Example A tire has $V = 0.0150\,m^3$ on a $5°C$ day where pressure outside is 1.02 atm. P_{gauge} in the tire is 1.70 atm. After 30 minutes of driving, the T inside the tire is $45.0°C$ and $V = 0.0159\,m^3$.

What is the new P_{gauge}? $P_{total} = P_{gauge} + P_{ambient}$

$\rightarrow P_i = 1.70 + 1.02 = 2.72\,atm$

$$\frac{P_i V_i}{T_i} = Nk = \frac{P_f V_f}{T_f} \rightarrow P_f = \frac{P_i V_i T_f}{V_f T_i}$$

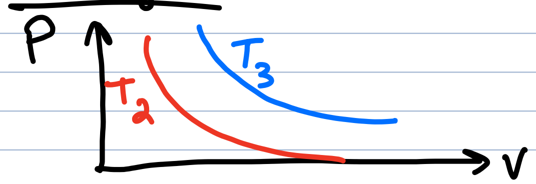
$$= (2.72\,atm)\frac{0.0150\,m^3}{0.0159\,m^3}\,\frac{318\,K}{278\,K} = 2.94\,atm \rightarrow P_{f\,gauge} = P_f - P_{ambient} = 1.92\,atm$$

ch03 1st Law of Thermodynamics

Concept Q s0.html
adding heat:

1. increase P
2. increase V
3. phase change
4. increase T

PV diagrams



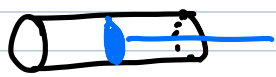
isotherm: T = constant = PV = constant (assuming N unchanged)

$T_3 > T_2$

curves are $\sim \frac{1}{x}$ makes sense since $P \propto \frac{1}{V}$

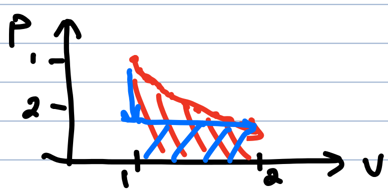
ch03 s1.html concept Q D

An automobile engine involves thermodynamic processes.

Consider a piston  Combustion raises T and/or P → V increases

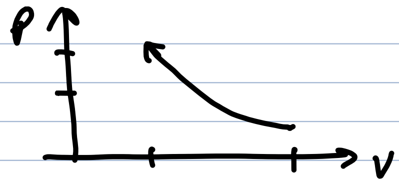
→ gas does work on piston

$$W = \int dW = \int \vec{F}\cdot d\vec{x} = \int PA\,dx = \int_{V_1}^{V_2} P\,dV$$



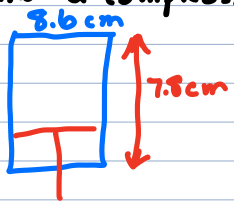
Work depends on path! The areas under the two curves differ

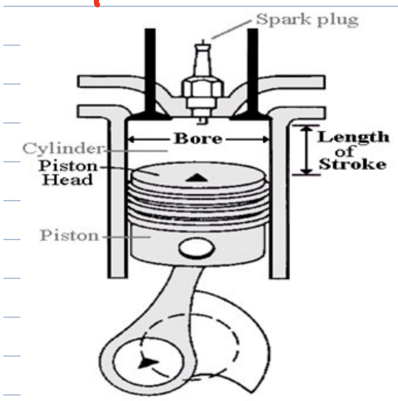
Suppose V↓ and P↑



Gas does "negative" work on the piston

<u>example</u> A Porsche Boxster has a 6-cylinder engine with a stroke length of 7.8 cm, a bore (cylinder diameter) of 8.6 cm, a total volume of 2687 cm^3 and a compression ratio of 11.3 : 1. Find its horsepower at 7200 rpm.





$$W = \int P\,dV = \int \frac{NkT}{V}\,dV \approx NkT_1 \int \frac{dV}{V}$$

$$= NkT_1 \ln V \Big|_1^2 = NkT_1 \ln V_2/V_1$$

$$= P_1V_1 \ln V_2/V_1 \rightarrow \text{if } P_1 = 1\,atm \text{ and } V_1 = 2687\,cm^3$$

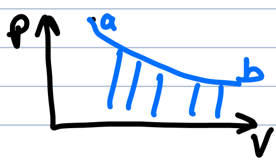
$$\rightarrow W = 660\,J$$

$1\,hp = 746\,W = 746\,J/s$ and $\frac{7200\,rev/min}{60\,sec/min} \rightarrow 120\,\frac{rev}{sec}$; $120\,\frac{stroke}{sec}$

→ Power in energy/time → $\frac{work}{stroke} = \frac{660\,J}{\frac{1}{120}\,sec} \cdot \frac{1\,hp}{746\,W} = 106\,hp$

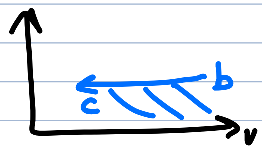
<u>more PV fun!</u>

Gas expands



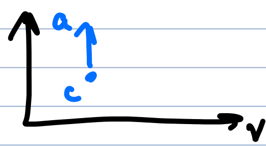
Work done by gas is > 0

Gas shrinks



work done by gas < 0

P increases without changing V

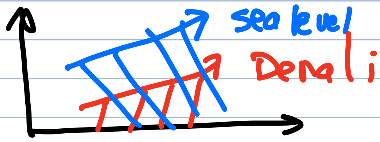


no work done by gas

→ Total work done over the complete cycle is positive: $W_{ab} + W_{bc} + W_{ca} > 0$

ch03/concept Q s2 → [D] most work

ch03/concept Q s3



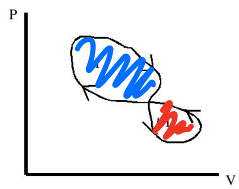
1st Law of Thermo

$\Delta U = Q - W$ where U is the internal (KE+PE) energy of a system
→ adding heat Q increases U
→ Doing work W decreases U

Concept Q s4.html

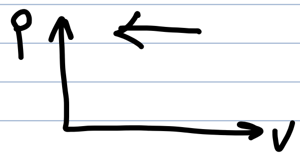
1) (A) →

2) (B)
3) (A) →

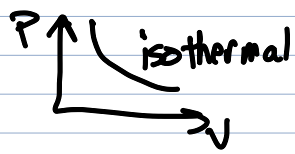


4) (A)
5)

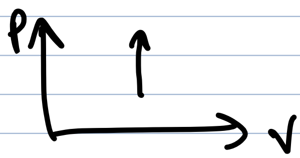
Blue area is larger than red area



isobaric $W_{gas} < 0$



$T =$ constant $\Rightarrow \Delta U = 0$ since $U \sim \frac{3}{2}kT$



no change in V $\Rightarrow W = 0 \Rightarrow \Delta U = Q$
isochoric

→ come back to concept Q #4