AE 342, Spring 2008 **Exam 1** Name____________________

Instructions:

Answer 3 out of the 5 questions. No extra credit will be given for more than three answers. If more than three questions are attempted, CLEARLY indicate which questions are to be graded, otherwise only the first three answers will be graded, and the rest ignored.

Note: All information is given in metric and English units. You may select the units of your choice for each of the questions. **However, do NOT use different unit systems within a single question!!!!!!.**

Show all calculation steps to ensure that partial credit is earned, even if the final answer is incorrect. In cases where the answer is obviously wrong, some credit will be given if you identify this as an improbable answer.

Power Equations

$P = 2\pi TN/60{,}000$	$P = 2\pi TN/33{,}000$
$P = (MEP*A*L*N*n)/(rc * 60.\ 10^6)$	$P = (MEP*A*(L/12)*N*n)/(rc * 33000)$
$P = (MEP*D*N)/(rc * 60.\ 10^3)$	$P = (MEP*(D/12)*N)/(rc * 33000)$
$P = M_f*HV/3600$	$P = M_f*HV*778/60/33000$

Gas Equations

IDEAL GAS

$PV=(M/m)RT$ m for air = 29

Under Constant Pressure

$V1/V2 = T1/T2$

Under Constant Volume

$P1/P2 = T1/T2$

Adiabatic, Polytropic Expansion/Compression

$T2/T1 = (V1/V2)^{(k-1)} = (P2/P1)^{(k-1)/k}$

$P2/P1 = (V1/V2)^{(k)} = (T2/T1)^{k/(k-1)}$

Heat Addition

$Qin = M\ Cv(T2-T1)$	$Qin = M\ Cp(T2-T1)$	$K=Cp/Cv$
R=8.314 kJ / (kg mole K)	R= 1545 ft / (lbf ºR)	
Kelvin = 273 + degrees Celsius	Rankin = 460 + degrees Fahrenheit	

Units Conversions

1 BTU = 778 ft.lb of work	1 kN.m = 1 kJ	1 lb force = 4.45 Newton	1 Hp = 0.7457 kW
33000 ft.lb/min = 1 Hp	1 kJ/sec = 1 kW	1gal = 3.785 liters	1 BTU = 1.0551 kJ
550 ft.lb/sec = 1 Hp	1000 liters = 1 m^3	1 psi = 6.8948 kPa	1 gal = 231 cubic inches
1000 cm3 = 1 liter	1 inch = 0.0254 m	1 mile = 5280 ft	1 ft.lb = 1.356 N.m
1ft = 0.3048 meters	g = 9.81 (m/s^2)	g = 32.2 (ft/s^2)	

Force (N)=mass(kg)*gravity(m/s^2) 1 (N)= 1 (kg) * 9.81 (m/s^2)

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Question 1 (25 points)

In a governed engine test, the following information was collected. Use this information for reference in calculating the requested parameters (4 Stroke Engine).

Brake Torque = 650 Nm (450 ft.lb)
Fuel heat content = 38000 kJ/liter (136,000 BTU/gal)
Indicated Mean effective pressure = 1750 kPa (240 psi)
Fuel consumption = 50 liters/hour (13 gal/hr)
Air Density = 1.12 kg/m^3 (0.07 lb/ft^3)

Speed = 2200 rpm
Air Delivery Ratio (Vol Eff) = 300%
Engine displacement = 6.8 liter (415 in^3)
Fuel density = 800 kg/m^3 (50 lb/ft^3)

a). Calculate the Brake Power

b). Calculate the Brake Mean effective pressure

c). The Brake Thermal Efficiency in percent

d). The Indicated Power

e) The mechanical efficiency

f). Actual Mass flowrate of air entering engine

Question 2 (25 points)

A test to determine the mechanical efficiency of a four stroke engine was conducted. The following information was gathered during the tests. Use information listed below for reference in calculations below.

General information:

Engine displacement = 346 in^3 (5.6l) ,	Engine speed = 2400 rpm
Fuel Gasoline 20,000 BTU/lb (45,000 kJ/kg)	Air Density = 0.0719 lb/ft^3 (1.152 kg/m^3)
Fuel consumption = 65 lb/hr (30.5 kg/hr)	Brake Torque = 312 ft.lb (426 N.m)

The friction mean effective pressure for the engine has been found to follow the equations below (x=N/1000):

FMEP (psi) = $227.83x^2 - 888x + 864$ (English Units)

FMEP (kPa) = $1593.3x^2 - 6210.3x + 6040$ (Metric Units)

a). Calculate Brake power for this engine at 2400 rpm.

b).Calculate the Friction Power Pf of the engine at 2400 rpm

c).Calculate Indicated power, Pi for this engine at 2400 rpm.

d). Calculate the engine mechanical efficiency

e). Determine the indicated thermal efficiency of the engine.

f). Under these conditions, If the Air/Fuel ratio on a mass basis is 15:1. Find the mass flowrate of air entering the engine.

Question 3

A test to determine the mechanical efficiency of a four stroke, five-cylinder engine was conducted. The following information was gathered during the tests. Use information listed below for reference in calculations below.

General information:

Engine displacement = 284 in^3 (4.7 litres)
5 cylinders, 4 stroke cycle
Fuel Gasoline 122,000 BTU/gal (34,000 kJ/l)
Indicated thermal Efficiency of the engine = 0.50 (for all cylinders firing)

Test results:

Engine speed = 2200 rpm
5 cylinders firing, Measured Brake Torque = 165 ft.lb (225 N.m)
4 cylinders firing, Measured Brake Torque = 120 ft.lb (160 N.m)

a). Calculate Brake power for this engine at 2400 rpm.

b). Calculate Indicated power of the entire engine

c). Calculate the Friction Power of the entire engine

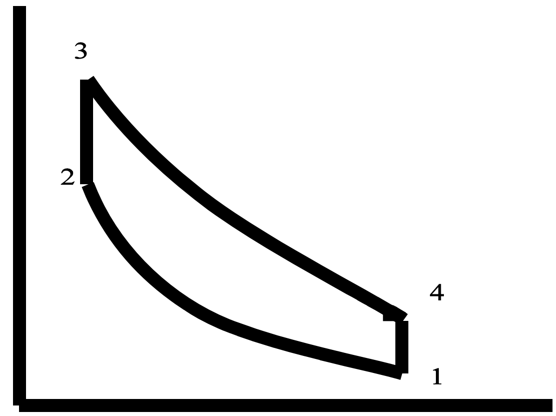
d). Calculate the engine mechanical efficiency

e). Determine the fuel consumption of the engine (gal/hr or l/hr) with all cylinder operating at 2200 rpm.

Question 4(25 points)

Consider the standard Otto cycle shown with the following conditions:

P1 = 101 kPa (14.7 psi)
T1 = 50 C (122 F)
k= 1.4
Cv = 0.719 kJ/kg.ºK (Cv = 0.171 BTU/lbm.ºR)
Heat Addition at constant volume = 1250 kJ/kg (625 BTU/lb)
Apparent Molecular Weight Air = 29



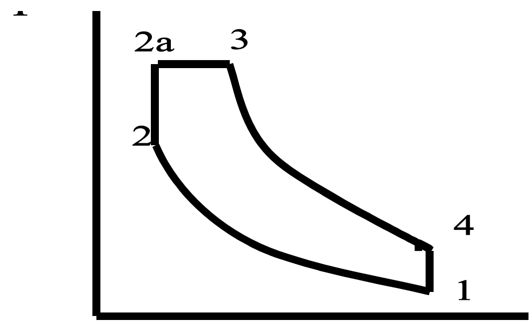
a). If the pressure at the end of the adiabatic compression stroke, P2 is 1856 kPa (270 psi). Determine the compression ratio of the engine, to the closet integer value.

b). Calculate the temperatures and pressure at points 2, 3, and 4 in the cycle.

c). Determine the net work per unit mass of air for the cycle

d). Calculate the indicated thermal efficiency for the cycle.

<u>Question 5 (25 points)</u>



Consider the dual cycle shown in the figure below. Given:

k=1.4,	k=Cp/Cv ,
Cv = 0.719 kJ/kg.ºK	(Cv = 0.171 BTU/lbm.ºR)
T1 = 27C	(80 F)
P1 = 101 kPa	(14.7 psi)
T2 = 659C	(1000 F)
T2a = 1927C	(3500 F)
T3 = 3027C	(5500 F)

i). Determine the compression ratio (V1/V2) of this cycle, to the closet integer value.

ii). Calculate the temperature T4 and pressures P2, P2a, P3, P4.

iii). Calculate the total energy input into the cycle per unit mass of air (processes 2-3).

iv). Determine the net energy lost per unit mass of air during the exhaust (blowdown) process.

v). Calculate the thermal efficiency of the cycle.