Ref. No.: Ex/ME(M2)/PC/B/T/313/2024

BACHELOR OF ENGINEERING IN MECHANICAL ENGINEERING EXAMINATION

THIRD YEAR FIRST SEMESTER - 2024

Subject: INTERNAL COMBUSTION ENGINE

Time: 3 hours **Full Marks: 100**

(Any of the used symbols carries its usual meaning.)

ANSWER QUESTION NO. 1 AND ANY FOUR FROM THE REST.

Q.1	(a)	Explain the basic difference in the working principle of an internal combustion engine and an external combustion engine with examples.	1+½×2
	(b)	With a neat sketch of the longitudinal-section of a single cylinder spark-ignition engine, label the following components: (i) TDC, BDC, and stroke length, (ii) crank shaft, crank and connecting rod, (iii) piston, cylinder, and spark plug, (iv) carburetor, inlet and exhaust valves.	2+1×4
	(c)	Explain the working principle of a four-stroke spark ignition engine on a P-v diagram representing all its strokes and respective processes clearly, and hence, indicate the following on it: (i) clearance volume, and (ii) stroke volume	4+1×2
	(d)	A four-cylinder four-stroke spark ignition engine has a bore of 80 mm and stroke of 80 mm. The compression ratio is 8. Calculate (i) the cubic capacity of the engine when volumetric efficiency of each cylinder is 80% and (ii) the clearance volume of each cylinder.	1½×2
	(e)	Write briefly the basic differences between spark ignition (S.I.) engine and compression ignition (C.I.) engine?	2
	(f)	What is 'scavenging' in case of a two-stroke engine?	1
Q.2	(a)	Derive an expression for the thermal efficiency of Otto cycle in terms of the compression ratio (r_k) and ratio of specific heats (γ).	6
	(b)	The pressure and temperature at beginning of a cycle of an internal combustion engine with isobaric heat supply are 0.1 MPa and 80°C, respectively. The compression ratio is 16 and the heat supplied is 850 kJ/kg. Plot the cycle on the P-v and T-s planes. Hence, calculate (i) the thermal efficiency and (ii) the mean effective pressure of the cycle assuming air as working fluid. Assume necessary data related to the problem, if required.	2+2+6
	(c)	Compare Otto and Diesel cycles on P-v and T-s planes for same compression ratio and same heat rejection. Hence, explain the basic reason behind using a petrol engine in a small size vehicle, generally.	1½×2+1
Q.3	(a)	Write two major assumptions in respect of the fuel-air cycle.	2
	(b)	A petrol engine having a compression ratio of 6 uses a fuel with calorific value of 42 MJ/kg. The air-fuel ratio is 15:1. Pressure and temperature at the start of the suction stroke are 1 bar and 57°C, respectively. Determine the maximum pressure in the cylinder if the index of	6+3

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compression is 1.3 and the specific heat at constant volume is given by $C_v = 0.678 + 0.00013\ T$ where T is in Kelvin. Then, find the thermal efficiency of the cycle, and compare this value with that obtained when $C_v = 0.717$ kJ/kg K. Write the assumptions, if required.

(c) Indicate the following losses on P-*v* diagram of an Otto cycle engine: 1½×6
(i) losses due to variable specific heats
(ii) losses due to dissociation
(iii) losses due to spark advance
(iv) burning time losses
(v) incomplete combustion losses
(vi) exhaust blowdown losses

Q.4 (a) With a neat sketch, present a typical valve timing diagram for a petrol engine, and write respective reasons behind such opening and closing of the valves. 2+½×4

(b) Write at least two desirable qualities of a fuel for the S.I. engines. How do a fuel for the S.I. engines is rated? Explain briefly. 2+2

(c) A petrol engine with a compression ratio of 7 used a mixture of isooctane and hexane as fuel. The pressure and temperature at the beginning of the compression process are 1bar and 55.22°C, respectively. If the fuel-air mixture is 19.05% rich and the maximum pressure developed is 115.26 bar then evaluate the composition of the mixture (in percentage weight). Take $C_v = 0.717$ kJ/kg-K, $(CV)_{hexane} = 43$ MJ/kg, $(CV)_{iso\text{-}octane} = 42$ MJ/kg and $PV^{1.31}$ is constant for the expansion and compression processes. 12

Q.5 (a) With a neat sketch and by labelling of all necessary components, explain briefly the working principle of a simple carburetor. 6+2+2×2
Explain why a rich mixture is required in case of idling condition. Explain the necessity of incorporating (i) an economizer system and (ii) an acceleration pump system in the carburetion system. Sketch the systems neatly.

(b) A simple jet carburetor is required to supply 5 kg of air and 0.5 kg of fuel per minute. The fuel specific gravity is 0.75. The air is initially at 1bar and 300K. Calculate the throat diameter for a flow velocity of 100 m/s. Velocity coefficient is 0.8. If the pressure drop across the fuel metering orifice is 0.80 of that of the throat, calculate orifice diameter assuming, $C_{df} = 0.60$ and $\gamma = 1.4$. 8

Q.6 (a) With a neat sketch and labelling each of the essential components, explain working principle of a battery ignition system. 6

(b) Briefly explain the stages of combustion in case of S.I. engines, and present each of the stages on the P-θ variation curve. Explain then the detonation phenomenon in case of S.I. engines. 3+1

(c) Consider a six-cylinder four-stroke gasoline engine. The bore of each cylinder is 80 mm and the stroke is 100 mm. The clearance volume per cylinder is 70cc. At a speed of 4000 rpm, the fuel consumption is 20 kg/h 10

and the torque developed is 150 Nm. Calculate (i) the brake power (ii) the brake mean effective pressure (iii) brake thermal efficiency if the calorific value of the fuel is 43000 kJ/kg and (iv) the relative efficiency on a brake power basis assuming the engine works on the constant volume cycle. γ = 1.4 for air.

Q.7 (a) What are the fundamental requirements of a fuel injection system in a compression ignition engine? 4

(b) Briefly explain the different types of fuel injection systems in case of compression ignition engines. 2×4

(c) Calculate the diameter of the fuel orifice of a four-stroke engine which develops 25kW per cylinder at 2500 rpm. The specific fuel consumption is 0.3 kg/kW h with a fuel of specific gravity 0.8762. The fuel is injected at a pressure of 150 bar over a crank travel of 25°. The pressure in the combustion chamber is 40 bar. 8

Q.8 Write short notes on (any four): 5×4

(a) Properties of the lubricants
(b) Pressure feed lubrication system
(c) Common rail injection system
(d) Forced circulation cooling system
(e) Emissions and catalytic converters
(f) Morse test
(g) Crankcase scavenged two stroke S. I. engine
(h) Jerk type fuel pump