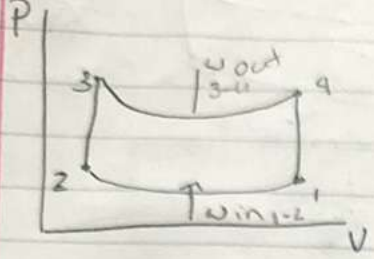
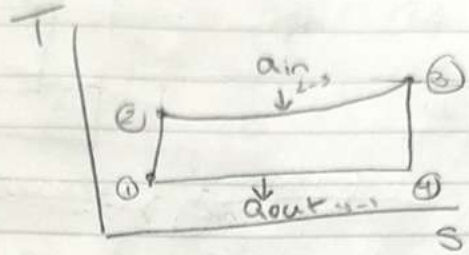
H.w 1.3

9-33)





$r = 8$

$C_v = 0.718$ kJ/kg·K

$C_p = 1.005$ kJ/kg·K

$k = 1.400$

$R = 0.287$ kJ/kg·K

State 1 (Isentropic) State 2 (Constant V) State 3 (Isentropic) State 4 (Constant V)

$T_1 = 300$ K

$P_1 = 95$ kPa

$v_1 = \frac{(0.287)(300)}{95}$

$= 0.9063$ m³/kg

$v_{r1} = 621.2$

$u_1 = 214.07$ kJ/kg

$v_2 = v_1/8$

$= 0.9063/8$

$v_2 = 0.11329$

$v_{r2} = \left(\frac{0.11329}{0.9063}\right)(621.2)$

$v_{r2} = 77.65$

$T_2 = 675$ K

$u_2 = 492.72$ kJ/kg

$u_3 = u_2 + 750$ kJ/kg

$= 492.72 + 750$

$u_3 = 1242.72$ kJ/kg

$T_3 = 1539$ K

$v_{r3} = 6.88$

$v_4 = 8(0.11329)$

0.9063

$v_{r4} = \left(\frac{0.9063}{0.11329}\right)$

$= 55.04$

$T_4 = 762.56$ K

$u_4 = 568.065$ kJ/kg

(a) Tempetur at the end is 1539K

$P_2 = \frac{(675)}{(300)}(95)(8) = 1710$ kPa

$\frac{(1710)(1539)}{673.17} = 3898.8$ kPa

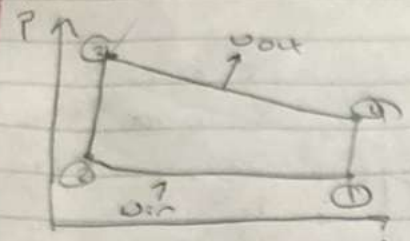
(b) $q_{4-1} = u_4 - u_1 = (568.665) - (214.07) = 353.995$ kJ/kg

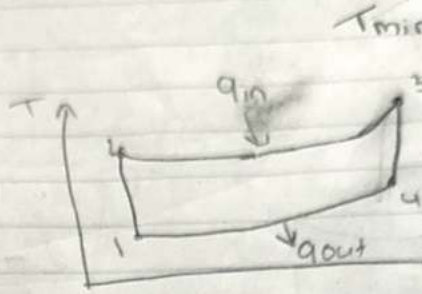
750 kJ/kg $- 353.995 = 393$ kJ/kg

(c) $\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{393}{750} = 0.524 = 52.4\%$

(d) $MEP = \frac{w_{net}}{v_{max} - v_{min}} = \frac{w_{net}}{v_1 - v_2} = \frac{393}{0.9063 - 0.11329} = 495$ kPa

9-36)





$T_{min} = 565R$

$T_{max} = 2860R$

$R = 0.069$

$n = 2500$

① isentropic ② v constant ③ isentropic ④ v constant

$T_1 = 565R$

$P_1 = 14 psia$

$v_1 = \frac{RT_1}{P_1} = 2.78$

$v_2 = v_1 / 10.20$

$v_2 = 0.2725$

$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$

$= 1430.6 R$

$T_3 = 2860R$

$v_3 = v_2$

$v_3 = 0.2725$

$v_4 = v_1$

2.78

$\frac{T_4}{T_3} = \left(\frac{v_3}{v_4}\right)^{k-1}$

$T_4 = 1129$

$w_{net} = w_{out} - w_{in} = c_v(T_3 - T_4) - c_v(T_2 - T_1) = 147.98 \text{ Btu/lbm}$

$\dot{w}_{net} = \frac{\dot{m}}{\dot{v}} w_{net}$

$v_1 = 0.6079$

$v_1 = \frac{RT_1}{P_1} = \frac{0.3704 \cdot 565R}{14} = 14.95 ft^3/lbm$

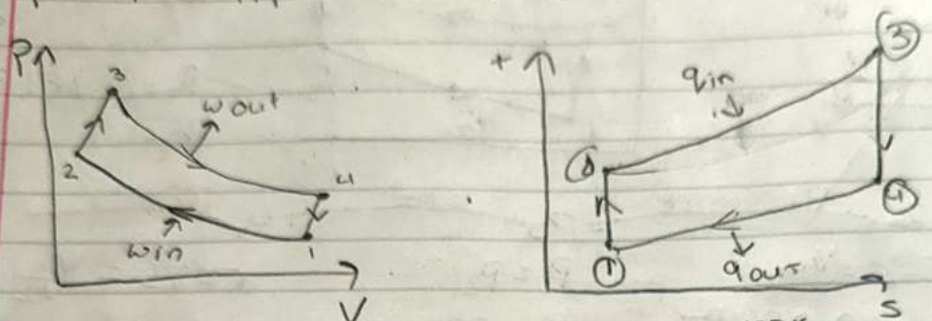
$m = \frac{v_1}{v_1} = \frac{0.6079}{14.95} = 0.00531 lbm$

$\dot{w}_{net} = \frac{0.00531 lbm}{\left(\frac{2 rev}{2500}\right)} \left(147.98 \frac{Btu}{lbm}\right) = 980.36 Btu/rev$

9-46

$r = 16 \quad r_c = 2$

$P = 95 \text{ kPa} \quad T = 27°C = 300K$



1 isentropic → 2 P constant → 3 isentropic → 4 V const

1	2	3	4
$P_1 = 95 kPa$	$r = 16 = \frac{v_1}{v_2}$	$P_2 = P_3$	$v_4 = v_1$
$T_1 = 300K$	$= 0.0566 m^3/kg$		$v_4 = 0.9063 m^3/kg$
$v_1 = \frac{0.287(300)}{95}$	$v_{r2} = \left(\frac{0.0566}{0.9063}\right)(621.2)$	$r_c = 2 = \frac{v_3}{v_2}$	$u_4 = 660$
$= 0.9063 m^3/kg$	$v_{r2} = 38.8$	0.1132	
$v_{r1} = 621.2$	$T_2 = 862K$	$T_3 = \frac{v_3}{v_2} T_2$	
$u_1 = 214.07$	$u = 890$	$= 1724K$	
		$u_3 = 1910$	

(a) $T_a = T_3 = 1724K$

(b) $\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{q_{in} - q_{out}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}}$

q_{in} (2-3) $= 1910 - 890 = 1020$

q_{out} (4-1) $= 660 - 214 = 446$

$w_{net} = 574 \qquad \eta_{th} = \frac{574}{1020} = 0.563 = 56.3\%$

(c) $MEP = \frac{574}{0.9063 - 0.0566} = 676 kPa$

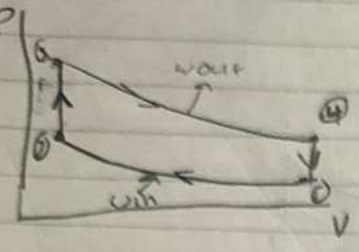
9-57) $r=22$ $r_c=1.8$ $P=97\text{kPa}$ $T=70°C=343K$ $V=2.4L$

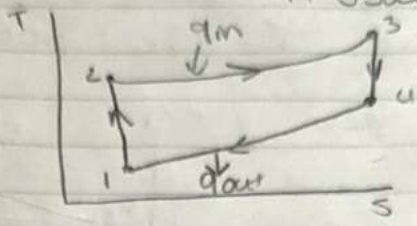
$n=3500\text{rpm}$ $C_p=1.005\ kJ/kg\cdot K$

$C_v=0.718\ kJ/kg\cdot K$

$R=0.287\ kJ/kg\cdot K$

$k=1.4$





1 — Isent — 2 — P constant — 3 — Isent — 4 — V constant

1	2	3	4
$T_1=343K$	$r=22=V_1/V_2$	$P_3=P_2$	$r=22=\frac{V_4}{V_2}$
$P_1=97\text{kPa}$	$=0.04614\frac{m^3}{kg}$	$P_3=7354.91K$	$=1.015\frac{m^3}{kg}$
$v_1=\frac{RT_1}{P_1}$	$\frac{T_2}{T_1}=\left(\frac{V_1}{V_2}\right)^{k-1}$	$r_c=1.8=\frac{V_3}{V_2}$	$\frac{T_4}{T_3}=\left(\frac{V_3}{V_4}\right)^{k-1}$
$=1.015\frac{m^3}{kg}$	$T_2=1181.4K$	$V_3=0.08298$	$T_4=781K$
	$P_2=\frac{RT_2}{V_2}=7354.91\text{kPa}$	$T_3=\frac{V_3P_3}{R}$	
		$T_3=2126.51K$	

$$w_{out_{3-4}}=\frac{R(T_4-T_3)}{1-k}=965.4\ kJ/kg$$

$$w_{in_{1-2}}=\frac{R(T_1-T_2)}{1-k}=601.552\ kJ/kg$$

$$w_{net}=363.84$$

$$\dot{w}_{net}=\frac{n}{120}w_{net}\dot{m}$$

$$m=\frac{V_1}{v_1}$$

$$\forall_d=0.0006\,m^3$$

$$r=\frac{\forall_c+\forall_d}{\forall_c}=22$$

$$\forall_c=0.00006m^3$$

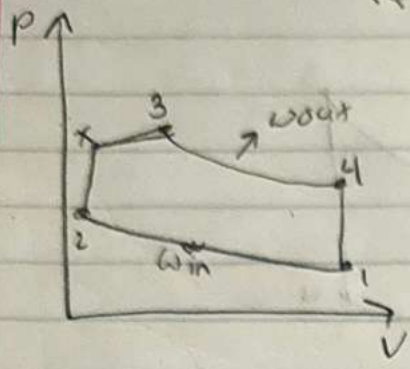
$$\forall_1=V_c+V_d=0.00066\,m^3$$

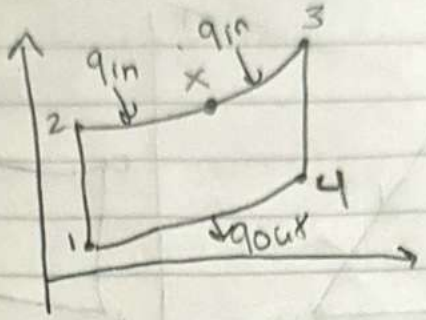
$$m=0.000652\,kg$$

$\dot{w}_{net}=6.923\text{kW}$ per Cylinder

$\boxed{\dot{w}_{net}=27.69\text{kW}}$

9-59E) $r = 15$ $r_c = 1.4$ $r_p = 1.1$ $P_1 = 14.2$ psia or 98 kPa $T_1 = 75°F$ $24°C \rightarrow 297K$





$R = 0.287$ kJ/kg·K
$c_p = 1.005$ kJ/kg·K
$c_v = 0.718$ kJ/kg·K
$k = 1.4$

1 Isentropic → 2 V Const → x (P Const, $v_x = v_2$, $v_x = 0.0580$ m³/kg) → 3 Isentropic ($P_3 = P_x$) → 4 V Const

$P_1 = 98$ kPa
$T_1 = 297$ K
$v_1 = \frac{RT_1}{P_1} = 0.8698 \text{ m}^3/\text{kg}$

$r = 15 = v_1 / v_2$
$v_2 = 0.0580 \text{ m}^3/\text{kg}$
$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$
$T_2 = 877.3$ K
$P_2 = \frac{RT_2}{v_2} = 4341.12$ kPa

$r_p = 1.1 = \frac{P_x}{P_2}$
$= 4775.2$ kPa
$T_x = \frac{v_x P_x}{R}$
$T_x = 965.02$

$P_3 = P_x$
$P_3 = 4775.2$ kPa
$r_c = 1.4 = \frac{v_3}{v_x}$
$v_3 = 0.0812 \frac{\text{m}^3}{\text{kg}}$
$T_3 = \frac{v_3 P_3}{R}$
$T_3 = 1351.03$ K

$r = k = \frac{v_4}{v_x}$
$v_4 = 0.87$
$\frac{T_4}{T_3} = \left(\frac{v_3}{v_4}\right)^{k-1}$
$T_4 = 523.21$
$P_4 = \frac{RT_4}{v_4}$
$P_4 = 172.6$ kPa

(a) $w_{net} = w_{out,\,x-4} - w_{in,\,1-2} = w_{out,\,x-3} + w_{out,\,3-4} - w_{in,\,1-2}$

$w_{out,\,x-3} = P_x(v_3 - v_x) = 110.78$ kJ/kg
$w_{out,\,3-4} = \frac{R(T_4 - T_3)}{1-k} = 593.96$ kJ/kg
$w_{in,\,1-2} = \frac{R(T_1 - T_2)}{1-k} = 416.37$ kJ/kg

$\boxed{w_{net} = 288.37 \text{ kJ/kg}}$

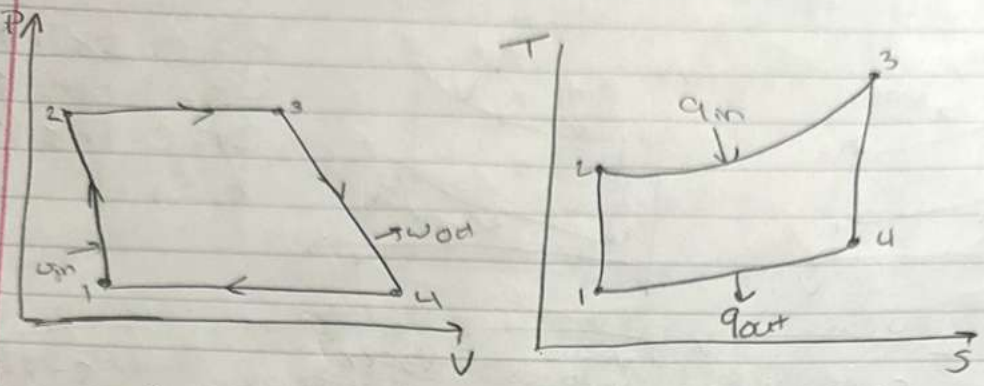
(b) $q_{in,\,2-3} + w_{out,\,3-4} = c_v(T_3 - T_2) + w_{out,\,x-3}$

$\boxed{q_{in} = 450.91 \text{ kJ/kg}}$

(c) $\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{288.37}{450.91}$

$\boxed{\eta_{th} = 0.639 \text{ or } 63.9\%}$

9-80) $r_p = 10$ $T_1 = 520\,R$ $T_3 = 2{,}000\,R$



1 —Isent→ 2 —Pconst→ 3 —Isent→ 4 —Pconst

$T_1 = 520\,R$ $P_2 = 10P_1$ $T_3 = 2000\,R$ $P_4 = P_3/10$

$Pr_1 = 1.2147$ $\frac{P_2}{P_1} = \frac{Pr_2}{Pr_1} = 10(1.2147)$ $Pr_3 = 174.0$ $= 17.40$

$= 12.147$ $T_4 = 1099.8\,R$

$T_2 = 996.48\,R$

$h_1 = 124\,\frac{Btu}{lbm}$ $h_2 = 240.11$ $h_3 = 504.71$ $h_4 = 265.83$

(a) Temperature exit $= T_2$

$\boxed{T_2 = 996.48\,R}$

(b) $w_{in,\,1-2} = h_2 - h_1 = 115.84\,Btu/lbm$ $w_{out,\,3-4} = h_3 - h_4 = 238.88\,Btu/lbm$

$\frac{w_{comp}}{w_{exp}} = \boxed{0.485}$

(c) $\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{238.88 - 115.84}{264.11} = 0.465$ or $\boxed{46.5\%}$

$q_{in,\,2-3} = 504.71 - 240.11 = 264.11$