For Air: k= 1.4; C_p = 1.004 kJ/kg K; C_v = 0.717 kJ/kg; R=0.287 kJ/kg K
For Helium: k= 1.66; C_p = 5.1926 kJ/kg; C_v = 3.1156 kJ/kg; R=2.0769 kJ/kg K
For Nitrogen: k= 1.4; C_p = 1.0398 kJ/kg; C_v = 0.743 kJ/kg; R= 0.2968 kJ/kg K

F.1 Consider a 210 MW steam power plant that operates on a simple Rankine cycle. Steam enters the turbine at 10 MPa and 500°C and is cooled in the condenser at a pressure of 10 kPa.
- a) Show the cycle on a T-s diagram with respect to saturation lines.
- b) Compute the thermal efficiency of the cycle.
- c) Compute the mass flow rate of the steam.

Thermal efficiency	
Mass flow rate of the steam	

F.2 Air is used as the working fluid in a simple ideal Brayton cycle that has a pressure ratio of 12, a compressor inlet temperature of 300 K, and a turbine inlet temperature of 1000 K. Determine the required mass flow rate of air for a net power output of 90 MW, assuming both the compressor and the turbine to be isentropic.

Assume constant specific heats at room temperature.

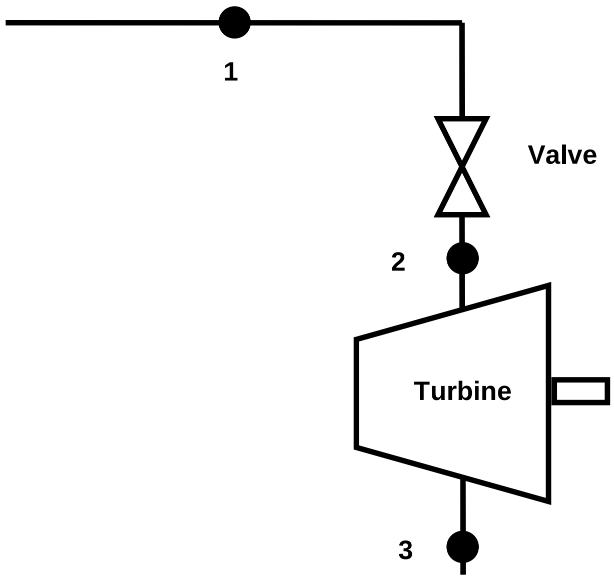
Mass flow rate (100 %)	
Mass flow rate (80 %)	

F.3 The compression ratio of an ideal Otto cycle is 8. At the onset of the compression stroke, the pressure is 0.1 MPa and the temperature is 15°C.
The heat supplied to air, per cycle, is 1800 kJ/kg. Determine:
-a) The pressure, the specific volume and the temperature at each state.
-b) The thermal efficiency.
Assume constant specific heats at room temperature.

	T	**P**	**v**
Point 1			
Point 2			
Point 3			
Point 4			
Thermal efficiency			

F.4 (Fun to try but not included this year 2016) The conditions at the inlet of a steam turbine can be controlled using a valve (see figure below). The pressure before the valve is 1.4 MPa and the temperature 300°C. The pressure at the turbine exit is fixed at 10 kPa. Assuming the expansion through the turbine is adiabatic and reversible, determine:

- The pressure at point (2) to produce 75% of the maximal work.



Pressure (2)	

F.5 Consider an ideal Rankine cycle using steam as the working fluid in which the condenser pressure is 10 kPa. The boiler pressure is 2MPa and the steam leaves the boiler as <u>saturated vapor</u>.

1. Show the cycle on a T-s diagram with respect to saturation lines.
2. Compute the thermal efficiency of the cycle. (Note that the quality at the outlet of the turbine will be between 70% and 100%).

Thermal efficiency	

F.6 Consider an air-standard Brayton cycle with air entering the compressor at 0.1 MPa and 15ºC and leaving at a pressure of 1.0 MPa. The maximum temperature is 1100ºC. Assume a compressor efficiency of 100%, a turbine efficiency of 100%, and <u>a pressure drop between the compressor and the turbine of 15 kPa</u>. Determine:

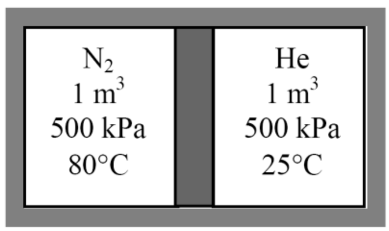
1. The compressor work.
2. The turbine work.
3. The thermal efficiency of this cycle.
4. The thermal efficiency of an ideal Brayton cycle working under the same conditions.

Assume constant specific heats at room temperature.

Compressor work	
Turbine work	
Thermal efficiency (actual)	
Thermal efficiency (ideal)	

F.7 Consider a well-insulated horizontal rigid cylinder that is divided into two compartments by a piston that is free to move but does not allow either gas to leak in to the other side. Initially, one side of the cylinder contains 1 m^3 of N_2 gas at 500 kPa and 80ºC while the other side contains 1 m^3 of He gas at 500 kPa and 25ºC. Now thermal equilibrium is established in the cylinder as a result of heat transfer through the piston. Using constant specific heats at room temperature, determine:

1. The final equilibrium temperature in the cylinder.
2. The final equilibrium temperature in the cylinder if the piston was not free to move.



Temperature (piston is free to move)	
Temperature (fixed piston)	

F.8 An ideal steam power plant operates between the pressure limits of 3 MPa and 50 kPa. The temperature of the steam at the turbine inlet is 400°C, and the mass flow rate of steam through the cycle is 60 kg/s.

- a) Show the cycle on a T-s diagram with respect to saturation lines.
- b) Compute the thermal efficiency of the cycle.
- c) Compute the net power output of the power plant.

Thermal efficiency	
Power output	

F.9 A steam power plant is proposed to operate between the pressures of 10 kPa and 2 MPa with a maximum temperature of 400°C.
What is the maximum efficiency possible from the power cycle?

F.10 In an air-standard Brayton cycle the air enters the compressor at 0.1 MPa and 15°C. The pressure leaving the compressor is 1.0 MPa, and the maximal temperature in the cycle is 1100°C.

- Sketch the T-s diagram.
- Determine the pressure and temperature at each point in the cycle.
- Determine the compressor work, turbine work, and cycle efficiency.

F.11

An air-standard Otto cycle has a compression ratio of 8. At the start of the compression process, the temperature is 300 K, and the pressure is 100 kPa. If the maximum temperature of the cycle is 1200 K:

1- sketch the P-v and T-s diagrams
2- the heat supplied per kg of air.
3- the net work done per kg of air.
4- the thermal efficiency of the cycle.

F.12

Air enters the compressor of gas turbine at 100 kPa and 25°C. For the pressure ratio of 5 and a maximum temperature of 850°C, determine the back work ratio (ratio between the work of the compressor and the work of the turbine) and the thermal efficiency using the Brayton cycle.

F.13

Steam is the working fluid in an ideal Rankine cycle. Saturated vapor enters the turbine at 8.0 MPa and saturated liquid exits the condenser at a pressure of 0.010 MPa. The net power output of the cycle is 100 MW:

1- sketch the P-v and T-s diagrams
2- the thermal efficiency.
3- the mass flow rate of the steam, in kg/h.