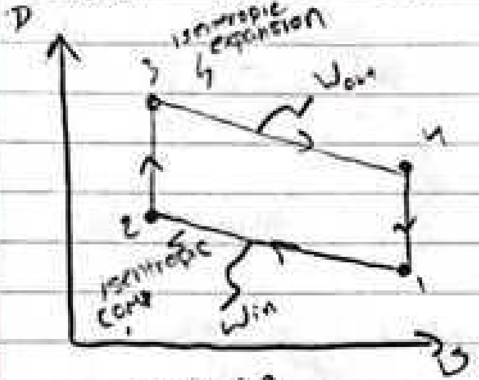
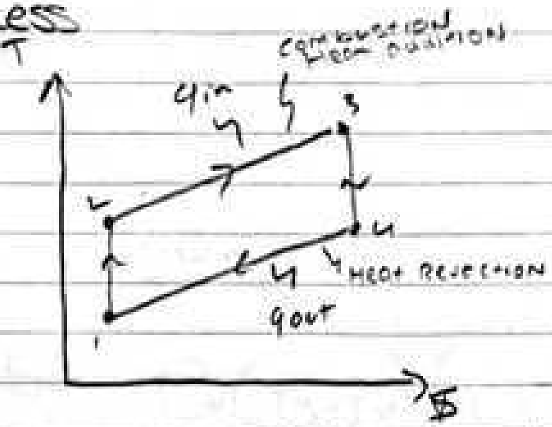
Homework 1.3

9-33 Ideal Otto Cycle
Compression RATIO of 8
beginning of compression Process, air is at 95 kPA and 27°C, and 750 kJ/kg of heat is transferred to air during the constant-volume heat addition Process





$\rightarrow (1) \xrightarrow{\text{isentropic compression}} (2) \xrightarrow[\rightarrow 750 \text{ kJ/kg} \rightarrow]{V\text{ const}} (3) \xrightarrow{\text{isentropic expansion}} (4) \xrightarrow{V = \text{const}}$

$P_1 = 95 kPA$
$T_1 = 27°C = 300°K$
$PV = RT$
$95V = \frac{0.2870(300)}{95}$
$v_1 = 0.906$

$8 = \frac{V_1}{V_2}$
$V_2 = \frac{0.906}{8}$
$V_2 = 0.11$
$\left(\frac{T_2}{300}\right) = \left(\frac{0.906}{0.11}\right)^{\frac{1.4-1}{1}}$
$T_2 = 697$
$P_2 = \frac{(0.287)(697)}{0.11}$
$P_2 = 18186.5$

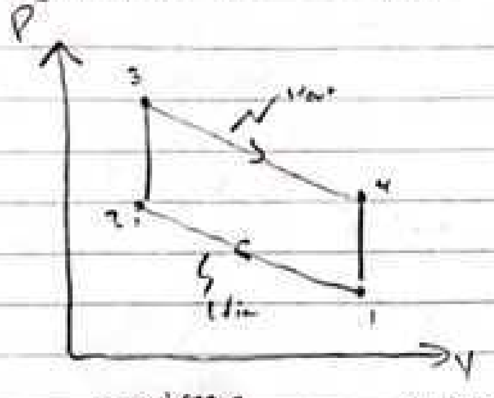
$V_3 = 0.11$

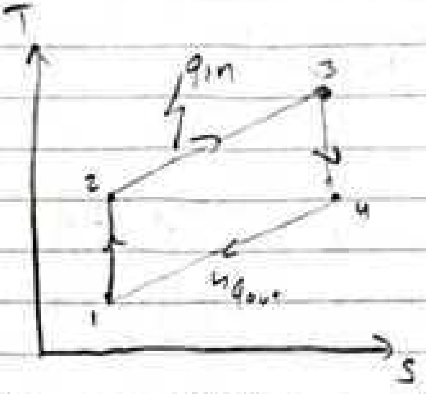
??

$V_4 = 0.906$

STROKE

9-36 Six Cylinder, 4 cylinder, ideal otto cycle takes in air at 14 PSIA and 105°F
Max Cycle temp 2400°F. Each Cylinder has a bore of 3.5 in. and each Piston has a Stroke of 3.9 in





→ ISENTROPIC COMPRESSION → V: CONST → ISENTROPIC EXPANSION → V = CONST →

① ② ③ ④

$P_1 = 14$ PSIA

$T_1 = 564.67 R$

$V = \frac{3.14(3.9)(3.5)^2}{4}$

$V_1 = 37.5$

$\left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{k-1}$

$T_2 = 564.67\left(\frac{37.5}{3.28}\right)^{1.4-1}$

$T_2 = 6455.8$

FORGOT ABOUT 9.6% VOLUME. MIN VOLUME CLOSE ENOUGH

$V_2 = 3.28$

$T_2 = 6455.8 R$

$T_3 = 2400°F + 459.67$
$= 2859.67$

$r = \frac{V_2}{V_1}$

$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1}$

$\frac{T_3}{T_1} = \left(\frac{V_2}{V_1}\right)^{\frac{1}{k-1}}$

$\left(\frac{T_3}{T_1}\right)^{\frac{1}{k-1}} = (r)$

$\left(\frac{2859.67}{564.67}\right)^{2.5} = r$

$(5.067)^{2.5} = r$

$r = 11.4$

$r = \frac{V_1}{V_2}$

$V_2 = \frac{V_1}{r}$

$V_2 = \frac{37.5}{11.4}$

$V_2 = 3.28$

$V_4 = 37.5$

$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{k-1}$

$T_4 = 2859.67\left(\frac{3.28}{37.5}\right)^{0.4}$

$T_4 = 1079.1 R$

How Much Power will this engine Produce when operated at 2500 RPM

$$W = C_v[(T_3 - T_2) - (T_4 - T_1)]$$ ← Found From NASA website

$$= 0.171[(6455.8 - 2855.67) - (1079.1 - 564.67)]$$

$$W = 526.9707$$

$$P = W\ CPS$$

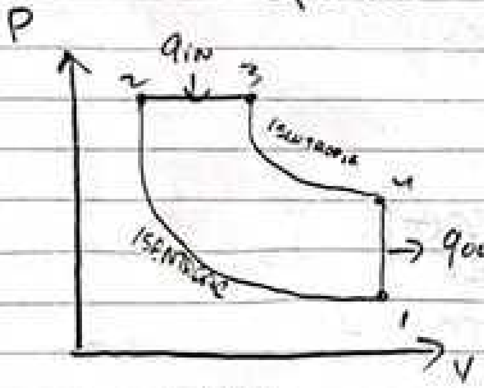
$$526.9707 \cdot \left(\frac{2500}{60}\right)$$

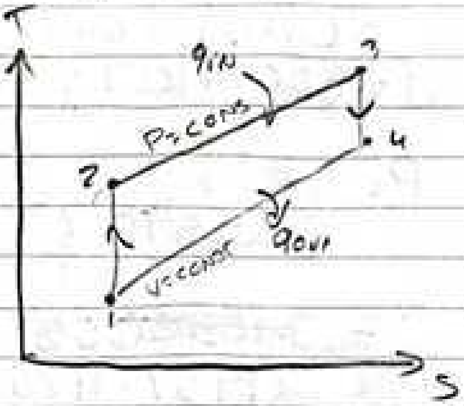
$$= \cancel{1404.5605}\ \text{WATTS}$$

$$21957.1125$$

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

9-46 Air Standard diesel cycle w/ Compression RATIO OF 16 and a CUTOFF RATIO OF 2. @ Beginning OF Compression Process, air is @ 95 KPA and 27°C. Variable Specific Heats





$$\rightarrow (1) \xrightarrow[\text{COMPRESSION}]{\text{ISENTROPIC}} (2) \xrightarrow{P = \text{CONST}} (3) \xrightarrow[\text{EXPANSION}]{\text{ISENTROPIC}} (4) \xrightarrow{V = \text{CONST}}$$

State 1

$P = 95 \text{ KPA}$

$T = 300 \text{ K}$

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

$V_1 = 4.42$

State 2

$V_2 = \frac{V_1}{r}$

$V_2 = \frac{4.42}{16}$

$V_2 = 0.28$

$\left(\frac{T_2}{T_1}\right) = \left(\frac{V_1}{V_2}\right)^{k-1}$

$T_2 = 300\left(\frac{4.42}{0.28}\right)^{1.4-1}$

$T_2 = 904.5 K$

$PV = RT$

$P = \frac{(1.4)(904.5)}{0.28}$

$P_2 = 4522.69$

State 3

$V_3 = 2V_2$

$V_3 = 0.56$

$\frac{V_2}{V_3} = \frac{T_2}{T_3}$

$\frac{0.28}{0.56} = \frac{904.5}{T_3}$

$1809 = T_3$

$P_3 = 4522.69$

State 4

$V_4 = 4.42$

$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{k-1}$

$T_4 = 1809\left(\frac{0.56}{4.42}\right)^{0.4}$

$T_4 = 791.67$

$PV = RT$

$P = \frac{1.4(791.67)}{4.42}$

$P = 250.75$

USED WRONG R VALUE :(

a) Temperature after heat addition Process

$\boxed{1809\ K}$

b) The thermal efficiency

$$\eta_{th_{Diesel}} = 1 - \frac{1}{r^{k-1}}\left[\frac{r_c^{k}-1}{k(r_c-1)}\right]$$

$$1 - \frac{1}{16^{1.4-1}}\left[\frac{2^{1.4}-1}{1.4(2-1)}\right]$$

$$\eta_{th_{Diesel}} = 0.61 = \boxed{61\%\ \text{Efficient}}$$

c) MEAN Effective Pressure

$$MEP = \frac{U_{net}}{v_1 - v_2} = \frac{296.77}{4.42-0.28} = \boxed{71.68}$$

$U_{net} = W_{out} - U_{in} = q_{in} - q_{out}$

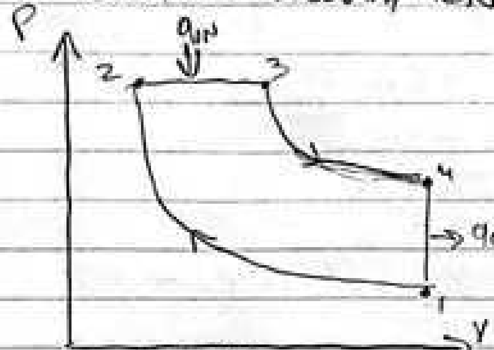
$W_{net} = C_v(T_3-T_2) - C_v(T_4-T_1)$

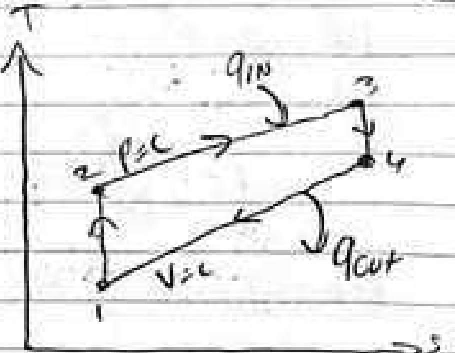
$W_{net} = 0.718(1809-904) - 0.718(791.67-300)$

$U_{net} = 296.77$

$= 296.77$

9-57 A four Cylinder two stroke 2.4-L diesel engine operates on ideal diesel cycle. Compression Ratio of 22 and Cutoff Ratio of 1.8. Air @ 70°C and 97 KPA at beginning of compression process. Cold air Standard Assumptions





$R_c = \frac{V_3}{V_2} = 1.8$

$r = 22$

$\xrightarrow{}$ ① $\xrightarrow[\text{COMPRESS}]{\text{ISENTROPIC}}$ ② $\xrightarrow{P=\text{CONST}}$ ③ $\xrightarrow[\text{Expansion}]{\text{ISENTROPIC}}$ ④ $\xrightarrow{V=\text{CONST}}$

①

$P = 97$ KPA

$T = 343$ K

$V = \frac{RT}{P}$

$= \frac{(0.287)(343)}{97}$

$V_1 = 1.01$

②

$r = \frac{V_1}{V_2}$

$V_2 = \frac{1.01}{22}$

$V_2 = 0.045$

$\frac{T_2}{343} = \left(\frac{1.01}{0.045}\right)^{1.4-1}$

$T_2 = 343\left(\frac{1.01}{0.045}\right)^{0.4}$

$T_2 = 1190.552$ K

$P = \frac{RT}{V}$

$P = \frac{(0.287)(1190.552)}{0.045}$

$P_2 = 7593.1$ KPA

③

$P_3 = 7593.1$

$1.8 = \frac{V_3}{V_2}$

$(1.8)(0.045) = V_3$

$V_3 = 0.081$

$PV = RT$

$T = \frac{PV}{R}$

$= \frac{(7593.1)(0.081)}{0.287}$

$T_3 = 2143$ K

④

$V_4 = 1.01$

$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{k-1}$

$T_4 = 2143\left(\frac{0.081}{1.01}\right)^{0.4}$

$T_4 = 781.06$ K

Determine How Much Power will be Produce When operated @ 3500 RPM

$$W = C_v\left[(T_3 - T_2) - (T_4 - T_1)\right]$$

$$= 0.718\left[(2143 - 1190.5) - (781 - 343)\right]$$

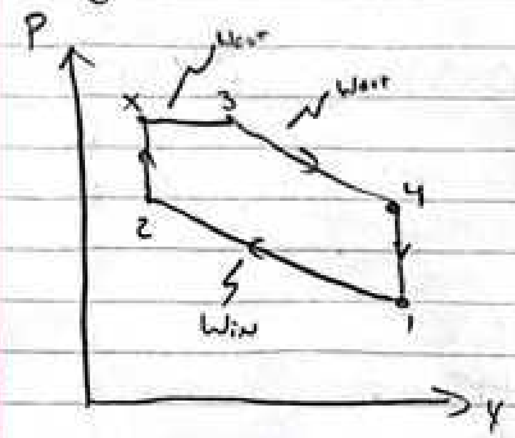
$$W = 369.411$$

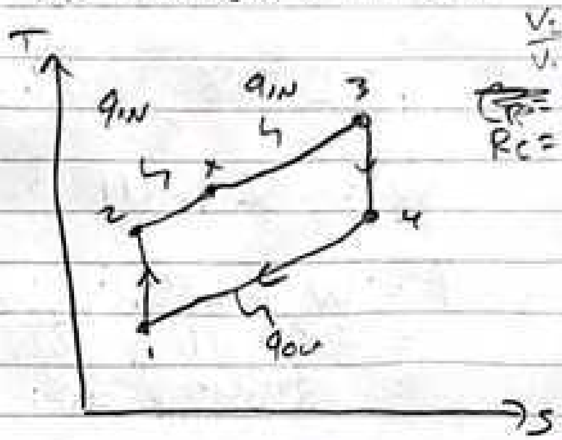
$$P = W \quad CPS$$

$$= 369.411 \cdot \frac{3500}{60}$$

$$= 21548.975 \text{ Watts}$$

9-59E An ideal dual cycle has a compression ratio of 15 and $C_R = 1.4$. Pressure Ratio during Constant Volume heat addition is 1.1. Beginning of COMPRESSION is $P_1 = 14.2$ PSIA, $T_1 = 75°F$





$\frac{V_1}{V_2} = 15$

$R_c = \frac{V_3}{V_2}$

$① \xrightarrow[\text{COMPRESSION}]{\text{ISENTROPIC}} ② \xrightarrow{V = CONST} ⓧ \xrightarrow{P = CONST} ③ \xrightarrow[\text{EXPANSION}]{\text{ISENTROPIC}} ④ \xrightarrow{V = CONST}$

$T_1 = 75° + 459.67$

$T_1 = 534.67\ R$

$P_1 = 14.2$ Psia

$P_1 V_1 = RT$

$V_1 = \frac{(0.287)(534.67)}{14.2}$

$V_1 = 10.8$

$V_2 = 15 V_1$

$V_2 = 162$

$\frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{k-1}$

$T_2 = 534.67\left(\frac{10.8}{162}\right)^{0.4}$

$T_2 = 1579.5$

$P = \frac{RT}{V}$

$P_2 = \frac{(0.287)(1579.5)}{162}$

$P_2 = 2.8$ PSIA

$PV = RT$

$T = \frac{PV}{R}$

$= \frac{(3.08)(162)}{0.287}$

$T_x = 1738.5$

$V_x = 162$

$P_x = 1.1 P_2$

$P_x = 3.08$

$P_3 = 3.08$

$V_3 = V_x \cdot R_c$

$= 162 \cdot 1.4$

$V_3 = 226.8$

$T = \frac{PV}{R}$

$= \frac{3.08 \cdot 226.8}{0.287}$

$T_3 = 2433.9 R$

$V_4 = 10.8$

$\frac{T_4}{T_3} = \left(\frac{V_3}{V_4}\right)^{k-1}$

$T_4 = 2433.9 \left(\frac{226.8}{10.8}\right)^{0.4}$

$T_4 = 726 K$

$P = \frac{RT}{V}$

$P_4 = \frac{(0.287)(7261)}{10.8}$

$P_4 = 19.13$

a) Calculate the cycles net specific work.

$$W_{net} = W_{out_{2-3}} + W_{out_{3-4}} - W_{in_{1-2}} = q_{in} - q_{out}$$

$$= (V_3 - V_2)(P_2) + \left(\frac{P_4 V_4 - P_3 V_3}{(1-1.4)}\right) - \left(\frac{P_2 V_2 - P_1 V_1}{1-1.4}\right)$$

$$= (226.8 - 162)(3.08) + \left(\frac{(19.13)(10.8) - (3.08)(226.8)}{1-1.4}\right)$$

$$- \left(\frac{(2.8)(162) - (14.2)(10.8)}{1-1.4}\right)$$

$$= 199.584 + 1229.8 - 750.6$$

$$W_{net} = 678.784$$

b) Specific Heat Addition

?

c) Thermal Efficiency

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

$$1 - \frac{1}{15^{0.4}}\left[\frac{1.4^{1.4} - 1}{1.4(1.4-1)}\right]$$

$$\eta_{th} = 0.6382 = 63.82\%$$

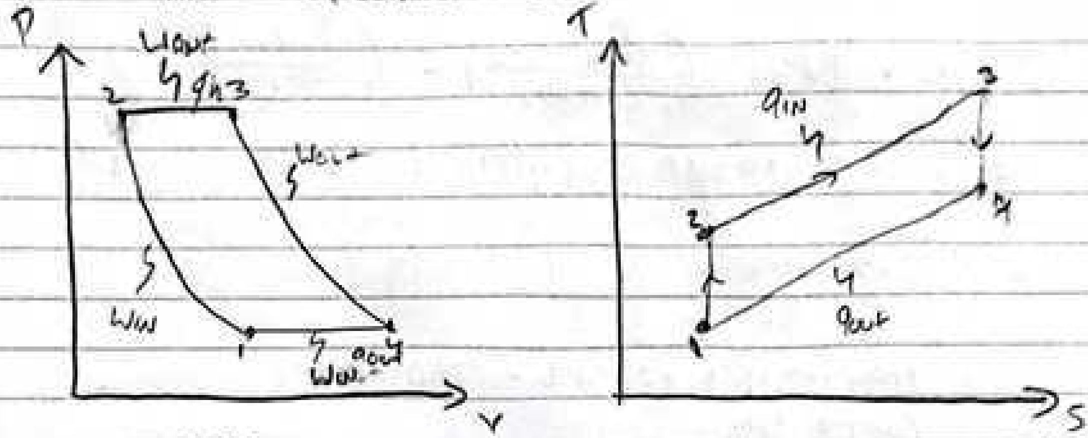
Efficient

9-90E Simple Ideal Brayton Cycle

Pressure Ratio of 10

Enters compressor @ 500R and the turbine @ 2000R

Variable Specific heat



① $\xrightarrow[\text{COMPRESSION}]{\text{ISENTROPIC}}$ ② $\xrightarrow{P=\text{CONST}}$ ③ $\xrightarrow[\text{Expansion}]{\text{ISENTROPIC}}$ ④ $\xrightarrow{P=\text{CONST}}$

$T_1 = 500R$ | $P_2 = 10P_1$ | $T_3 = 2000R$ | $P_4 = P_3/10$

$P_{r1} = 1.2147$ | $P_{r3} = 174.0$ | $P_4 = P_1$

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

$P_{r2} = 12.147$ | $P_{r4} = 17.40$

$T_2 = 996.48R$ | $T_4 = 1094.31R$

$h_1 = 124.27$ $h_2 = 240.11$ $h_3 = 504.71$ $h_4 = 265.83$

a: $T_2 = 996.88R$

b) $w_{in} = h_2 - h_1 = 115.84$

$w_{out} = h_3 - h_4 = 238.88$

$\frac{w_{in}}{w_{out}} = 0.485$

c) $\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{w_{out} - w_{in}}{q_{in}}$

$q_{in} = h_3 - h_2 = 264.60$

$\eta_{th} = 0.465$

46.54