TOPIC I - Systems and Energy

1st law of Thermodynamics (Lecture 3/3)

Contents

8. The First Law and the cyclic process
9. Internal Energy and the NFEE

Recreate the NFEE discussed in the last lecture, but from a more fundamental viewpoint

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Preamble:

"When any closed system is taken through a cycle the **net work done** by the system upon the surroundings **is equal to the net heat** supplied to the system from the surroundings."

Heat, (like work):

- crosses system boundaries
- is not a state property.

We shall show:

$$\Delta U = U_2 - U_1 = Q + W \qquad (9)$$

Known as the **non-flow energy equation (NFEE)**

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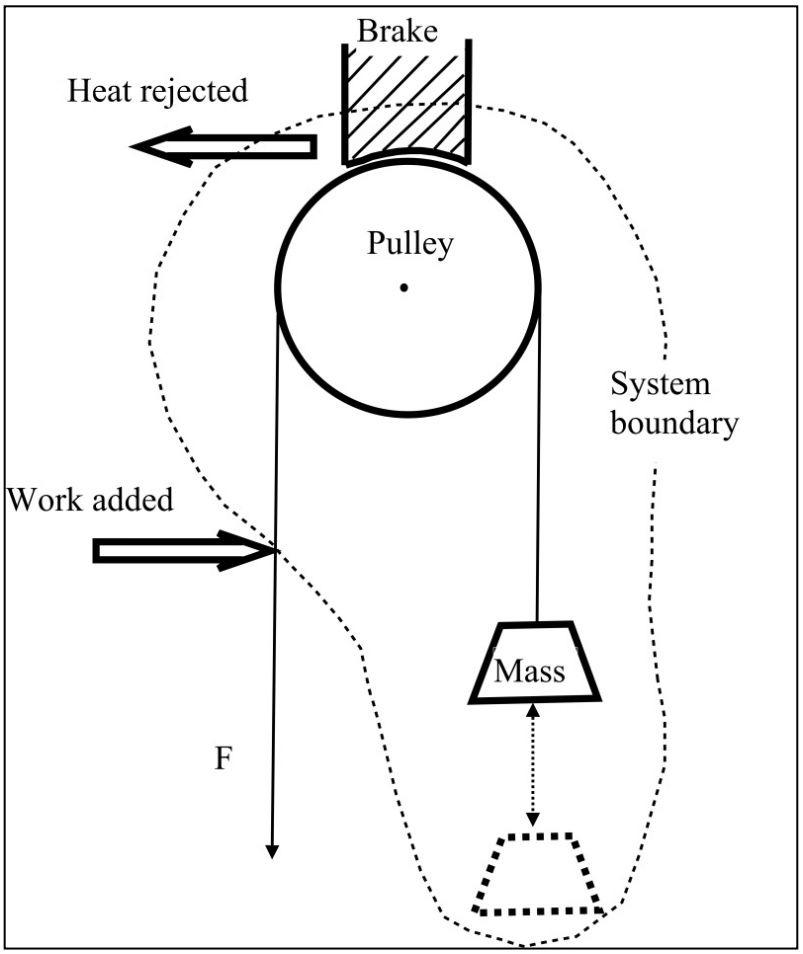
8. First Law and the Cyclic Process.

Identical start and end conditions.



* Weight raised and lowered to original location.

* Brake used to lower weight gently

* Heat and work cross boundary

First Law – for cyclic process

$$\Sigma\, \delta Q + \Sigma\, \delta W = 0 \qquad (9)$$

total heat addition + total work addition = 0 (if cyclic)

First law is an ***axiom***.

The First Law of Thermodynamics

9. Internal Energy and the NFEE

Corollary 1 "There exists a property of a closed system such that a change in its value is equal to the difference between the heat supplied and the work done during any change of state."

This means internal energy, U

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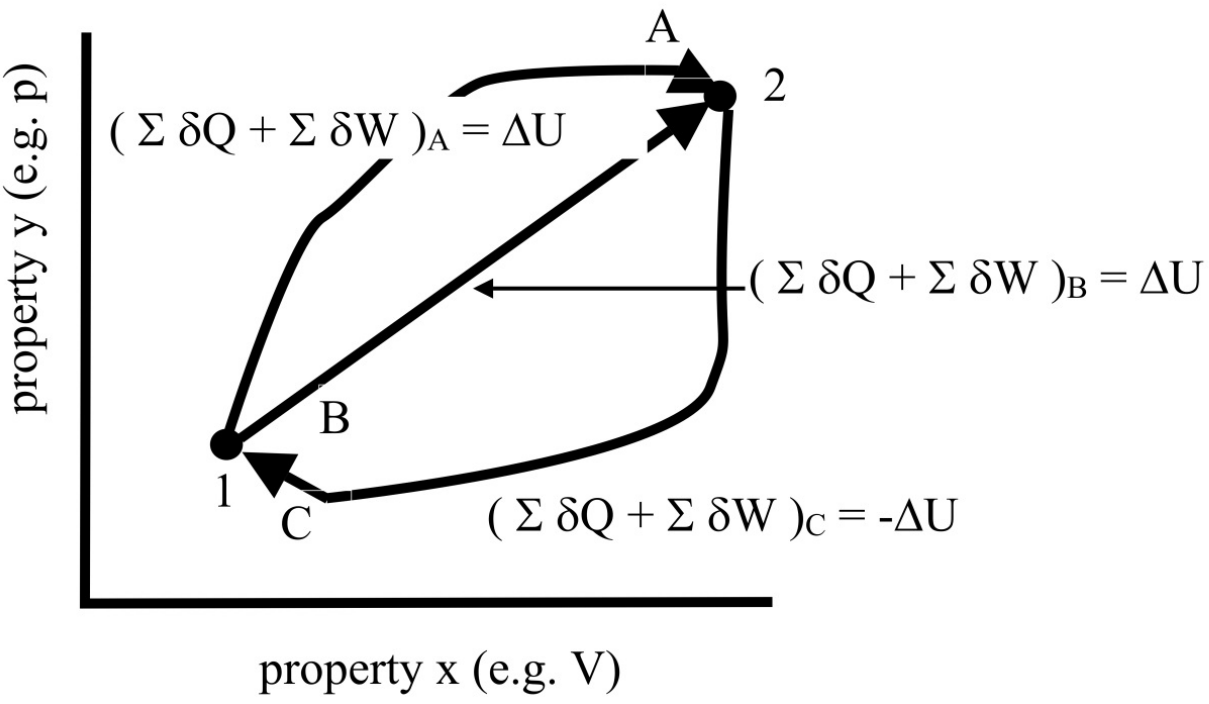
Compare cycles AC and BC. Show that work and heat transfer for A and B are identical.

$$\Sigma\ \delta Q + \Sigma\ \delta W = 0$$



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Let $\Delta U = \Sigma\ \delta Q + \Sigma\ \delta W$. For cycles AC and BC

$$\Delta U \text{ (forward)} = -1 \times \Delta U \text{ (reverse)}$$

$$\Delta U \text{ (A)} = -1 \times \Delta U \text{ (C)} = \Delta U \text{ (B)}$$

Since ΔU is independent of path (A or B) U is a state property of the system

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Quantity ΔU (the change in internal energy) is independent of path and therefore a property of state. In general:

$$Q_{12} + W_{12} = U_2 - U_1 \quad or$$

$$Q_{12} + W_{12} = \Delta U$$

Corollary 2: The internal energy of an isolated system remains unchanged.

Corollary 3: A perpetual motion machine of the first kind is impossible

Conclusions

The NFEE (above) applies to closed, stationary sytems. Internal energy, U, is a property of state.