Energy

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Work

- Energy needed to enact a force through some displacement
- Measured in Joules (J)
  - W=force parallel (to displacement)*displacement or fd(cosθ)
  - Assume force is constant
  - Specify if the object is doing the work or if it is having work done on it
  - Specify what force is doing the work

What is Energy?

- Energy is the ability to do stuff
- Energy is a scalar quantity (no direction)
- Energy is conserved, meaning that it cannot be created or destroyed
- Measured in Joules (J)

Types of Energy

- Kinetic Energy
- Potential Energy
    - Gravitational Potential Energy
    - Elastic Potential Energy
- Nuclear
- Thermal
- Chemical

Potential Energy

- How much energy an object has by virtue of its position or configuration
- Can only be defined for conservative forces
  - Gravitational: mgh
  - Elastic: ½(k)(X^2)

Gravitational potential energy

- The change in potential energy that has physical meaning
- The work done by gravity depends only on the height, NOT ON THE PATH YOU TAKE!
- $PE_g = mgh$ = weight x height
- Example: A brick that has a mass of 20 kg is lifted 3m above the ground, what is the potential Energy of the brick?

$$PE_g = mgh = 20kg \times 9.81m/s \times 3m^{2} = 588.6\ J$$

Elastic Potential Energy

- Spring Force: **Hooke's Law**
- Fs= -kx (k is spring constant ↠ measure of stiffness)
- This value is NEGATIVE because force is opposite displacement ("restoring force")

❖ PEe=½ kx^2

❖ Example: The spring constant of one spring is 220N/m, and the spring has a potential energy of 40J, How much is the spring stretched?

PEe=½ kx^2   40J=½ (220N/m)(X^2)   x=0.60m

Conservative Forces

- Forces in which only the initial and final positions are important
  - Path of the object doesn't matter
  - Ex: Gravity, spring, elastic

Non-conservative Forces

- Forces in which the path of the object matters in addition to the initial and final positions of the object
    - Potential Energy can’t be defined for non-conservative forces
    - Ex: Friction, air resistance, tension, applied force

Dissipative Forces

- Forces that reduce the total amount of mechanical energy when an object is in motion
  - Ex: Friction

Energy Transformation

- Potential energy at the beginning equals the kinetic energy at the end
- Ex: Stone in freefall
  - At the top the energy is all potential
  - Mid-air the energy is both potential and kinetic
  - Just before the stone hits the ground the energy is only kinetic

Work-Energy Theorem

- Net work= conservative forces+non-conservative forces (change in kinetic energy)
- Include all forces acting on the system
  - Conservative forces= change in potential energy
  - Non-conservative forces= change in kinetic energy+change in potential energy

Mass Energy

- Einstein: “All mass have intrinsic, internal energy just by virtue of their existence”.
- $E=mc^2$
- c= the speed of light =3.00 x 10^8 m/s

Power

- The rate at which the work is done
- OR the rate at which energy is transformed
- $P=W/t$
- Unit is Watts (W)

Machines

- Simple machines: device that use only the forces directly applied and accomplish their task with a single motion
- Input vs. Output
- W in= W out
- Mechanical Advantage: the ratio of output force to input force
- MA=F out/F in

Lever

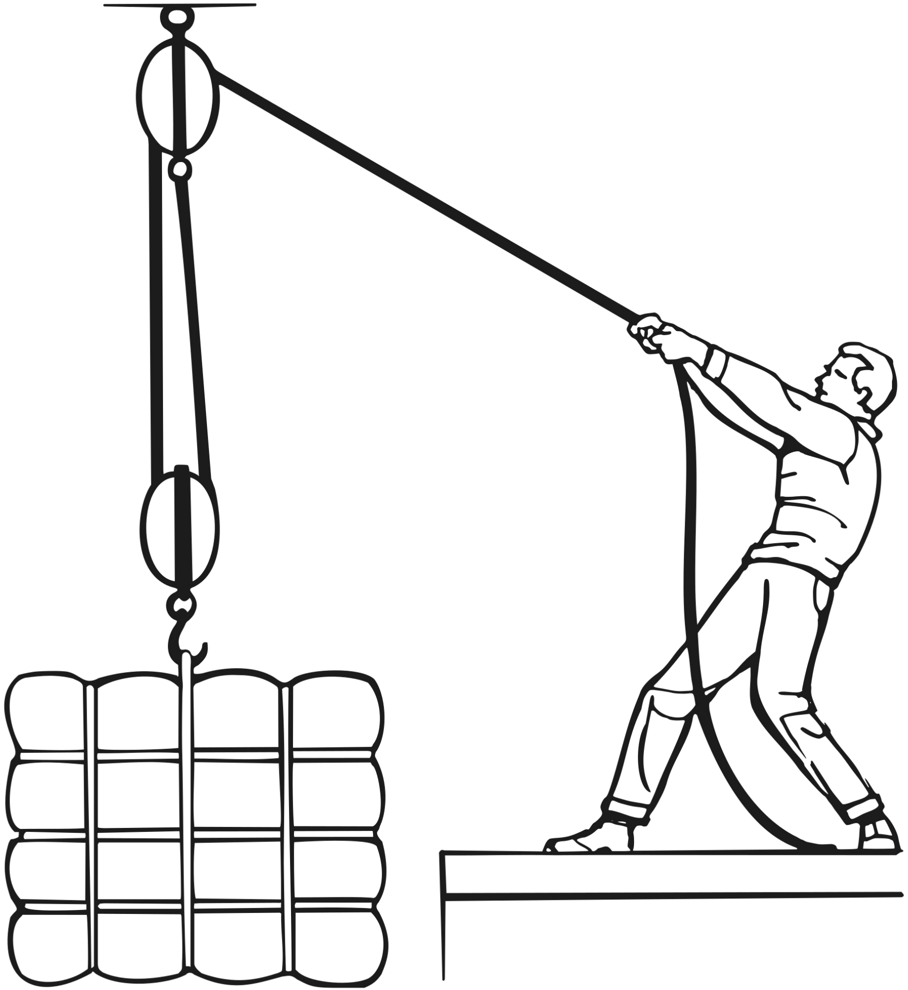
- Includes a stiff structure (the lever) that rotates around a fixed point called the fulcrum
  - Mechanical Advantage of lever=Fout/Fin=Lin/Lout
  - L= Length of the lever, F= Force

Ramps

- Draw problem with given forces/measurements
  - MA=Length of ramp/height of ramp

Pulleys

- Like levers and ramps, pulleys sacrifice displacement to achieve a greater force
    - MA is shown by how many ropes there are



Efficiency

- Output WORK/ Input WORK*100= % efficiency
- Always smaller than 1

Practice Problem

- A roller coaster car of 150 kg starts on a hill that is 30m tall and it moves at 20m/s. It must travel down the first hill and up a second hill that is 10m tall.
  - What is the potential energy at the top of the starting hill?
  - What is the velocity at the bottom of first hill?
  - What is the kinetic energy at the bottom of the second hill if the velocity changes to 25m/s?

Answers

- 44,145 J
- 31.4 m/s
- 46,875 J