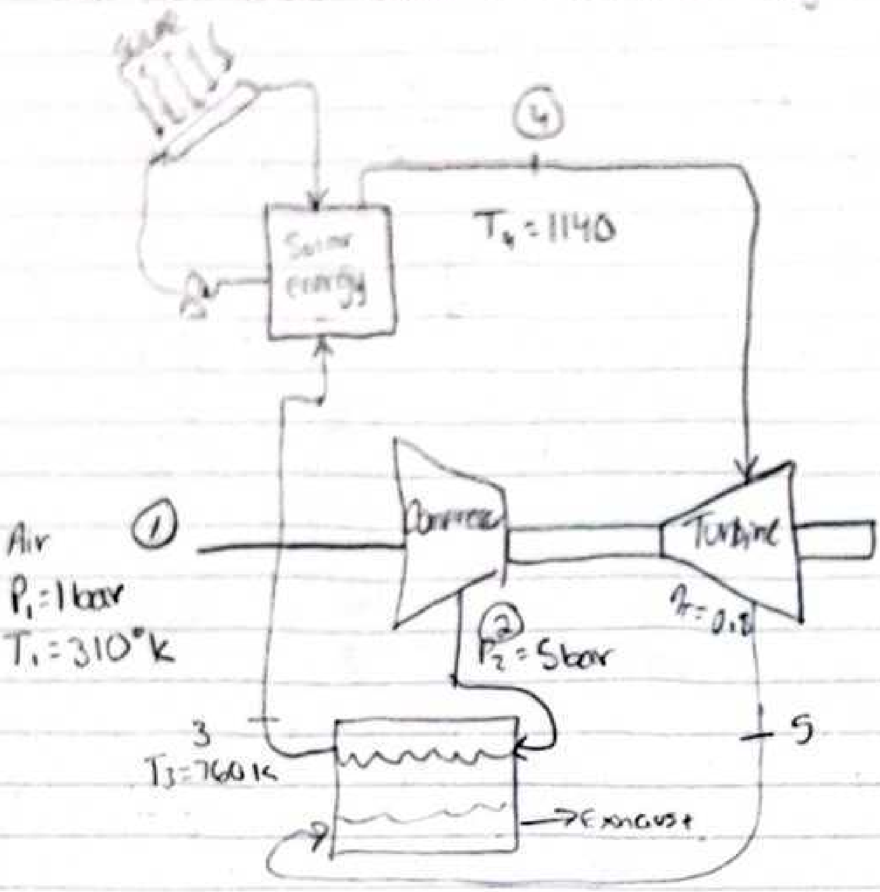
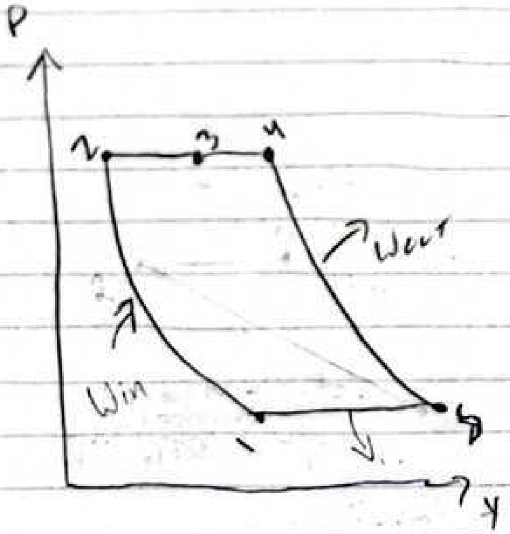
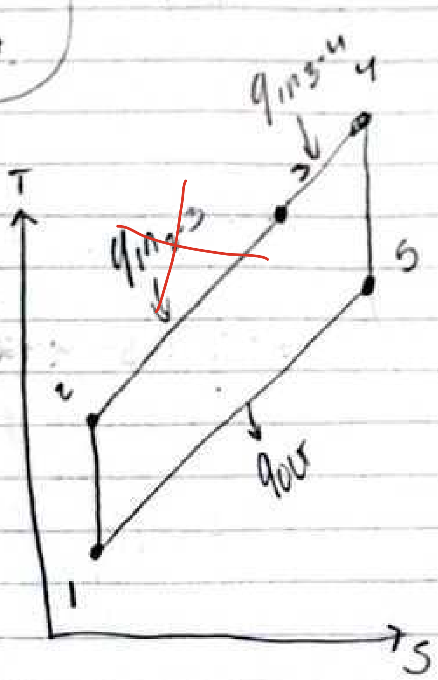
$25 \quad \frac{55}{90} + \frac{9.5}{10} = \frac{64.5}{100}$

TEST 1

1. Solar energy proposed solution as heat source in an ideal cold air standard cycle







−1

Assuming Cp, Cv CONSTANT

① Isentropic Compression → ② P = const → ③ P = const → ④ Isentropic Exp → ⑤ P = const

$P_1 = 1\text{bar}$, $T_1 = 310\text{K}$

$P_2 = 5\text{bar}$, $T_2 = 490\text{K}$, $h_2 = 492.74$

$P_3 = 5\text{bar}$, $T_3 = 760\text{K}$, $h_3 = 778.18$

$P_4 = 5\text{bar}$, $T_4 = 1140\text{K}$, $h_4 = 1207.57$

$P_5 = 1\text{bar}$, $T_5 = 719.78$

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \qquad \frac{T_5}{T_4} = \left(\frac{P_5}{P_4}\right)^{\frac{k-1}{k}}$$

$$T_2 = 310\text{K}\left(\frac{5}{1}\right)^{\frac{1.4-1}{1.4}} \qquad T_5 = 1140\left(\frac{1}{5}\right)^{\frac{1.4-1}{1.4}}$$

$$T_2 = 490.98\text{ K} \qquad T_5 = 719.78\text{K}$$

-1

a) Thermal Efficiency and Heat exchanger effectiveness

$$\eta_T = \frac{W_{net}}{q_{in}}$$

$$W_{net} = W_{out} - W_{in} = W_{out\,4\text{-}5} - W_{in\,1\text{-}2} = 337.84 - 181.88 = 155.96$$

$$W_{out\,4\text{-}5} = h_5 - h_4 = C_p(T_4 - T_{5.}) = 1.005(1140 - 719.72)$$
$$= 422.3 \cdot 0.8 = 337.84$$

-1

$$W_{in\,1\text{-}2} = h_2 - h_1 = C_p(T_2 - T_1) = 1.005(490.98 - 310)$$
$$= 181.88$$

$$q_{in} = \cancel{q_{in\,2\text{-}3}} + q_{in\,3\text{-}4}$$

-1

$$(h_3 - h_2) + (h_4 - h_3)$$
$$(778.18 - 492.74) + (1207.57 - 778.18)$$
$$= 714.83$$

$$\eta_T = \frac{155.96}{714.83}$$
$$= 21.8\%$$

$$\varepsilon = \frac{h_3 - h_2}{h_4 - h_2} = \frac{\text{actual}}{\text{max}}$$
$$= \frac{778.18 - 492.74}{1207.57 - 492.74}$$

$0.3993 = 39.93\%$

effective

-3

b) The air mass flow rate, in kg/s, for a net power output of 500 kW

$$\dot{m} = \frac{\dot{W}_{given}}{W_{net}} = \frac{500 \text{ kW}}{155.96} = 3.20 \frac{kg}{s}$$

c) What would be the thermal efficiency if the heat exchanger were operating at 100% effectiveness

-5

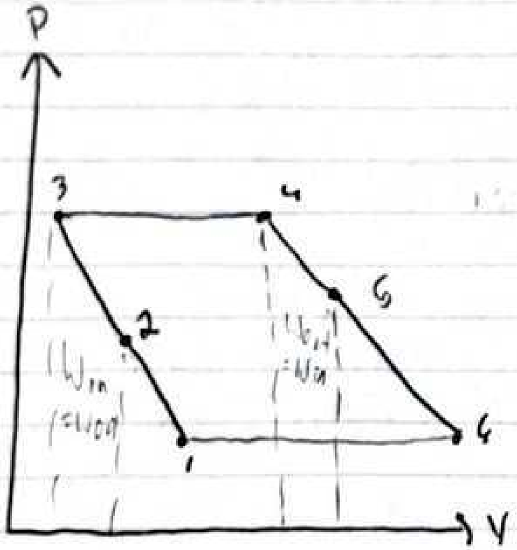
$$\eta_B = 1 - \frac{T_1}{T_5}$$

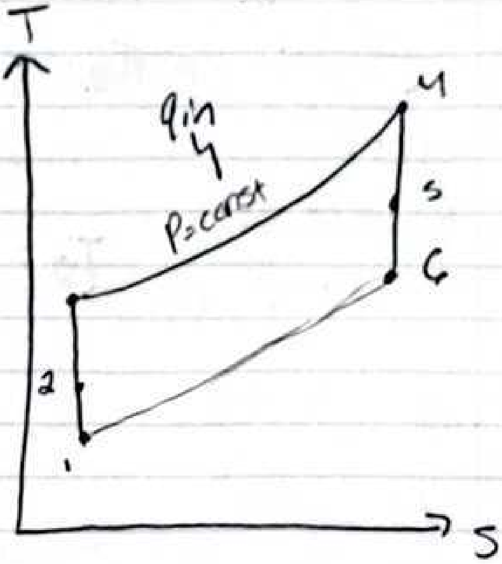
$$= 1 - \frac{310}{719.78} = 56.9\%$$

-5 NO Writing

-10

2) A turbojet aircraft flies w/ a velocity of 900 km/h at an altitude where Temp is -35°C and P is 40 kPa. Combustion gases enter turbine at 950°C. The turbine produces 500 kJ/kg of work, all of which is used to drive the compressor. Assuming an isentropic efficiency of 80% for the compressor, an isentropic efficiency of 90% for the turbine and using variable Specific heats.





Diffuser Compressor Burner Turbine Nozzle

ISENT DIFFER (1) → (2) ISENT → (3) PCONST → (4) ISENT 500 kJ/kg → (5) ISENT → (6)

$T_1 = 238k$ $T_2 = 239.45$ $T_4 = 1223k$ $P_6 = 40kpa$

$P_1 = 40\ kPA$ $P_2 = 40.85$

$V_1 = 900\ km/h$ $V_2 = 0$

$q_{in}\ Cp(T_5 - T_4)$

$v_1 = \frac{RT_1}{P_1}$ $v_2 = \frac{RT_2}{P_2}\ 1.68$

$T_5 = 1729007.k$ WRONG TOO HIGH

$= \frac{0.2870 \cdot 238}{40}$

$= 1.708$

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

$Wc = WT$

$Cp(T_2 - T_1) = Cp(T_4 - T_5)$

$239.45 - 238 = (1223 - T_5)$

$1.45 = 1223 - T_5$

$T_5 = 1221.55$

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

$P_2 = P_1 \cdot \left(\frac{T_2}{T_1}\right)$

$P_2 = 40.85$

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

$T_2 = T_1 + \frac{V_1^2}{2Cp}$

$= 238 + \frac{\cancel{400}^2}{2(1.005)}$

$T_2 = 239.45\ K$

−4

$\eta_T = \frac{h_4 - h_{5a}}{h_4 - h_{5s}}$

$.90 = \frac{1301 - h_{5a}}{1301 - 1905.93}$

$h_4 = 1301$

$h_5 = 1845.437$

$h_5 = 1905.93$ interpolation app

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

$T_3 = T_2 + \frac{V_2^2}{2cp}$

$= 239.45 + \frac{1.68^2}{2(1.004)}$

$\frac{1221.007}{1223} = \left(\frac{P_5}{41.69}\right)$

−5

$T_3 = 240.85$

$P_5 = 41.62$

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

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

$\frac{240.85}{239.45} = \left(\frac{P_3}{40.85}\right)^{\frac{0.4}{1}}$

$T_6 = 1221.55 = \left(\frac{40}{41.6}\right)^{\frac{1.4-1}{1.4}}$

$T_6 = 1207.9$

$P_3 = 41.69$

−9

a) Pressure of Combustion gases @ Turbine exit

$P_5 = 41.62$ kPA

b) Velocity of the gases at the nozzle exit

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

$$= \sqrt{2(1.005)(1221.55 - 1207.9)}$$

$$V_6 = 5.237 \text{ km/h}$$

c) The thrust for engine if diffuser inlet diameter is 1.6m

Correct equations wrong numbers

$$\dot{m} = \rho_1 V_1 A_1$$

$$= \frac{1}{v} \cdot V_1 \cdot \pi r^2$$

$$= \frac{1}{1.708} \cdot 900 \cdot (\pi \cdot 0.8^2)$$

$$\dot{m} = 1059.46$$

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

$$= 9479165.608$$

UH OH

-5 NO Writing