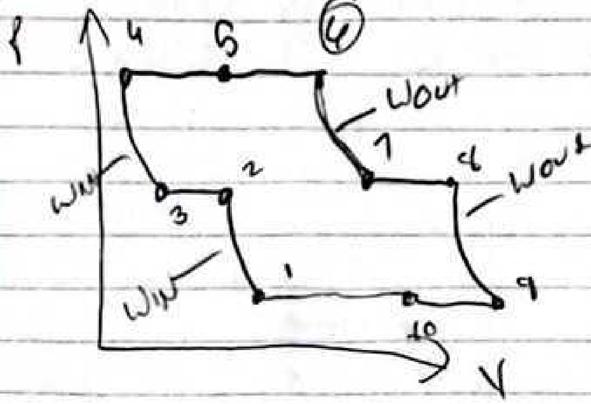
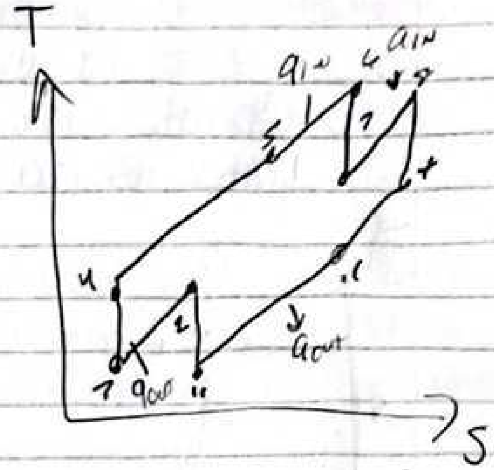
9-123





$1 \xrightarrow{\text{isent}} 2 \xrightarrow{P\text{const}} 3 \xrightarrow{\text{isent}} 4 \xrightarrow{P\text{const}} 5 \xrightarrow[P\text{const}]{\cancel{\text{isent}}} 6 \xrightarrow{\text{isentrop}} 7 \xrightarrow{P\text{const}} 8 \xrightarrow{\text{isent}} 9 \xrightarrow{P\text{const}} 10 \xrightarrow{P\text{con}}$

$P_1 = 100\,kPa$, $T_1 = 290.15\,K$

$V_1 = \frac{RT_1}{P_1} = 0.833$

$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \rightarrow T_2 = 431.16\,K$

$P_2 = r_p P_1$, $P_2 = 400\,kPa$

$V_2 = \frac{RT_2}{P_2} = 0.31\,\frac{m^3}{kg}$

$P_3 = P_2$, $P_3 = 400\,kPa$

$T_3 = T_1$, $T_3 = 290.15\,K$

$V_3 = \frac{RT_3}{P_3} = 0.21\,\frac{m^3}{kg}$

$P_4 = r_p P_3$, $P_4 = 1600$

$P_5 = P_4$, $P_5 = 1600\,kPa$

$T_5 = T_4 + 20$, $T_5 = 451.08\,K$

$V_5 = 0.081\,\frac{m^3}{kg}$

$P_6 = P_5$, $P_6 = 1600\,kPa$

$q_{in} = C_p(T_6 - T_5)$

$q_{in} = 300\,\frac{kJ}{kg}$

$T_6 = T_5 + \frac{q_{in}}{C_p}$

$T_6 = 749.61\,K$

$V_6 = 0.134\,\frac{m^3}{kg}$

$P_7 = P_6 / r_p$, $P_7 = 400\,kPa$

$\frac{T_7}{T_6} = \left(\frac{P_7}{P_6}\right)^{\frac{k-1}{k}} = T_7 = 504.5\,K$

$V_7 = 0.362\,\frac{m^3}{kg}$

$P_8 = P_7$, $P_8 = 400\,kPa$

$T_8 = T_7 + \frac{q_{in}}{C_p}$

$T_8 = 808.08\,K$

$V_8 = 0.576\,\frac{m^3}{kg}$

$P_9 = P_8$, $P_9 = 1600\,kPa$

$P_{10} = P_1$, $P_{10} = 100$

$h_{10} - h_9 = h_5 - h_4$

$C_p(T_9 - T_{10}) =$

$C_p(T_5 -$

$T_{10} = T_9 \frac{(T_5 - T_4)}{20}$

$T_{10} = 520.51\,K$

$V_{10} = 1.474\,\frac{m^3}{kg}$

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

$W_{net} = W_{out_{6-7}} + W_{out_{8-9}} - W_{in_{1-2}} - W_{in_{3-4}}$

$W_{out_{6-7}} = h_6 - h_7 = C_p(T_6 - T_7) = 246.267\,kJ/kg$

$W_{out_{8-9}} = h_8 - h_9 = C_p(T_8 - T_9) = 263.8$ " "

$W_{in_{1-2}} = h_2 - h_1 = C_p(T_2 - T_1) = 141.7$ " "

$W_{in_{3-4}} = h_4 - h_3 = C_p(T_4 - T_3) = 141.62$ " "

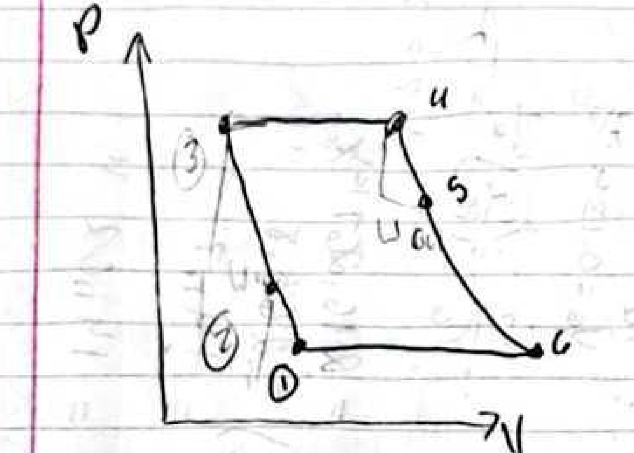
$W_{net} = 226.801\,kJ/kg$

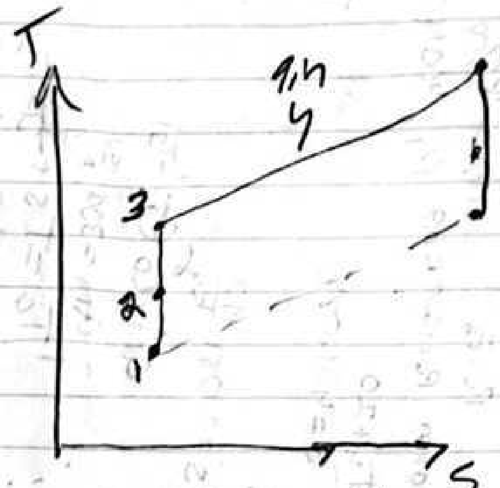
$q_{in} = q_{in_{5-6}} + q_{in_{7-8}} =$

$300 + 300$

$\eta_{th} = 0.378$

9-127) A turbojet flying with $V = 900$ ft/s w/ Altitude of 20000 ft, Ambient conditions are 7 psia and 10°F. The pressure ratio across the compressor is 13, and the temp of the inlet is 2400R





$$① \xrightarrow[\text{Diffuser}]{\text{Isentropic}} ② \xrightarrow{\text{Isentropic}} ③ \xrightarrow{P=\text{const}} ④ \xrightarrow{\text{Isent}} ⑤ \xrightarrow[\text{Nozzle}]{\text{Isent}} ⑥ \xrightarrow{P=\text{const}}$$

$V_1 = 900$ ft/s

$T_1 = 10°F = 469.67R$

$P_1 = 7$ PSIA

$$\frac{V_1^2}{2} + h_1 = \frac{V_2^2}{2} + h_2$$

$$\frac{V_1^2}{2} = C_p(T_2 - T_1)$$

$$T_2 = T_1 + \frac{V_1^2}{2c_p} = 469.67 + \frac{900}{}$$

$$\frac{RT}{P_1} = 24.85$$

$$T_2 = 469.67 + \frac{24.85}{2(0.240)}$$

$\sqrt{T_2} = 521.44$

$P_2 = \frac{P_3}{13}$

$$\frac{P_2}{7} = \left(\frac{521.44}{469.67}\right)^{\frac{k}{k-1}}$$

$P_2 = 7.21$ PSIA

$P_3 = 13 P_2$

$P_3 = 93.73$ Psia

$$T_3 = T_2\left(\frac{P_3}{P_2}\right)^{\frac{k-1}{k}}$$

$$= 521.44\left(\frac{93.73}{7.21}\right)^{\frac{1.4-1}{1.4}} = 1084.2$$

$T_4 = 2400R$

$P_4 = P_3$

$P_4 = 93.73$

$V_4 =$ PV=RT $\frac{(.24)(2400)}{93.73}$

$V_4 = 6.14$ ft³/lbm

$W_c = W_T$

$(h_3 - h_2) = (h_4 - h_5)$

$C_p(T_3 - T_2) = C_p(T_4 - T_5)$

$T_5 = T_4 - (T_3 - T_2)$

$T_5 = 2400 - (1084 - 521.44)$

$T_5 = 1837.44$

$V_5 = 0$

$P_6 = 7$ kPa

$$\frac{T_6}{T_5} = \left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}} = 1143.6$$

$$\frac{P_5}{P_4} = \left(\frac{T_5}{T_4}\right)^{\frac{k}{k-1}}$$

$P_5 = 36.8$

a) a Pressure at turbine exit ?

36.8 PSIA

b) The velocity of exhaust gas

$$\frac{\cancel{V_5^2}^{\,0}}{\cancel{2}} + h_5 = \frac{V_6^2}{2} + h_6$$

$$\frac{V_6^2}{2} = c_p (T_5 - T_6)$$

$$V_6 = \sqrt{2 c_p (T_5 - T_6)}$$

$$= \sqrt{2(0.24)(1837.44 - 1143.6)}$$

$$V_6 = 18.25 \text{ Ft/s}$$

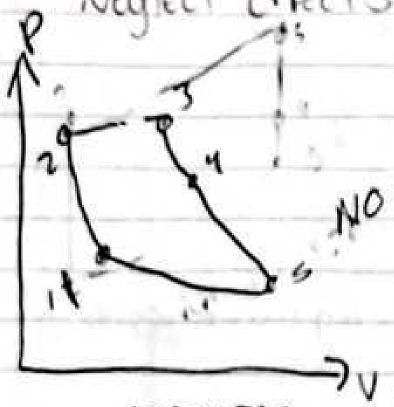
c) The Propulsive efficiency

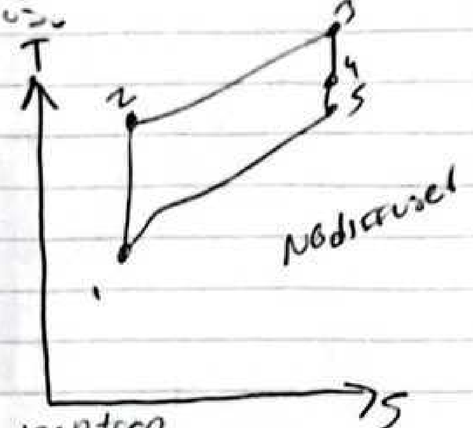
$$\eta_p = \frac{\text{Propulsive Power}}{\text{Energy input Rate}} = \frac{W_p}{q_{in}}$$

$$= \dot{m} (V_{exit} - V_{inlet}) V_{aircraft}$$

$$= \dot{m} (18.25 - 900) 900$$

9-135| Aircraft Powered by a turbojet engine has a pressure ratio of 9. Stationary on ground
Ambient air is 7°C and 95 kPa
enters engine at a rate of 20 kg/s
The jet has a heating value of 42,700 kJ/kg
and it is burned completely at a rate 0.5 kg/s
Neglect effects of diffuser





① $\xrightarrow{\text{Isentropic}}$ Compress ② $\xrightarrow{\text{Pconst}}$ 42700 kJ/kg ③ $\xrightarrow{\text{Isentrop}}$ $W_c = W_t$ ④ $\xrightarrow{\text{Isent}}$ Nozzle ⑤ $\longrightarrow$

$P_1 = 95$ kPa
$T_1 = 280$ K,
$\dot{m} = 20$ kg/s

$P_2 = P_1 9$
$P_2 = 855$ kPa
$T_2 = 280\left(\frac{855}{95}\right)^{\frac{1.4-1}{1.4}}$
$T_2 = 674.3$ K

$P_3 = 855$ kPa

$P_5 = 95$ kPa

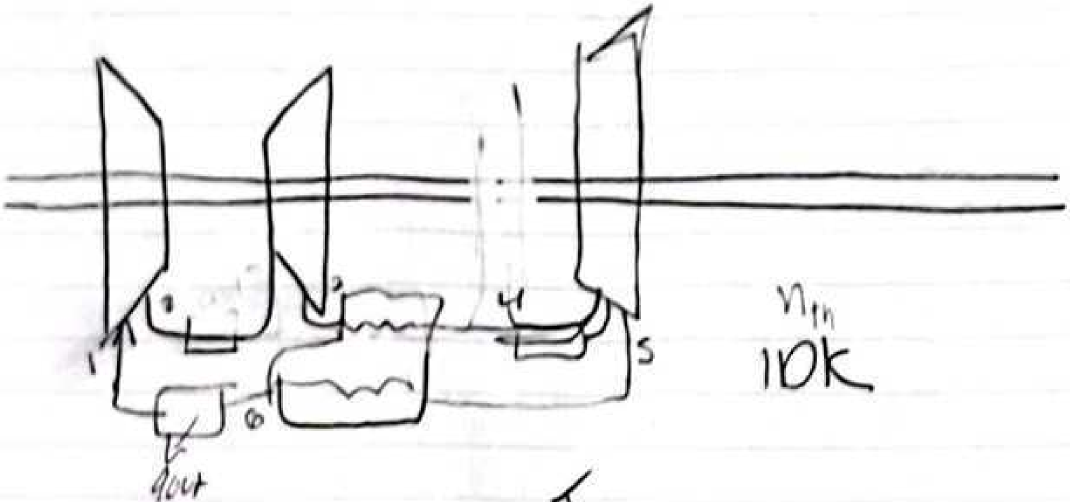
$q_{in} = h_3 - h_2$
$42700 = \ldots$
$h_3 = 1748.5$

$h_4 = h_3 - h_2 + h_1$
$h_4 = 1347.36$
$\cancel{h_5} =$
$h_r = 877.5$
$q_{in} = C_p(T_3 - T_2)$
$q_{in} = C_pT_3 - C_pT_4$
$q_{in} + C_pT_2 = C_pT_3$
C_p

$F = \dot{m}v_5 = 20 \cdot 969.6$
$= 19392$ N

$h_4 + \frac{V_4^2}{2} = h_5 + \frac{V_5^2}{2}$
$V_5 = 969.6 \frac{m}{s}$

9-169) Consider an ideal gas-turbine cycle w/ one stage of compression and compression and two stages of expansion and regeneration. Compression ratio across each turbine stage is the same, high pressure turbine turbine exhaust gas enters the regenerator and then enters the low-pressure turbine for expansion to the compressor inlet



η_{th}
10K