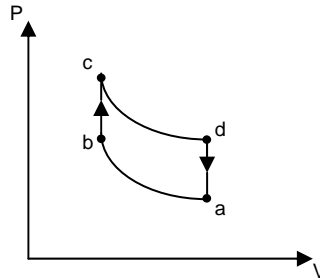


Homework #2

Problems to hand in

1. A diatomic ideal gas has a (total) heat capacity given by $C_v = \frac{5}{2}Nk$. One mole of such a gas performs a transformation from an initial state for which the temperature and volume are 291°K and $21 \times 10^3 \text{ cm}^3$, to a final state in which the temperature and volume are 305°K and $12.7 \times 10^3 \text{ cm}^3$. This particular transformation is represented on the (V, p) plane by a straight line. Find the work performed and the heat absorbed or discharged by the system.
2.
 - a. Show that if a (monoatomic) ideal gas undergoes an adiabatic expansion, then $T / P^{2/5} = \text{const}$.
 - b. Use this result to calculate the dependence of the temperature of the atmosphere on the height above sea level. Assume that the force due to gravity has magnitude mg , and that the average molecular weight of air is 28.88. You should find that by going to a higher altitude, the temperature changes by -13.6 degrees/kilometer.
2. The operation of an automobile internal combustion engine can be approximated by a reversible cycle known as the Otto cycle. The P-V diagram for this cycle is shown in the figure. Paths ab and cd are adiabatic, and paths bc and da are at constant volume.



Show that, assuming a monoatomic ideal gas is used, the efficiency of an Otto cycle engine is

$$1 - \left(\frac{V_a}{V_b} \right)^{-2/3}.$$

In an automobile, the cycle works as follows. A fuel-air mixture enters the engine's cylinder at point a and is compressed adiabatically (the "compression stroke") to point b. At b, ignition occurs via the spark plug, and the burning of the fuel adds heat $|Q_H|$ to the system at approximately constant volume. The temperature and pressure rise, and then in the "power stroke" cd, the gas expands adiabatically. In the "exhaust stroke" da, heat $|Q_L|$ is ejected to the environment. In a real engine, the gas leaves the engine and is replaced by a new fuel-air mixture.

Other problems (don't hand in, but these might appear on the exam)

1. Are these exact differentials? If so, find the functions F :

a) $dF = (3y + e^x)dx + (3x + \cos y)dy$

b) $dF = (3x^2y + 8xy^2)dx + (x^3 + 8x^2y + 12y^2)dy$

c) $dF = (4x^3e^{x+y} + x^4e^{x+y} + 2x)dx + (x^4e^{x+y} + 2y)dy$

2. Find an integrating factor g such that

$$dF = \left[g \left(\frac{y^2}{2} + 2ye^x \right) \right] dx + \left[g(y + e^x) \right] dy$$

is exact. What is F ?

3. Calculate the work performed by a body expanding from an initial volume of 3.12 liters to a final volume of 4.01 liters at the pressure of 2.34 atmospheres.

4. Calculate the pressure of 30 grams of hydrogen inside a container of 1 cubic meter at the temperature 18°C .

5. Calculate the density and specific volume of nitrogen at the temperature 0°C and one atmosphere of pressure.

6. Calculate the work performed by 10 grams of oxygen expanding isothermally at 20°C from 1 to 0.3 atmospheres of pressure.

7. If all the gravitational potential energy gained by lifting one kilogram of water is converted to heat and delivered to the water, how high must one lift this mass so that the temperature rises by 10°C ?

8. Work through the examples on exact and inexact differentials on pages 26-32 in Greiner.