These problems are due on Friday, Sept 18.

1. A cylinder fitted with a piston contains argon gas at 20 lbf/in\(^2\) and 50F. The initial volume of the gas is 5 ft\(^3\). The gas is now compressed in a polytropic process to 100 lbf/in\(^2\) and 350 F.
   a) what is the polytropic exponent, \(n\)? 1.4034
   b) What is the work done during this process (Btu)? – 27.0 Btu
   c) what is the heat transfer during this process (Btu)? – 10.4 Btu

2. A piston-cylinder contains 1 kg of methane gas at 700 kPa and 40 C. The piston cross sectional area is 0.5 m\(^2\) and the total external force restraining the piston is directly proportional to the cylinder volume squared. Heat is transferred to the methane until the temperature is 1100C.
   a) What is the final pressure (kPa)? 1875 kPa
   b) What is the work done (kJ)? 183 kJ
   c) How much heat is transferred (kJ)? 2023 kJ

3. Air is compressed in a piston-cylinder polytropically with \(n = 1.2\) from 100 kPa and 300 K to 1000 kPa.
   a) calculate the work required. (kJ/kg) – 201.4 kJ/kg
   b) calculate the heat transfer required if \(c_p = \text{const.}\) (kJ/kg) – 99.96 kJ/kg
   c) calculate the heat transfer required if \(c_p\) varies with temperature. (kJ/kg) – 100.2 kJ/kg

4. Nitrogen gas flows continuously through an electric heater, entering at 90 lbf/in\(^2\) and 60F and exiting at 85 lbf/in\(^2\) and 1800F. Neglect changes in kinetic and potential energy.
   a) Calculate the required heat transfer (kJ/kg). 464.7 Btu/lbm (1078.6 kJ/kg)

5. Superheated steam enters an insulated nozzle at 3MPa and 350C with a low velocity and exits at 1.6MPa with a velocity of 550 m/s. The steam mass flow rate is 0.5 kg/s.
   a) Determine the state (temperature if superheated, quality if 2-phase) of the steam exiting the nozzle. 269.4 C
   b) Determine the exit area of the nozzle. 135 mm\(^2\)