Final exam (22.11.2013) Examiner: Jussi Maunuksela

In the exam, you are allowed to use

- your copy of the property tables handout.

Remember to

1. write down the exam date, course code and name of examiner to **every** answer sheet
2. hand back your question paper and formula collection attached to your exam answers.

Start a new page for each of these exam questions:

1. Write a short answers:
   (a) Air at normal temperature and pressure contained in a closed tank adheres to the continuum hypothesis. When sufficient air has been drawn from the tank, explain why the hypothesis no longer applies to the remaining air.
   (b) Define the term "property" and list typical intensive properties of thermodynamic systems.
2. In mountains, air cooling can be caused by air flow up a steep slope or mountain side. Using thermodynamic analysis, estimate the change in temperature of rising air with elevation under adiabatic conditions, in K/m.
3. Create a systematic approach for estimating the average velocity at the exit (v_e) of a hair dryer (suom. *hiustenkuivain*) with a known power rating ($\dot{W}_e$) using values measured with a thermometer (suom. *lämpömittari*) and a tape measure (suom. *mittanauha*).
4. An inventor claims to have developed a device requiring no energy transfer by work or heat transfer, yet able to produce hot and cold streams of air from a single stream of air at an intermediate temperature. The invertor provides steady-state test data indicating that when air enters at a temperature of 21°C and a pressure of 5 bar, separate streams of air exit at temperatures of −49°C and 126°C, respectively, and each at a pressure of 1 bar. Sixty percent of the mass entering the device exits at the lower temperature. Evaluate the invertor's claim, employing the ideal gas model for air and ignoring changes in the kinetic and potential energies of the streams from inlet to exit. Draw a schematic of the system.
5. An ideal gas with constant specific heat ratio k enters a turbine operating at steady state at T_1 and p_1 and expands adiabatically to T_2 and p_2. When would the value of the second law (exergetic) turbine efficiency exceed the value of the isentropic turbine efficiency? Ignore the effecs of motion and gravity.