"PROBLEM STATEMENT"
"A 4-stroke SI engine with 3.0 liters of displacement and a 8.9:1 compression ratio"
"has an output torque of 236 Nm at 3000 RPM. At this operating point, the brake"
"specific fuel consumption is measured as 0.89 MJ/kg. The volumetric flow rate of"
"air is 0.068 m³/s and the inlet conditions of 20°C and 1 bar. The heating value of"
"the fuel used in the engine is 44 MJ/kg. Find the volumetric efficiency, the mass"
"flow rate of air, the mass flow rate of fuel, the air/fuel ratio, the arbitrary efficiency,”
"and the ideal Otto cycle efficiency."

"KNOWNS"
\[ nr = 2\text{[dim]} \]
\[ Vs = 3000E-6\text{[m}^3\text{]} \]
\[ T = 236\text{[N}\cdot\text{m]} \]
\[ Bsfc = 0.09\text{[kg/MJ]}^\text{1/convert(MJ,kJ)} \]
\[ Vdot_{air} = 0.068\text{[m}^3\text{/s]} \]
\[ rc = 8.9\text{[dim]} \]
\[ T_{in} = 293\text{[K]} \]
\[ P_{in} = 101\text{[kPa]} \]
\[ Q_{HV} = 44E3\text{[kJ/kg]} \]
\[ N = 50\text{[1/s]} \]
\[ R = 0.286\text{[kJ/kg-K]} \]
\[ k = 1.4\text{[dim]} \]

"EQUATIONS"
\[ p = T^2*p^N \]
\[ p = bmepe^VS*N/nr \]
\[ \eta_o = 1/(Bsfc*Q_{HV}) \]
\[ \eta_{otto} = 1-1/(rc)^{(k-1)} \]
\[ \eta_v = Vdot_{air}/(Vs*N/nr) \]
\[ \rho_{in} = P_{in}/(R*T_{in}) \]
\[ mdot_{air} = Vdot_{air}^\text{*rho}_{in}^\text{*convert(kg/s, g/s)} \]
\[ mdot_{fuel} = Bsfc^p \]
\[ A_F = mdot_{air}/mdot_{fuel} \]

SOLUTION
Unit Settings: SI C kPa kJ mass deg
\[ A_F = 12.28\text{[dim]} \]
\[ \eta_o = 0.02525\text{[dim]} \]
\[ k = 1.4\text{[dim]} \]
\[ N = 50\text{[1/s]} \]
\[ P_{in} = 101\text{[kPa]} \]
\[ rc = 8.9\text{[dim]} \]
\[ T_{in} = 293\text{[K]} \]
\[ bmepe = 988554\text{[Pa]} \]
\[ \eta_{otto} = 0.5629\text{[dim]} \]
\[ mdot_{air} = 81.96\text{[g/s]} \]
\[ nr = 2\text{[dim]} \]
\[ mdot_{fuel} = 6.673\text{[g/s]} \]
\[ P = 74142\text{[W]} \]
\[ R = 0.286\text{[kJ/kg-K]} \]
\[ T = 236\text{[N-m]} \]
\[ Vs = 0.003\text{[m}^3\text{]} \]

No unit problems were detected.

KEY VARIABLES
\[ \eta_v = 0.9067\text{[dim]} \]
\[ \text{volumetric efficiency} \]
\( \text{mdot}_{\text{air}} = 81.96 \ [\text{g/s}] \) \quad \text{mass flow rate of air}

\( \text{mdot}_{\text{fuel}} = 6.673 \ [\text{g/s}] \) \quad \text{mass flow rate of fuel}

\( A_f = 12.28 \ [\text{[dim]}] \) \quad \text{air/fuel ratio}

\( \eta_\text{o} = 0.2525 \ [\text{[dim]}] \) \quad \text{arbitrary efficiency}

\( \eta_{\text{oto}} = 0.5829 \ [\text{[dim]}] \) \quad \text{otto cycle efficiency}