A 4-cylinder laboratory test engine is supplied with isooctane fuel (C8H18) at a rate of 1.5 x 10-3 kg/sec. The fuel air equivalence ratio, phi, is 0.8.

a) The mixture is lean. This means the FA is less than the stoichiometric FA. So the mixture is lean
if phi < 1.

b) Calculate the air flow rate in kg/sec.

$\phi = 0.8$

$$FA = \frac{\textbf{MolarMass}['C8H18']}{\frac{12.5}{\phi} \cdot [\textbf{MolarMass}('O2') + 3.773 \cdot \textbf{MolarMass}('N2')]}$$

$fuelflow = 0.0015$ [kg/sec]

$airflow = \frac{fuelflow}{FA}$ [kg/sec]

c) Write and balance the chemical equation describing the combustion process.

C8H18 + 12.5/(0.8)(O2 + 3.773 N2) = n1 CO2 + n2 H2O + n3 O2 + n4 N2

$8 = n1$

$18 = 2 \cdot n2$

$$\frac{12.5}{\phi} \cdot 2 = 2 \cdot n1 + n2 + 2 \cdot n3$$

$$\frac{12.5}{\phi} \cdot 2 \cdot 3.773 = 2 \cdot n4$$

d) Calculate the mole fractions of each of the gases making up the exhaust.

$nT = n1 + n2 + n3 + n4$

$$y_{CO2} = \frac{n1}{nT}$$

$$y_{H2O} = \frac{n2}{nT}$$

$$y_{O2} = \frac{n3}{nT}$$

$$y_{N2} = \frac{n4}{nT}$$

2. This is a continuation of the previous problem. The heating value of the fuel is 42000 kJ/kg. The mechanical efficiency is 0.83, the fuel conversion efficiency (based on brake work/power) is 0.34, and the combustion efficiency is 0.93. We estimate that 35% of the energy entering the engine in the fuel is transferred to the cooling system. Calculate in kW

a) the brake power

$\eta_f = 0.34$

$\eta_m = 0.83$

$\eta_c = 0.93$

$Q_{HV} = 42000$ [kJ/kg]

$Power_{In} = Q_{HV} \cdot fuelflow$ [kW]

$P_b = \eta_f \cdot Power_{In}$ [kW]

b) the friction power

$$\eta_m = \frac{P_b}{P_b + P_f}$$

c) the indicated power

$P_i = P_b + P_f$

d) the heat transfer

$Qdot = 0.35 \cdot Power_{In}$ [kW]

e) the total power in the exhaust gas

$P_{exh} = Power_{In} - Qdot - P_b - P_f$

f) the rate at which chemical energy leaves the engine in the exhaust gas

$P_{exhchem} = [1 - \eta_c] \cdot Power_{In}$

Unit Settings: [kJ]/[K]/[kPa]/[kmol]/[radians]

airflow = 0.02825 [kg/sec]	η_c = 0.93	η_f = 0.34	η_m = 0.83
FA = 0.05309	fuelflow = 0.0015 [kg/sec]	n1 = 8	n2 = 9
n3 = 3.125	n4 = 58.95	nT = 79.08	ϕ = 0.8
$Power_{In}$ = 63 [kW]	P_b = 21.42 [kW]	P_{exh} = 15.14 [kW]	$P_{exhchem}$ = 4.41 [kW]
P_f = 4.387 [kW]	P_i = 25.81 [kW]	Qdot = 22.05 [kW]	Q_{HV} = 42000 [kJ/kg]
y_{CO2} = 0.1012	y_{H2O} = 0.1138	y_{N2} = 0.7455	y_{O2} = 0.03952