1. A stationary piston-cylinder device contains 2 kg of air at 27°C and 100 kPa. The air is now compressed to a pressure of 500 kPa according to the relation $PV^{1.4}$ = constant. Determine the following:

   (a) the initial volume of air. (7%)

   (b) the final volume of air. (7%)

   (c) the work input during the process. (7%)

   (d) the change in total internal energy of the system ($\Delta U$). (7%)

   (e) the amount of heat transfer (Q) during the process. (7%)

Gas constant of air, $R = 0.287\ \text{kJ/kgK}$ ; Idea gas properties of air are given:

| Temperature - $T$ – (K) | Enthalpy – $h$ – (kJ/kg) | Relative Pressure - $p_r$ - | Internal Energy - $u$ - (kJ/kg) |
|---|---|---|---|
| 250 | 250 | 0.733 | 178 |
| 300 | 300 | 1.39 | 214 |
| 350 | 350 | 2.38 | 250 |
| 400 | 401 | 3.81 | 286 |
| 450 | 452 | 5.76 | 323 |
| 500 | 503 | 8.41 | 359 |
| 550 | 555 | 11.9 | 397 |
| 600 | 607 | 16.3 | 435 |
| 650 | 660 | 21.9 | 473 |

2. A power plant operates on a regenerative vapor power cycle with one open feedwater heater. Steam enters the first turbine stage at 12 MPa, 520°C and expands to 1 MPa, where some of the steam is extracted and diverted to the open feedwater heater operating at 1 MPa. The remaining steam expands through the second turbine stage to the condenser pressure of 6 kPa. Saturated liquid exits the open feedwater heater at 1 MPa. (At the state of first turbine exit: x = 0.9931; h = 2764.2kJ/kg. At the state of second turbine exit: x = 0.7727; h = 2018.3 kJ/kg) For isentropic processes in the turbines and pumps, determine for the cycle

(a) the specific enthalpies of the steam at two turbine exits, respectively, in kJ/kg; (7%)

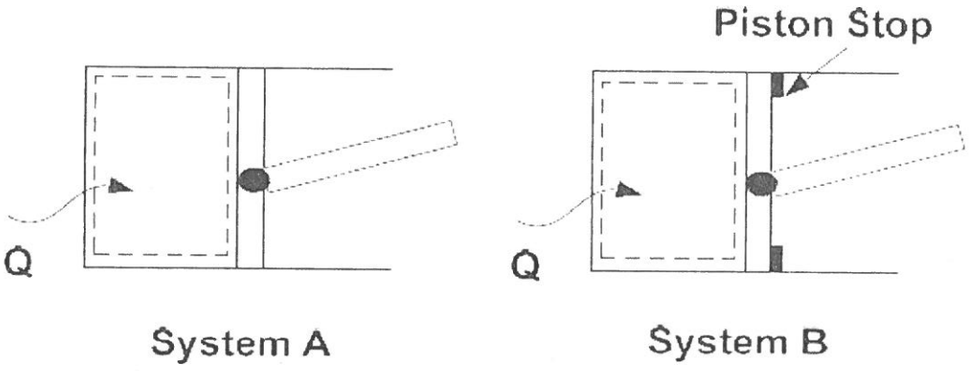
(b) the fraction of extracted steam; (7%)

(c) the turbine work, in kJ/kg; (7%)

(d) the heat addition, in kJ/kg; (7%)

(e) and the thermal efficiency. (7%)

3. Consider two piston-cylinder devices shown below. In system A, heat is added, the piston is free to move, and it is found that the magnitude of work done is more than the magnitude of heat added. In system B, heat is added when the piston is resting against a set of stops; therefore, the piston cannot move. Assume that changes in kinetic and potential energy are negligible. You must provide justification with appropriate equation(s) to receive full credit.




(a) What happens to internal energy when heat is added in system A? (increases; decreases; or remains the same ? 8%)

(b) What happens to internal energy when heat is added in system B? (increases; decreases; or remains the same ? 7%)

4. An inventor claims to have developed a power cycle capable of delivering a net work output of 410 kJ for an energy input by heat transfer of 1000 kJ. The system undergoing the cycle receives the heat transfer from hot gases at a temperature of 500 K and discharges energy by heat transfer to the atmosphere at 300 K. Evaluate this claim. (15%)