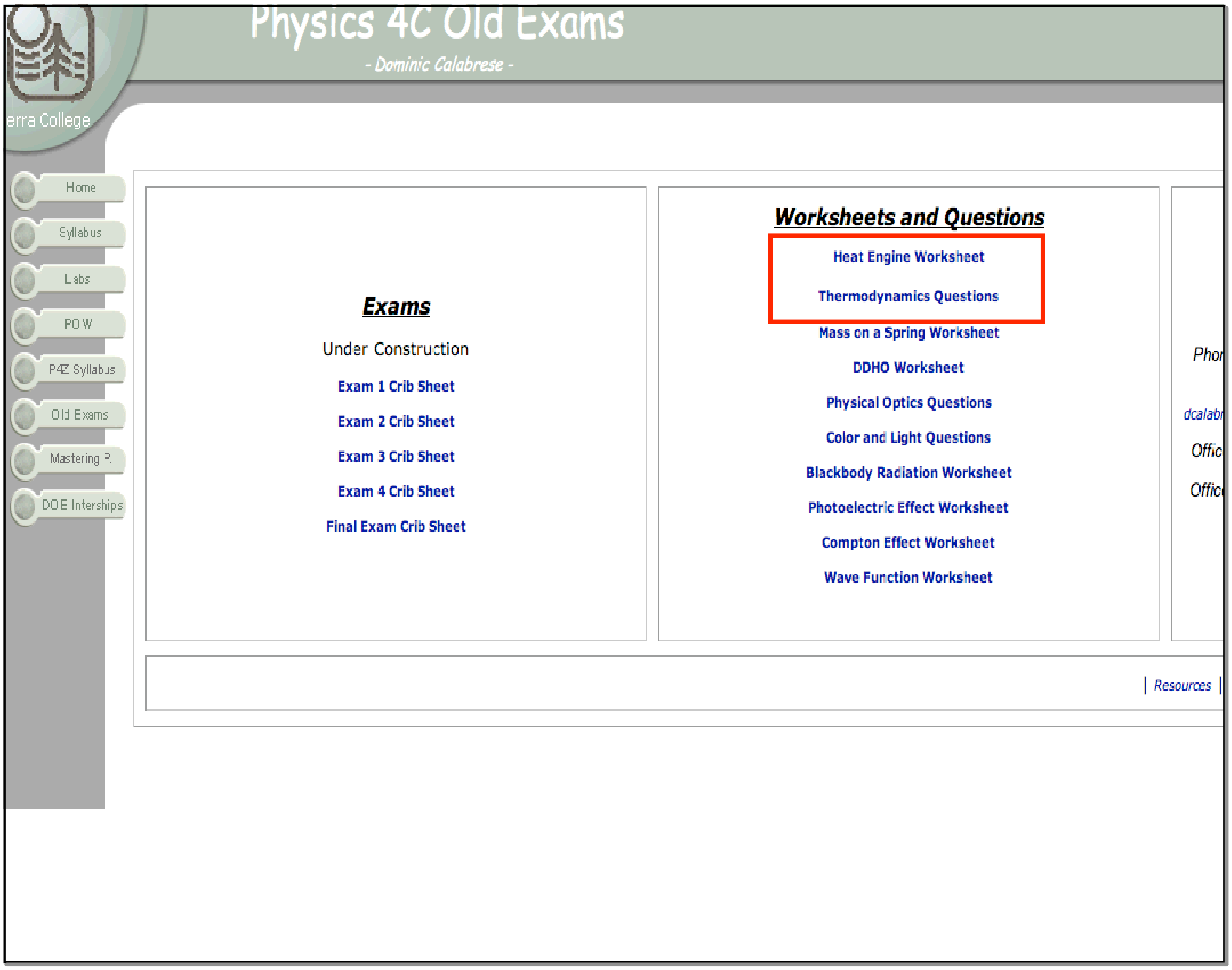
**Reminders 02-04-08:**
- -POW 2 Due by 5PM
- -3rd Homework due Feb 6.
- -Heat Engine Worksheet due Wednesday.
- -Read Ch. 20 and Chapter 3 of Understanding Thermodynamics
- -Exam 1 February 13
- -POW 3 due Feb 13
- -Summer Internships REU & DOE
- -Phi Theta Kappa see Prof. Houpis

**Outline:**
- -1st Law of Thermodynamics Examples
- -Reversible Processes
- -Heat Engines
- -2nd Law of Thermodynamics


Physics 4C Old Exams
- Dominic Calabrese -
erra College
Home
Syllabus
Labs
POW
P4Z Syllabus
Old Exams
Mastering P.
DOE Interships
Exams
Under Construction
Exam 1 Crib Sheet
Exam 2 Crib Sheet
Exam 3 Crib Sheet
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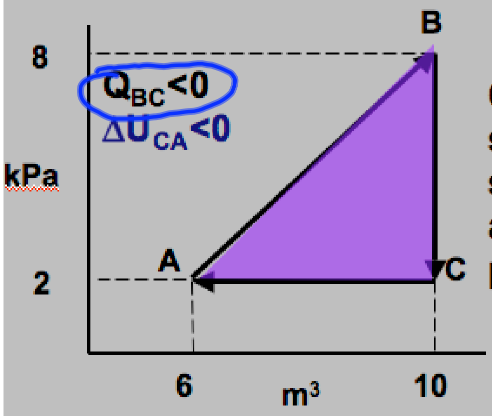
Final Exam Crib Sheet
Worksheets and Questions
Heat Engine Worksheet
Thermodynamics Questions
Mass on a Spring Worksheet
DDHO Worksheet
Physical Optics Questions
Color and Light Questions
Blackbody Radiation Worksheet
Photoelectric Effect Worksheet
Compton Effect Worksheet
Wave Function Worksheet
| Resources |

- When an ideal gas undergoes a free expansion, its temperature is unchanged. Yet, when the gas undergoes an adiabatic expansion against a piston, its temperature drops. Why the difference?




Consider the process shown. Determine the signs of Q, W, and ΔU associated with each process.

$\Delta U = Q - W$

$\Delta U_{cycle} = 0$

$Q_{cycle} > 0$

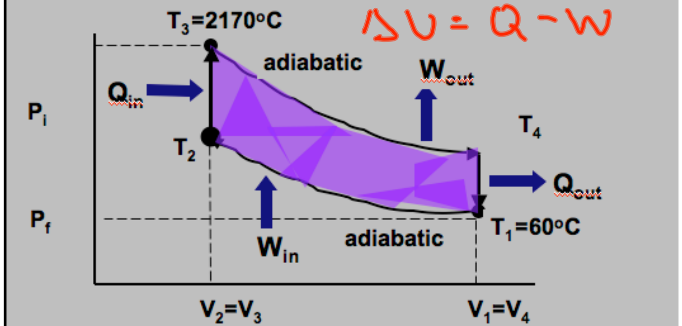
$W_{AB} > 0$ $W_{BC} = 0$

$W_{CA} < 0$ $W_{cycle} > 0$

$\Delta U_{BC} < 0$ $Q_{CA} < 0$ and less than $W_{CA}$

$\Delta U_{AB} > 0$ $Q_{AB} > 0$ greater than $W_{AB}$

Consider the PV diagram of Internal Combustion Engine




Otto Cycle (1876)

$\Delta U = Q - W$

## Internal Combustion Engine Cycle (Continued)

**Given Information**

$P_1$=1atm; $T_1$=60°C

$P_2$=15atm; $T_3$=2170°C

$\gamma = C_p/C_v = 1.4$ (ideal gas)

$V_2=V_3$; $V_1=V_4$

What are $T_2$, $T_4$, $W_{in}$/mole, $W_{out}$/mole, $Q_{out}$/mole, $W_{cycle}$/mole, and $V_2/V_1$=r the compression ratio of the engine?

If the process 1→2 is isothermal, what is work done per mole of the gas?

$W_{23} = 0$

$W_{41} = 0$

$W_{12} = -\Delta U_{12}$

$W_{12} = n C_v (T_1 - T_2)$

$\frac{W_{12}}{n} = C_v (T_1 - T_2)$

$C_v = \frac{5}{2} R$

$T_1 V_1^{r-1} = T_2 V_2^{r-1}$

$V = \frac{nRT}{P}$

$T_1 \left(\frac{nRT_1}{P_1}\right)^{r-1} = T_2 \left(\frac{nRT_2}{P_2}\right)^{r-1}$

$T_1 (T_1)^{r-1} \left(\frac{1}{P_1}\right)^{r-1} = T_2 (T_2)^{r-1} \left(\frac{1}{P_2}\right)^{r-1}$

$T_1^{r} P_1^{1-r} = T_2^{r} P_2^{1-r}$

$T_1^{r} \left(\frac{P_1}{P_2}\right)^{1-r} = T_2^{r}$

$\left[T_1^{r} \left(\frac{P_1}{P_2}\right)^{1-r}\right]^{\frac{1}{r}} = T_2 = T_1 \left(\frac{P_1}{P_2}\right)^{\frac{1-r}{r}}$

$r = 1.4$

$T_2 = 333\text{K} \left(\frac{1}{15}\right)^{\frac{1-1.4}{1.4}} = 722\text{K}$

$= 449°\text{C}$

$\frac{W_{12}}{n} = \frac{5}{2} R (333 - 722) = -8080 \frac{\text{J}}{\text{mol}}$

- A gasoline engine in a large truck takes in 10,000J of heat and delivers 2000J mechanical work per cycle. The heat is obtained by burning fuel with a heat of combustion $L_C=5.0\times10^4$J/g.
  - What is the efficiency of this engine?
  - How much heat is discarded per cycle?
  - How much gasoline is burned each cycle?
  - If there are 25 cycles/s, what is its output power?

$$e = \frac{W}{Q_H} = \frac{2000\,J}{10{,}000\,J} = 0.2 \quad 20\%$$

$$Q_C = 10{,}000\,J - 2{,}000\,J = 8000\,J$$

$$m = \frac{Q}{L_C} = \frac{10{,}000\,J}{50{,}000\,J/g} = 0.2\,g$$

$$P = \left(25\,\frac{\text{cycles}}{s}\right)\left(2000\,J/\text{cycle}\right)\left(\frac{1\,hp}{746\,W}\right) = 67\,hp$$

$$W_{34} = -\Delta U = n C_v (T_3 - T_4)$$

$$\frac{W_{34}}{n} = \frac{5}{2} R (T_3 - T_4)$$

$$T_3 = 2170°C$$

$$V_2 = V_3 \; ; \quad V_1 = V_4$$

$$T_3 V_3^{r-1} = T_4 V_4^{r-1}$$

$$T_4 = T_3 \left(\frac{V_3}{V_4}\right)^{r-1} = T_3 \left(\frac{V_2}{V_1}\right)^{r-1}$$

$$T_1 V_1^{r-1} = T_2 V_2^{r-1} \qquad \frac{T_1}{T_2} = \left(\frac{V_3}{V_1}\right)^{r-1}$$

$$T_4 = T_3 \left(\frac{T_1}{T_2}\right)$$

$$(2170 + 273)\left(\frac{333}{722}\right) = 1127K$$

$$854°C$$

$$\frac{W_{34}}{n} = \frac{5}{2} R (2170°C - 854°C)$$

$$= 27.3 \, kJ/mol$$