AE 342, Spring 2008 Test **Exam 2** Name____________________

Instructions:

Answer three out of the six 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 relevant 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.

Combustion

Atomic Mass of Carbon (C) =12, Hydrogen (H) =1 Nitrogen (N) =14, Oxygen (O) =16,

$r_s = (\rho_s/\rho_p)*(f_s/f_p)*(m_p/m_s)$

IDEAL GAS PV=(M/m)RT R=8.134 kJ / (kg mole K)

Turbines

Compressor Work W = M Cp(T2-T1)

$P_{rc} = (P_1 + \text{Boost})/P_1 = P_2/P_1$ $1/T_{rc} = T_2/T_1 = 1 + [P_{rc}^{(k-1)/k} - 1]/e_c$

$e_v = P_{rc} * T_{rc} = [P_{rc} * e_c]/[e_c + (P_{rc}^{(k-1)/k} - 1)]$

Note: e_c = (Theoretical Temperature Difference / Actual Temperature Difference)

Units Conversions

1 BTU = 778 ft.lb of work	1 kN.m = 1 kJ	1 pound force = 4.45 Newton
33000 ft.lb/min = 1 Hp	1 kJ/sec = 1 kW	1 gal = 3.785 liters
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 meters
1 mile = 5280 ft	1 ft.lb = 1.356 N.m	1 ft = 0.3048 meters
1 Hp = 0.7457 kW	1 BTU = 1.0551 kJ	

Force (N)=mass(kg)*gravity(m/s^2) 1 (N)= 1 (kg) * 9.8 (m/s^2)

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Question 1

A diesel engine accelerating under varying loads. The fuel used is $C_{15}H_{32}$

Note: Atomic Mass of Carbon (C) =12, Hydrogen (H) =1 Nitrogen (N) =14, Oxygen (O) =16

Assume for each molecule of oxygen (O_2) in air there are 3.76 molecules of Nitrogen (N_2)

$$C_{15}H_{32} + ??[O_2 + 3.76N_2] \Rightarrow ??C0_2 + ??H_20 + ??C0 + ??0_2 + ??N_2$$

a). Determine the Stoichiometric combustion equation and Stoichiometric Air/Fuel ratio.

b) Determine actual combustion equation at a Fuel Equivalence Ratio of 0.92 and the actual Air/Fuel ratio

c) If 21.2 kg of fuel is burnt in this engine at a fuel equivalence ratio of 0.92. How many kilograms of CO_2 will be produced?

Question 2 (25 points)

Blended fuels are sometimes used in engines. Different ethanol blends can can be used for automobiles. Given the following information:

	Chemical Formula	Density	Heating Value
Ethanol	C_2H_5OH	0.780 kg/L	21 000 kJ/L
Gasoline (Octane)	C_8H_{18}	0.740 kg/L	35 000 kJ/L

Note: For every mole of an oxygen molecule in air, there are 3.76 moles of nitrogen molecules.

a). For a 15% Ethanol Blend (by vol) Determine the composite fuel molecule $C_{xc}H_{yc}0_{zc}$ which can be used to represent blended fuel.

b). Show the balanced Stoichiometric combustion equation for the composite molecule.

c). Calculate the Stoichiometric air to fuel ratio for the fuel blend.

Question 3 (25 points) This question continues on the next page

The points T10 , T20 , and T90 refer, respectively to the temperatures on the fuel distillation curve at which 10, 50 and 90 % of the fuel has been distilled.

a). Why is it important that the T10 temperature is not too high. What would the effect of increasing the T10 temperature be on starting an engine in cold weather?

b). Engine warm up depends on the T50 temperature of the fuel. For gasoline would the T50 temperature be increased or decreased at higher elevations when compared to fuels use at sea level Explain your reasoning.

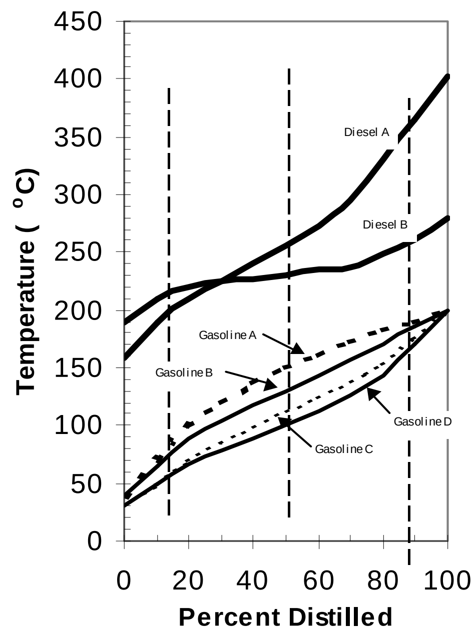
c) Identify which of of gasoline fuels (A,B,C,D) above would be utilized in the following regions and seasons. In each case, justify your answers based on the most important characteristics of the fuel and operating conditions.

i). Elevation 100ft, during the summer months.

ii). Elevation 100ft, during the winter months.

iii). Elevation 6000ft, during the summer months

iv). Elevation 6000ft, during the winter months.



Distillation curves for several fuels

d). A turbo-charger is installed on a naturally aspirated engine which operated on #2 diesel. What would your recommendation for the type of diesel to be used; #1 diesel (higher cetane, high cost) or #2 diesel (low cetane, lower cost), after installation of the turbo-charger. Justify your recommendation, in terms of cost and engine operating characteristics with the different fuels.

<u>Question 3 (continued)</u> **This question continues on from the previous page**

e) The Self-Ignition Temperature (SIT) and ignition delay of a fuel is an important characteristic for both diesel and gasoline engines. For the two conditions below, discuss the relevance of SIT and ignition delay on in terms of auto-ignition and/or detonation (depends on engine type), peak pressure and rate of pressure rises .

(i) Using a fuel with a low SIT and short ignition delay in a spark injection engine.

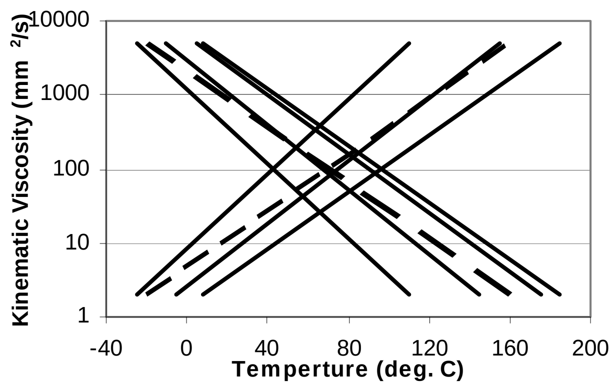
(ii) A fuel with a long ignition delay in a diesel engine

iii). The ignition delay of a diesel fuel depends on the self-ignition temperature of the fuel, temperature and pressures in the combustion cylinder.

> i). The only diesel fuel available has a relatively high self ignition temperature. You are required to make the recommendations for purchasing a diesel engine for a stationary generator. The following engine are available with the same power, 1) An diesel engine with a large diameter bore and low rpms, 2) A high compression ratio diesel engine with smaller displacement and bore that runs at high rpm's generating the same power 3) A turbo charged, ratio diesel engine with the same pistons dimensions, compression ratio and rpm as engine (2) but has fewer pistons. Which engine would you choose? Give the reasons why you selected that engine and why you rejected the other engines.

<u>Question 4 (25 points)</u> This question continues on the next page

The diagram below shows the changes in viscosity for SAE70, SAE 30 oil, SAE 10W oil, SAE 60 and SAE 10W-30 oil and other unidentified liquids.



a). Label the respective oils on the diagram. That is which is the SAE30, SAE10W, SAE10W-30 oil and SAE70 oil.

b). The following oils are available for use in an engine,

SAE 5W,	SAE 5W-30,	SAE 5W-40,	SAE 5W-50,
SAE 10W,	SAE 10W-30,	SAE 10W-40,	SAE 10W-50,
SAE 20,	SAE 30,	SAE 40,	SAE 50.

The engines your company operates can be classed into two general categories, a) high speed engines with high tolerance parts and b) low speed engines with wider tolerance parts. The engines may be operating in machines that 1). Always operate in locations with high temperatures, or 2). Always locates in locations with low temperatures or 3) operate in both locations 1 and 2). The cost of oils is important and straight weight oils are significantly cheaper that multi-grade oils. Select the appropriate oil for the following situations and **<u>justify each answer</u>**. **Note: Do not use the same oil in two situations.**

(i) High Speed/Cold Location

(ii) High Speed/Hot Location

(iii) High Speed/Both Locations

(iv) Low Speed/Cold Location

(v) Low Speed/Hot Location

(vi) Low Speed/Both Locations

c) Describe the fundamental difference between a full flow lubrication system and a bypass lubrication system.

d) Why is it necessary to have a bypass valve contained within the oil filter of a full-flow lubrication system?

<u>Question 4</u> This question continues on from the previous page

Complete the following table to show crank angle degree of the relative strokes for each piston. Enter into the table, the crank angle degrees for the **start and end of each of the four stokes**, including the crank angle degrees when **intake and exhaust valve would be in the open and close**. Assume that a crank angle of 0 degrees corresponds with the piston 1 at TDC at the beginning of the intake stroke. Assume that intake valve opens 10º before TDC and closes 45º after BDC; and that exhaust valve closes 12º after TDC and opens 40º before BDC. Pistons are number from the front of the engine. (Note: Consider firing order)

a) All cylinders for the 6 cylinder, 4 stroke engine (Firing order, 1,5,3,6,2,4)

	Intake Stroke		Comp. Stroke		Power Stroke		Exh. Stroke		Intake Valve		Exhaust Valve	
	Start	End	Start	End	Start	End	Start	End	Opens	Close	Opens	Close
Example: 3 cylinder, 4 Stroke Engine. Firing Order: 1,2,3												
Piston #1	0	180	180	360	360	540	540	720	710	225	495	12
Piston #2	240	420	420	600	600	60	60	240	230	465	15	252
Piston #3	480	660	660	120	120	300	300	480	470	705	255	492
Part a: 6 cylinder, 4 Stroke Engine. Firing Order: 1,5,3,6,2,4												
Piston #1	0											
Piston #5												
Piston #3												
Piston #6												
Piston #2												
Piston #4												

b) If the 6 cylinder engine is stopped at a crankshaft angle of 180 degrees. Clearly, identify the valves (Exhaust and intake) for all 6 pistons, which could have their valve clearance adjusted with the crankshaft is at this position and which valves you should not adjust. **State how you decided on which valves to adjust.**

c) Briefly describe the fundamental difference between rotary and in-line diesel injection pumps, on fuel injection timing (Start & End injection) as you change the amount of fuel injected. (You may assume that there is no advance mechanism operating)

d) What is the purpose of the aneroid on an injector pump and how does it operate.

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Question 5(25 points)

IDEAL GAS $PV=(M/m)RT$ $R=8.134$ kJ / (kg mole K)

$P_{rc} = (P_1 + Boost)/P_1$ $1/T_{rc} = T_2/T_1 = 1+ [P_{rc}^{(k-1)/k} -1]/e_c$

$e_v = P_{rc}*T_{rc} = [P_{rc}*e_c]/[e_c + (P_{rc}^{(k-1)/k} -1)]$

Note: e_c = (Theoretical Temperature Difference / Actual Temperature Difference)

Inlet Gases K=1.4, C_p = 1.107 kJ/kg.°K

A turbocharger is fitted to a 7L to provide an 4-cycle engine rated at 118 kW at 2200 rpm. The ambient air density is 1.16 kg/m^3, and the desired A/F ratio of the turbocharged engine is 27:1. It is assumed that a BSFC of 0.27 kg/kW.h can be achieved. Assume the compressor efficiency is 0.76.

a) Calculate mass flowrate of fuel required.

b) Calculate mass flowrate of air required.

c) Calculate the volumetric efficiency required.

d) Given that ambient air temperature, T1=293 °K, and the compressor efficiency (e_c) = 0.76. Determine the compressor pressure ratio p_{rc} that is required

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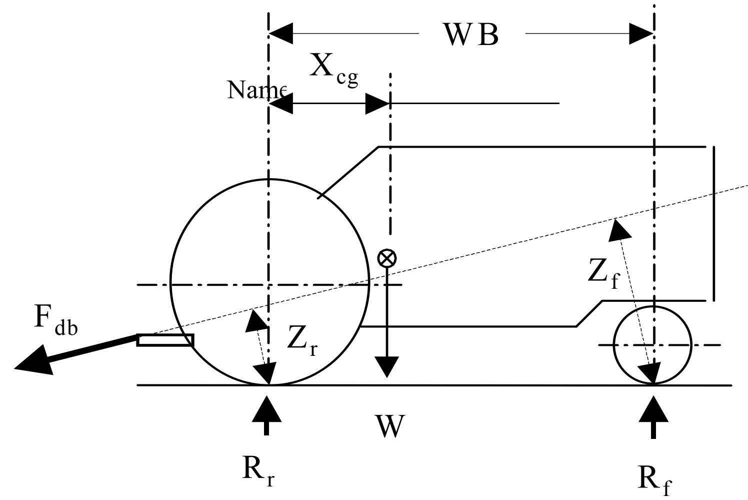
Question 6

Given the following information for the tractor shown



Static Weight on Tractor

(zero drawbar pull)	15000 lb.	(7000 kg)
Wheelbase	120"	(3000 mm)
Tread Width	60"	(1500 mm)
Xcg	36	(900 mm)
Z_{cg}	40"	(1015 mm)

a) Given the following Z_r= 25" (625mm) and Z_f=75" (1900 mm) and F_{db} = 7500 lb. (33000 N) determine the following

i). The dynamic front axle reaction force.

ii) The dynamic rear axle reaction force.

b). Determine the drawbar pull required such that the remaining reaction force on the front axles is only 1000 lb (450 kg). (Assume the direction of pull does not change)

d). Determine the maximum slope the tractor could climb without becoming unstable, with drawbar pull of 2500 lb (10000 N). (Assume that the line of action of the pull with respect to the tractor does not change)