Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem 2019-20
Course Code: MEC 213
Course Name: IC ENGINES & FUELS
Program & Sem: B.Tech (MEC) & VII

Date: 01.10.2019
Time: 9.30 to 10.30 AM
Max Marks: 40
Weightage: 20%

Instructions:
(i) Read the question properly and answer accordingly.
(ii) Question paper consists of 3 parts.
(iii) Scientific and Non-programmable calculators are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries four marks **(3Qx4M=12M)**

1. Differentiate between SI & CI Engines. (C.O.NO.1) [Knowledge]

2. With a neat sketch Explain IC engine Terminology (C.O.NO.1) [Knowledge]

3. Define the following with formulae and mention its units. (C.O.NO.1) [Knowledge]

   a) Thermal Efficiency

   b) Specific Fuel Consumption

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries ten marks **(2Qx6M=12M)**

4. Draw the sketches of 4 strokes working strokes of compression ignition Engine. Mention opening and closing of valves during different strokes. (C.O.NO.1) [Comprehension]

5. Differentiate why 4 stroke engines are dominated over 2 stroke engines.

(C.O.NO.1) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries eight marks. **(2Qx8M=16M)**

6.

a) Compare Otto, Diesel & Dual Combustion Cycle with PV & T-s Diagram. [5M]

(C.O.NO.1) [Comprehension]

b) An engine working on Otto cycle has the following conditions: Pressure at the beginning of compression is 1 bar and pressure at the end of compression is 11 bar. Calculate the compression ratio and air standard efficiency of the engine [3M]

(C.O.NO.1) (Application)

7. Calculate all engine performance parameters for the following data: A single cylinder 4-stroke IC engine has a bore of 180mm, stroke of 200mm and a rated speed of 300 rpm. Torque on the brake drum is 200Nm and mean effective pressure is 6 bar. It consumes 4 kg of fuel in one hour. The calorific value of the fuel is 42000 kJ/kg. [8M]

(C.O.NO.1) (Application)

SCHOOL OF ENGINEERING

Semester: 7th Semester

Course Code: MEC 213

Course Name: IC Engines & fuels

Date: 01/10/2019

Time: 1 Hour

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	CO1	UNIT-1		4								4
2	CO1	UNIT-1		4								4
3	CO1	UNIT-1	4									4
4	CO1	UNIT-1					6					6
5	CO1	UNIT-1					6					6
6.a	CO1	UNIT-1					5					5
6.b	CO1	UNIT-1									3	3
7	CO1	UNIT-1									8	8
	Total Marks		4	8			17				11	40 Marks

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

[I hereby certify that All the questions are set as per the above guide lines. Mr. Muralidhara D M]

D. 7
2/7/16

SCHOOL OF ENGINEERING

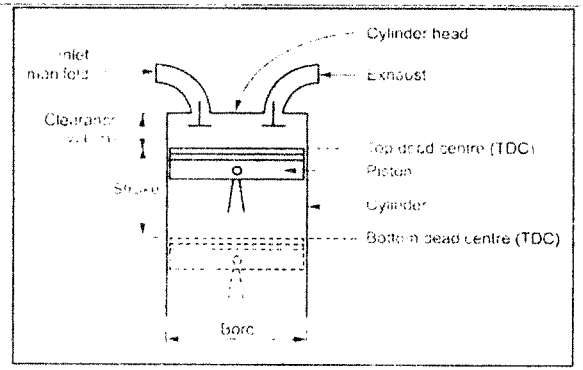
SOLUTION

Semester: 7th Semester
Course Code: MEC 213
Course Name: **IC Engines & fuels**

Date: 01/10/2019
Time: 1 Hour
Max Marks: 40
Weightage: 20%

Part A (3Q x 4M =12 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Petrol Engine** / **Diesel Engine** The petrol engine works on Otto cycle i.e. on constant volume. / The diesel engine works on diesel cycle i.e. on constant pressure. The air and petrol are mixed in the carburetor before they enter into the cylinder. / The fuel is fed into the cylinder by a fuel injector and is mixed with air inside the cylinder. The petrol engine compresses a mixture of air and petrol which is ignited by an electric spark. / The diesel engine compresses only a charge of air and ignition is done by the heat of compression. Compression ratio is low. / Compression ratio is higher in diesel engine. Less power is produced due to lower compression ratio. / Due to higher compression ratio more power is produced. Petrol engine is fitted with a spark plug / It is fitted with a fuel injector. Burns fuel that has high volatility. / Burns fuel that has low volatility.	**Any Four Differences. Each difference one Marks**	5 Min

2	 **Bore:** The inside diameter of the cylinder is called Bore. **Top dead center (TDC):** The extreme position of the piston near to the cylinder head is called top dead center or TDC. **Bottom dead center (BDC):** The extreme position of the piston nearer to the crankshaft is called bottom dead center or BDC. **Stroke:** It is the linear distance travelled by the piston from the TDC to BDC or BDC to TDC. **Clearance volume (V_C):** It is the volume of cylinder above the top of the piston, when the piston is at the TDC. **Swept volume or Stroke volume (V_S):** It is the volume swept by the piston as it moves from BDC to TDC or TDC to BDC. **Compression ratio(R_C):** The ratio of the total cylinder volume to the clearance volume is called Compression ratio. Total cylinder volume = Stroke volume (V_S) + Clearance volume (V_C) $$R_C = \frac{V_S + V_C}{V_C}$$ **Piston Speed:** The average speed of the piston is called piston speed. Piston speed = **2*L*N** Where: L = Stroke length in m. N = Speed of engine in RPM.	**Sketch-2 Marks** **Explanation-3 Marks**	5 Min
3	**Thermal efficiency (η_{th}):** It is defined as the ratio of power output to the heat supplied by combustion of fuel. $$\eta_{th} = \frac{Power\ output}{Heat\ supplied} * 100$$ Heat supplied = $m_f * CV$ in **kJ/kg** Where, m_f = Mass of fuel in **kg/sec** CV = calorific value of fuel in **kJ/kg** The power output may be indicated power (IP) or Brake power (BP). **Indicated Thermal efficiency($\eta_{I_{th}}$):** It is defined as the ratio of indicated power to the heat supplied by combustion of fuel. $$\eta_{I_{th}} = \frac{IP}{m_f * CV} * 100$$ **Brake Thermal efficiency($\eta_{B_{th}}$):**	**Each Definition-1 Mark,** **Each Formulae-0.5 Marks,** **Each Unit-0.5 Marks**	5 Min

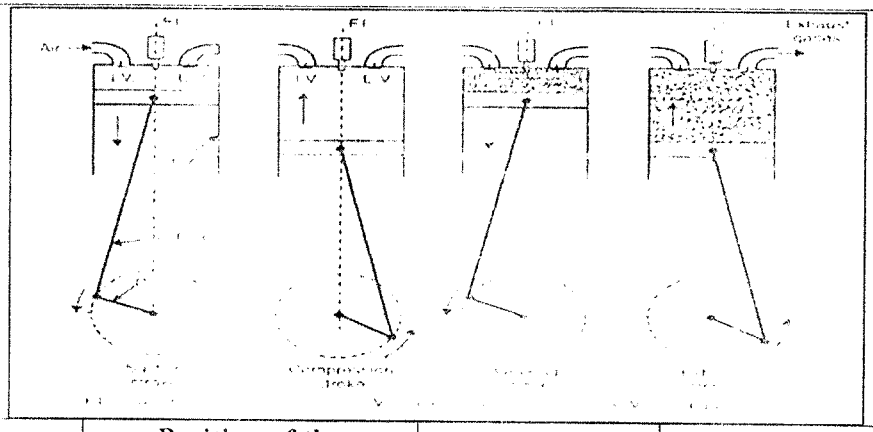
	It is defined as the ratio of brake power to the heat supplied by combustion of fuel. $$\eta_{B_{th}} = \frac{BP}{m_f * CV} * 100$$ **Brake Specific Fuel Consumption *(BSFC)*:** It is defined as the mass of the fuel consumed in one hour by an engine in developing 1 kW of brake power. This can be expressed as $$BSFC = \frac{Mass\ of\ the\ fuel\ consumed\ in\ kg/hr}{Brake\ power\ developed\ in\ kW} \quad \text{kg / kWhr}$$ $$BSFC = \frac{m_f}{BP}$$		

Part B

(2Q x 6M = 12 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

4



Stroke	Position of the piston		Inlet valve	Exhaust valve	Crank rotation
	Initial	**Final**			
Suction	TDC	BDC	Open	Close	0^0 - 180^0
Compression	BDC	TDC	Close	Close	180^0 - 360^0
Power Working	TDC	BDC	Close	Close	360^0 - 540^0
Exhaust	BDC	TDC	Close	Open	540^0 - 720^0

Figure 4
Marks
Table-2 **Marks**

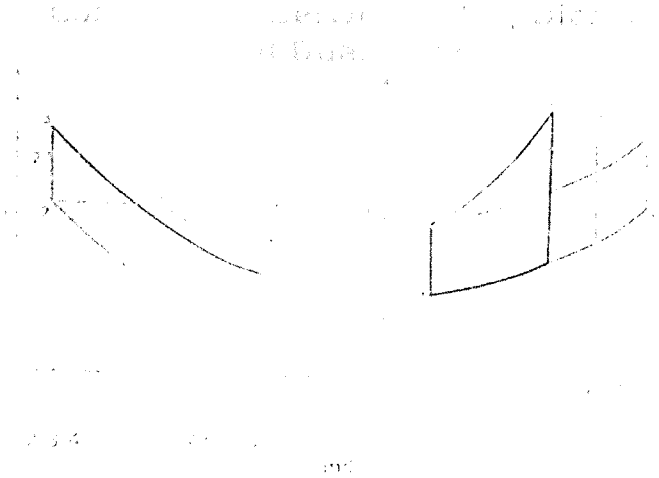
10 Min

5	**Two Stroke Engine** It has one revolution of crankshaft within one power stroke. It can generate high torque compare to 4 strokes engine. It used port to inlet and outlet of fuel. 2 stroke engines require lighter flywheel compare to other engines because it generates more balanced force due to one revolution for one power stroke. The charge is partially burn and mix with the burn gases during inlet. It is due to port mechanism. Easy lubrication due to lubrication oil mix with the fuel. More lubricating oil requires because some oil burns with fuel. These engines give less thermal efficiency. It has high power to weight ratio compare to others. It creates more noise.	**Four Stroke Engine** It has two revolution of crankshaft between one power strokes. It generates less torque due to 2 revolution of crankshaft between one power strokes. It used valve to inlet and outlet. It requires heavy flywheel because it generates unbalance force due to two revolutions for one power stroke. In four stroke engine charge is fully burn and does not mix with burn charge in ideal condition. Comparatively complicated lubrication. Comparatively less lubricating oil requires. These engines give more thermal efficiency. 4 stroke engines have less power to weight ratio. It is less noisy.	**Any Four Differences. Each difference one Marks**	5 Min

Part C

(2Q x 8M = 16 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question

6.a.		Pv Diagram -3 Marks T-s diagram-2 Marks	5 Min
6.b			5 Min
7	**Solution:** For single cylinder engine, n= 1; For a 4-stroke engine, K = 1/2; d = 180mm = 0.18m; $A = \frac{\pi d^2}{4} = \frac{\pi(0.18)^2}{4} = 0.0254m^2$; L = 200mm = 0.2m; N = 300 rpm; Torque, T = 200Nm; P_{mi} = 6 bar; m_f = 4kg/hr = $\frac{4}{60*60} = 1.11*10^{-3}$ kg sec; CV = 42000 kJ/kg **(i) Brake power** $BP = \frac{2\pi NT}{60*1000}$ kW	Each Component final value with units -1.5 Marks Each Formulae-0.5 Marks	10 Min

$$BP = \frac{2\pi * 300 * 200}{60 * 1000}$$

$$\mathbf{BP = 6.28\ kW}$$

(ii) Indicated power

$$IP = nP_mLANK\left(\frac{10}{6}\right) \quad kW$$

$$IP = 1 * 6 * 0.2 * 0.0254 * 300 * \frac{1}{2}\left(\frac{10}{6}\right) \quad kW$$

$$\mathbf{IP = 7.63\ kW}$$

(iii) Brake thermal efficiency

$$\eta_{B_{th}} = \frac{BP}{m_f * CV} * 100$$

$$\eta_{B_{th}} = \frac{6.28}{1.11 * 10^{-3} * 42000} * 100$$

$$\boldsymbol{\eta_{B_{th}} = 13.47\%}$$

(iv) Mechanical efficiency

$$\eta_{mech} = \frac{BP}{IP} * 100$$

$$\eta_{mech} = \frac{6.28}{7.63} * 100$$

$$\eta_{mech} = 82.3\%$$

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BENGALURU

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20
Course Code: MEC 213
Course Name: I C ENGINES & FUELS
Program & Sem: B.Tech & VII

Date: 19.11.2019
Time: 9.30 AM to 10.30 AM
Max Marks: 40
Weightage: 20%

Instructions:
(i) *Write the sketches neatly.*
(ii) *Non programmable scientific calculator are allowed.*

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries five marks. (4Qx5M=20M)

1. What is the need for alternate fuels for IC Engines ?
(CO2) [Knowledge]
2. Write a short note on Fuel Feed Pump.
(CO2) [Comprehension]
3. Discuss the main functional requirements in a fuel injection system.
(CO2) [Knowledge]
4. Give the advantages and disadvantages of LPG. (CO2) [Knowledge]

Part B [Thought Provoking Questions]

Answer the Question. The Question carry eight marks. (1Qx8M=8M)

5. In Jaynagar, the BBMP workers are collecting 10 Tons of Municipal Waste every week and facing lot of problems to disperse the municipal waste. With respect to this, explain the process how this municipal waste can be utilized in IC Engines.

[8M](CO2) [Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The Question carry twelve marks. (1Qx12M=12M)

6. Explain the following with the neat sketch:
a) Simple carburetor b) Port injection MPFI system
[6+6=12M](CO2) [Comprehension]

SCHOOL OF ENGINEERING

ODD Semester: 2019-2020
Course Code: MEC 213
Course Name: I C Engines & Fuels

Date: 19/11/2019
Time: 9.30am to 10.30am
Max Marks: 40 MARKS
Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	CO1	Module 2	H									5
2	CO1	Module 3		M								5
3	CO1	Module 2	H									5
4	CO1	Module 2	H									5
5	CO1	Module 2					M					8
6	CO1	Module 3				H						12
	Total Marks		15	5		12	8					40

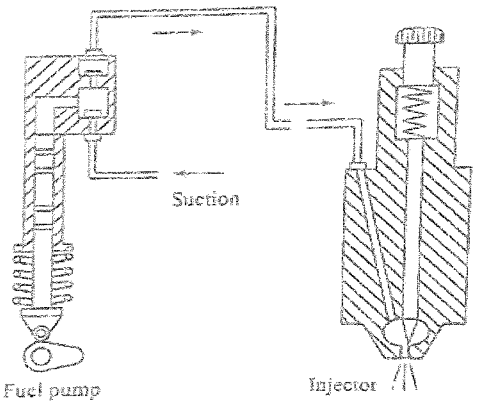
SCHOOL OF ENGINEERING

ODD Semester: 2019-2020
Course Code: MEC 213
Course Name: I C Engines & Fuels

Date: 19/11/2019
Time: 9.30am to 10.30am
Max Marks: 40 MARKS
Weightage: 20%

Part A (3Q x4 M =12 Marks)

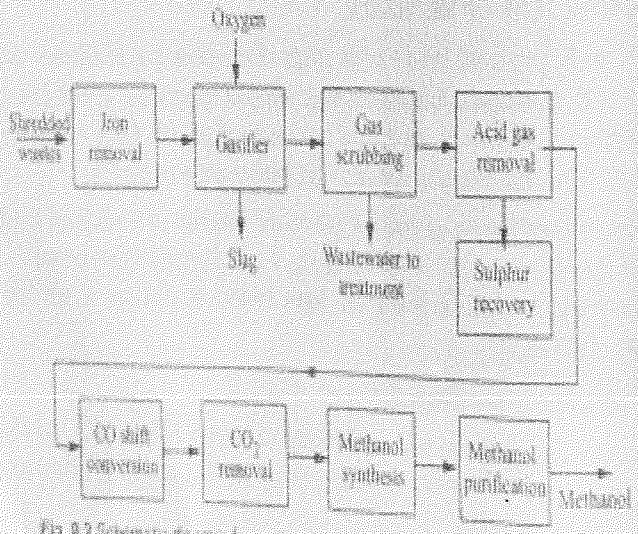
Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**NEED FOR ALTERNATE FUELS:** Necessities for the search of Alternative fuels are: 1. To ensure that when the short fall in crude oil occurs, there can be a smooth transition to other fuels. 2. To provide long-term security of supply because well over half of the world's crude oil is in the Middle East. 3. To improve air quality because the alternative fuel may give cleaner exhaust gases as, for example, is claimed for methanol as a replacement for gasoline. However, the improvements in exhaust emissions resulting from the use of reformulated gasoline's will delay the general introduction of alternative fuel such as methanol. 4. To overcome the absence of an indigenous crude oil supply together with an adverse balance of payments situation. An example has been the use of ethanol as an automotive fuel in brazil, where expensive crude oil had to be imported but ethanol could be manufactured relatively cheaply(when world sugar prices were low)by fermenting sugar cane.	**Five points Each point carry 1 mark**	5 in

2	8.4 FUEL FEED PUMP A schematic sketch of fuel feed pump is shown in Fig.8.4. It is of spring loaded plunger type. The plunger is actuated through a push rod from the cam shaft. At the minimum lift position of the cam the spring force on the plunger creates  *Fig. 8.4 Schematic diagram of fuel feed pump* a suction which causes fuel flow from the main tank into the pump. When the cam is turned to its maximum lift position, the plunger is lifted upwards. At the same time the inlet valve is closed and the fuel is forced through the outlet valve. When the operating pressure gets released, the plunger return spring ceases to function resulting in varying of the pumping stroke under varying engine loads according to the quantity of fuel required by the injection pump.	**Sketch carries 2 Explanation marks**	**10min**
3	**Functional requirements of a fuel injection system** ✓ For successful running and getting good performance from an internal combustion engine, the following requirements must be met by a fuel injection system. ✓ Accurate metering of the fuel injected per cycle. ✓ Correct fuel injection timing. ✓ Full control over rate of fuel injection. ✓ Proper atomization of the fuel. ✓ Proper spray pattern to ensure mixing of air and fuel. ✓ Uniform distribution of fuel in the combustion chamber. ✓ To supply equal quantity of the fuel in all the cylinders (in case of multi cylinder engine). No lag between beginning and end of injection process.	**Any four Particular Requirements. Each carries 1.5 Marks**	**5min**
4	**Advantages LPG** 1. Propane has low cold-start emissions due to its gaseous state. 2. Propane has lower peak pressure during combustion than conventional fuels, which generally reduces noise and improves durability. 3. LPG fuel systems are sealed and evaporative losses are negligible. 4. Propane is easily transportable and offers 'stand-alone' storage capability with simple and self-contained LPG dispensing facilities, with minimum support infrastructure. 5. LPG vehicles do not require special catalysts. 6. Propane contains negligible toxic components. **Disadvantages**	**Any three advantages and two disadvantages**	**5min**

	1. Propane tanks are pressure vessels and thus weigh more than the equivalent diesel tank. 2. Propane is heavier than air, which requires appropriate handling. 3. Propane vapor flammability limits in air are wider than those of petrol, which makes LPG ignite more easily. 4. Propane has a high expansion coefficient so that tanks can only be filled to 80% of capacity. 5. Propane in liquid form can cause cold burns to the skin in case of inappropriate use.		

Part B

(1Q x8 M = 8Marks)

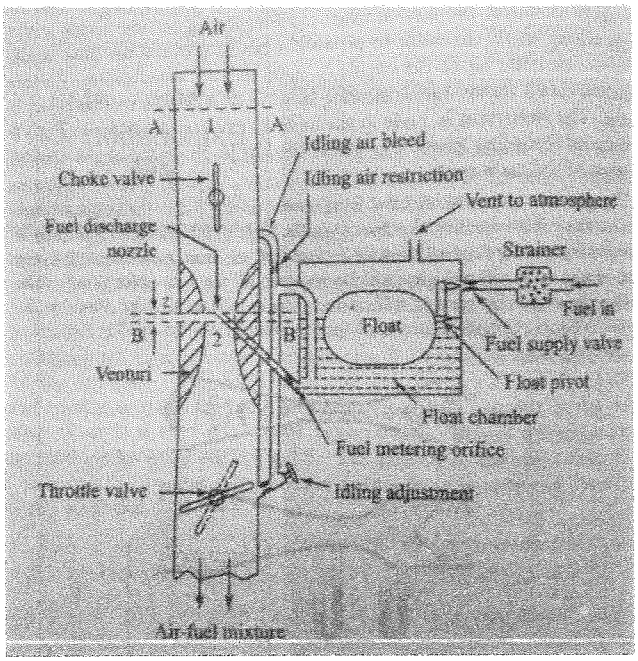
Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	(b) Methanol from Municipal Solid Wastes. The waste can be converted to methanol. Figure 9.2 shows a schematic diagram. The wastes are first shredded and then passed under a magnet to remove ferrous materials. The iron free wastes are then  Fig. 9.2 Schematic diagram for methanol production from municipal solid wastes	Sketch – 4M Explanation – 4M	10min

Part C

(Q x M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6 a.	**Carburetor** is a device that mixes air and fuel for <u>internal combustion engines</u> in the proper <u>air–fuel ratio</u> for combustion. Essential Parts of carburetor are 1. Choke and throttle 2. Fuel strainer 3. Float chamber 4. Main fuel metering and idling nozzles And rest are 5. Venturi 6. Fuel discharge nozzle 7. Float	SKETCH – 3M EXPLANATION – 3M for Each Question	20 min

8. Float pivot
9. Fuel metering orifice
10. Idling adjustment



6.b. Port injection:

9.4.1 Port Injection

In the port injection arrangement, the injector is placed on the side of the intake manifold near the intake port (Fig.9.3). The injector sprays gasoline into the air, inside the intake manifold. The gasoline mixes with the air in a reasonably uniform manner. This mixture of gasoline and air then passes through the intake valve and enters into the cylinder.

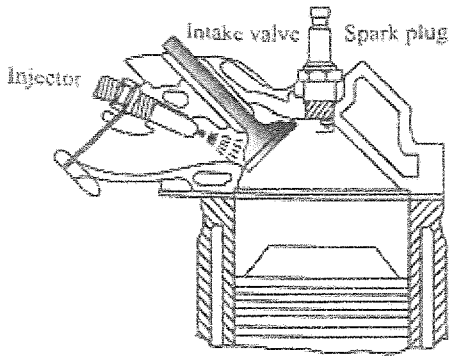


Fig. 9.3 Port injection

Every cylinder is provided with an injector in its intake manifold. If there are six cylinders, there will be six injectors. Figure 9.4 shows a simplified view of a port or multi point fuel injection (MPFI) system.

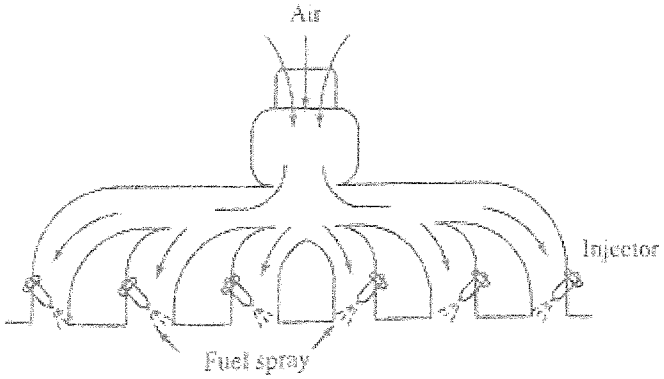


Fig. 9.4 Multi-point fuel injection (MPFI) near port

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SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20 | **Date**: 27 December 2019

Course Code: MEC 213 | **Time**: 9:30 AM to 12:30 PM

Course Name: IC ENGINES AND FUELS | **Max Marks**: 80

Program & Sem: B.Tech (MEC) & VII | **Weightage**: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.

(ii) Question paper consists of 3 parts.

(iii) Scientific and Non-programmable calculators are permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 4 marks. (5Qx4M=20M)

1. Define Mean Effective Pressure and Brake Specific Fuel consumption with formula. (C.O.No.1) [Knowledge]
2. Explain Trans Esterification Process with chemical reaction. (C.O.No.2) [Comprehension]
3. What are different types of air fuel mixtures. (C.O.No.3) [Knowledge]
4. Explain Octane No and Cetane No, mention it's value for petrol and diesel engines. (C.O.No.4) [Comprehension]
5. State different types of pollutants from automobiles and their causes. (C.O.No.5) [Knowledge]

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries 10 marks. (2Qx10M=20M)

6. Why engine performance parameter curves are drawn with respect to crank angle rotation? draw (P-Θ) curves for Otto and Diesel Cycle. (C.O.No.4) [Comprehension]
7. Mention the reason for NO_x Formation and Explain EGR Technique with neat sketches. (C.O.No.2) [Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 10 marks. **(4Qx10M=40M)**

8. Explain stages of combustion in SI Engine with neat sketches.

(C.O.No.3) [Comprehension]

9. Explain Knocking, and compare knocking for SI and CI engines with neat sketches.

(C.O.No.4) [Comprehension]

10. A single cylinder 4-stroke IC engine has a bore of 180mm, stroke of 200mm and a rated speed of 300 rpm. Torque on the brake drum is 200Nm and mean effective pressure is 6 bar. It consumes 4 kg of fuel in one hour. The calorific value of the fuel is 42000 kJ/kg. Determine (i) Brake power (ii) Indicated power (iii) Brake thermal efficiency (iv) Mechanical efficiency

(C.O.No.1) [Application]

11. Explain MPFI system with neat sketches. (C.O.No.4) [Application]

SCHOOL OF ENGINEERING

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

Semester: VII

Course Code: MEC 213

Course Name: IC ENGINE

Date: 27/12/2019

Time: 9.30 a.m.-12.30 a.m.

Max Marks: 80

Weightage: 40%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K	C	A	C			A			
1	1	1	4									4
2	2	2		4								4
3	3	3	4									4
4	4	4		4								4
5	5	5	4									4
6	1	1					10					10
7	2	2					10					10
8	3	3										10
9	4	4	10									10
10	5	5								10		10
11	4	3								10		10

		Total										80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

SCHOOL OF ENGINEERING

Semester: VII

Course Code: MEC 213

Course Name: IC ENGINE

Date: 27 Dec 2019

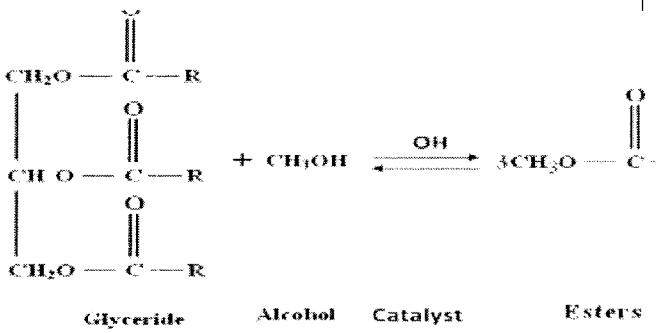
Time: 9.30 a.m.-12.30 a.m.

Max Marks: 80

Weightage: 40%

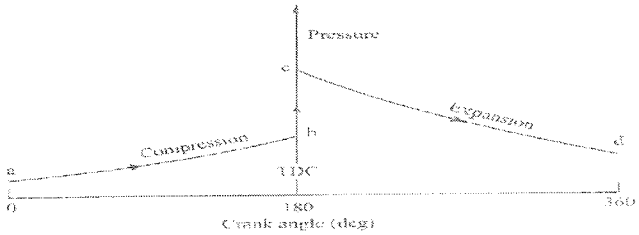
Part A (Q x M = Marks)

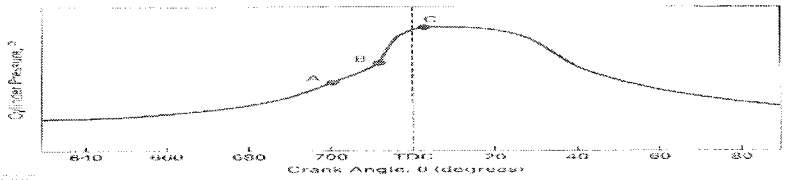
Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Mean Effective Pressure** :It is the mean or average pressure acting on the piston during the power stroke. The indicated mean effective pressure of an engine is obtained from the indicator diagram. The indicated diagram on the P-V diagram, for one cycle at that load, drawn with the help of an indicator fitted on the engine. $P_m = \frac{\left[\text{Net area of the indicator diagram}(a)\text{in } \mathbf{m^2}\right] \times \left[\text{Spring value of the spring used in the indicator } (S)\text{in } \mathbf{bar/m}\right]}{\text{Length of the indicator diagram}(l)\text{in } \mathbf{m}}$ $P_m = \frac{Sa}{l}$ bar **Brake Specific Fuel Consumption (BSFC):** It is defined as the mass of the fuel consumed in one hour by an engine in developing I kW of brake power. This can be expressed as	**1 mark for each correct definition and 1 mark for formula.**	**10 min.**

	$$BSFC = \frac{Mass\ of\ the\ fuel\ consumed\ in\ kg/hr}{Brake\ power\ developed\ in\ kW}$$ $$BSFC = \frac{m_f}{BP}$$		
2.	Transesterification or alcoholysis is defined as the process in which nonedible oil is allowed to chemically react with alcohol. In this reaction, methanol and ethanol are the most commonly used alcohols because of their low cost and availability. This reaction has been widely used to reduce the viscosity of nonedible oil and for the conversion of triglycerides into ester. 	**2 mark for definition 2 mark for chemical reaction**	**5 min**
3.	(i) chemically correct mixture (ii) rich mixture and (iii) lean mixture Chemically correct or stoichiometric mixture is one in w just enough air for complete combustion of the fuel. For exa one kg of octane (C_8H_{18}) completely 15.12 kg of air is req chemically correct A/F ratio for C_8H_{18} is 15.12:1; usually to 15:1. This chemically correct mixture will vary only sligh cal value between different hydrocarbon fuels. It is always c the chemical equation for complete combustion for a particul *plete combustion* means all carbon in the fuel is converted t hydrogen to H_2O. A mixture which contains less air than the stoichiometri is called a rich mixture (example, A/F ratio of 12:1, 10:1 et A mixture which contains more air than the stoichiometr is called a lean mixture (example, A/F ratio of 17:1, 20:1 et	**4 marks for correct explaination**	**7 min.**
4	Value of octane no for petrol is 87-95, and cetane no for diesl fuel is 40-60	**2 marks for each correct defination**	**10 min**

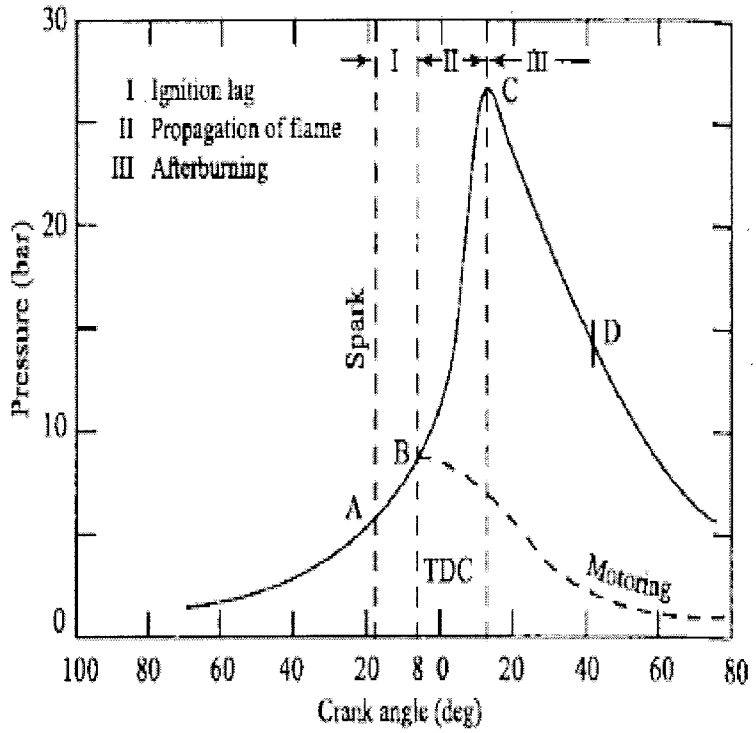
	❑ Definition: It indicates the % by volume of iso-octane in a mixture of iso-octane and heptane which exhibit the same characteristics of the fuel in a standard engine under a set of operating conditions. Definition: It indicates the % by volume of normal cetane in a mixture of Cetane ($C_{16}H_{34}$) and α-methyl naphthalene ($C_{11}H_{10}$) which exhibit the same ignition characteristics (ID) as the test fuel when combustion is carried out under specified operating conditions.		
5.	• Carbon Monoxide (CO) • Volatile Organic Compounds (VOCs) • Oxides of Nitrogen (NOx) • Sulfur Dioxide (SO2) • Particulate Matter (PM10) • Lead (Pb)	**1 mark for each correct formula**	**5 min**

Part B (2Q x 10M = Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	Crank angle rotation is most important independent parameter of ic engine which is always constant for a cycle. For otto cycle and diesel cycle  a → b : Compression b → c : Combustion c → d : Expansion	6 marks for correct solution	15 min

	 **A : point of fuel injection** **B : point of ignition** **C : end of fuel injection** **AB : delay period**		
7	No_x are formed at higher temperature when nitrogen in air breaks combines with oxygen and forms gases. In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NOx) emissions reduction technique used in petrol/gasoline and diesel engines. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. This dilutes the O2 in the incoming air stream and provides gases inert to combustion to act as absorbents of combustion heat to reduce peak in-cylinder temperatures. NO x is produced in high temperature mixtures of atmospheric nitrogen and oxygen that occur in the combustion cylinder, and this usually occurs at cylinder peak pressure. Another primary benefit of external EGR valves on a spark ignition engine is an increase in efficiency, as charge dilution allows a larger throttle position and reduces associated pumping losses.	4 marks for correct solution and 2 marks correct answer	15 min

Part C (4Q x 10M =40 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
8		5 marks for diagram 5 for explaination	15 min