Fasit BYPE1500 Fysikk Øving 4: 1st law of thermodynamics

Oppgaver for beregning først lov

1. What is the change in internal energy of a system which does 4.50×10^5 J of work while 3.00×10^6 J of heat transfer occurs into the system, and 8.00×10^6 J of heat transfer occurs to the environment?
   Fasit:5.45*10^6 J

Work done by system	$W = 4.50 \times 10^5$ J	
Heat into system	$Q_{in} = 3.00 \times 10^6$ J	positive (heat going in)
Heat out of system	$Q_{otu} = - 8.00 \times 10^6$ J	negative (heat going out)

$\Delta U = Q - W$

$\Delta U = Q_{in} - Q_{out} - W$

$\Delta U = 3.00 \times 10^6 \text{ J} - 8.00 \times 10^6 \text{ J} - 4.50 \times 10^5 \text{ J}$

$\Delta U = - 5.45 \times 10^6 \text{ J}$

Oppgaver for beregning PV diagram og arbeid

2. Steam to drive an old-fashioned steam locomotive is supplied at a constant gauge pressure of 1.75×10^6 N/m2 (about 250 psi) to a piston with a 0.200 m radius.

   (a) By calculating PΔV, find the work done by the steam when the piston moves 0.80 m. Note that this is the net work output, since gauge pressure is used.

   $W = P\,\Delta V$

   $\Delta V = \pi\, r^2 \cdot d = \pi\,(0.20 \text{ m})^2 \cdot 0.8 \text{ m} = 0.10 \text{ m}^3$

   $W = P\,\Delta V = 1.75 \times 10^6 \text{ N/m2} \cdot 0.10 \text{ m}^3 = 1.75 \times 10^5 \text{ J}$

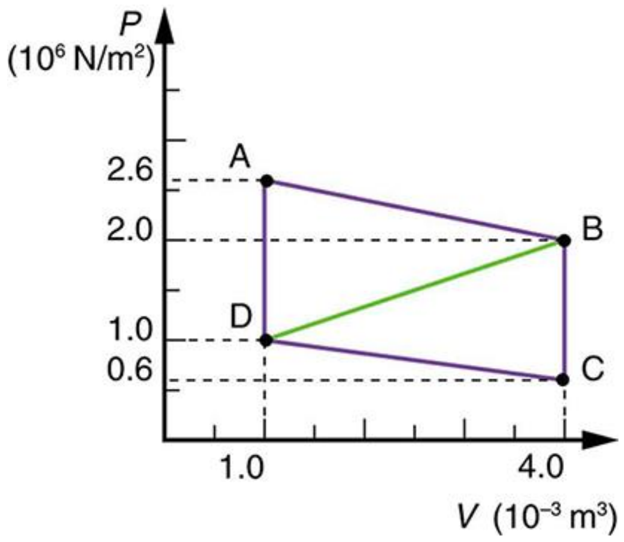
   (b) Now find the amount of work by calculating the force exerted times the distance traveled. Is the answer the same as in part (a)?

   $W = F \cdot d$

   $F = P \cdot A$

   $W = P \cdot \pi\, r^2 \cdot d = 1.75 \times 10^5$ J same as part a)

3. Heat engine operates along this PV diagram



a) Calculate the net work output if the Heat engine follows the path ABCDA for one cycle
Fasit: 4.5 kJ

Work is done in processes A-B and C-D. The processes D-A and B-C are constant volume and no work is done.

We can either use

$$W = \int_A^B PdV + \int_C^D PdV$$

Integral along the paths A-B and C-D

Or we can use Work = area enclosed by the curve ABCDA

Work = area of triangle ABD + area of triangle BCD

$A_{ABD} = \frac{1}{2}(P_A - P_B) \cdot (V_B - V_A) = \frac{1}{2}$(2.6 – 1.0) X 10^{-6} N/m2 · (3.0 X 10^{-3} m^3)

$W_{ABD} = A_{ABD}$ = 2.4 X 10^3 Joules

And

$A_{BCD} = \frac{1}{2}(P_B - P_C) \cdot (V_B - V_D) = \frac{1}{2}$(2.0 – 0.6) X 10^{-6} N/m2 · (3.0 X 10^{-3} m^3)

$W_{BCD} = A_{BCD}$ = 2.1 X 10^3 Joules

Total work:

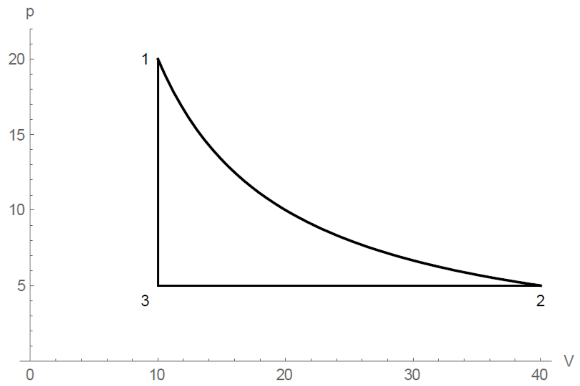
W = $W_{ABD} + W_{BCD}$ = 2.4 kJ + 2.1 kJ = 4.5 kJ

b) Calculate the net work output if the Heat engine follows the path ABDA for one cycle
Fasit: 2.4 kJ

Work in ABDA = Area of triangle ABD

$W_{ABD} = A_{ABD}$ = 2.4 kJ

4. Figur 1 viser et P V – diagram av en arbeidssyklus for en varmekraftmaskin som arbeider med oksygengass. Gassen består av n mol O_2 molekyler.



Prosess 1-2 er en isoterm ekspansjon fra tilstand (P1, V1, T1) til tilstand (P2, V2, T2), prosess 2-3 er en isobar kompresjon fra tilstand (P2, V2, T2) til tilstand (P3, V3, T3), og prosess 3-1 er en isokor prosess fra tilstand (P3, V3, T3) til tilstand (P1, V1, T1).

Den universell gasskonstanten er R.
Du skal ikke regne med numeriske verdier i denne oppgaven, og ikke bruke diagrammet til å anslå verdier.

a) Hva er temperaturen T2 uttrykt ved T1?
Hva er trykket P3 uttrykt ved P2?
Hva er volumet V3 uttrykt ved V1?

T2 = T1 fordi prosessen er isoterm
P3 = P2 fordi prosessen er isobar
V3 = V1 fordi prosessen er isokor

b) Maskinen har et kompresjonsforhold r = 4. som sier at V2/V1 = 4.
Vis at T1/ T3 = 4. (Bruk ideell gasslov)

Use: $P\,V = n\,R\,T$ and $T_1 = T_2$

$$\frac{P_1 V_1}{P_2 V_2} = \frac{n\,R\,T_1}{n\,R\,T_2}$$

$$P_1 V_1 = P_2 V_2$$

$$\frac{P_1}{P_2} = \frac{V_2}{V_1} = 4$$

Use: $P\,V = n\,R\,T$ and $V_1 = V_3$

$$\frac{P_1 V_1}{P_3 V_3} = \frac{n\,R\,T_1}{n\,R\,T_3}$$

$$\frac{T_1}{T_3} = \frac{P_1}{P_3} = \frac{P_1}{P_2} = 4$$

c) Hvor mye varme tilføres systemet ved prosess 1 – 2?
Bruk først lov, og arbeid W = areal i P V plot
Fasit: Q = nR T1 ln(4)

Process 1 – 2 is isothermal, and ΔU = 0

From 1st law ΔU = Q – W and Q = W = work done

As the gas expands and does work, heat is added to keep temperature constant

$$W = \int_1^2 P\,dV$$

Using $P\,V = n\,R\,T$

$$P = \frac{n\,R\,T}{V}$$

$$W = \int_1^2 \frac{n\,R\,T}{V}\,dV = n\,R\,T \int_1^2 \frac{1}{V}\,dV = n\,R\,T\,(\ln V_2 - \ln V_1)$$

$$W = n\,R\,T\,(\ln V_2 - \ln V_1) = n\,R\,T\,\ln\left(\frac{V_2}{V_1}\right)$$