ANNOUNCED QUIZ #7 – ME 3030 — Section 001 – Fall 2025

SOLUTION

NAME: _____

This is an open book quiz. You may use a four function calculator. An unsigned honors pledge will result in a zero.

1. Consider an air-standard Diesel cycle where the compression begins at a state of $p_1 = 95\text{kPa}$, $T_1 = 27°\text{C}$, and $\forall_1 = 6$ liters. If the displacement volume is 5.6 liters and the cutoff ratio is 2.4, determine the work generated per cycle in units of kJ.

GIVEN: A.S. Diesel, $r_c = 2.4$, $P_1, T_1, \forall_1$,

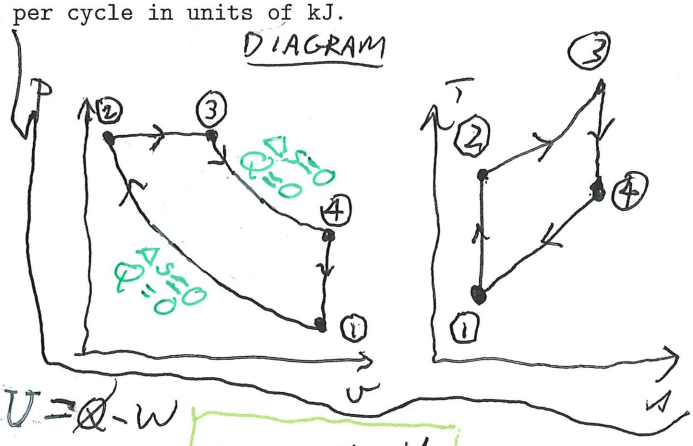
FIND: $W_{cyc} = ?\,kJ$

ASSUME: All air-standard assumptions

ANALYSIS: $W_{cyc} = W_{23} + W_{34} - W_{12}$

$W_{23} = \int_2^3 P\,d\forall = P\int_2^3 d\forall = P(\forall_3 - \forall_2)$ ← Need $P_2 = P_3 = ?$

DIAGRAM



For $3\to4$ $\Delta U = \cancel{Q} - W$ $\quad \frac{W_{34}}{m} = u_3 - u_4$

For $1\to2$ $\Delta U = \cancel{Q} - W$ $\quad \frac{W_{12}}{m} = u_2 - u_1$

So, also need (u_1, u_2, u_3, u_4)

Volumes: $\forall_1 = 6\,l$ $\quad \forall_1 - \forall_2 = 5.6\,l$ so $\forall_2 = 0.4\,l$ $\quad r_c = 2.4 = \forall_3/\forall_2 \to \forall_3 = 0.96\,l$

Now, $1\to2$ isentropic $\frac{\forall_1}{\forall_2} = \frac{v_{r1}}{v_{r2}} \to \frac{6\,l}{0.4\,l} = \frac{621.2}{v_{r2}}$ $\quad v_{r2} = 41.41$ interpolating $\to P_{r2} = 58.48$, $T_2 = 843\,K$

$T_1 = 300\,K$ $\quad u_1 = 214.07\ \frac{kJ}{kg}$ $\quad u_2 = 627.6\ kJ/kg$

Also $\frac{P_{r2}}{P_{r1}} = \frac{P_2}{P_1} \to \frac{58.48}{1.3860} = \frac{P_2}{95\text{kPa}}$ $\quad P_2 = P_3 = 4{,}008\text{kPa}$

③ $\frac{\cancel{P_3}\forall_3}{\cancel{T_3}} = \frac{P_2\forall_2}{T_2}$ $\quad T_3 = T_2\left(\frac{\forall_3}{\forall_2}\right) = (843K)\left(\frac{0.96\,l}{0.4\,l}\right)$ $\quad T_3 = 2023\,K$ → interpolating → $v_{r3} = 2.674$

$u_3 = 1700.8\ \frac{kJ}{kg}$

④ $\frac{v_{r4}}{v_{r3}} = \frac{\forall_4}{\forall_3} \to \frac{v_{r4}}{2.674} = \frac{6\,l}{0.96\,l}$ $\quad v_{r4} = 16.713$ → interpolating → $u_4 = 884.99\ \frac{kJ}{kg}$

Need m: $P\forall = mRT$ $\quad m = P_1\forall_1/RT_1 = \frac{(95kPa)(.006m^3)}{\left(\frac{8.314\,kJ/kmol\cdot K}{28.97\,kg/kmol}\cdot 300K\right)}$ $\quad m = 0.00662\,kg$

So, $W_{23} = (4{,}008\text{kPa})(0.96l - 0.4l)(.001\,l/m^3)$ $\quad W_{23} = 2.24kJ$

$W_{34} = (0.00662kg)(1700.8\,kJ/kg - 884.99\,kJ/kg)$ $\quad W_{34} = 5.40kJ$

$W_{12} = (0.00662kg)(627.6\,kJ/kg - 214.07\,kJ/kg)$ $\quad W_{12} = 2.74kJ$

$W_{cyc} = W_{net} = 4.90\,kJ$ ← ANS.

I HAVE NEITHER PROVIDED OR RECEIVED HELP DURING THIS QUIZ.

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SIGNATURE