
Elson Edmonds II
Jonah T. Spraggins

$r = 15 \quad r_c = 1.4 \qquad r_p = 1.1$

$c_p = 1.005 \quad v_? = .287$

$c_v = .718 \quad k = 1.4$

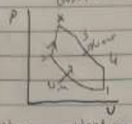
$1\,psi = 6.894\,kPa$

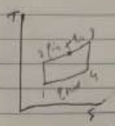
Hw 1.3

33, 36, 46

57, 59, 80

9.59)





$\xrightarrow{} (1) \xrightarrow{s\ const} (2) \xrightarrow{v\ const} (x) \xrightarrow{P\ const} (3) \xrightarrow{s\ const} (4) \xrightarrow{v\ const}$

(1)	(2)	(x)	(3)	(4)
$P_1 = 97.9\,kPa$	$P_2 = 434.21$	$P_x = 477.63$	$P_3 = 477.63$	$P_4 = 172$
$T_1 = 297.04\,K$	$T_2 = 877.5$	$T_x = 965.7$	$T_3 = 1351.3$	$T_4 = 533.7$
$v_1 = .87$	$v_2 = .068$	$v_x = .068$	$v_3 = .08$	$v_4 = .87$

$T_1 = (75 - 32)\frac{5}{9} + 273$

$T_1 = 297\,K$

$v_2 = \frac{v_1}{r}$

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

$v_3 = \frac{v_3}{T_3} = v_x$

$v_4 = v_1$

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

$P_4 = \frac{R T_4}{v_4}$

$P_x = r_p P_2$

$T_3 = \frac{P_3 v_3}{R}$

$v_1 = \frac{R T_1}{P_1}$

$P_2 = \frac{R T_2}{v_2}$

$T_x = \frac{P_x v_x}{R}$

$q_{in,x} = c_v (T_x - T_2) = .718 (965.2 - 877.5) = 62.96$

$q_{in,3} = c_p (T_3 - T_x) = 1.005 (1351.2 - 965.2) = 388.03$

$q_{in} = 62.96 + 388.03$

$q_{in} = 450.99$

$q_{out} = c_v (T_4 - T_3)$

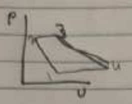
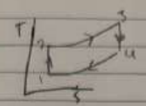
$= .718 (533.3 - 1351.7)$

$q_{out} = -594.5$

$W_{net} = q_{in} - q_{out} = 451 + 594.5 = 1045.49$

$\eta_{th} = \frac{W_{net}}{q_{in}} \rightarrow \frac{1045.49}{450.99} \rightarrow 2.318$

$r_p = 10$

9.8 a)  

① →Isent→ ② →P const→ ③ →Isent→ ④ →P const→

①	②	③	④
$T_1 = 520R$	$T_2 = 996.4R$	$T_3 = 2100R$	$P_4 = P_1$
$P_{r1} = 1.21$	$P_{r2} = 12$	$P_{r3} = 174$	$T_4 = 1149.3$

$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}} \Rightarrow P_{r2} = \frac{P_2}{P_1}(P_{r1})$ $\qquad$ $P_{r4} = \left(\frac{P_4}{P_3}\right)P_{r3}$

$P_{r2} = 12.14$ $\qquad$ $P_{r4} = 17.4$

$T_2 = 996.4$

$h_1 = 124.27$ $\qquad$ $h_2 = 240.11$ $\qquad$ $h_3 = 534.71$ $\qquad$ $h_4 = 265.83$

$\frac{W_{comp}}{W_{turb}} = \frac{W_{in,1\text{-}2}}{W_{out,3\text{-}4}}$ $\qquad$ $W_{in,12} = h_2 - h_1 = 115.84$

$W_{out,34} = h_3 - h_4 = 238.8$

$\Rightarrow \frac{115.84}{238.4} = .485$

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

$\eta_{th} = .465$

$P_2(v_3 - v_2)$

$q_{in} = q_{in,\,2-x} + q_{in,\,x-3}$

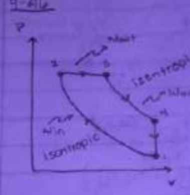
q_{x-3}

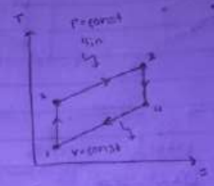
$q_{in,\,x-3} - q_{out,\,x-3} + w_{in,\,x-3} - w_{out,\,x-3} = u_3 - u_x$

$q_{in,\,x-3} = (u_3 - u_x) + w_{out,\,x-3}$

$= c_v(T_3 - T_x) + w_{out,\,x-3}$

9-46





$r = 16 \quad r_c = 2 \quad T_1 = 27^\circ C = 300\,K \quad P_1 = 95\,kPa$ Variable cp & cv

PV=RT

$\xrightarrow{}$ ① $\xrightarrow{\text{Isent}}$ ② $\xrightarrow{P\ \text{const}}$ ③ $\xrightarrow{\text{Isent}}$ ④ $\xrightarrow{V\ \text{const}}$

①

$\boxed{P_1 = 95\,kPa}$

$\boxed{T_1 = 300\,K}$

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

$= \frac{(1.4)(300)}{95}$

$\boxed{v_1 = 4.421\ \frac{m^3}{kg}}$

②

$r = \frac{v_1}{v_2}$

$16 = \frac{4.421}{v_2}$

$\boxed{v_2 = 0.276\ \frac{m^3}{kg}}$

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

$T_2 = \left(\frac{4.421}{0.276}\right)^{1.4-1} \cdot 300$

$\boxed{T_2 = 909.892\,K}$

$P_2 = \frac{RT_2}{v_2}$

$P_2 = \frac{(1.4)(909.892)}{0.276}$

$\boxed{P_2 = 4615.141\,kPa}$

③

$P_3 = P_2$

$\boxed{P_3 = 4615.141\,kPa}$

$r_c = \frac{v_3}{v_2} = \frac{v_3}{v_2}$

$2 = \frac{v_3}{0.276}$

$\boxed{v_3 = 0.552}$

$\frac{P_3 v_3}{R} = T_3$

$T_3 = \frac{(4615.141)(0.552)}{1.4}$

$\boxed{T_3 = 1819.3\,K}$

④

$v_4 = v_1$

$\boxed{v_4 = 4.421\ \frac{m^3}{kg}}$

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

$T_4 = \left(\frac{0.552}{4.421}\right)^{k-1} \cdot 1819.3$

$\boxed{T_4 = 791.54\,K}$

$P_4 = \frac{RT_4}{v_4}$

$P_4 = \frac{(1.4)(791.54)}{4.421}$

$\boxed{P_4 = 250.65\,kPa}$

$\eta_{th\,diesel} = \cancel{1 - \frac{1}{r^{k-1}}\left(\frac{r_c^k - 1}{k}\right)} \quad \frac{w_{net}}{q_{in}} \quad \cancel{q_{in,\,2-3} = c_v(T_3 - T_2) + w_{out,\,2-3}}$

$w_{net} = w_{out,\,2-3} + w_{\ldots,\,3\ldots}$

$= 1 - \frac{1}{r^{k-1}}\left(\frac{r_c^k - 1}{k(r_c - 1)}\right)$

$MEP = \frac{w_{net}}{v_{max} - v_{min}} = \frac{w_{net}}{v_3 - v_1}$

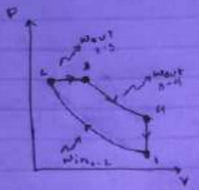
$\eta_{th} = 0.613$

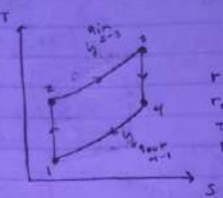
$\boxed{\eta_{th} = 61.3\%}$

$\boxed{MEP = 676\,kPa}$

$\boxed{T = 1819.3\,K}$

9-57





$r = 22$
$r_c = 1.8$
$T_1 = 70°C = 343K$
$P_1 = 97kPa$
3500 rpm

$\rightarrow (1) \xrightarrow{\text{Isent.}} (2) \xrightarrow{P\text{ const}} (3) \xrightarrow{\text{Isent.}} (4) \xrightarrow{v\text{ const}}$

(1)

$[P_1 = 97kPa]$
$[T_1 = 343K]$
$v_1 = \frac{RT_1}{P_1}$
$v_1 = \frac{0.287(343)}{97}$
$[v_1 = \cancel{\ldots}\ \frac{m^3}{kg}]$
$[1.015]$

(2)

$r = 22 = \frac{v_1}{v_2}$
$[v_2 = \cancel{0.225}\ \boxed{0.0461} \frac{m^3}{kg}]$
$\frac{T_2}{T_1} = \left(\frac{v_1}{v_2}\right)^{k-1}$
$T_2 = \left(\frac{1.015}{0.0461}\right)^{0.4} \cdot 343$
$[T_2 = 1181.131K]$
$P_2 = \frac{RT_2}{v_2} = \frac{(0.287)(1181.131)}{0.0461}$
$[7353.25]$
$[P_2 = \cancel{7342.23kPa}]$

(3)

$P_3 = P_2$
$[P_3 = 7353.25]$
$r_c = \frac{v_3}{v_2}$
$1.8 = \frac{v_3}{0.0461}$
$[v_3 = 0.083]$
$T_3 = \frac{P_3 v_3}{R}$
$T_3 = \frac{(7353.25)(0.083)}{0.287}$
$[T_3 = 2126.5.5K]$

(4)

$v_4 = v_1$
$[v_4 = 1.015 \frac{m^3}{kg}]$
$\frac{T_4}{T_3} = \left(\frac{v_3}{v_4}\right)^{k-1}$
$T_4 = \left(\frac{0.083}{1.015}\right)^{0.4} \cdot 2126.5.5$
$[T_4 = 781.1K]$
$P_4 = \frac{RT_4}{v_4}$
$[P_4 = 2208 kPa]$

$P = \frac{W_{net}}{n_{rev}/60}$
$\boxed{P = 118.5kW}$

$w_{net} = w_{out,2-3} + w_{out,3-4} - w_{in,1-2}$

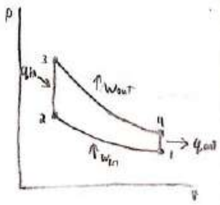
9-33E | MET 350 | HW 13

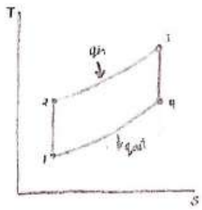
Jonah Spraggins
Matthew Hearc
Elson Edmond

- Given
- Air
- $P_1 = 14\,psia = 96.53\,kPa$
- $T_1 = 60°F = 288.71\,K$
- $T_3 = 1500°F = 1088.71\,K$
- $r = 9$
- $c = const.$ @ Room T

1-2 Isentropic ($s = const.$)
2-3 Isochoric ($v = const.$)
- Q_{in}

3-4 Isentropic ($s = const.$)
4-1 Isochoric ($v = const.$)
- Q_{out}





- Required:
- MEP = ?
- $Q_{in} = ?$
- $Q_{out} = ?$ } when $P = 140\,hp$

- Solution

1 $T_1 = 288.71\,K$
- $P_1 = 96.53\,kPa$
- $v_1 = \frac{R \cdot T_1}{P_1} = 0.858\,m^3/kg$

2 $v_2 = \frac{v_1}{r} = 0.095\,m^3/kg$
- $T_2 = \left(\frac{v_1}{v_2}\right)^{k-1} \cdot T_1 = 696.25\,K$
- $P_2 = \frac{R \cdot T_2}{v_2} = 2103.41\,kPa$

9-33E | MET 350 | HW 13

3 $T_3 = 1088.71K$

- $\forall_3 = \forall_2 = 0.095 m^3/Kg$
- $P_3 = \frac{R \cdot T_3}{\forall_3} = 3289.05 KPa$

4 $\forall_4 = \forall_1 = 0.858 m^3/Kg$

- $T_4 = \left(\frac{\forall_3}{\forall_4}\right)^{K-1} \cdot T_3 = 451.45K$
- $W_{1-2} = \frac{R \cdot (T_2 - T_1)}{1-K} = -292.41 KJ/Kg$
- $W_{3-4} = \frac{R \cdot (T_4 - T_3)}{1-K} = 457.23 KJ/Kg$
- $W_{net} = W_{3-4} - W_{1-2} = -749.64 KJ/Kg$
- $MEP = \frac{W_{net}}{\forall_1 - \forall_2} = -982.49 KPa$
- $\eta_{th}^{otto} = 1 - \frac{T_4 - T_1}{T_3 - T_2} = 0.59$
- $q_{in} = \frac{W_{net}}{\eta_{th}^{otto}} = \boxed{-1665.24 KJ/Kg}$
- $q_{out} = (1 - \eta_{th}^{otto}) \cdot q_{in} = \boxed{-682.75 KJ/Kg}$