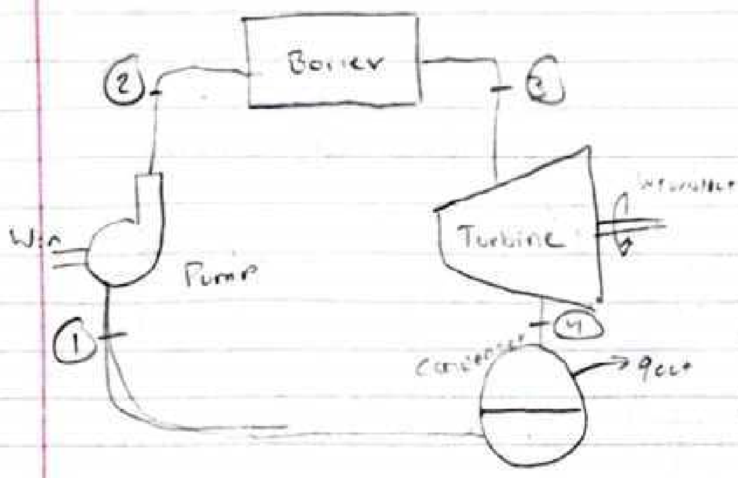
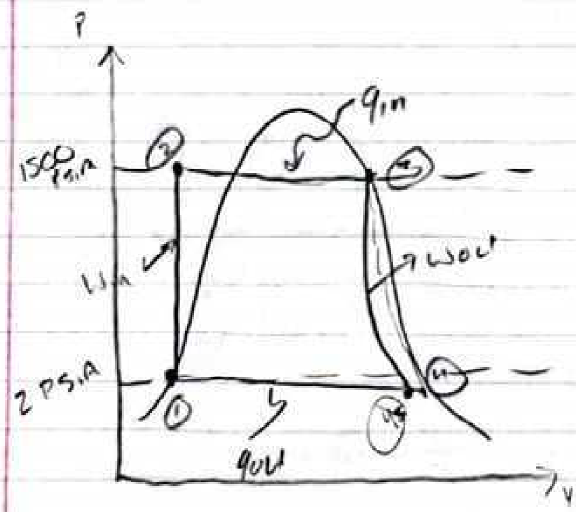
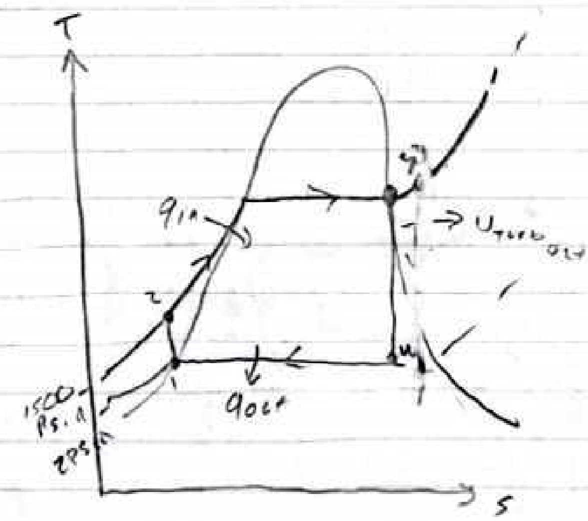
10-18 Homework 2.1

A Steam Rankine Cycle operates between 1500 psia in the boiler and 2 psia in condenser. Turbine inlet temp: 800°F. Turbine isentropic efficiency is 90 percent. Cycle produces 2500 kW of Power







$$① \xrightarrow{\text{isent}} ② \xrightarrow{P\ \text{const}} ③ \xrightarrow{\text{isentropic}} ④ \xrightarrow{P,T\ \text{const}} ④a$$

126.02°F (state 1) — 700F (state 3)

①	②	③	④
$T_1 = 585.69\,R$	$T_2 =$	$T_3 = 1259.67\,R$	$T_4 = 585.69\,R$
$P_1 = 2$ PSIA	$P_2 = 1500$ PSIA	$P_3 = 1500$ PSIA	$P_4 = 2$ PSIA
$h_1 = 94.02$	$h_2 = 118.33254$	$h_3 = 1363.1$	$h_4 = 1115.58$
$S_1 = 0.17499$	$S_2 = 0.17499$	$S_3 = 1.5064$	$S_4 =$

$$h_2 - h_1 = V_1(P_2 - P_1)$$
$$h_2 = h_1 + V_1(P_2 - P_1)$$
$$h_2 = 94.02 + 0.01623(1500 - 2)$$
$$h_2 = 118.33294$$

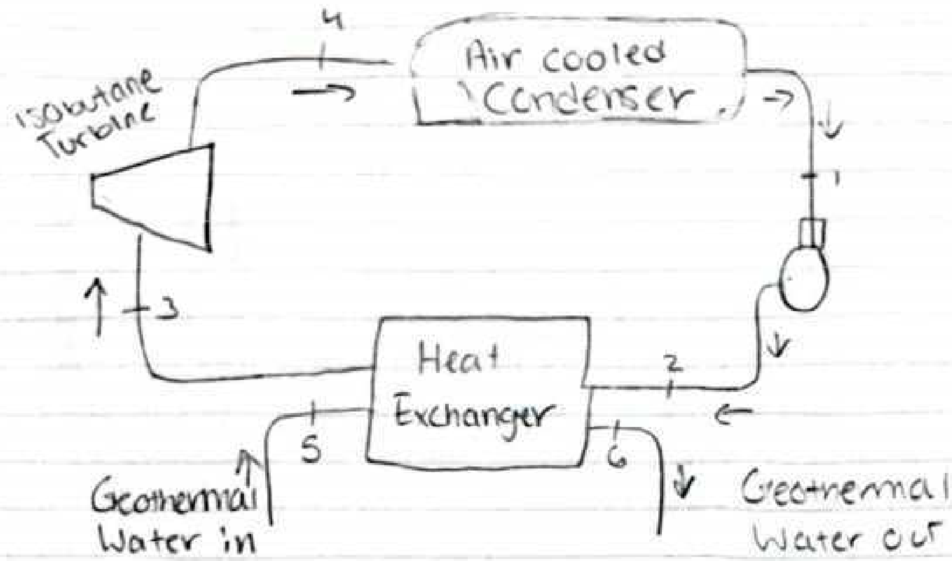
$$X_2 = \frac{h - h_f}{h_{fg}} \qquad h_{f_2} = 611.41 \qquad h_{g_2} = 557.42$$
$$= \frac{118.33254 - 611.41}{557.42}$$

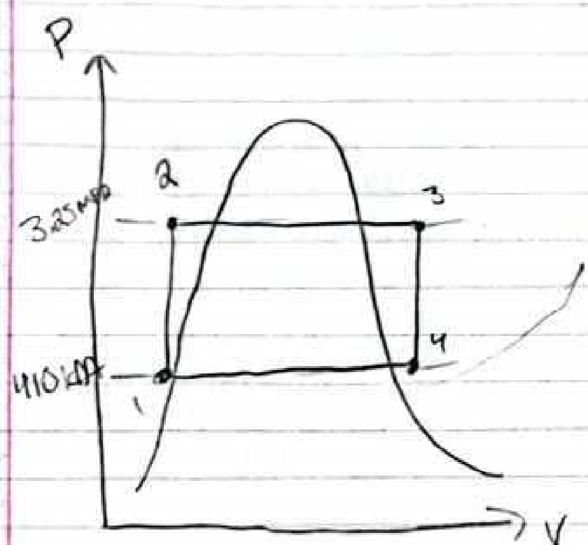
interpolation

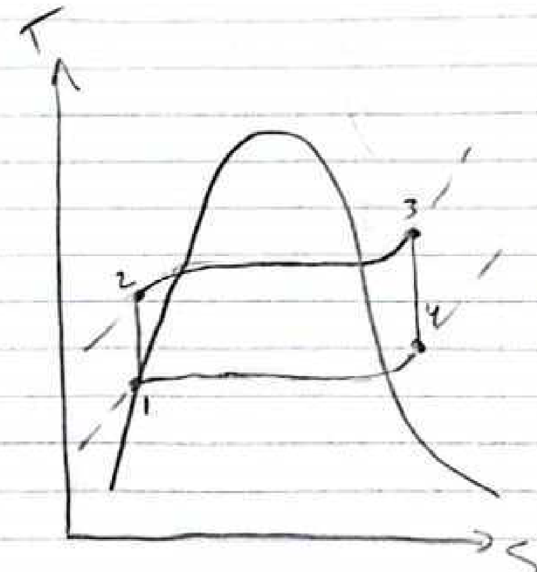
$$\eta_T = \frac{h_3 - h_{4a}}{h_3 - h_{4s}}$$
$$.90 = \frac{1363.1 - h_{4a}}{1363.1 - 1115.58}$$
$$222.57 = 1363.1 - h_{4a}$$
$$h_{4a} = 1140.53$$

a) Calculate the mass flow rate through the boiler.

10-25) Binary Geothermal Power Plant







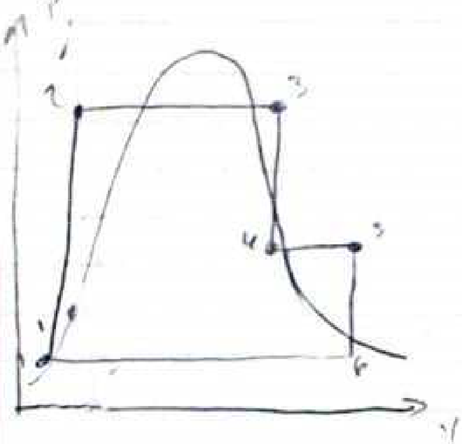
ISOBUTANE

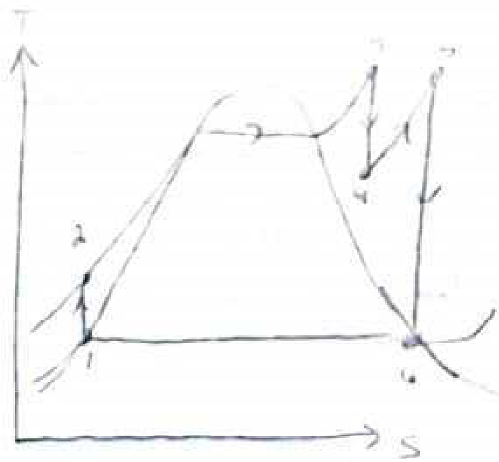
PCONST

$① \xrightarrow{\text{ISENT}} ② \xrightarrow{\text{PCONST}} ③ \xrightarrow{\text{ISENT}} ④$

①	②	③	④	⑤	⑥
$P_1 = 410$ kPA	$P_2 = 3{,}25$ MPA	$P_3 = 3{,}93$ MPA	$P_4 = 410$ kPA		
		$T_3 = 147°C$	$T_4 = 79{,}5°C$	$T_5 = 160°C$	
		$\dot{m}_3 = 305.6$			

10-34) Steam Power Plant: Ideal Reheat Rankine Cycle





① $\xrightarrow{\text{Isent}}$ ② $\xrightarrow{\text{Pconst}}$ ③ $\xrightarrow{\text{Isent}}$ ④ $\xrightarrow{\text{Pconst}}$ ⑤ $\xrightarrow{\text{Isent}}$ ⑥ $\xrightarrow{\text{Pconst}}$

$\boxed{P_1 = 20\ \text{kPa}}$ $\boxed{P_2 = 5000\ \text{kPa}}$ $\boxed{P_3 = 5000\ \text{kPa}}$ $\boxed{P_4 = 1200\ \text{kPa}}$ $P_5 = 1200\ \text{kPa}$ $\boxed{P_6 = 20\ \text{kPa}}$

$\boxed{x_1 = 0}$ $\boxed{x_4 = .96}$ $\boxed{x_6 = .96}$

$\boxed{T_1 = 60.06}$ $\boxed{T_4 = 187.96}$ $\boxed{T_6 = 60.06}$

$\boxed{h_1 = 251.42}$

$S_4 = S_{f4} + x_4 S_{fg4}$

$= 2.2159 + .96 \cdot 4.3058$

$S_6 = S_{f6} + x_6 S_{fg6}$

$= 0.832 + .96(7.0752)$

$\boxed{S_1 = 0.8320}$ $\boxed{S_2 = 0.8320}$

$\boxed{V_1 = 0.001017}$ $\boxed{S_3 = 6.349468}$ $\boxed{S_4 = 6.344468}$ $\boxed{S_6 = 7.624192}$

Inter $\boxed{T_3 = 328.77}$

$h_4 = h_{f4} + x_4 h_{fg4}$

$h_6 = h_{f6} + x_6 h_{fg6}$

$\boxed{h_3 = 3008.33}$ $h_4 = 798.33 + .96 \cdot 1985.4$

$= 251.42 + .96(2357.5)$

$\boxed{h_4 = 2704.314}$ $\boxed{h_6 = 2514.716}$

$h_2 = V_1(P_2 - P_1) + h_1$

$= 0.001017(5000 - 20) + 251.42$

$\boxed{h_2 = 256.48644}$

$\boxed{S_5 = 7.624192}$

$\boxed{T_5 = 482.01}$

$\boxed{h_5 = 3438.02}$

a) Determine temperature @ each inlet

$T_3 = 328.77\ C^{o}$ $\quad T_5 = 482.01$

b) Determine Cycle efficiency

$\eta_{th} = \frac{W_{net}}{q_{in}}$ $\quad W_{net} = W_{out_{3-4}} + W_{out_{5-6}} - W_{in_{1-2}}$

$= (h_3 - h_4) + (h_5 - h_6) - (h_2 - h_1)$

$W_{net} = 1222.25534$

$q_{in} = q_{in_{2-3}} + q_{in_{4-5}}$

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

$= 2751.845 + (733.706$

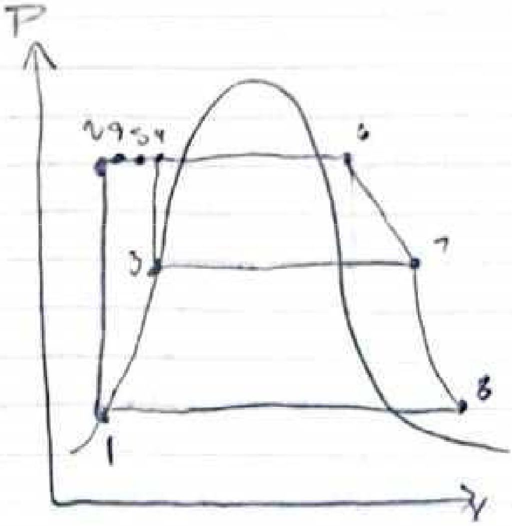
$= 3485.55$

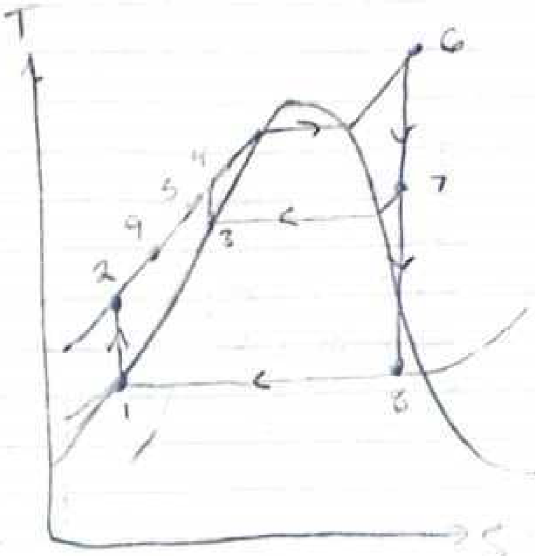
$\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{1222.25534}{3485.55}$

$\eta_{th} = 0.35 = 35\%$

Scanned with CamScanner

10-48)





Pconst   Pconst   P const

$1 \xrightarrow[(1-y)]{\text{isentr}} 2 \quad 3 \xrightarrow{\text{isentropic}} 4 \xrightarrow{\text{Pconst}} 5 \xrightarrow{\text{Pconst}} 6 \xrightarrow{\text{isent}} 7\,(y) \xrightarrow{\text{isent}} 8\,(1-y) \quad 9$

1	2	3	4	5	6	7	8	9
$P_1 = 20$ kPa	$P_2 = 3000$ kPa	$P_3 = 1000$ kPa	$P_4 = 3000$ kPa	$P_5 = 3000$ kPa	$P_6 = 3000$ kPa	$P_7 = 1000$ kPa	$P_8 = 10$ kPa	$P_9 = 3000$ kPa
$X_1 = 0$		$X_3 = 0$			$T_6 = 350°C$	$T_7 = 216.76$		
$T_1 = 60.06C$		$T_3 = 179.88°C$			$h_6 = 3116.1$	$h_7 = 2852.87$		
$h_1 = 251.42$		$h_3 = 762.51$			$S_6 = 6.7450$	$S_7 = 6.7450$	$S_8 = 6.7450$	
$V_1 = 0.001017$		$V_3 = 0.001127$						
$S_1 = 0.8320$		$S_3 = 2.1381$						

$V_1(P_2 - P_1) = (h_2 - h_1)$

$0.001017(2980) = (h_2 - 251.42)$

$\boxed{h_2 = 254.45066}$

$\boxed{T_2 \approx 60.06}$

$\boxed{V_2 \approx 0.001017}$

$V_3(P_4 - P_3) = h_3 - h_4$

$0.001127(2000) = 762.51 - h_4$

$\boxed{h_4 = 760.256}$

$X = \dfrac{6.745 - 0.832}{7.0752}$

$\boxed{X = 0.83}$

$h_8 = h_f + x_8 h_{fg8}$

$= 251.42 + 0.83 \cdot 23...$

$\boxed{h_8 = 2357.545}$

a) $W_{6-7} + W_{7-8}$

$(h_6 - h_7) + (h_8 - h_7)$

$= 758.57 \ kJ/kg$

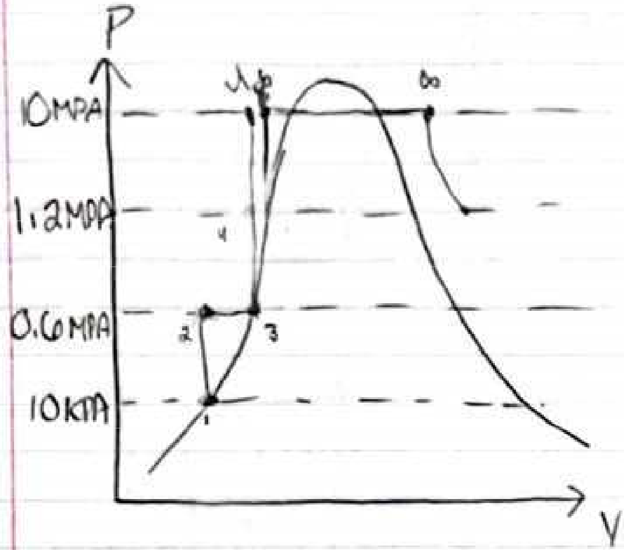
b) $W_{1-2} + W_{3-4}$

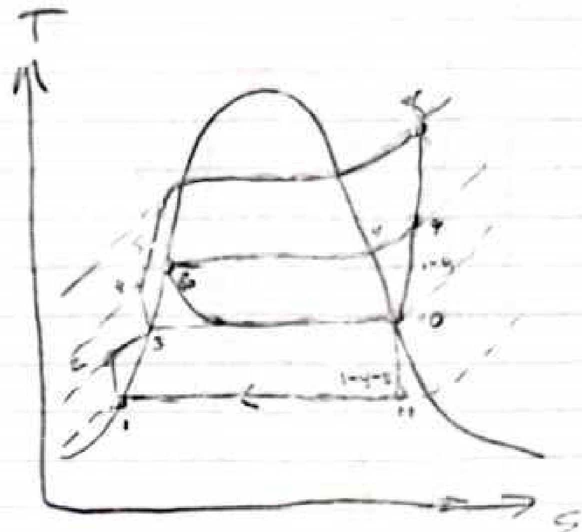
$(h_2 - h_1) + (h_3 - h_4)$

$(254.45 - 251.42) + (762.51 - 760.256)$

b) $5.284 \ kJ/kg$

10-53 Ideal steam Regenerative Rankine cycle





Pump isent $(1-y-z)$ → Pconst → Pump isent → Pconst → Pconst → Pconst → isent → isent → isent

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪

State 1
$\boxed{P_1 = 10\text{ kPa}}$
$\boxed{x_1 = 0}$
$\boxed{T_1 = 45.81\text{ C}}$
$\boxed{v_1 = 0.001010}$
$\boxed{h_1 = 191.81}$
$\boxed{s_1 = 0.6492}$

State 2
$\boxed{P_2 = 0.6\text{ MPa}}$

State 3
$\boxed{P_3 = 0.6\text{ MPa}}$
$\boxed{x_3 = 0}$
$\boxed{T_3 = 158.83}$
$\boxed{v_3 = 0.001101}$
$\boxed{h_3 = 670.38}$
$\boxed{s_3 = 1.9308}$

State 4
$\boxed{P_4 = 10\text{ MPa}}$

State 5
$\boxed{P_5 = 10\text{ MPa}}$
$\boxed{T_5 = 187.96}$
$\boxed{h_5 = 798.33}$

State 6
$\boxed{P_6 = 1.2\text{ MPa}}$
$\boxed{x_6 = 0}$
$\boxed{T_6 = 187.96}$
$\boxed{v_6 = 0.001138}$
$\boxed{h_6 = 798.33}$
$\boxed{s_6 = 2.2154}$

State 7
$P_7 = 0.6\text{ MPa}$

State 8
$\boxed{P_8 = 10\text{ MPa}}$
$\boxed{T_8 = 600°C}$
$\boxed{h_8 = 3625.8}$
$\boxed{s_8 = 6.9045}$
$s_9 = s_8$

State 9
$\boxed{P_9 = 1.2\text{ MPa}}$
$\boxed{h_9 = 2974.5}$
$\boxed{s_9 = 6.9045}$

State 10
$\boxed{P_{10} = 0.6\text{ MPa}}$
$\boxed{x_{10} = 1}$
$\boxed{T_{10} = 158.83}$
$\boxed{h_{10} = 2756.2}$
$s_{10} = 6.7593$
$\boxed{h_{10} = 2820}$

State 11
$P_{11} = 10$

$v_1(P_2 - P_1) = (h_2 - h_1)$
$0.001010(600 - 10) = h_2 - 191.81$
$\boxed{h_2 = 192.4665}$

$v_3(P_4 - P_3) = (h_4 - h_3)$
$\boxed{h_4 = 671.69}$

$s_{11} = s_9$
$s_{11} = s_9$

$x_{11} = \dfrac{s_{11} - s_f}{s_{fg}}$
$= \dfrac{6.9045 - 0.6}{7.4996}$

$x_{11} = 0.8341$

$h_{11} = h_f + x_{11} h_{fg}$
$= 191.81 + 0.83 \times 2\ldots$
$\boxed{h_{11} = 2187}$

$q_{in} = h_8 - h_5$
$q_{in} = 3625.8 - 798.33$
$= 2827$

$q_{out} = (1-y-z)(h_{11} - h_1)$
$= (1 - 0.0340 - 0.1694)(2187 - 191.81)$
$= 1549.38\ \text{kJ/kg}$

$W_{net} = 2827 - 1549.38$
$\boxed{W_{net} = 1278\ \text{kJ/kg}}$

$m = \dfrac{400{,}000}{1278} = \boxed{313\ \text{kg/s}}$

$m_9(h_9 - h_6) = m_5(h_5 - h_4)$
$y(2974.5 - 798.33) = 1(798.33 - 696.73)$
$\boxed{y = 0.0344}$

$m_7 h_7 = m_2 h_2 + m_{10} h_{10} = m_3 h_3$
$y h_7 + (1-y-z)h_2 + z h_{10} = h_3$

$z = \dfrac{(h_3 - h_2) - y(h_7 - h_2)}{h_{10} - h_2}$

$= \dfrac{477.98 - 32.744}{2628.5}$

$\boxed{z = 0.1694}$

$\eta = 1 - \dfrac{q_{out}}{q_{in}}$
$= 1 - \dfrac{1549}{2827}$
$\boxed{45.2\%}$