2.76 / 2.760 Lecture 13: Interfaces/forces

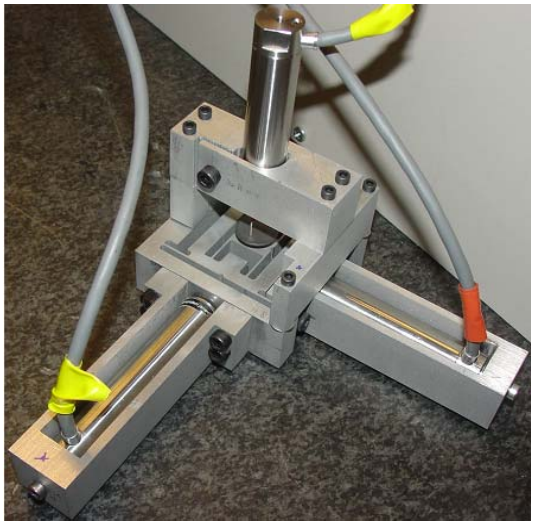
Pictures removed for copyright reasons.

Purpose of today

Bolted joints (pointers)

Kinematic coupling experiment

- ❑ Repeatability
- ❑ Stiffness
- ❑ Metrology issues
- ❑ Perspective for use in STM

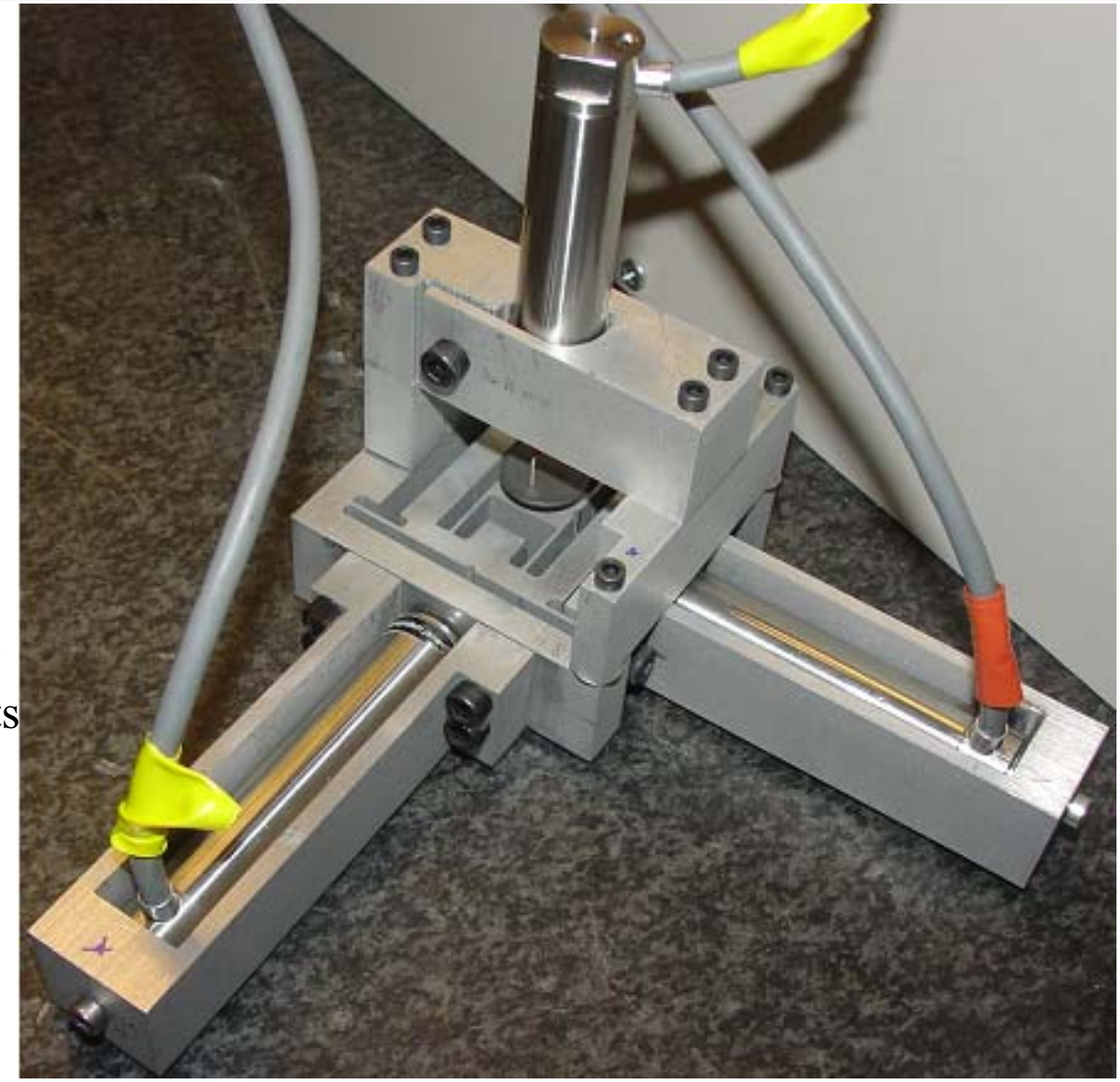


Project questions/design help

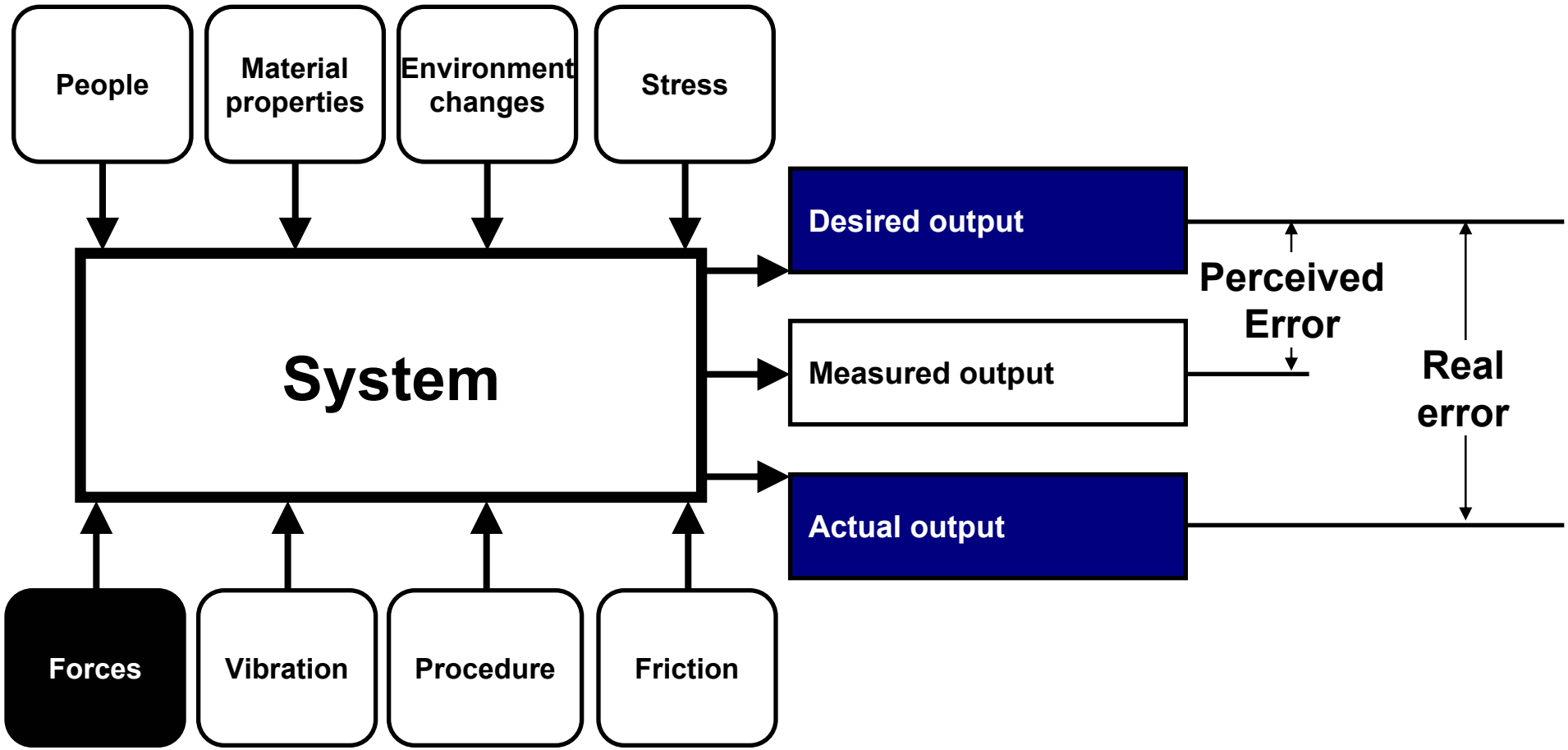
Bolted stiffness and stability

Qualitatively determine:

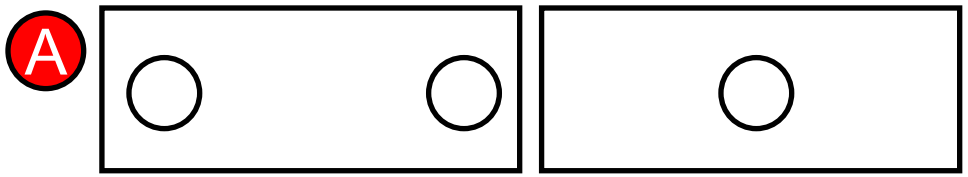
- ❑ What is good?
- ❑ What is bad?
- ❑ Think about:
  - Static loads
  - "Dynamic" loads
  - Bending moments
  - Mass



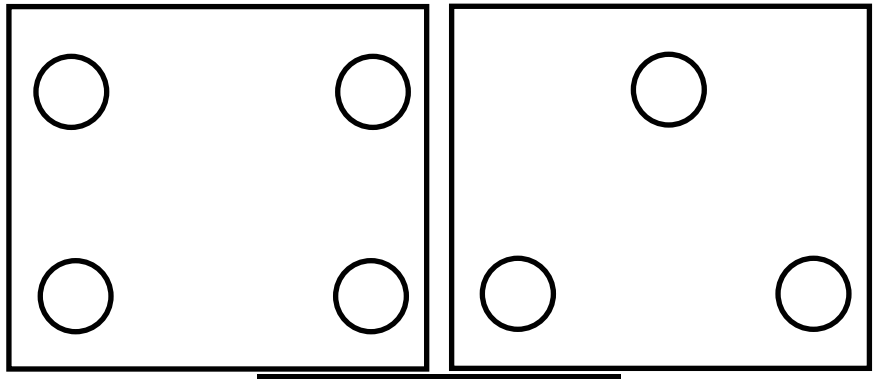
Minimize variation



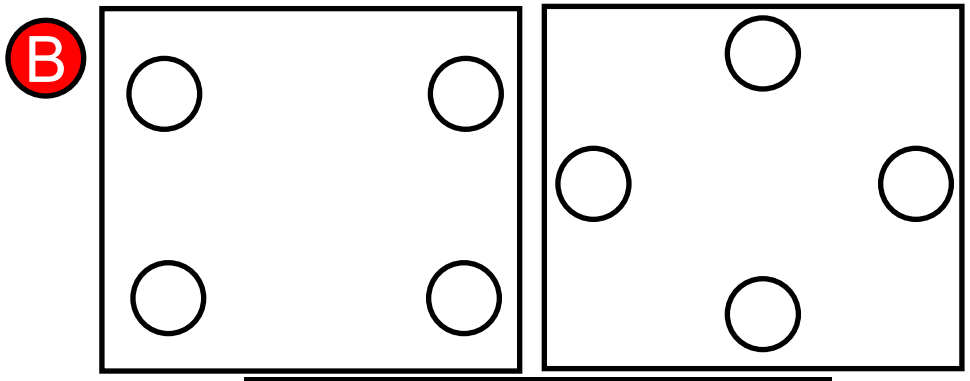
Bolted joint topology



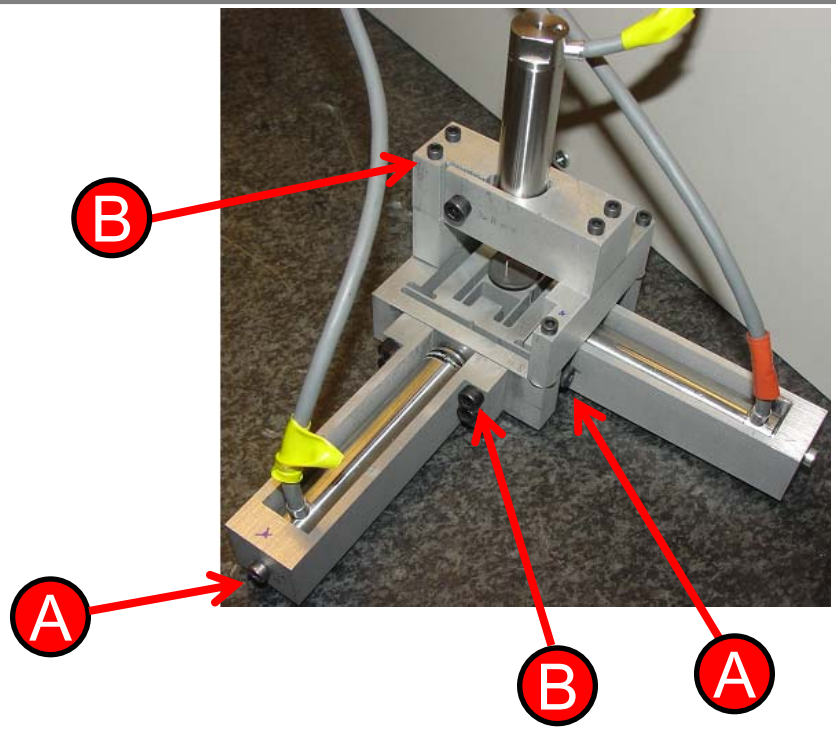
Singular



Over constraint



In-plane Moment stiffness



Bolt physics

Rough estimate:

$$E_{in} = E_{out} + E_{stored} + E_{"generated"}$$

$$F_{bolt} = A_{cross} \cdot \frac{\sigma_{yield}}{FS}$$

$$T_{applied} \cdot \theta = T_{f-threads} \cdot \theta + T_{f-head} \cdot \theta + E_{stretch} + 0$$

$$T_{applied} \cdot \theta = T_{f-threads} \cdot \theta + T_{f-head} \cdot \theta + E_{stretch} + 0$$

$$T_{applied} \cdot \theta = \left(C_1 \cdot r_{bolt} \cdot \mu_{f-threads} \cdot F_{bolt}\right) \cdot \theta + \left(C_2 \cdot r_{bolt} \cdot \mu_{f-head} \cdot F_{bolt}\right) \cdot \theta + \int_0^{\delta} F_{bolt} \cdot dx$$

Interface variation

On average get about 30 – 50% of contact at mechanical interfaces

These “little springs” reduce joint stiffness

Stiffness important for dynamic disturbances

Use potting to stiffen up the joint interface…

Calculate joint stiffness: Shigley/Mischke Machine Design

KC Experiment

Study: Sensitivity due to mechanical interface

- ❑ Step 1: Setup – pay attention up front
- ❑ Step 2: Test repeatability
  - Non-lubricated (35 mates)
  - Lubricated (35 mates)
- ❑ Step 3: Test stiffness
  - Preload levels 1, 2 and 3 (note moment arms….)
- ❑ Step 4: Compare theory (spread sheet) and measured

E = 30 Mpsi $\nu = 0.28$ R_i = measured

Questions to think about

- ❑ How do (not should) lateral & axial stiffness scale with preload?
- ❑ Plate stiffness (sweet spot) to prevent metrology errors?
- ❑ How repeatable is your bio-unit preload?
- ❑ Who has the best repeatability?
- ❑ What are the implications for your STM?