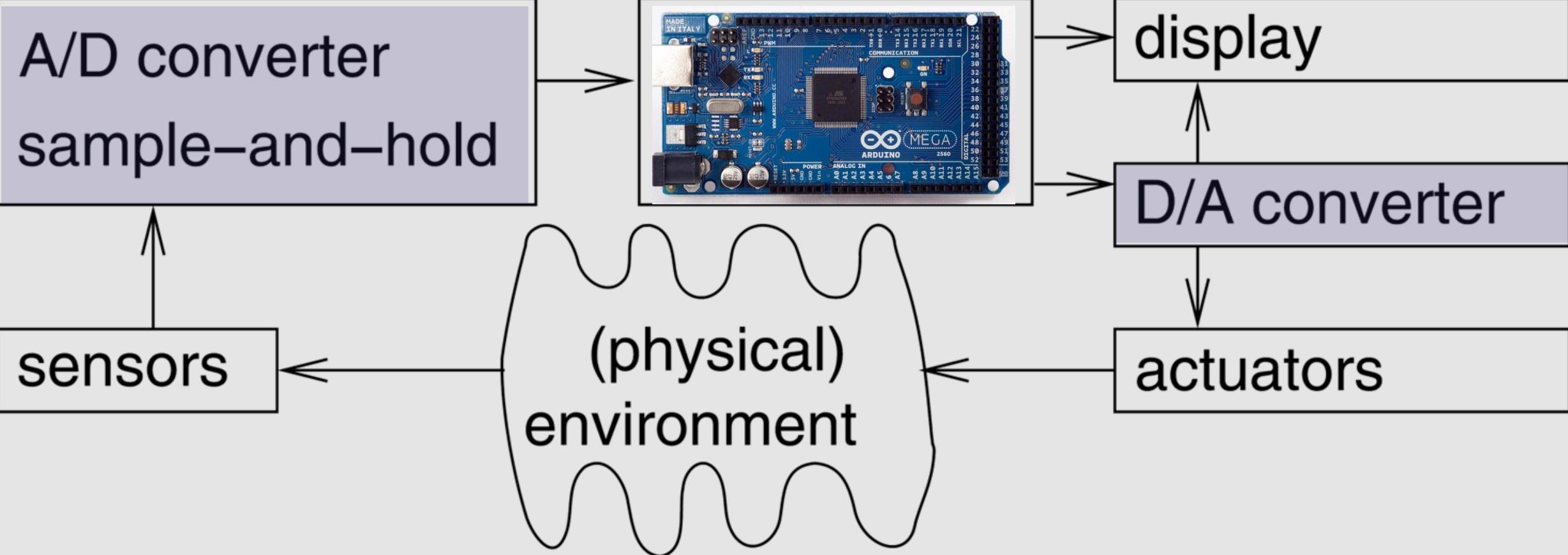


Machine elements and functions of products

GIZMO

2021 DE2-Gizmo (Physical Computing)
Lecture 2

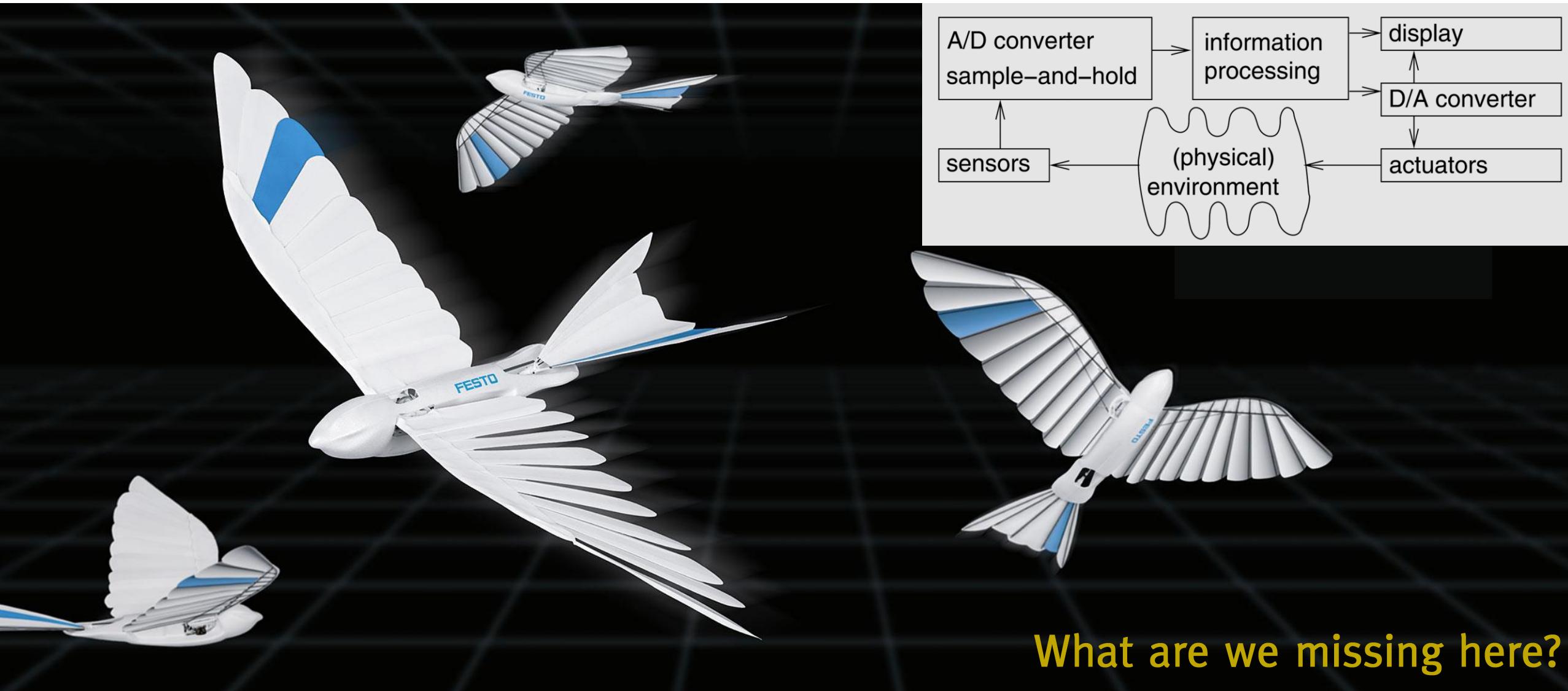
Dyson School of
Design Engineering



Hardware in the Loop (Cyber-Physical System)

FESTO

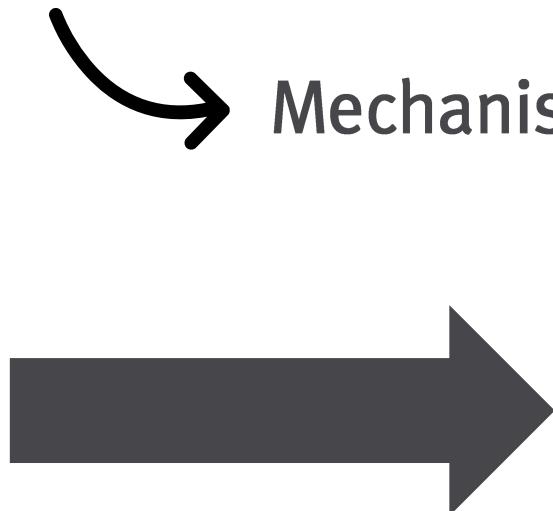
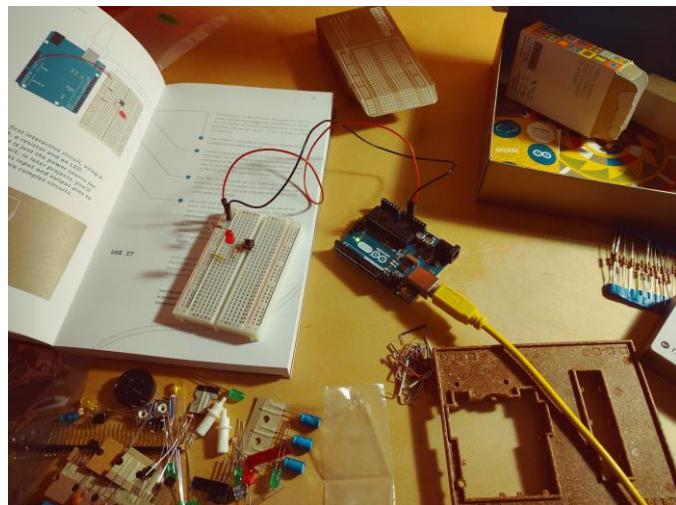
Festo BionicSwift (2020)



What are we missing here?

Physical Embodiment

- Forms and ensures functionality of the system
- Composed of *devices that modify force or motion* which consist of a number of *interrelated units*



Mechanisms and machine elements



A/D converter
sample-and-hold



display

sensors



(physical)
environment



D/A converter

actuators

Physical
embodiment

(Extended) Hardware in the Loop

Types of Machine Elements

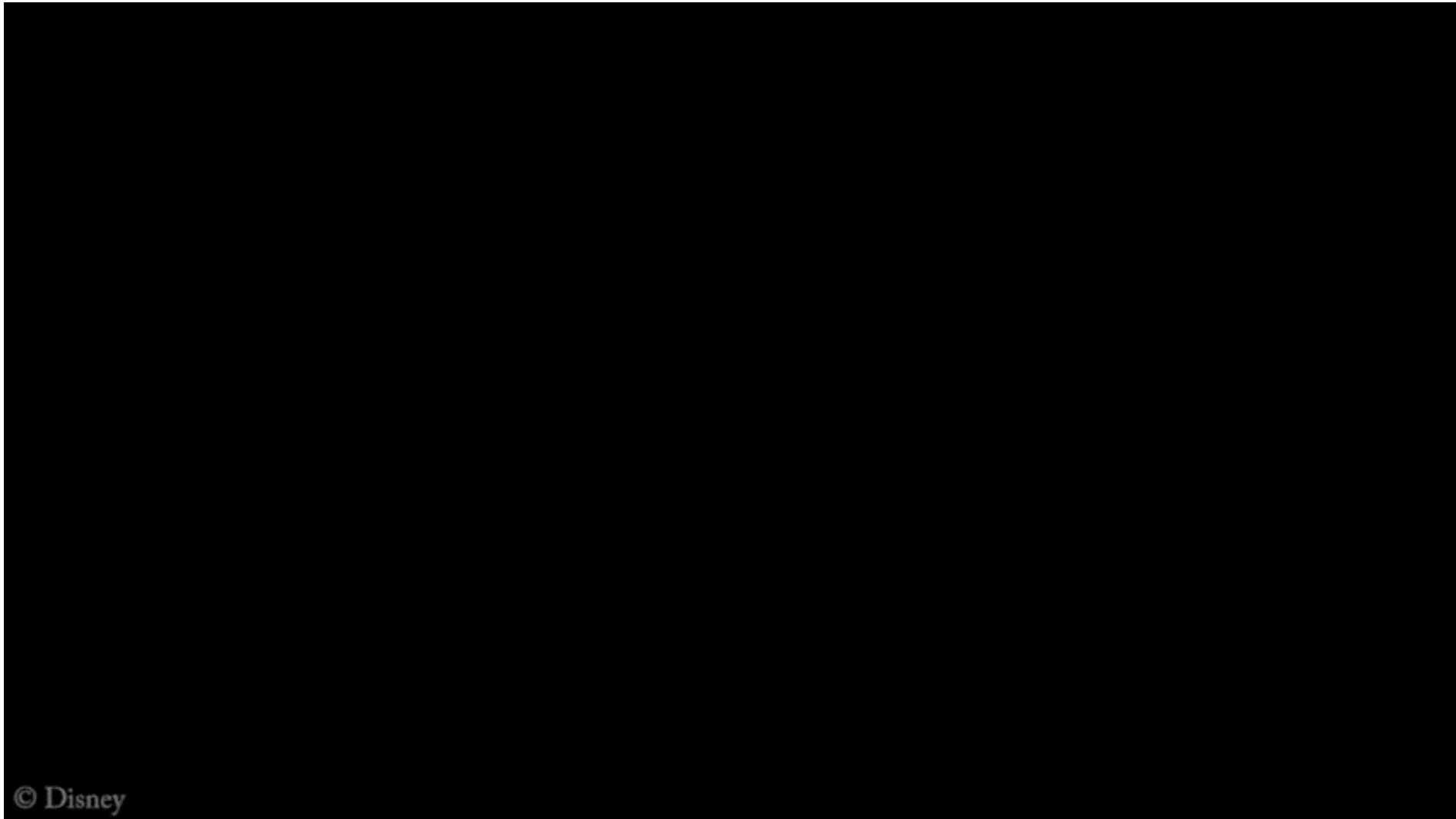
Lecture 4

- *Energy conversion*
- Energy transmission
- Energy storage/absorption
- Locating
- Friction reduction
- Switching
- Sealing
- *Sensors*

Lecture 6



Machine Elements for Energy Transmission



Design of
mechanical
characters
(Disney, 2013)

© Disney

Machine Elements for Energy Transmission Functions

1. Transmit power from point A to point B
2. Match torque and speed between source and load
3. Change direction of shaft rotation
4. Synchronize motion
5. Generate specific motion pattern



Machine Elements for Energy Transmission

Types

- Gears
- Belts and chains
- Cables and ropes
- Cams
- Levers
- Joints and linkages
- Shafts

Lecture 7



Worm Gear



Helical Gear



Double Helical Gear
(Herringbone Gear)



Straight Bevel Gear



Spiral Bevel Gear



Miter Gear



Internal Gear



Spur Gear



Rack and Pinion

Machine Elements for Energy Transmission



Transmitted power

$$P = T_i \omega_i = T_o \omega_o$$

Transmission ratio

$$i = T_i / T_o = \omega_o / \omega_i$$

Inverse relationship

$T \uparrow$ as $\omega \downarrow$

Transmission efficiency

$$\eta = (T_o \omega_o) / (T_i \omega_i)$$

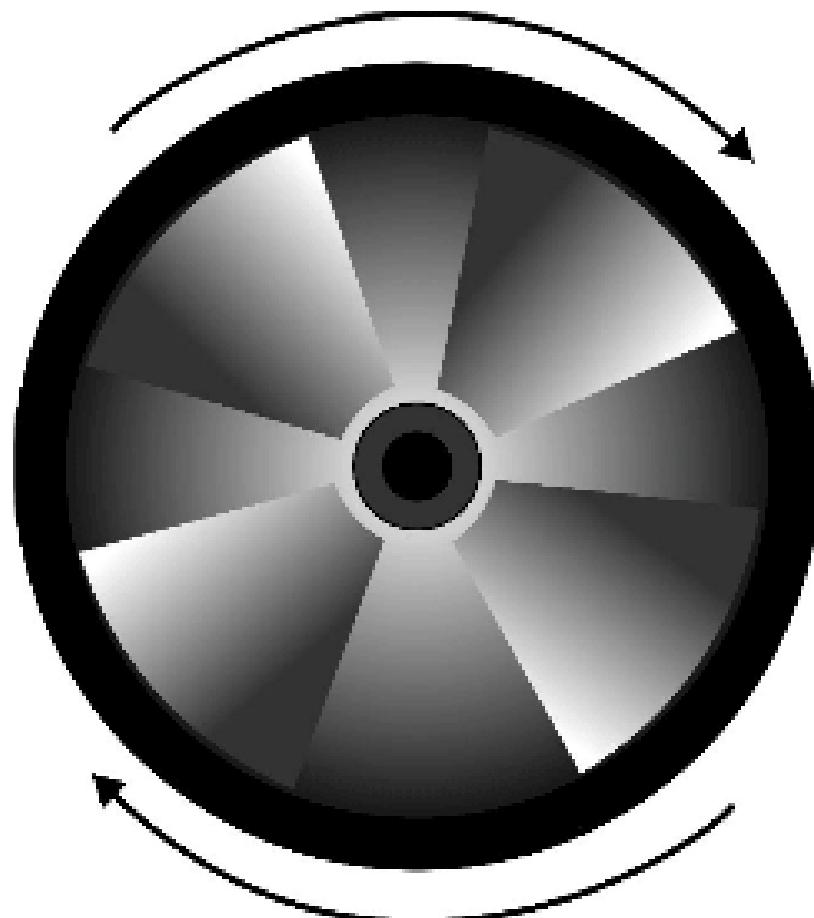
Machine Elements for Energy Storage/Absorption

$$E = U + K$$

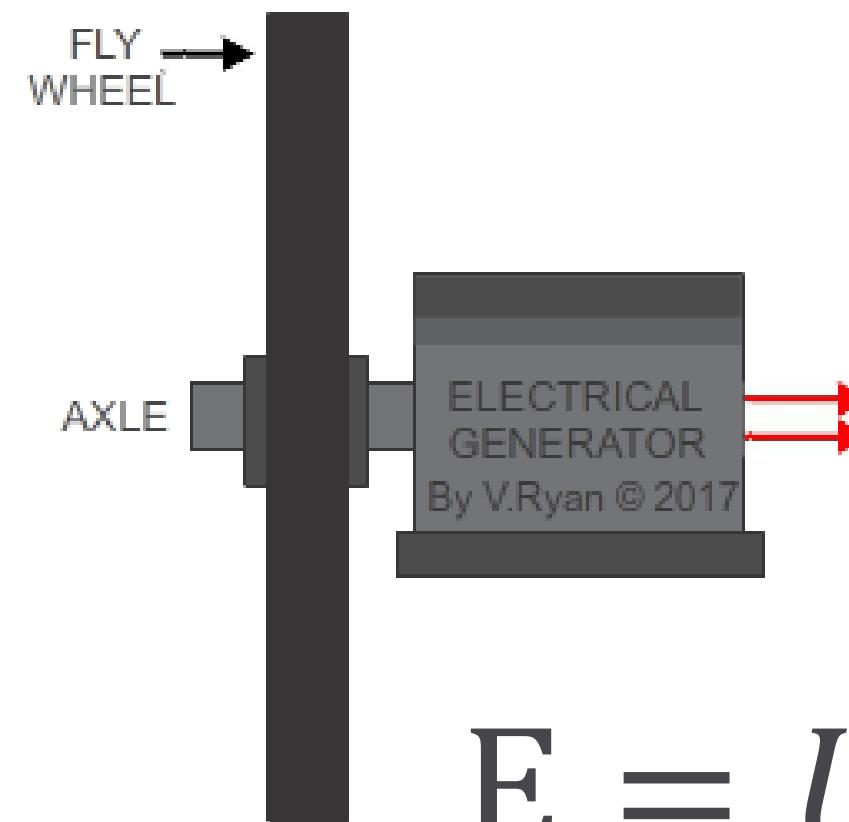
Mechanical energy

Machine Elements for Energy Storage/Absorption

FRONT VIEW



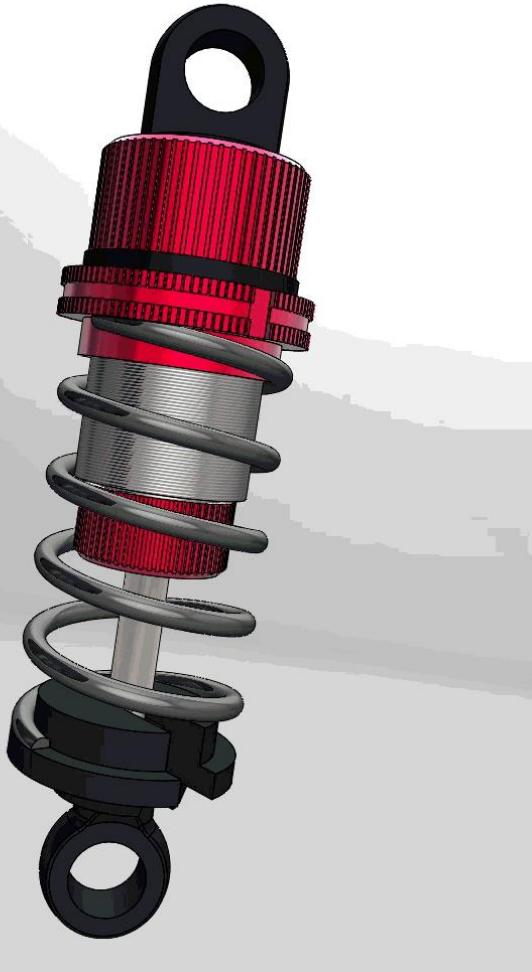
SIDE VIEW



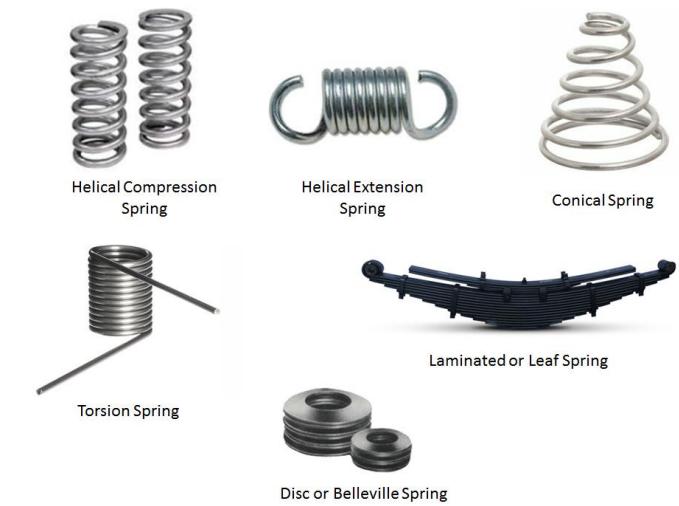
Flywheels

$$E = U + K$$

Machine Elements for Energy Storage/Absorption

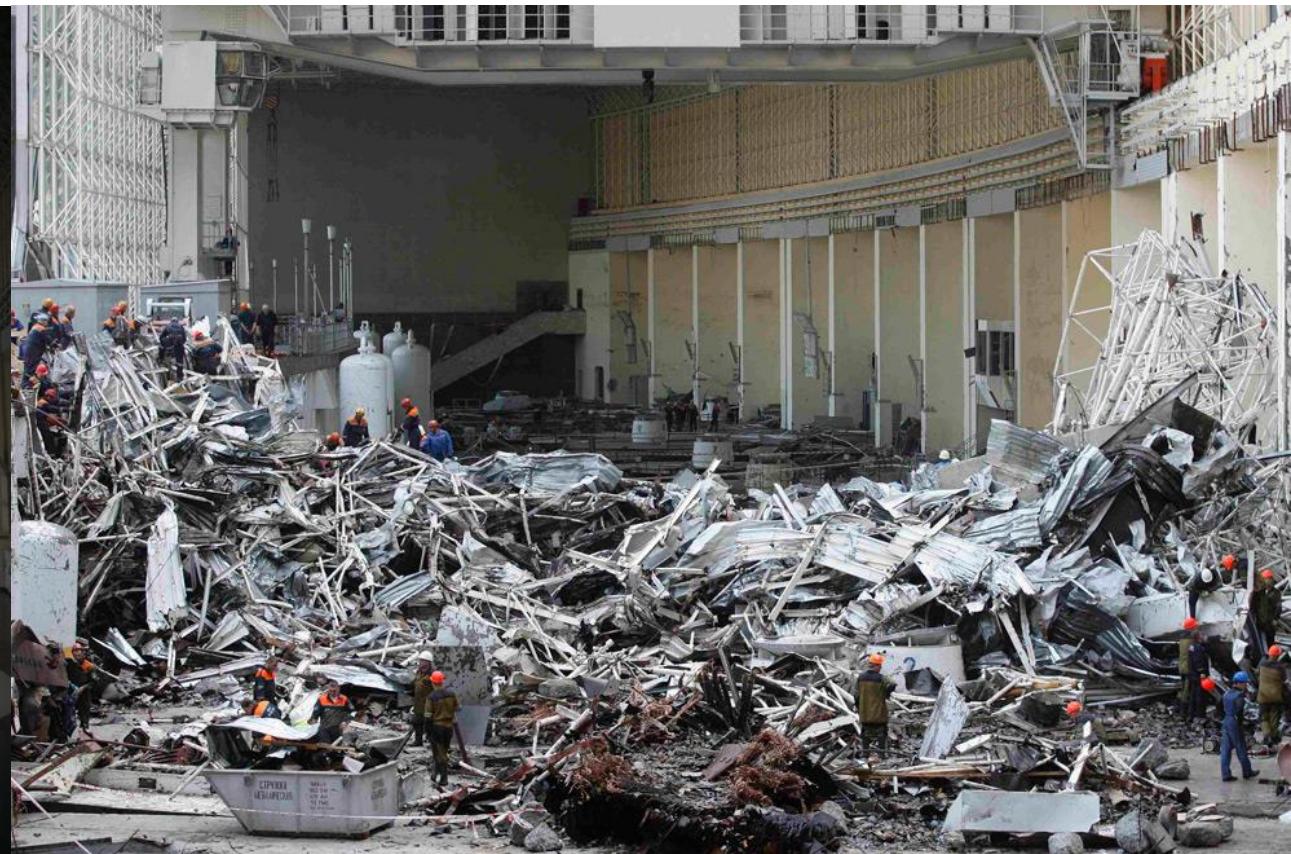


Springs



$$E = U + K$$

Machine Elements for Locating



The Sayano-Shushenskaya dam accident (2009)

Machine Elements for Locating

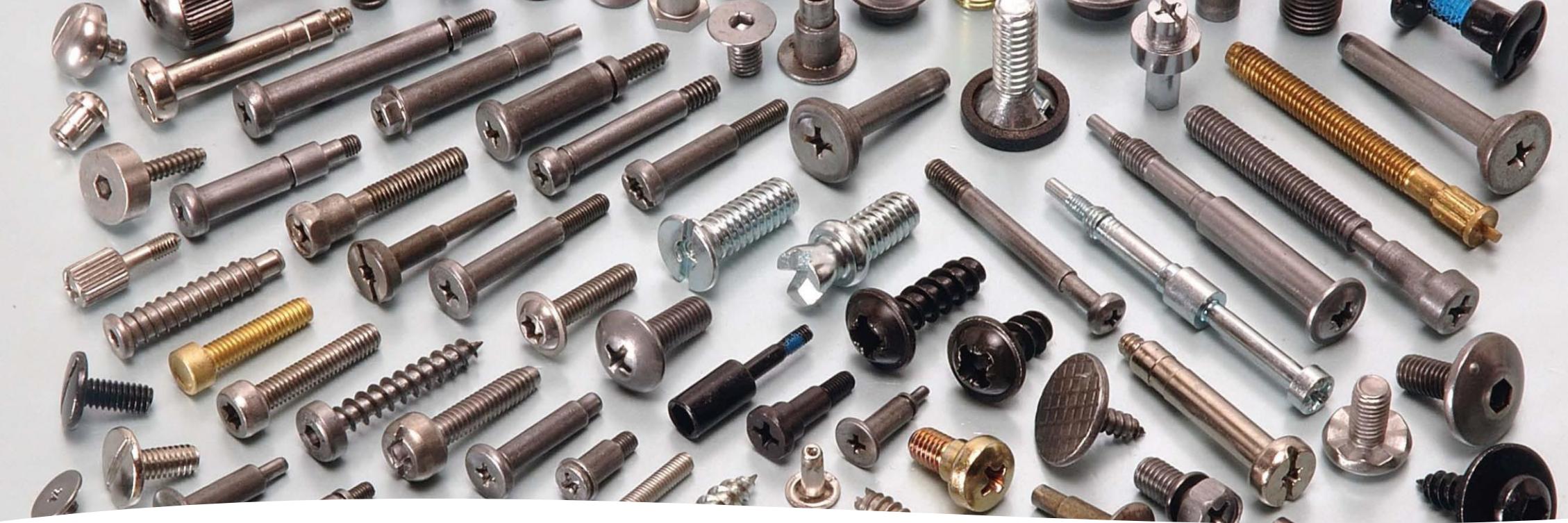


[Video 1](#)

The Sayano-Shushenskaya dam accident (2009)



[Video 2](#)



Machine Elements for Locating

- Bolts
- Nuts and lock nuts
- Screws
- Washers
- Nails
- Pins
- Rivets
- Fits
- Adhesives
- Welds

Machine Elements for Friction Reduction

Six possible options of surface contact between two bodies



Revolution



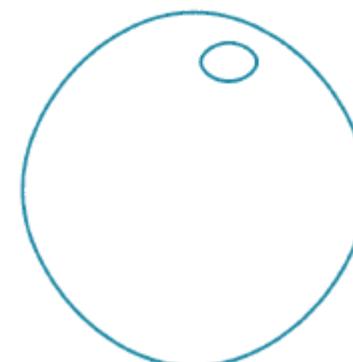
Translation



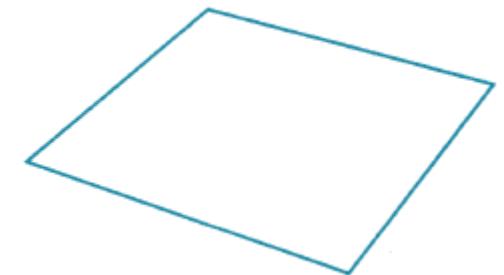
Helicoidal



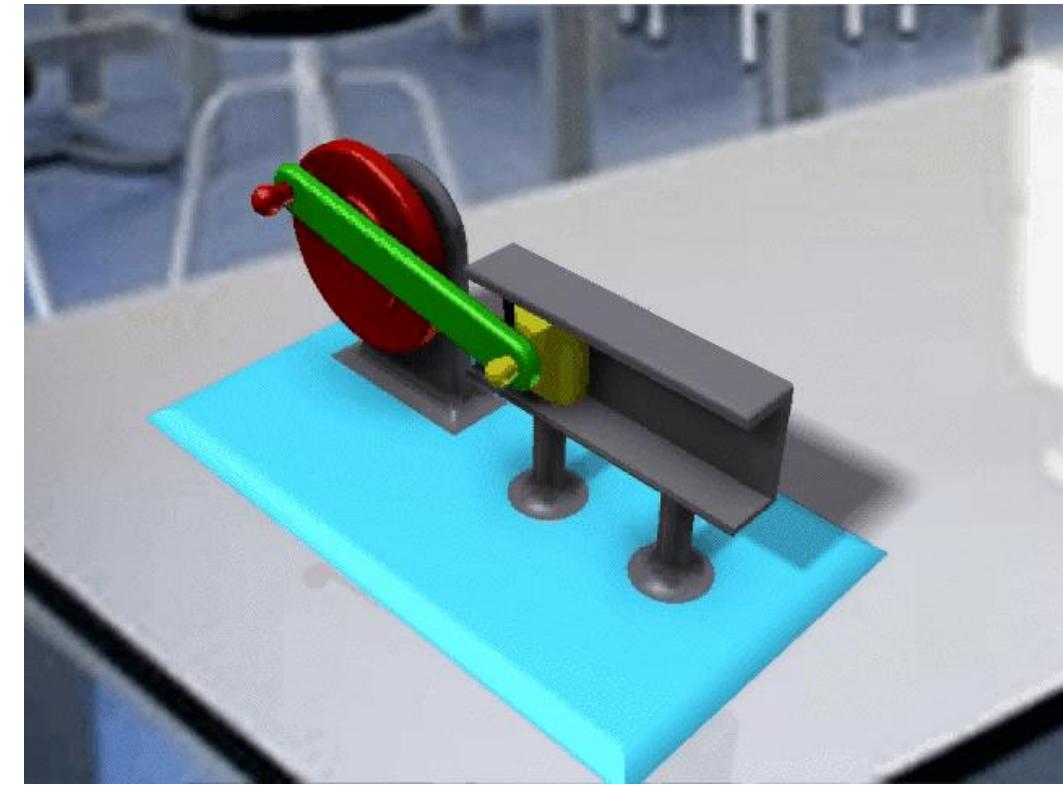
Cylinder



Sphere

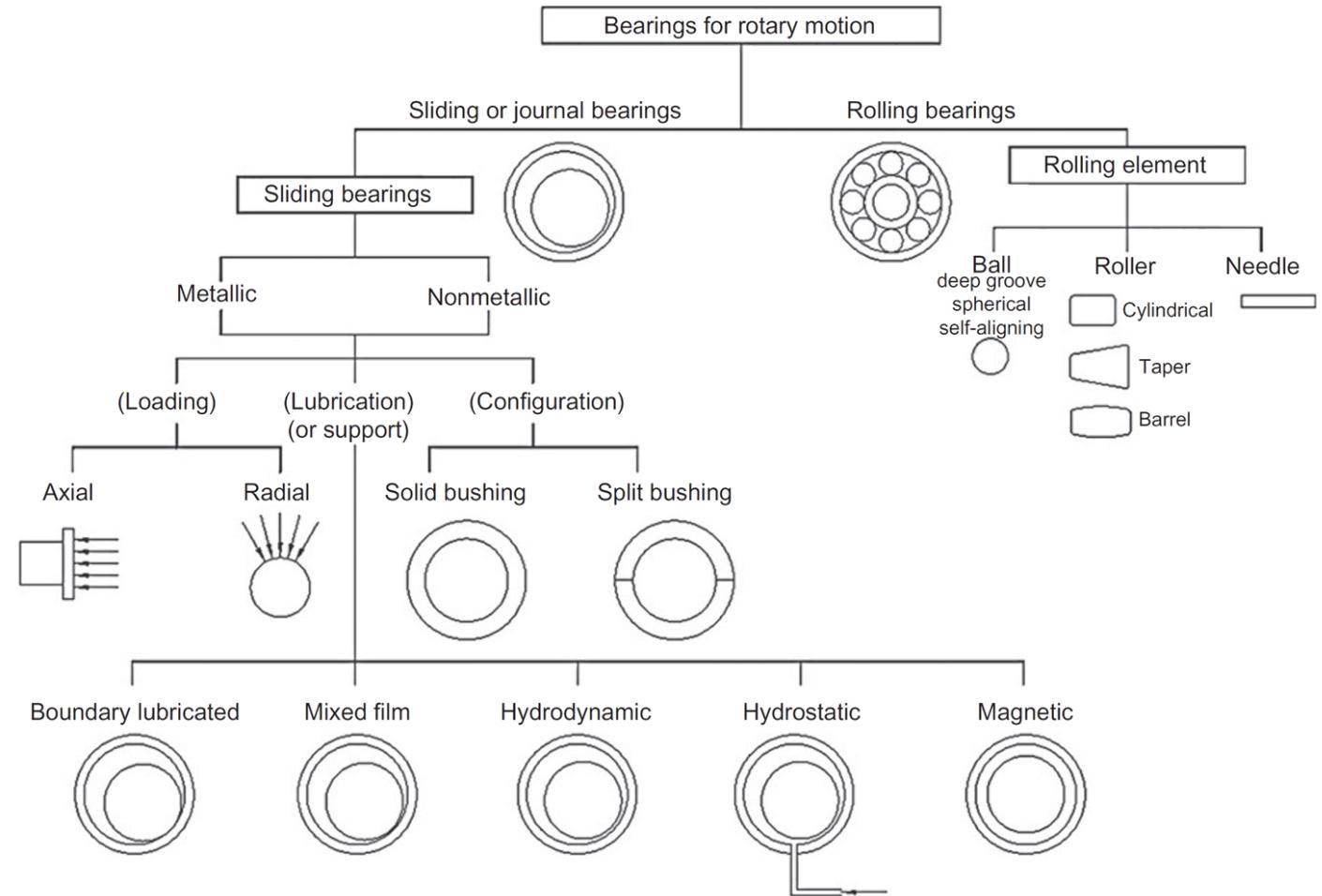


Plane



Machine Elements for Friction Reduction

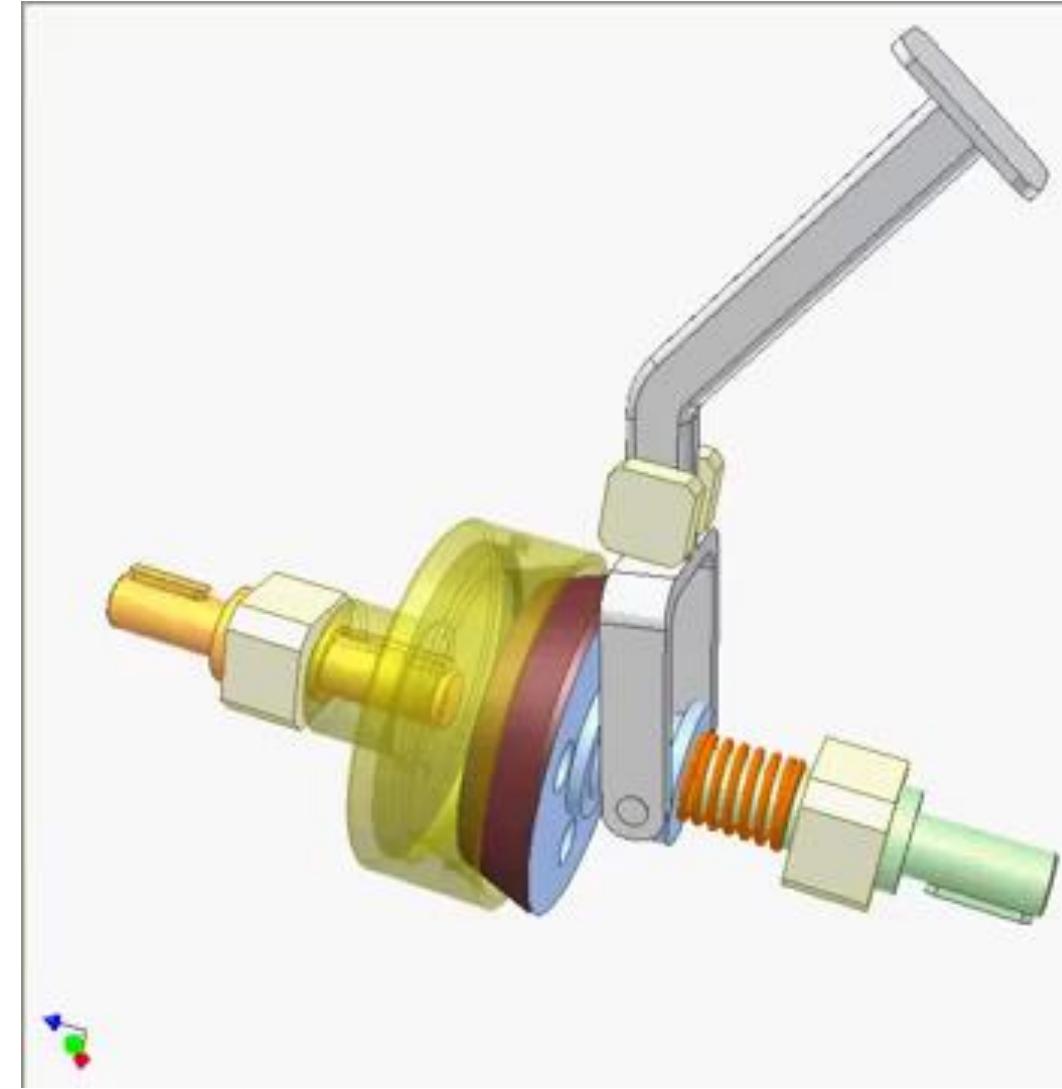
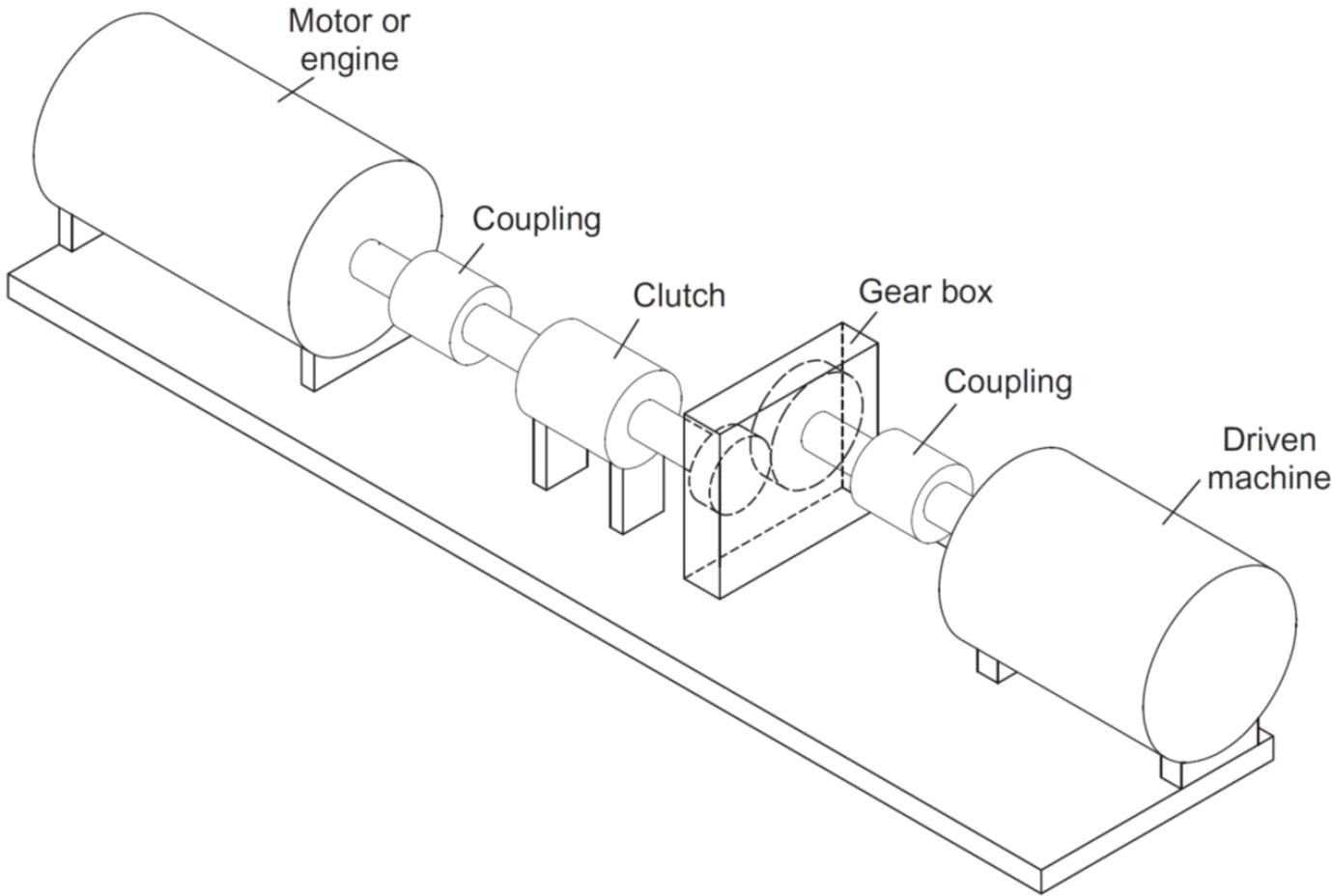
Revolution and translation contacts are facilitated by rotary and linear bearings, respectively



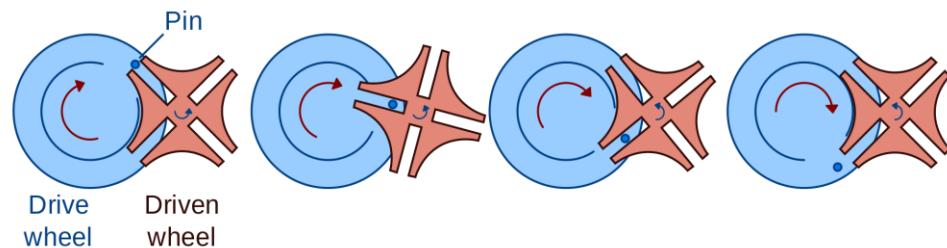
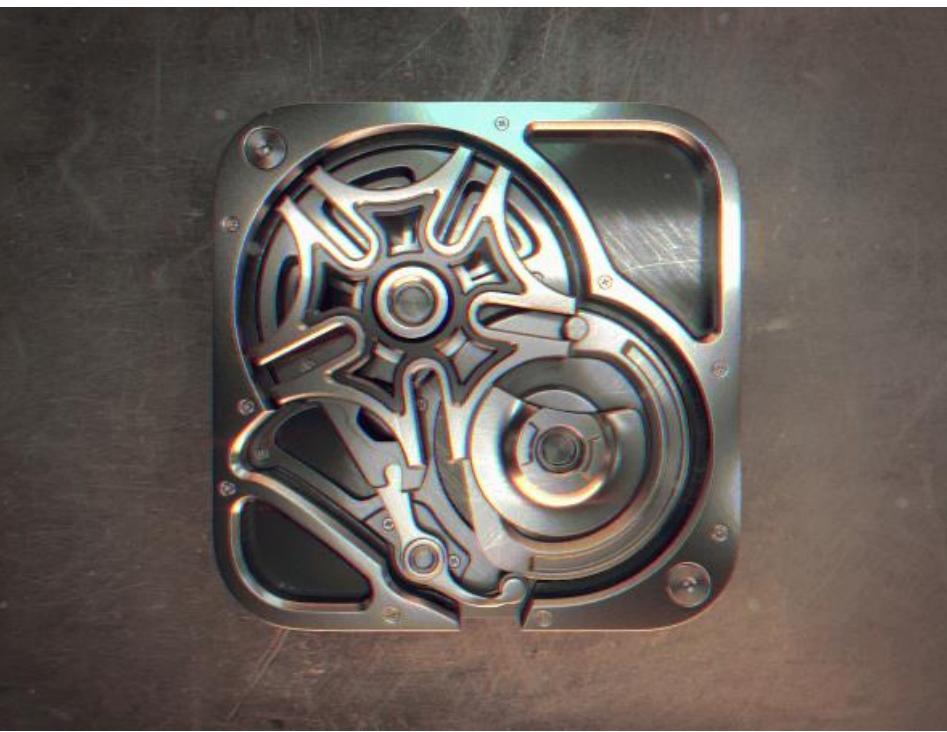
Machine Elements for Switching

[Video](#)

Clutches



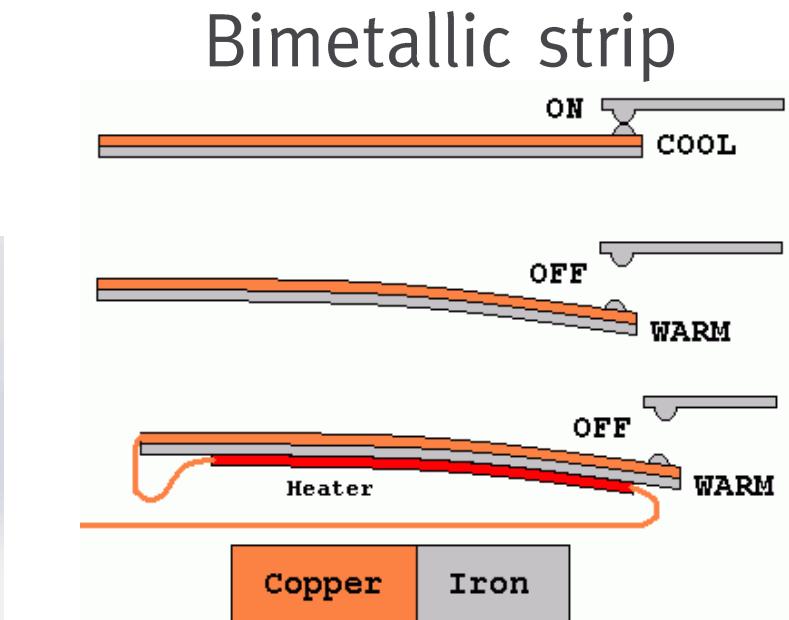
Machine Elements for Switching



Geneva mechanism



Ratchet and pawl



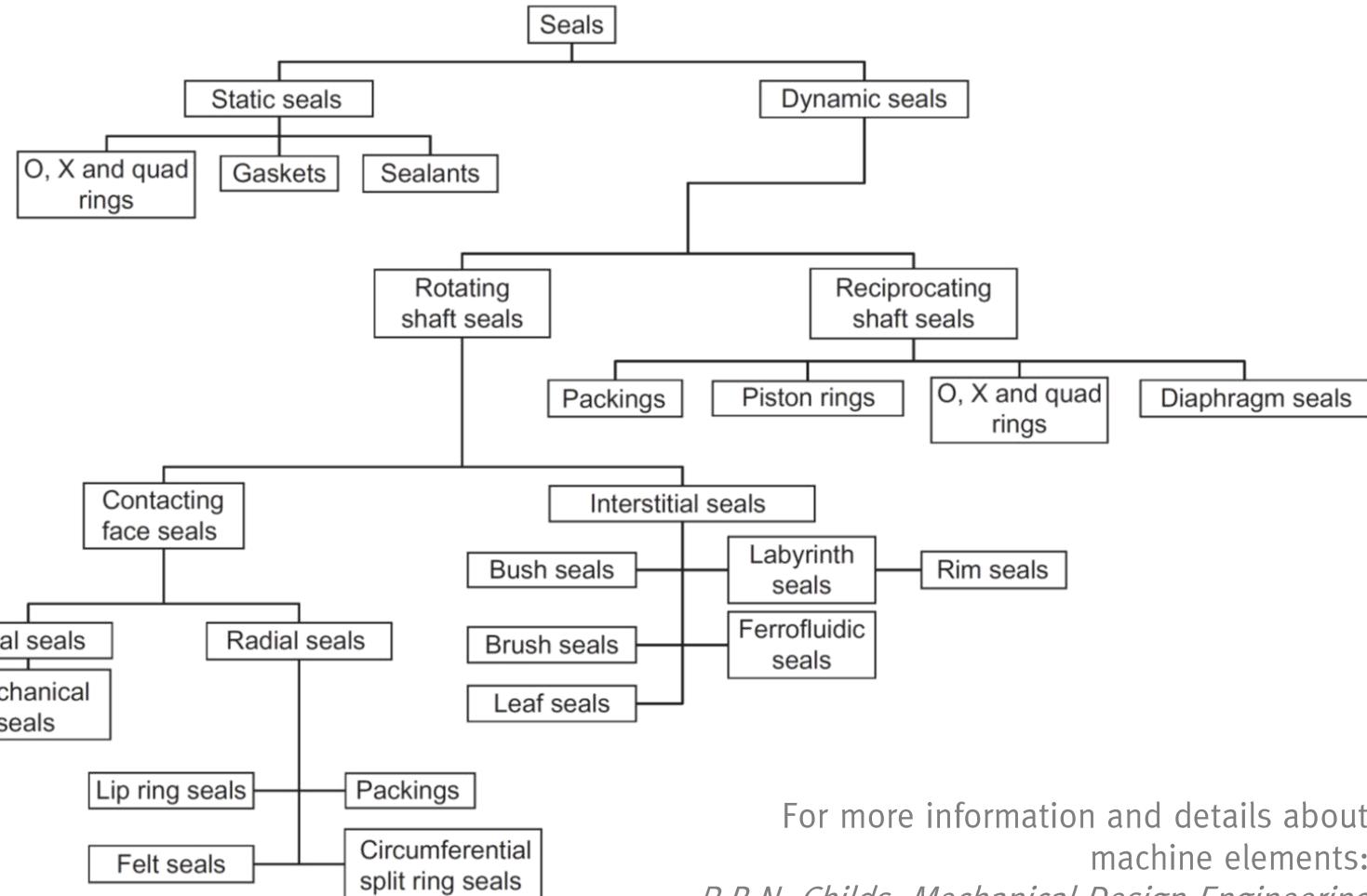
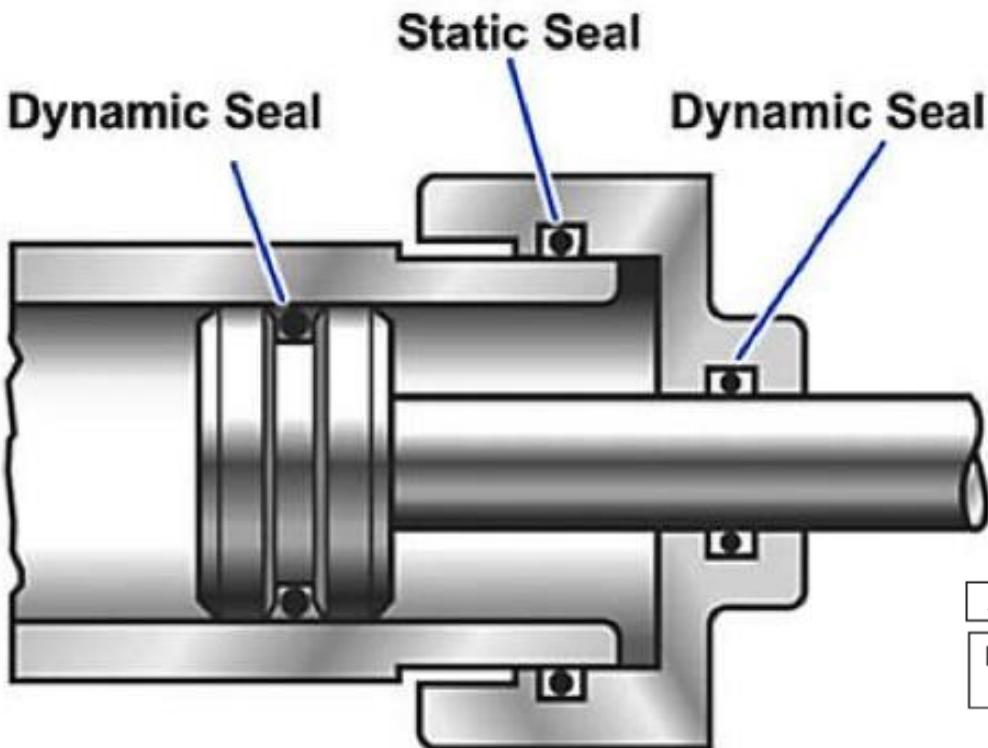
Valves

Machine Elements for Sealing

Seals prevent or limit leakage of fluids or particulates



Machine Elements for Sealing



For more information and details about
machine elements:

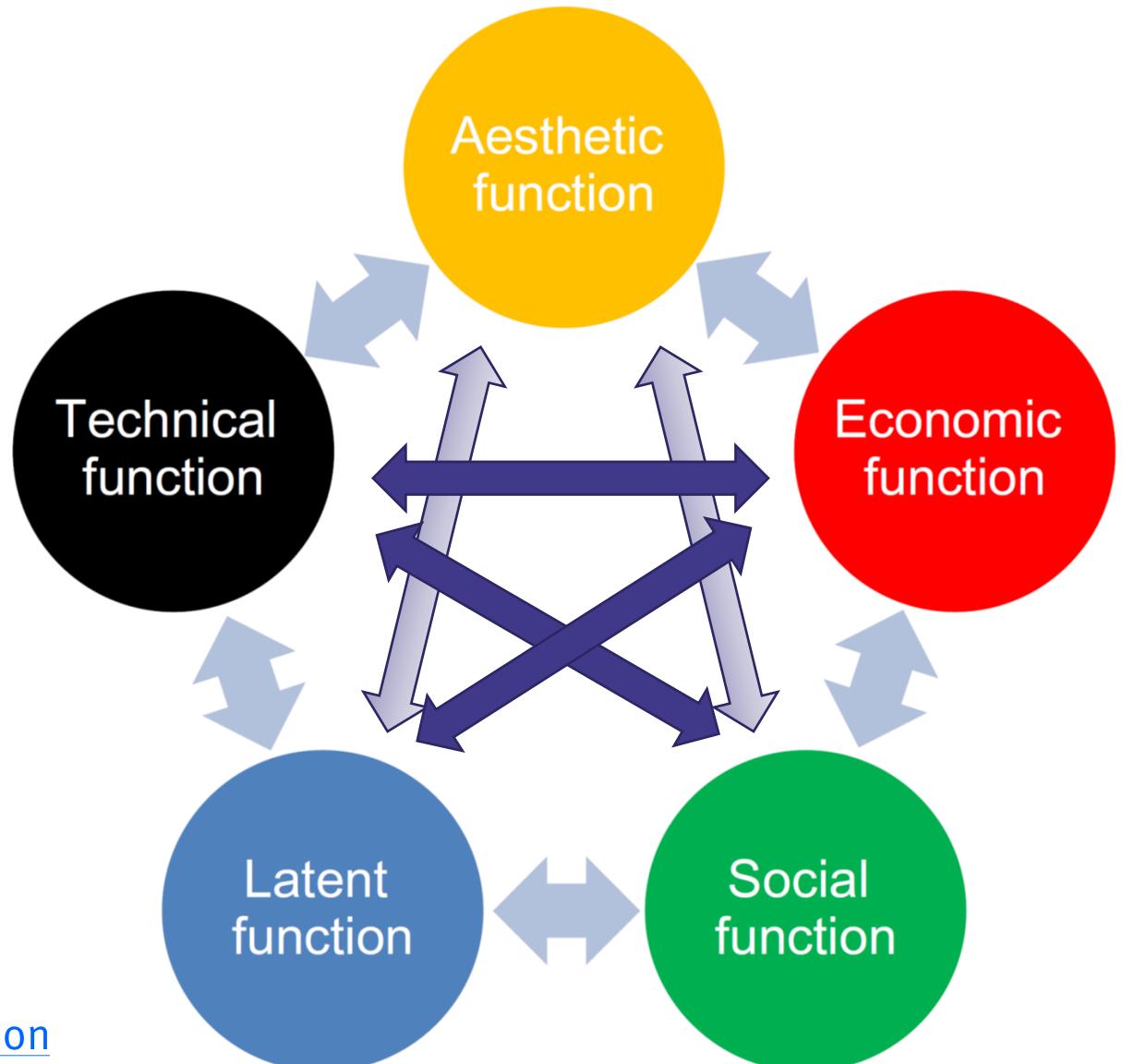
*P.R.N. Childs, Mechanical Design Engineering
Handbook, Butterworth-Heinemann, 2019*

Functions of Products

Establishing the function required or analysing what the features of a design actually perform can be a key step in machine design



[The Alessi 'Juicy Salif' Lemon Squeezer \(1990\)](#)



<https://doi.org/10.7227%2F1JME.41.4.4>

<https://www.designsociety.org/download-publication/30775/ON+THE+FUNCTIONS+OF+PRODUCTS>

internal component

sub-component

[annotation]

external component

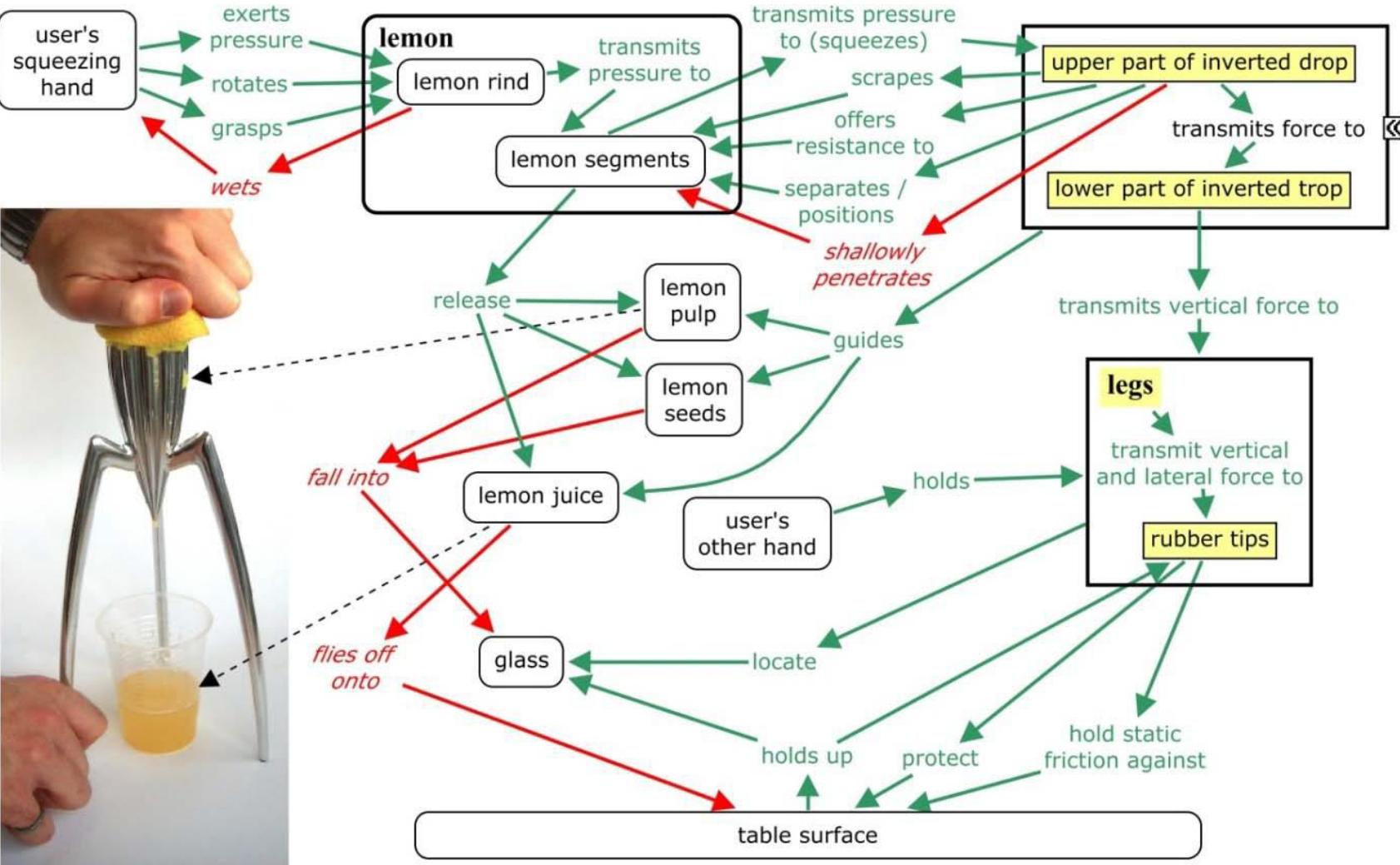
beneficial
interaction

harmful
interaction

Functions of Products

Technical function (or use function)

- *Basic*
 - *Secondary*
- Means to perform the basic function



internal component

sub-component

annotation

external component

beneficial
interactionharmful
interaction

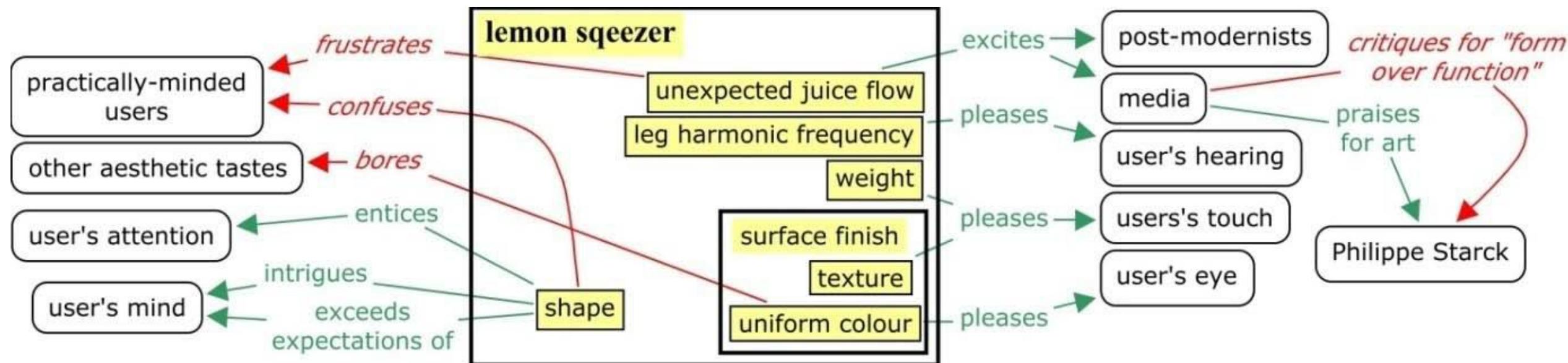
Functions of Products

Aesthetic function

Response or reaction manifested through the senses



- Pleasing, displeasing, and indifferent*



internal component

sub-component

annotation

external component

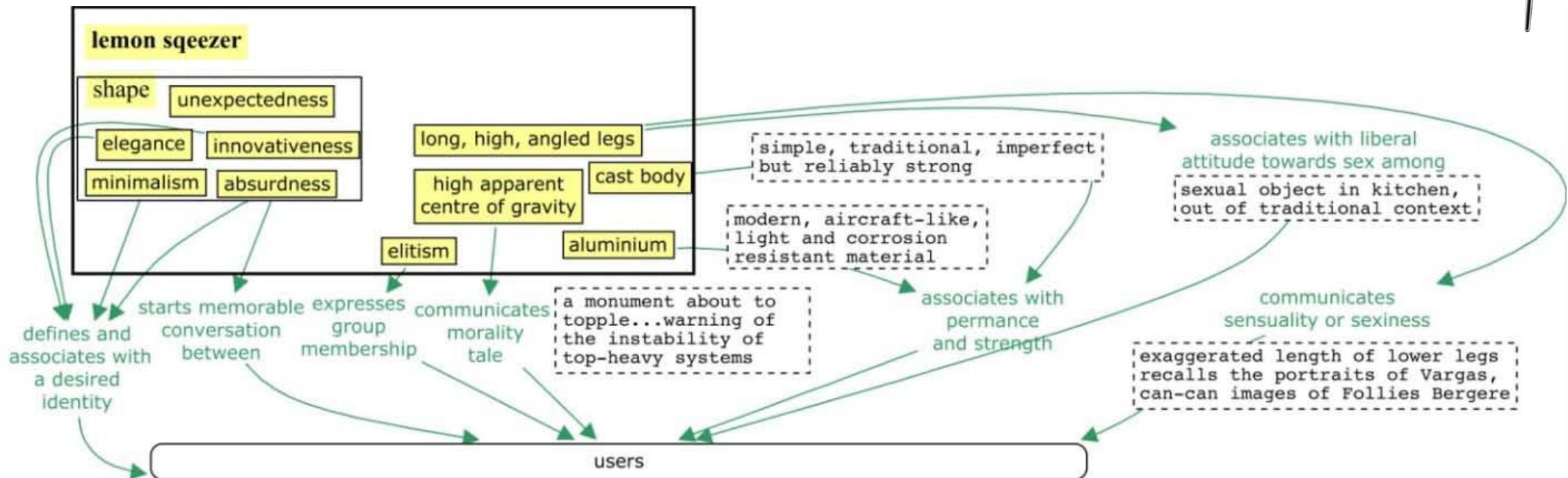
beneficial
interaction

harmful
interaction

Functions of Products

Social function

Related to people's manner of thinking of and talking about artefacts: *association, communication and identification, and memento*





annotation

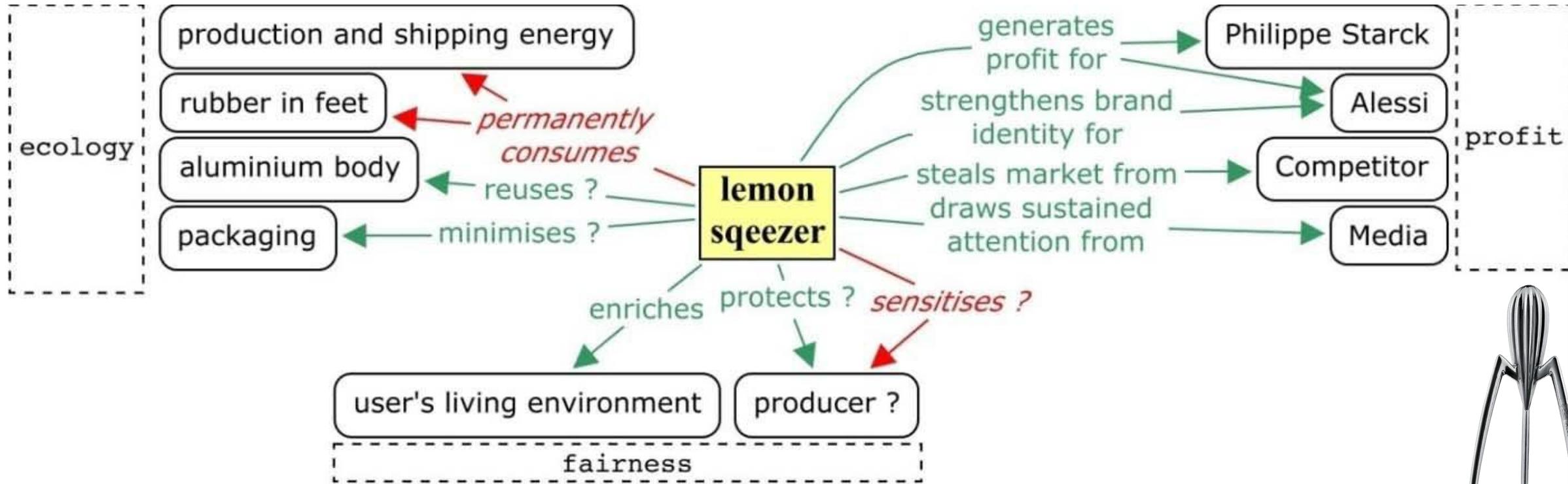
external component

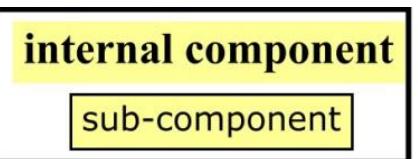
beneficial
interactionharmful
interaction

Functions of Products

Economic function

Profit, ecology, and fairness





[annotation]

external component

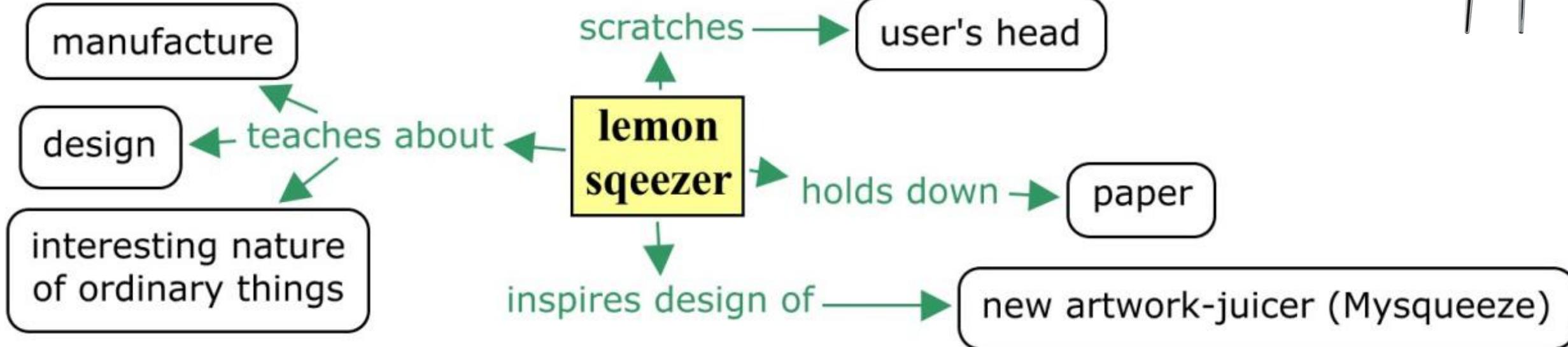
beneficial interaction

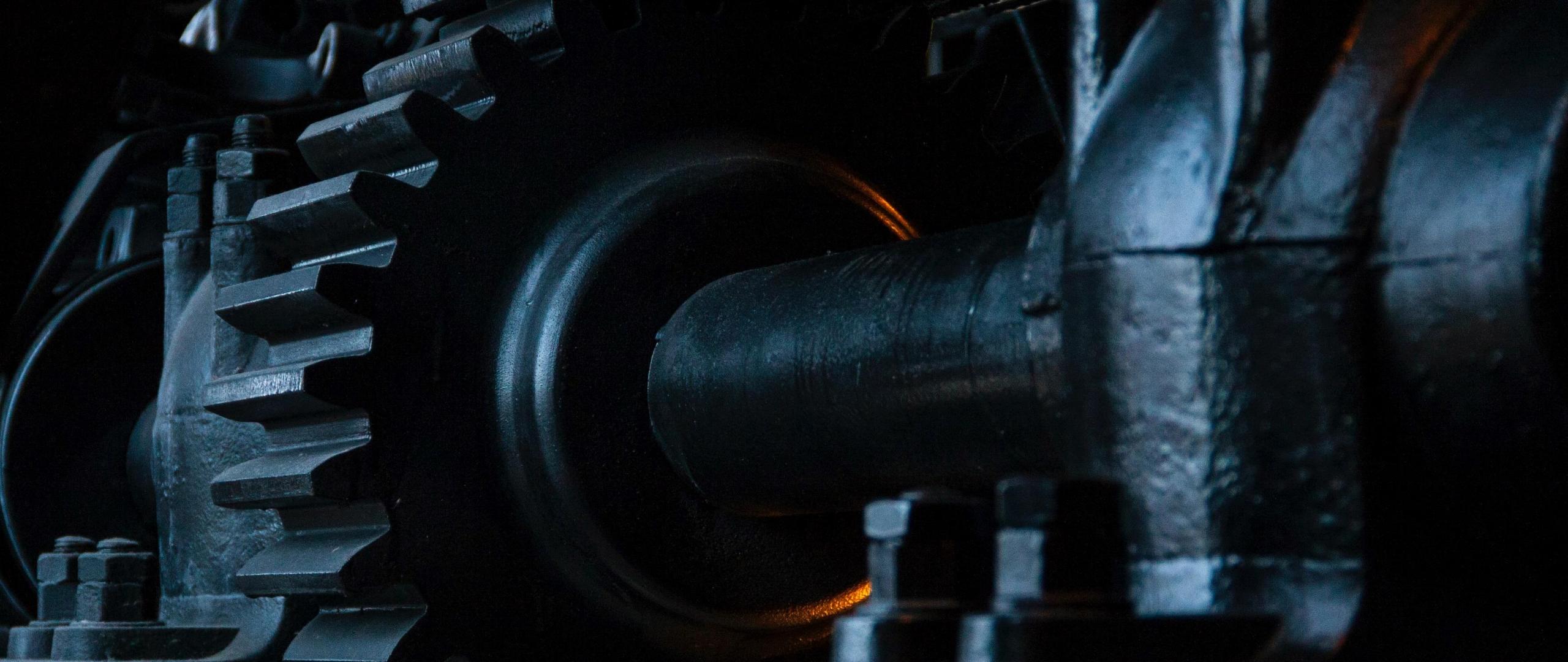
harmful interaction

Functions of Products

Latent function

Unexpected functions. Understanding them provides benefits to inform future design work





Machine elements and functions of products

GIZMO

2021 DE2-Gizmo (Physical Computing)
Lecture 2



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