BENGAL ENGINEERING & SCIENCE UNIVERSITY, SHIBPUR
B.E. 5TH SEMESTER (ME) FINAL EXAMINATIONS, 2011
Internal Combustion Engine (ME 502)

Full Marks: 70 **Time: 3 hrs**

Use separate answer script for each half
Answer SIX questions, taking THREE from each half
The questions are of equal value.

FIRST HALF

1. (a) If an ideal Otto cycle is running with a compression ratio of r and delivering an efficiency of η, deduce a mathematical expression to represent the relative change in efficiency due to change in specific heat at constant volume (C_v). [5]
(b) With a neat schematic diagram, describe the operating principle of a battery ignition system. [6]

2. (a) Define Octane number of an SI engine fuel. [2]
(b) Compare between battery and magneto ignition system. [4]
(c) An SI engine is running with a compression ratio of 6 and air-fuel ratio of 15:1. Pressure and temperature at the beginning of suction stroke is 1 bar and 57 °C respectively. Determine the maximum pressure in the cylinder, if the index of compression is 1.3 and the specific heat at constant volume follows $C_v = 0.678 + 0.00013\,T$, where T is in Kelvin. Take CV = 42 MJ/kg. [5]

3. (a) Briefly discuss the effect of different factors on ignition delay for an SI engine. [6]
(b) A four-stroke gas engine has a cylinder diameter of 25 cm and stroke length of 45 cm. Following observations were made during a test run of that engine. [5]

Duration of test	=	40 min
Total number of revolutions	=	8080
Total number of explosions	=	3230
Net load on the brake	=	90 kg
Effective diameter of brake	=	1.6 m
Indicated mean effective pressure	=	5.8 bar
Volume of gas used	=	7.5 m^3
Gauge pressure of supplied gas	=	136 mm of water
Atmospheric pressure	=	760 mm of water
Atmospheric temperature	=	17 °C
Calorific value of gas	=	19 MJ/m^3 at NTP
Rise in cooling water temperature	=	45 °C
Total supply of cooling water	=	180 kg

Draw up a heat balance sheet and calculate indicated thermal efficiency & brake thermal efficiency. Take C_p for water = 4.18 kJ/kg K.

4. (a) Briefly discuss the role of different factors in deciding the firing order in a four-cylinder SI engine. [5]

(b) A 1.6 litre cubic capacity four-stroke SI engine has a volumetric efficiency of 75% at a speed of 5000 rpm. The carburetor gives an air-fuel ratio of 14. Air velocity at the throat is 100 m/s. Take C_{da} = 0.9, C_{df} = 0.7, lip height = 5 mm and specific gravity of fuel = 0.8. Atmospheric pressure and temperature are 1 bar and 27 °C. An allowance must be made for the emulsion tube and its diameter may be assumed to be $\frac{1}{25}$ of the choke diameter. Determine the size of the venture throat and main jet diameter. Take C_p for air = 1.005 kJ/kg K. [6]

5. (a) With a schematic diagram, discuss the method of back suction control in correcting the drawback of a simple carburetor. [4]

(b) What are the effects of knocking in SI engine? [3]

(c) A four-cylinder four-stroke diesel engine develops a power of 180 kW at 1500 rpm. The *bsfc* is 0.2 kg/kWh. At the beginning of injection, pressure is 30 bar and the maximum cylinder pressure is 50 bar. The injection is expected to begin at 200 bar and maximum injector pressure is set at 500 bar. Take effective pressure difference to be equal to the average pressure difference over the injection period. Determine the total orifice area required per injector if the injection takes place over 15° crank angles. Take C_d for injector = 0.7 and specific gravity of fuel = 0.875. [4]

2 marks have been reserved for neatness

BENGAL ENGINEERING AND SCIENCE UNIVERSITY, SHIBPUR
B.E. 5th SEMESTER MECHANICAL EXAMINATIONS, 2011

Internal Combustion Engine (ME-502)

Full Marks: 70 **Time: 3 hrs**

i) **Use separate Answer Script for each half**
ii) **All questions carry equal marks.**
iii) **Attempt any six questions taking three from each half.**
iv) **Assume suitable data where necessary.**

SECOND HALF

6. a) What is critical pressure ratio in a nozzle. Derive an expression for critical pressure ratio for a nozzle and show that if a nozzle is operated at critical pressure ratio the velocity of the fluid flowing through it is equal to velocity of sound under that condition.
b) Gases expand in a propulsion nozzle from 3.5 bar and 425^0C down to a back pressure of 0.97 bar at the rate of 18 kg/s. Taking a coefficient of discharge of 0.99 and a nozzle efficiency of 0.94, calculate the required throat and exit areas of the nozzle. For the gases take adiabatic index $\gamma=1.333$ and $C_p=1.11$ KJ/kg K. Assume that the inlet velocity is negligible.

7a) Explain the following terms with respect to jet propulsion:
i) Thrust Specific Fuel Consumption ii) Propulsive Efficiency iii) Thermal Efficiency of Turbojet Engine
b) A turbojet engine inducts 51 kg of air per second and propels an aircraft with an uniform flight speed of 912 Km/h. The isentropic enthalpy change for the nozzle is 200 KJ/Kg and its velocity coefficient is 0.96. If the fuel air ratio is 0.0119 and the calorific value of the fuel is 42 MJ/Kg, determine the following:
i) Thermal efficiency of the engine ii) Thrust specific fuel consumption iii) Propulsive Efficiency

8. A turbojet aircraft is flying at an altitude of 10 Km above sea level, where the ambient conditions are 24 kPa and -50^0C. The speed of the aircraft is 800 km/h. The pressure ratio in the compressor is 10:1 and its isentropic efficiency is 0.9. There is a

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stagnation pressure drop of 0.14 bar in the combustion chamber. The gas turbine inlet temperature is 820^0C and its isentropic efficiency is 0.92. The efficiency of nozzle is 92% with nozzle outlet area of 0.08 m^2. Considering the intake duct efficiency to be 90% and lower calorific value of fuel to be 43300 KJ/Kg, find the thrust in N and specific fuel consumption in Kg/Nh of thrust. Assume the nozzle to be convergent. Take C_{pa} =1.005 KJ/Kg K, γ_a=1.4, C_{pg} =1.15 KJ/Kg K, γ_g=1.333. Take mechanical efficiency of the drive and combustion efficiency to be 98% each.

9. At design speed following data is applied to gas turbine cycle employing a separate power turbine, heat exchanger and intercooler between two stage compression:

Isentropic efficiency of compressor each stage: 84%
Isentropic efficiency of compressor turbine: 90%
Isentropic efficiency of power turbine: 85%
Turbine to compressor transmission efficiency: 99%
Pressure ratio in each stage of compression: 2:1
Temperature after intercooler: 295 K
Air mass flow rate: 13.65 Kg/s
Heat Exchanger effectiveness: 0.75
Maximum turbine temperature (both): 900 K
Ambient temperature: 288.15 K
LHV of fuel: 43100 KJ/Kg
Calculate the following: i) Net output ii) Specific fuel consumption iii) Overall thermal efficiency

10. Write short notes on the following (any three)

i) Off design performance of a convergent-divergent nozzle ii) Polytropic efficiency iii) Ramjet engine iv) Nozzle efficiency v) Afterburner in jets