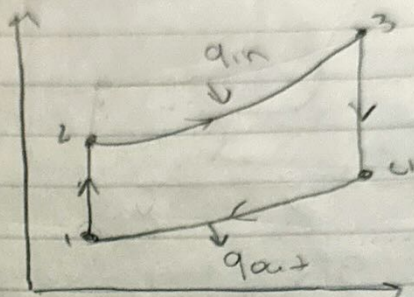
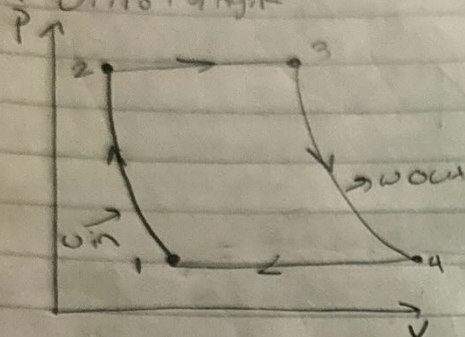


H.W 1.4

9-88) $\gamma_p = 10$ $P_1 = 70 \text{ kPa}$ $T_1 = 273 \text{ K}$ $R = 0.287 \text{ kJ/kg} \cdot \text{K}$
 $k = 1.4$ $c_p = 1.005 \text{ kJ/kg} \cdot \text{K}$ $\dot{m} = 1 \text{ kg/s}$ $\dot{Q}_{1-2} = 500 \text{ kJ}$
 $C_v = 0.718 \text{ kJ/kg} \cdot \text{K}$



① Isen ② P constant ③ Isen ④ P constant

$$\begin{aligned}
 P_1 &= 70 \text{ kPa} & P_2 &= 10 P_1 & P_3 &= P_2 & P_4 &= P_1 \\
 T_1 &= 273 \text{ K} & &= 700 \text{ kPa} & P_3 &= 700 \text{ kPa} & P_4 &= 70 \text{ kPa} \\
 v_1 &= \frac{RT_1}{P_1} & \frac{T_2}{T_1} &= \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} & T_3 &= 1024.5 & \frac{T_4}{T_3} &= \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}} \\
 &= 1.12 \frac{\text{m}^3}{\text{kg}} & T_2 &= 527.1 \text{ K} & v_3 &= \frac{RT_3}{P_3} & T_4 &= 409.84 \\
 & & v_2 &= \frac{RT_2}{P_2} & v_3 &= 0.411 \text{ m}^3/\text{kg} & v_4 &= \frac{RT_4}{P_4} \\
 & & &= 0.216 \text{ m}^3/\text{kg} & & & &= 1.64 \text{ m}^3/\text{kg}
 \end{aligned}$$

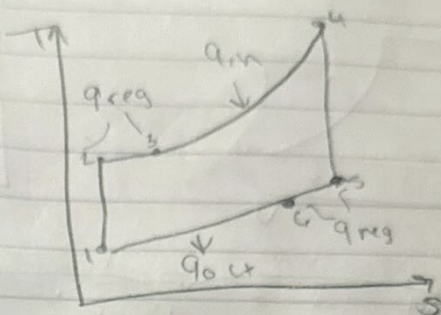
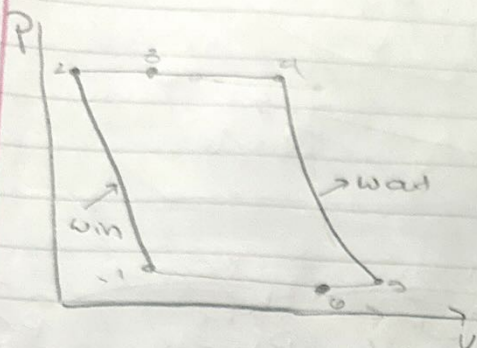
a) $w_{\text{net}} = \dot{m} w_{\text{net}}$

$$\begin{aligned}
 w_{\text{net}} &= c_p (T_3 - T_4) - c_p (T_2 - T_1) = 362.71 \text{ kJ/kg} \\
 w_{\text{net}} &= 1 \times 362.71 \text{ kJ/kg} = \boxed{362.71 \text{ kW}}
 \end{aligned}$$

$$b) \eta_{\text{th}} = \frac{w_{\text{net}}}{q_{\text{in}}} = \frac{362.71}{500} = 0.725 \text{ or } \boxed{72.5\%}$$

9-99)

$P_1 = 100 \text{ kPa}$ $T_1 = 303 \text{ K}$ $\gamma = 1.6$ $T_{\text{max}} = 1073 \text{ K}$
 $T_3 = T_5 = 10$



1 $\xrightarrow{\text{Isen}}$ 2 $\xrightarrow{P \text{ const}}$ 3 $\xrightarrow{P \text{ const}}$ 4 $\xrightarrow{\text{Isen}}$ 5 $\xrightarrow{P \text{ const}}$ 6 $\xrightarrow{P \text{ const}}$

$P_1 = 100 \text{ kPa}$ $P_2 = 10 \text{ Pa}$ $P_3 = P_2$ $T_4 = 1073 \text{ K}$ $P_5 = P_6 = 100 \text{ kPa}$ $P_6 = P_1 = 100 \text{ kPa}$
 $T_1 = 303 \text{ K}$ $T_3 = T_5 = 10$ $P_4 = 10 \text{ Pa}$ $\frac{T_3}{T_4} = \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}}$ $T_6 = T_5 - (T_3 - T_2)$
 $V_1 = \frac{RT_1}{P_1} = 0.870 \text{ m}^3/\text{kg}$ $\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$ $T_2 = 545.8 \text{ K}$ $T_3 = 545.8 \text{ K}$ $T_4 = 1073 \text{ K}$ $T_5 = 555.8 \text{ K}$ $T_6 = 505 \text{ K}$
 $V_2 = \frac{RT_2}{P_2} = 0.107 \text{ m}^3/\text{kg}$ $V_3 = \frac{RT_3}{P_3} = 0.156 \text{ m}^3/\text{kg}$ $V_4 = \frac{RT_4}{P_4} = 0.308 \text{ m}^3/\text{kg}$ $V_5 = \frac{RT_5}{P_5} = 1.59 \text{ m}^3/\text{kg}$ $V_6 = \frac{RT_6}{P_6} = 1.09 \text{ m}^3/\text{kg}$

a) $W_{\text{net}} = (P(T_4 - T_5) - P(T_2 - T_1))$
 $1.005(1073 - 555.8) - 1.005(585 - 303)$
 $= 236.4 \frac{\text{kJ}}{\text{kg}}$

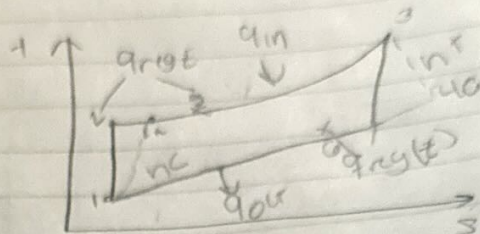
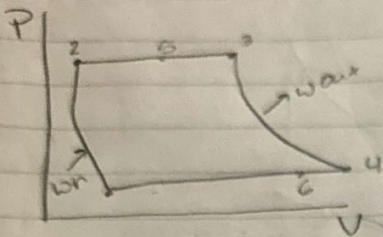
$\dot{W}_{\text{net}} = \dot{m} W_{\text{net}}$

$115 \text{ kW} = \dot{m} (236.4) = 0.4864 \text{ kg/s}$

$Q_{\text{in}} = \dot{m} c_p (T_4 - T_3) = 257.7 \text{ kW}$

$Q_{\text{out}} = \dot{m} c_p (T_6 - T_1) = 142.7 \text{ kW}$

9-107) $\gamma_p = 7$ $T_{min} = 310 \text{ K}$ $T_{max} = 1130 \text{ K}$
 $\eta_c = 0.75$ $\eta_T = 0.82$ $\epsilon = 0.63$



1 $\xrightarrow{1-2 \text{ isentropic}}$ 2 $\xrightarrow{2-3 \text{ P const}}$ 3 $\xrightarrow{3-4 \text{ isentropic}}$ 4 $\xrightarrow{4-1 \text{ P const}}$ 1

$T_1 = 310 \text{ K}$ $P_2 = 7P_1$ $P_5 = P_2$ $T_3 = 1130 \text{ K}$ $P_3 = 7P_1$ $P_4 = P_1$ $P_6 = P_1$
 $\epsilon = \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = 546.53 \text{ K}$ $\epsilon = \frac{T_3 - T_2}{T_4 - T_2}$ $P_3 = 2006 \text{ K}$ $\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{\gamma-1}{\gamma}} = 663.02 \text{ K}$ $T_6 = T_{4c}(T_5 - T_4)$
 $\eta_c = \frac{T_2 - T_1}{T_2 - T_1} \rightarrow T_2 = 617.37 \text{ K}$ $T_5 = 702.16 \text{ K}$ $\eta_T = \frac{T_3 - T_4}{T_3 - T_4} = 747.82 \text{ K}$ $x_6 = 663.02 \text{ K}$

$P_1 = 1.55 \text{ uG}$ $\epsilon = \frac{h_5 - h_2}{h_{4c} - h_2}$ $\frac{P_4}{P_3} = \frac{P_1}{P_3}$ $P_{r1} = 28.5494$ $h_6 = h_{4c}(h_5 - h_2)$
 $\frac{P_2}{P_1} = \frac{P_2}{P_1}$ $h_5 = 738.44 \frac{\text{KJ}}{\text{kg}}$ $T_4 = 698.63 \text{ K}$ $h_6 = 682.97$
 $P_{r2} = 10.8222$ $T_5 = 723.35 \text{ K}$ $h_3 = 129.24 \frac{\text{KJ}}{\text{kg}}$ $T_6 = 671.71 \text{ K}$
 $T_2 = 537.02 \text{ K}$ $h_1 = 310.24 \frac{\text{KJ}}{\text{kg}}$ $h_2 = 311.26$ $h_4 = 711.7077$

$\eta_c = \frac{h_2 - h_1}{h_{2a} - h_1} = 546.52 \frac{\text{KJ}}{\text{kg}}$ $T_{2a} = 610.70 \text{ K}$

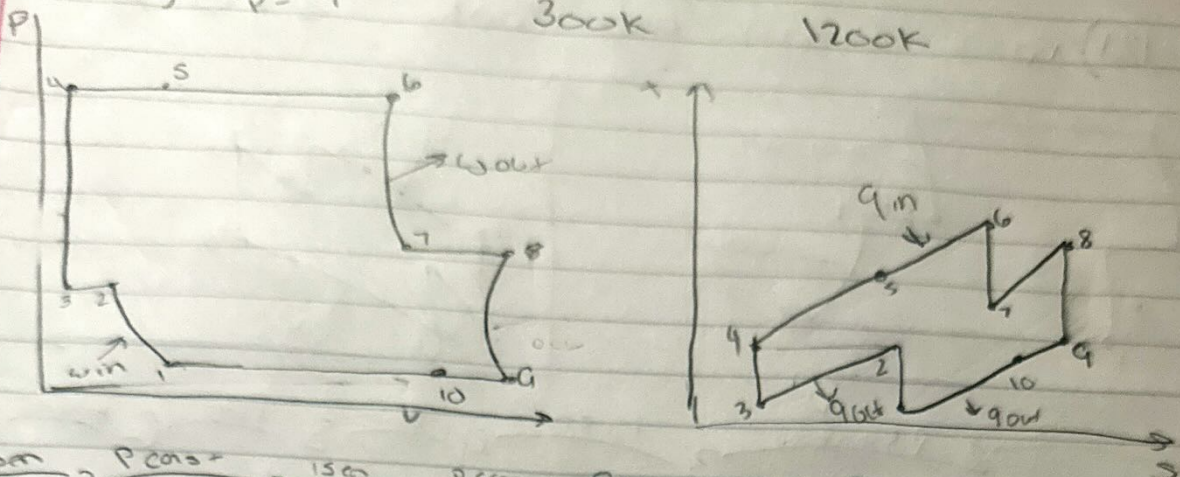
$\eta_T = \frac{h_3 - h_{4c}}{h_3 - h_1} \rightarrow 803.14 \frac{\text{KJ}}{\text{kg}}$ $T_{4c} = 782.84 \text{ K}$

a) $T_{T_{\text{turb}} \text{ out}} = T_{4c} = 782.84 \text{ K}$

(b) $w_{\text{net}} = w_{\text{out}} - w_{\text{in}}$
 $w_{\text{in}} = h_{2a} - h_1 = 308.03 \frac{\text{KJ}}{\text{kg}}$
 $w_{\text{out}} = h_3 - h_{4c} = 416.105 \frac{\text{KJ}}{\text{kg}}$
 $w_{\text{net}} = 108.075 \text{ KJ/Kg}$

c) $\eta_{th} = \frac{w_{\text{net}}}{q_{\text{in}}}$ $q_{\text{in}} = h_3 - h_5 = 480.81 \text{ KJ/Kg}$
 $\eta_{th} = 0.225 \text{ or } 22.5\%$

9-119) $r_p = 9$



$1 \xrightarrow{15m} 2 \xrightarrow{P_{comp}} 3 \xrightarrow{15m} 4 \xrightarrow{P_{comp}} 5 \xrightarrow{P_{comp}} 6 \xrightarrow{15m} 7 \xrightarrow{P_{comp}} 8 \xrightarrow{15m} 9 \xrightarrow{P_{comp}} 10 \xrightarrow{P_{comp}} 1$

$T_1 = 300K, P_2 = 9P_1, T_3 = 300K, P_4 = 9P_3, T_5 = 1200K, P_6 = 9P_5, T_7 = 1200K, P_8 = 9P_7, T_9 = 1200K, P_{10} = 9P_9, T_{10} = 300K$

$P_{r1} = 1.3860, P_{r2} = P_{r1} \cdot 9 = 12.474, P_{r3} = 1.3860, P_{r4} = P_{r3} \cdot 9 = 12.474, P_{r5} = 238.0, P_{r6} = P_{r5} \cdot 9 = 2142, P_{r7} = 238.0, P_{r8} = P_{r7} \cdot 9 = 2142, P_{r9} = 238.0, P_{r10} = P_{r9} \cdot 9 = 2142$

$h_1 = 300.19 \text{ kJ/kg}, h_2 = 545.2 \text{ kJ/kg}, h_3 = 300.19 \text{ kJ/kg}, h_4 = 545.2 \text{ kJ/kg}, h_5 = 1277.79 \text{ kJ/kg}, h_6 = 550.64 \text{ kJ/kg}, h_7 = 1277.79 \text{ kJ/kg}, h_8 = 550.64 \text{ kJ/kg}, h_9 = 1277.79 \text{ kJ/kg}, h_{10} = 300.19 \text{ kJ/kg}$

$T_2 = 545.2K, T_4 = 545.2K, T_6 = 1925K, T_8 = 1925K, T_{10} = 300K$

$$W_{net} = W_{out} + W_{out} - W_{in} - W_{in}$$

$$W_{out} = CP(T_6 - T_7) = 728.63$$

$$W_{in} = CP(T_2 - T_1) = 246.22$$

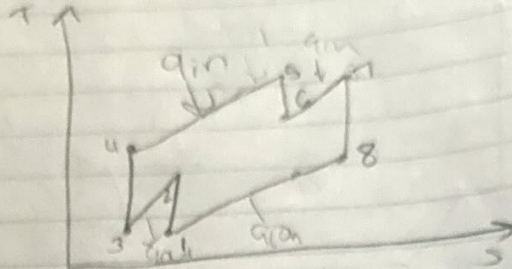
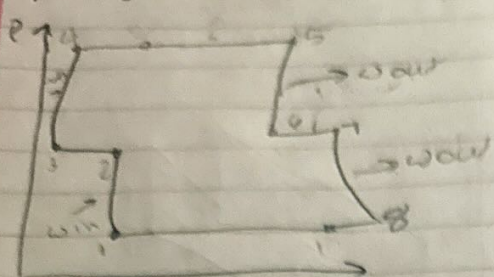
$$W_{net} = 728.63 - 246.22 = 482.41$$

$$W = m \times W_{net}$$

$$110 \text{ MW} = m \times 482.41$$

$$m = 0.228 \text{ kg/s}$$

9-121) $r_p = 3$ $T_1 = 300\text{K}$ and 1200K $\epsilon = 0.75$



1-Isen 2- P_{case} 3-Isen 4- P_{case} 5- P_{case} 6- P_{case} 7- P_{case}

$T_1 = 300\text{K}$ $P_2 = 3P_1$ $T_3 = 300\text{K}$ $P_4 = P_2$ $T_5 = 1200\text{K}$ $P_6 = P_5/3$ $T_7 = 31200\text{K}$

$P_1 = 1.3860$ $P_2 = 4.158$ $P_3 = 1.3860$ $P_4 = 4.158$ $P_5 = 238$ $P_6 = 79.33$ $P_7 = 238$

$h_1 = 300.191$ $h_2 = 411.26$ $h_3 = 300.191$ $h_4 = 411.26$ $h_5 = 1277.79$ $h_6 = 946.4$ $h_7 = 1277.8$

8

$P_8 = P_6$

$P_8 = 79.33$

$h_8 = 946.4$

a) $\frac{W_{\text{comp}}}{W_{\text{exp}}} = \frac{W_{1-2}}{W_{5-6}}$ $W_{\text{in}} = h_2 - h_1 = 111.07$ $W_{\text{out}} = h_5 - h_6 = 331.39$

$\frac{W_{\text{comp}}}{W_{\text{exp}}} = 0.335$

$\eta_{\text{th}} = \frac{W_{\text{net}}}{q_{\text{in}}}$ $q_{\text{in}} = (h_5 - h_4) + (h_7 - h_6) = 1197.9$

$\eta_{\text{th}} = 0.18$

b) $0.75(946.4 - 411.26) = 401.35 \text{ kJ/kg}$

$q_{\text{in}} = (1197.96 - 401.35) = 796.61$

$\eta_{\text{th}} = \frac{W_{\text{net}}}{q_{\text{in}}}$

$\eta_{\text{th}} = 0.276$