

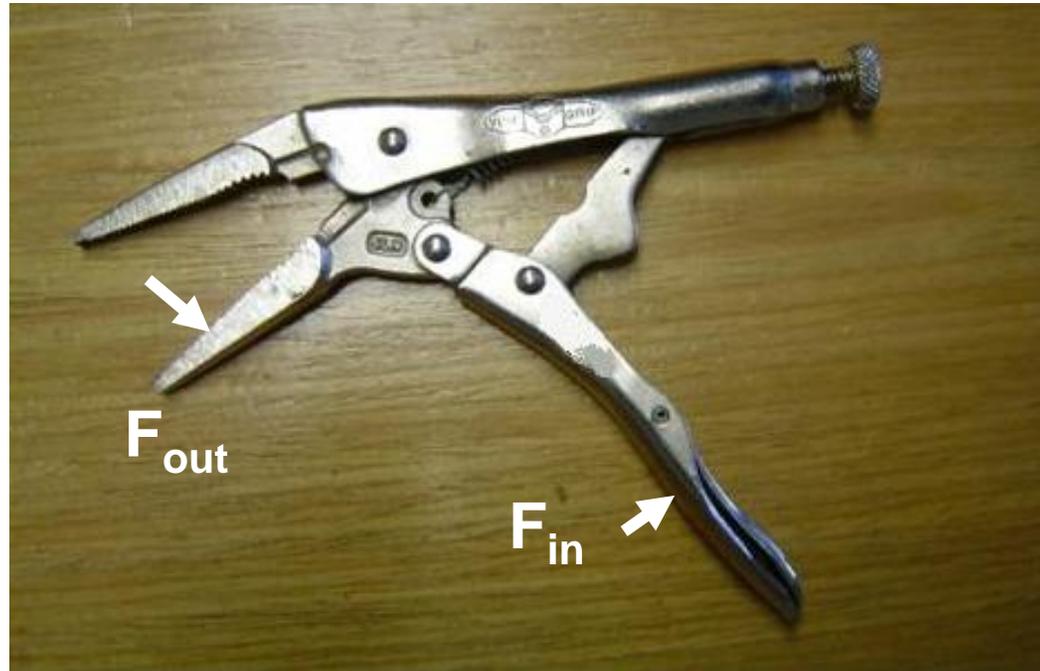
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2.007 Design and Manufacturing I  
Spring 2009

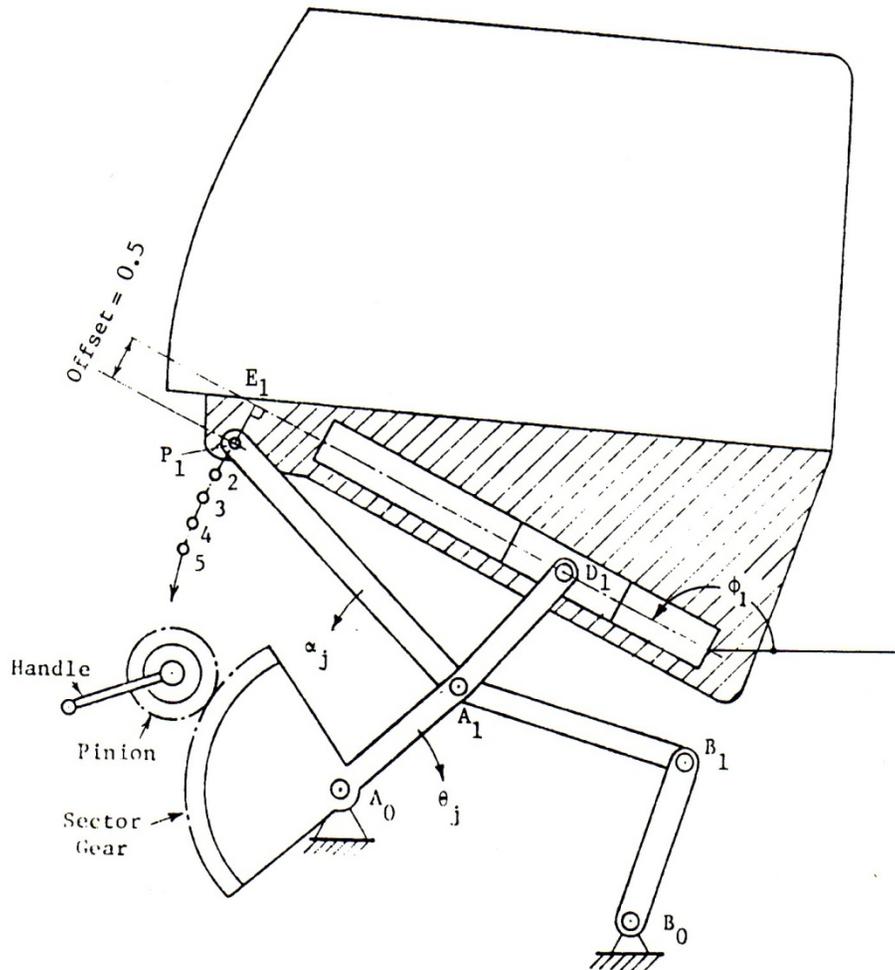
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2.007 –Design and Manufacturing I

# Mechanisms: Force Transmission



Presented by Dan Frey on 3 MAR 2009



- How many degrees of freedom does this mechanism have?

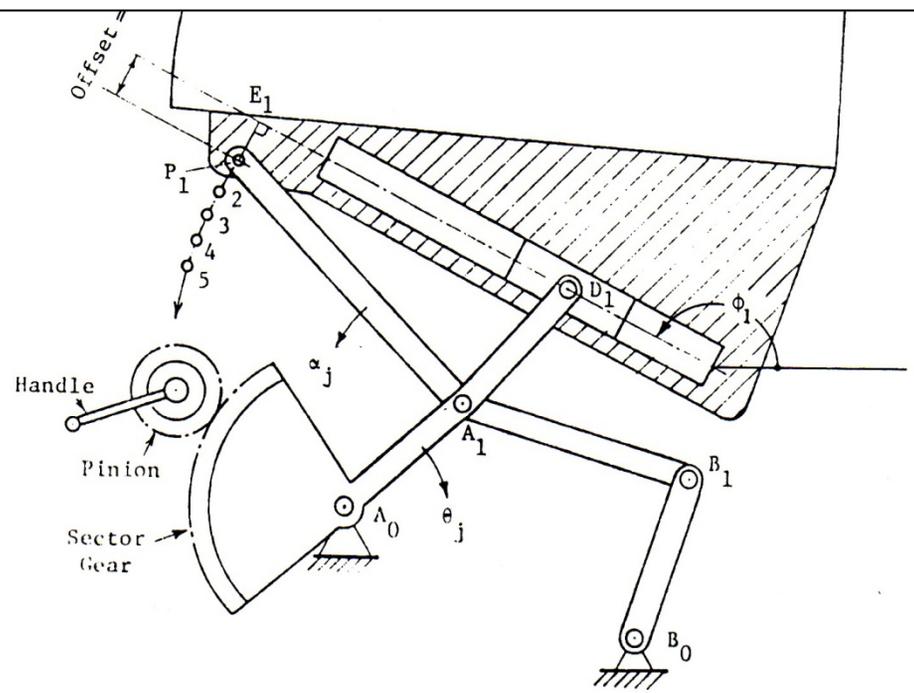
- 1) 1
- 2) 2
- 3) 3
- 4) 0

Source: Fig. 4-31 in Suh, C. H. *Computer Aided Design of Mechanisms Part A*. Self-published book, 1989. Courtesy of Dr. C. H. Suh. Used with permission.

The answer is one degree of freedom. Six bodies are in the mechanism if we include the block sliding within the window. Sliding motion constrains the block within the window (-2DOF). There are also 7 full pin joints (-2DOF each). Finally, there is traction between the pinion and the sector gear

$$6*3-2-7*2-1=1.$$

How many degrees of freedom does this mechanism have?



- 1) 1
- 2) 2
- 3) 3
- 4) 0

Source: Fig. 4-31 in Suh, C. H. *Computer Aided Design of Mechanisms Part A*. Self-published book, 1989. Courtesy of Dr. C. H. Suh. Used with permission.

- How many degrees of freedom does this mechanism have (not including the vehicle, wheels, etc)?

1) 1

2) 2

3) 3

4) 0

The answer is two degrees of freedom. Four bodies are in the mechanism if we include the pneumatic pistons. There are 6 full pin joints (-2DOF each) if we include the pivots at both ends of each pneumatic. Finally, each pneumatic can change length adding 1 DOF each.

$$4*3-6*2+2*1=2.$$

- How many degrees of freedom does this mechanism have (not including the vehicle, wheels, etc)?

1) 1

2) 2

3) 3

4) 0

# Today's Agenda

- Discuss homework #2
- Contest updates
- Forces in mechanisms
  - Some useful mechanisms
  - Solving systems of equations
  - Virtual work
  - Friction in mechanisms
  - Ratchets
- Distribute and discuss homework #1

# HW#2 Problem #1

1) (25 total) You're building a small, electric-powered vehicle to climb up a 20 degree ramp (similar slope as the ramp into the contest starting box). The vehicle will be operated by two servomotors that can continuously rotate the output shafts that attach directly to wheels on the left and right sides of the vehicle. The manufacturer's specifications indicate each servo is capable of a no load speed of 50 rpm and a stall torque of  $0.3 \text{ N}\cdot\text{m}$  (similar to the specs of the HS-311 standard servos in the kit). The total vehicle weight along with its payload is **12 N (a little more than the weight of a liter of water)**. All the wheels have a radius of 6cm. The front and rear axles are 20cm apart. The center of gravity of the vehicle and payload is halfway between the front and rear wheels and is 3cm above the surface on which the vehicle runs.

## NOTES:

A solution with any value of weight is fine, as long as you really explain what happens.

Give some thought to the forces on the "free" (not driven) wheels

# Sensors

- Contact (mechanical)
- Proximity (optical)
- Range (acoustic)
- Force (piezo)

Images removed due to copyright restrictions. Please see

<http://media.digikey.com/photos/Honeywell%20Photos/BZ-2RW82.jpg>

<http://www.trossenrobotics.com/store/i/is.aspx?path=/images/Pimages/S-10-GP2D120.jpg>

<http://www.parallax.com/Portals/0/Images/Prod/2/280/28015-M.jpg>

[http://media.digikey.com/photos/Parallax%20Photos/MFG\\_30056.jpg](http://media.digikey.com/photos/Parallax%20Photos/MFG_30056.jpg)

# Rules Clarifications

- First level bales should be in the target area and touching the playing field
- If and only if an opponent blocks the target, you may use countermeasures such as stacking on the blocking device or something else above that
- You can take one bale from the opponent's side – no other bales or cans can be removed from the opponent's side

# Spirit of the Rules

- One model = NFL football
- Evolved over decades
- Thousands of rules
- Hundreds of terms “fumble” “forward pass” “eligible receiver” ...
- Dozens of types of penalties “clipping”, “neutral zone infraction”, ...

<http://www.nfl.com/rulebook>

# Spirit of the Rules

- Another model = Calvinball

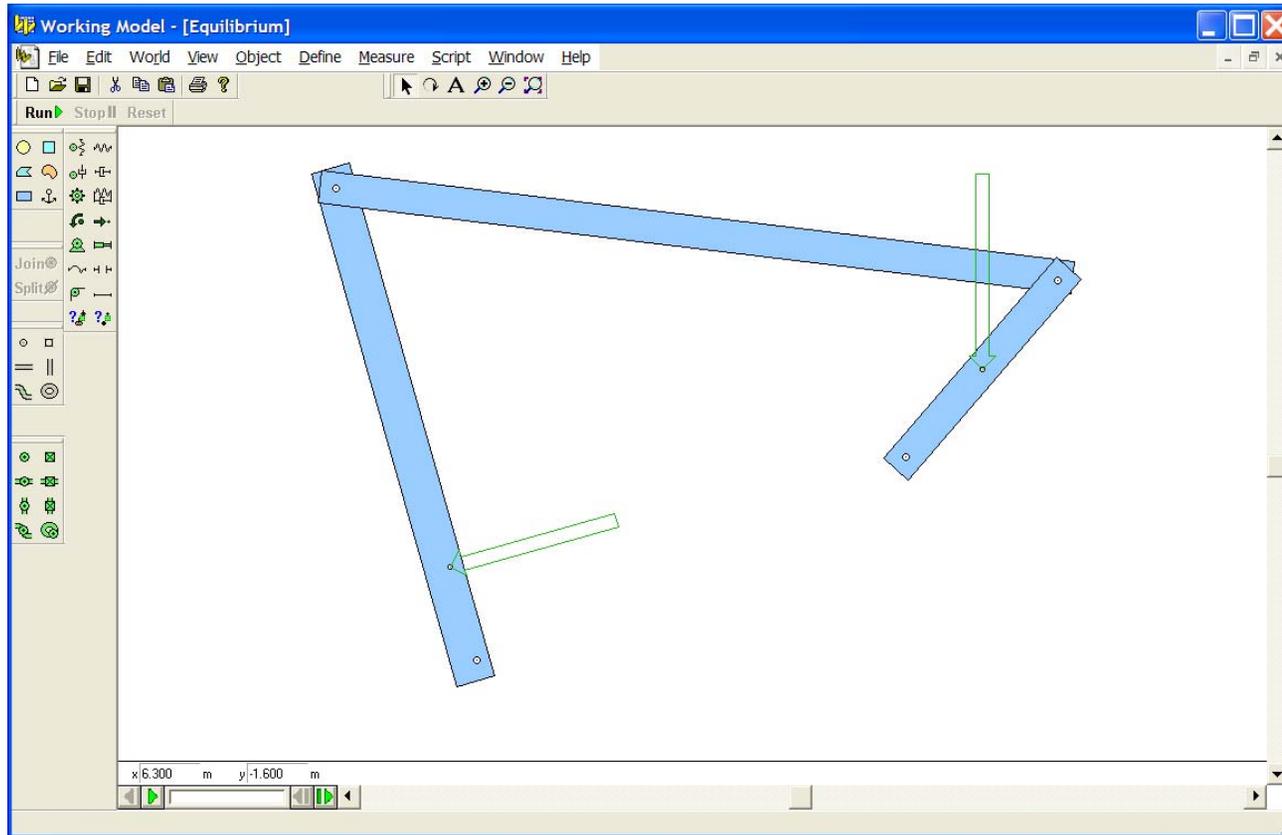
*Other kids' games are all such a bore!  
They've gotta have rules and they gotta keep score!  
Calvinball is better by far!  
It's never the same! It's always bizarre!  
You don't need a team or a referee!  
You know that it's great, 'cause it's named after me!*

Image removed due to copyright restrictions. Please see  
<http://bartel.org/calvinball/files/tcball.gif>

# Spirit of the Rules

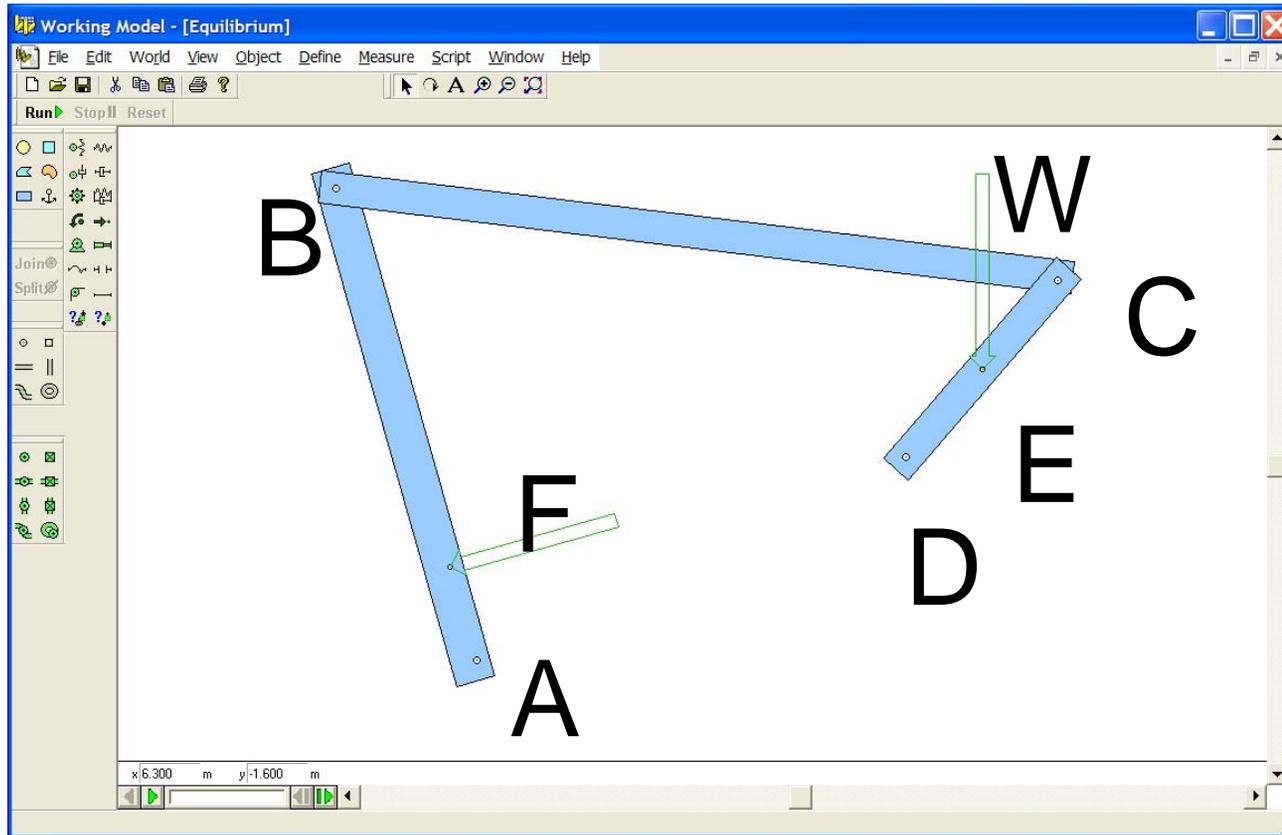
- A better fit? = Pick up volleyball
- There are rules
- Enough to give the game some structure
  - e.g., people try not to “carry” when setting
- If you focus very much on the rules, it might ruin the game for everyone

# Two Force Members



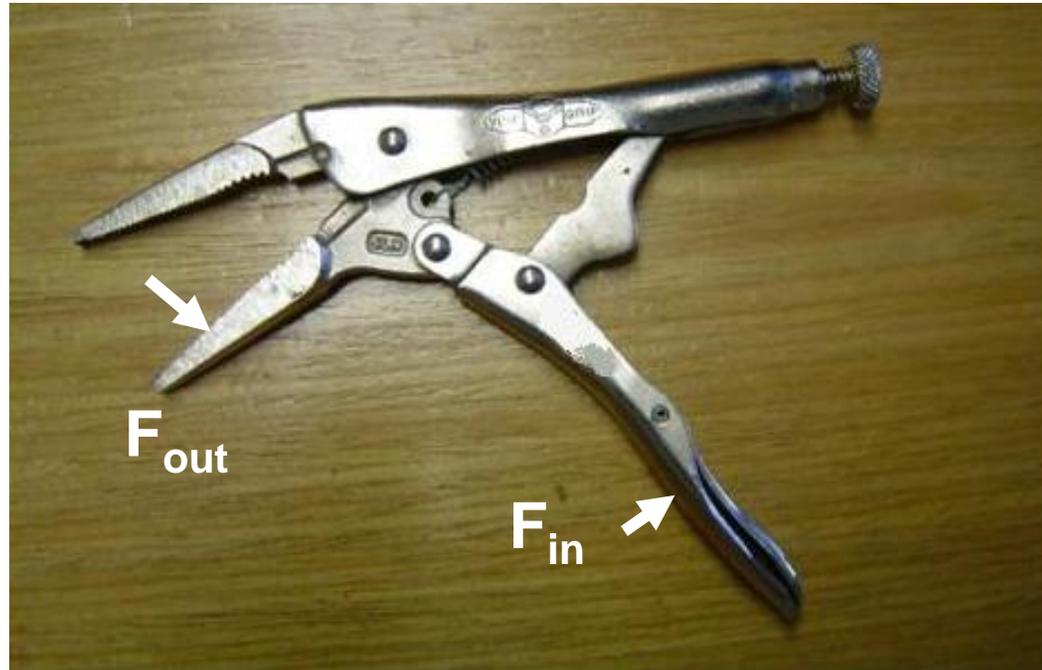
- If the only forces on a body act through 2 pin joints, then the net force acts along the line between the 2 joints.

# Analyzing Static Forces in Mechanisms



- What force  $F$  will keep this mechanism from moving?
- One way to find out -- write the equations of equilibrium

# Analyzing Static Forces in Mechanisms

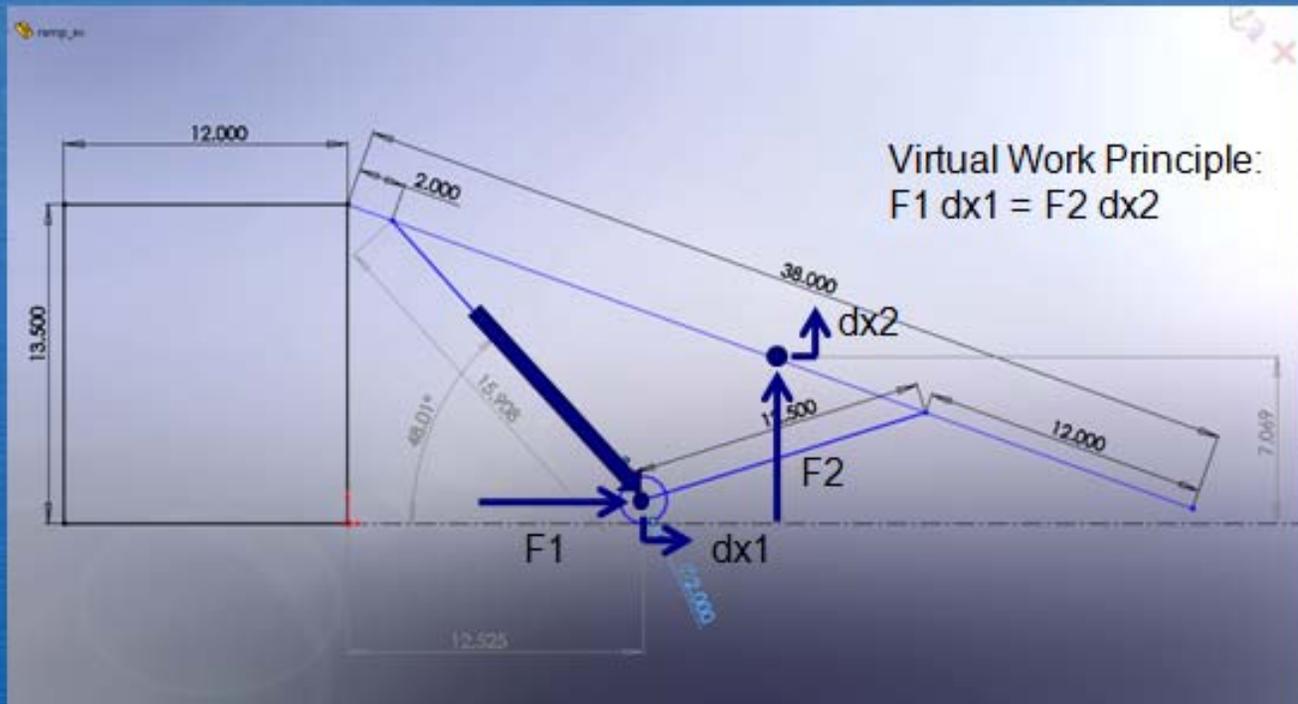


Approximately what is the ratio  $F_{out}/F_{in}$ ?

# From Lecture on “Basic Parts 1”



## Geometry



# From 2.003

## Example: Tethered Cart

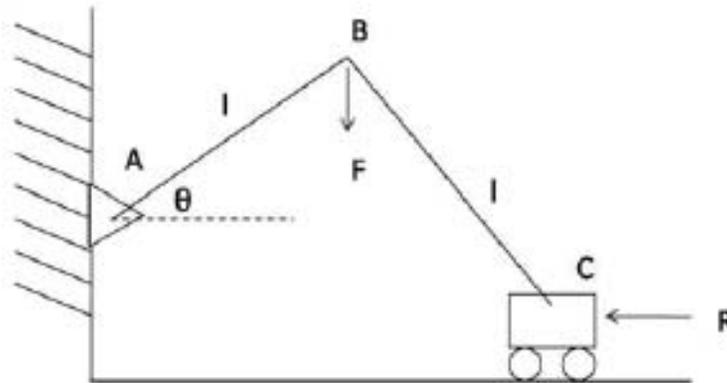


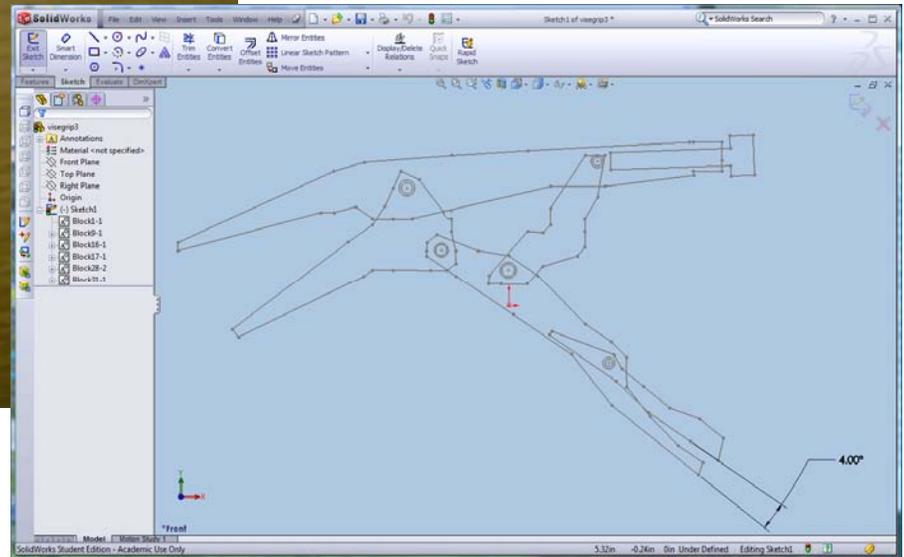
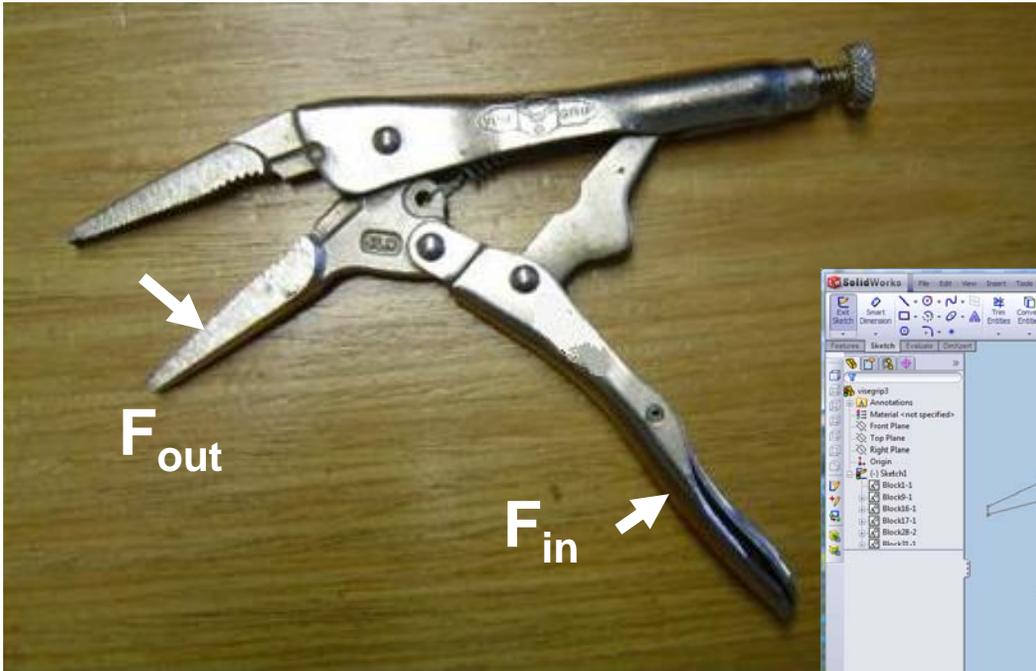
Figure 4: Tethered cart. The cart is attached to a tether that is attached to the wall. Figure by MIT OCW.

$$\delta w = F\delta y_B - R\delta x_c = 0$$

# From the Wikipedia

- Virtual work on a system is the work resulting from either virtual forces acting through a real displacement or real forces acting through a virtual displacement. In this discussion, the term displacement may refer to a translation or a rotation, and the term force to a force or a moment. ...

# Analyzing Static Forces in Mechanisms



Approximately what is the ratio  $F_{out}/F_{in}$ ?

# Toggle Points and Mechanisms



Check out what happens to the ratio  $F_{out}/F_{in}$ !

# Oil Filter Wrench

Image removed due to copyright restrictions. Please see any photo of a band-type oil filter wrench.

- Band attached to lever
- Two full pin joints
- How are the force on the lever and the tension in the strap related?
- How does the tension in the strap change along its length?

# Drum Brakes

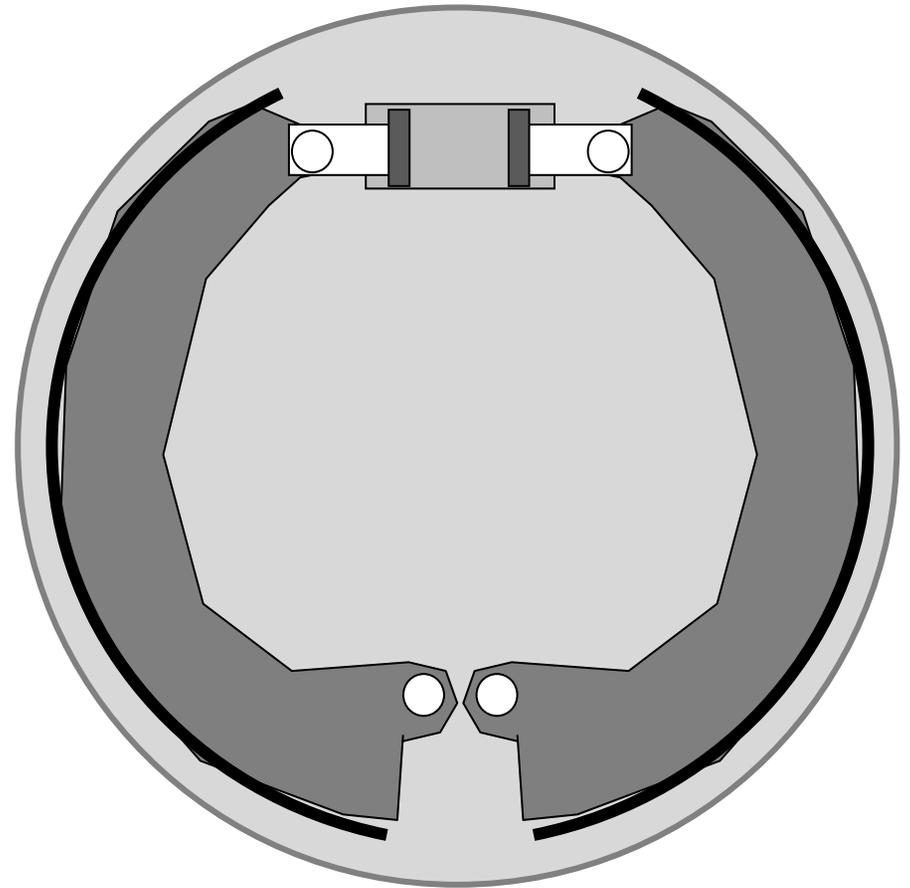
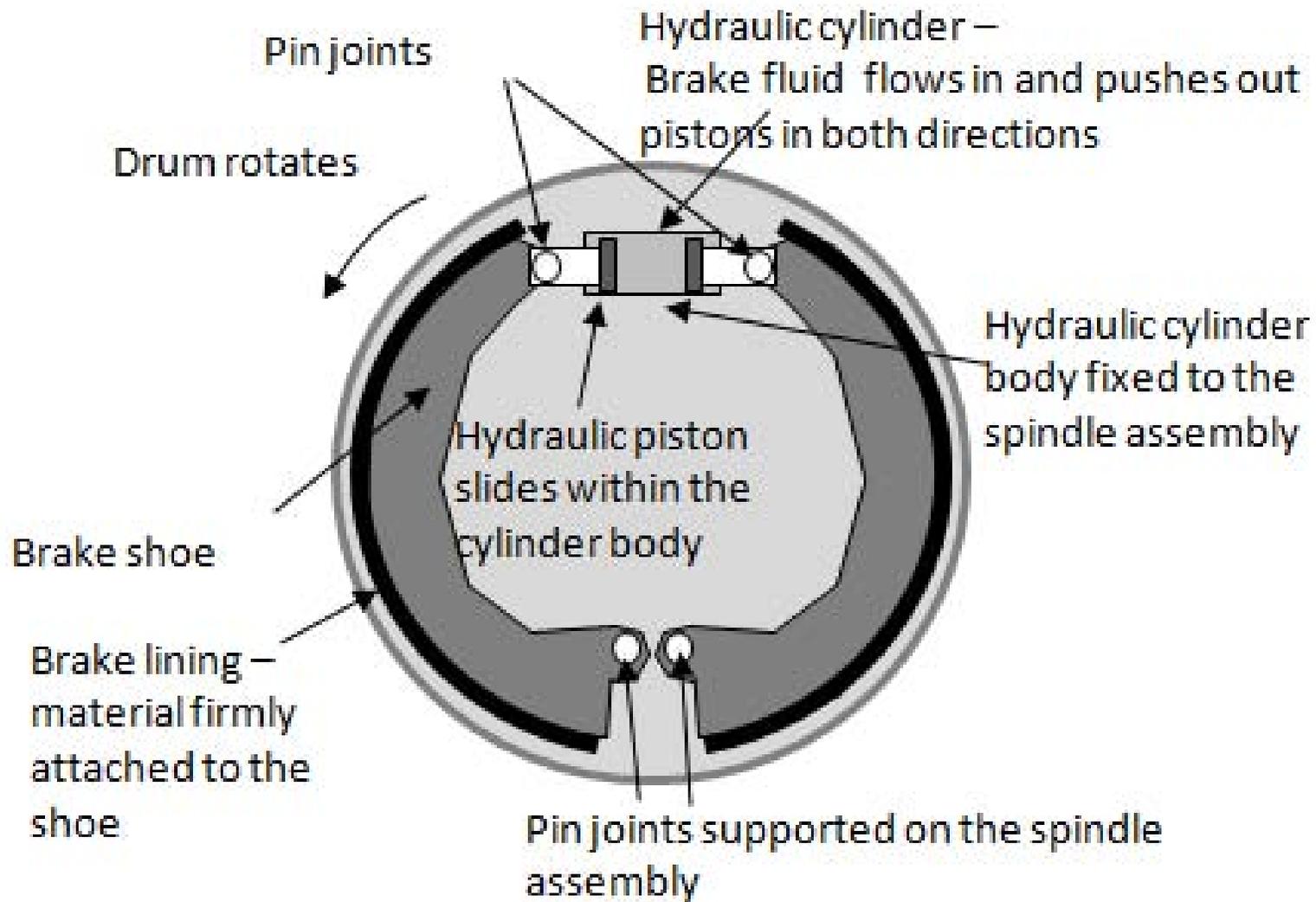


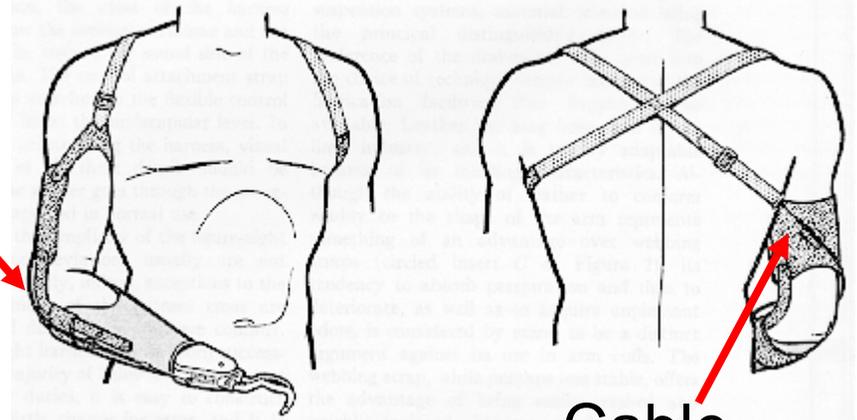
Image removed due to copyright restrictions. Please see any photo of a drum brake, such as [http://commons.wikimedia.org/wiki/File:Trabant\\_601\\_duplex\\_brake.jpg](http://commons.wikimedia.org/wiki/File:Trabant_601_duplex_brake.jpg)

# Drum Brakes

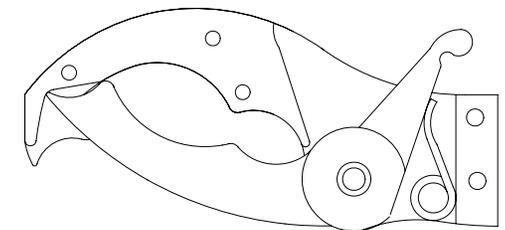
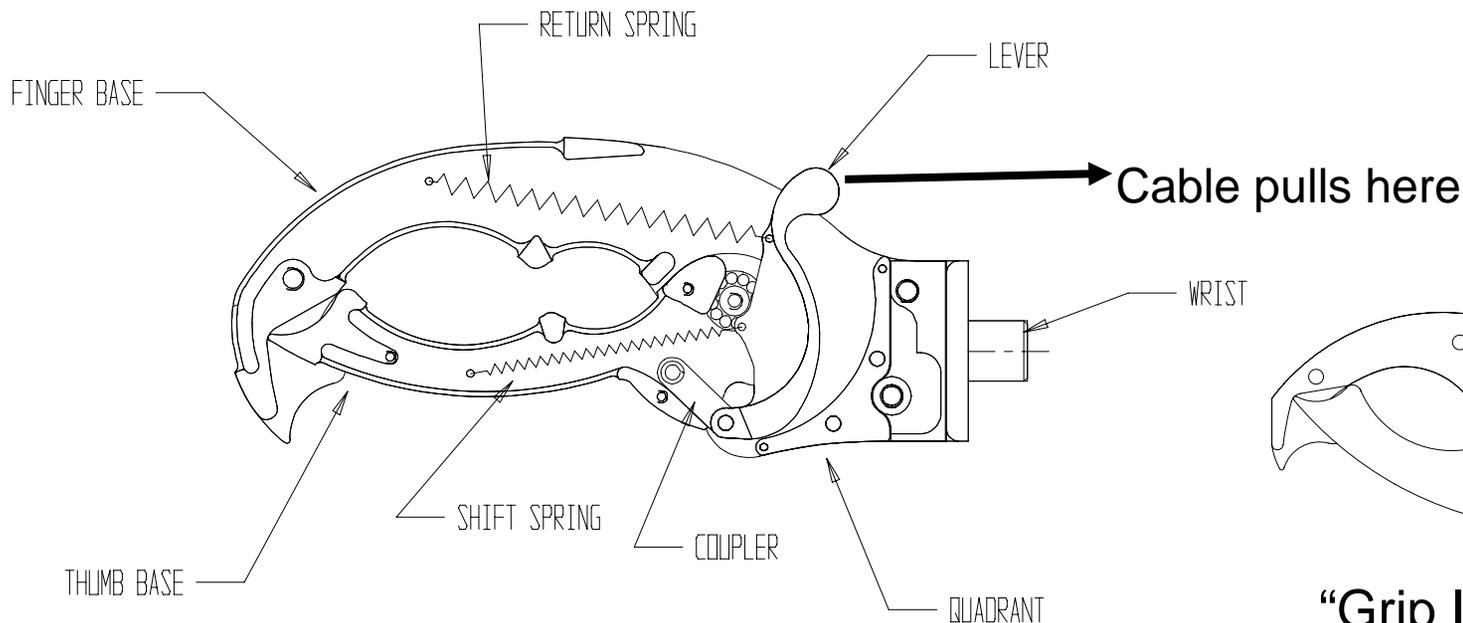


# A Prosthetic Prehensor

Cable runs within a housing down the arm



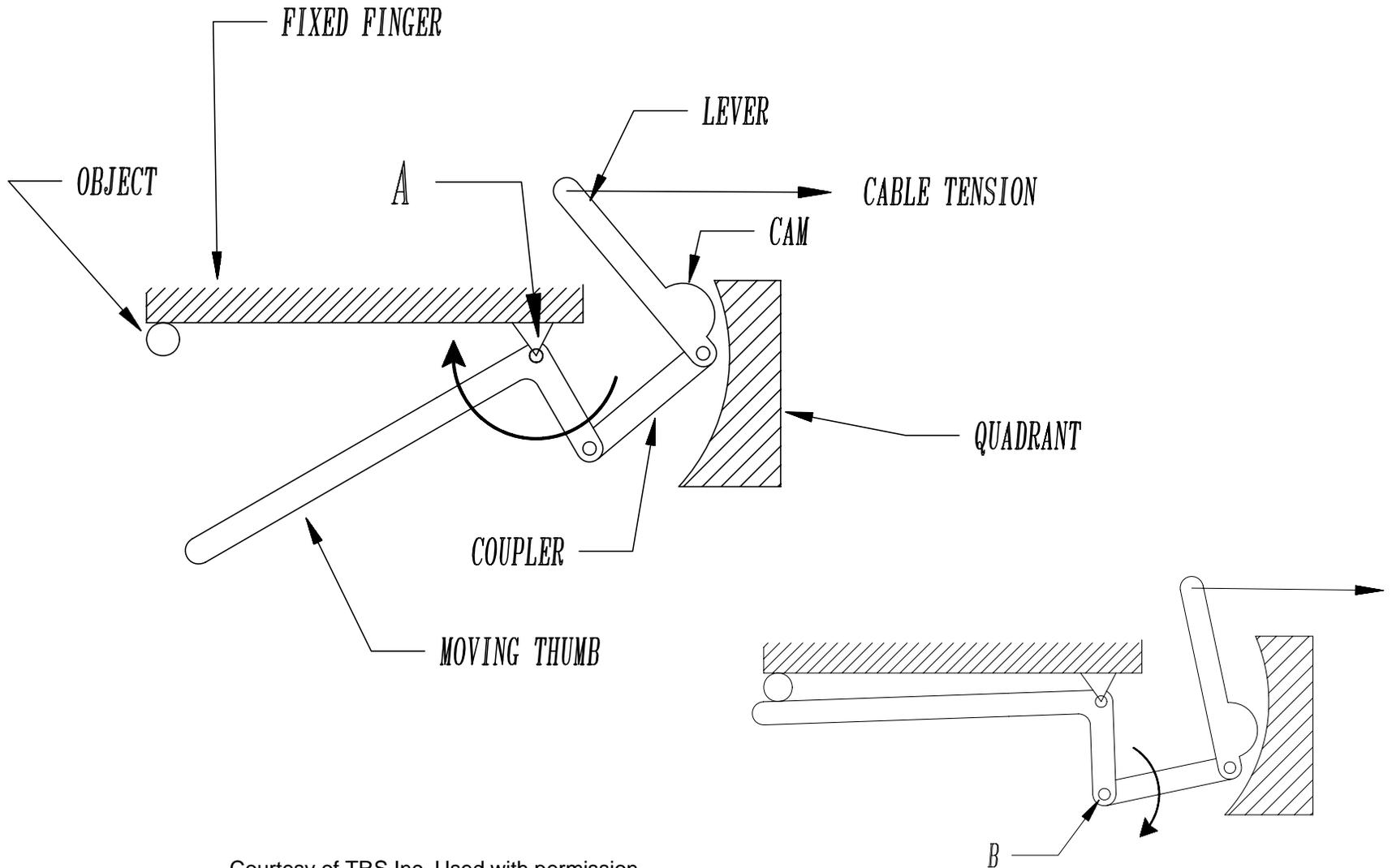
Cable attached to harness



“Grip III” by TRS Inc.

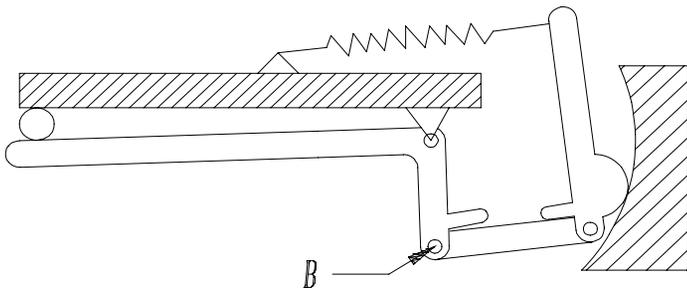
Courtesy of TRS Inc. Used with permission.

# Sizing Mode

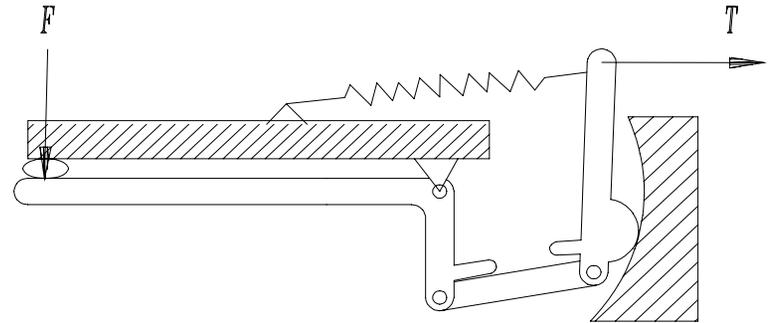


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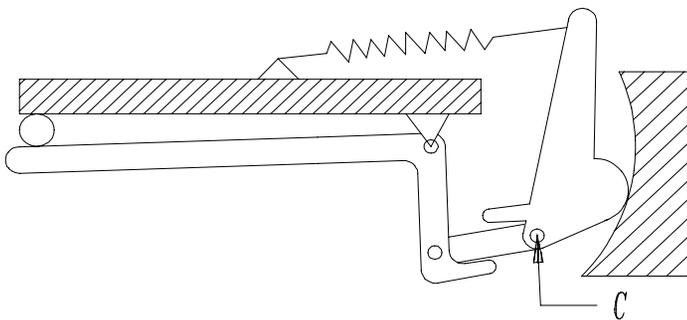
# Gripping Mode



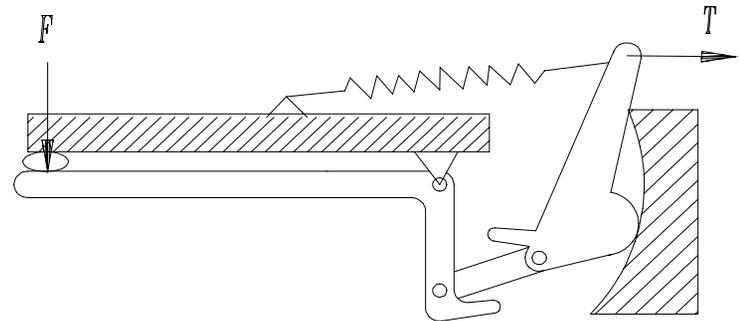
VMA I MECHANISM - AFTER SHIFT



VMA I MECHANISM - AT LIMIT OF MOBILITY

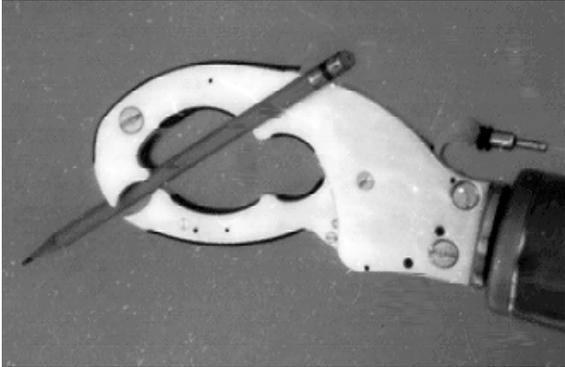


VMA II MECHANISM  
STOP FOR COUPLER SWITCHED TO OTHER SIDE



VMA II MECHANISM - AT TOGGLE POINT

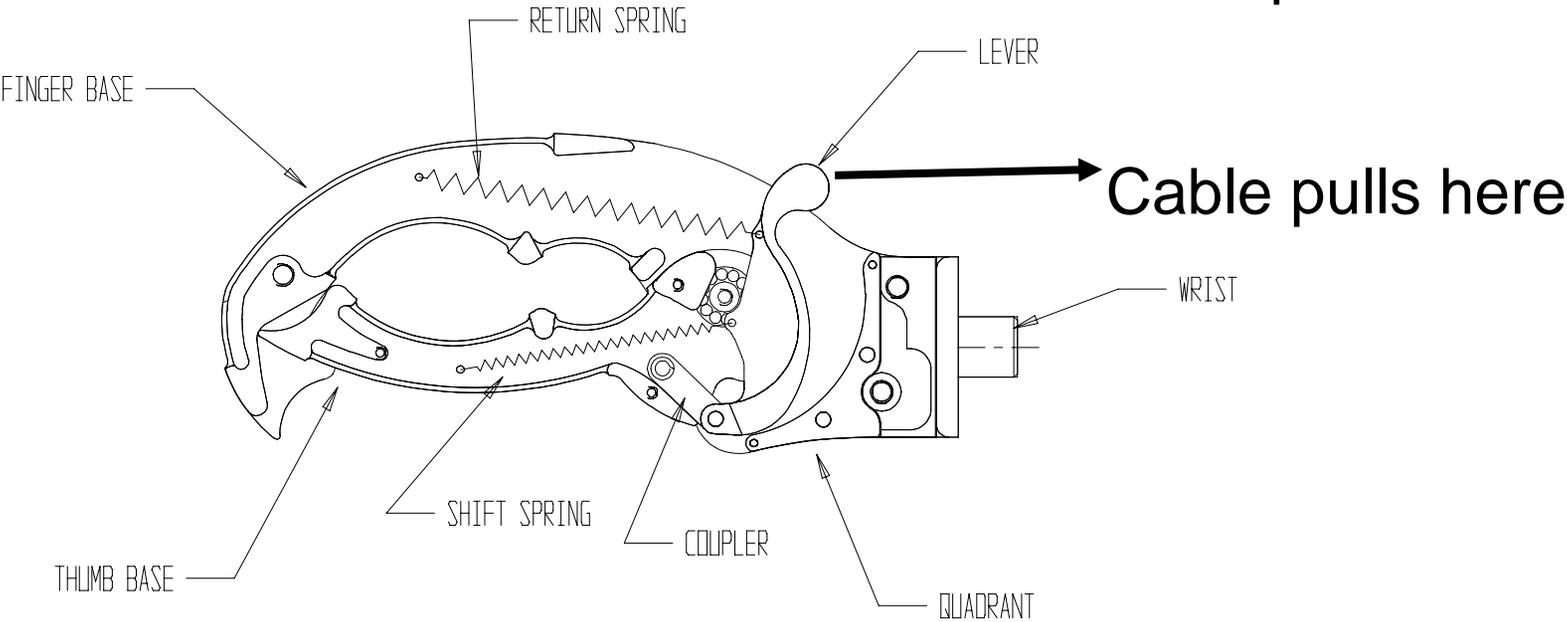
# How will the Mechanism Function?



output  
grip  
force



input cable tension



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# Next Steps

- Thursday 5 MAR, 11 AM
  - Lecture on CAD
  - HW #2 DUE
- Quiz #1 on 10 MAR, 11AM-12:30
  - Open book, open notes, etc.
  - Computer use OK, not really needed
  - Based on
    - Homework
    - Lecture material (especially concept questions)
  - Not so easy, you'll want to study