Aalto University
School of Engineering

COE-C2007 Themodynamics, 2022

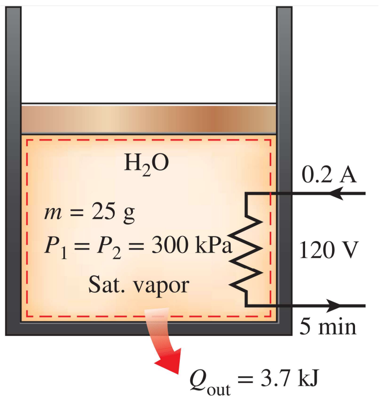
Learning Exercise 2

The exercise is to be completed independently (do not copy paste from other students) and returned as a single pdf report with appropriate use of pictures and charts, as well as presentation of used equations in possible calculations. Name the uploaded pdf-file so that it tells the course, learning exercise number and your name, like Thermodynamics_LE2_Lastname.pdf

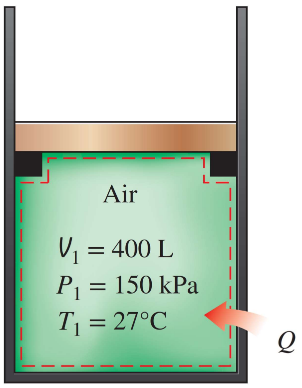
No single question/problem is compulsory, but a minimum of 50 % of points is required in order to pass the exercise. Include also your name and student number on the first page of the report. A proper length of an answer per question would be maximum 1 page. The time for answering this exercise is estimated not to exceed 8 hours, provided that you have attended lectures.

Return DL of LE2: Friday January 28, 2021, 23:55, in MyCourses.

1. A piston–cylinder device contains 25 g of saturated water vapor that is maintained at a constant pressure of 300 kPa. A resistance heater within the cylinder is turned on and passes a current of 0.2 A for 5 min from a 120-V source. At the same time, a heat loss of 3.7 kJ occurs. (a) Show that for a closed system the boundary work Wb and the change in internal energy ΔU in the first-law relation can be combined into one term, ΔH, for a constant-pressure process. (b) Determine the final temperature of the steam.? **(10 Points) (Lecture 3)**

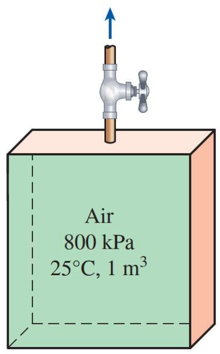


2. A piston–cylinder device initially contains air at 150 kPa and 27°C. At this state, the piston is resting on a pair of stops, as shown in Fig. 4–32, and the enclosed volume is 400 L. The mass of the piston is such that a 350-kPa pressure is required to move it. The air is now heated until its volume has doubled. Determine (a) the final temperature, (b) the work done by the air, and (c) the total heat transferred to the air**. (10 Points) (Lecture 3)**

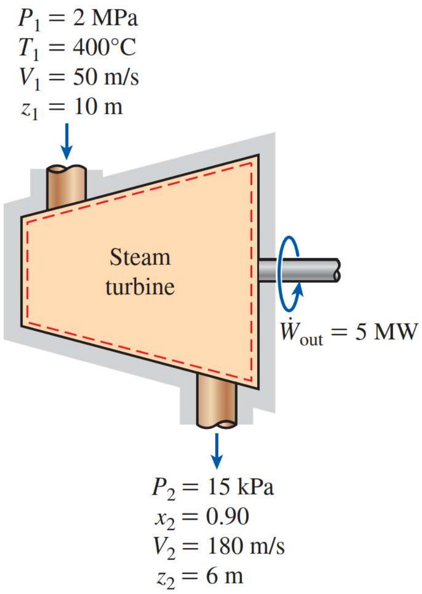


3. Determine the enthalpy of liquid water at 100°C and 15 MPa (a) by using compressed liquid tables, (b) by approximating it as a saturated liquid, and (c) by using the correction given by $h_{@P,T} \cong h_{f\,@\,T} + v_{f\,@\,T}(P - P_{sat\,@\,T})$. **(15 Points) (Lecture 3)**

4. A tank with an internal volume of 1 m3 contains air at 800 kPa and 25°C. A valve on the tank is opened, allowing air to escape, and the pressure inside quickly drops to 150 kPa, at which point the valve is closed. Assume there is negligible heat transfer from the tank to the air left in the tank.
(a) Using the approximation $h_e \approx constant = h_{e,avg} = 0.5(h_1 + h_2)$, calculate the mass withdrawn during the process.
(b) Consider the same process but broken into two parts. That is, consider an intermediate state at $P_2 = 400kPa$, calculate the mass removed during the process from $P_1 = 800kPa$ to P_2 and then the mass removed during the process from P_2 to $P_3 = 150kPa$, using the type of approximation used in part (a), and add the two to get the total mass removed.
(c) Calculate the mass removed if the variation of he is accounted for. **(15 Points) (Lecture 4)**

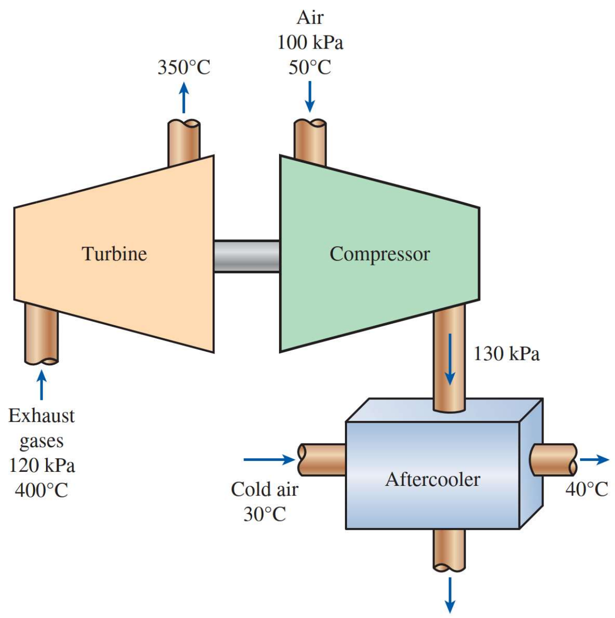


5. The power output of an adiabatic steam turbine is 5 MW, and the inlet and the exit conditions of the steam are as indicated in Fig. 5–31. (a) Compare the magnitudes of Δh, Δke, and Δpe. (b) Determine the work done per unit mass of the steam flowing through the turbine. (c) Calculate the mass flow rate of the steam. **(20 Points) (Lecture 4)**



6. The turbocharger of an internal combustion engine consists of a turbine and a compressor. Hot exhaust gases flow through the turbine to produce work, and the work output from the turbine is used as the work input to the compressor. The pressure of ambient air is increased

as it flows through the compressor before it enters the engine cylinders. Thus, the purpose of a turbocharger is to increase the pressure of air so that more air gets into the cylinder. Consequently, more fuel can be burned and more power can be produced by the engine.In a turbocharger, exhaust gases enter the turbine at 400°C and 120 kPa at a rate of 0.02 kg/s and leave at 350°C. Air enters the compressor at 50°C and 100 kPa and leaves at 130 kPa at a rate of 0.018 kg/s. The compressor increases the air pressure with a side effect: It also increases the air temperature, which increases the possibility that a gasoline engine will experience an engine knock. To avoid this, an aftercooler is placed after the compressor to cool the warm air with cold ambient air before it enters the engine cylinders. It is estimated that the aftercooler must decrease the air temperature below 80°C if knock is to be avoided. The cold ambient air enters the aftercooler at 30°C and leaves at 40°C. Disregarding any frictional losses in the turbine and the compressor and treating the exhaust gases as air, determine (a) the temperature of the air at the compressor outlet and (b) the minimum volume flow rate of ambient air required to avoid knock. **(30 Points) (Lecture 4)**



7. **Your free feedback on the first weeks and time spent on this learning exercise.** (This does not affect the grading)