Module 6: Intelligent Devices based on Smart Materials

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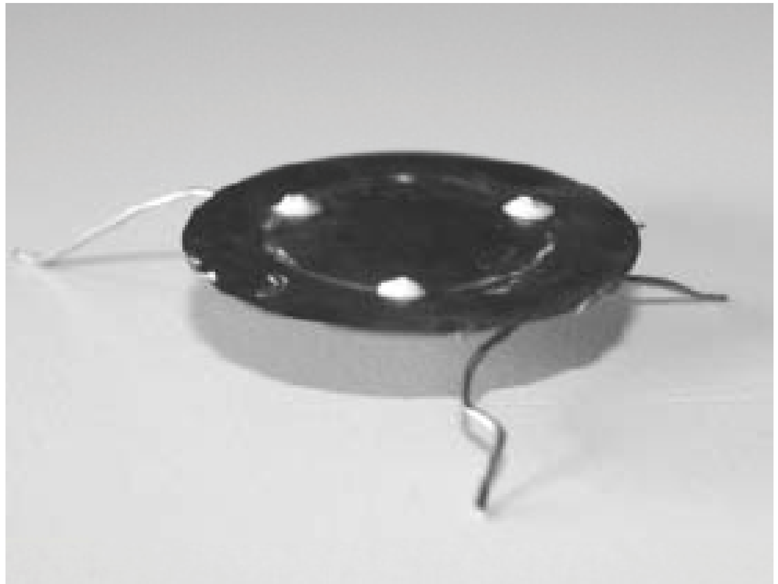
Topics Covered in the Last Lecture

- HBLS Smart Actuators
- Multilayered Piezoelectric Materials
- Design Issues
- Advanced Devices



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Intelligent Devices (Part 1)

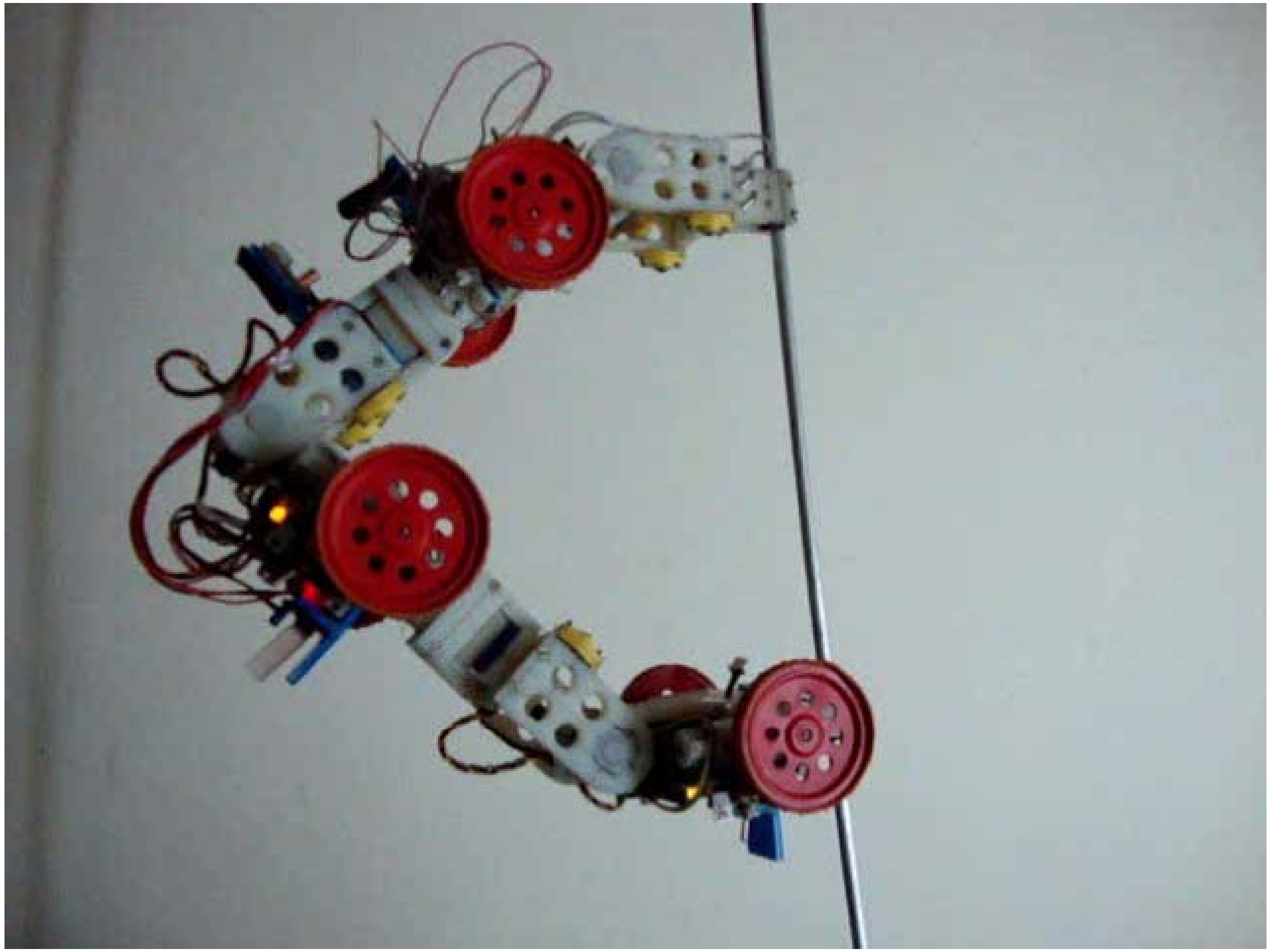
This lecture will cover

- Piezoelectric Inchworm Devices
- Inchworm devices for Actuation
- Sizes and Specifications

Piezoelectric Inchworm Devices

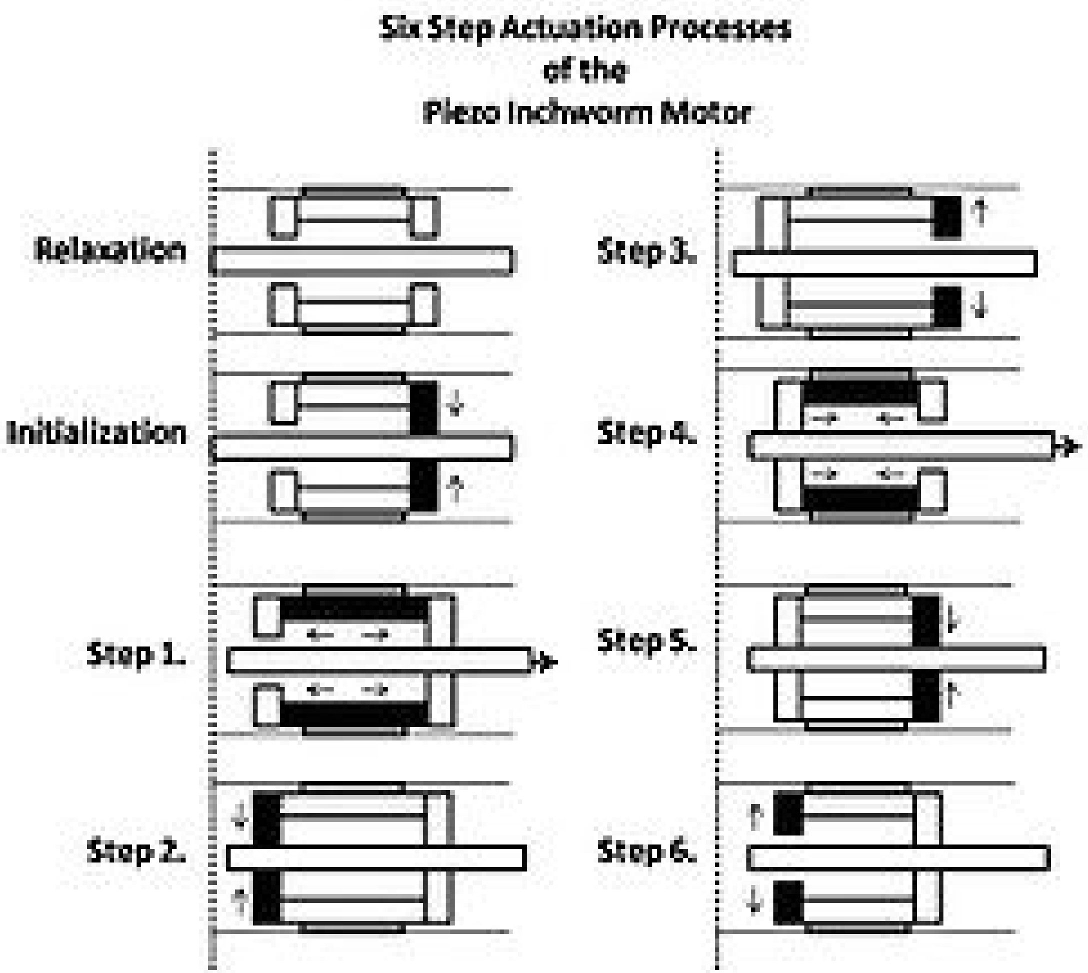
- Such devices are used to develop small-scale walking systems, micromanipulators and patch-clamping.
- In a simple form, it involves three piezo-actuators – (two clamps and one lateral system)
- There are six-steps in the actuation process. Depending on fixity – this may either result in worm-like movement or linear motor action. Brisbane (1964) achieved a speed of about 50mm/second using this actuator.

What is inchworm motion?

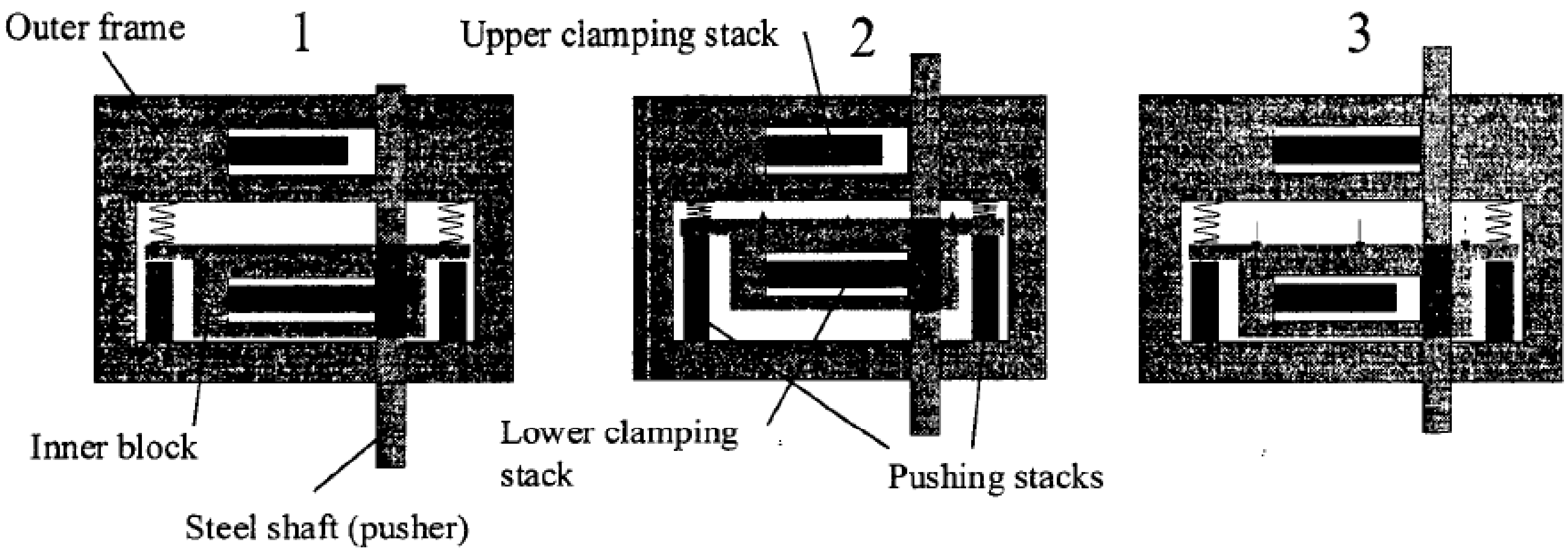


Ref: Wikipedia

Inchworm Motion using Piezo-stack



Inchworm used as Exciter

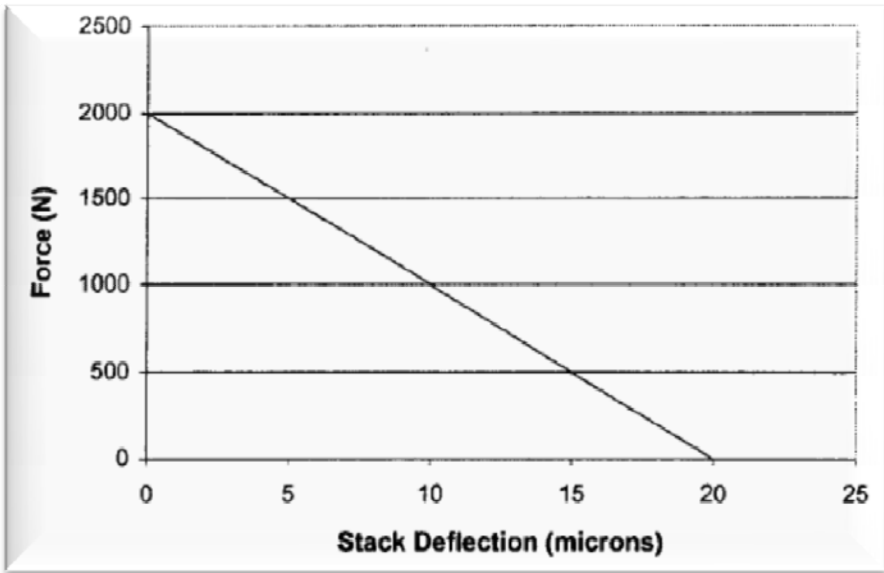


Material: Titanium Block with Piezo-stack

Frank et al, 1999

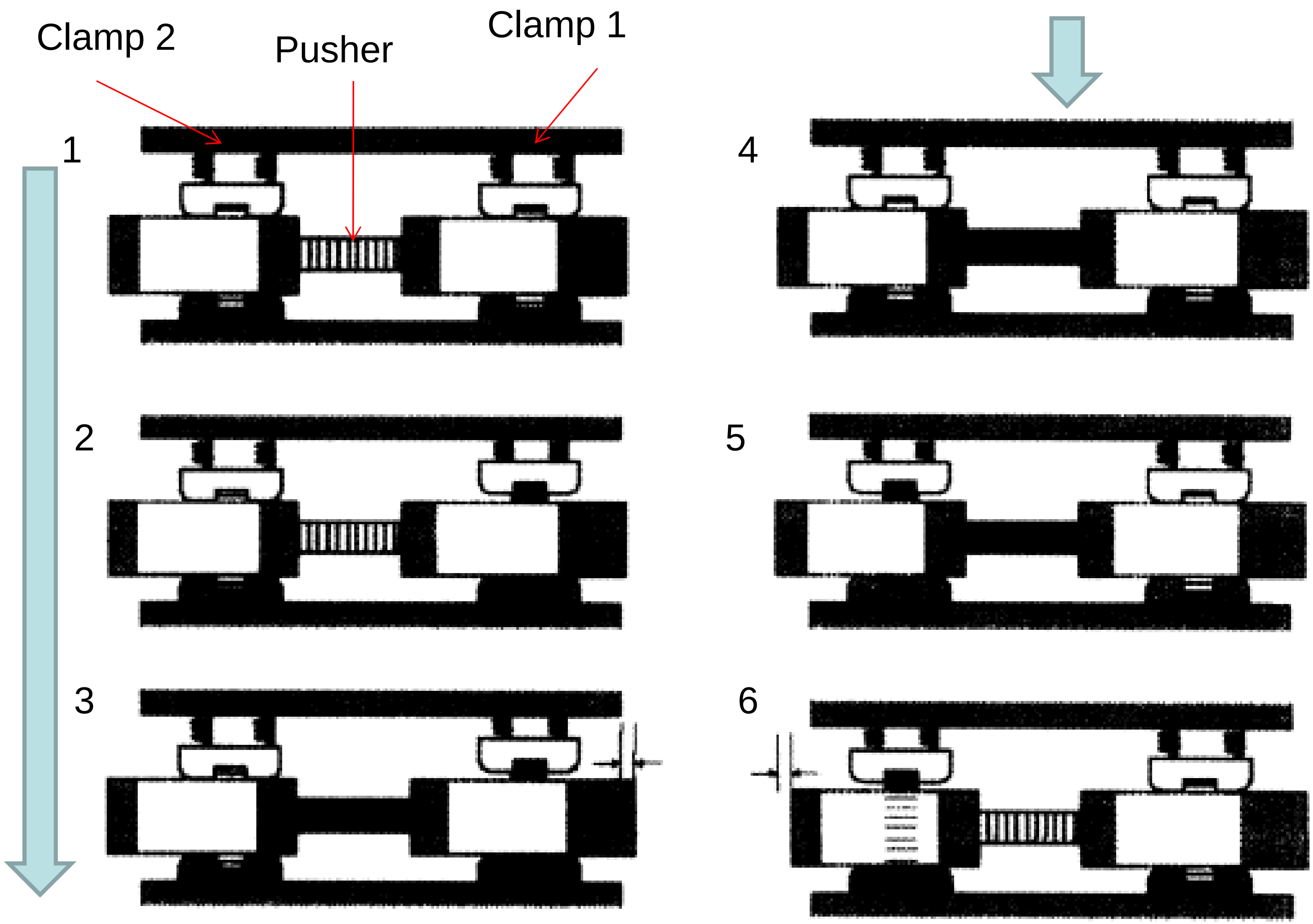
Sizes and other Characteristics

- Size – 82 x 57 x 13 mm
- High actuation force about 150 N
- Free deflection up to 20 µm

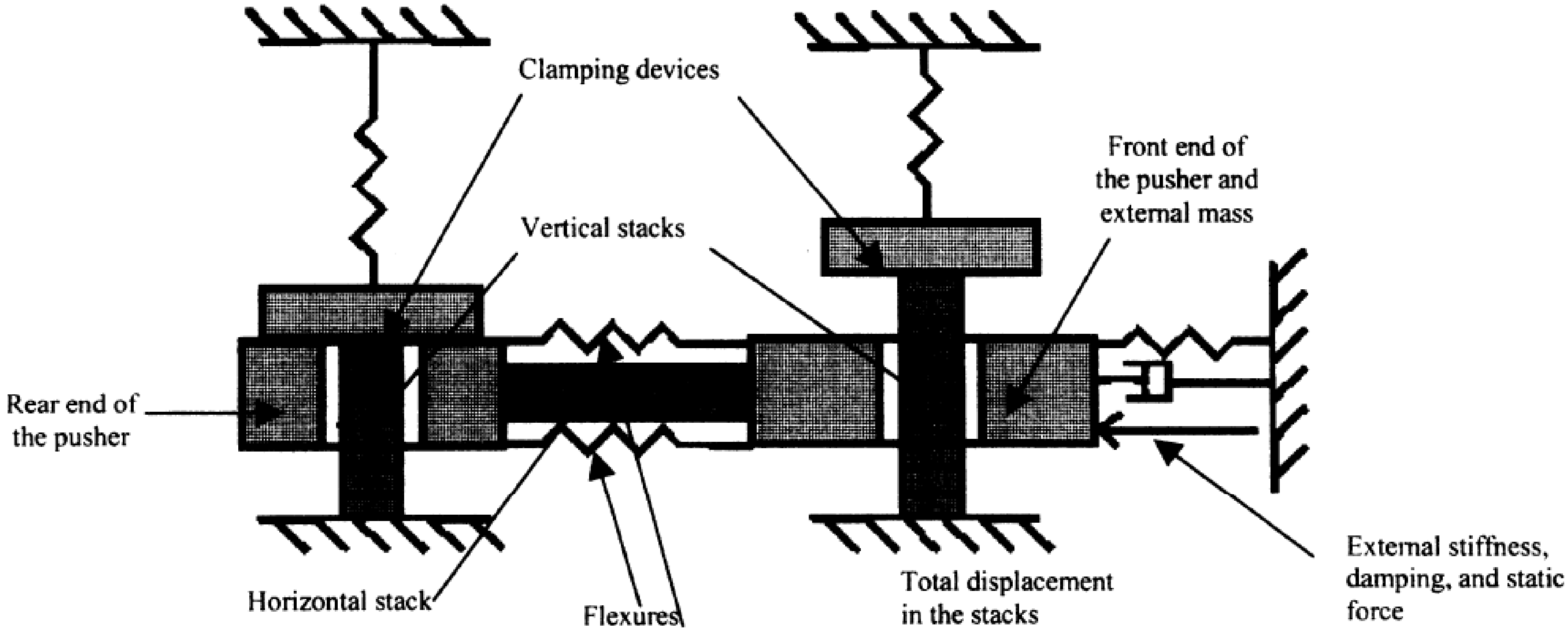


Further advancement:

- A High Force, High Displacement, High Energy Inchworm is recently developed at Penn-state university (2010).
- This is based on two clamps and one central pusher. The clamps are a combination of spring-mass system and piezo-ceramic stack that works on the pusher.
- The pusher itself is a piezo-ceramic stack which can deflect up to 10µm.

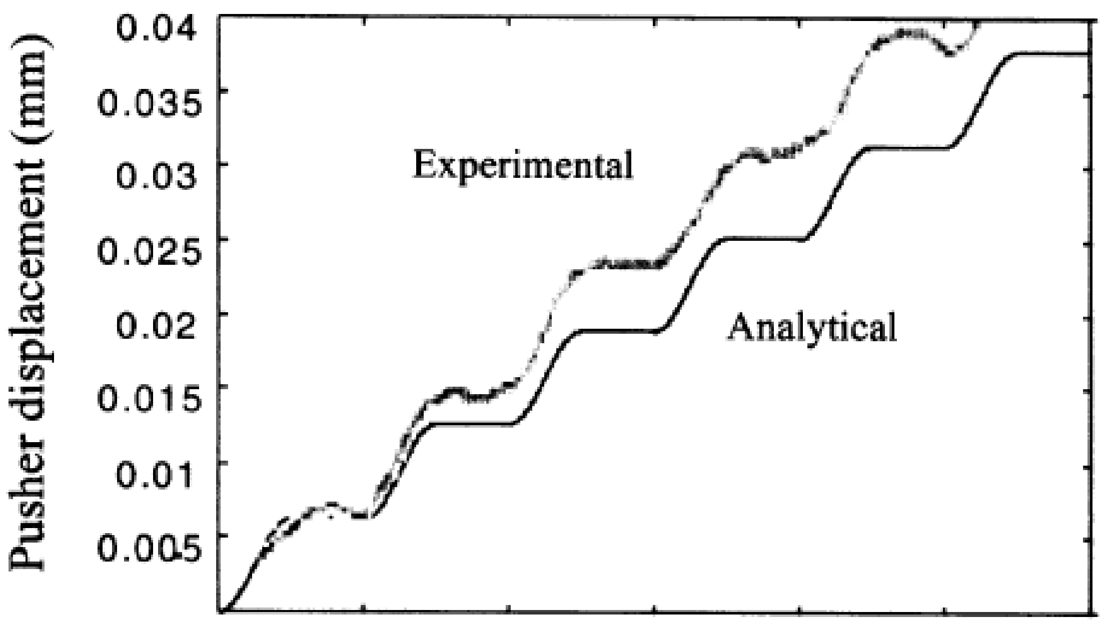


Galante et al 2011


Clamping devices
Front end of the pusher and external mass
Vertical stacks
Rear end of the pusher
Horizontal stack
Flexures
Total displacement in the stacks
External stiffness, damping, and static force

Size and other Characteristics

- Size – 60mmx40mmx20mm
- Operating frequency range 0-1000 Hz
- Velocity close to 6mm/sec
- Static Force close to 200N, Stall >40N



Special reference for this lecture

- Micro-mechatronics by Uchino & Giniewicz, Marcel, Dekker
- Modelling and Dynamic Simulation of Vibration driven Robots, Becker *et al*, 2011
- A Piezoelectric driven inchworm locomotion device, Lobonitu *et al*, 2001

END OF LECTURE 38