15-394 Intermediate Rapid Prototyping

Fall 2017

Instructor: Dave Touretzky

Your TAs

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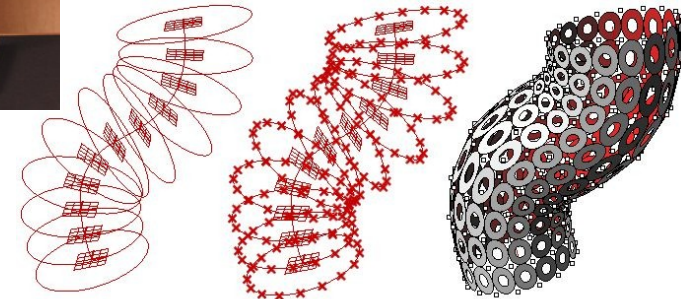
What Is This Course About?

I. Mechanism Design

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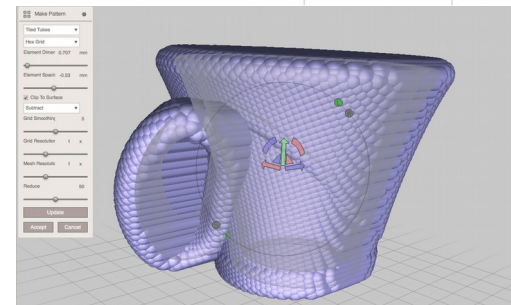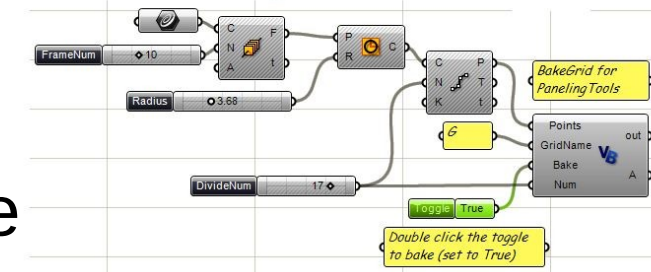- Simulation in SolidWorks
- Assembly of working artifacts

II. Computation With Geometric Primitives

- Grasshopper

III. Capturing and Manipulating 3D Structure

- Scanning with AutoDesk Fusion 360
- Meshmixer
- 3D printing

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Prerequisites

- SolidWorks (comparable to 15-294)

- Fire extinguisher training: sign up today!

- Rabbit Laser checkout

Assignments

- There are four assignments, 10 points each:
  - Automaton
  - Mechanisms
  - Slicer
  - Statue

- There is a final project, for which you'll have a couple of weeks.
  - It's worth 30 points – nearly half your grade.
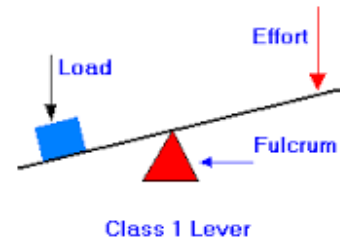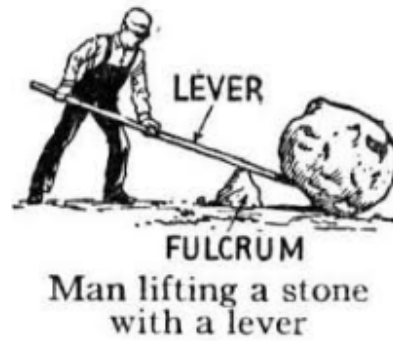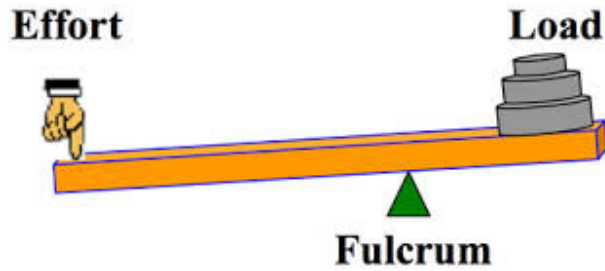 - **Don't wait until the last minute!**
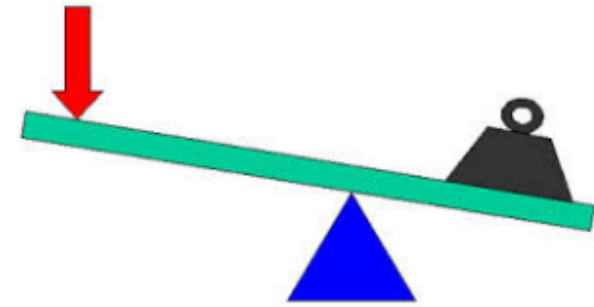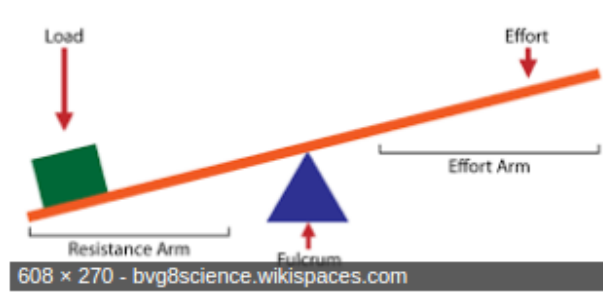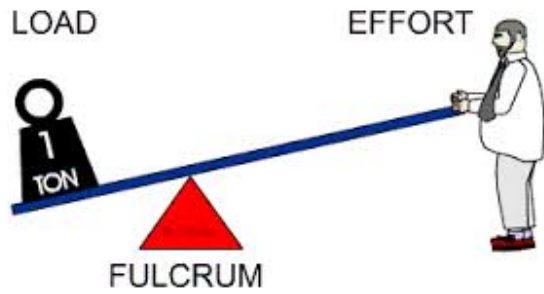
Communication

- We'll use Piazza for all class announcements.

- Please ask questions via Piazza, not in private email, unless there is a need to keep something confidential.
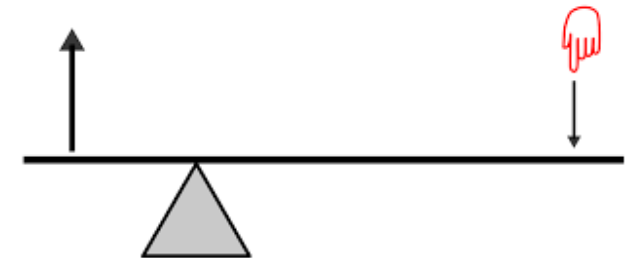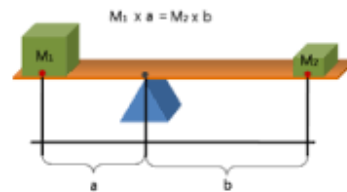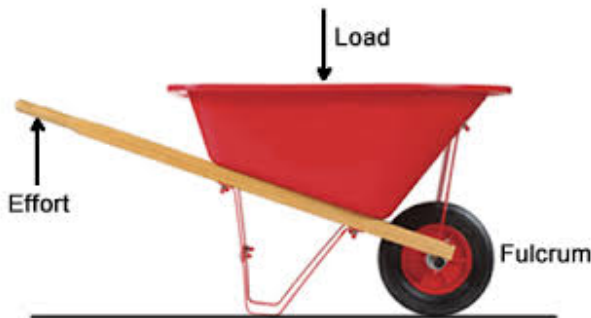
Six Classical Simple Machines

- Lever
- Wheel and axle
- Pulley

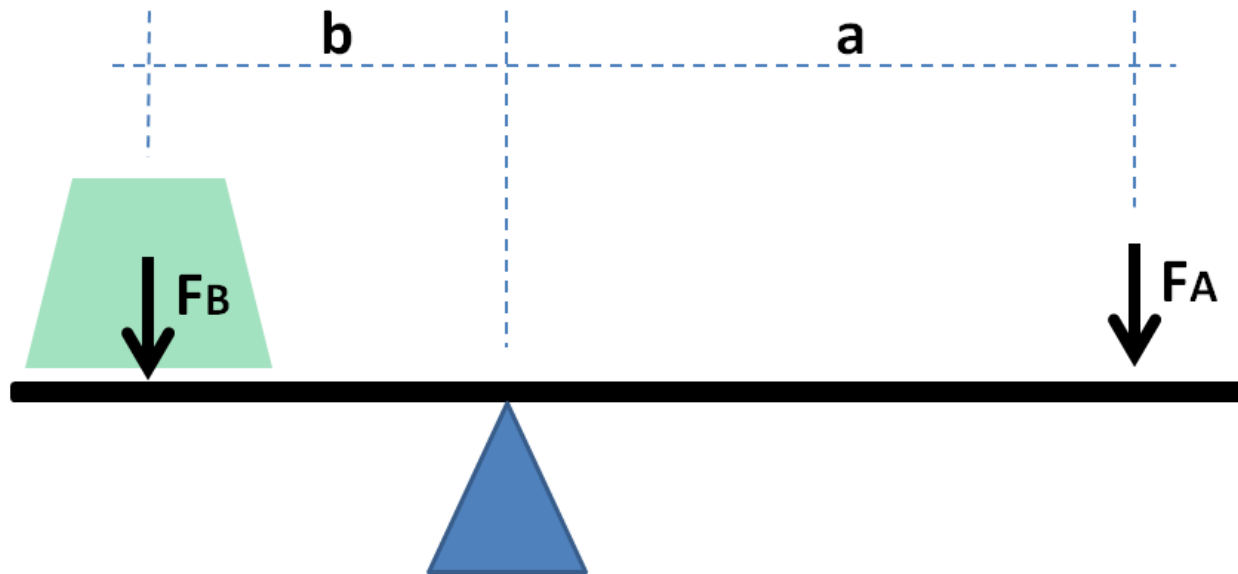- Inclined Plane
- Wedge
- Screw
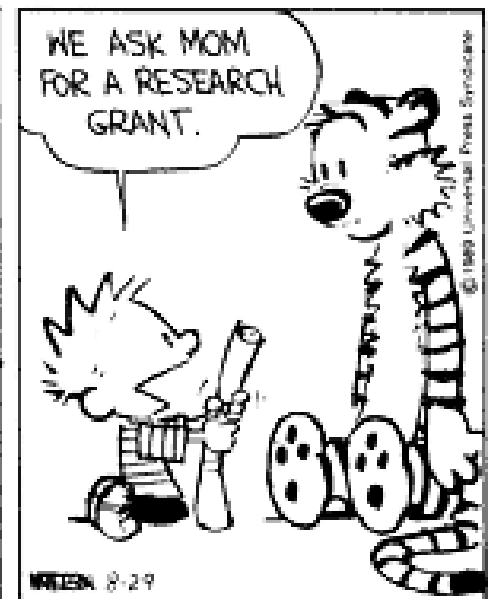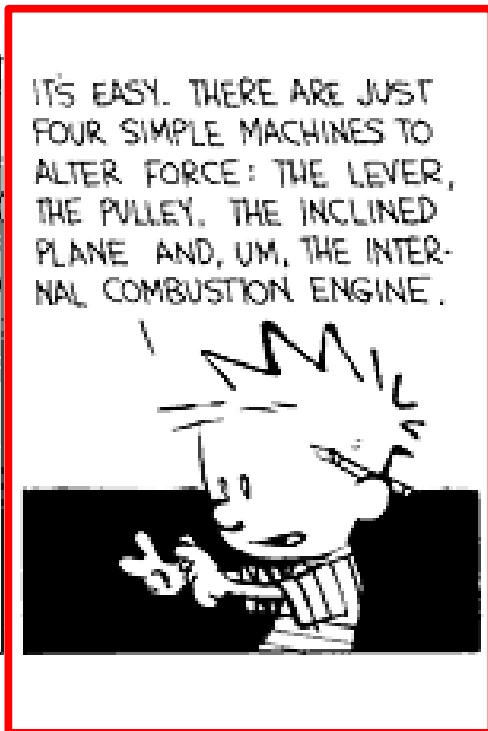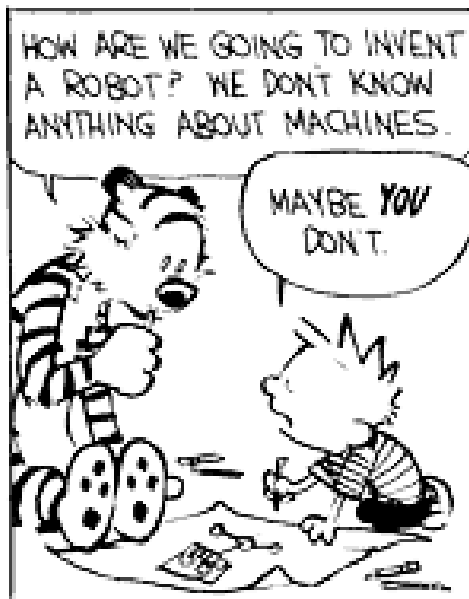
(1) The Lever

Mechanical Advantage

- The ratio of input force to output force.
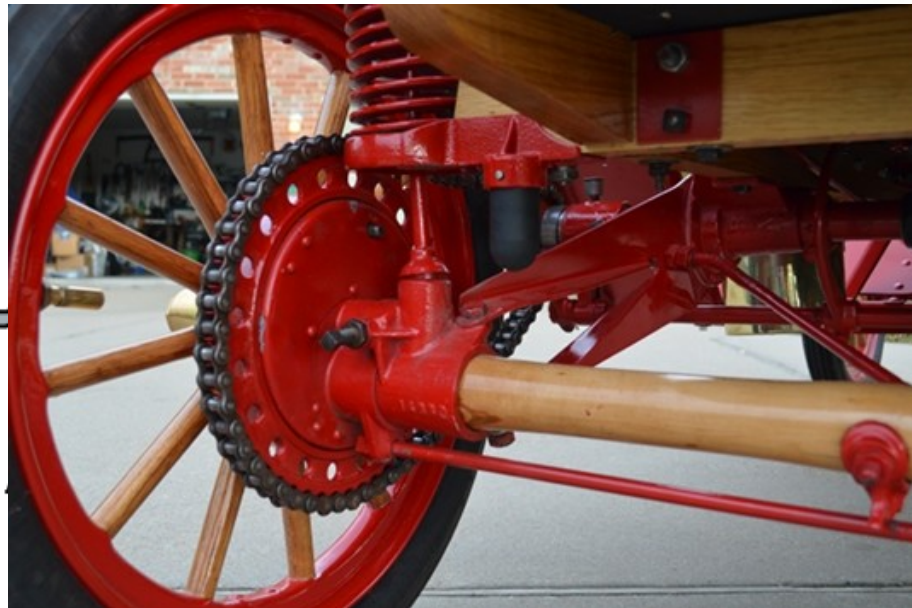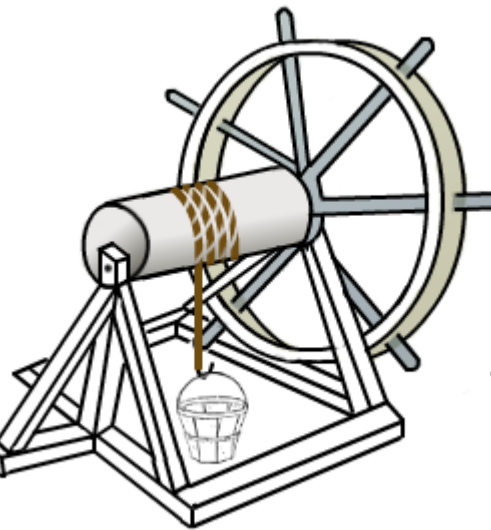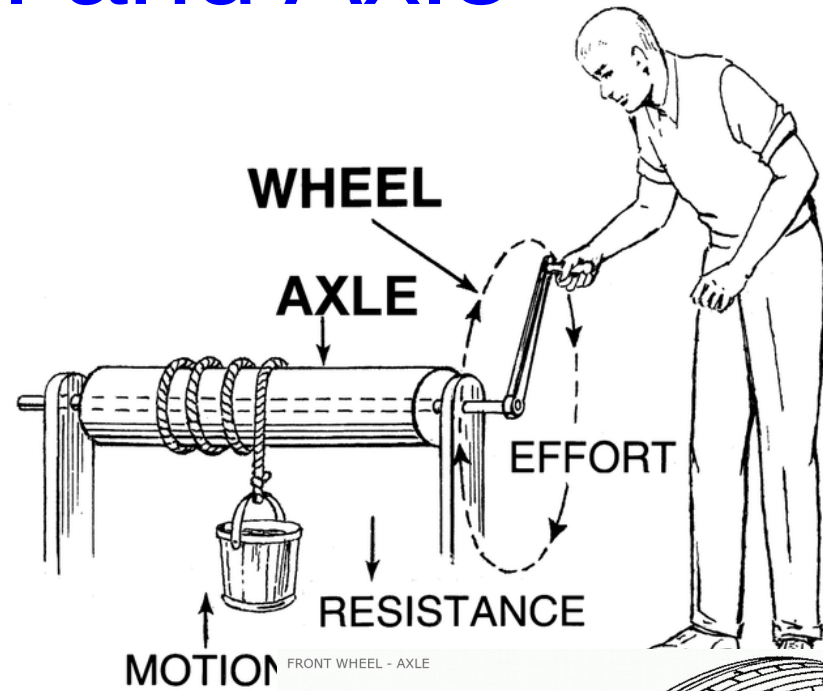- Ideal simple machines preserve power while trading force for distance traveled.
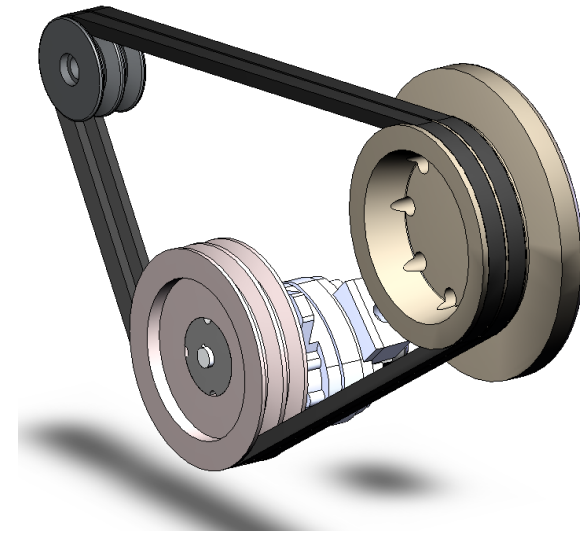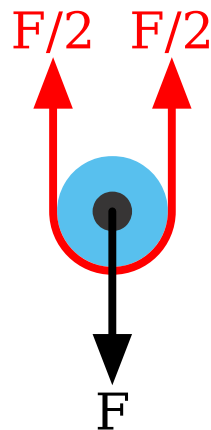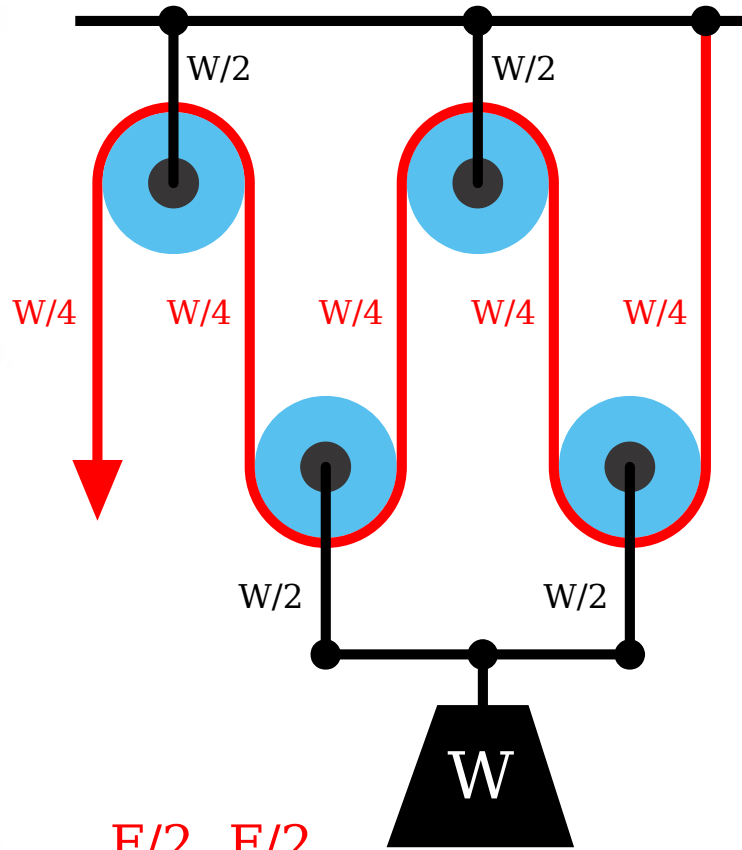
Law of the lever (Archimedes):

$$a \times F_A = b \times F_B$$

(2) Wheel and Axle

Wheel

Axle

WHEEL

AXLE

EFFORT

RESISTANCE

MOTION

FRONT WHEEL - AXLE

10

(3) The Pulley

25 N

25 N   25 N   25 N   25 N

25 N

100 N

W/2   W/2

W/4   W/4   W/4   W/4   W/4

W/2   W/2

W

F/2   F/2

F

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(4) The Wedge

A Wedge (Axe)

Force direction

Object (Wood)

Change in direction   Change in direction

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Input Force

Wedge

Output Force   Output Force

Input Force
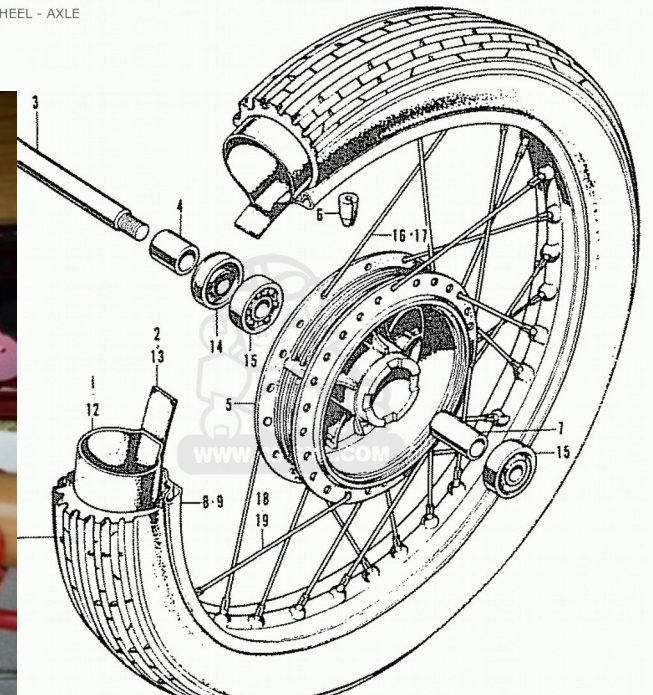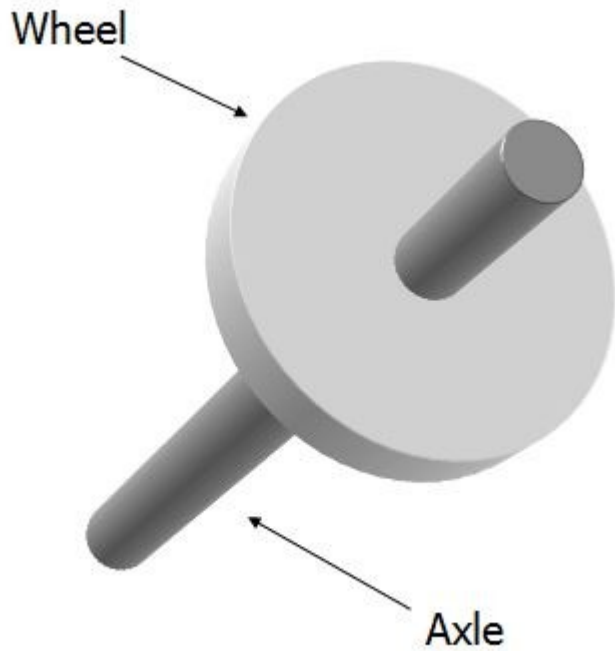
Wedge
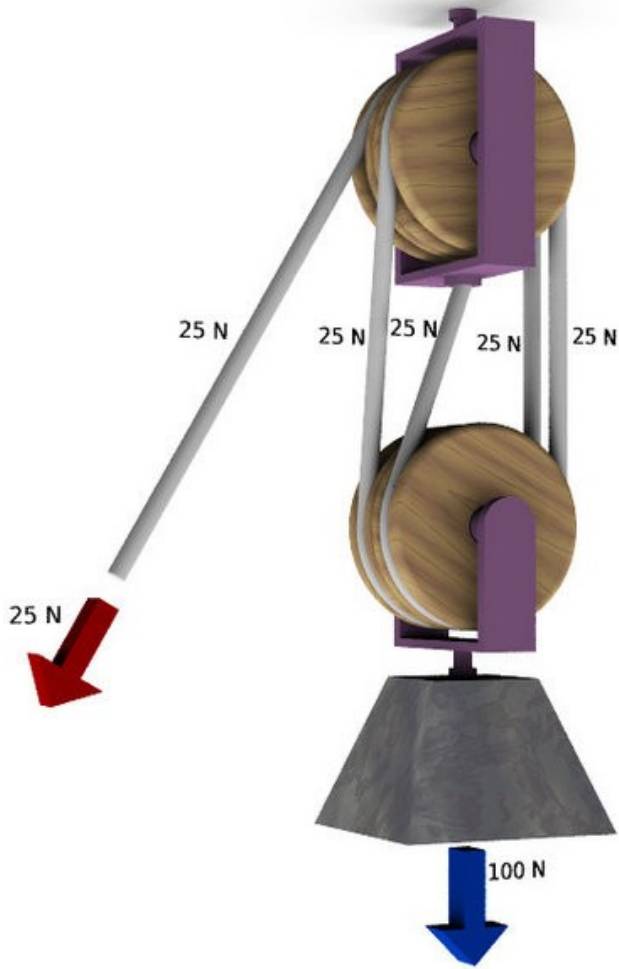
Inclined plane

Output Force
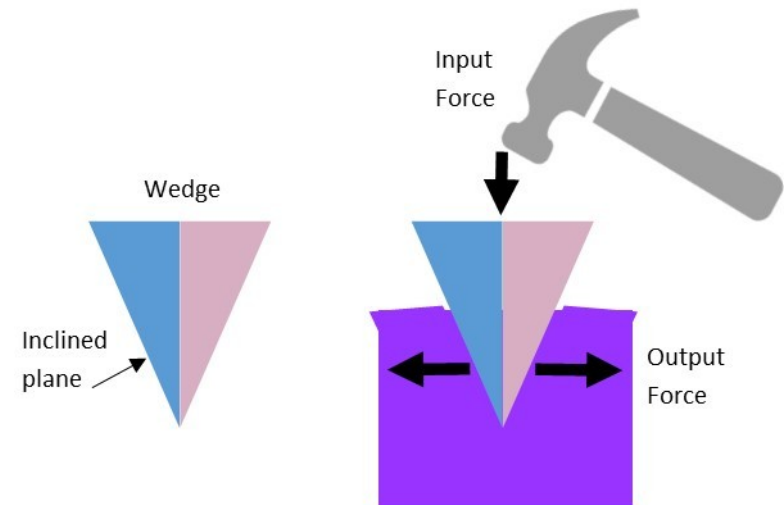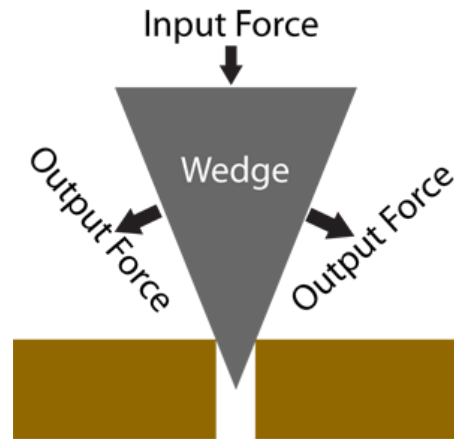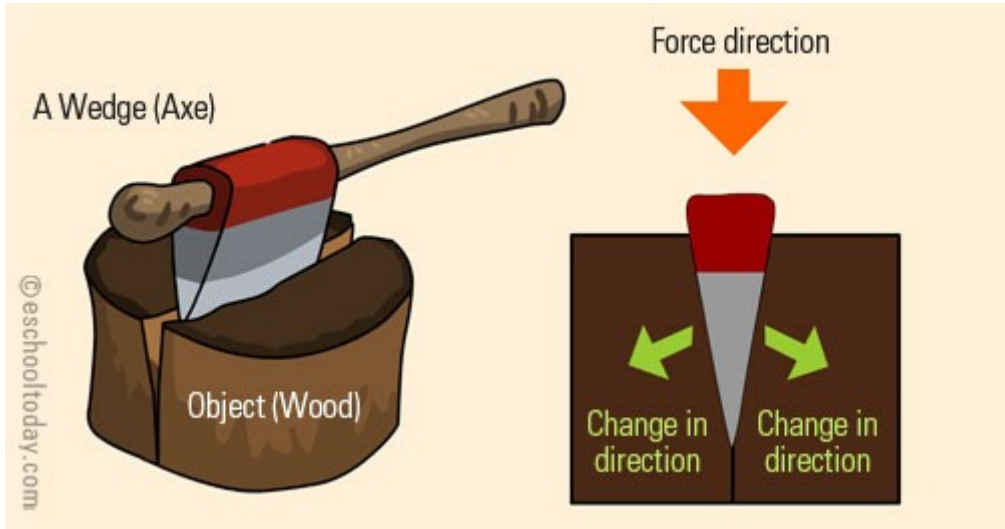
A wedge is a moving *inclined plane.*

(5) The Inclined Plane

Load

Force

N

f

$mg \sin\theta$

$mg \cos\theta$

mg

θ

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

Using an inclined plane requires less effort over a longer distance.

with inclined plane

effort needed = 10 kg

without inclined plane

effort needed = 25 kg

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SCREW
(simple machine)

(6) The Screw

Ridges
(narrow inclined plane wrapped around a cylinder)

Cylindrical shaft

F_L

R

D_E Distance moved by Effort

D_L

F_E

Screw jack
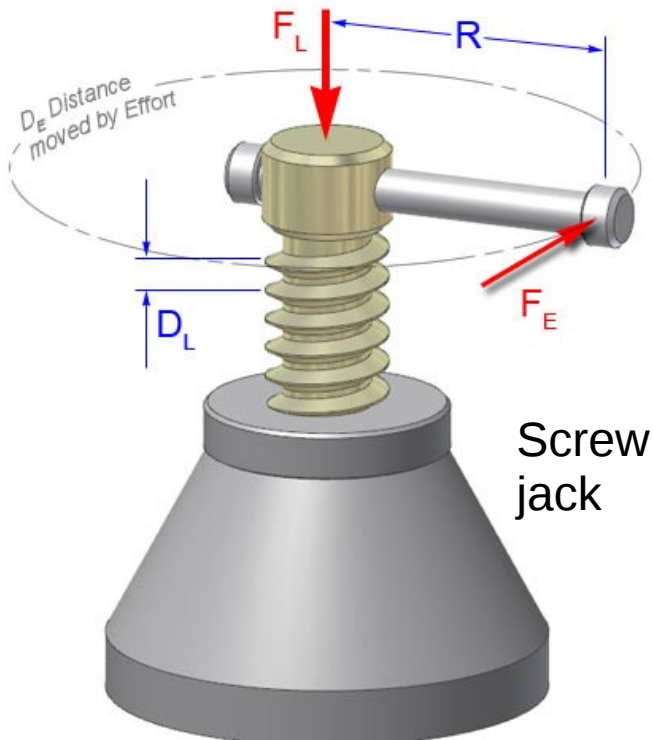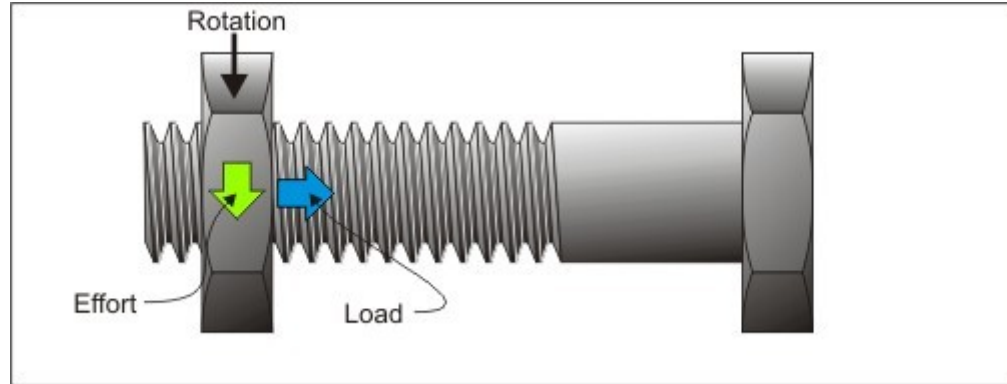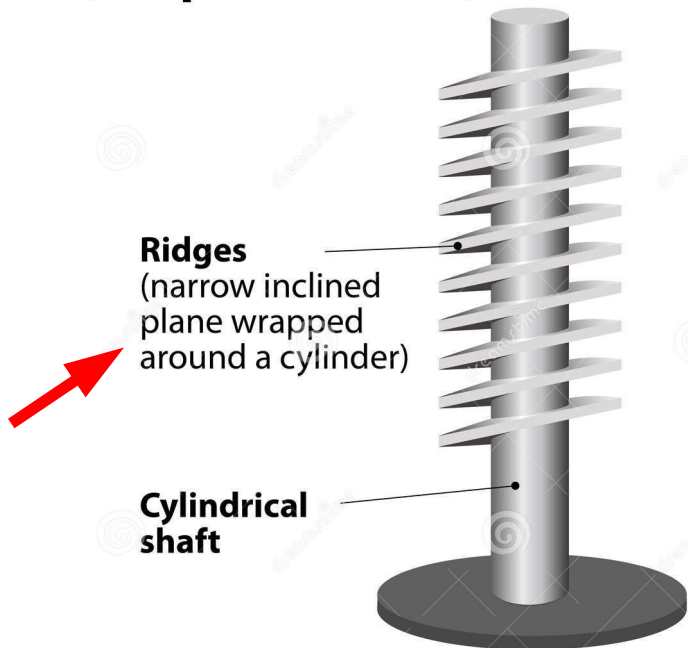
Archimedes screw pump
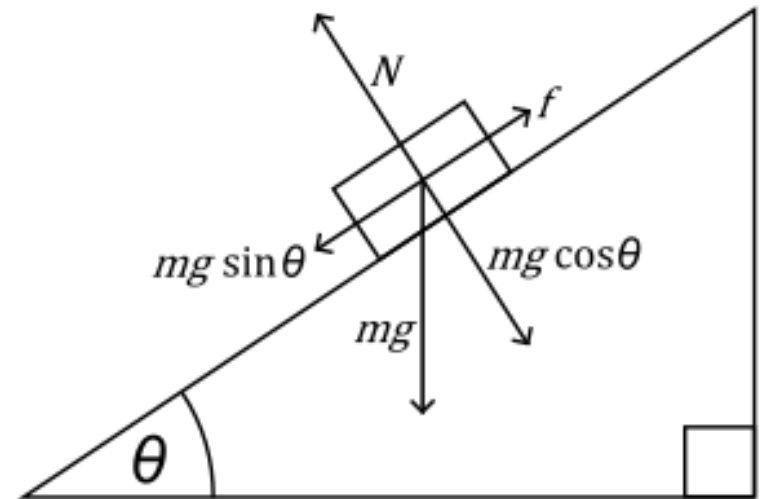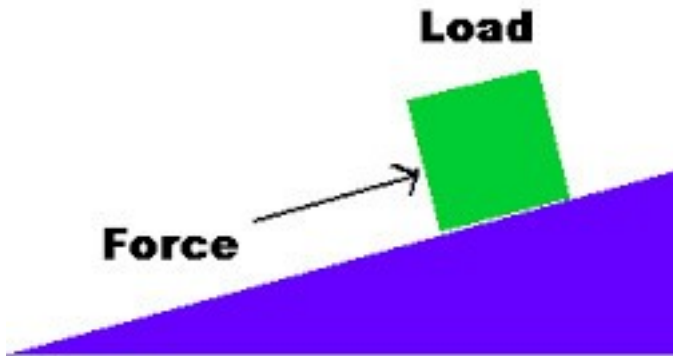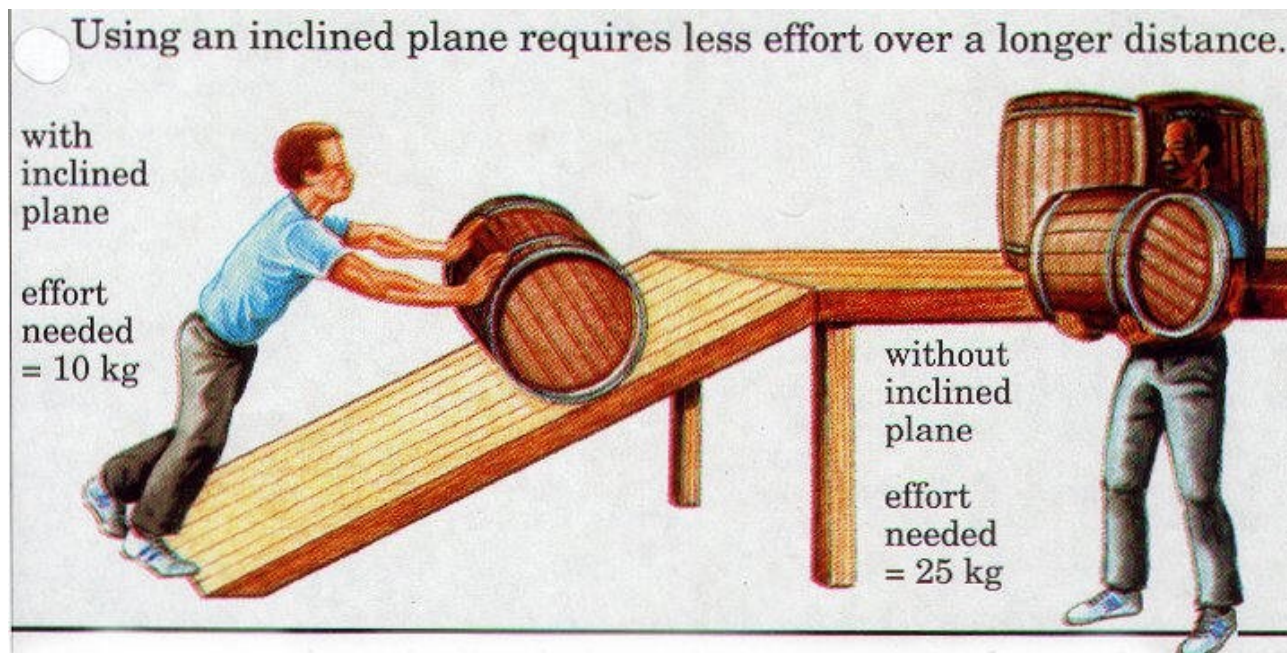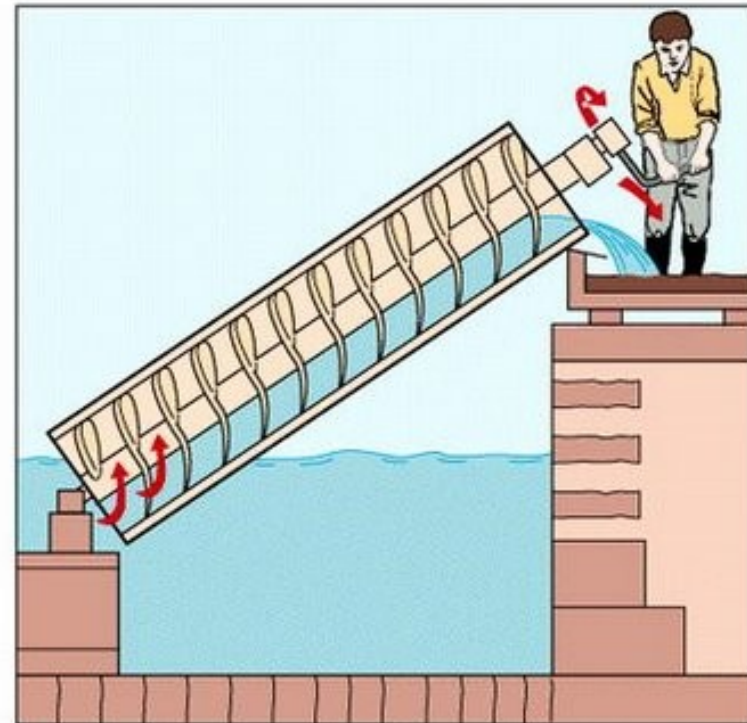
Equivalence of Simple Machines

- Reuleaux (19th century mechanical engineer):

    - A lever, pulley, and wheel and axle are the same device: a body rotating about a hinge.
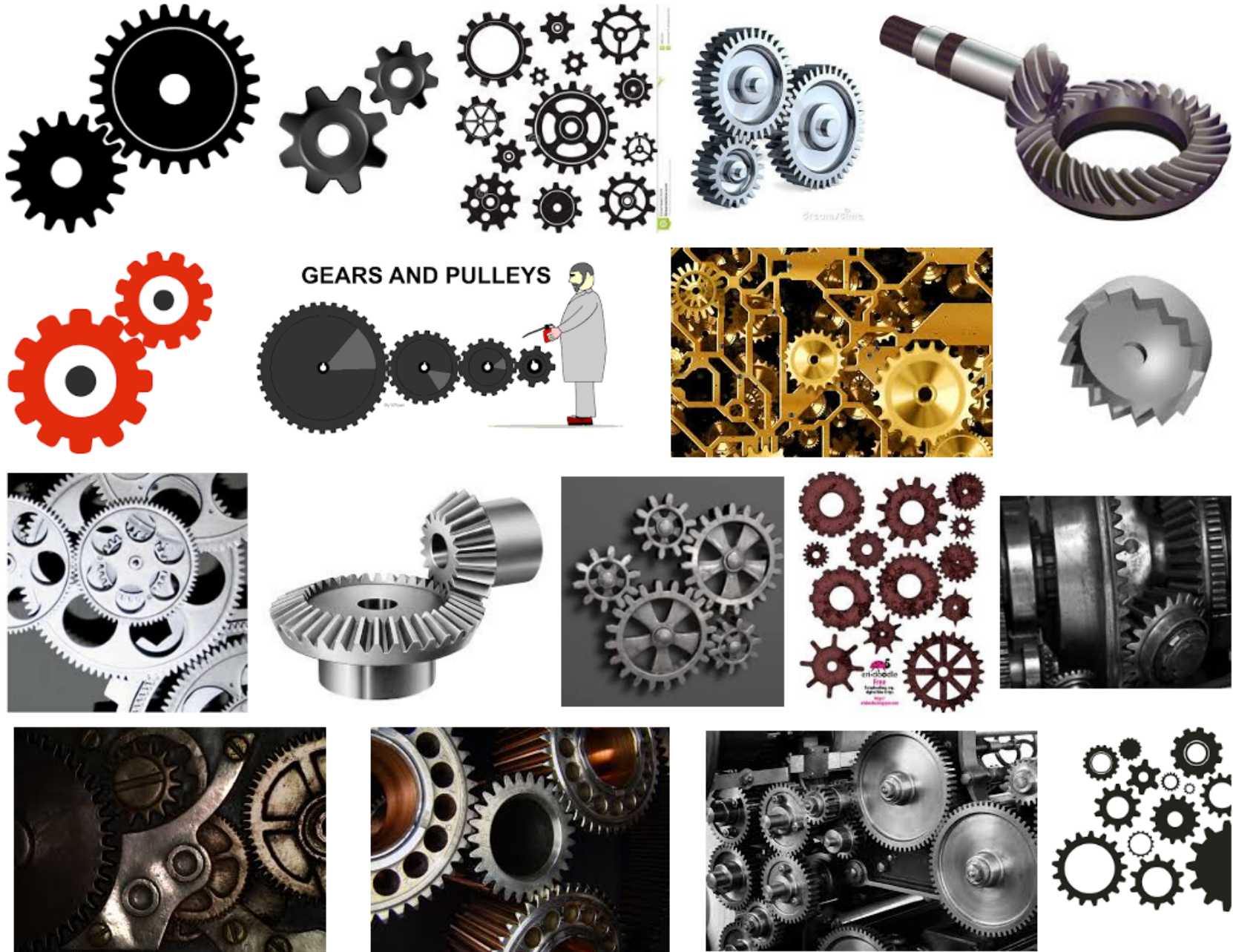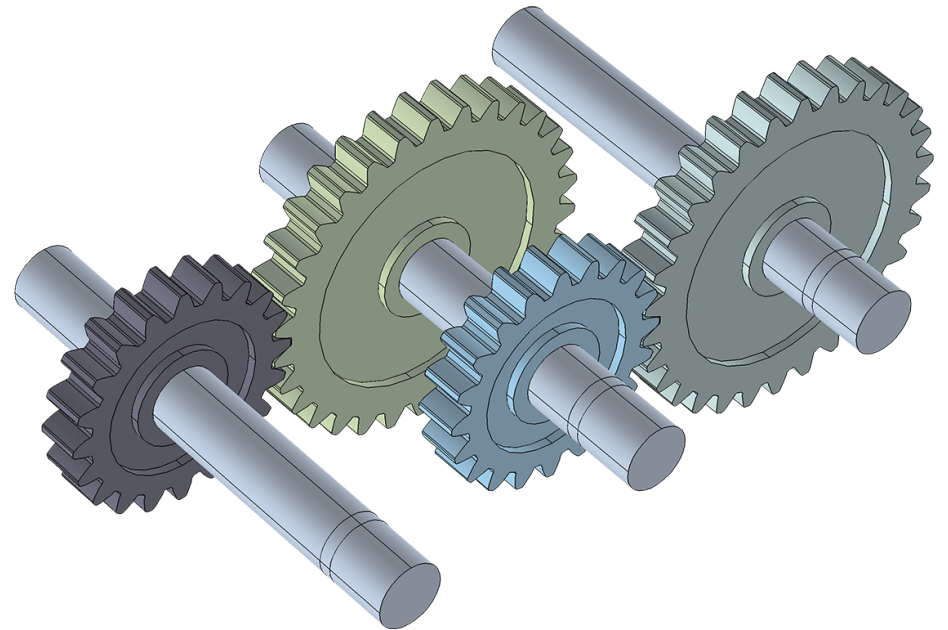
    - An inclined plane, wedge, and screw are the same device: a block sliding on a surface.

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

SUN
INFERIOR
SUPERIOR
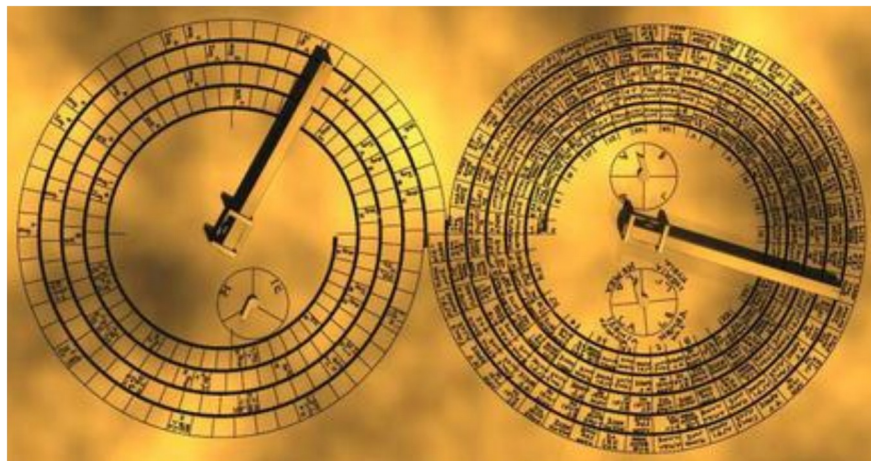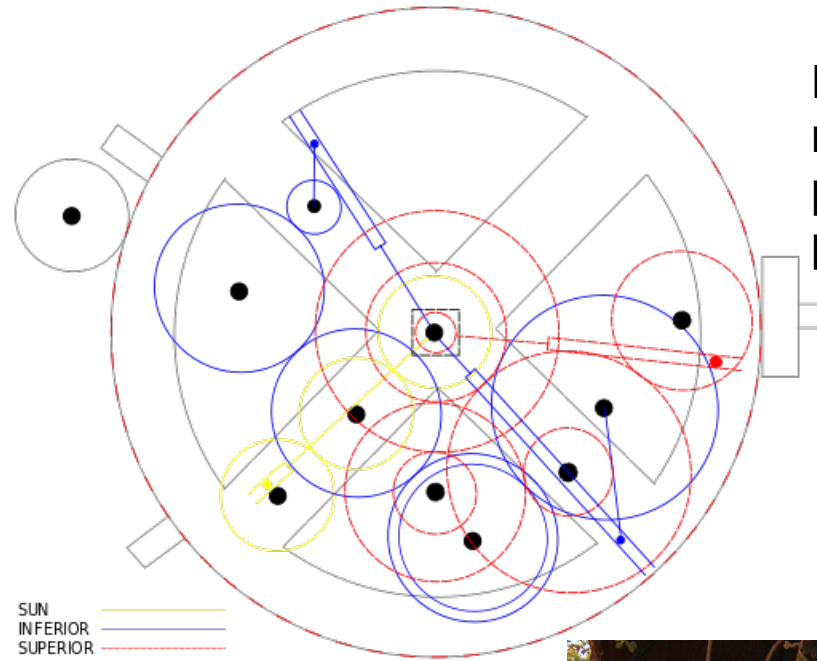
Back: 19 and 76 year cyclic calendars