MAGIC MOTION: A STUDY IN ENERGY

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Q: What is a Perpetual Motion Machine (PMM)?

A: PMMs are a class of mechanisms which are **powered directly by the energy they create**. With zero energy losses, a PMM will perform work infinitely and... **perpetually** remain in motion!

BACKGROUND

HISTORY: THE DREAM OF INFINITE ENERGY

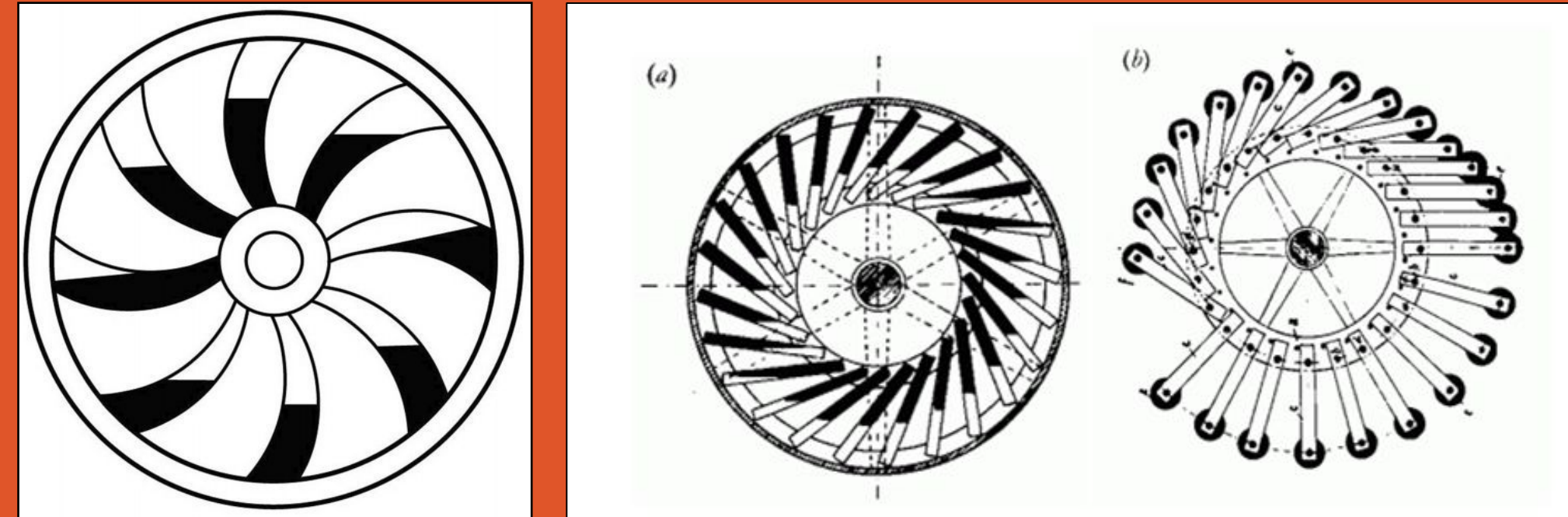- Bhāskara II's Wheel (circa 1150 CE [1])

Figure 1: Diagram Depiction of Bhāskara II's Wheel   Figure 2: Diagrams of Changing Centers of Mass PMMs

- Mariano di Jacopo, a.k.a. "Taccola" (circa 1400 [2])

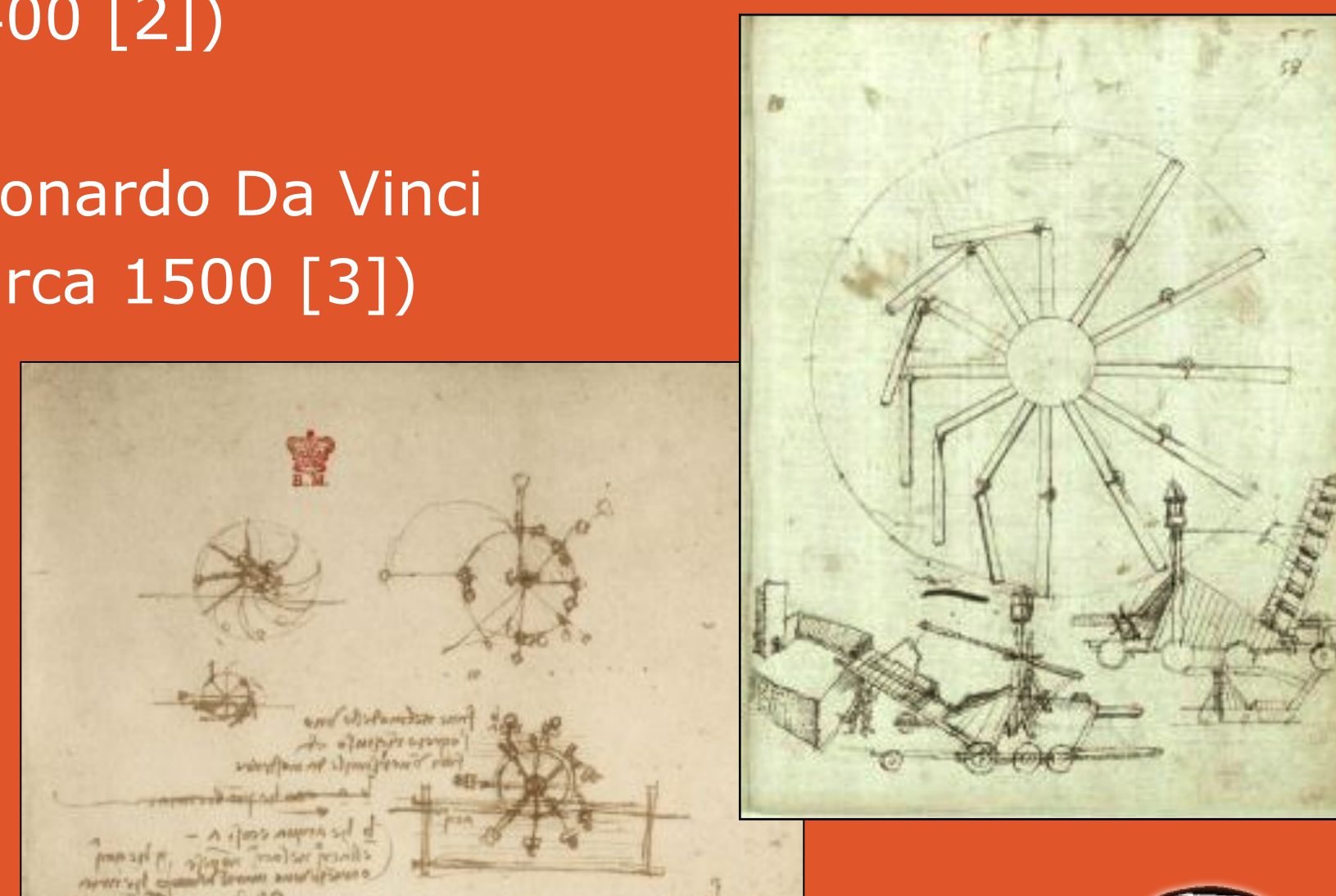- Leonardo Da Vinci (circa 1500 [3])

Figure 3: Leonardo Da Vinci sketches of PMMs (Above, Left)
Figure 4: Taccola sketch of changing center of mass PMM (Above, Right)

- Robert Boyle (circa 1600 [2])

Figure 5: Drawing of Boyle's "Capillary Bowl" PMM

- This lineage of inquiry became the Study of Thermodynamics (energy transfer) that we know today:
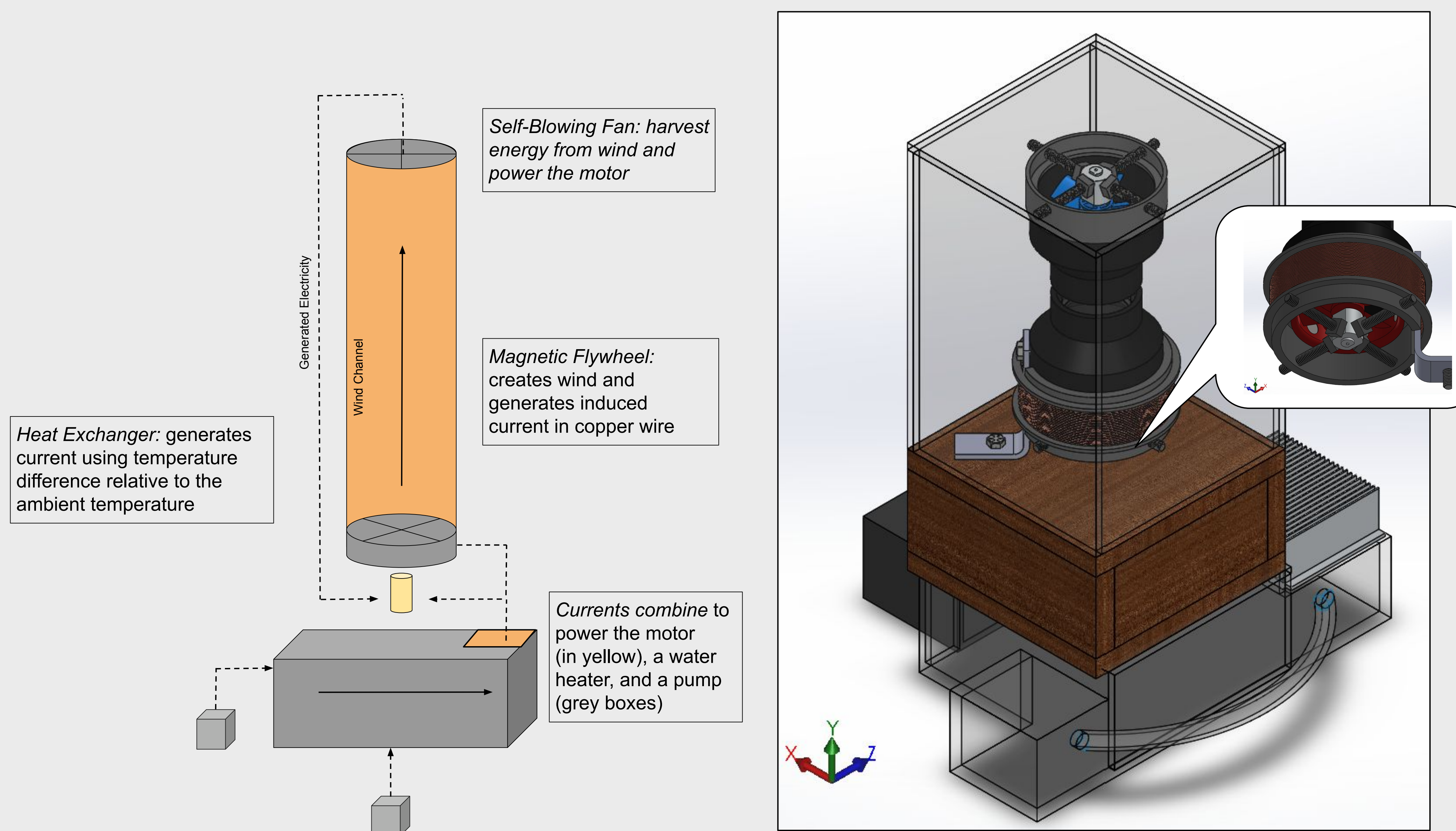 - Consider inefficiencies
    - Excess Heat (Friction, Resistance, etc)
    - Sound
    - Other forms of Vibrations (which do not contribute to the work) are sources of energy loss
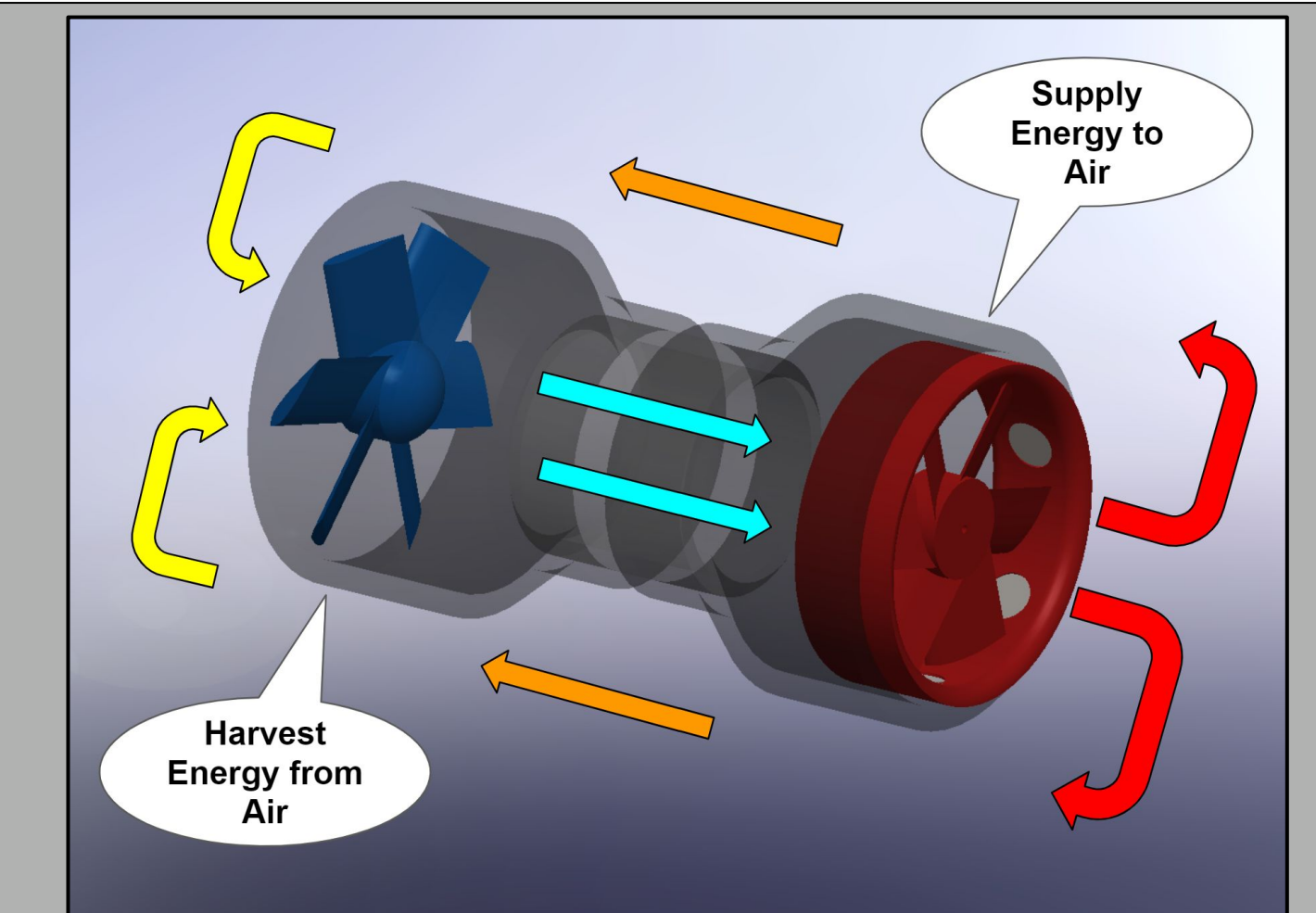   - Entropy

- Poster References
  1. Bhāskara, and Ṭhakkura Muralīdhara. The siddhānta śiromaṇi of Bhāskarāchārya: With His Own Exposition the vāsanābhāshya. Banaras: Chowkhamba Sanskrit Series Office, 2007.
  2. Ceccarelli, Marco. "Renaissance of Machines in Italy: From Brunelleschi to Galilei through Francesco Di Giorgio and Leonardo." Mechanism and Machine Theory. Pergamon, March 4, 2008. https://www.sciencedirect.com/science/article/abs/pii/S0094114X08000074.
  3. "Leonardo da Vinci and Perpetual Motion," Museo Galileo, 12-Jan-2020. [Online]. Available: https://www.museogalileo.it/en/museum/explore/temporary-exhibitions/1802-leonardo-da-vinci-and-perpetual-motion.html#:~:text=Leonardo%20has%20a%20central%20place,motion%20cannot%20exist%20in%20nature. [Accessed: 03-May-2023].

Heat Exchanger: generates current using temperature difference relative to the ambient temperature

Self-Blowing Fan: harvest energy from wind and power the motor

Magnetic Flywheel: creates wind and generates induced current in copper wire

Generated Electricity

Wind Channel

Currents combine to power the motor (in yellow), a water heater, and a pump (grey boxes)

THEORY + APPLICATION:

- Subsystem I
  - *Self-Blowing Fan*

$$Power = \dot{m}\left[\left(\frac{P}{\rho} + \frac{v^2}{2} + gz\right)_{in} - \left(\frac{P}{\rho} + \frac{v^2}{2} + gz\right)_{out}\right]$$

Supply Energy to Air
Harvest Energy from Air

- Subsystem II
  - *Self-Spinning Magnetic Flywheel*
   - **Faraday's Law** in electromagnetism

$$\varepsilon = -N\frac{\Delta\phi_M}{\Delta t}$$

Faraday's Law

N = number of loops
$\Delta\phi_M$ = change in magnetic flux
Δt = change in time
ε = induced voltage (also known as emf)

Closed Loop (Coil) Provides Current to Power supply

Rotating Magnets Result in Change in magnetic flux

Relevant Variables:

$\dot{m}$ = Mass Flow Rate

C = Specific Heat

Q = Heat Flow Rate

T = Temperature

P = Pressure

ϱ = Density
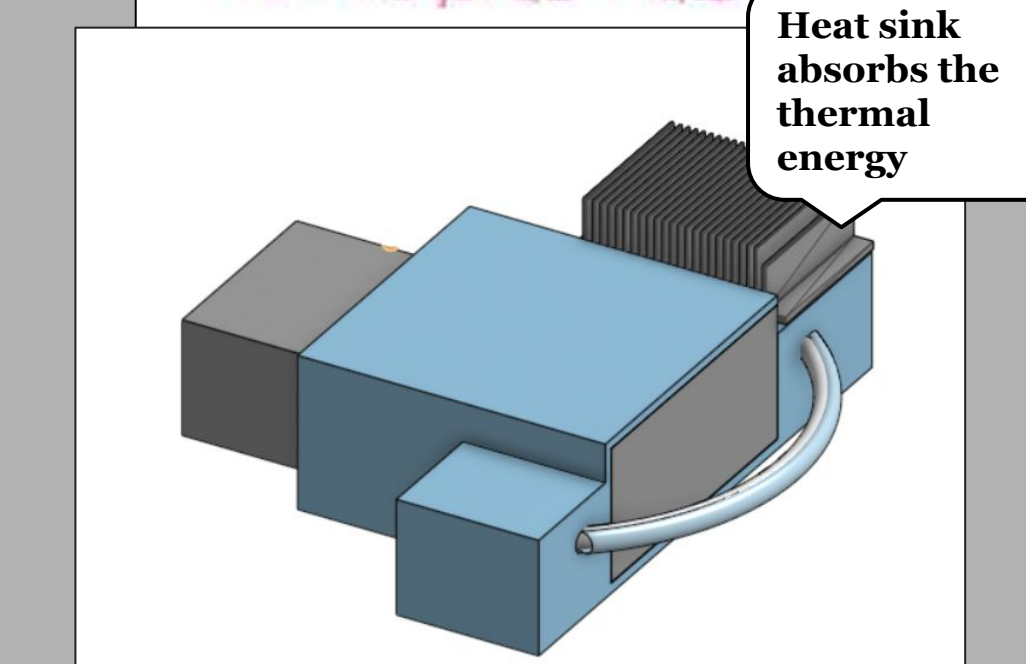
v = Velocity

g = Gravity
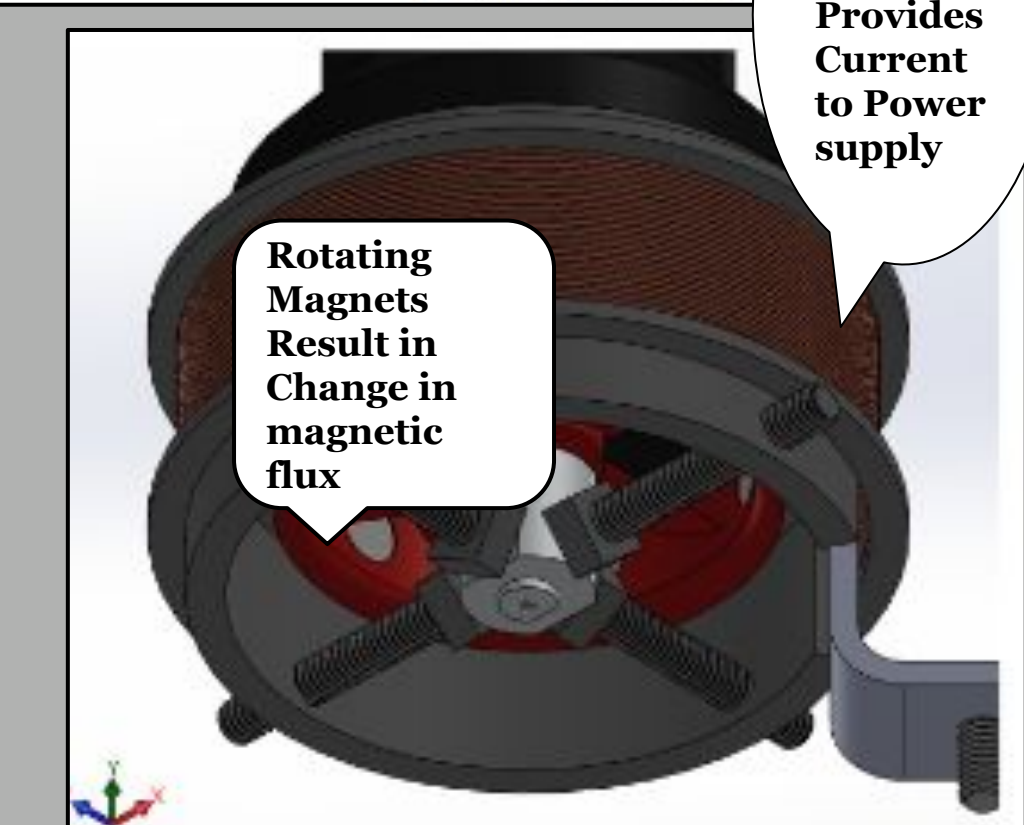
- Subsystem III
  - *Self-Heating/ Self-Pumping Heat Exchanger*

$$\dot{Q} = \dot{m}_c C_{pc}(T_{c,out} - T_{c,in})$$
$$\dot{Q} = \dot{m}_h C_{ph}(T_{h,in} - T_{h,out})$$

Heat sink absorbs the thermal energy

- By combining all three subsystems, the team studied the role of energy losses within the system as a whole

If you want to learn more, consider:
- What is energy loss?
  - Conservation of Energy
    - Energy cannot be created or destroyed, only transferred or transformed.
  - 2nd Law of Thermodynamics
    - Entropy (chaos, disorder, randomness) in any natural or spontaneous system can only increase or remain constant

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