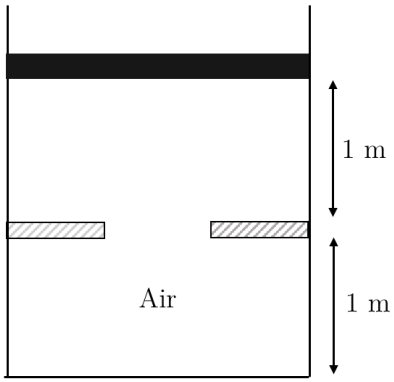
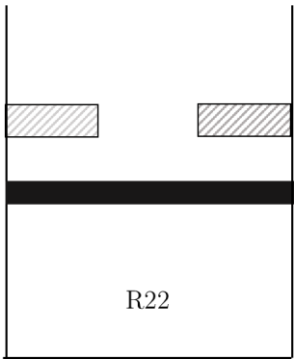
Tutorial-II
Energy, Heat and Work
&
First Law (Closed System)

1. A piston/cylinder arrangement is initially as shown in Fig. It contains air at 150 kPa, 400°C. The setup is allowed to cool to the ambient temperature of 20°C. Answer the following:
   a. Is the piston resting on the stops in the final state?
   b. What is the final pressure in the cylinder?
   c. What is the specific work done by the air during this process?
   d. What is the heat transfer per unit mass of air in the process?

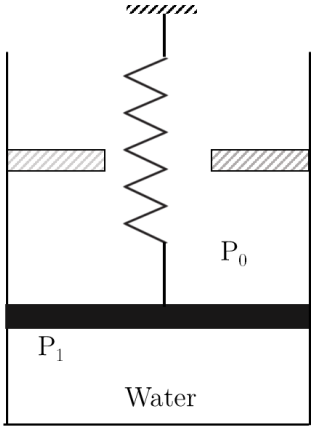


2. Fluid R-22 is contained inside a piston/cylinder as shown in (see Fig.), where the volume is 11 L when the piston hits the stops. The initial state is 15°C, 150 kPa with volume of 10 L. This system warms up to 30°C.
   a. Is the piston at the stops in the final state?
   b. Find the work done by R-22 during this process.
   c. Determine the total heat transfer in the overall process.



3. A balloon behaves such that the pressure inside it is proportional to the diameter squared. It contains 2 kg of ammonia initially at 0°C and 60% quality. The balloon and ammonia are now heated so that a final pressure of 600 kPa is reached. Considering the ammonia as the control mass, find the amount of work done and heat transfer in this process.

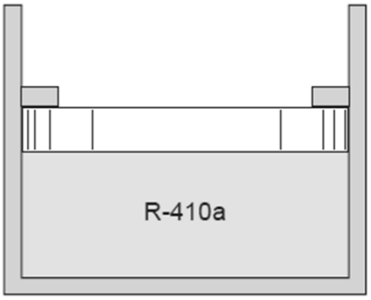
4. Two kilograms of water is contained inside a piston/cylinder (see Fig.) with a massless piston loaded with a linear spring and an outside atmospheric pressure P_0 = 100 kPa. Initially the spring force is zero and $P_1 = P_0$ and volume of water = 0.2 m³. Heat is now added until the pressure reaches 1.2 MPa. When the piston just hits the upper stops the volume is 0.8 m³ and T= 600°C. Find the final temperature, show the P-V diagram and find the heat transfer during the process.



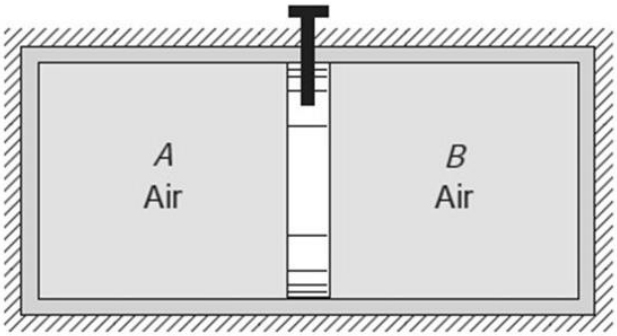
5. Air at 200 kPa, 30°C is contained in a cylinder/piston arrangement with initial volume 0.1 m^3. The inside pressure balances ambient pressure of 100 kPa in addition to an externally imposed force that is proportional to $V^{0.5}$. Now heat is transferred to the system to obtain a final pressure of 225 kPa. Find the final temperature and the work done in the process.

6. A spring-loaded piston/cylinder arrangement contains R-134a at 20°C, 24% quality with a volume 50 L. The setup is heated and thus expands, moving the piston. It is noted that when the last drop of liquid disappears the temperature is 40°C. The heating is stopped when T= 130°C. Sketch the process on P-v diagram and determine the final pressure of R134a (*may require iteration*).

7. A piston/cylinder shown in Fig. contains 0.5 m^3 of R-410a at 2 MPa, 150°C. The piston mass and atmosphere give a pressure of 450 kPa that will float the piston. The whole setup cools in a freezer. Find the heat transfer and sketch the process on P–v chart if the final temperature = −20°C.



8. An insulated cylinder is divided into two parts of 1 m^3 each by an initially locked piston, as shown in Fig. Side A has air at 200 kPa, 300 K, and side B has air at 1.0 MPa, 1000 K. The piston is now unlocked so that it is free to move, and it conducts heat so that the air comes to a uniform temperature $T_A = T_B$. Find the mass in both A and B and the final T and P.



9. A piston/cylinder arrangement B is connected to a 1-m^3 tank A by a line and valve, shown in Fig. Initially both contain water, with A at 100 kPa, saturated vapor and B at 400°C, 300 kPa, 1 m^3. The valve is now opened, and the water in both A and B comes to a uniform state.

a. Find the initial mass in A and B.

b. If the process results in $T_2 = 200°C$, find the heat transfer and the work.