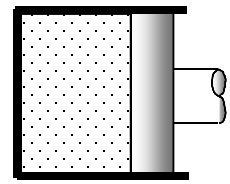
EXAMPLE: Air-standard Diesel cycle

An **air-standard** Diesel cycle has a compression ratio of 15. Before the adiabatic compression, the air is at 100 kPa and 20°C. 1600 kJ/kg of thermal energy is added during the constant pressure heat addition.

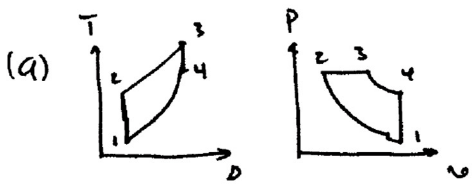


(a) Sketch the cycle on P-v and T-s diagrams.
(b) Find the heat transfer and work (per unit mass) for each process in kJ/kg.
(c) Find cut-off ratio for the cycle.
(d) Find the cycle efficiency. For a **cold**-air-standard, the cycle efficiency is given by

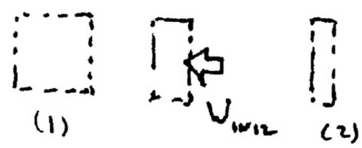
$$\eta_{cold-air} = 1 - r^{1-k}\frac{r_c^{\,k} - 1}{k(r_c - 1)}.$$

How does your value compare to this?

(a)



b)



COE, FINITE TIME, CLOSED SYS

$U_2 - U_1 = Q_{12} + W_{IN,12}$ ($Q_{12} \to 0$)

$m(u_2 - u_1) = W_{12,IN}$

$w_{IN,12} =$

$u_1 = 209.3$ kJ/kg

SINCE $\Delta_2 - \Delta_1 = 0$

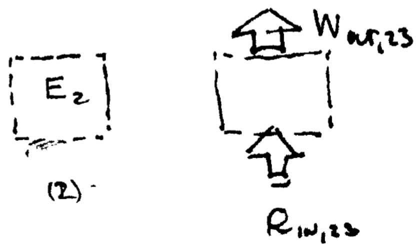
$\frac{v_2}{v_1} =$

$v_{r2} = \underline{\qquad} = \underline{\qquad} =$

$\therefore\ T_2 =$

& $u(T_2) =$

$w_{IN,12} = \ldots =$ **405 kJ/kg**



CoE FINITE TIME, CLOSED

$$U_3 - U_2 = Q_{23,IN} - W_{23,OUT}$$

$$u_3 - u_2 = q_{23,IN} - w_{23,OUT}$$

A TRIC

$$W_{OUT,23} = \int_2^3 p\, dV$$

B/C CONST p

$$w_{OUT,23} = \int_2^3 p\, dv =$$

$\therefore$

$$u_3 - u_2 =$$

$$q_{23,IN} =$$

$$h_2 = h(T_2) = 851 \text{ KJ/kg}$$

$\therefore$ $1600 \text{ KJ} = h_3 - 851 \text{ KJ/kg}$ $h_3 = 2451 \text{ KJ/kg}$

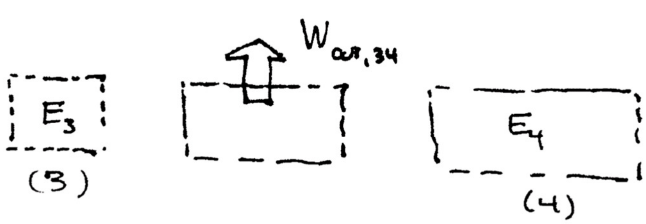
$\Rightarrow T_3 =$

$u_3 =$

BACK TO WORK (HA!)

$$w_{OUT,23} = P_2(v_3 - v_2) \quad \text{OR FROM CoE}$$

$$= \ldots = \boxed{382 \text{ KJ/kg}}$$



CoE, FINITE TIME, CLOSED

$$w_{34,out} =$$

SINCE $s_4 - s_3 = 0$

$v_{r4} =$ $\qquad\qquad$ $v_4 = v_1 =$

$v_3 =$

WHAT IS $P_3 = ?$ $\quad P_3 = P_2$.

BUT WHAT IS $P_2 = ?$ $\quad$ MUST GO BACK TO $(1) \rightarrow (2)$.

SINCE $s_2 - s_1 = 0$

$$\frac{P_2}{P_1} = \qquad P_2 = P_1 \frac{\quad}{\quad} = (100\ \text{kPa})\left[\frac{\quad}{\quad}\right] = 4230\ \text{kPa}!!$$

NOW

$$v_{r4} = v_{r3}\left(\frac{v_4}{v_3}\right) = v_{r3}\left(\frac{R_{AIR} T_1 / P_1}{R_{AIR} T_3 / P_2}\right) = (2.1482)\left[\frac{293\text{K}/100\text{kPa}}{2158\text{K}/4230\text{kPa}}\right]$$

$= 12.36$

$\Rightarrow T_4 =$

$u_4 =$

$w_{34,out} = \ldots = \boxed{842.\ \text{kJ/kg}}$

CoE, FINITE TIME, CLOSED

$q_{out,41} =$ $\qquad \ldots = \boxed{780\ \text{kJ/kg}}$

(d)

$$\eta = \frac{w_{NET,OUT}}{q_{IN}} = \frac{\quad}{\quad} = \ldots = 0.513$$

$= \boxed{51.3\%}$

(c) $r_{co} =$ $(P_3 = P_2)$

$$= \left(\frac{2158\,K}{826\,K}\right) = \boxed{2.61}$$

(e) $$\eta_{COLD} = 1 - (r)^{1-k} \frac{(r_{co}^{\,k} - 1)}{k(r_{co} - 1)}$$

$$= 1 - (15)^{1-1.4} \frac{(2.61^{1.4} - 1)}{1.4(2.61 - 1)} =$$

$$= \boxed{}$$

THAN $\eta_{AIR\ STANDARD}$.