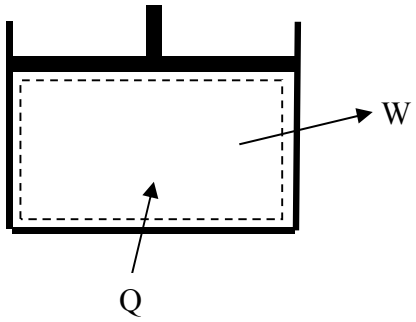
CANKAYA UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL ENGINEERING DEPARTMENT

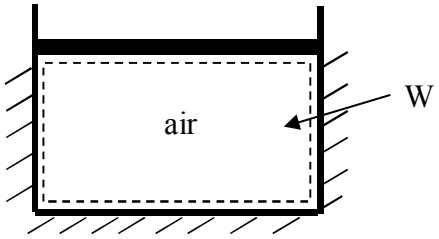
ME 211 THERMODYNAMICS I

CHAPTER 2 EXAMPLES

1) Oxygen at 300 K expands slowly and isothermally from 100 kPa to 45 kPa. The mass of oxygen is 0.052 kg. Using ideal gas model find the work done.



2) A well insulated piston cylinder assembly contains 0.031 m^3 of air at 40°C and 102 kPa. Find the work required to compress the air slowly to 350 kPa.



3) A shaft rotates at a rate of 120 rev per minute against a constant torque of 1000 N.m. Calculate the power required to rotate the shaft Find the work required to rotate the shaft through 60 revolutions.

4) One forth kg of a gas contained within a piston and cylinder assembly undergoes a constant-pressure process at 5 bar beginning at $v_1 = 0.2$ m^3/kg. For the gas as the system, the work is -15kJ. Determine the final volume of the gas, in m^3.

5) A gas is compressed from $V_1 = 0.3$ m^3, $p_1 = 1$ bar to $V_2 = 0.1$ m^3, $p_2 = 3$ bar. Pressure and volume are related linearly during the process. For the gas, find the work, in kJ.

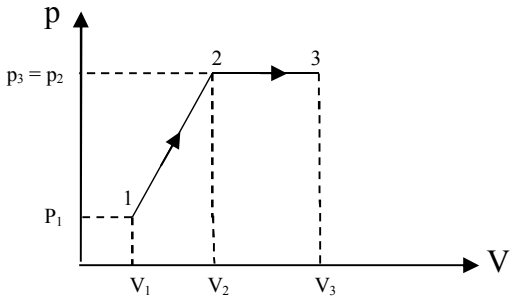
6) A closed system undergoes a process during which there is energy transfer from the system by heat at a constant rate of 10 kW, and power varies with time according to:

$$\dot{W} = \begin{cases} -8t & 0 < t < 1h \\ -8 & t > 1h \end{cases} \quad (h\_hour)$$

where t is time in hour and $\dot{W}$ is in kW.

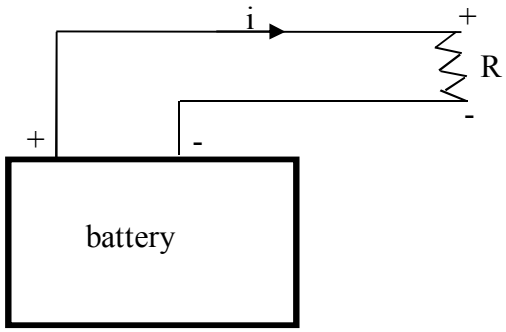
a) What is the time rate of change of system energy at t = 0.6 h, in kW?
b) Determine the change in system energy after 2 h, in kJ.

7) Carbondioxide (CO_2) is slowly heated from an initial temperature of 50°C to a final temperature of 500°C. The process occurs in two steps. In the first step, pressure varies linearly with volume; in the second step pressure is constant as shown in the figure below:



The initial pressure, p_1, is 100 kPa and the final pressure, p_3, is 150 kPa. The temperature, T_2, at at the end of first step is 350°C. If the mass of CO_2 is 0.044 kg, calculate the total work done.

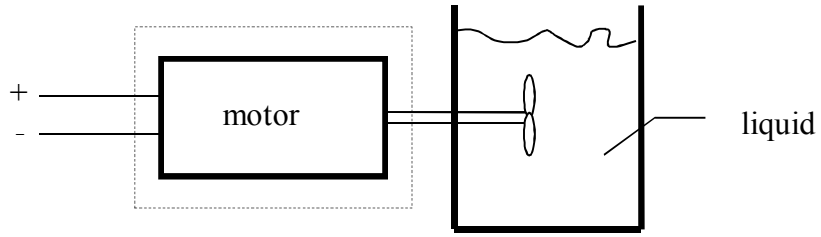
8) In the simple circuit shown in the figure below, the battery has a voltage of 10 Volts and the resistor has a resistance of 25Ω. In the span of 5 minutes how much work is done by battery on the resisters?



9) A constant speed motor drives a paddle-wheel that is submerged in a viscous fluid. With time, the temperature of the liquid increases, the liquid viscosity decreases and less work is needed for the stirring action. The torque applied as a function of time is determined experimentally to be:

$$\Gamma = A + Be^{-mt}$$

If the motor rotates at constant speed of ω (rpm) calculate the work done by motor on the liquid in the first t_f minutes of operation.



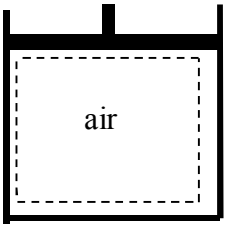
10) An elastic balloon has a diameter of 0.5 m and is filled with gas at a pressure of 200kPa.The gas is heated so that its diameter increases to 0.6 m and a pressure to 250 kPa. During the process, the pressure is proportional to the balloon's diameter.Calculate
(a) The work done by the gas during the process
(b) The work done by the balloon on the atmosphere.

11) Measured data for pressure versus volume during the expansion of gases within the cylinder of an internal combustion engine are given in the table below. Using data from the table, complete the following:
(a) Determine a value of n such that the data are fit by an equation of the form, $pV^n = constant$
(b) Evaluate analytically the work done by the gases, in kJ,. using Eq. 2.17 along with the result of part (a)
(c) Using graphical or numerical integration of the data, evaluate the work done by the gases, in kJ.
(d) Compare the different methods for estimating the work used in parts (b) and (c). Why are they estimates different?

Data Point	***p* (bar)**	***V* (cm3)**
1	15	300
2	12	361
3	9	459
4	6	644
5	4	903
6	2	1608

12) A gas is contained in a piston cylinder assembly. The gas is compressed when 670 J of work are done on it. Over the same period, a paddle wheel does 182 J of work on the gas and internal energy decreases by 201 J. How much heat has been transferred during the process? Was the gas heated or cooled?

13) Air is contained in a vertical piston-cylinder assembly by a piston of mass 50 kg and having a face area of 0.01 m^2.

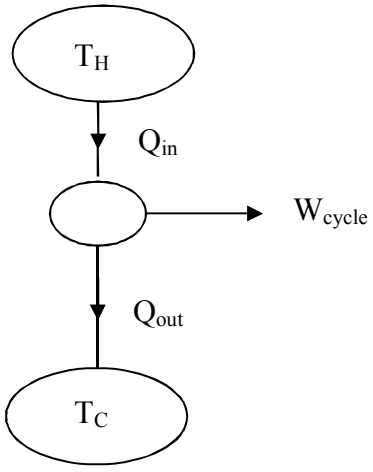


The mass of the air is 5 g, and initially the air occupies a volume of 5 liters. The atmosphere exerts a pressure of 100 kPa on top of the piston. The volume of the air slowly decreases to 0.002 m^3 as the specific internal energy of the air decreases by 260 kJ/kg. Neglecting friction between the piston and cylinder wall, determine the heat transfer to air, in kJ.

14) During a cycle ,composed of 4 processes, the heat transfers were 23 BTU, -4 BTU, -10 BTU, and 2 BTU. Determine the net work for the cycle.

15) Helium gas is contained in a closed rigid tank. An electric resistor in the tank transfers energy *to* the gas at a constant rate of 1 kW. Heat transfer *from* the gas to its surroundings occurs at a rate of 5*t* watts, where *t* is time, in minutes. Plot the change in energy of the helium, in kJ, for $t \geq 0$ and comment.

16) For the power cycle operating as shown:



The heat transfers are Q_{in} = 50 kJ and Q_{out} = 35 kJ. Determine the net work, in kJ and the thermal efficiency.