Machine Design Experiments using Mechanical Springs to Foster Discovery Learning

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Student-Centered Learning

- Advantages
  - Short-term mastery
  - Long-term retention
  - Depth of understanding
  - Critical thinking
  - Creative problem-solving skills

Student-Centered Learning

- Methods
  - Active-Learning
  - Cooperative Learning
  - Collaborative Learning
  - Inductive Learning

Engineering Hall, Marquette

Machine Design Laboratory

Core Competency Skills

- Identify machine components
- Know proper nomenclature
- Measure parameters (force, speed, …)
- Select components from catalogs
- Distinguish normal and used components
- Recognize proper and abnormal behavior
- Reverse engineer systems
- Develop engineering intuition
- Justify design choices

Machine Design Labs

- Emphasis: hands-on experiences, discovery learning, component selection, design challenges
- Two hour lab sessions, max of 12 students
- Teams of two to three students
- Multiple stations
- In-lab and post-lab deliverables

Experiments

- *Lab 1*: Introduction to Machine Systems & Elements
- *Lab 2*: Stress Measurements and Concentrations
- *Lab 3*: Press and Shrink Fits
- *Lab 4*: Flexible Components
- *Lab 5*: Design of Systems with Flexible Components
- *Lab 6*: Gears & Design of Gear Systems
- *Lab 7*: Bearings
- *Lab 8*: Springs
- *Lab 9*: Bolts and Fasteners
- *Lab 10*: Bicycles

Lab 8: Springs

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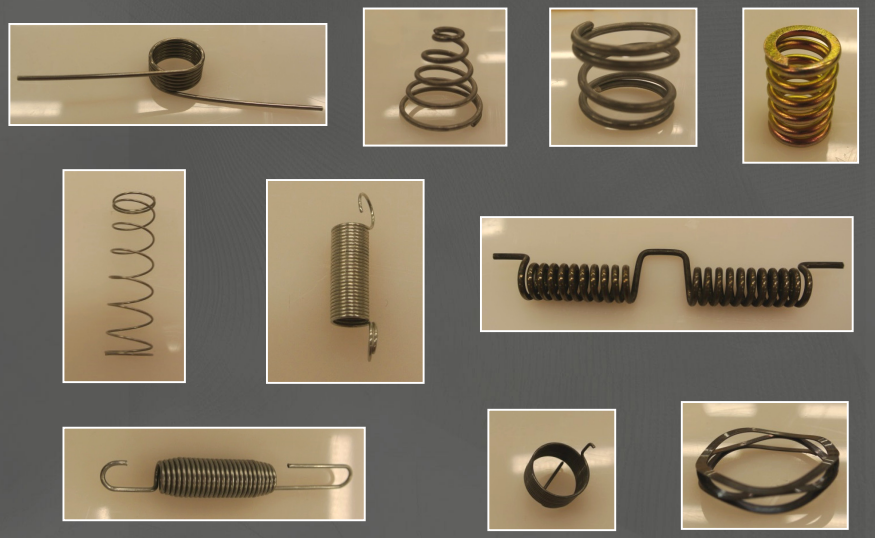
Overview of Spring Experiments

- Identify spring types (tension, compression, torsion) and appropriate applications (automotive latches, key fobs, pens).
- Disassemble and re-assemble padlocks.
- Measure stiffness and achieve desired stiffness with series and parallel combinations of springs
- Experimentally determine shear moduli and stiffnesses of wire and 3D printed springs.

Assorted Springs

Different Types of Springs



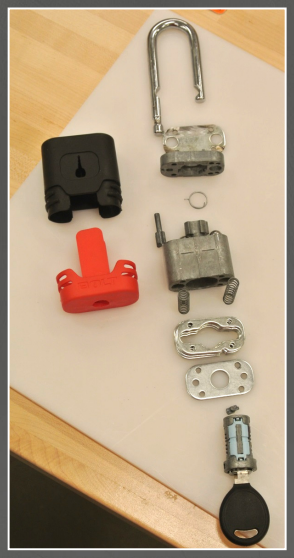
Padlocks

Strattec Lock

American Lock

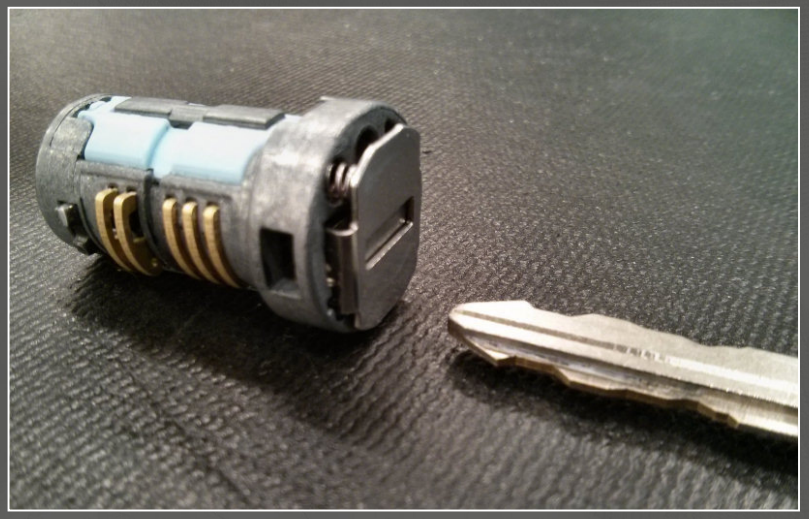
Padlock Components

Strattec Lock



American Lock

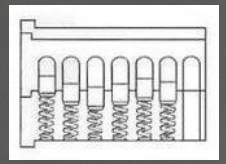
STRATTEC Padlock Cylinder



Padlocks Disassembled

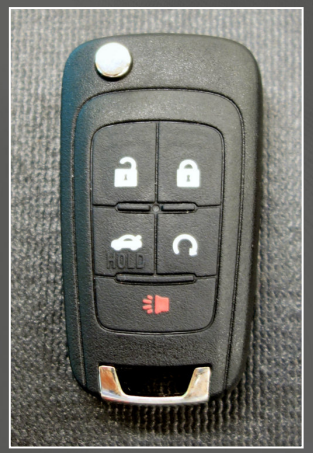
American Lock Pins & Springs

Pins & Springs



Cylinder

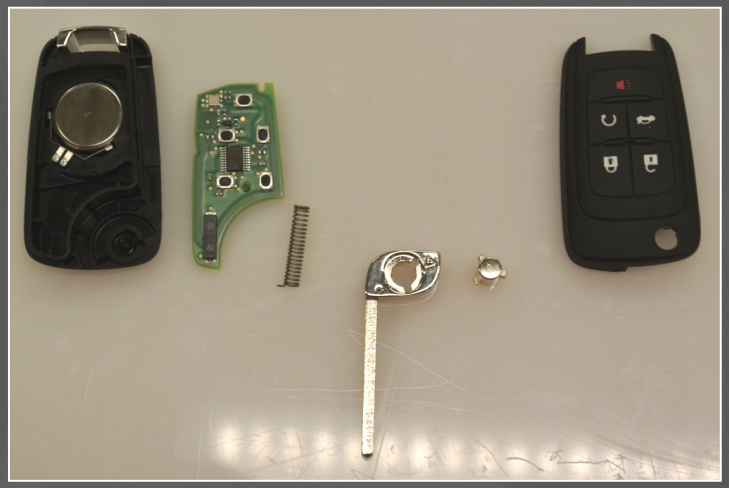
Key Fob for Chevy Cruze



Key Fob

Chevy Cruze

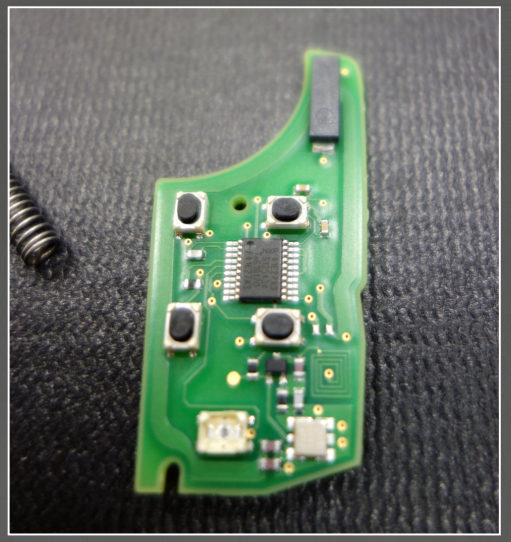
Key Fob Disassembled



Key Fob Spring

Key Fob Spring

Key Fob Circuit Board

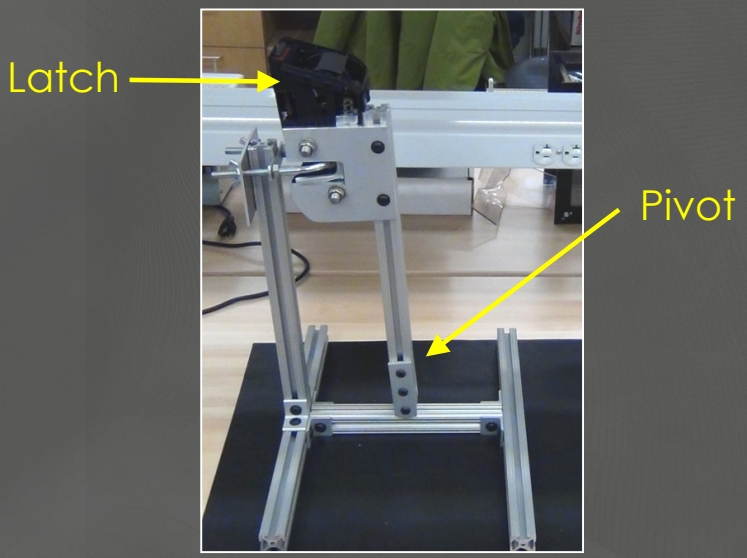


Cadillac CTS Rear Seats

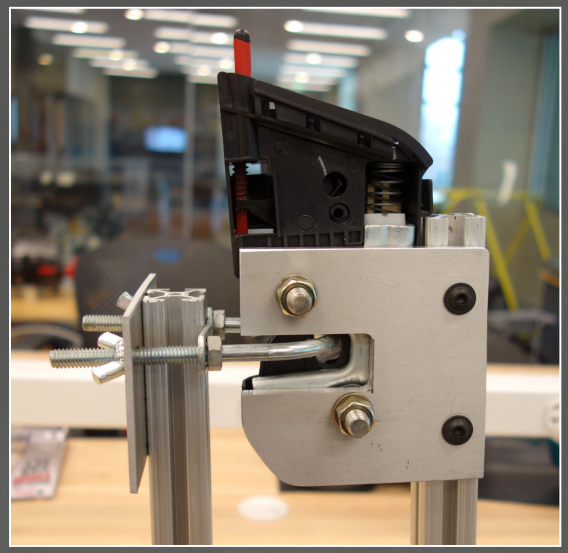
Cadillac CTS

Seatback Latch Mechanism

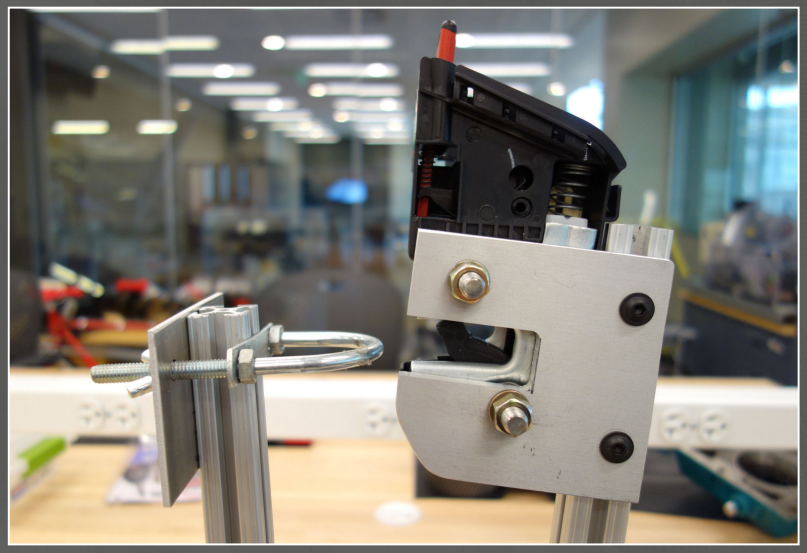
Fixture for Seatback Latch



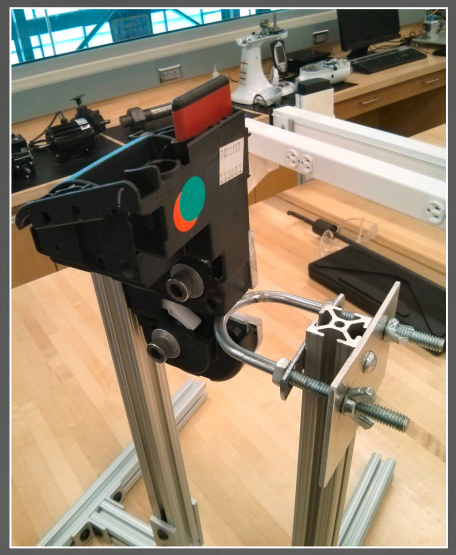
Locked Seatback Latch



Operation of Seatback Latch

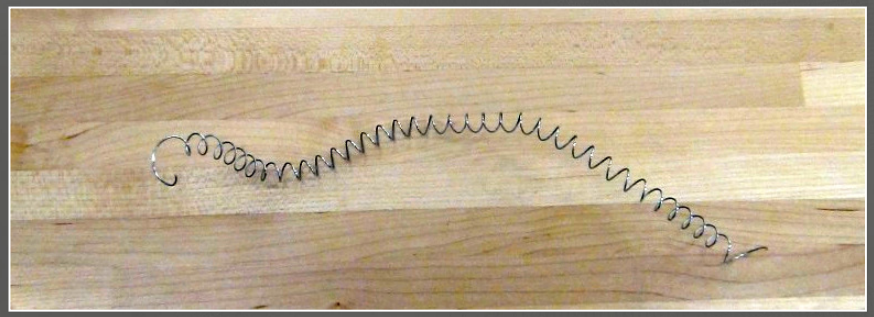


Seatback Latch



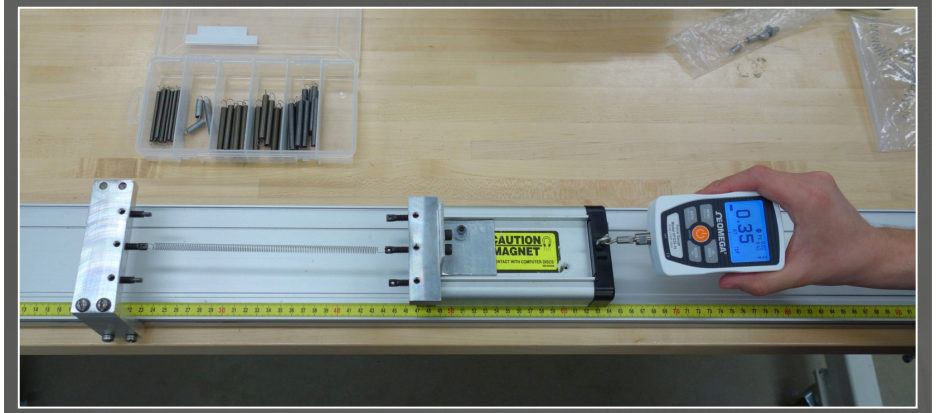
Measuring Spring Stiffness

Overextended Spring



Spring Variability

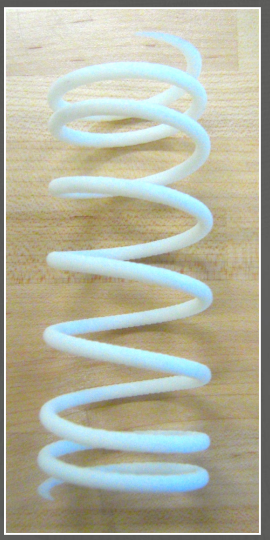
Test-Rig for Measuring Stiffness



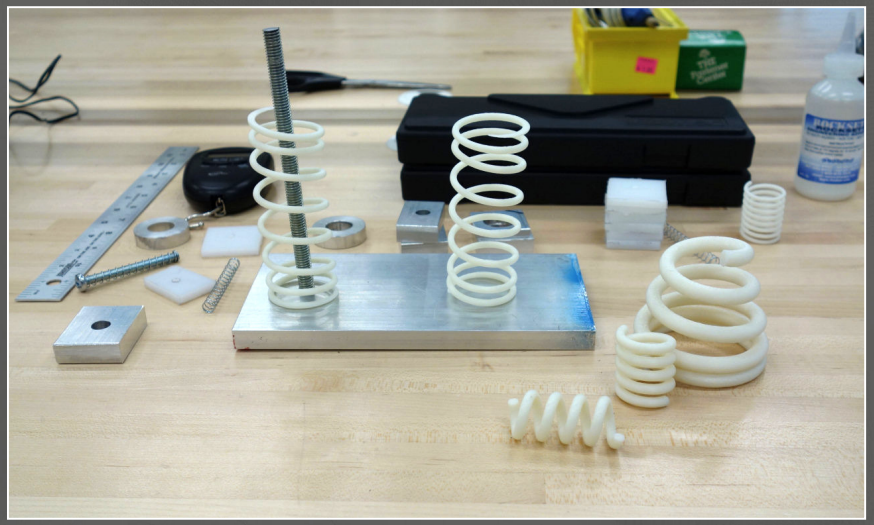
Stiffness of Parallel Springs

Spring Kit

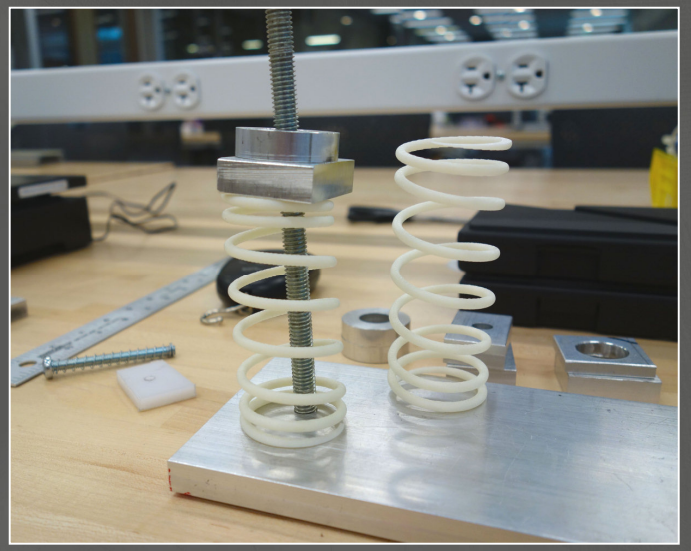
3D Printed Springs



3D Printed Springs



Properties of 3D Printed Springs



Stiffness of 3D Printed Springs

Closing

- Experiments using mechanical springs were developed to foster student-centered learning in a Machine Design course.
- The experiments were introduced this Spring.
- Educational benefits:
  (1) hands-on learning with real hardware,
  (2) machine design challenges that promote active-learning, and
  (3) experience working in teams.

Future Opportunities

- The use of 3D printed springs raises many unanswered questions.
  - Variability in material properties
  - Spring life
- The topic of springs can be generalized to compliant component design.

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