

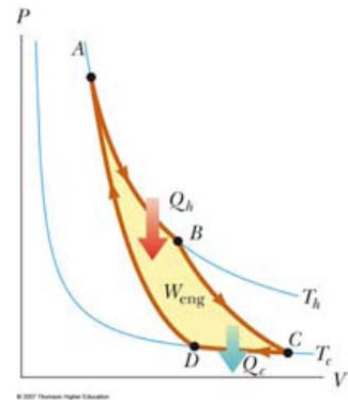


SN: _____, Name: _____

ABSOLUTELY NO CHEATING!

Problems (5 Problems, total 100%)

- Carnot Engine:** (total 20%) Refer to the figure on the right for the P-V diagram of a typical Carnot Engine. The heat (energy) absorbed in the isothermal expansion at temperature T_h is Q_h , and the isothermal compression at temperature T_c gives up heat (energy) Q_c . (a) (10%) what is the efficiency (e) of the Carnot engine in terms of the temperature T_h and T_c ? (b) (5%) What is the requirement to have a perfect efficiency, i.e. $e=1$? (c) (5%) Why it is not possible to have an ideal engine ($e=1$) in reality? Assume, the Carnot Engine operates with ideal gas and the PV relationship for the ideal gas is $PV^\gamma = constant$, where $\gamma=C_p/C_v$.



- Electric field of a charged sphere:** (20%) What is the electric field of a spherically symmetric charged sphere of total charge Q ? (1) at a distance r outside the sphere from the center, (2) at a distance r from the center inside the sphere. (3) Plot the electric field as a function of distance from the center of the sphere. Assume the radius of the sphere is R .
- Electric dipole in electric field:** (20%) Suppose an electric dipole (P) with charge Q , separated by a distance $2a$ is placed in an electric field E . The dipole makes an angle θ with the electric field. (1) What is the torque of the dipole experienced due to the electric field? (2) What is the electric potential in this system, i.e. the energy stored in this dipole-electric field system?
- Free expansion and entropy:** (20%) (a) What is entropy? Can you give a quantitative definition on entropy in terms of measurable quantity such as heat (Q) and temperature (T)? (b) In the adiabatic free expansion case, suppose ideal gas free-expanded from an enclosed compartment of volumes $V_i \rightarrow V_f$ at temperature T , what is the entropy change in this process of this system?

- Charged Ring:** (20%) Refer to the figure on the right, (1) what is the electric field at a distance x from the center of the ring at point P ? (2) What will be the electric field if x is significantly large than a ?

