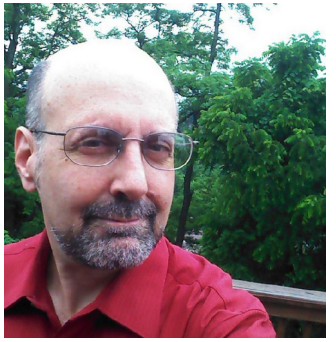
15-394: Intermediate Rapid Prototyping

Instructor: Dave Touretzky



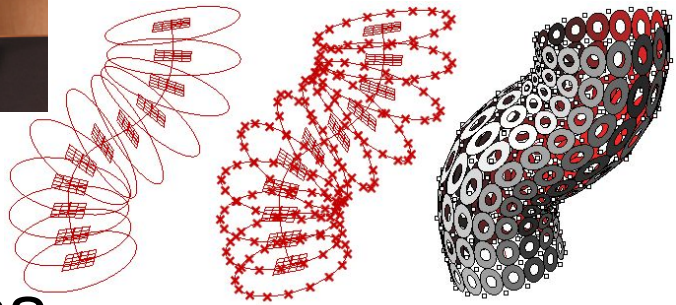
Teaching Assistant: Avery Lavine

https://www.cs.cmu.edu/afs/cs/academic/class/15394-f25

What Is This Course About?

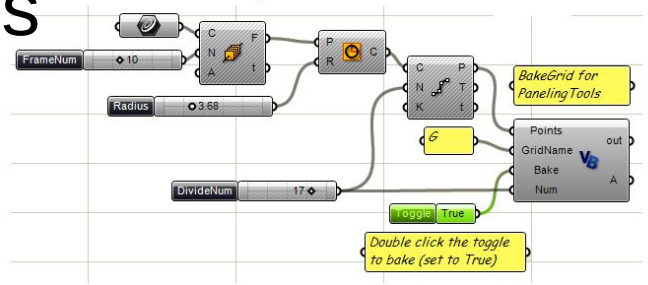
I. Mechanism Design

- Designing with gears, linkages, cams, etc.
- Simulation in SolidWorks
- Assembly of working artifacts



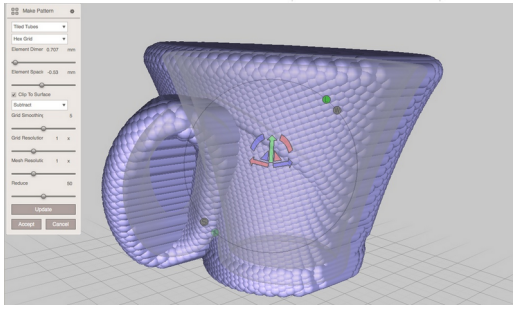
II. Computation With Geometric Primitives

- Grasshopper



III. Manipulating 3D Structure

- Mesh manipulation
- 3D printing



Prerequisites

- SolidWorks (comparable to 15-294)
- Fire extinguisher training: sign up today!
- Helix laser cutter checkout

SolidWorks and Grasshopper

- You must have a machine that can run SolidWorks and Grasshopper.
- Mac users must use Boot Camp or Parallels to run Windows.
- Virtual Andrew is also an option.

Assignments

- There are four assignments:
  - Mechanism (20 points)
  - Automaton (20 points)
  - Studded surface (15 points)
  - Organic shape (in class; 5 points)
- There is a final project, for which you'll have a couple of weeks.
  - It's worth 30 points – nearly half your grade.
  - **Don't wait until the last minute!**

Attendance

- Attendance is worth 10% of your grade.
- Fill in the sign-in sheet each class.
- Up to three unexcused absences without penalty.
- No penalty for illness or participation in certain university-sanctioned events.

Communication

- We'll use Canvas for all class announcements.

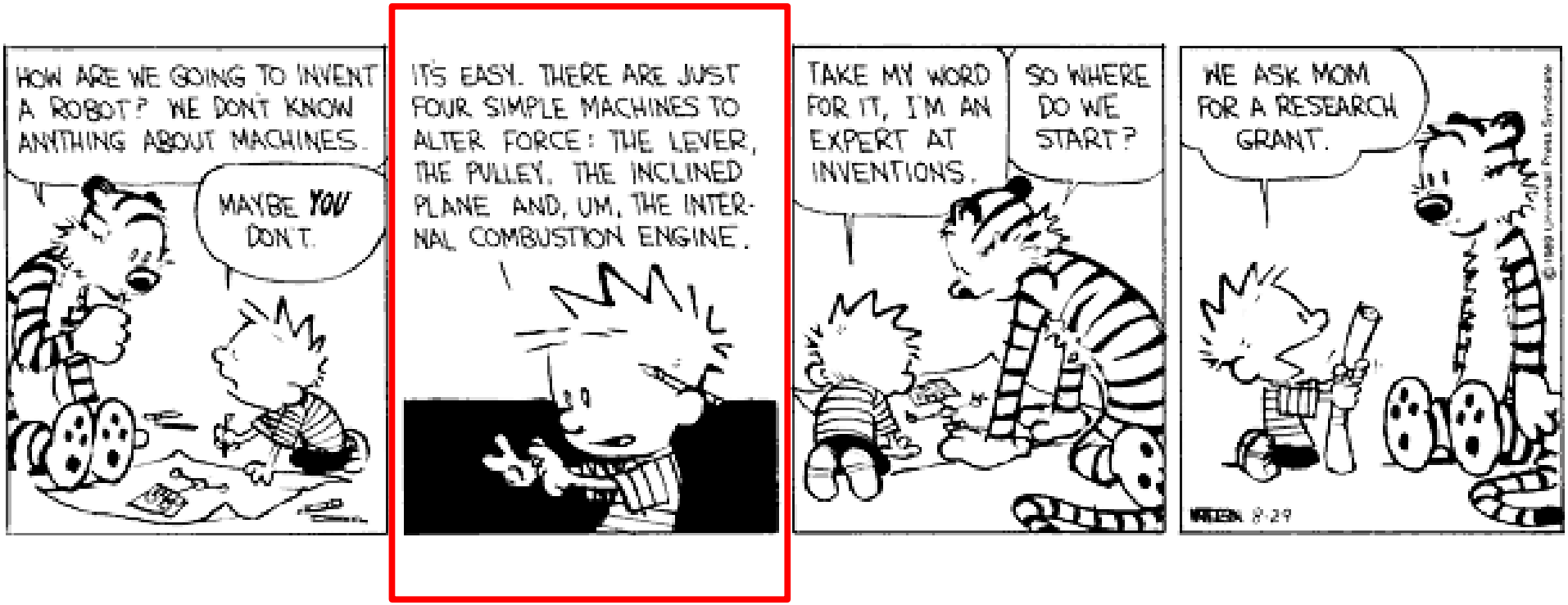
- Please ask questions via Discussions in Canvas, not in private email, unless you need to post code or SolidWorks files.

Academic Integrity

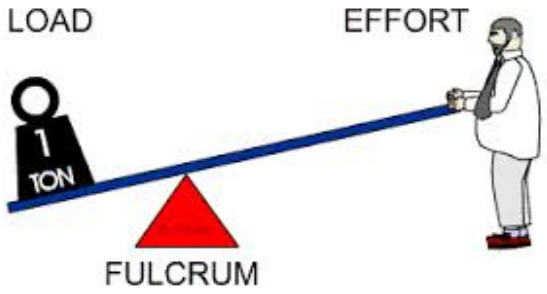
- The work you turn in must be your own.
  - You can help a fellow student with a SolidWorks error, but you can't share your code with them.
  - If you need help with an assignment, ask a TA or the instructor.
- Cite your sources.
  - It's fine for your final project to build on the work of others. Just make sure to cite your sources of inspiration and make clear how you have modified or extended their design.

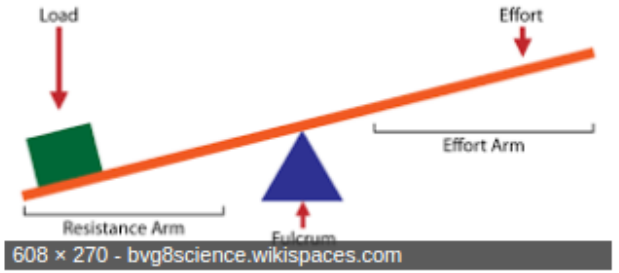
Six Classical Simple Machines

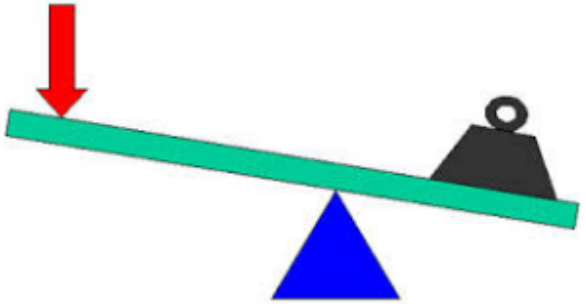
- Lever
- Wheel and axle
- Pulley
- Inclined Plane
- Wedge
- Screw

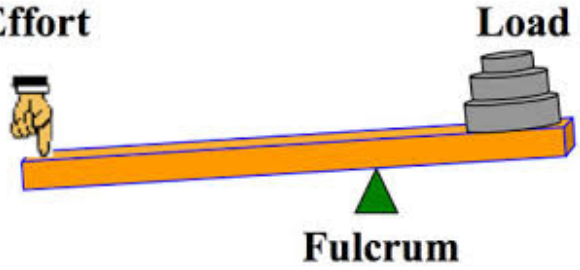


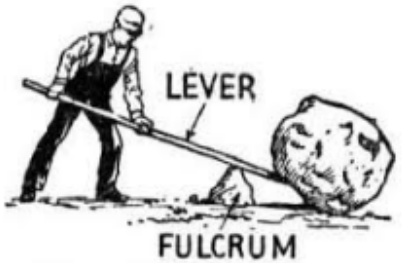
(1) The Lever

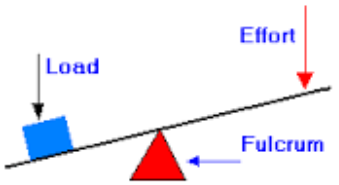


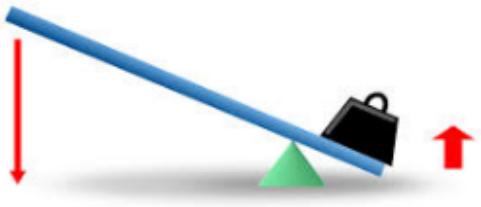




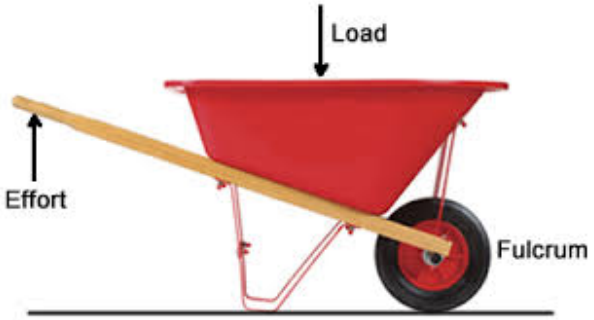


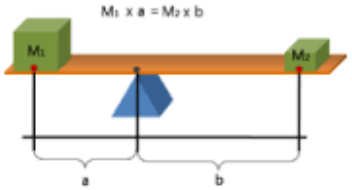


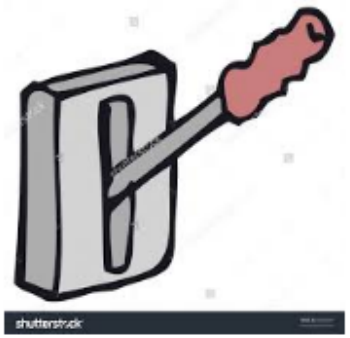


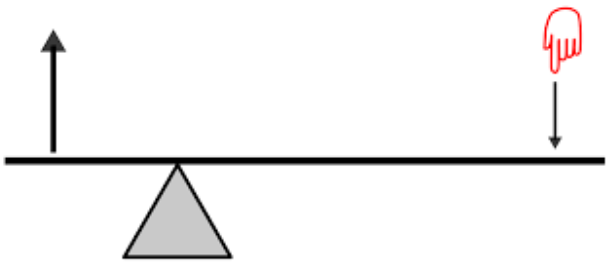


LEVER



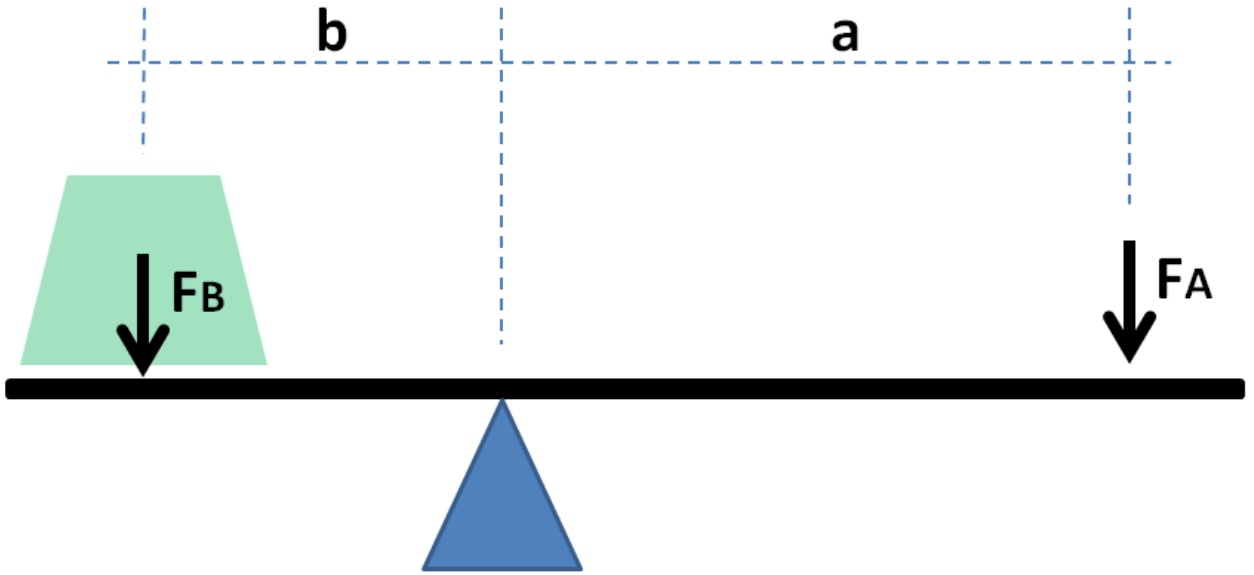






Mechanical Advantage

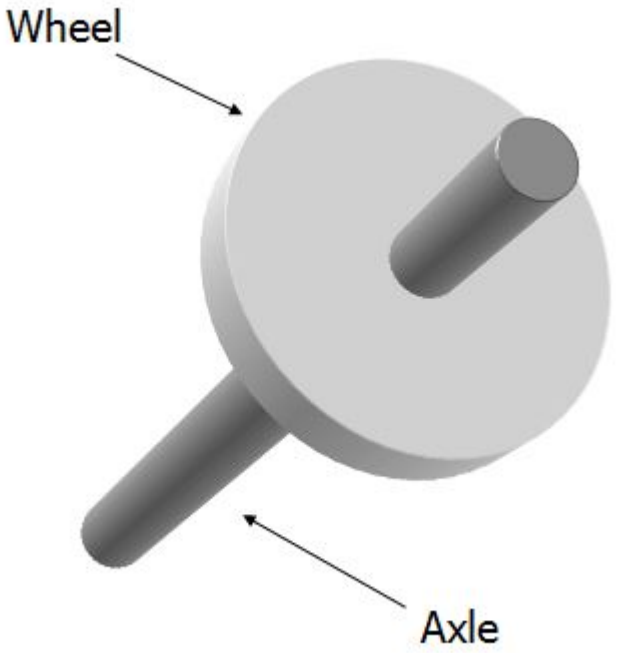
- The ratio of input force to output force.
- Ideal simple machines preserve power while trading force for distance traveled.

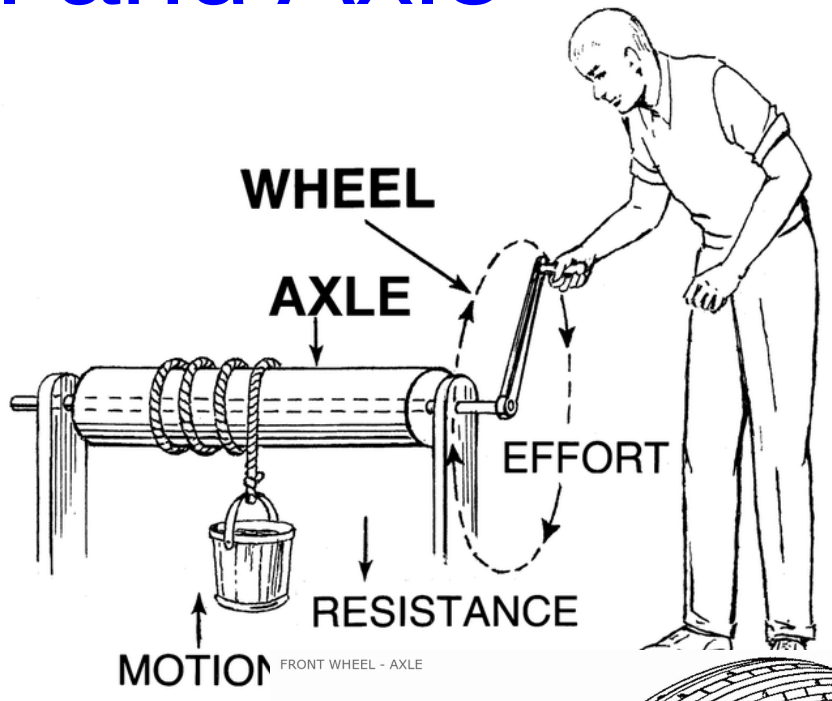


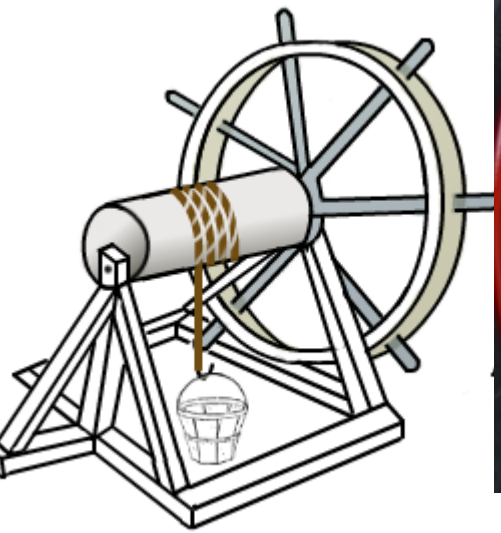
Law of the lever (Archimedes):

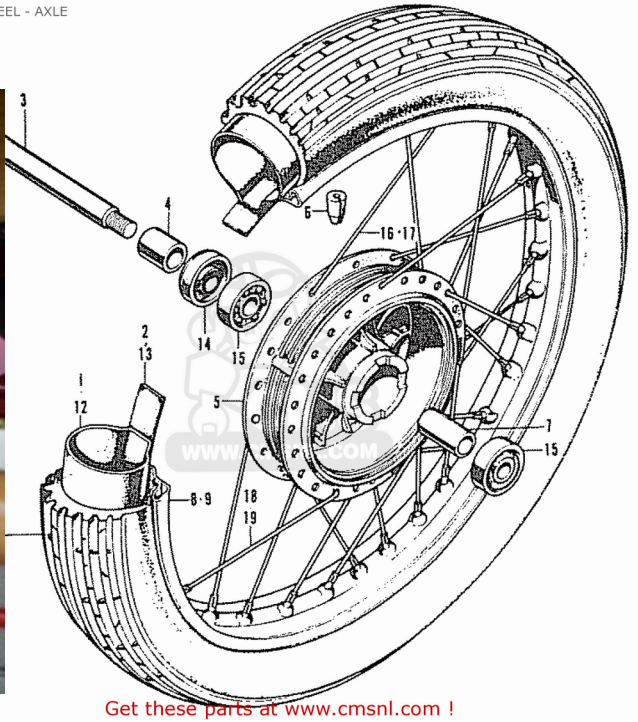
$a \times F_A = b \times F_B$

(2) Wheel and Axle



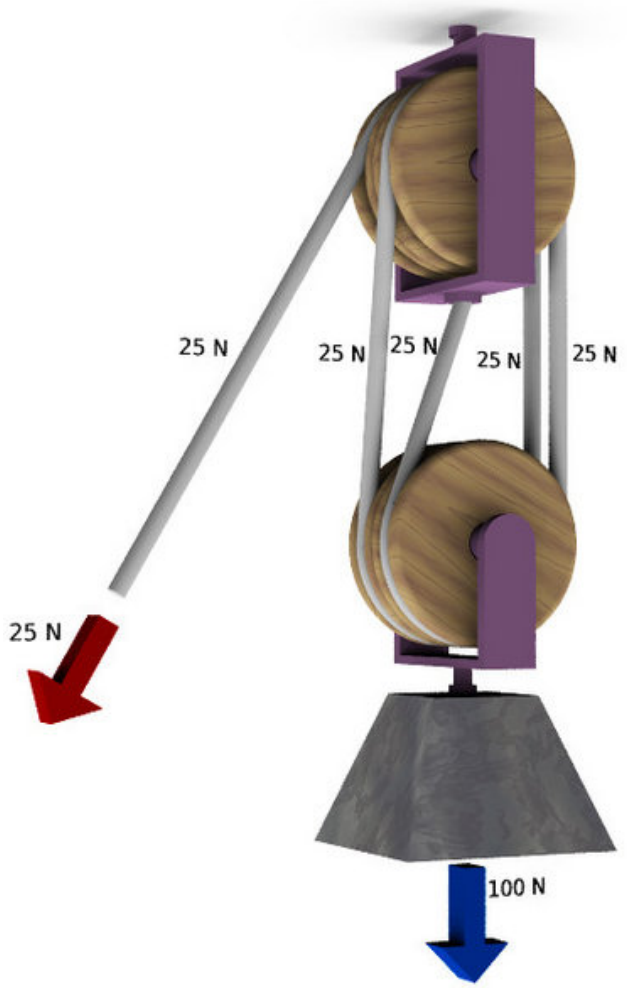


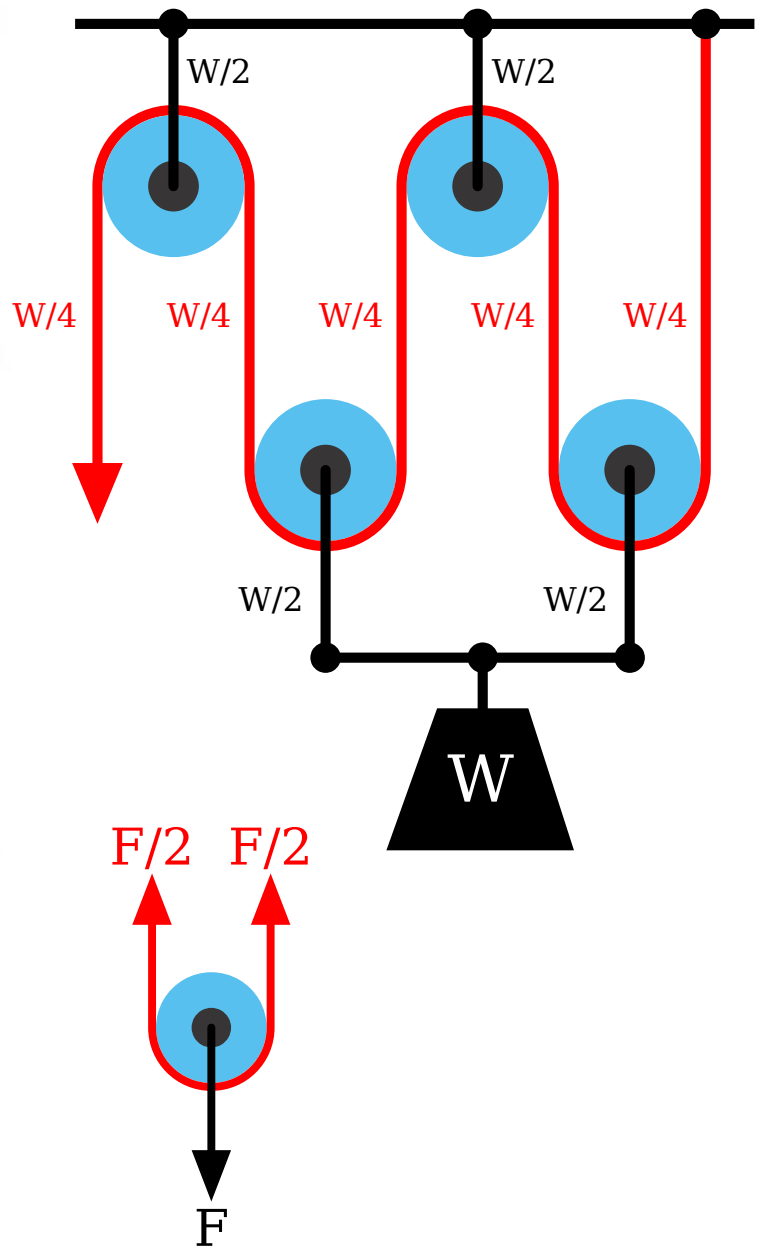


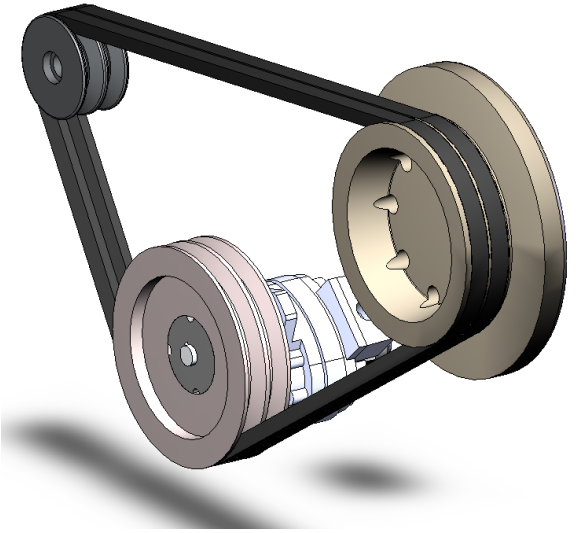


Get these parts at www.cmsnl.com !

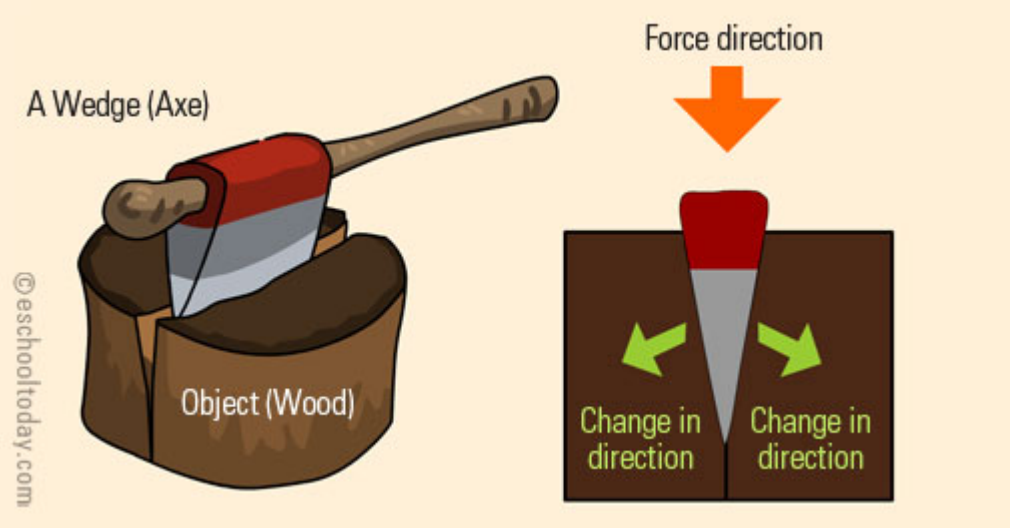
(3) The Pulley

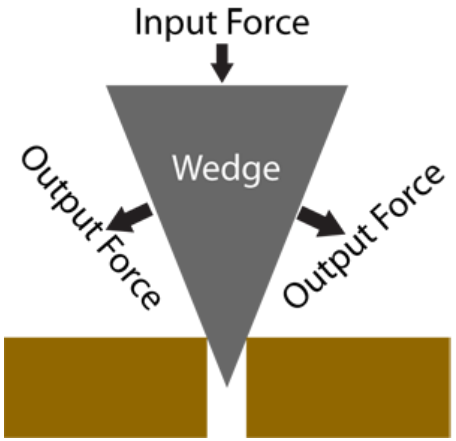


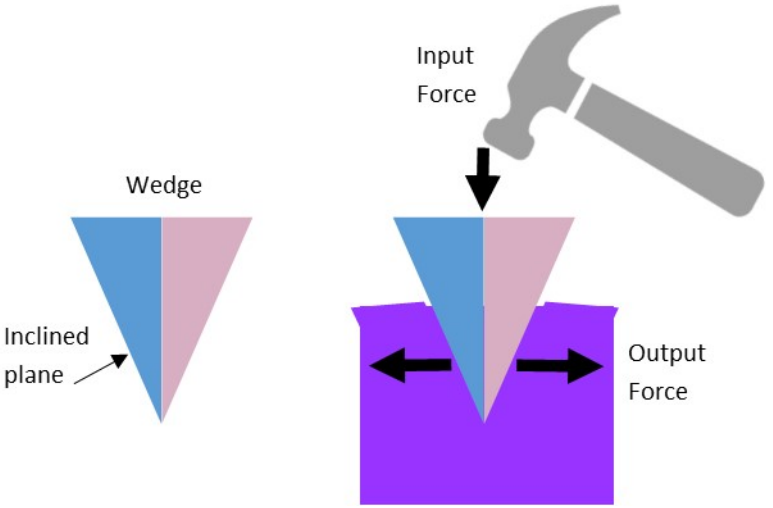




(4) The Wedge

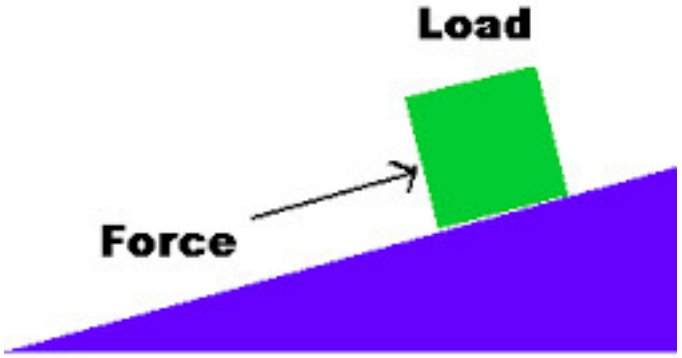


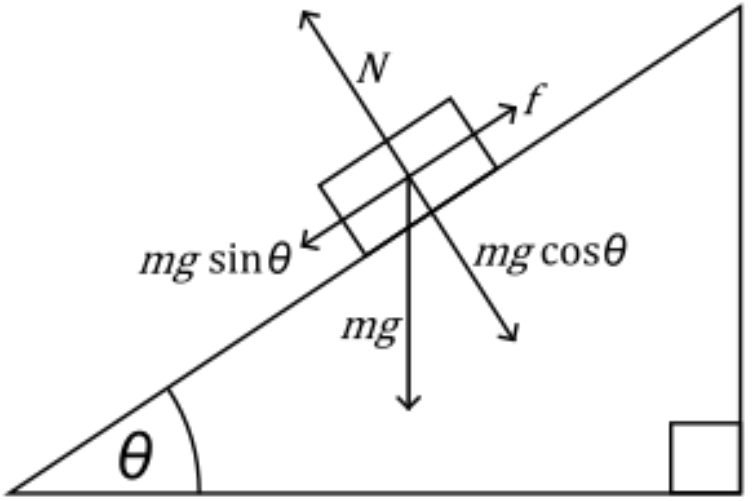




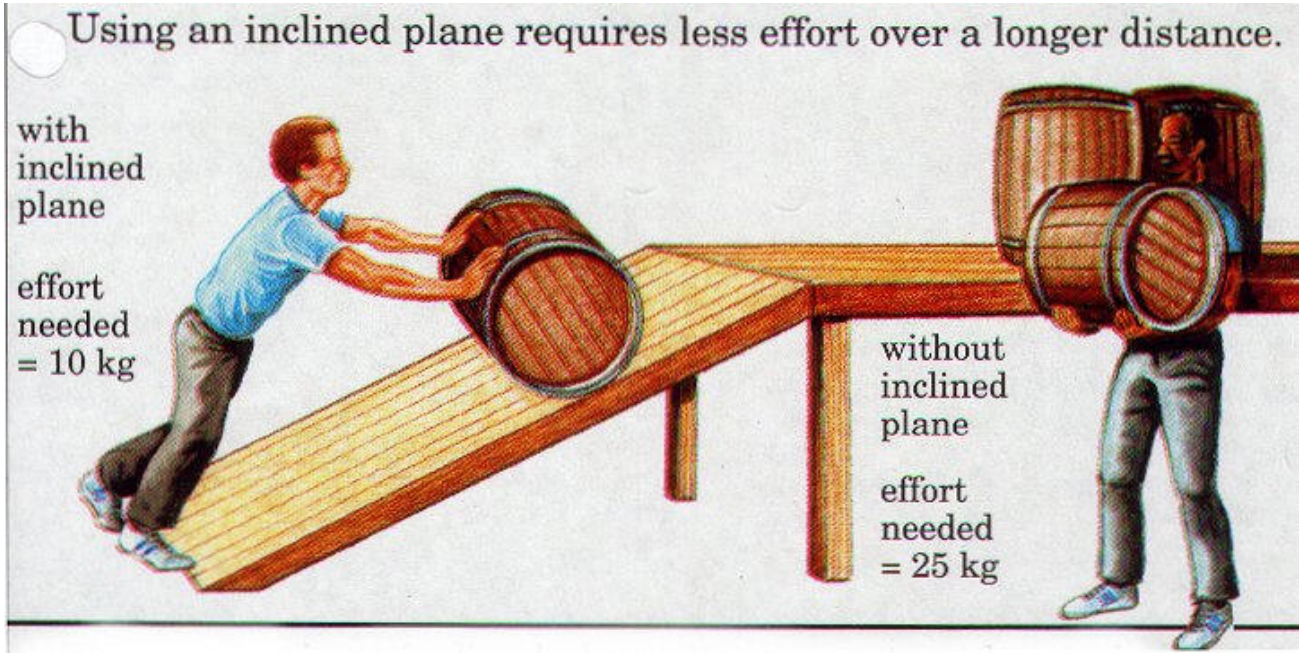
A wedge is a moving *inclined plane.*

(5) The Inclined Plane

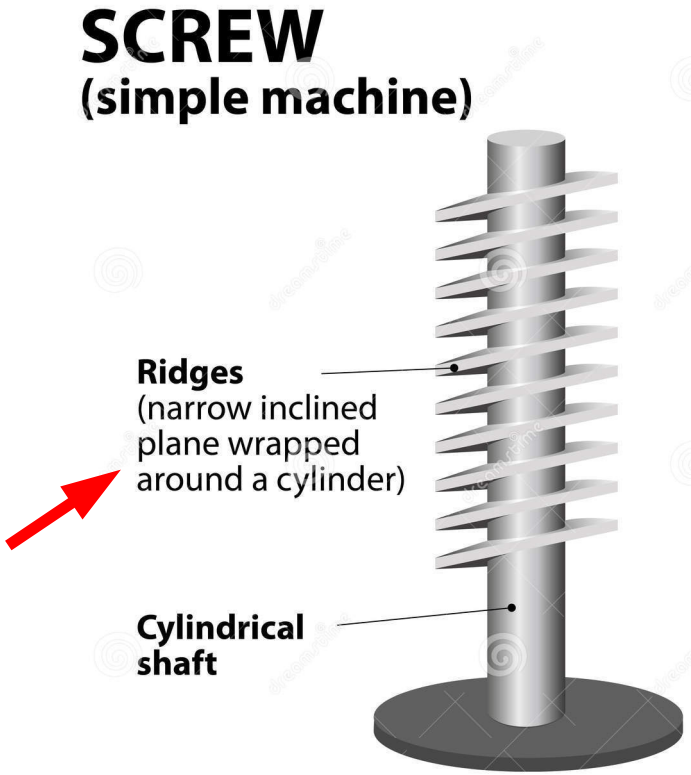


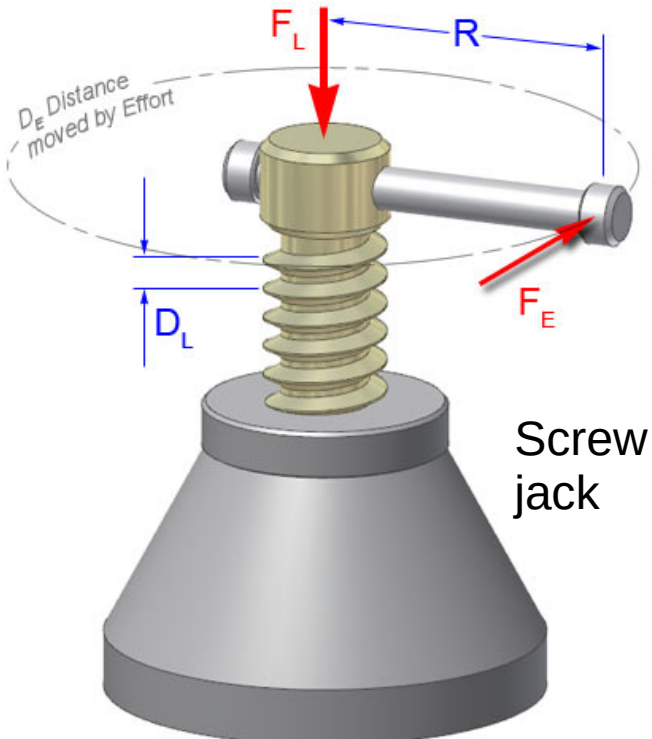


Tradeoff: less force over a longer distance to do the same amount of work.

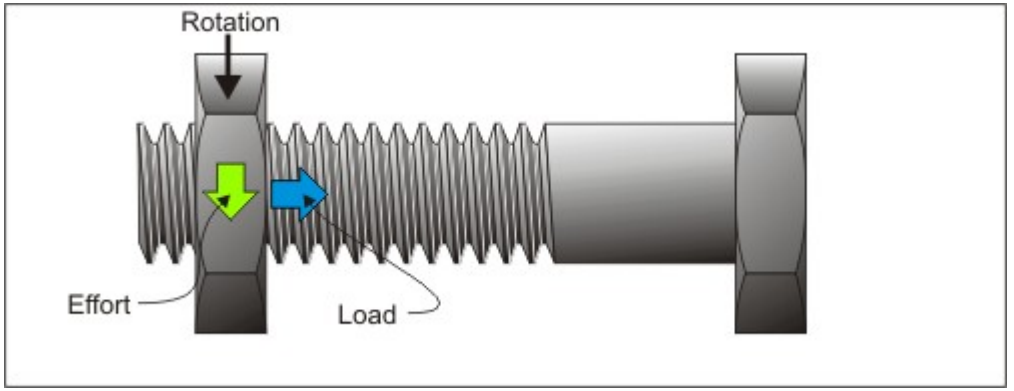


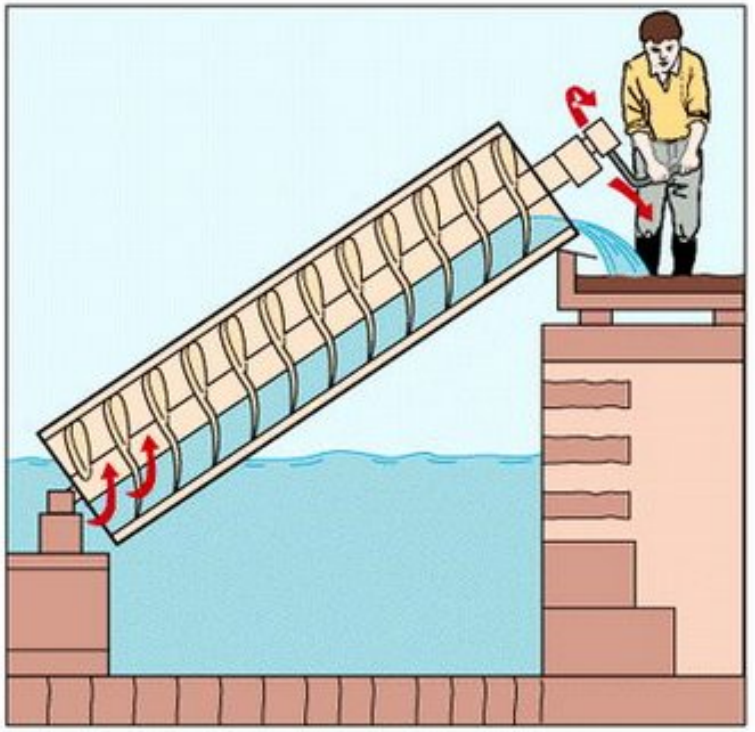
(6) The Screw





Screw jack





Archimedes screw pump

Equivalence of Simple Machines

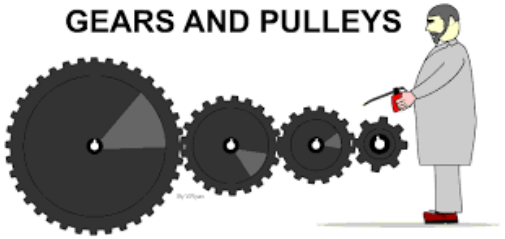
- Reuleaux (19th century mechanical engineer):
  - A lever, pulley, and wheel and axle are the same device: a body rotating about a hinge.
  - An inclined plane, wedge, and screw are the same device: a block sliding on a surface.

Gears Are Meshed Levers













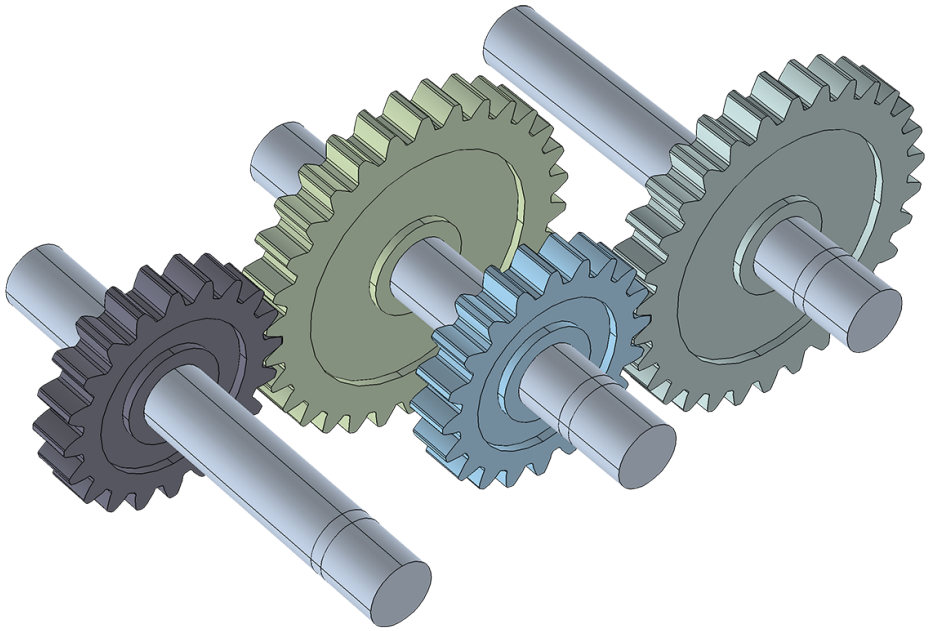




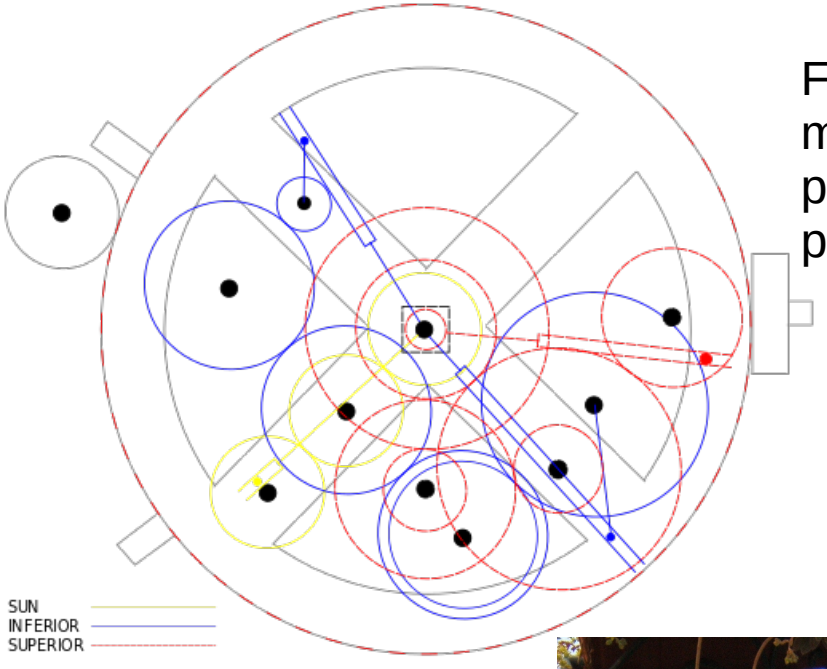


Compound Machines

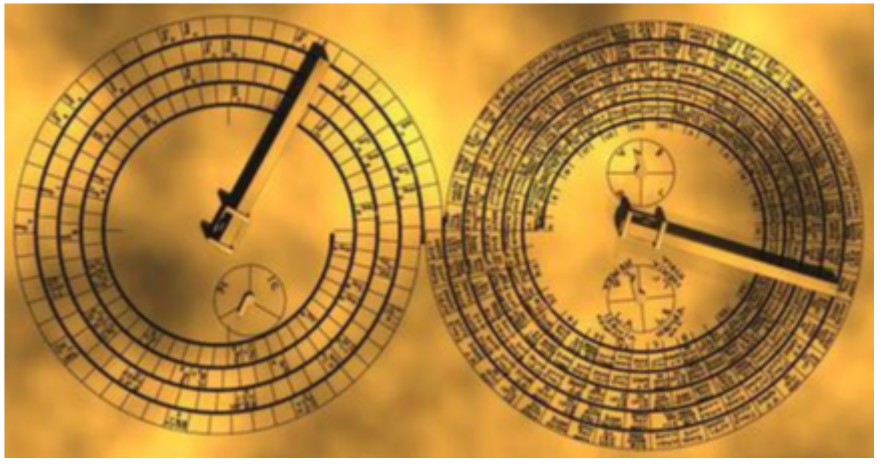
- Formed from a set of simple machines connected in series.
- The output force of one machine provides the input force to the next.
- Example: a gear train.
- **Linkages** are machines that aren't necessarily connected in series: they can contain branches and loops.



Antikythera Mechanism (205-100 B.C.)



Front: sun, moon, and planet positions



Back: 19 and 76 year cyclic calendars