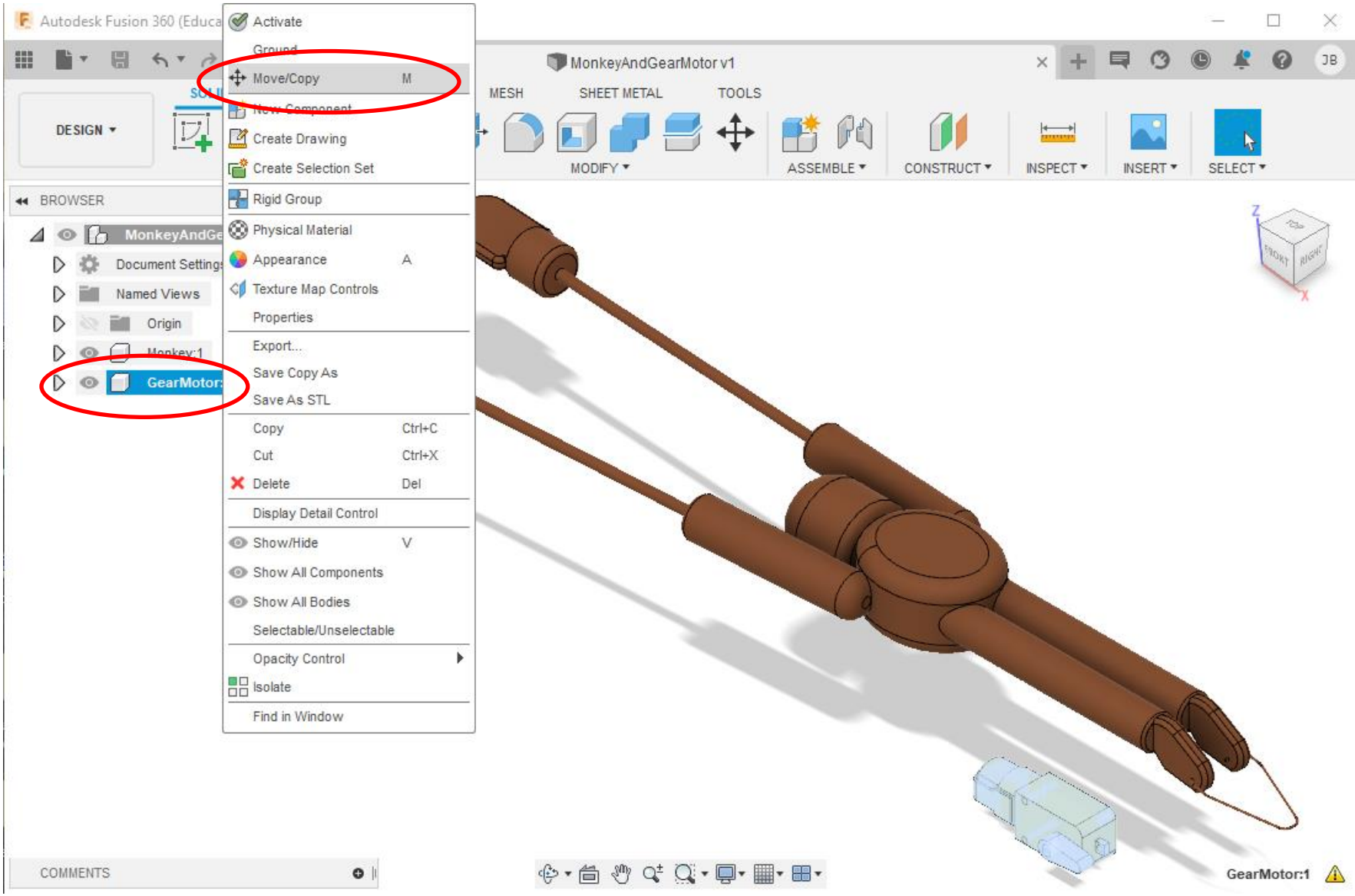
Download **the "MonkeyWithGearMotor.f3d" file from Schoology** and then using Open from the File menu click on "Open from my computer" and navigate to the location you downloaded the file to, ie "Downloads" folder. Note that by default Fusion 360 saves and opens files from their "cloud", however, you can select "Export" when saving and "Open from my computer" when opening if you wish to keep files on your computer.

The "MonkeyWithGearMotor-Rev1.f3d" starting project



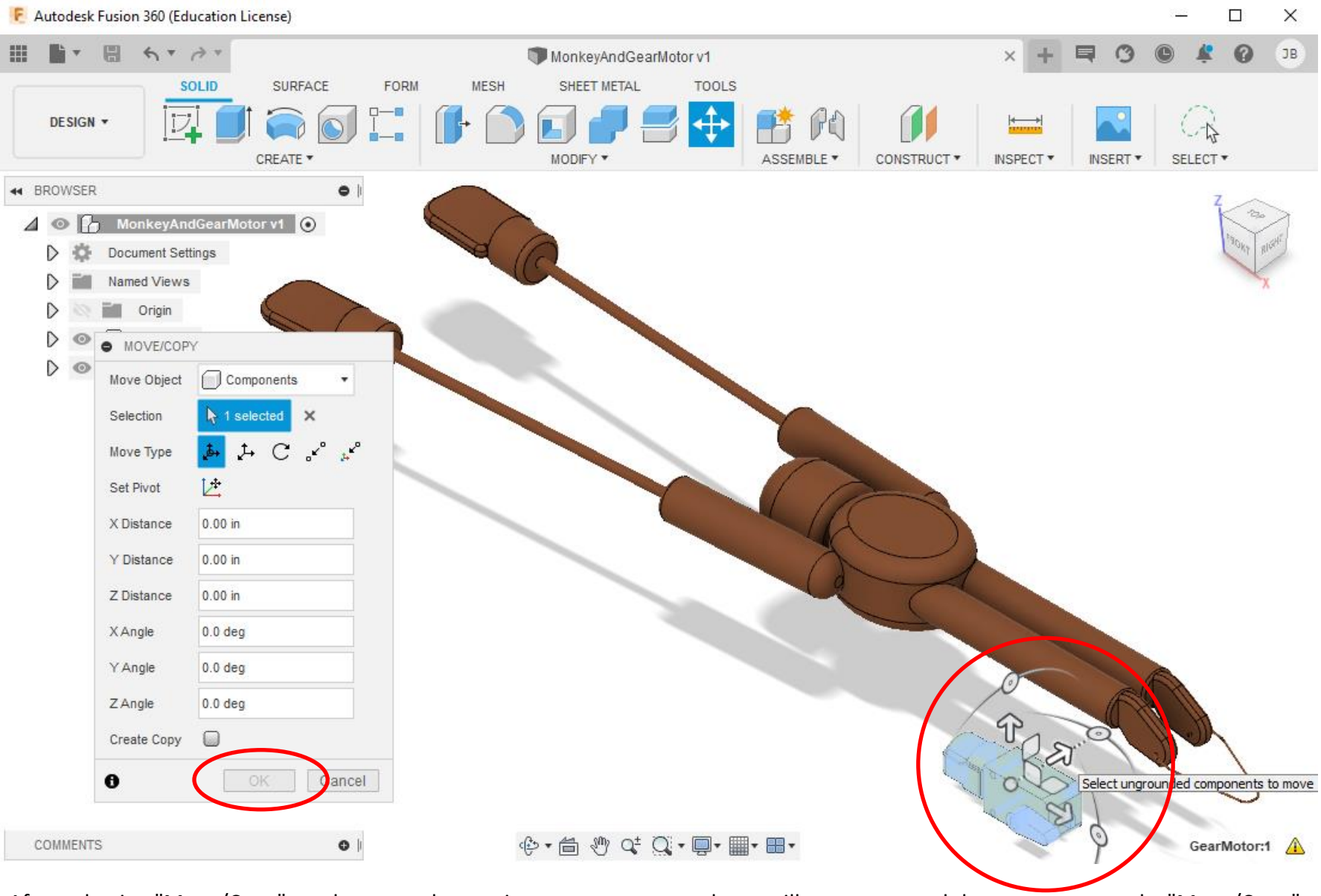
Here is the starting project with our monkey (in its stretched state) and a gear motor, which you can see as components circled in the Browser. Example mechanical mechanisms and off-the-shelf compnents are also included. The page titled **"CAD File Mechanism Example Components"** discusses these components. When the gear motor is powered the monkey will be released to begin its flying screaming journey. Note the loop through the feet of the monkey, which a part can hold and then release. Another aspect of the design is a part that takes the place of the fingers.

Moving your monkey and gear motor



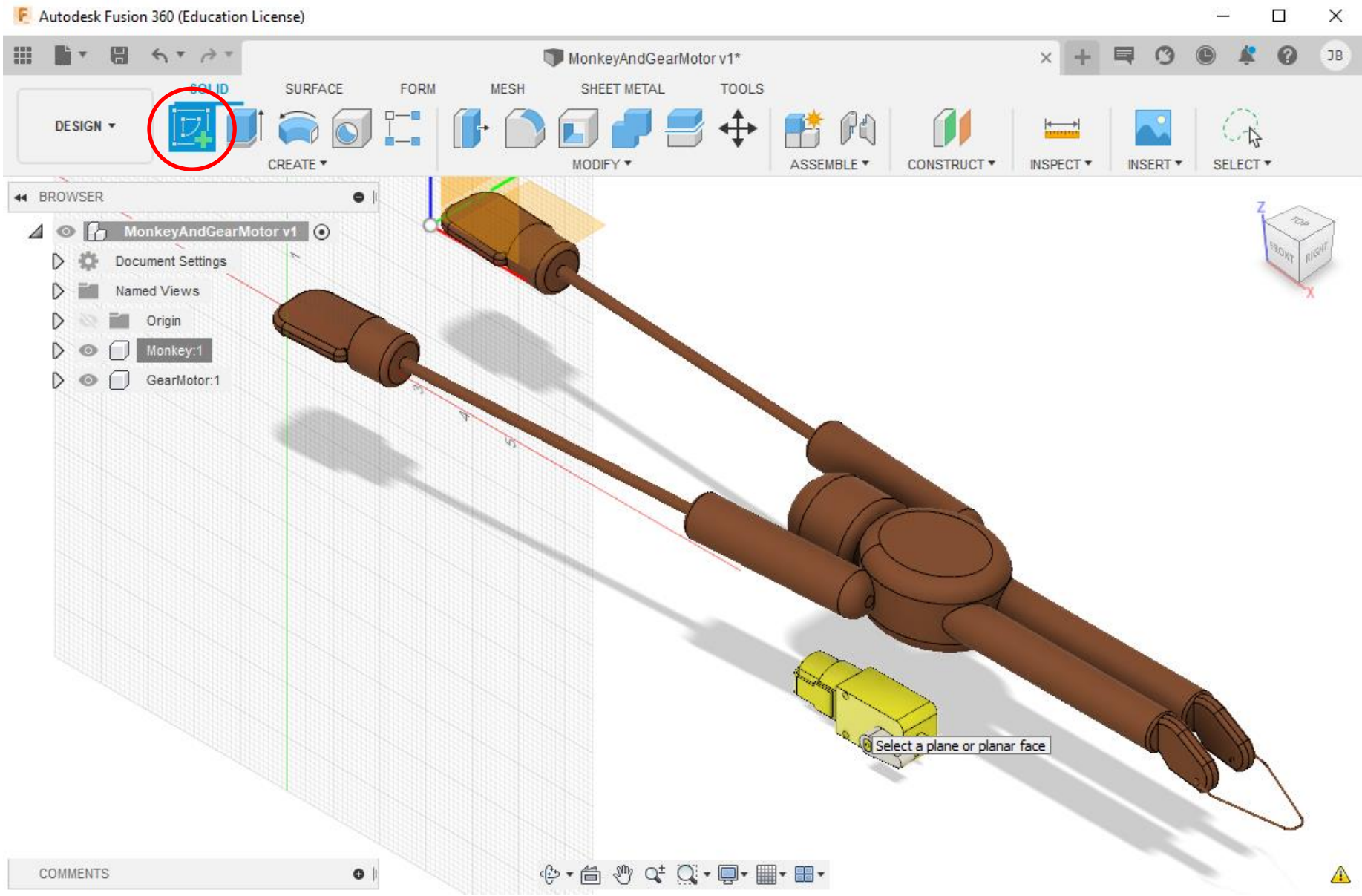
As you work on your design you will need to move and/or rotate your monkey and gear motor at times. Because they are "Components" you can select "Monkey" or "GearMotor" on the left, right-click, and select "MoveCopy". Here we do so for the GearMotor. See next page.

Moving the gear motor



After selecting "Move/Copy", as shown on the previous page, arrows and arcs will appear around the component and a "Move/Copy" window will open. You can use the arrows to move the component or the arcs to rotate the component and then click "OK". You can also enter corresponding distances and/or angles in the boxes. If we had selected the monkey, these arrows and arcs would appear around the monkey.

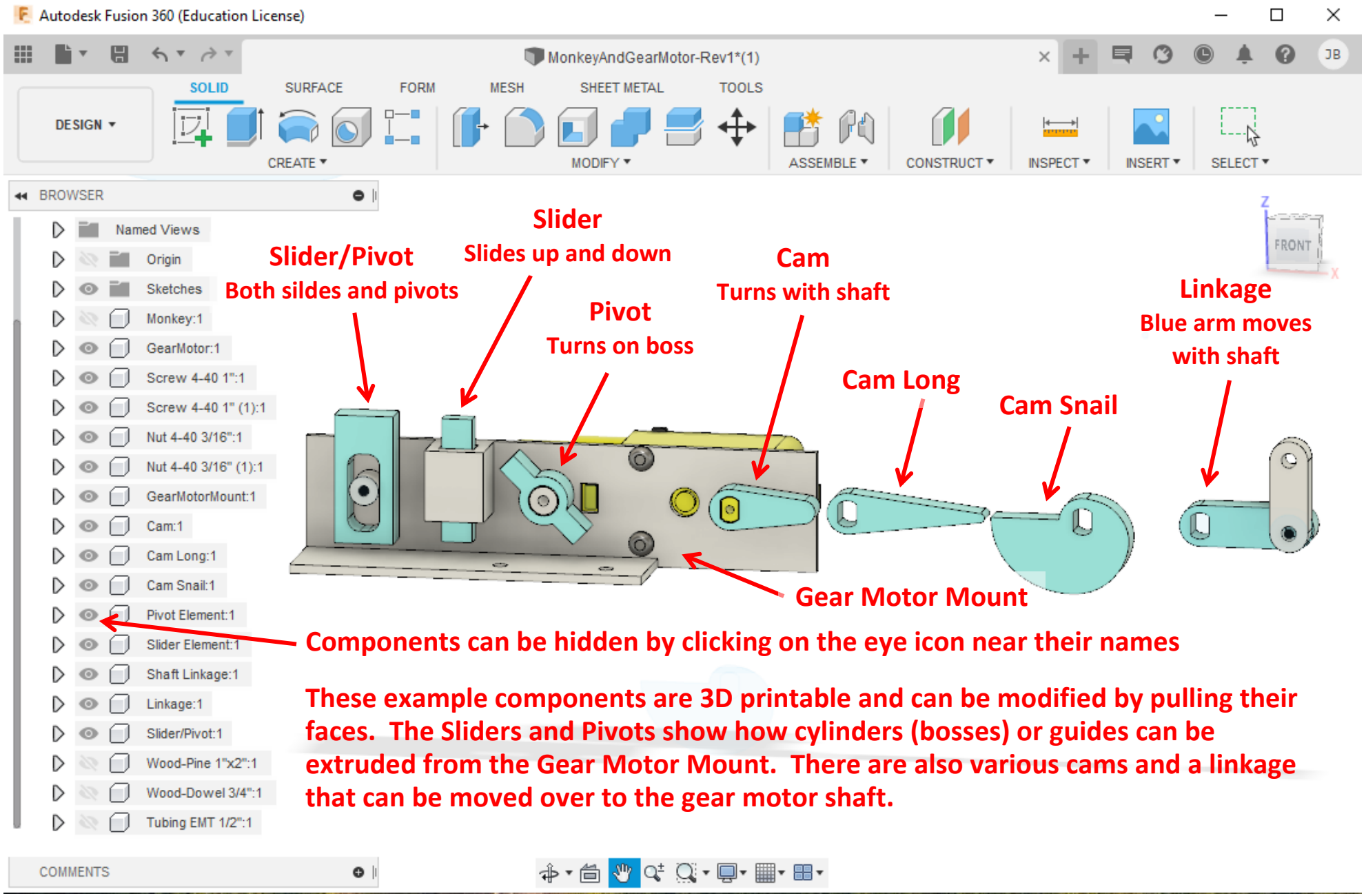
Starting to sketch



At any time, before or after moving components, you can create a sketch to extrude into a body. After clicking on the top "Sketch" icon, you have to choose a plane or surface. Here, the surface of the gear motor was selected. This is one possible place to start because you will be designing a part that the motor will attach to.

CAD File Mechanism Example Components (in file "MonkeyWithGearMotor Rev1.f3d")

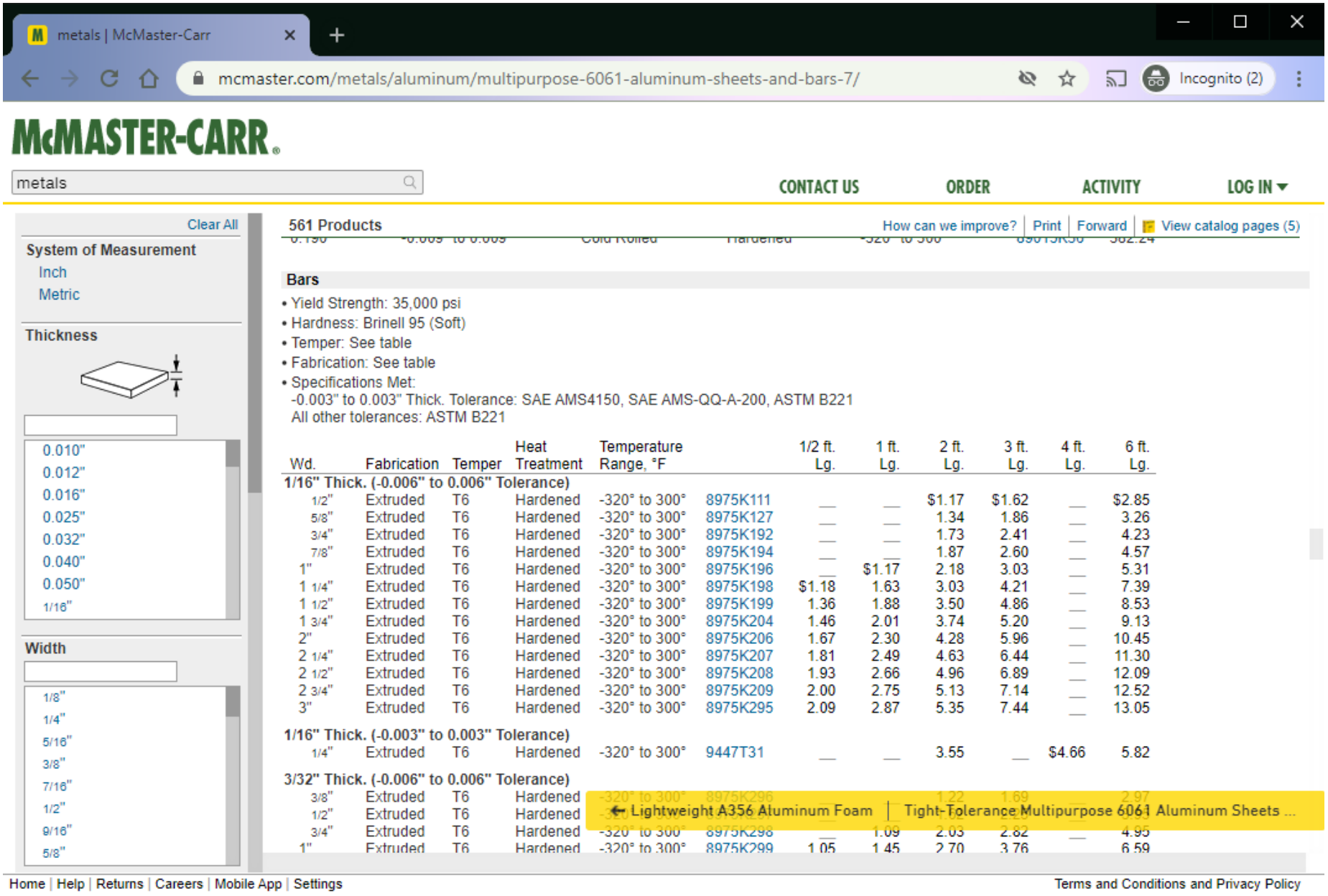
The file "MonkeyWithGearMotor Rev1.f3d" contains example mechanism components



Off-the-Shelf Part Examples

The following pages show some examples of parts that can be incoporated into your design. You are not restricted to these parts. You can use other parts if you wish.

McMaster-Carr (mcmaster.com) 6061 Aluminum bars



metals | McMaster-Carr

mcmaster.com/metals/aluminum/multipurpose-6061-aluminum-sheets-and-bars-7/

McMASTER-CARR

metals

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Clear All

System of Measurement
Inch
Metric

Thickness

0.010" 0.012" 0.016" 0.025" 0.032" 0.040" 0.050" 1/16"

Width

1/8" 1/4" 5/16" 3/8" 7/16" 1/2" 9/16" 5/8"

561 Products

How can we improve? | Print | Forward | View catalog pages (5)

Bars

- Yield Strength: 35,000 psi
- Hardness: Brinell 95 (Soft)
- Temper: See table
- Fabrication: See table
- Specifications Met:
  -0.003" to 0.003" Thick. Tolerance: SAE AMS4150, SAE AMS-QQ-A-200, ASTM B221
  All other tolerances: ASTM B221

Wd.	Fabrication	Temper	Heat Treatment	Temperature Range, °F		1/2 ft. Lg.	1 ft. Lg.	2 ft. Lg.	3 ft. Lg.	4 ft. Lg.	6 ft. Lg.
1/16" Thick. (-0.006" to 0.006" Tolerance)											
1/2"	Extruded	T6	Hardened	-320° to 300°	8975K111	—	—	$1.17	$1.62	—	$2.85
5/8"	Extruded	T6	Hardened	-320° to 300°	8975K127	—	—	1.34	1.86	—	3.26
3/4"	Extruded	T6	Hardened	-320° to 300°	8975K192	—	—	1.73	2.41	—	4.23
7/8"	Extruded	T6	Hardened	-320° to 300°	8975K194	—	—	1.87	2.60	—	4.57
1"	Extruded	T6	Hardened	-320° to 300°	8975K196	—	$1.17	2.18	3.03	—	5.31
1 1/4"	Extruded	T6	Hardened	-320° to 300°	8975K198	$1.18	1.63	3.03	4.21	—	7.39
1 1/2"	Extruded	T6	Hardened	-320° to 300°	8975K199	1.36	1.88	3.50	4.86	—	8.53
1 3/4"	Extruded	T6	Hardened	-320° to 300°	8975K204	1.46	2.01	3.74	5.20	—	9.13
2"	Extruded	T6	Hardened	-320° to 300°	8975K206	1.67	2.30	4.28	5.96	—	10.45
2 1/4"	Extruded	T6	Hardened	-320° to 300°	8975K207	1.81	2.49	4.63	6.44	—	11.30
2 1/2"	Extruded	T6	Hardened	-320° to 300°	8975K208	1.93	2.66	4.96	6.89	—	12.09
2 3/4"	Extruded	T6	Hardened	-320° to 300°	8975K209	2.00	2.75	5.13	7.14	—	12.52
3"	Extruded	T6	Hardened	-320° to 300°	8975K295	2.09	2.87	5.35	7.44	—	13.05
1/16" Thick. (-0.003" to 0.003" Tolerance)											
1/4"	Extruded	T6	Hardened	-320° to 300°	9447T31	—	—	3.55	—	$4.66	5.82
3/32" Thick. (-0.006" to 0.006" Tolerance)											
3/8"	Extruded	T6	Hardened	-320° to 300°	8975K296	—	—	1.22	1.69	—	2.97
1/2"	Extruded	T6	Hardened	-320° to 300°	8975K297	—	—	1.49	2.06	—	3.63
3/4"	Extruded	T6	Hardened	-320° to 300°	8975K298	—	1.09	2.03	2.82	—	4.95
1"	Extruded	T6	Hardened	-320° to 300°	8975K299	1.05	1.45	2.70	3.76	—	6.59

← Lightweight A356 Aluminum Foam | Tight-Tolerance Multipurpose 6061 Aluminum Sheets ...

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McMaster-Carr (mcmaster.com) Steel Threaded Rod

threaded rods | McMaster-Carr

mcmaster.com/threaded-rods/low-strength-steel-threaded-rods-9/

McMASTER-CARR

threaded rods

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Clear All

System of Measurement
Inch

Thread Size
2-56
3-48
4-40
5-40
6-32
8-32
10-24
10-32

Thread Type
UN12 UNF
UNC UNS

Length
1/2"
5/8"
3/4"
7/8"
1"
1 1/4"
1 1/2"
1 3/4"

751 Products

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Low-Strength Steel Threaded Rods

Steel

Lg.	Tensile Strength, psi	Hardness	Pkg. Qty.		Pkg.
5/16"-18					
5/8"	50,000	Rockwell B61	50	91565A582	8.42
3/4"	50,000	Rockwell B61	50	91565A583	9.83
7/8"	50,000	Rockwell B61	50	91565A580	8.53
1"	50,000	Rockwell B61	50	91565A584	10.12
1 1/4"	50,000	Rockwell B61	50	91565A585	12.28
1 1/2"	50,000	Rockwell B61	50	91565A587	13.98
1 3/4"	50,000	Rockwell B61	50	91565A588	15.71
2"	50,000	Rockwell B61	25	91565A591	9.15
2 1/4"	50,000	Rockwell B61	25	91565A592	10.23
2 1/2"	50,000	Rockwell B61	25	91565A593	11.48
3"	50,000	Rockwell B61	10	91565A595	5.45
3 1/2"	50,000	Rockwell B61	10	91565A597	6.43
4"	50,000	Rockwell B61	10	91565A599	7.48
5"	50,000	Rockwell B61	10	91565A603	7.96
6"	50,000	Rockwell B61	10	91565A605	9.91
7"	50,000	Rockwell B61	10	91565A607	11.09
8"	50,000	Rockwell B61	10	91565A609	12.88
1ft.	50,000	Rockwell B61	1	98790A330	.81
1 1/2ft.	50,000	Rockwell B61	1	98790A056	1.02
2ft.	50,000	Rockwell B61	1	98790A030	1.13
2 1/2ft.	50,000	Rockwell B61	1	98790A057	1.50
3ft.	50,000	Rockwell B61	1	98837A030	1.72
4ft.	50,000	Rockwell B61	1	98837A055	2.33
5ft.	50,000	Rockwell B61	1	98837A056	2.91
6ft.	50,000	Rockwell B61	1	98910A030	3.42
8ft.	50,000	Rockwell B61	1	98910A048	4.66
12ft.	50,000	Rockwell B61	1	98950A030	7.18
5/16"-24					
1ft.	50,000	Rockwell B61	1	98791A049	.76

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McMaster-Carr (mcmaster.com) Threaded Steel Pipe

standard pipe fittings | McMaster

mcmaster.com/standard-pipe-fittings/iron-and-steel-pipe-and-pipe-fittings/standard-wall-steel-thre...

Incognito (2)

McMASTER-CARR

standard pipe fittings

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Clear All

Pipe Size

1/8
1/4
3/8
1/2
3/4
1
1 1/4
1 1/2
2
2 1/2
3
4
6

Thread Type

NPT
BSPT

Threading

Threaded on Both Ends

Fully Threaded

Threaded on One End

714 Products

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NPT Threaded on Both Ends— 1/8 to 1 Pipe Size

- For Use With: Air, Natural Gas, Oil, Steam, Water
- Specifications Met: ASTM A733, ANSI/ASME B1.20.1, ASTM A53
- Fittings: Use Class 125 or 150 Iron and Steel

Lg.	Construction	Material		Each
1/8 Pipe Size				
1 1/2"	Welded	Black-Coated Steel	44615K421	$1.45
2"	Welded	Black-Coated Steel	44615K431	1.45
2 1/2"	Welded	Black-Coated Steel	44615K441	1.68
3"	Welded	Black-Coated Steel	44615K451	1.68
3 1/2"	Welded	Black-Coated Steel	44615K551	2.09
4"	Welded	Black-Coated Steel	44615K461	2.09
4 1/2"	Welded	Black-Coated Steel	44615K141	3.95
5"	Welded	Black-Coated Steel	44615K471	3.95
5 1/2"	Welded	Black-Coated Steel	44615K153	4.55
6"	Welded	Black-Coated Steel	44615K481	4.55
6 1/2"	Welded	Black-Coated Steel	44615K171	5.99
7"	Welded	Black-Coated Steel	44615K491	5.99
7 1/2"	Welded	Black-Coated Steel	44615K71	7.59
8"	Welded	Black-Coated Steel	44615K521	5.99
8 1/2"	Welded	Black-Coated Steel	446	
9"	Welded	Black-Coated Steel	446	
9 1/2"	Welded	Black-Coated Steel	446	
10"	Welded	Black-Coated Steel	446	
10 1/2"	Welded	Black-Coated Steel	446	
11"	Welded	Black-Coated Steel	446	
11 1/2"	Welded	Black-Coated Steel	446	
12"	Welded	Black-Coated Steel	446	
14"	Welded	Black-Coated Steel	445	
16"	Welded	Black-Coated Steel	445	
18"	Welded	Black-Coated Steel	445	
20"	Welded	Black-Coated Steel	445	
22"	Welded	Black-Coated Steel	44	

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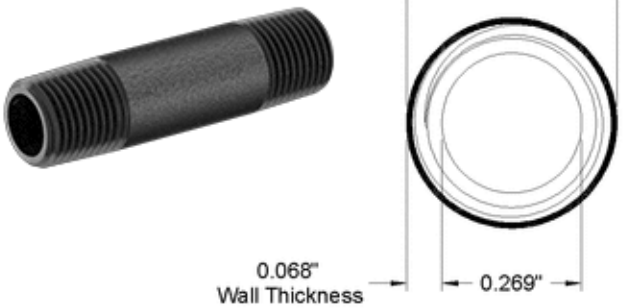
Pipe sizes can be a little crazy. Here it is shown that a 1/8" pipe has a 0.405" outer diameter. This would be rigid enough for our needs.

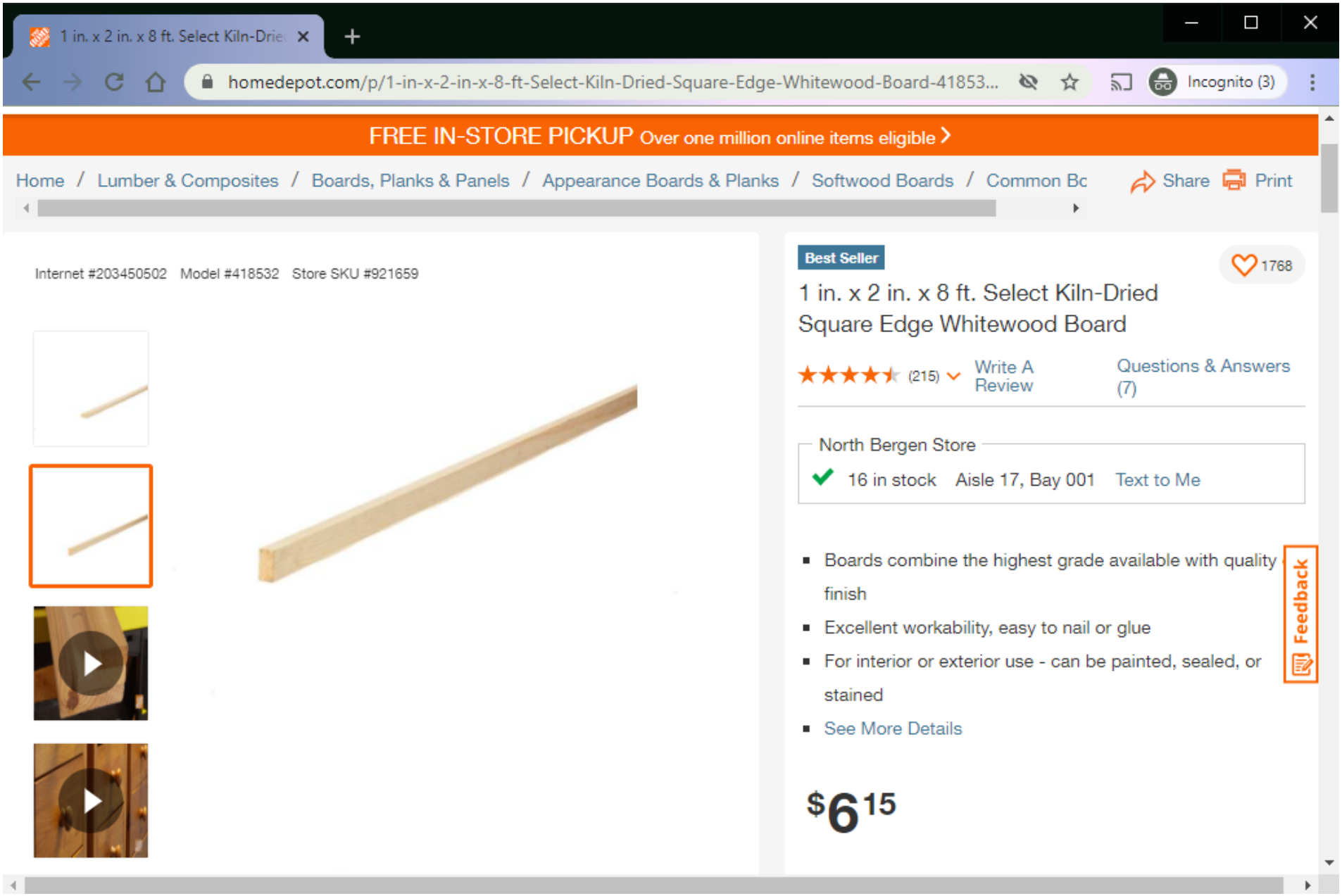
Standard-Wall Steel Pipe Nipple

Threaded on Both Ends, 1/8 NPT, 1-1/2" Long



Home Depot Wood

A 2x4 piece of lumber would be overkill for us. Consider something like a 1x2. We can make a few launchers from this 8 foot piece of wood.



Home Depot Wooden Dowel

Alexandria Moulding 3/4 in. x 48

homedepot.com/p/Alexandria-Moulding-3-4-in-x-48-in-Hardwood-Full-Round-Dowel-02534-R0048C/206013197

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Internet #206013197 Model #02534-R0048C Store SKU #148229

3/4 in. x 48 in. Hardwood Full Round Dowel

177

by **Alexandria Moulding** >

(15) Write A Review Questions & Answers (3)

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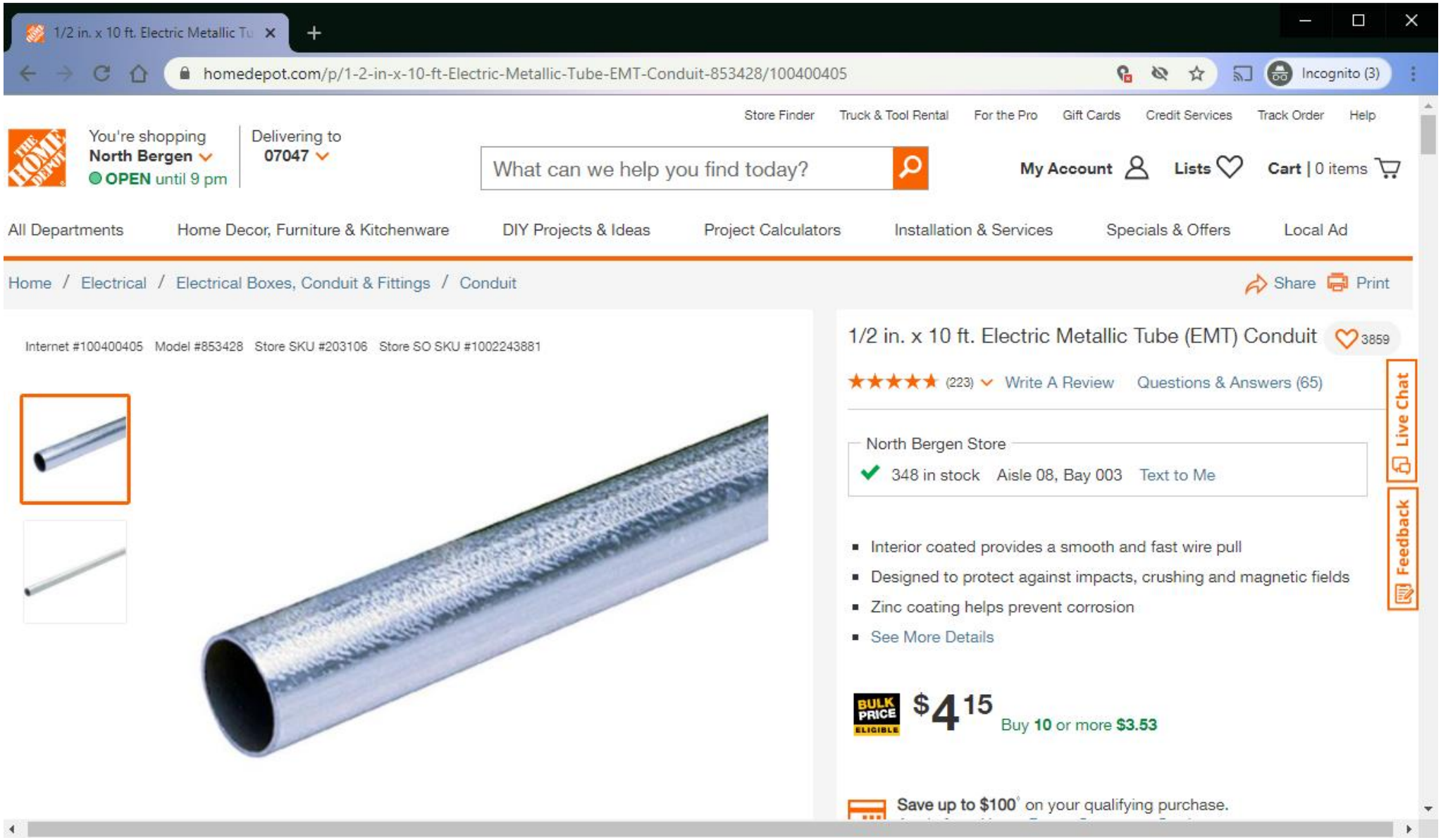
Available

Ship to Home
Not available for this

Scheduled Delivery
As soon as

Home Depot 1/2" Electrical Conduit (Outer Diameter = 0.706", Inner Diameter = 0.622")



Home Depot Shelving Standards

Everbilt

24 in. L - White Shelf Tracks Light Duty Vertical Rail

(44) Questions & Answers (11)

$4.98

- 24 in. length creates a versatile shelving system
- Combine with single-slot track brackets and wooc
- Durable powder coated design provide strength a rust
- View More Details

ClosetMaid

ShelfTrack 30 in. L White Standard Support Bracket for Wire Shelf Track, Shelving Hardware (1-Pack)

(2220) Questions & Answers (135)

$8.98

- Durable steel construction with white epoxy fini
- Double-slotted design provides added strength
- Compatible with ShelfTrack Closet Systems
- View More Details

Product Length (in.): **30.4 in**

12 in | **30.4 in** | 48 in | 60 in | 84 in