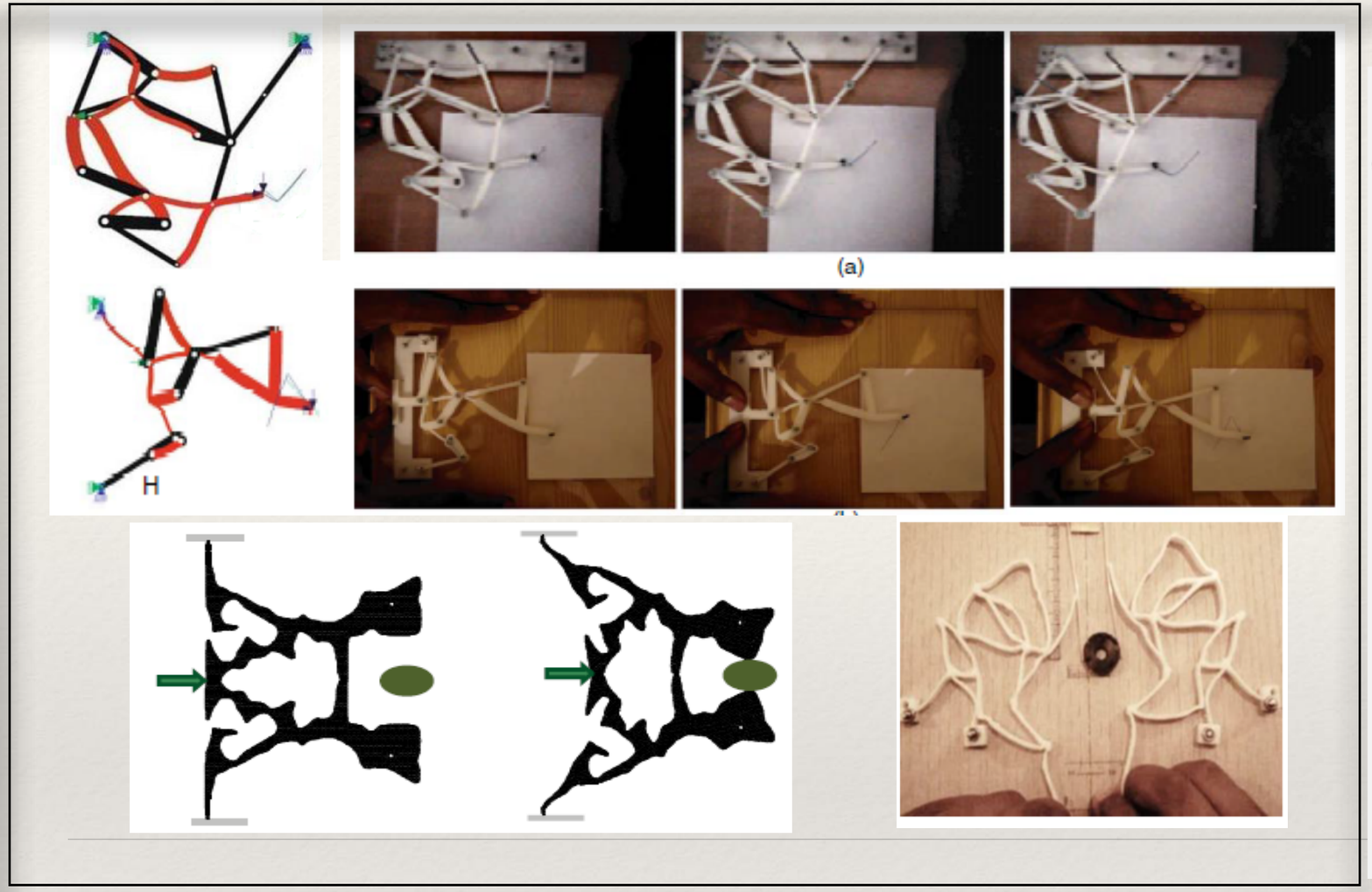
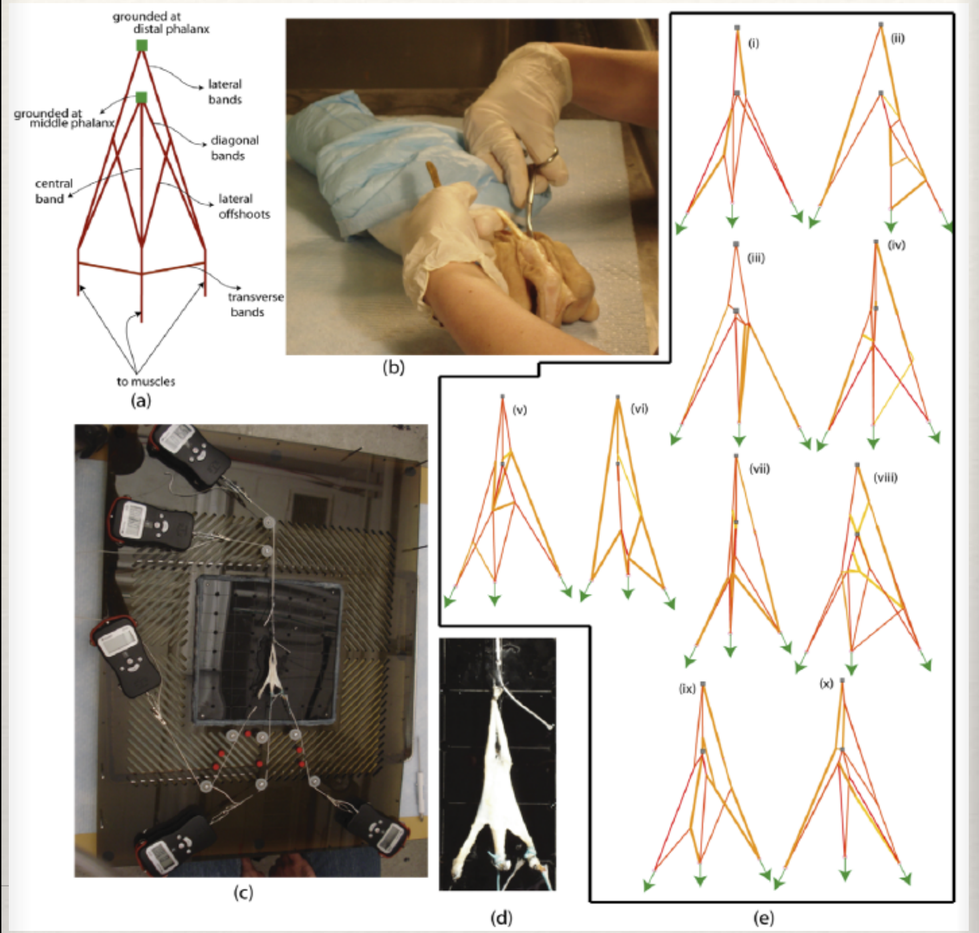
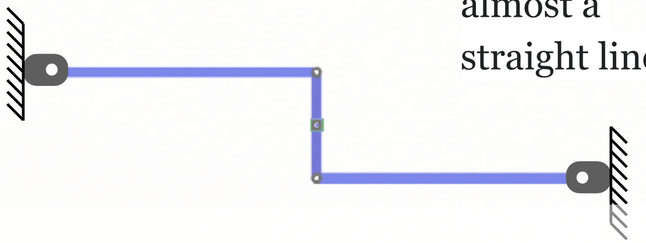




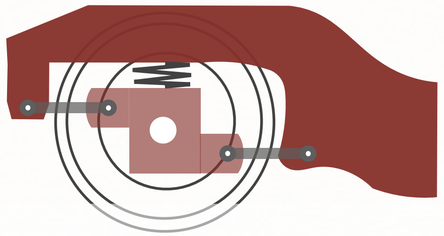
Compliant Mechanisms (ME 851)

Anupam Saxena
Professor
Indian Institute of Technology Kanpur

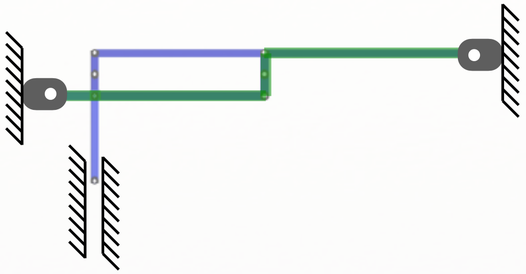


almost a
straight line

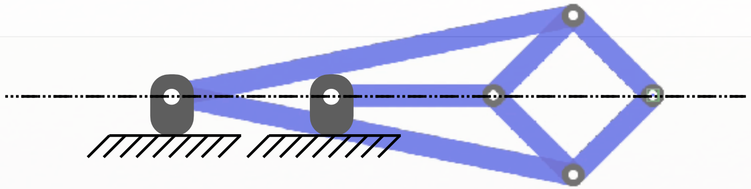
Watt's (almost) Straight Liner



suspension
systems



Watt's Parallel motion Linkage



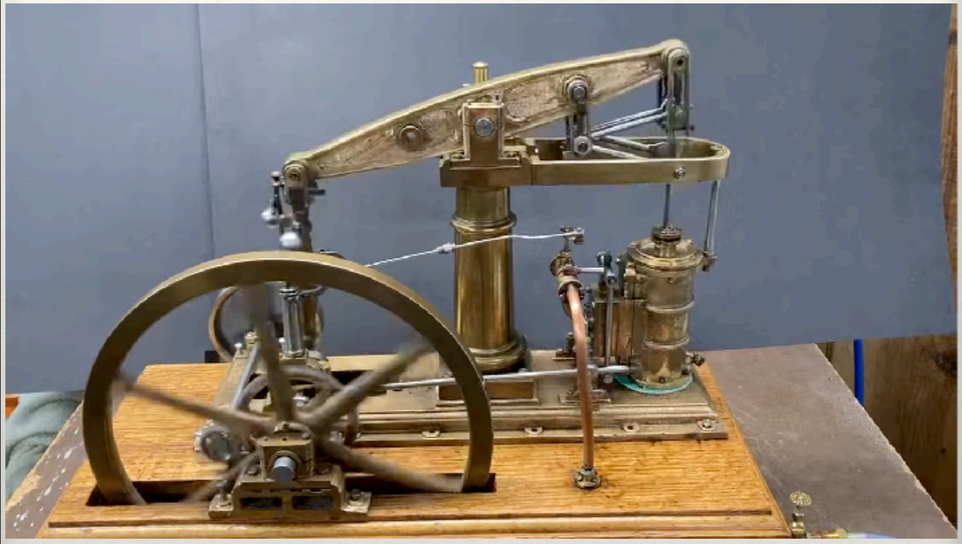
Peaucellier – Lipkin (exact) Straight Liner

Function and Advantages

Force, **Motion** and/or **Energy** Transfer

Function, **Path** and **Motion** Generation

Repeatability



Brad E Smith: https://www.youtube.com/watch?v=tFtsr1-l2vI

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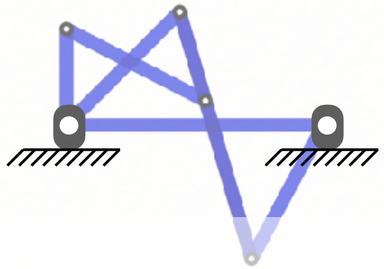
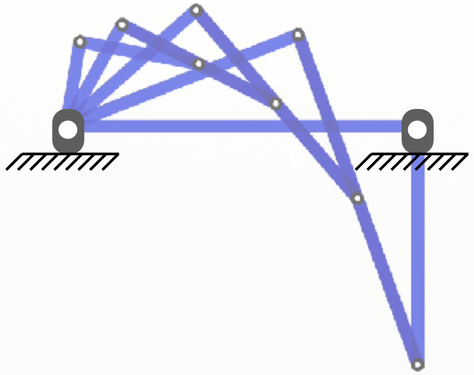
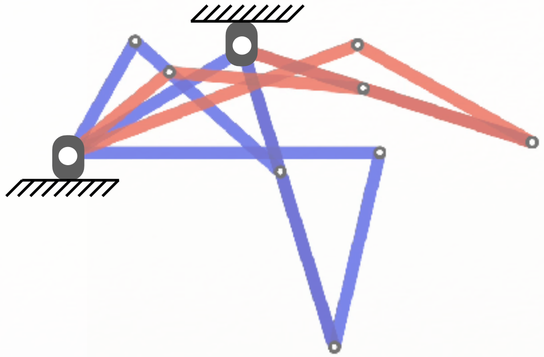


Kempe's Angle Doubler



Kempe's Angle Quadrubler



Kempe's Angle Additor

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Function, **Path** and **Motion** Generation

Repeatability

Compliant Mechanisms (ME 851)

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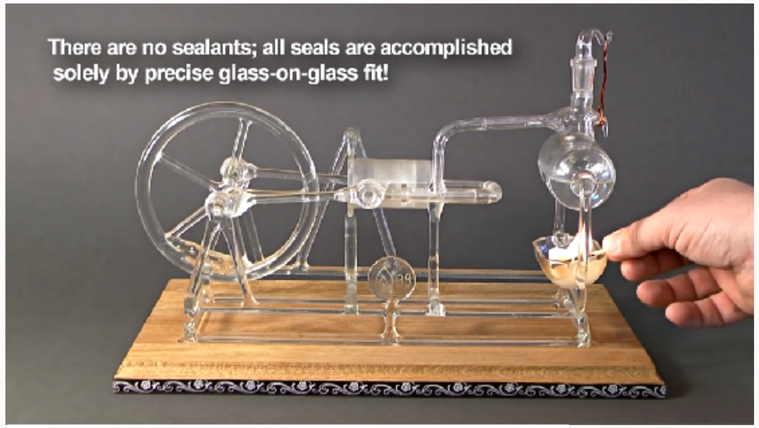
Mechanisms: Designed, Existed and Developed over CENTURIES

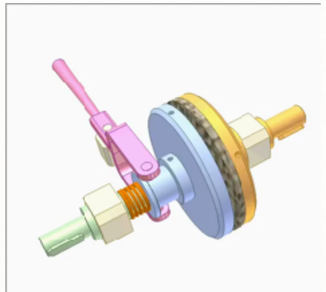
Libraries and cool Animations available

Stephenson's STEAM ENGINE



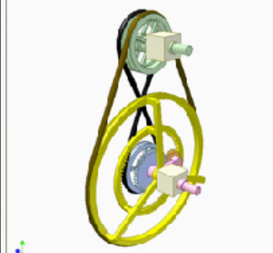
Pokáčovo Kanál : https://www.youtube.com/watch?v=73txXT21aZU

1700 ANIMATED MECHANICAL MECHANISMS

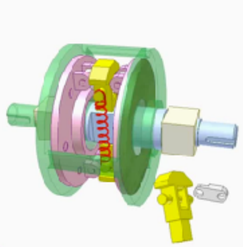


Friction clutch I

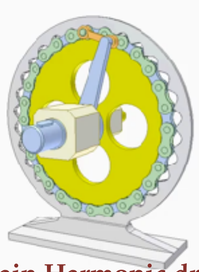
Multi-shaft driller



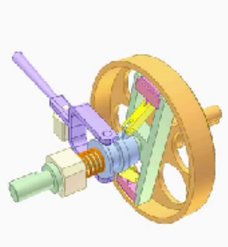
Belt & Gear drive



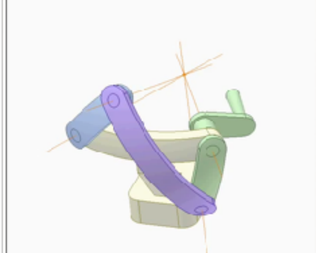
Centrifugal Clutch



Chain Harmonic drive



Friction clutch II



Spherical 4 bar

Function and Advantages

Force, **Motion** and/or **Energy** Transfer

Function, **Path** and **Motion** Generation

Repeatability

Dr. Nguyen Duc Thang
Hanoi, Vietnam
1946-2002 (RETIRED)

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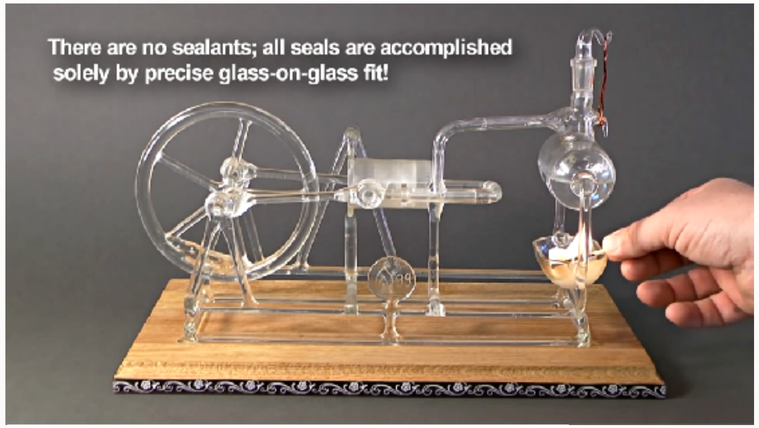

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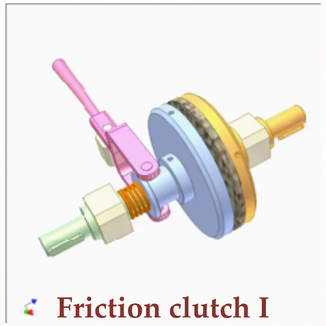

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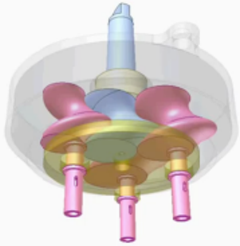
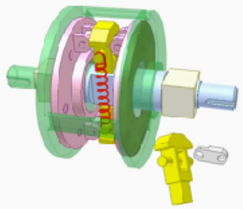
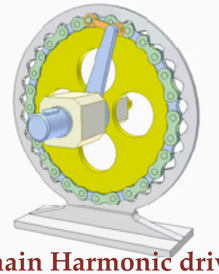


Multi-shaft driller

Belt & Gear drive



Centrifugal Clutch



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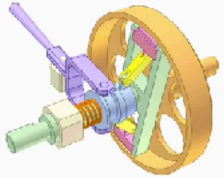

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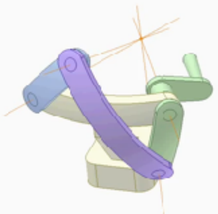

Spherical 4 bar

Function and Advantages

Force, **Motion** and/or **Energy** Transfer

Function, **Path** and **Motion** Generation

Repeatability

Disadvantages

Friction

- Wear and Tear
- Lubrication

Vibrations

- Noise

Need for Assembly

- Backlash (play)

Compliant Mechanisms (ME 851)

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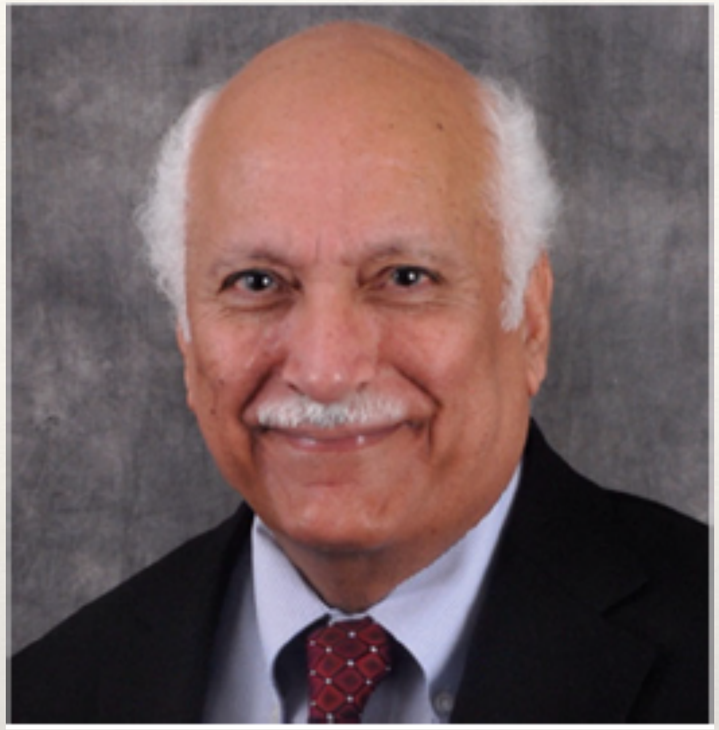
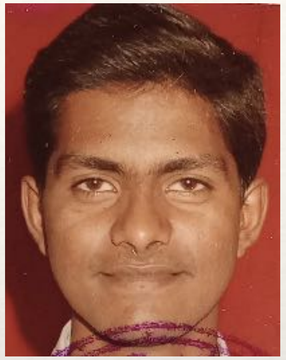


https://engineering.purdue.edu/ME/Seminars/2021/compliant-mechanisms-memory-lane-and-some-novel-and-exciting-applications/amidha.PNG

Prof. Ashok Midha

A (my) Little Story

Masters student at UT 1995-97



https://www.utoledo.edu/engineering/mechanical-industrial-manufacturing-engineering/people/kramer.html

Fall of 1996 Purdue University

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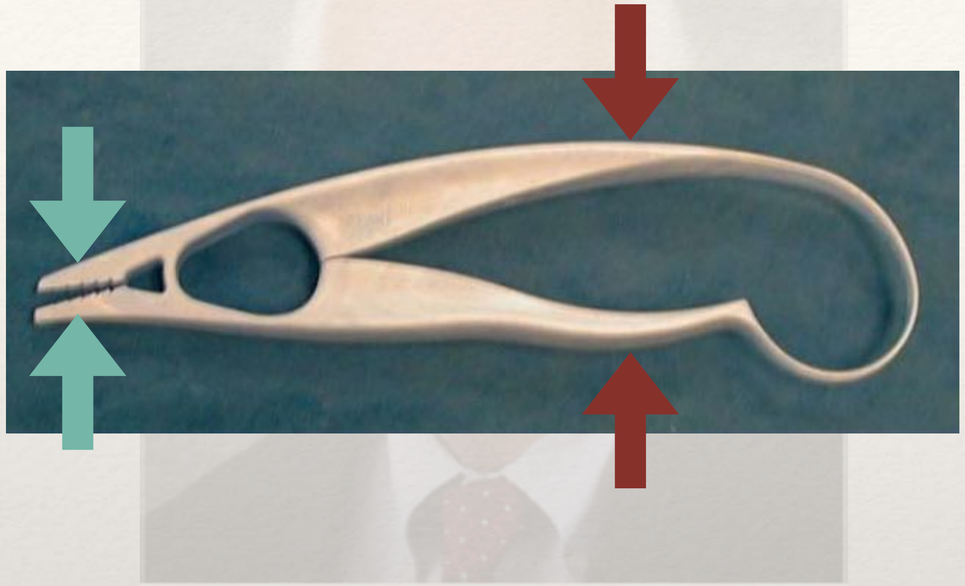

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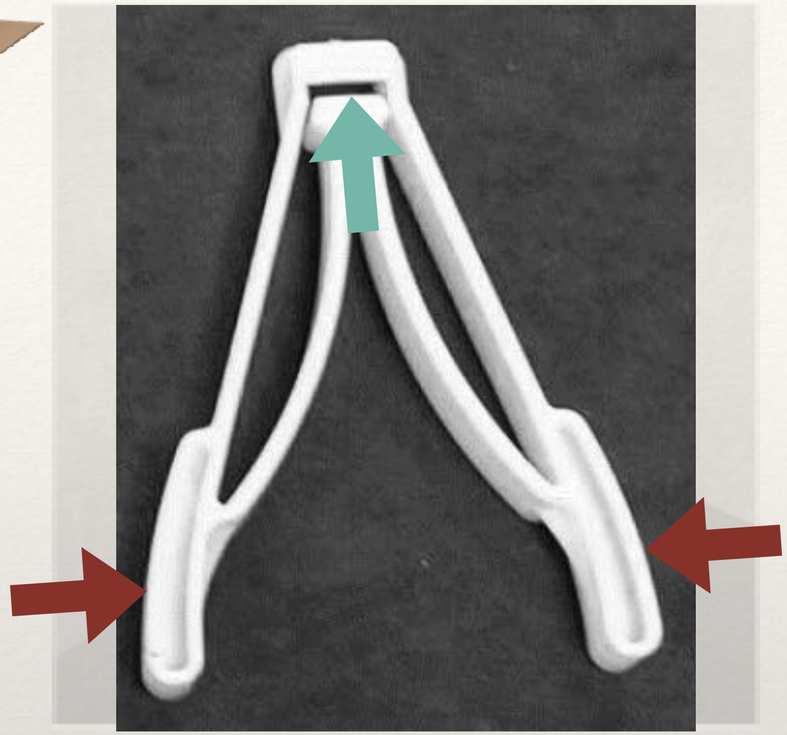

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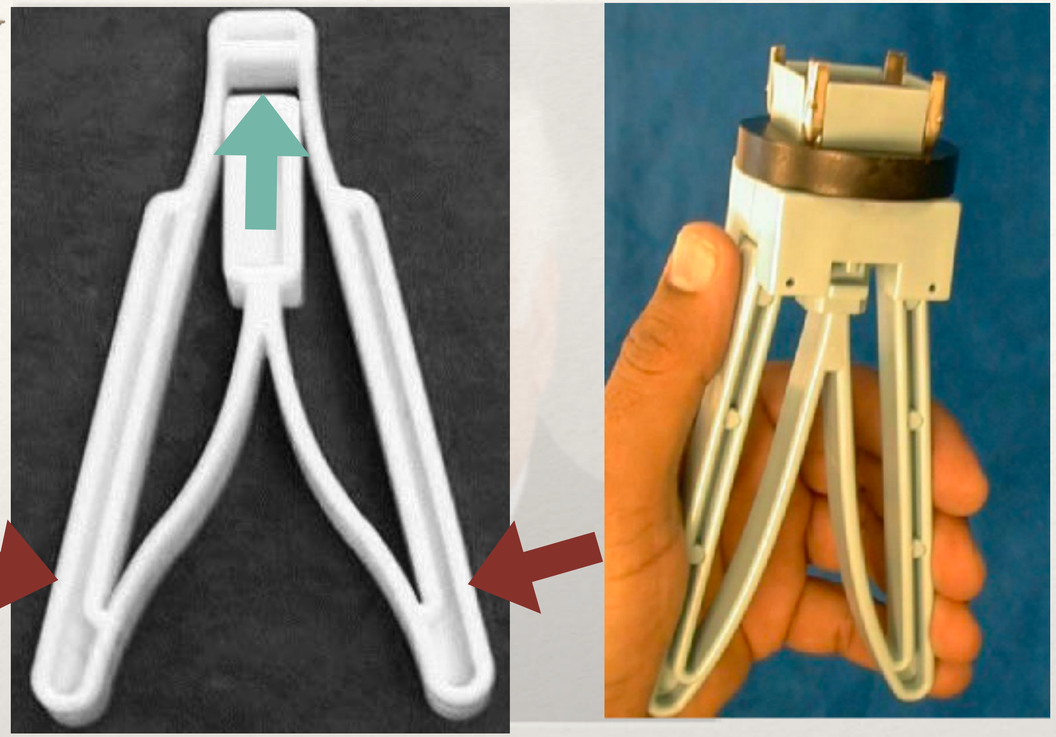
AMP Chip Carrier Extractor



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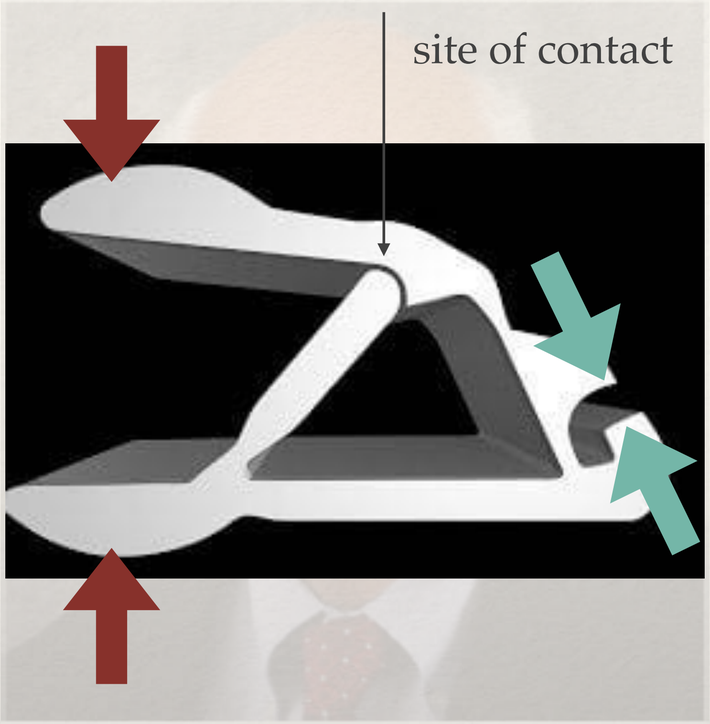

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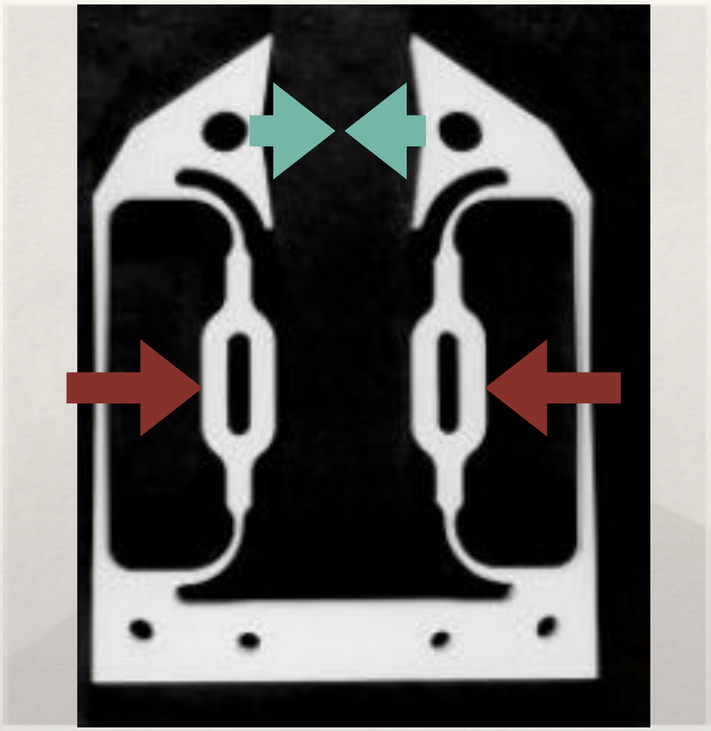

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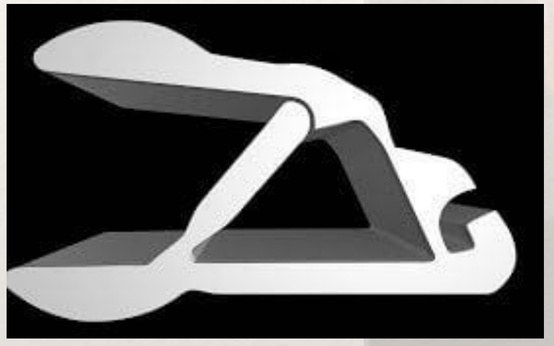

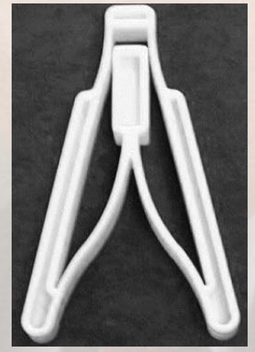

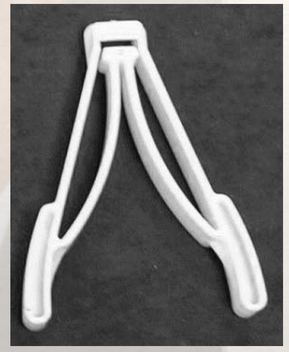

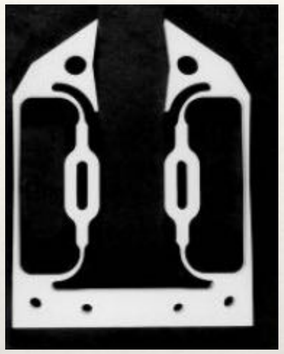

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Prof. Ashok Midha

Mechanical Elements

~~Hinges ?~~ ~~Sliders ?~~

~~Belt-pulley ?~~ ~~Chain-sprocket?~~

~~Gears?~~

What are these then?

Monolithic (**Single-piece**) Devices
Force, Motion, Energy Transfer
While performing desired
function, *path*, *motion* generation
Through purely
(Large) *elastic deformation*

Compliant Mechanisms (ME 851)

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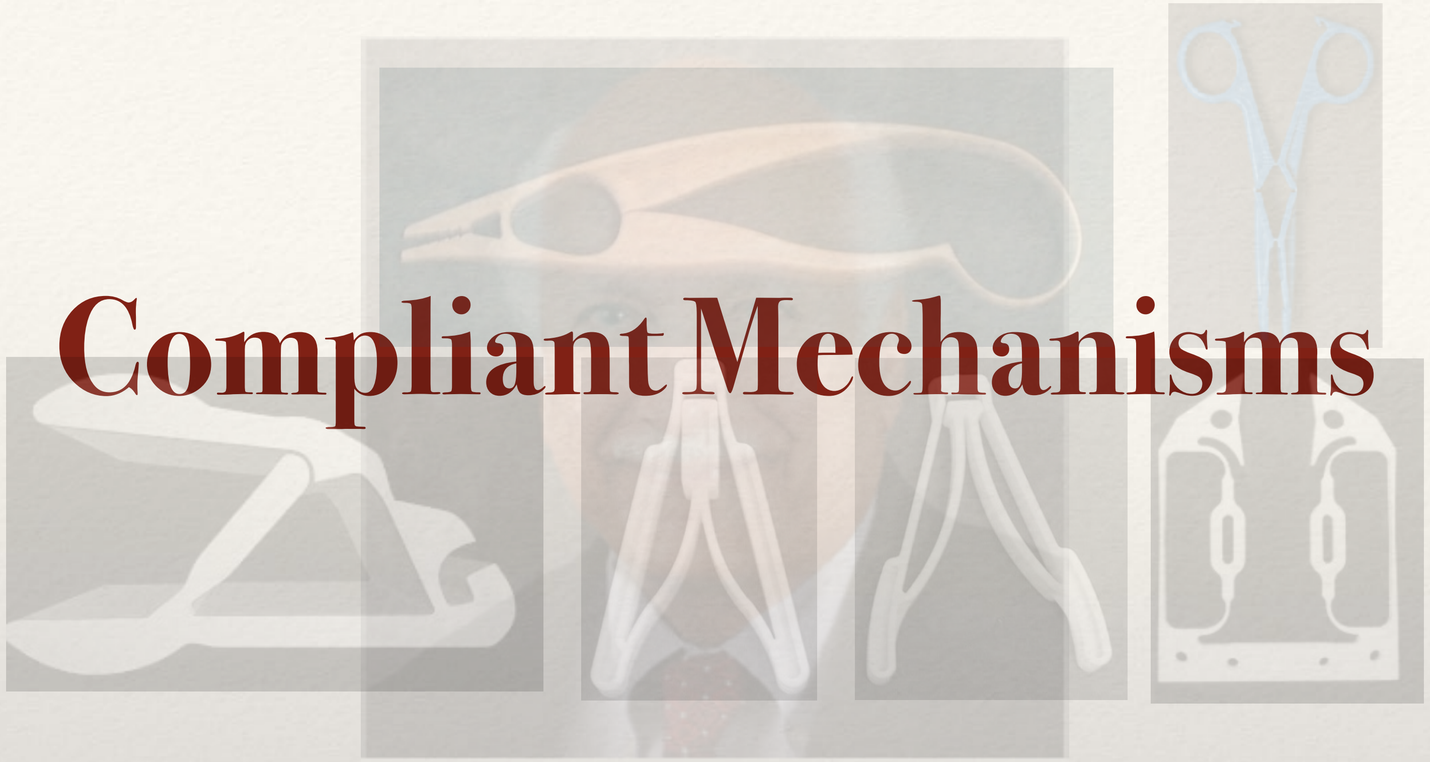
Compliant Mechanisms



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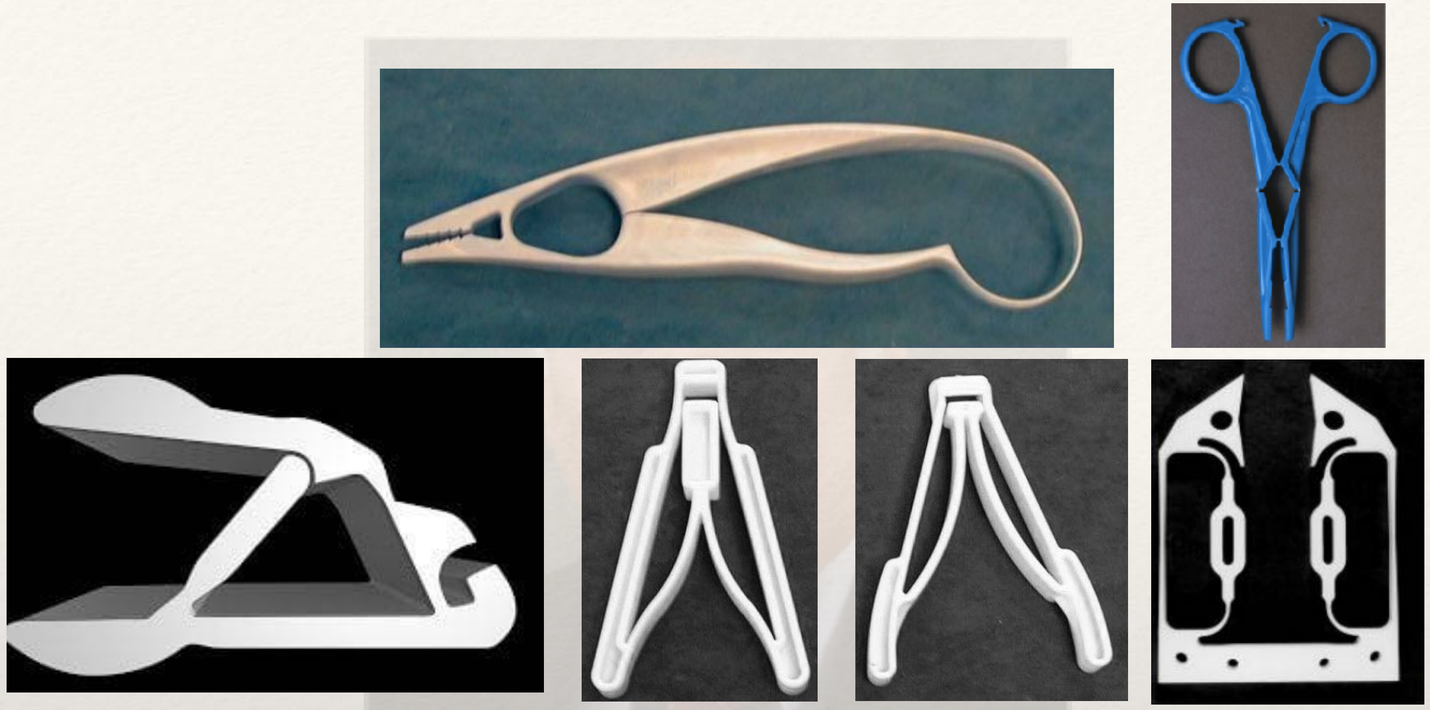

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Prof. Ashok Midha

Function and Advantages

Force, **Motion** and/or **Energy** Transfer

Function, **Path** and **Motion** Generation

Repeatability

Disadvantages (Would we now witness)

~~**Friction**~~

~~Wear and Tear~~

~~Lubrication~~

~~**Vibrations**~~

~~Noise~~

~~**Need for Assembly**~~

~~Backlash (play)~~

Compliant Mechanisms (ME 851)

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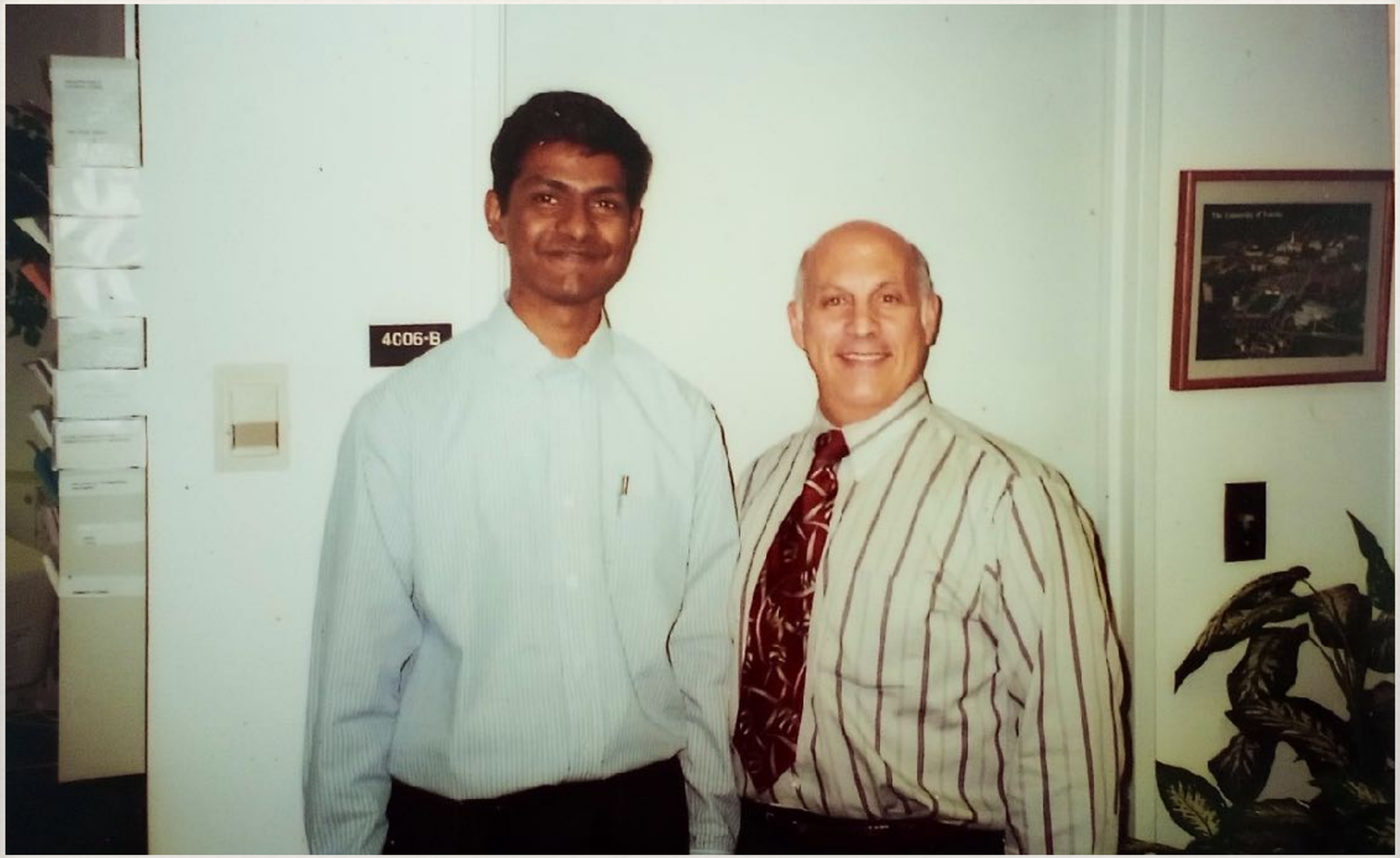

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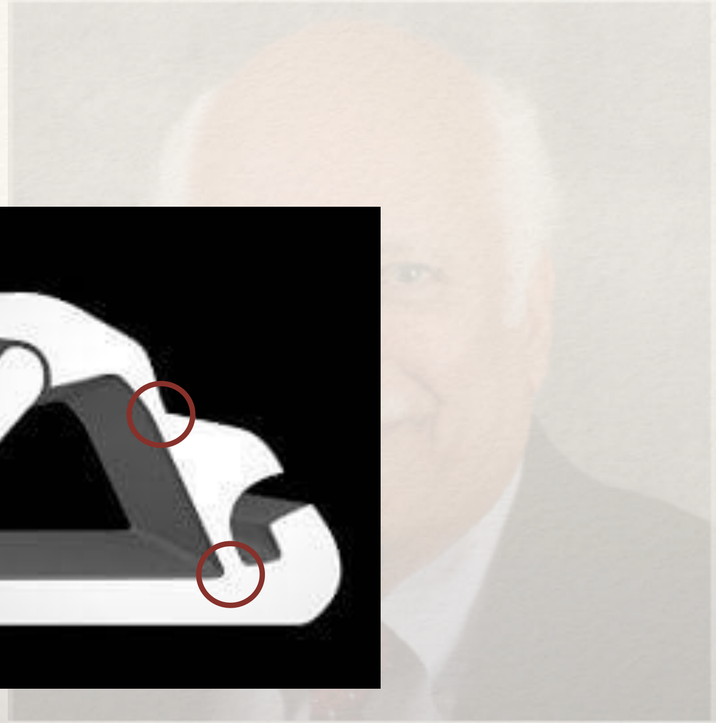

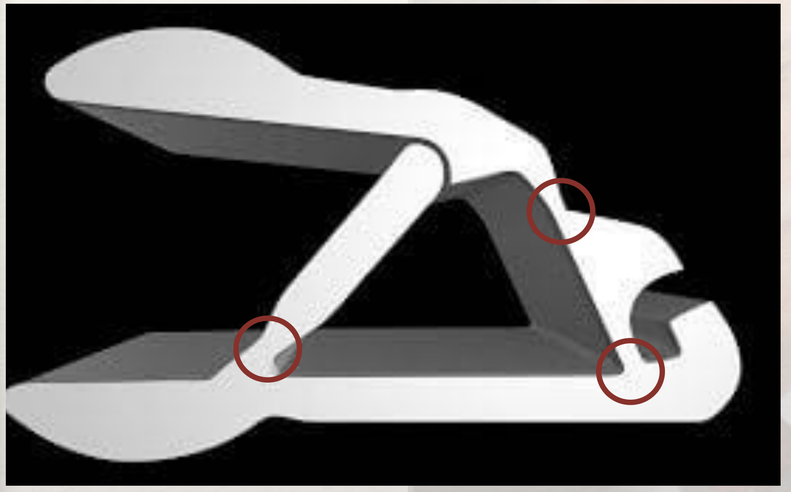

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Prof. Ashok Midha

Flexibility is concentrated

FLEXURES

LUMPED
COMPLIANT MECHANISMS

Compliant Mechanisms (ME 851)

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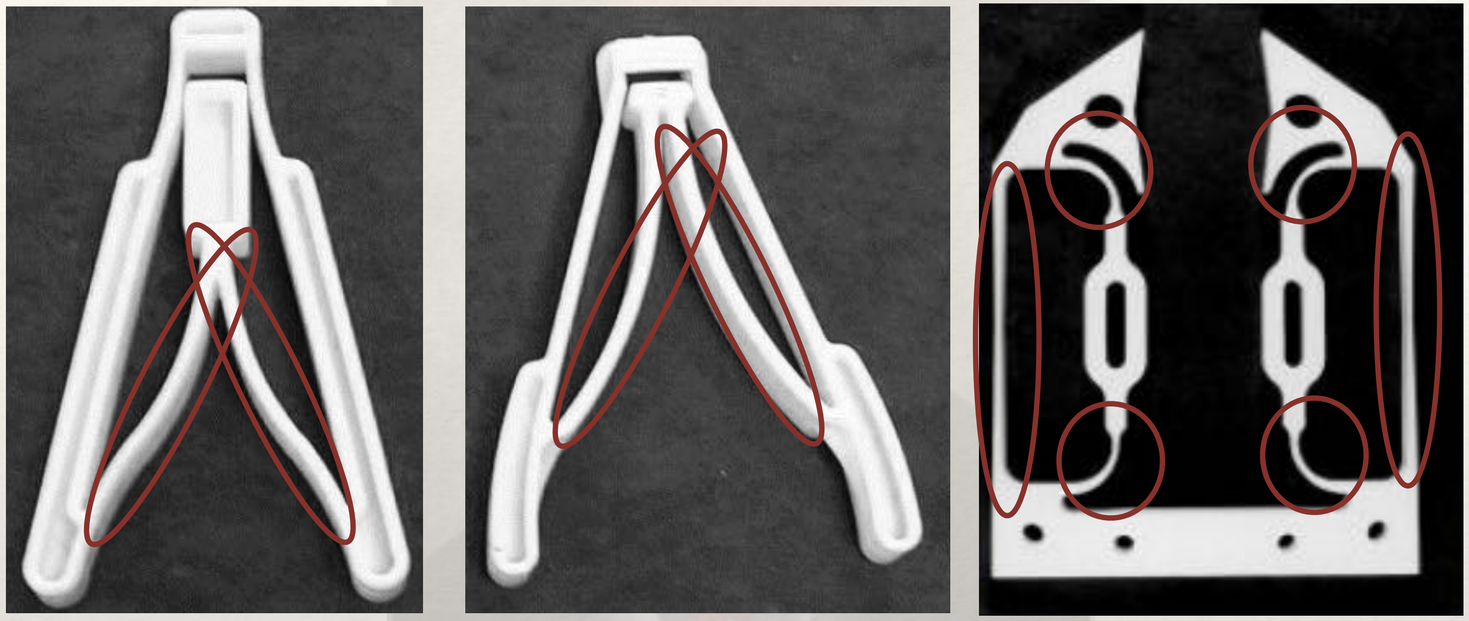

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Flexibility is Distributed

DISTRIBUTED COMPLIANT MECHANISMS

Compliant Mechanisms (ME 851)

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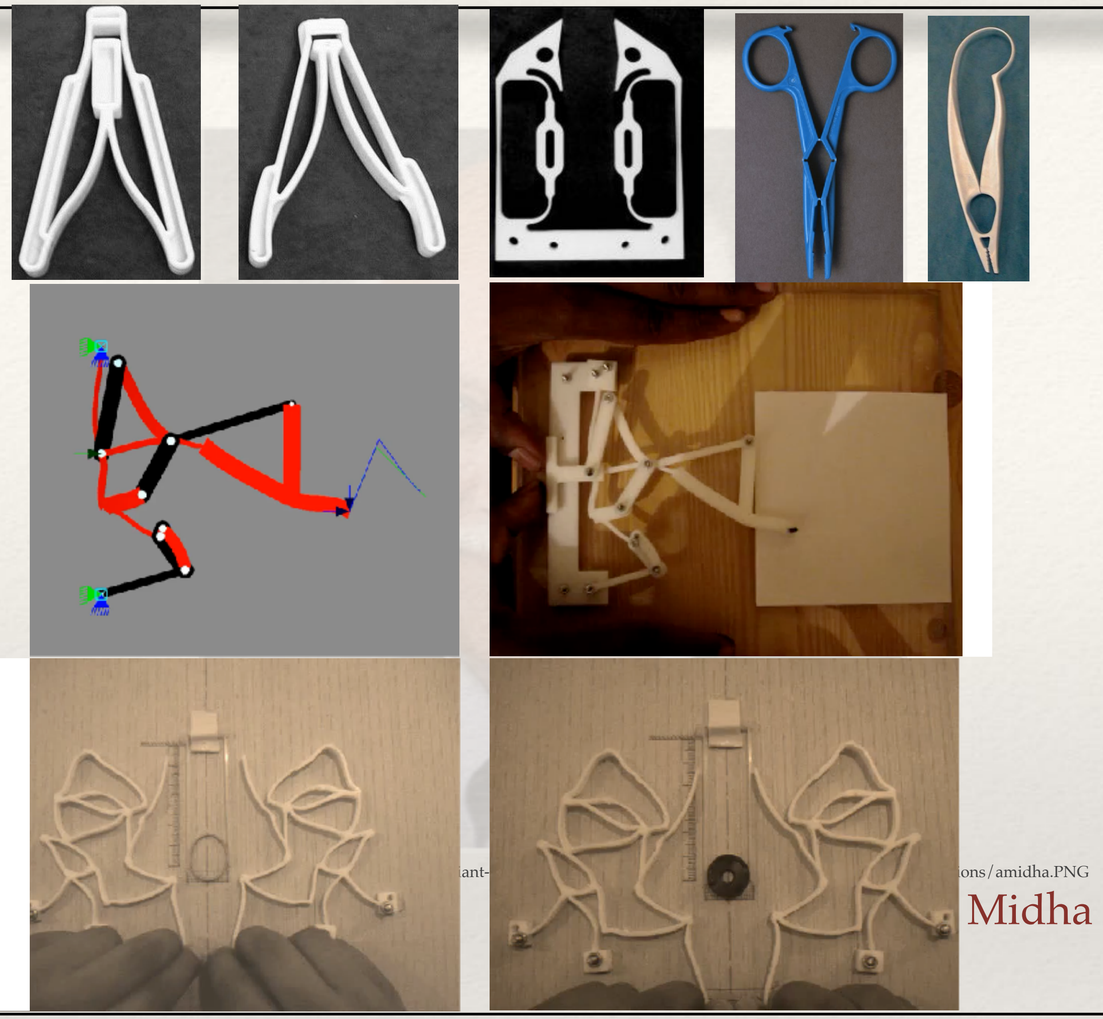

FULLY COMPLIANT MECHANISMS

No rigid-body joints

ALL Members undergo elastic deformation

PARTIALLY COMPLIANT MECHANISMS

SOME rigid-body joints

SOME Members undergo elastic deformation

CONTACT-AIDED COMPLIANT MECHANISMS

No rigid-body joints

ALL Members undergo elastic deformation

Pseudo joints at contact sites

Compliant Mechanisms (ME 851)

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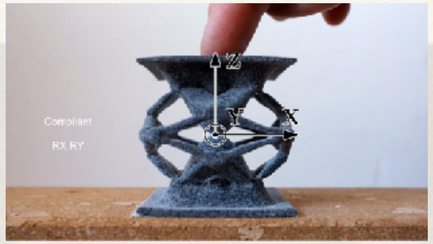
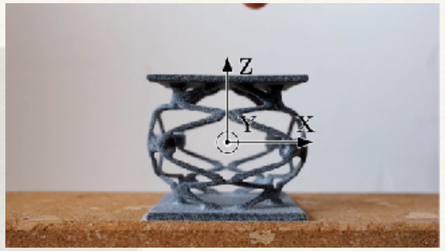
Indian Institute of Technology Kanpur

(MANY) Youtube videos

https://www.youtube.com/watch?v=FW6Vx2g9OCI





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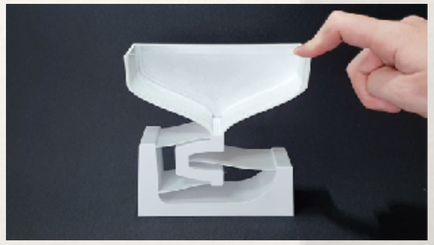

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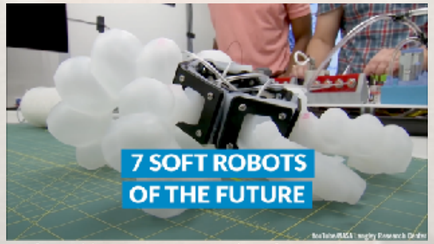

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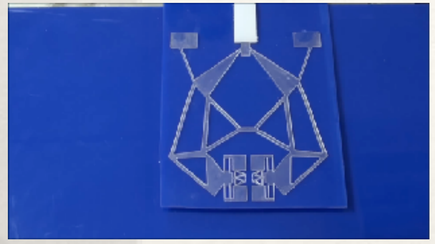
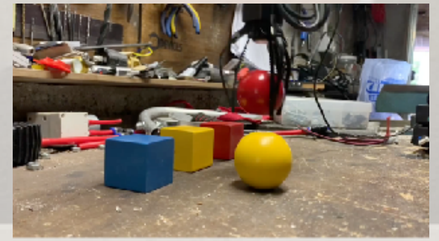


https://www.youtube.com/watch?v=K-vw1-a3UUM



https://www.youtube.com/watch?v=C-SbMsYNTxM

https://www.youtube.com/watch?v=T5wnomW_CJE

(MANY) MORE out there!

APPLICATIONS ...

Aerospace/Automotive
- Sensing, Actuation, Grasp, Manipulation

Biomedical/Healthcare
- Orthotic/Prosthetic devices

Robotics
- Soft/Medical

Miniature Scales
- Micro/Nano Electro Mechanical Systems

Space
- Foldable/Deployable mechanisms

Product Design

Special Purpose Mechanisms
- Statically balanced mechanisms
- Bistability
- Constant I/O force mechanisms

Compliant Mechanisms (ME 851)

Anupam Saxena
Professor
Indian Institute of Technology Kanpur

HOW DO WE CONCEIVE (DESIGN) COMPLIANT MECHANISMS

Intuition/Experience based	Building Block Approach
FACT (Freedom And Constraint Topologies)	Specific Synthesis Approaches
Rigid-body replacement (PRBM)	(Large Deformation) Structural Optimization

References: **Personal Notes**

WEB Course: **Prof. G. K. Ananthasuresh: Compliant Mechanisms: Principles and Design**

https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-me22/

Great Deal of Web material

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Indian Institute of Technology Kanpur

TENTATIVE OUTLINE

L2: Generic Design Philosophy: Is concurrent design process sustainable?

L3-L4: Understanding kinematics, kinetics, kinetostatics, dynamics… R-B and C

L5: Flexures — Lumped Compliance

L6-L7: Nonlinear FEM — introduction: trusses with torsional springs — K & K

L8-L14: Pseudo-Rigid-Body-Models (lumped and distributed compliance)

L8-L10: Incentive, 4 bar, function, path, motion generation

L9-L14: Models for various beams, loading and boundary conditions

L5-L22: Structural Optimization: beams, four-nodes, hexes, small deformation, large deformation

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