

1.1) Terminology and the First Law of Thermodynamics

Terminology

Property: Macroscopic characteristic of a system to which a numerical value can be assigned at any given time (i.e. temperature, volume, mass)

State: Condition of a system as described by its properties

Phase: Composition and structure of a substance (solid, liquid, and vapor)

Energy and Energy Transfer

Units: Joules (J), Btu, lb-ft

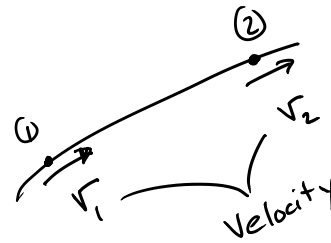
Note: 1 J = 1 N-m

Kinetic Energy

Energy of a mass due to its velocity

$$KE = \frac{1}{2} m v^2$$

Kinetic Energy (left of =)
 mass (under m)
 velocity (under v)



$$\Delta KE = KE_2 - KE_1$$

change

$$= \frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$$

Potential Energy

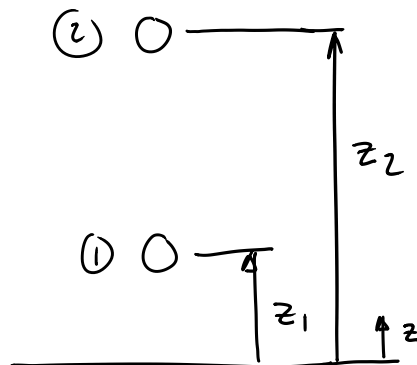
Energy due to the vertical position of a mass

$$PE = m g z$$

mass (over m)
 elevation (over z)
 Acceleration due to gravity (under g)

$$g = 9.81 \text{ m/s}^2$$

$$= 32.2 \text{ ft/s}^2$$



$$\Delta PE = PE_2 - PE_1$$

$$= m g z_2 - m g z_1$$

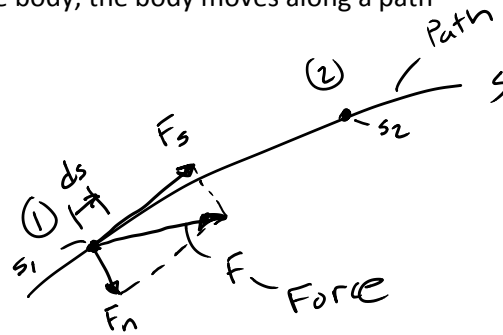
ENGR 2240 – Thermodynamics
 Section 1: First Law of Thermodynamics

Other Forms of Energy

- Energy at the molecular level
- Types of energy that is not kinetic or potential energy
- Grouped together and is called **Internal Energy (U)**

Energy Transfer by Work

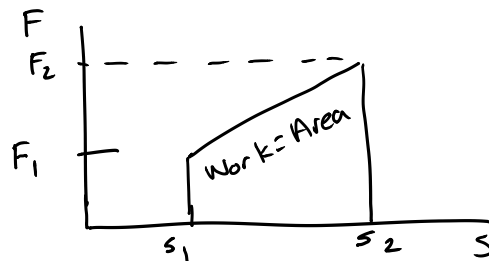
A force does work on a body if while acting on the body, the body moves along a path



$$W = \int_{s_1}^{s_2} F_s ds$$

(Work Position)

Work \Rightarrow Area under the Force vs Position graph



Work is not a Property

Sign Convention for Work

\$W > 0\$ if work is done **by** the system **on** the surroundings

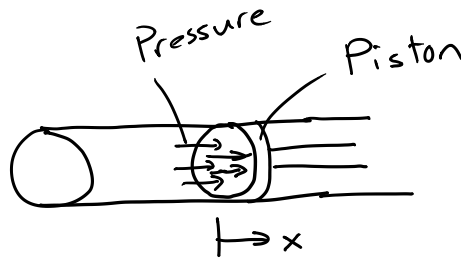
\$W < 0\$ if work is done **on** the system **by** the surroundings

ENGR 2240 – Thermodynamics
 Section 1: First Law of Thermodynamics

Work Due to Expansion or Compression

$$W = \int_{s_1}^{s_2} F_s ds$$

$s = x$



$$W = \int_{x_1}^{x_2} F dx$$

$$F = \text{Pressure} \times \text{Area}$$

$$W = \int_{x_1}^{x_2} P A dx$$

$= \text{Volume} = dV$

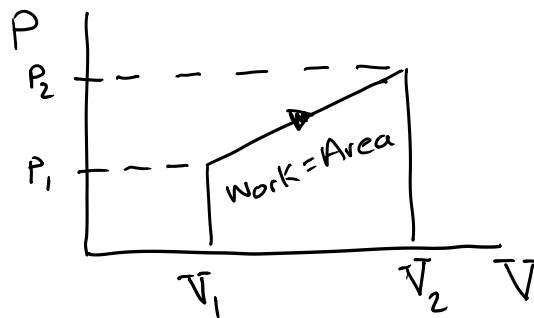
$$F = pA$$



$$W = \int_{V_1}^{V_2} p dV$$

V_2 - final volume
 V_1 - initial volume

$$W = \int_{V_1}^{V_2} p dV$$



ENGR 2240 – Thermodynamics
Section 1: First Law of Thermodynamics

Energy Transfer by Heat

Variable: Q

Modes of Heat Transfer

Convection: Energy transfer between a solid surface and an adjacent moving gas or liquid

Conduction: Transfer from more energetic particles to less energetic adjacent particles through a medium

Radiation: Energy is transferred by electromagnetic waves called photons

Sign Convention for Heat Transfer

$Q > 0$ if heat transfer is **to** the system **from** the surroundings

$Q < 0$ if heat transfer is **from** the system **to** the surroundings

Energy Balance (The First Law of Thermodynamics)

Change in Energy of the System = Energy Transferred to and from the System

$$\Delta KE + \Delta PE + \Delta \bar{U} = Q - W$$

- Could also use rates : \dot{Q} & \dot{W}
- Could also use specific quantities

$$\bar{U} = J, Btu$$

$$u = J/kg, Btu/lb$$

↳ specific internal energy