Problem 1

An aircraft engine takes in an amount 8800 J of heat and discards an amount 6400 J each cycle.
(a) What is the mechanical work output of the engine during one cycle?
(b) What is the thermal efficiency of the engine (answer in percentage)?

Problem 2

A gasoline engine takes in 1.45×10^4 J and delivers 3800 J of work per cycle. The heat is obtained by burning gasoline with a heat of combustion of 4.60×10^4 J/g.
(a) What is the thermal efficiency in percent?
(b) How much heat is discarded in each cycle?
(c) Knowing that the heat of combustion is $Q_H = mL_c$, determine the mass of fuel in grams that is burned in each cycle.

Problem 3

A monatomic ideal gas has pressure p_1 and temperature T_1. It is contained in a cylinder of volume V_1 with a movable piston, so that it can do work on the outside world.

Consider the following three-step transformation of the gas:

1. The gas is heated at constant volume until the pressure reaches Ap_1 (where $A > 1$).
2. The gas is then expanded at constant temperature until the pressure returns to p_1.
3. The gas is then cooled at constant pressure until the volume has returned to V_1.

It may be helpful to sketch this process on the pV plane.

Answer the following questions using the parameters p_1, V_1, T_1, and A.
(a) How much heat Q_1 is added to the gas during step 1 of the process?
(b) How much work W_2 is done by the gas during step 2?
(c) How much work W_3 is done by the gas during step 3?

Problem 4

The Otto-cycle engine in a Mercedes-Benz SLK230 has a compression ratio of 8.8.
(a) What is the ideal efficiency of the engine? Use $\gamma = 1.40$.
(b) The engine in a Dodge Viper GT2 has a slightly higher compression ratio of 9.6. How much increase in the ideal efficiency results from this increase in the compression ratio?

Problem 5

A freezer has a coefficient of performance of 2.40. The freezer is to convert 1.80 kg of water at 25.0 °C to 1.80 kg of ice at −5.0 °C in one hour.
(a) What amount of heat must be removed from the water at 25.0 °C to convert it to ice at −5.0 °C, $|Q_C|$?
8.09×10^5 J
(b) How much electrical energy is consumed by the freezer during this hour, $|W|$?
(c) How much wasted heat is rejected to the room in which the freezer sits, $|Q_H|$?

Problem 6

An ice-making machine operates in a Carnot cycle. It takes heat from water at 0.0 °C and rejects heat to a room of temperature 21.5 °C. Suppose that a mass 83.0 kg of water at 0.0 °C is converted to ice at 0.0 °C.
(a) How much heat is rejected to the room, $|Q_H|$?

(b) How much energy must be supplied to the device, $|W|$?

Problem 7

A Carnot engine performs 2.5×10^4 J of work in each cycle and has an efficiency of 66%.
(a) How much heat does the engine extract from its heat source in each cycle?
(b) If the engine exhausts heat at room temperature (20.0 °C), what is the temperature of its heat source?

Problem 8

A teenager with nothing better to do adds heat to 0.410 kg of ice at 0.0 °C until it is all melted.
(a) What is the change in entropy of the water?
(b) The source of heat is a very massive body at a temperature of 25.0 °C. What is the change in entropy of this body?

Problem 9

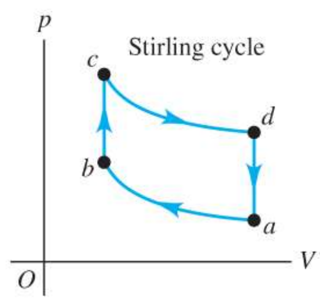
Two moles of an ideal gas undergo a reversible isothermal expansion from 2.52×10^{-2} m^3 to 4.37×10^{-2} m^3 at a temperature of 27.1 °C. What is the change in entropy ΔS of the gas?

Problem 10

A thin partition divides a thermally insulated vessel into a lower compartment of volume V and an upper compartment of volume 2V. The lower compartment contains n moles of an ideal gas; the upper part is evacuated. When the partition is removed, the gas expands and fills both compartments. How many moles n of gas were initially contained in the lower compartment if the entropy change of the gas in this free-expansion process is 17.28 J/K?

Problem 11

In an ideal Stirling engine, n moles of an ideal gas are isothermally compressed, pressurized at constant volume, allowed to expand isothermally, and then cooled at constant volume, as shown in the figure. The expansion takes place at temperature T_H and the compression at temperature T_C. The quantity $B = p_c/p_d = p_b/p_a$ is called the compression ratio of the engine.



(a) Determine the work done in terms of T_H, n, R, and B during the expansion phase.
(b) Determine the work done in terms of T_C, n, R, and B during the compression phase.
(c) An ideal Stirling engine uses 1 mole of helium as its working substance and has a compression ratio of 10, temperature reservoirs at 100 °C and 20 °C, and a frequency of operation of 100 Hz. What is its power output?