

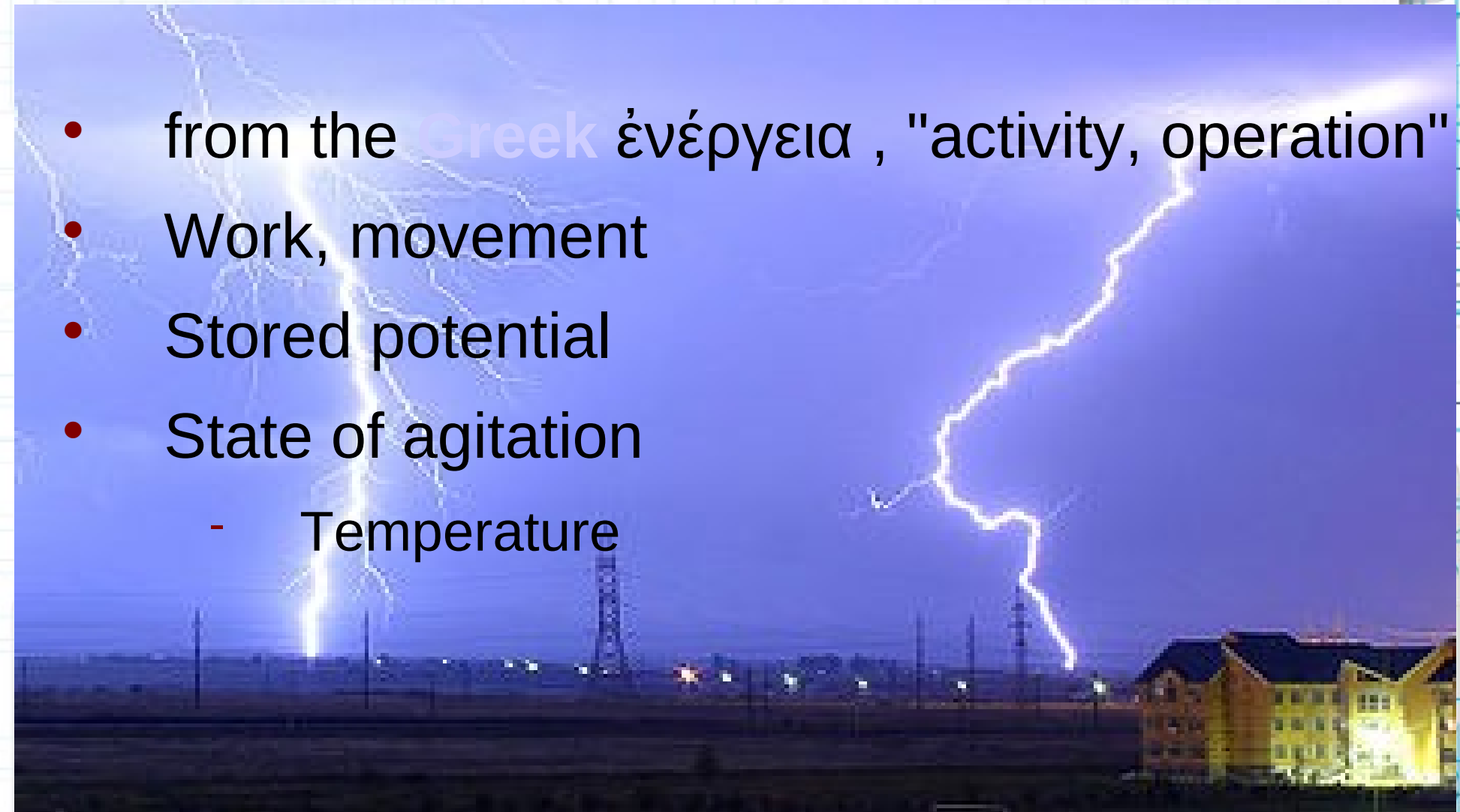
Energy is what makes the world go 'round

Przemek Klosowski



What is Energy?

- from the **Greek** ἐνέργεια , "activity, operation"
- Work, movement
- Stored potential
- State of agitation
 - Temperature

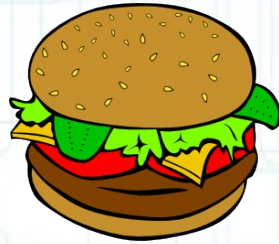


Energy: can't live without it

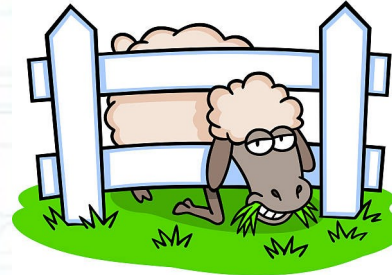
- Potential energy: *bottled up*
 - Gravitational
 - Chemical
 - Nuclear
 - Elastic
- Kinetic energy: *in motion*
 - Mechanical
 - Radiation
 - Thermal

We need Energy to Live

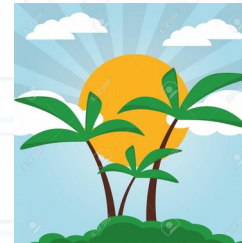
- We get it from food



- Food gets it from plants



- Plants get it from the Sun



- Sun gets it from burning nuclear fuel

We need Energy to Live

- We get it from food
- Food gets it from plants
- Plants get it from the Sun
- Sun gets it from burning nuclear fuel
- **WHAT IF IT RUNS OUT?!?!?**

**EVERYONE
CALM
DOWN.**



Will Sun “run out of gas”?

- Yes it will
- Fortunately it'll take 1.5 billion years
- Hopefully we'll figure something out in the meantime...

... but you need to get busy studying science because it's your job to start looking for the solution!

Energy Is Conserved

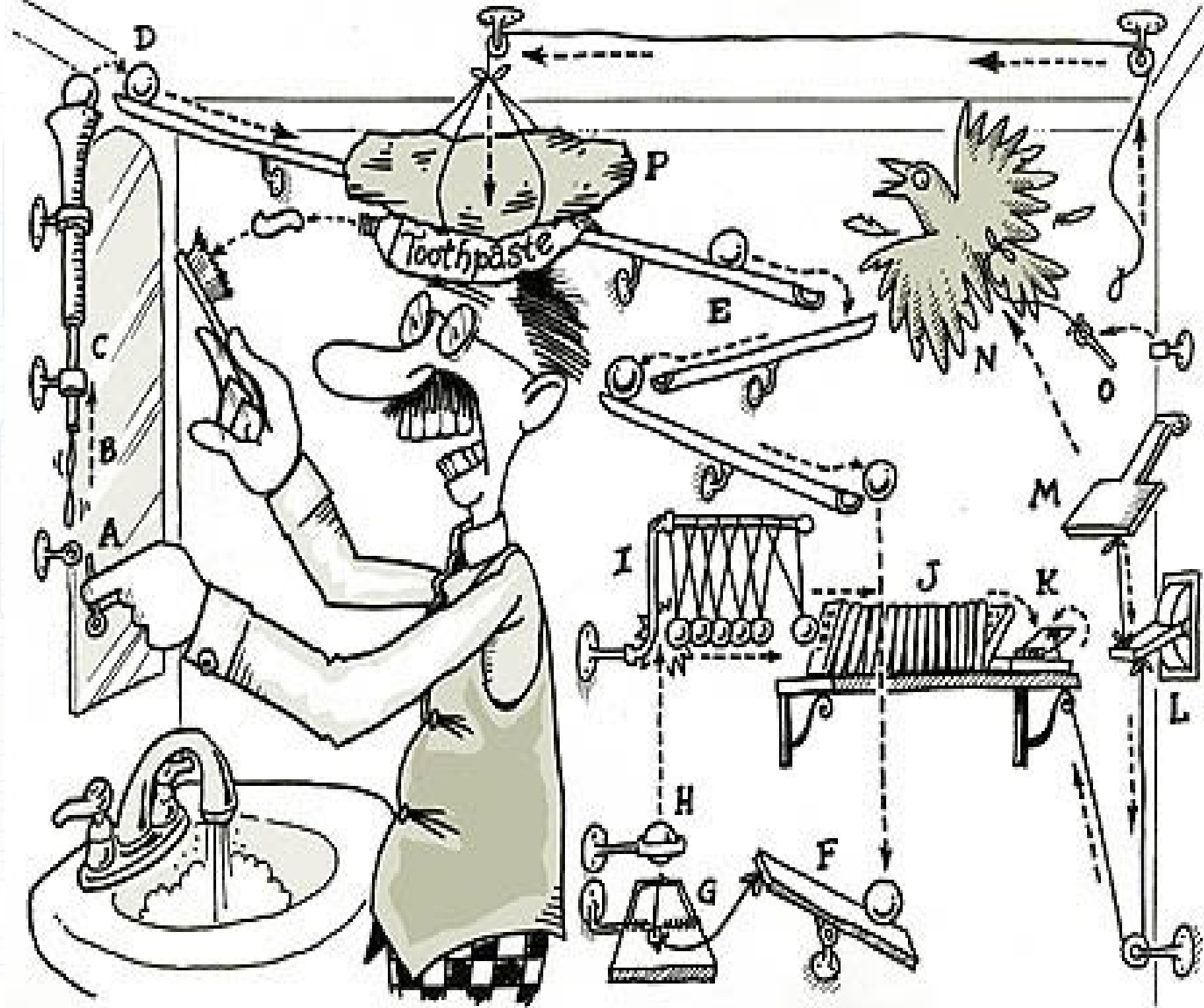
- All the forms of energy are equivalent
- They can convert into each other
- Pendulum
 - Kinetic \Leftrightarrow potential
- Firing a gun
 - Chemical \Rightarrow kinetic \Rightarrow potential
- Sun
 - Nuclear \Rightarrow radiation \Rightarrow thermal \Rightarrow chemical



**Energy
Is
Conserved**

Conservation of Energy

- A fundamental law of physics
 - You can't lose OR gain the energy
- Other laws can be derived from it
 - Advanced mechanics
 - Hamiltonian (total energy)
 - Quantum mechanics
 - I'd love to explain this but it's a little too long



Conservation of Energy

- Perpetuum Mobile
 - IMPOSSIBLE :(
- Great life-guiding principle

Conserve your energy for worthy things

Energy and Power

- **Energy** and work are equivalent
 - Similar to money
- **Power** is the capacity to do work
 - Would you like a hundred dollars?

Energy and Power

- **Energy** and work are equivalent
 - Similar to money
- **Power** is the capacity to do work
 - Would you like a hundred dollars?
 - What if I gave it to you over 100 years

$$\text{Power} = \text{Energy} / \text{Time}$$

- More examples:
 - Distance and speed
 - Flow of anything
 - Even velocity of money i.e. cash flow

How do we measure Energy

Joule: basic unit of work, named after James Prescott Joule

1 Joule : effort to push against 1 Newton of force for 1 meter

Example

Lifting a pack of cheese from the floor to the table



Useful fact about electricity

When you buy electricity, you buy energy

- Electricity costs about 15 cents per kWhr
- kWhr: kilo=1000, Watt=Joule/second, hour
- 1 year has about 31 million seconds

1 Watt costs about 1 \$ per year

Turn off those lights!!

Various energies: Food

- 1 calorie is the amount of thermal energy needed to heat 1cm^3 of water by 1 deg C
- 1 food **C**alorie = 1000 calories
- 1 hamburger is around 400 Calories
- Which is 1.7 million Joules, enough to accelerate 4000 lb SUVs to 65 mph, twice
- So, driving wastes a lot of hamburgers :)

The ice-cream diet mistake

- Eat a cup (250 grams) of ice cream
 - 300 Calories
- your body has to heat it up by 30 deg C
 - 7500 calories!!
- Can you lose weight by eating ice cream?
- NO! you are off by a factor of 1000
 - 300 Calories is 300,000 calories

Various energies: electrical

Heating 1 liter (1000 ccm) of water, from room temperature (around 20C) to boiling (100C)

- 80,000 calories or 300,000 Joules
- Water boiler is typically 1000 Watts
- so it takes 300 seconds or about 5 minutes

Spot the Energy



Spot the Energy



Spot the Energy



Spot the Energy



But First Let's Talk About Units

- Units are about agreeing on how you measure properties of things
 - Length, Area, Volume, Mass, time, electric charge, current, speed, energy, ...
- Units let you compare things
 - Which rope is longer?
 - How long are they?
- Similar things share the same unit
- Everything has units

Measuring with Units

- Length: inches (meters, feet, miles)
 - Area,
 - Volume
- Mass: Kilogram (pound)
- Time: second (hour, month, day)
- Electric current: Ampere
- Unit of light: Candela

Basic and derived units

- Five basic units are enough
 - SI or international units
MKSA: meter, kilogram, second, Ampere
 - Imperial or British/US units
inch, pound, second, mile
 - Other units: furlong per fortnight, etc

Only used in US and Burma;
British gave up in the 70s

Basic and derived units

- Combine basic units for derived units:
 - speed = distance / time
meter/second
 - lollipops per afternoon
 - Easter Chocolate eggs per square yard
 - Cars per traffic lane per second

Tricks with Units

Check your work: units have to agree.

Example: what is the mass of a gallon of milk? We know that

- milk density is 1.02 g/cm^3
- a gallon is 3.78 liters
- Do we multiply or divide by density?
 - Divide? $\text{Liter} / (\text{g/cm}^3) \Rightarrow \text{cm}^6/\text{g}$ **NOPE**

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 - Divide? Liter / $(\text{g/cm}^3) \Rightarrow \text{cm}^6/\text{g}$ **NOPE**
 - Multiply? Liter * $\text{g/cm}^3 \Rightarrow \text{g}$ **YES**