Machine Design Experiments using Gears to Foster Discovery Learning

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Discovery Learning

- Students posed with a challenge "discover" solutions with limited guidance.
- Student-centered pedagogical methods include active, cooperative, collaborative, project-based, and inductive learning.

Student-Centered Learning

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

Machine Design Laboratory

Machine Design Labs

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

Laboratory 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

First Week Gear Lab Activities

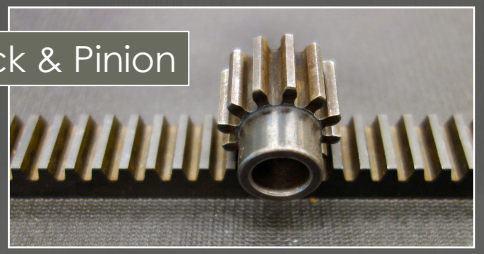
- **Station 1**: Gear Identification & Applications.
- Station 2: Automotive HVAC Baffle Gear Motor: measurement, gear train analysis, results.
- Station 3: KitchenAid Mixer: disassembly, assembly, design concept questions.
- Station 4: Gear Clock Design Challenge

Gear Nomenclature

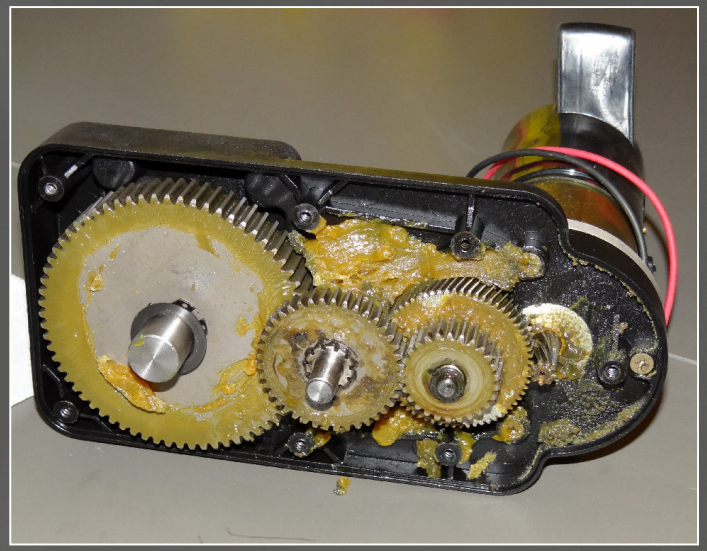

Helical Gear


Worm


Spiral Bevel Gears

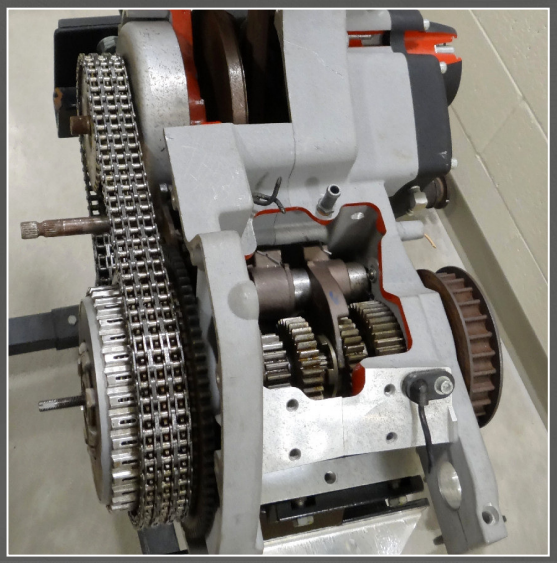

Rack & Pinion

RV Leveler



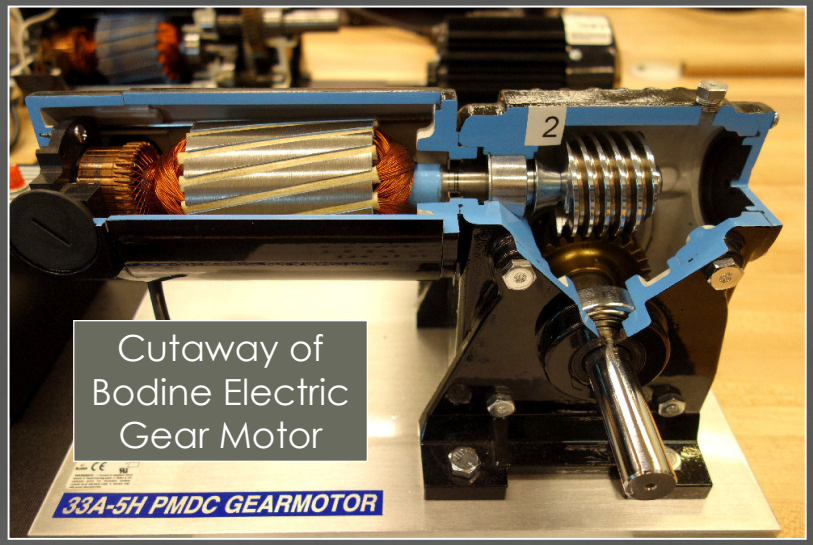
RV Leveler

Buell Blast Transmission

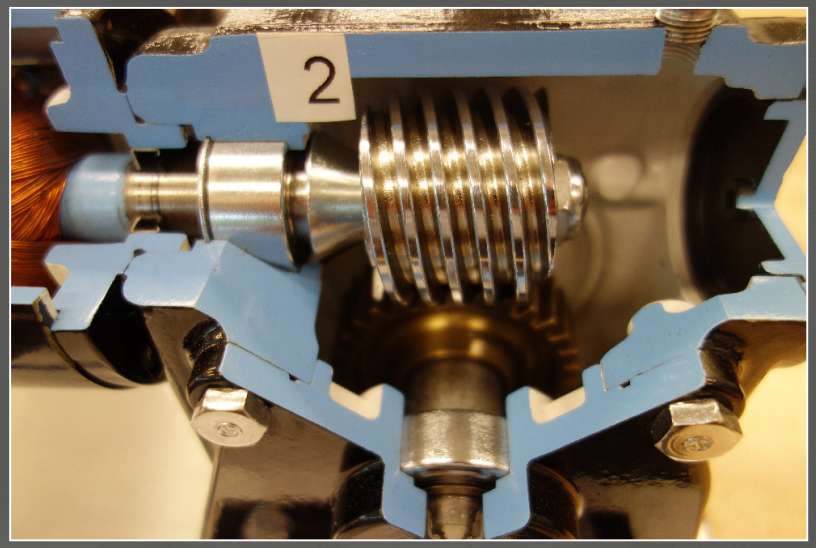


Buell Blast Transmission

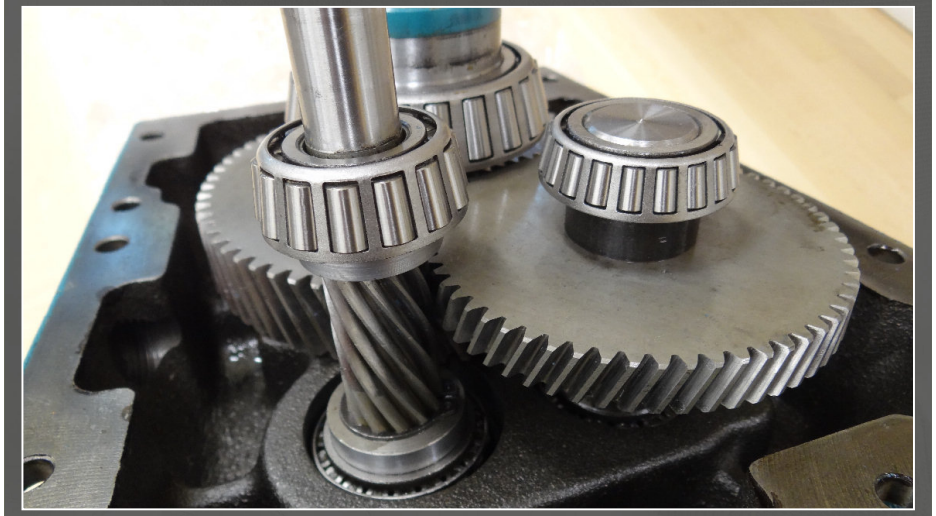
Electric Gear Motor



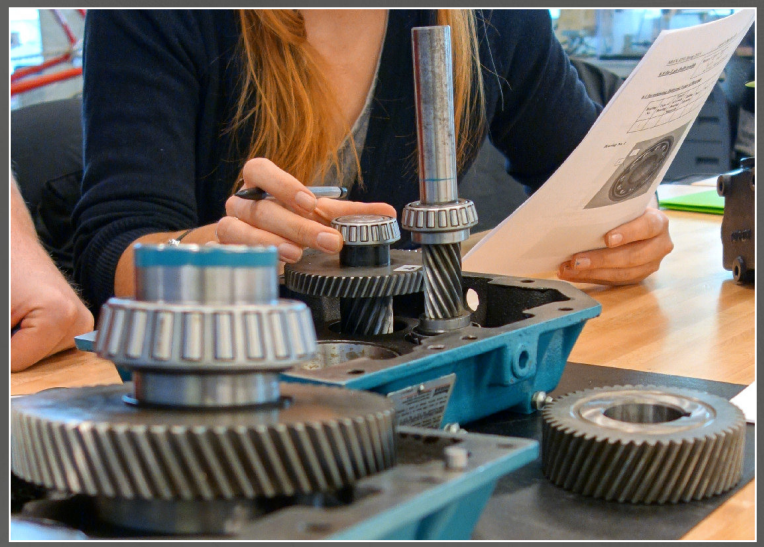
Electric Gear Motor



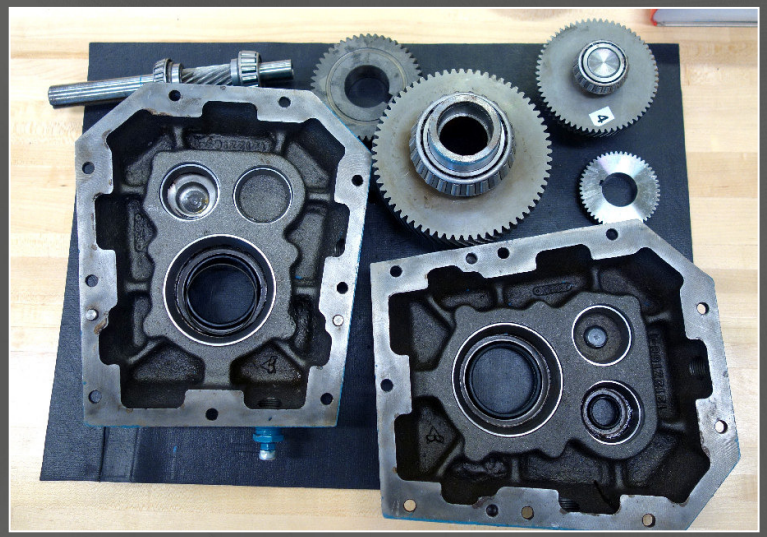
Falk Gearbox



Falk Gearbox Components



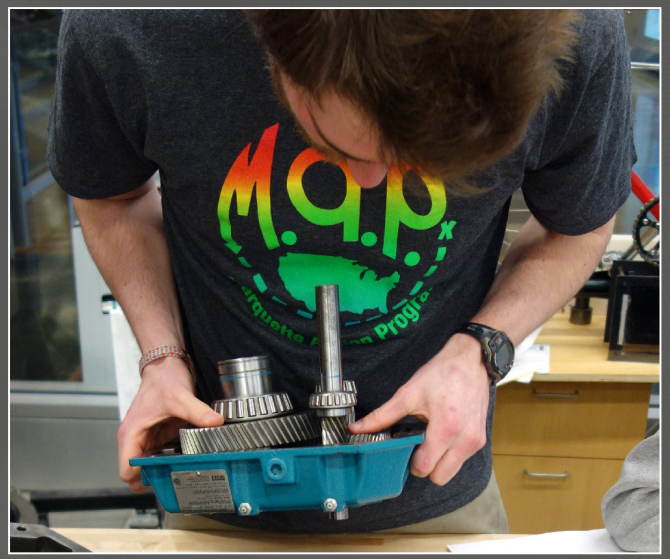
Falk Gearbox Disassembled



Falk Gearbox Assembly

Falk Gearbox Assembly

Falk Gearbox Assembly



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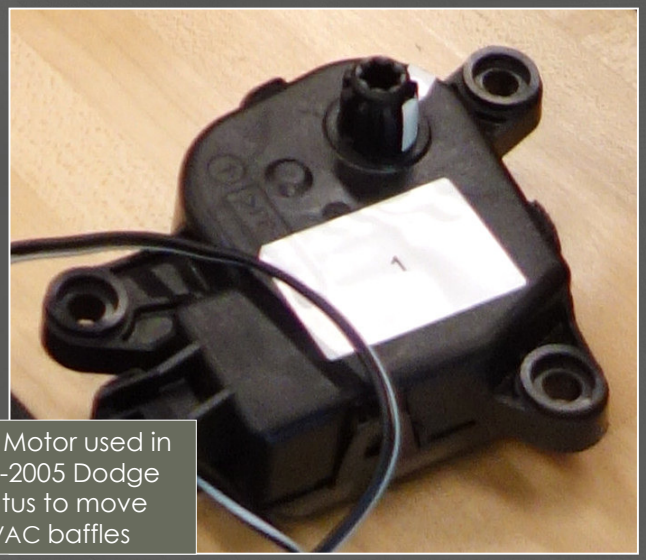
HVAC Baffle Gear Motor



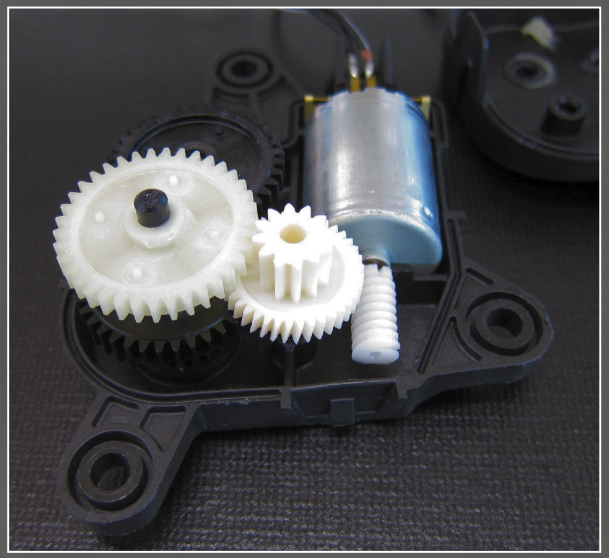
Gear Motor used in 2002-2005 Dodge Stratus to move HVAC baffles

HVAC Baffle Gear Motor

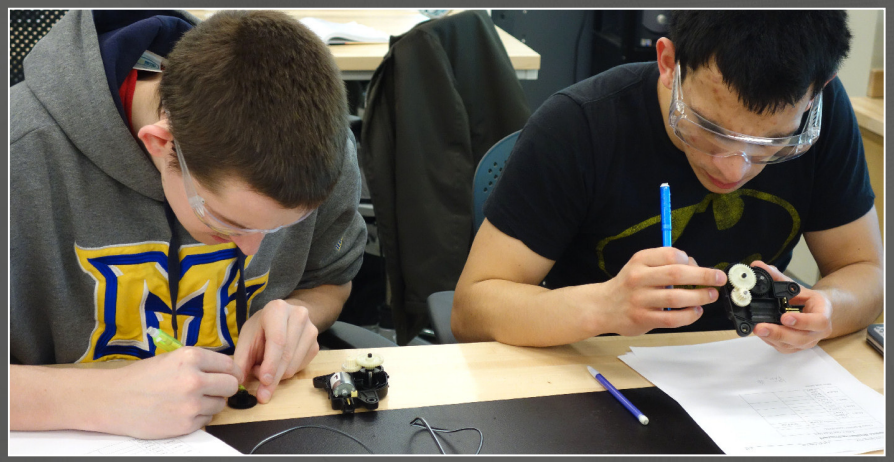
Measuring Output Shaft Speed

HVAC Baffle Gear Motor

HVAC Baffle Gear Motor



HVAC Baffle Gear Motor



HVAC Baffle Gear Motor

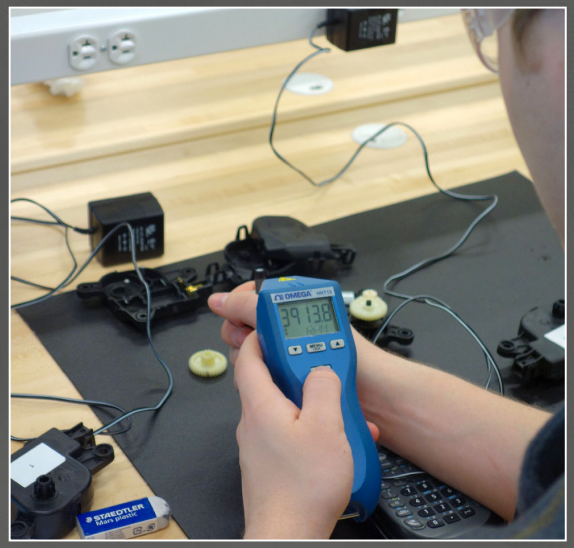
Counting Number of Gear Teeth

HVAC Baffle Gear Motor

HVAC Baffle Gear Motor

Measuring Speed of Motor

HVAC Baffle Gear Motor



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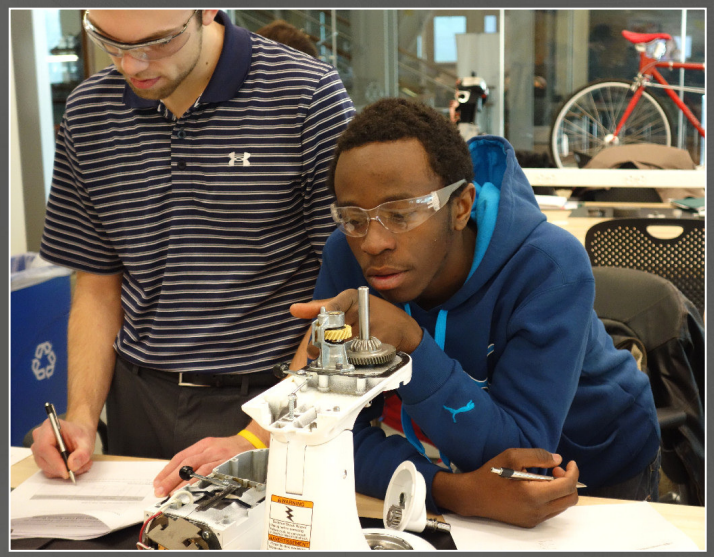
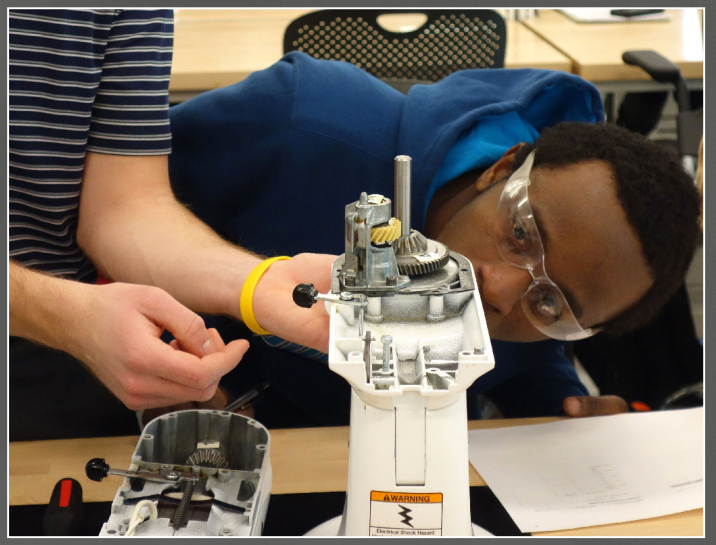
KitchenAid Mixer



KitchenAid Mixer



KitchenAid Mixer

KitchenAid Mixer

Mixer Disassembly

Mixer Disassembly

Mixer Disassembly

Mixer Disassembly

All Those Mixers and No Cake?

Mixer Re-assembly

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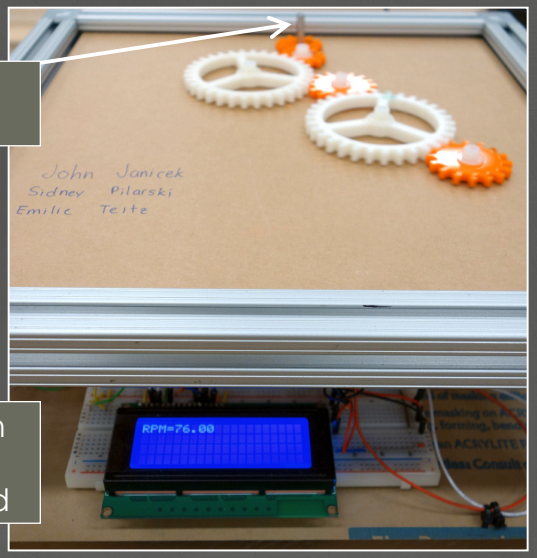
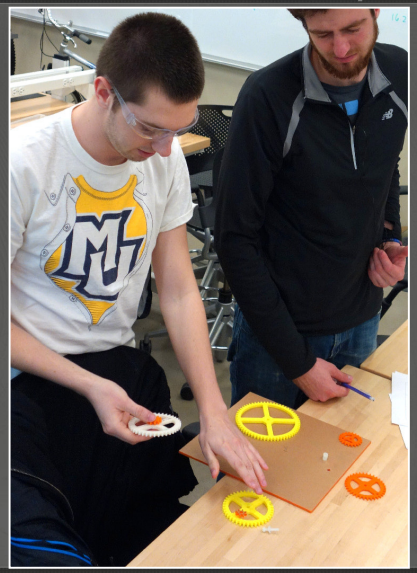
Gear Clock Challenge

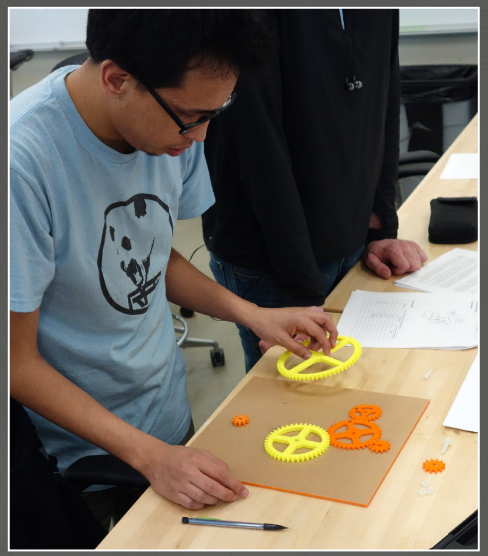


Second Week Lab Activities

Gear Clock Layout



Gear Clock Layout

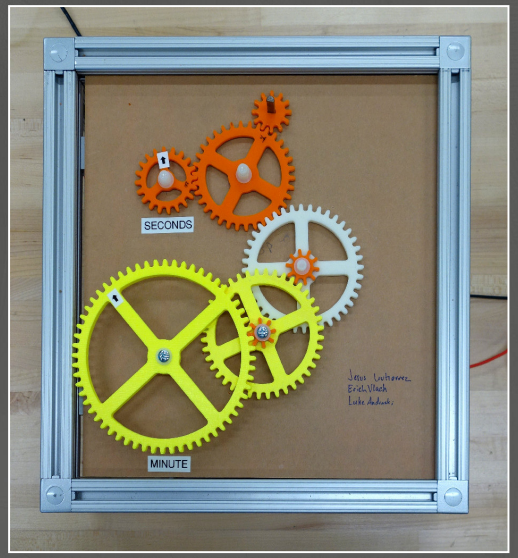


Drill Holes in Mounting Plate

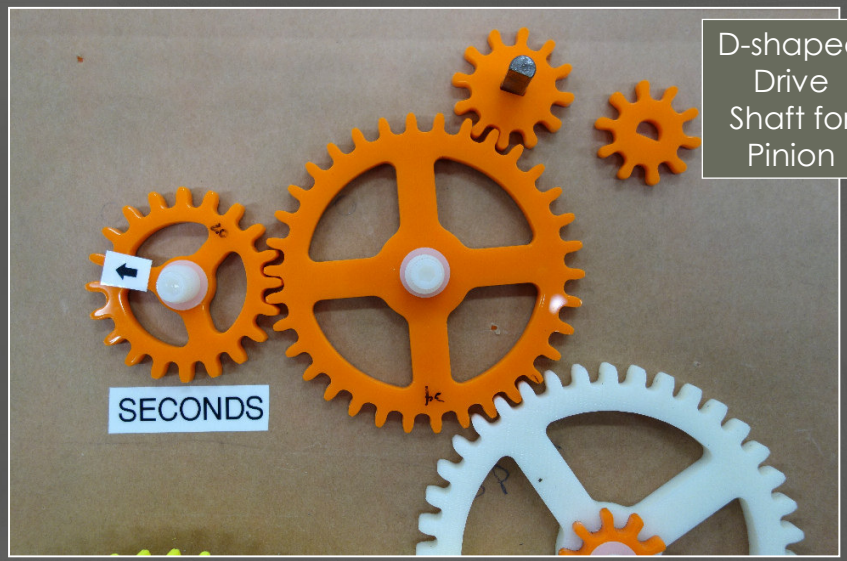
Drill Holes in Mounting Plate

Gear Clock Testing

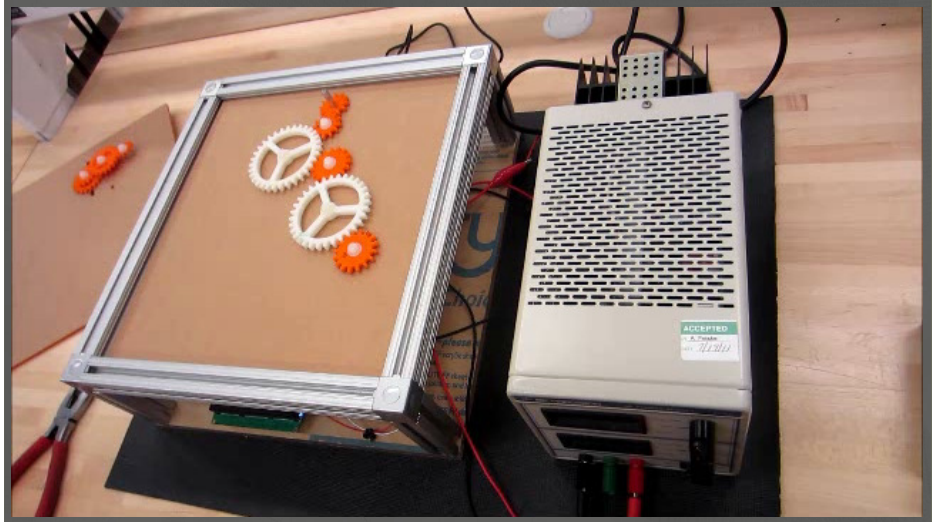
Gear Clock Testing



Gear Clock – Zoomed in



Gear Clock Testing



What Did Students Learn?

- Discovery Learning activities give students pragmatic hands-on experiences that teach
  - Multiple acceptable design solutions
  - Successful prototypes require proper components, e.g., gears with involute tooth profiles
  - Assembly issues are real, e.g., center-to-center distances in gear trains must be accurate

What Did We Learn?

- Machine Design course needs a balance of theory and hands-on activities.
  - Laboratory component of course essential.
  - Some students struggled with gear train analysis and had 'eureka' moments in lab.
- Design challenges where students build and test hardware are fun and promote learning.
- Past students want to improve labs and create new discovery learning experiences.

Closing

- Experiments were designed to give students discovery learning experiences with gears used in mechanical systems.
- Experiments fostered student-centered learning in a Machine Design course by
  - hands-on learning with real hardware
  - machine design challenges, and
  - team work.

Future Opportunities

- Extend clock design challenge to include accuracy and …
  - Cost, Weight, Size, Manufacturability/Assemblability
- Add torque measurement, shearing of teeth
- Generalize to other components (escapement mechanisms) used in clocks
- Conduct detailed assessment

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