Improving Prosthetic Prehension

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Project Objective:

- Improve grasping performance of prosthetic prehensors
- Emphasis on body-powered devices

Outline

- Voluntary-opening prehensors
  - Vector Grip
  - Vector Hook
- Voluntary-closing prehensors
  - Variable Mechanical Advantage Prehensor
  - Child's Hand
- General prehension research
  - Quantification of grasp
  - Powder grip

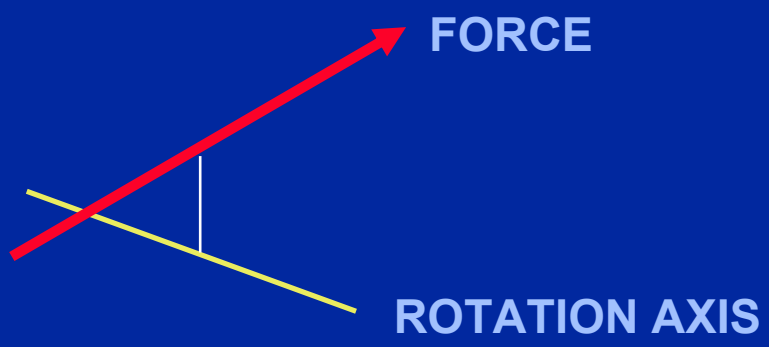
Voluntary-opening prehensors

- **Main advantage:**
  - **Maintain grasp with no cable tension required**
- **Main disadvantage:**
  - **Difficult to adjust grip force**

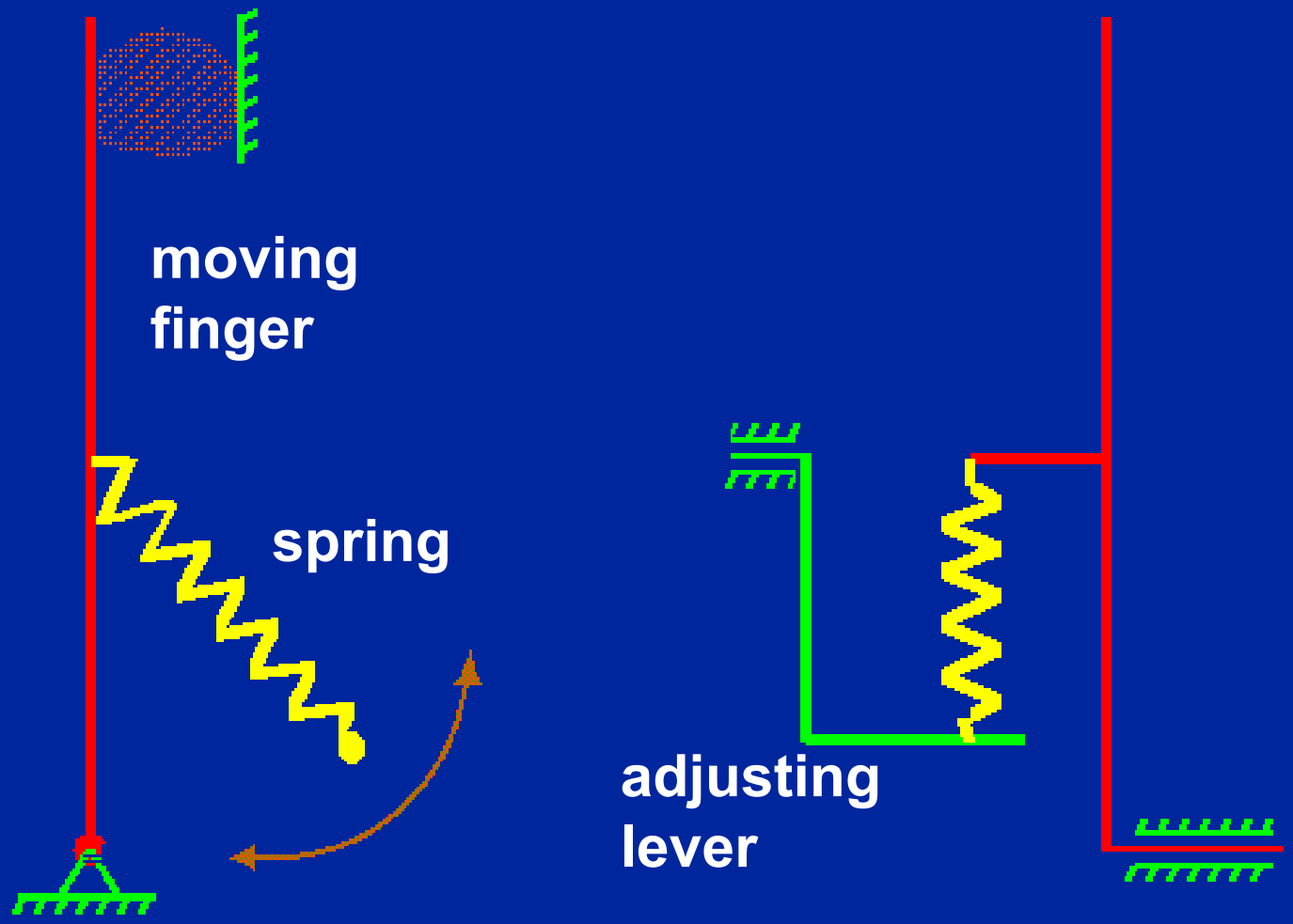
The vector concept

- Goal: pinch force adjustable from 1 to 15 lb.

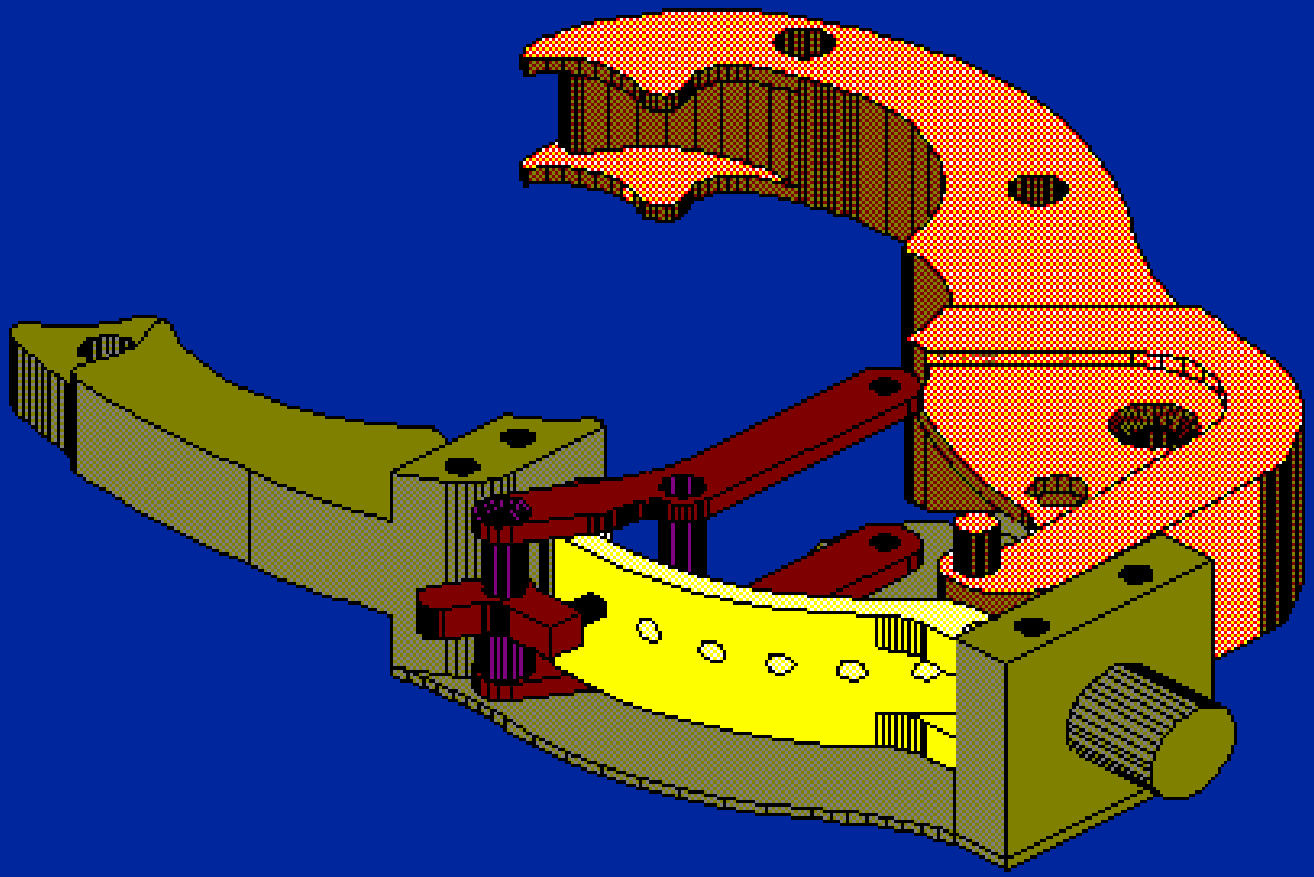
- Adjust *angle* of elastic force to adjust grip force
- If spring length doesn't change, no energy is required to make the adjustment



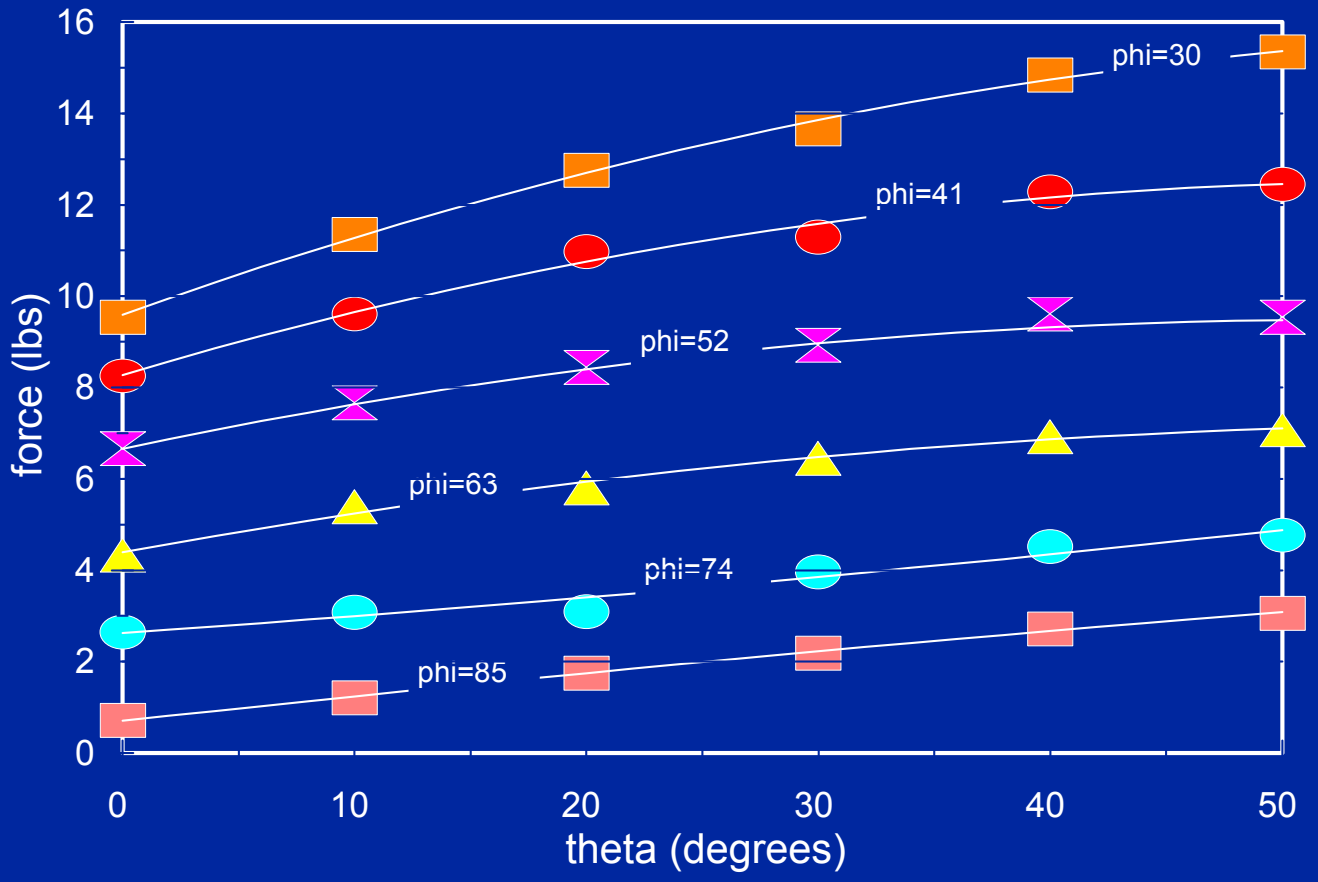
The Vector Concept



Vector Grip



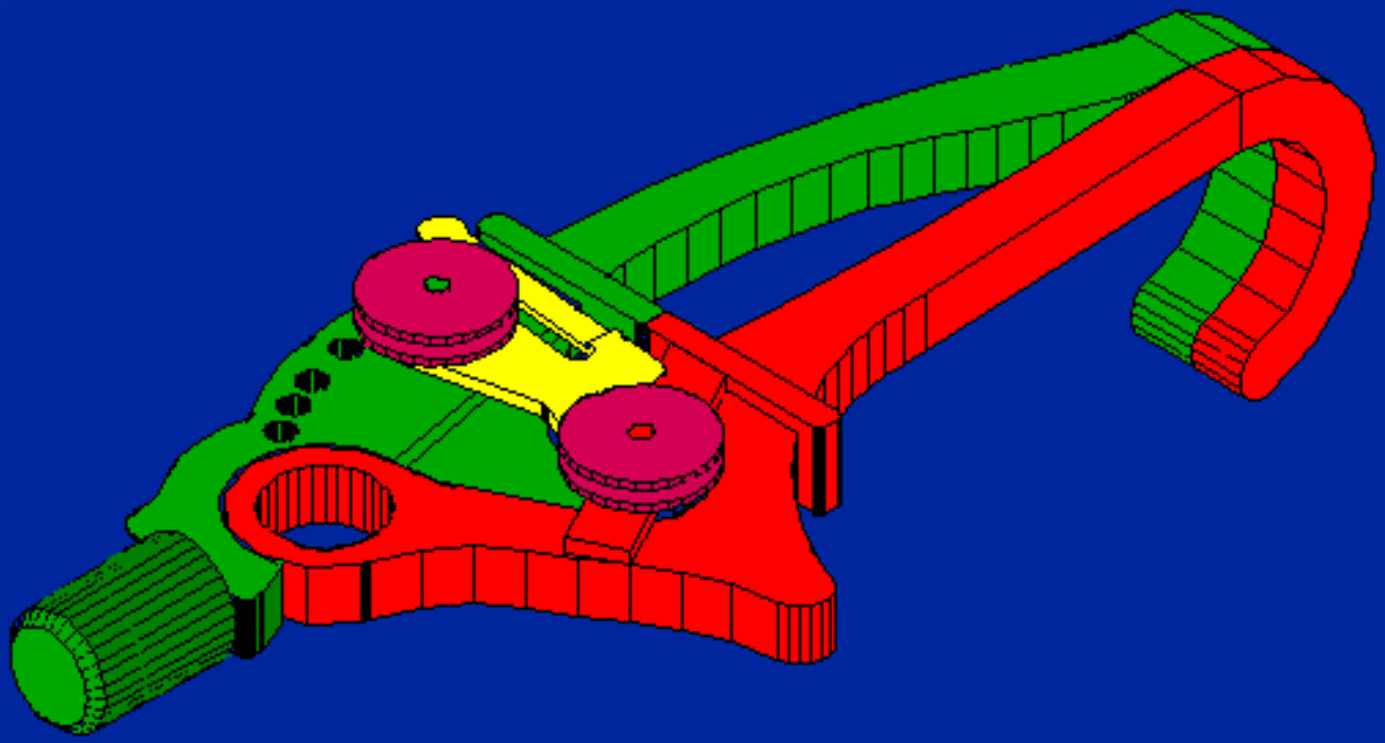
Grip force v/s Angle of opening



Results of amputee evaluation Vector Grip

- Reliable, simple mechanism
- Significant functional improvement over split hook
- Easily adjustable grip force
- Would like even lighter grasp level
- Could be slimmer
- Additional testing in progress

Vector Hook



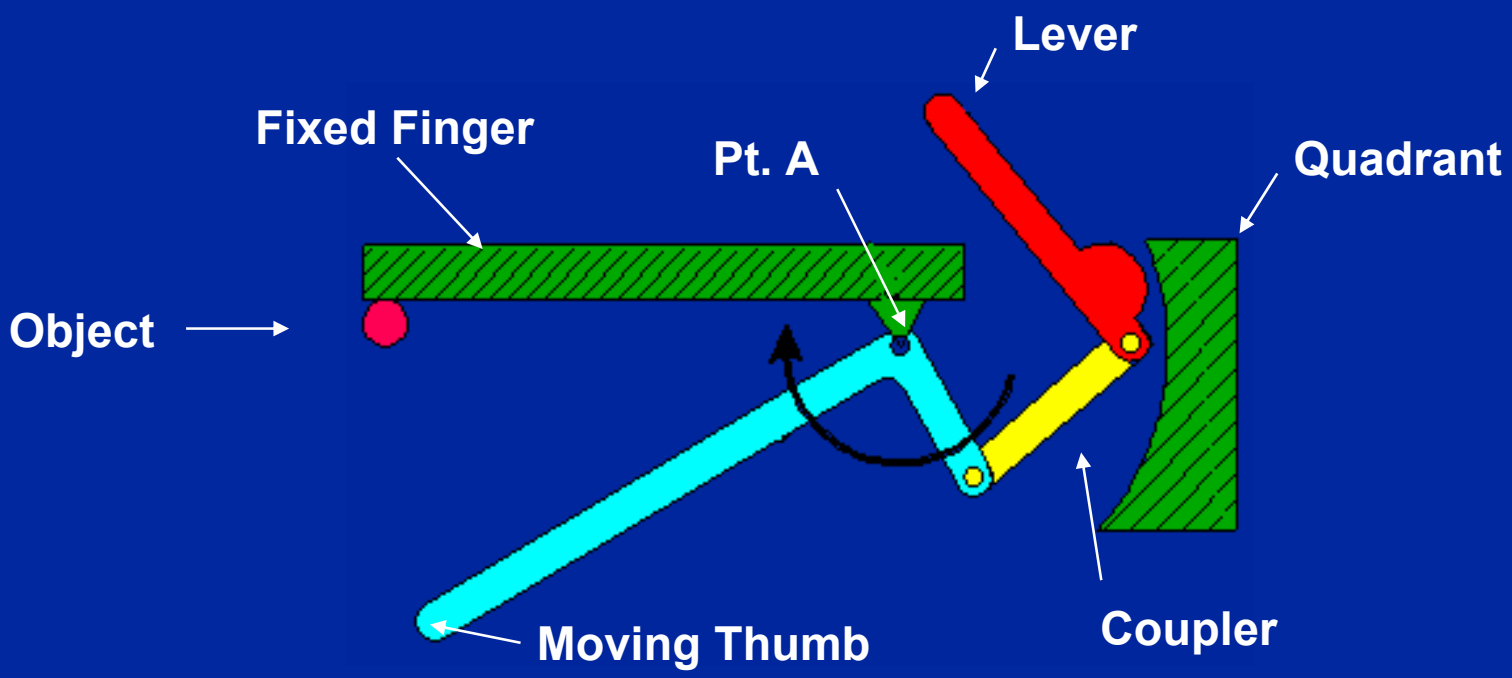
Voluntary-closing prehensors

- **Advantages:**
  - Natural control
  - Variable grip force
- **Disadvantages:**
  - Fingers are wide open with no cable tension
  - No way to keep fingers closed

Variable Mechanical Advantage (VMA)

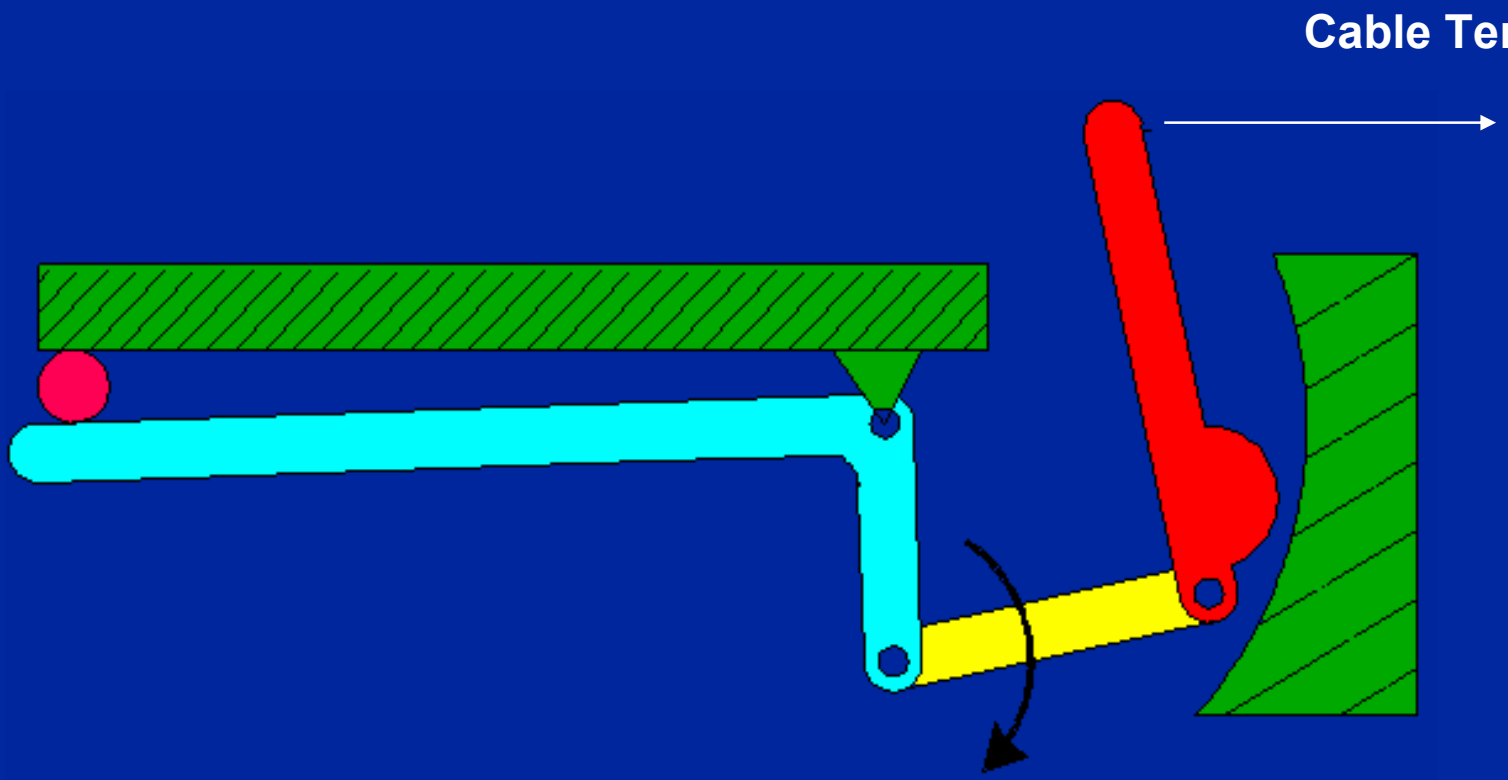
- **Concept:**
  - ***Sizing*** **and** ***gripping*** **are distinct phases of grasp**
  - **Both require minimal mechanical energy**
  - **Shift the mechanism when an object is encountered to enhance gripping performance:**
    - **Sizing requires less cable excursion**
    - **Magnified grip force generation**
  - **Modeled after Northwestern U. “Synergetic Prehensor”**

VMA Prehensor - Sizing Mode



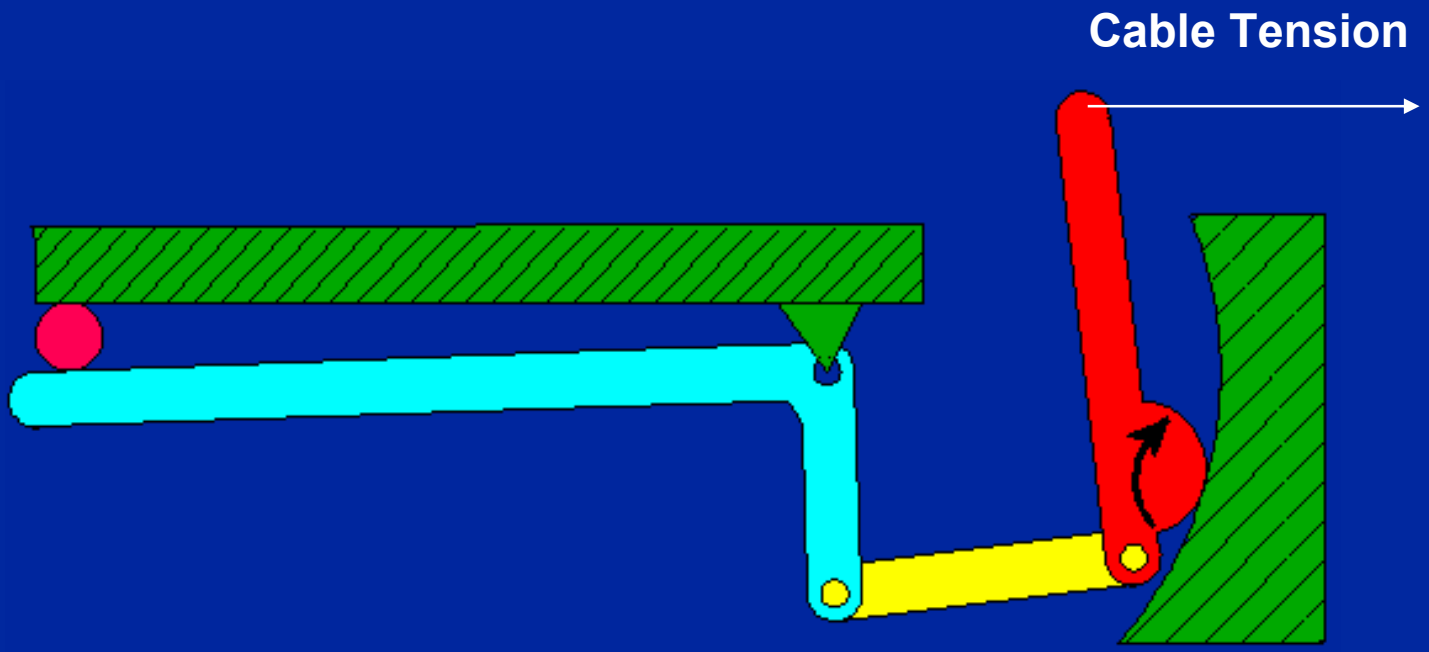
Thumb, Coupler, and Lever all Rotate about Pt. 'A'

Shifting Mode



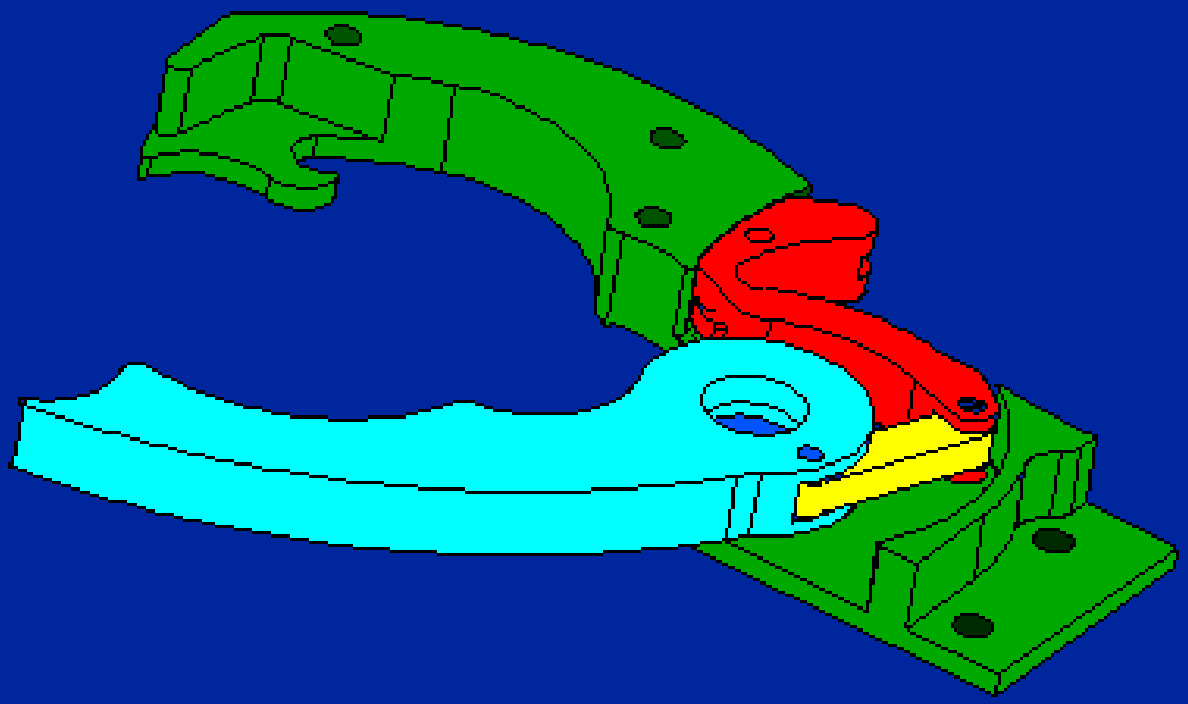
Lever and Coupler Rotate as One Rigid Body

Gripping Mode

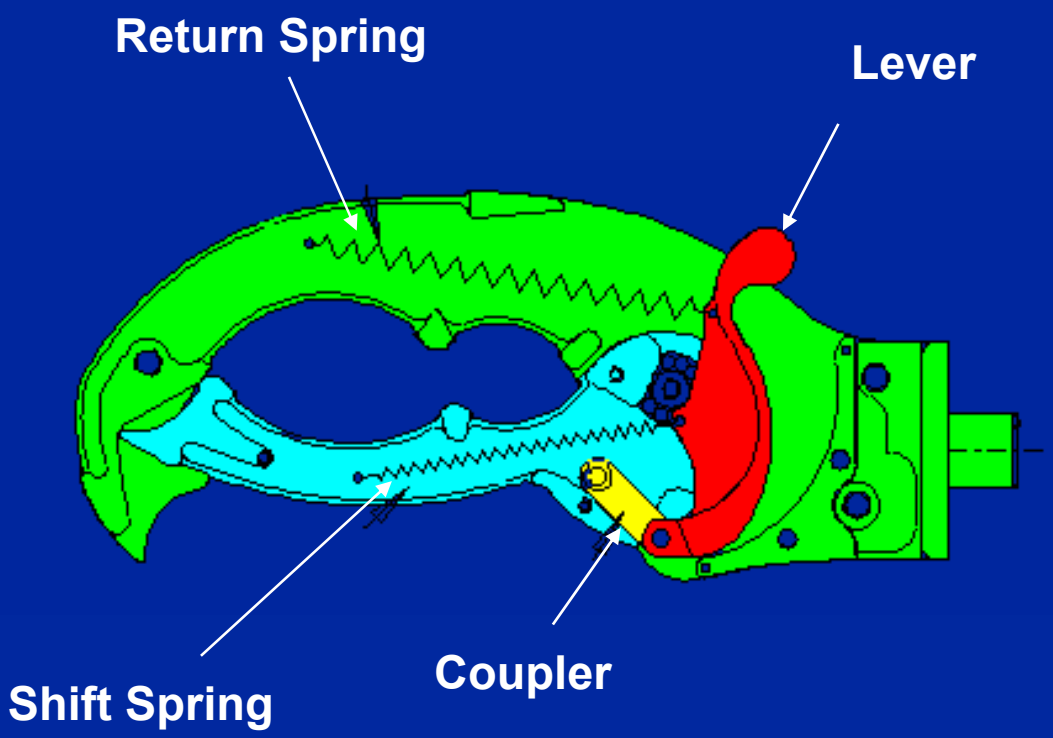


Cam Rolls without Slipping on Quadrant

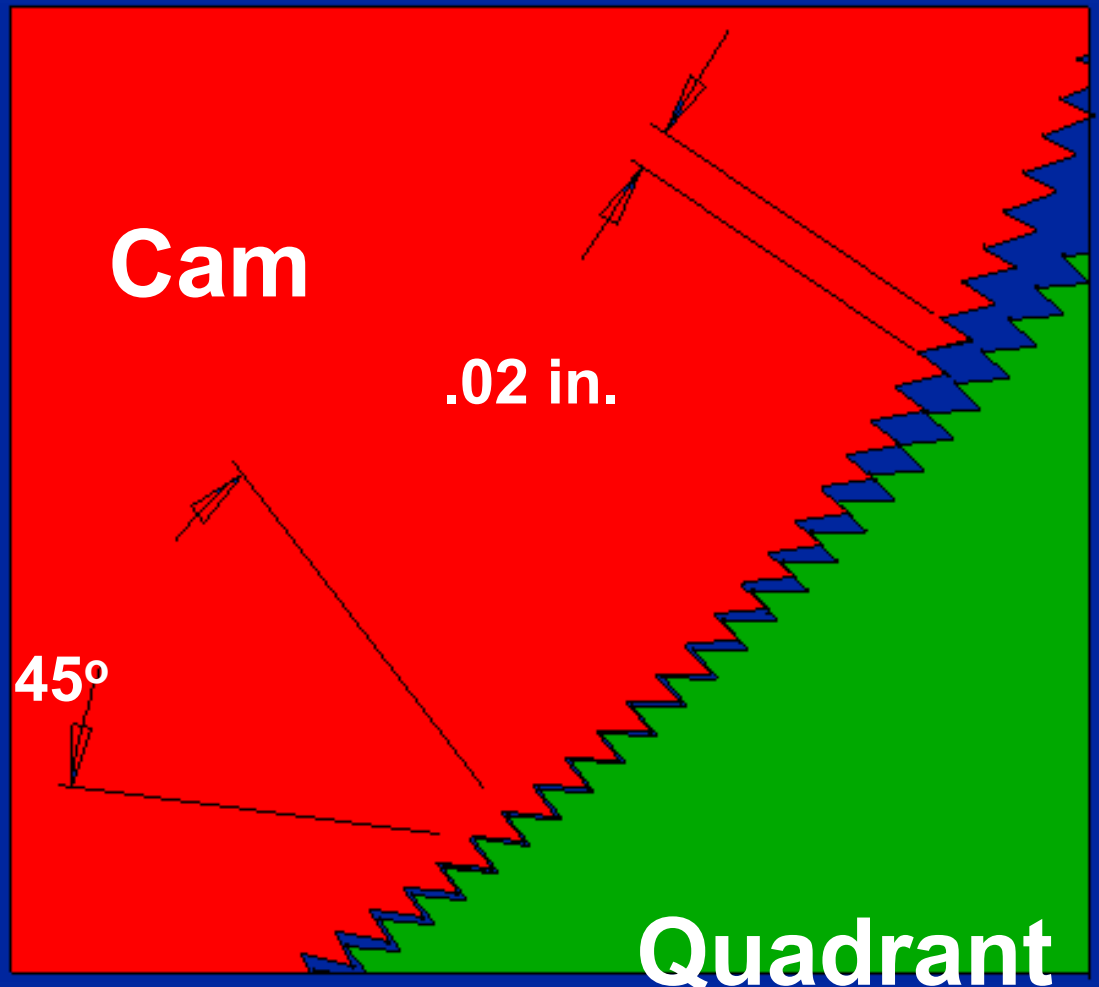
First VMA Prototype



The VMA Prehensor

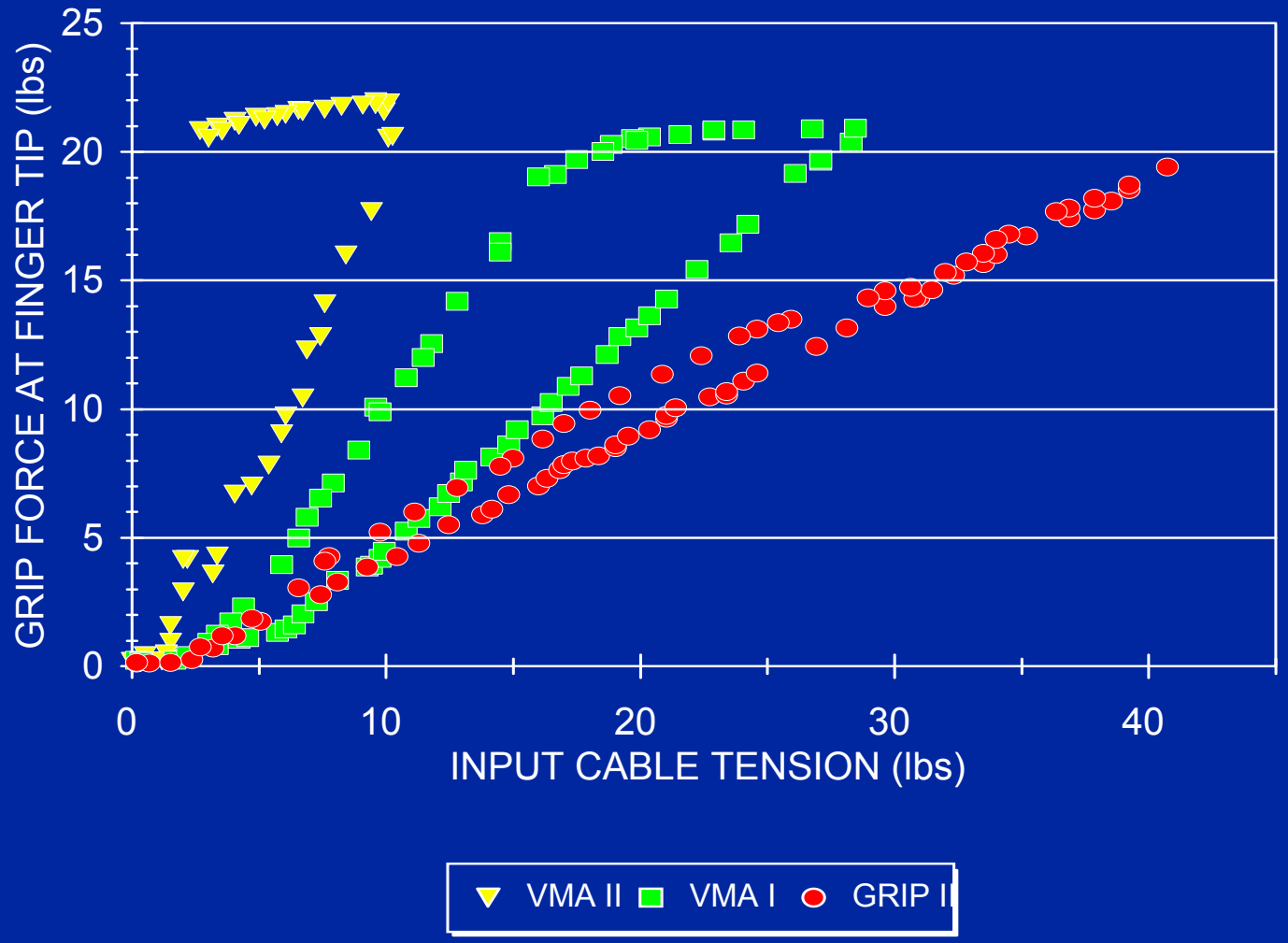


Ratchet Teeth



VMA II PREHENSOR

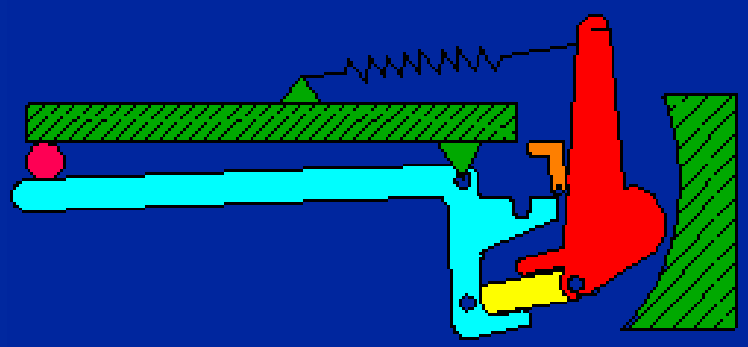
COMPARED TO VMA I & GRIP II



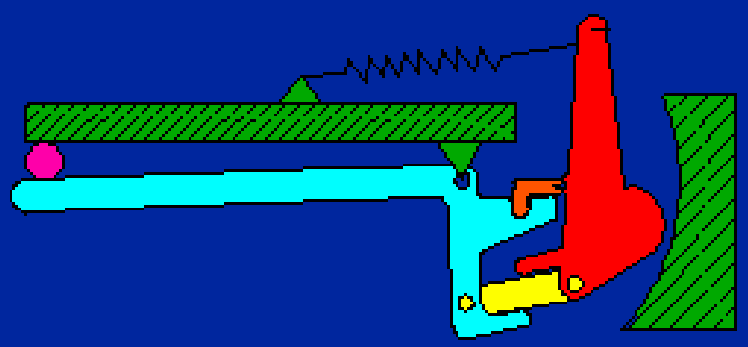
Results of amputee evaluation VMA Prehensor

- Works reliably
- Holding assist function works well
- Shifts prematurely with compliant objects
- “Free-wheel” switch convenient to use
  - Provides alternate mode of operation
- Additional field testing in progress

Proposed Free-Wheel Switch



VMA Mode



Free-Wheel Mode

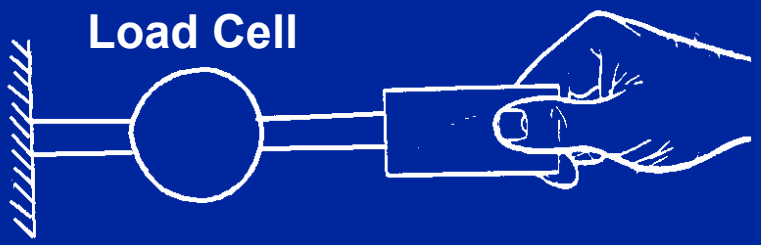
Child's Hand

- Anthropomorphic hand shape
- Designed for maximum efficiency
  - Voluntary closing body powered
  - No cosmetic glove
- Electrically operated lock
  - Battery operated
    - Commercially available battery
    - Long battery life (weeks)
  - Eliminate jamming found in locking prehensors
    - e.g. APRL hook, hand

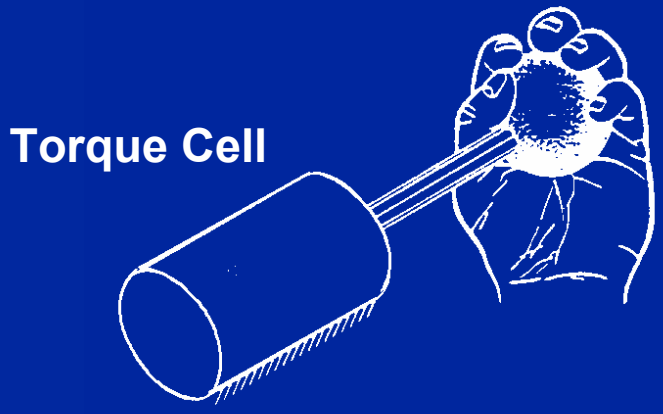
General Prehension Research

Quantification of grip force

Linear Pull Test



Torque Test



"Powder Grip"

Dr. David Simpson, Edinburgh, Scotland, 1971

Relaxed
Loose "Skin"

Gripping Object
Taut "Skin"