Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language errors such as grammatical, spelling errors should not be given more. Importance (Not applicable for subject English and Communication Skills).

4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.

6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.

7) For programming language papers, credit may be given to any other program based on equivalent concept.

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1.A) Attempt any three of the following : 12

a) Write four difference between S.I. and C.L. engine 4

Answer : 1 mark each point. (any 4)

Sr. No	S.I. ENGINE	C.I. ENGINE
1	It work's on Otto cycle.	It work's on Diesel cycle.
2	It is theoretically more efficient.	It is theoretically less efficient.
3	Actual efficiency is less due to lower compression ratio.	Actual efficiency more due to higher compression ratio.
4	It works with homogeneous mixture.	It receives heterogeneous mixture.
5	A/F ratio nearly constant for all loads.	A/F ratio varies considerably with the load.
6	It works on Quantity governing.	It works on Quality governing.
7	A single flame front develop & traverses through mixture.	Ignition takes place simultaneously at many points.
8	Compression ratio is low, about 10:1, limited by detonation.	Compression ratio is Higher, about 18:1 to 20:1.
9	Compression pressure is 7bar to15 bar.	Compression pressure is 30bar to50 bar.
10	Maximum pressure is 45 bar to 50 bar.	Maximum pressure is 60 bar to 70 bar.
11	High speed engine (5000 rpm).	Low speed engine (about 3000 rpm).
12	Easier starting due to loser cranking effort.	Difficult to start due to requirement of greater cranking effort to over come higher compression.

b) Describe four properties of S.I. engine fuel. 4

Answer: 1 mark each

Properties of S.I. engine fuel.

1. Volatility: Volatility is a measure of how easy a fuel evaporates. For fuel to burn properly in the cylinder, its vaporization point should be near the temperature in the intake manifold. If the liquid fuel (that is not atomized) enters the cylinders, it will not burn. The volatility of fuel affects starting and warm- up time, Vapour lock, Crankcase oil Dilution, operating range performance.
2. Knock Resistivity – The tendency of a fuel to knock varies in different engines & in the same engine under different operating conditions knock Resistivity of a fuel (usually petrol) is measured by Octane Rating.
3. Sulphur Content $\Rightarrow$ All petrols have some Sulphur.(Due to low boiling Sulphur compounds-sulphides, disulphides & mercaptans tend to be concentrated intro petrol by distillation.) Sulphur troubles in 3 ways $\rightarrow$ corrosion, odour & poor explosion characteristics of petrol fuels. High Sulphur causes corrosion in the muffler & tail pipe of the exhaust system during cold weather because of the condensation of moisture and formation of sulphurous & sulphuric acid.
4. Gum Content $\Rightarrow$ All fuels oxidize slowly in presence of air. The oxidation of unsaturated hydrocarbons (+ unstable Sulphur & nitrogen compounds) results in formation of resinous material called gum. Oxidised petrol shows a loss of anti knock quality. High gum content fuels may clog carburettor jets, promote sticking of automatic chokes, sticking of the intake valves, piston rings, & promote formation of manifold deposits, reducing volumetric efficiency. Hence gum content & tendency to form gum is limited in gasoline specifications.

c) State four additives in S.I. engine fuels. State the purpose of using the same. 4

Answer : Petrol Additives 1 mark each (any 4 points)

Sr. No.	Additive	Purpose
1	Octane Improver (Tetra ethyl lead)	It has a positive effect on the Octane number.
2	Anti- aging additives	Improves stability during the storage.
3	Oxidation inhibitors	Avoids reaction of some compounds of petrol with each other and with oxygen- thus help in controlling gum and deposit formation during storage.

4	Rust Inhibitors	To protect components of the fuel supply system from rusting.	
5	Metal Deactivators	To inhibit reactions between the petrol and metal in the fuel supply system.	
6	Detergents	To keep the carburettor jets clean and thus prevent their clogging.	

d) What are the effects of engine variables of flame propagation — 4

Answer: Effects of engine variables on flame propagation — 1 mark each (any 4 points)

1) Fuel –Air ratio:- Maximum flame velocities occur when mixture strength is 110% of stoichiometric . Lean mixtures release less thermal energy resulting in lower flame temperature & flame speed. Very rich mixtures have incomplete combustion (Some carbon only burns to CO & not to CO_2), which results in production of less thermal energy & hence flame speed is again low.
2) Compression ratio-A higher compression ratio increases the pressure & temperature of the working mixture & decrease the concentration of residual gases. High pressures & temperature of the compressed mixture also speed up the flame propagation.
3) Intake temp & pre-increase in the intake temperature & pressure increases the flame speed.
4) Engine load:-With increases in the engine load the cycle pressures increase. Hence the flame speed increases.
5) Turbulence:-The flame speed is very low in non-turbulent mixtures. A turbulent motion of the mixture intensifies the processes of heat transfer & mixing of the burned & unburned portions in the flame front (diffusion). These two factors cause the velocity of turbulent flame to increase practically in proportion to the turbulence velocity. However, excessive turbulence is also undesirable.
6) Engine speed – the higher the engine speed the greater the turbulence inside the cylinder. For this reason the flame speed increases almost linearly with engine speed. The crank angle required for the flame propagation, which is the main phase of combustion, will remain almost constant at all speed.
7) Engine size- engine of similar design generally run at the same piston speed. This is achieved by smaller engine having larger RPM & larger engines having smaller RPM. Due to the same piston speed. The inlet velocity, the degree of turbulence & the flame speed are nearly same in similar engines regardless of the size. i.e. the number of crank degrees required for flame travel will be about the same irrespective of engine size, provided the engine are similar.

B) Attempt any one of the following : — 6

a) What is Diesel knocking? How is it controlled? — 6

Answer:

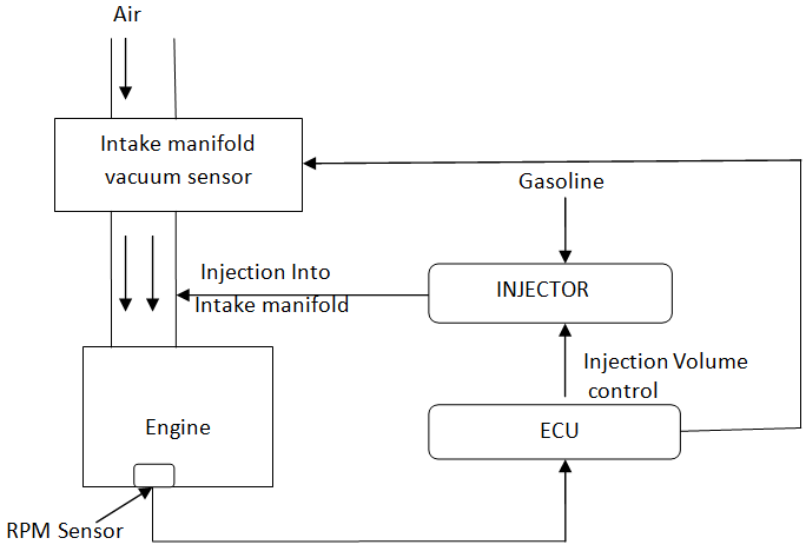
Diesel knocking : — 3

The knock phenomenon of C.I. engine depends upon delay period. If delay period is small then less amount of fuel is admitted into cylinder. When small amount of fuel is burns then there is smooth pressure rise, so there is no knocking.

If the delay period is very long, then more amount of fuel is accumulated in the combustion chamber. When it actually burns, sudden pressure rise will cause the cylinder wall to vibrate, thus it produces noise and this is said to be knocking.

Methods of controlling Diesel knocking: — 3

1) The delay period can also be reduced by reducing the degree of turbulence as it will reduce heat loss. However, it will increase the combustion period and thus reduce thermal efficiency.
2) The delay period can be reduced by adding chemical dopes, called ignition accelerators (ethyl-nitrate and amyl – nitrate).
3) Delay period can be reduced by arranging the injectors so that only small amount of fuel is injected at first.

b) Draw neat sketch of D-MPFI system and write its working.	6
Answer: The D –MPFI system is the manifold fuel injection system. • In this type, the vacuum in the intake manifold is first sensed. In addition it senses the volume of air by its density. • As air enters into the intake manifold, the manifold pressure sensor detects the intake manifold vacuum and sends the information to the ECU. • The speed sensor also sends information about the rpm of the engine to the ECU. • The ECU in turns sends commands to the injector to regulate the amount of gasoline supply for injection. When the injector sprays fuel in the intake manifold the gasoline mixes with the air and the mixture enters the cylinder. D- MPFI System  	4 2
2. Attempt any Two of the following .	16
a) Compare MPFI and carburettor fuel system.	08
Answer:	

MPFI system	Carburettor fuel system
1) In this there is cold start injectors in addition to main injector which operates only when temperature is low to provide rich mixture.	1) In this choke valve is used to provide a rich mixture for easy starting engine, when temperature is low.
2) Coolant temperature is measured by sensor, which detects the low temperature and transformed into an electrical signal and sent to ECU to provide appropriate Air: fuel mixture for cold starting.	2) In carburettor, there is no sensor to measure the coolant temperature, but manually or automatically operated Choke valve are present. This ensures rich charge for cold starting.
3) It does not have any special correction device during high speed, but ECU will adjust the mixture according to the inputs signals.	3) At high speeds the carburettor provides a very lean mixture and hence it has special compensate device.
4) In this engine load is detected by the opening angle of the throttle valve and this signal transformed to ECU and there is greater injection volume to provide power air fuel ratio.	4) Carburettor consists of power systems which gives extra rich air fuel mixture when vehicle is over loaded or accelerated suddenly.
5) Fuel is injected into the port.	5) Fuel gets drawn in the mixing chamber due to the vacuum at the venturi.
6) It uses top feed injector.	6) It uses a nozzle to discharge fuel into the venturi.

(1 mark each, any 8 points.)

7) Fuel injectors are equal to the number of cylinders.	7) Fuel is mixed with air across various discharge passages or nozzle near the throttle valve.
8) Costly fuel pump is needed to generate the required injection pressure.	8) Cheaper fuel feed pump is sufficient.
9) All cylinders receive equal quantity and quality of air: fuel mixture	9) Mixture mal-distribution occurs at cold start and during high speeds.
10) More accurate fuel injection control is obtained. It increases fuel economy.	10) Improper fuel: air ratio control results in poor fuel economy.
11) This is costly system.	11) This is a cheaper system.
12) Very low exhaust emission is achieved to meet the strict emission norms.	12) Exhaust emission is above the prevailing emission norms for four wheelers.
13) Easy to service and diagnose.	13) Difficult to service and diagnose.

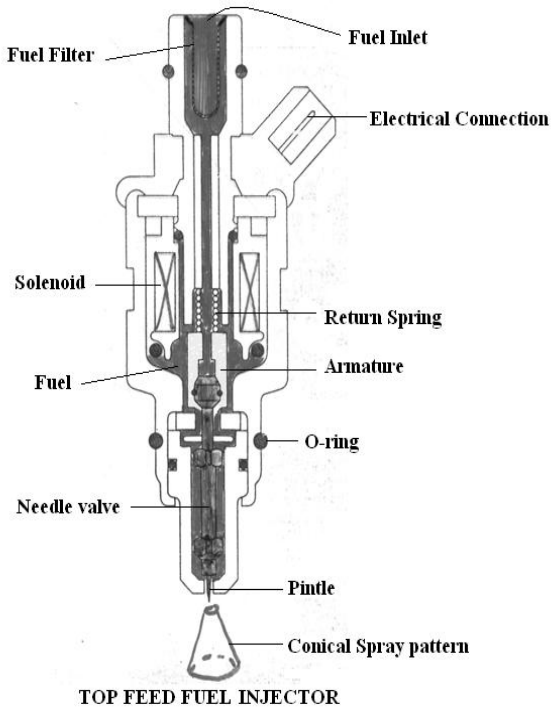
b) Explain with neat sketch top feel electronic fuel injector. — 08

Answer:

In MPFI system, Top feed fuel Injector is used. These injectors are solenoid-operated valves that are opened and closed by means of electric pulses from the ECU. The injectors are mounted in the intake manifold and spray onto the back of the intake valves. In general, one injector is used for each cylinder. — 04 marks

The injected fuel mass is determined by the injector opening time (for a given pressure drop across the injector). In MPFI systems, each engine cylinder is assigned an electromagnetic fuel injector, which is activated individually for each cylinder. In this way, both the fuel mass appropriate to each cylinder and the correct start of injection are calculated by the control unit (ECU).

The amount of fuel sprayed from the injectors is controlled by cycling the injectors open and close. More fuel will be sprayed out when the injector pulse is longer. In order to operate properly, the fuel must spray as a liquid throughout the injection. Injection pressure is approximately 2 bar to 3.5 bar. Pressure helps to keep the fuel as a liquid throughout the system. When the solenoid coil is energized, the Pintle is pulled up. System pressure then forces fuel between the Pintle and discharge opening to form a fine spray pattern that has a cone shape. — 04



TOP FEED FUEL INJECTOR

c) What is EGR? Explain its working with sketch.	08

Answer:

EGR is Exhaust Gas recirculation: The EGR system is used to reduce the amount of NOx in the exhaust. NOx production increases as the temperature inside the combustion chamber rises due to acceleration or heavy engine loads, because high temperature encourages the nitrogen and oxygen in air to combine. Therefore, the best way to decrease the production of NOx is to hold down the temperature in the combustion chamber. — 02

Working:

Exhaust gas consists mainly of CO_2 and H_2O which are inert gases and do not react with oxygen; the EGR system recirculates these CO_2 & H_2O gases through the intake manifold in order to reduce the temperature at which combustion takes place. When the air: fuel mixture & exhaust gases are mixed together, the proportion of fuel in the air: fuel mixture naturally falls (mixture becomes leaner), & in addition, some of the heat produced by combustion of this mixture is carried away by the exhaust gas. — 03

The maximum temperature attained in the combustion chamber therefore falls, reducing the amount of NOx produced. The EGR system allows a small amount of exhaust gas (less than 10% of total) to be supplied into the incoming air: fuel mixture.

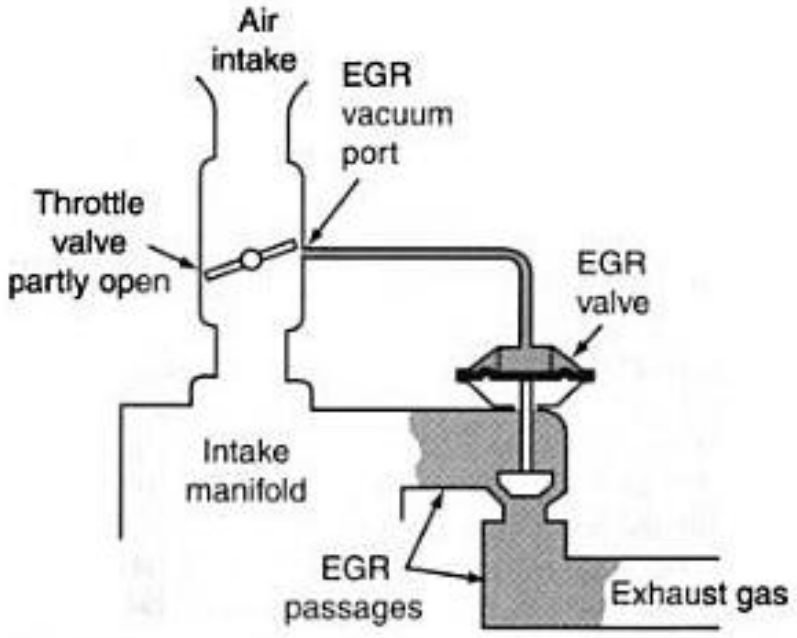


Fig: The EGR valve controls the amount of Exhaust flowing back into the intake manifold — 03

Q 3 Attempt any TWO of the following. 16

a) Compare performance characteristics of S.I and C.I. engine. 08

Answer: Comparison of S.I. engine and C.I. engine on the basis of Performance characteristics is as follows. 02 Marks each (Any Four points)

Parameter	S.I. engine	C.I. Engine
Power Output per unit weight	2.7 kg/ KW.	6.5 Kg / KW. The CI engines may be 2 to 3 times heavier than comparable SI engines.
Power output per unit displacement	30 KW per litre for S.I. engines. (Air craft engine=75 KW/litre) This indicates the tendency of the SI engine to occupy less space for the same power output.	High speed C.I. engine delivers 15 KW/ litre (approx) of piston displacement.
Acceleration:	A change in the quantity of mixture supplied to the SI engine,on the other hand,is accomplished through a relatively indirect control depending upon throttle opening and the resultant velocity of the air through the carburetor venturi.	The CI engine inherently produces the best acceleration since the injection system offers direct control of the quantity of fuel injected and a rapid and positive means of changing this quantity.
Reliability:	The SI engine has low reliability.	The CI engine has high reliability.
Fuel Economy	It has moderate fuel economy at both full and part load. It has poor idling fuel economy.	It has better fuel economy at both full load, part load and at idling.
Fuel Safety	The SI engine fuels are relatively more volatile and are a great fire hazard when not handled carefully.	CI engine fuels have lower volatility and are safer, resulting in reduced fuel fire hazard.

b) Explain the stages of combustion in S.I. engines with sketch. 08

Answer: Stages of combustion in S.I. Engine.

Stage I:-Ignition Lag or Preparation Phase.

It is a chemical process which depends on-nature of fuel, temperature & pressure, proportion of exhaust gas, rate of burning and temperature .It is the growth and development of a semi propagating nucleus of flame.(At the moment of spark discharge, the temperature exceeds $10{,}000^0$ c)

i. At the end of this stage, the first rise of pressure (on indicator diagram) can be detected. It is the point where the line of combustion departs from the compression line.

ii. The start of first stage is ignition of charge (a sufficiently homogeneous mixture of vaporized fuel, air & residual gases), leaving behind a thin thread of the flame. From this thin thread combustion spreads to envelop of mixture immediately surrounding it.

Stage II: - Propagation of flame 04

-It is a simple, pure and mechanical process. The starting point of the second stage is where first measurable rise of pressure can be seen on the indicator diagram. i.e. the point where the line of the combustion departs from the compression line. During second stage, the flame spreads throughout the combustion chamber. The second stage ends as maximum pressure (on indicator diagram) is reached.

Stage III →After burning

End of second stage means completion of flame travel. But it does not result in complete heat release (burning of fuel).

Even after the passage of flame, some chemical adjustments continue throughout the expansion stroke-near the walls and behind the turbulent flame front. The rate of combustion reduces due to surface of the flame front becoming smaller and reduction in turbulence.

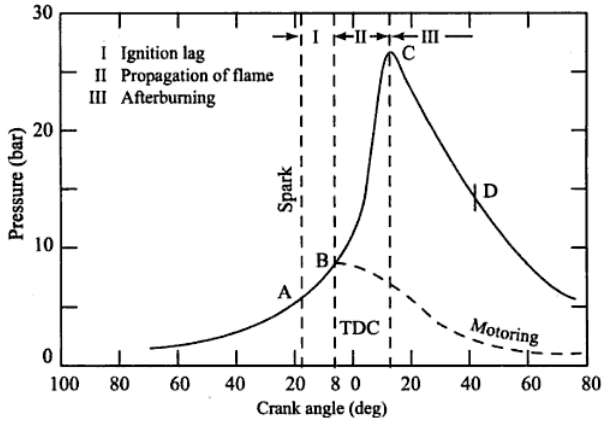


Fig: Stages of Combustion in S.I. Engine — 04

c) What is Hybrid Vehicle? Explain working with the help of layout of a series Hybrid Vehicle. — 08

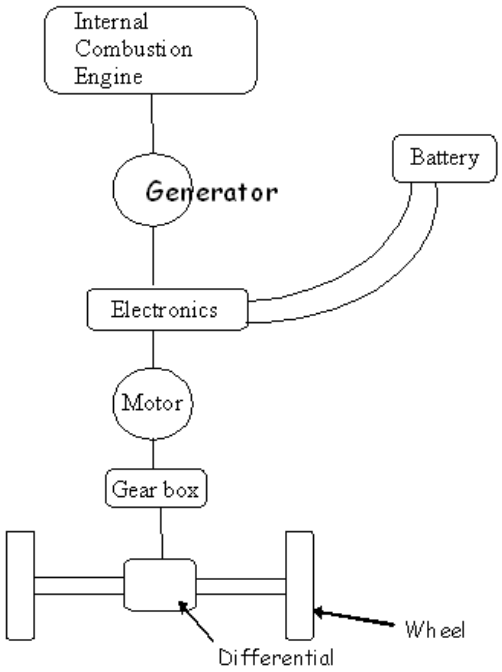
Answer:

Hybrid Vehicle: A hybrid vehicle is one that uses two different methods to propel the vehicle. A hybrid electric vehicle, abbreviated HEV uses both an internal combustion engine and an electric motor to propel the vehicle. Most hybrid vehicles use a high-voltage battery pack and a combination electric motor and generator to help or assist a gasoline engine. The types of hybrid electric vehicles include series, parallel, and series-parallel designs. — 02

Series-Hybrid vehicle Working:

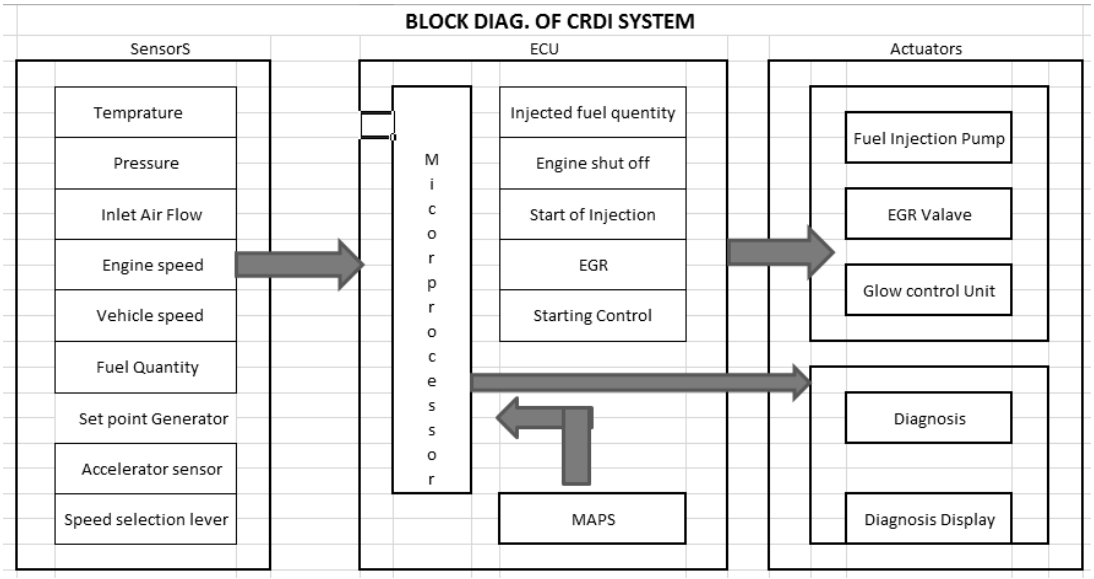
In a series-hybrid design, sole propulsion is by a battery-powered electric motor, but the electric energy for the batteries comes from another on-board energy source, such as an internal combustion engine. In this design, the engine turns a generator and the generator can either charge the batteries or power an electric motor that drives the transmission. The electric motor propels the car.
The internal combustion engine never powers the vehicle directly. — 03

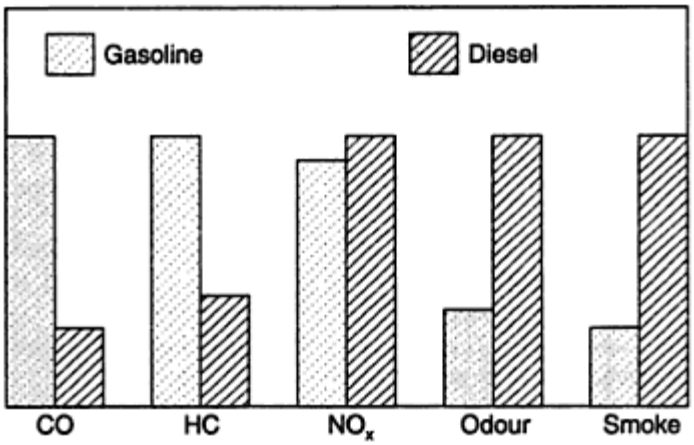
Series Hybrid Vehicle

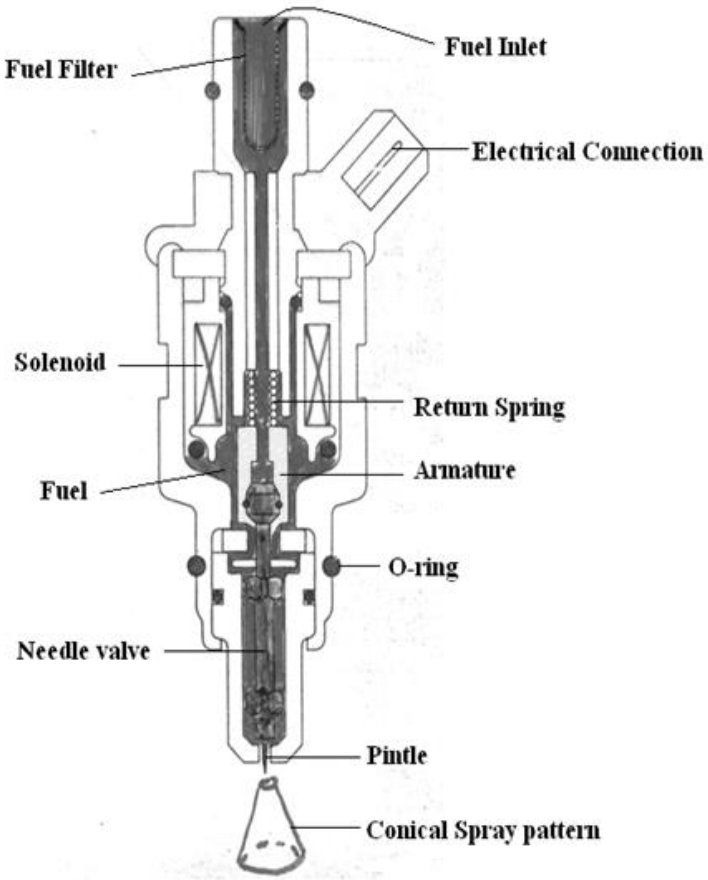


— 03

Q 4 A) Attempt any THREE of the following.	12
a) Why compression ratio of C.I. engine is required more than S.I. engine? Justify your answer.	04
Answer: Reason: (Parameter / S.I. Engine / C.I. Engine) Self Ignition Temperature of fuel / ≈ 300°C (Petrol). / ≈ 250°C (Diesel). Air: fuel Ratio Requirement / 14.7: 1 / 14.5:1 Actual air fuel ratio / 9:1 to 16:1 / 20:1 to 100:1 As the compression ratio of an engine is increased, it results in the following. 1. Compression pressure is increased to about 30 to 50 bar 2. Maximum cylinder pressure in the cycle is increased to about 60 to 70 bar. 3. Cylinder temperature rises to about 550°C, which is above the critical temperature of diesel i.e. about 250 °C. Justification: As the fuel: air mixture is to be ignited by the compression ignition, it is essential to have at least 550°C as the compressed air temperature. This ensures quick evaporation of fuel and mixing to result in charge that may fall within ignition limits for self ignition. Further, to avoid the knocking, the ignition delay should be shorter. This is achieved by higher charge temperature. Thus to make a C.I. Engine to operate effectively, the compression ratio of the C.I. Engine should be around 18: 1 to 22: 1.	02 02
b) Explain the construction and working of Throttle Body injection (TBI).	04
Answer: Construction of Throttle Body injection (TBI) System. It uses the throttle valve to meter the intake air while injecting the fuel intermittently above the throttle valve. The intake manifold then distributes the fuel to the individual cylinders. Various sensors monitor all important engines operating data, which are then used to calculate the triggering signals for the injectors and other system actuators. The bottom feed injector is located above the throttle valve. *Note: Credit may be given for figure.* Working of Throttle Body injection (TBI). The TBI System uses a computer to control the amount of fuel injected into the manifold. It is considered as indirect type of injection. Air is drawn into the engine and passes by the injector nozzle. The exact amount of fuel necessary for the conditions of operation is added. The injector sprays gasoline into the air in the intake manifold where the gasoline mixes with air.This mixture then passes through the throttle valve and enters into the intake manifold.	2 2
c) What is detonation? Explain at least two factors which control detonation.	04
Answer: Detonation: A very sudden rise of pressure during combustion accompanied by metallic hammer like sound is called detonation. Detonation is auto-ignition of last part of homogeneous charge occurring near the end of combustion, before the flame front reaches it. In auto- ignition, the burning is almost instantaneous which results in extremely rapid release of energy causing pressure of the end gas to rise almost 3 to 4 times , from about 50 bar to 150 - 200 bar. This large pressure differential gives rise to a severe pressure wave which strikes the cylinder wall and sets it vibrating, giving rise to a characteristic high pitched metallic ringing sound as if stroke struck by light hammer.	02

Factors which Control detonation: 1. Inreasing engine RPM: It reduces load on the engine by shifting to lower gear. 2. Retarding spark: It reduces maximum cycle temperature, thereby reducing tendency to detonate. 3. Reducing pressure in the inlet manifold by throttling: It reduces intake pressure and maximum pressure in the cycle. 4. Making the ratio too lean or too rich: it results in lower heat release during combustion process thereby reducing maximum pressure in the cycle. 5. Water injection: water injection increases the delay period as well as reduces the flame temperature. 6. Use of high octane fuel can eliminate detonation: It results in longer ignition delay period and results in normal combustion even at a higher compression ratio.	02 (any 2 points)
d) What are the effects of engine maintenance on exhaust emission?	04
Answer: **S.I. engine maintenance** determines Whether the engine will operate at designed air: fuel ratio & for how long. This includes *Checking of* : piston ring wear, lubrication , cooling , deposits , dirt on air cleaner element , sticking choke valve & other factors that are likely to affect the air: fuel ratio supplied or it's combustion in combustion chamber. For example, a misfire allows an entire air: fuel charge to be exhausted without combustion; a very dirty air cleaner can reduce A: F ratio, generally increasing emissions of HC & CO. **C.I. engine maintenance** decides the Smoke level. Lubricating oil flowing past the piston rings, results in blue – white smoke. Blue – white smoke , other than during cold starting , indicates that piston rings are worn –out & maintenance is needed. Maintenance affects injection characteristics (i.e. affects spray penetration→ inadequate/excess; droplet size-unsuitable; duration of injection-excessive, secondary injection & improper dispersion-atomization. All these characteristics substantially increase the smoke level). Good Maintenance of injectors is a must for lower smoke levels.	02 02
B) Attempt any one of the following.	06
a) Explain CRDI system with block diagram.	06
Answer: 	03

Working: • In the common rail direct injection system different sensors are used for operation. These sensors collect information about engine operating condition and send signal to the CRDI System. • Microprocessor receives the sensor signals, converts the signal in required format and then processes the signals. e.g. Analog signals are converted into digital signals. Digital signals are amplified. Then the data is compared with the look- up tables. In the Logic and power modules, the actuators are controlled for desired control of the system. The actuators include Fuel injectors, EGR valve, Glow control unit etc. • The signal to the actuators is given in the required form like analog signals. • Information is also available in form of Diagnostic trouble codes at the dashboard. It can also be availed from the EDC using a scan tool.	03
b) Compare diesel and gasoline emission.	06
Answer: Comparison of Diesel and Gasoline emission. • The diesel engines if properly maintained have very little CO in their exhaust and a small amount of smoke, while the petrol engine exhausts significant amount of CO and UBHC. • NO_x emission from petrol engine is found to be lower than that of Diesel engine. • The odour of diesel engine emission is considerably more and causes irritation. • Particulate Matter emission is significantly more from diesel engine.  • **Fig. Comparison of emissions and odour from gasoline and diesel engines.**	04 02
5.Attempt any two of the following :	16
a) Draw neat sketch of electronic fuel injector and write its working.	08
Answer: Electronic fuel injectors are solenoid-operated valves that are opened and closed by means of electric pulses from the ECU. The injectors are mounted in the intake manifold and spray onto the back of the intake valves. The injected fuel mass is determined by the injector opening time (for a given pressure drop across the injector). In MPFI systems, each engine cylinder is assigned an electromagnetic fuel injector, which is activated individually for each cylinder. In this way, both the fuel mass appropriate to each cylinder and the correct start of injection are calculated by the control unit (ECU). The amount of fuel sprayed from the injectors is controlled by cycling the injectors open and close. More fuel will be sprayed out when the injector pulse is longer. In order to operate properly, the fuel must spray as a liquid throughout the injection. Injection pressure is approximately 2 bar to 3.5 bar. Pressure helps to keep the fuel as a liquid throughout the system. When the solenoid coil is energized, the Pintle is pulled up. System pressure then forces fuel between the Pintle and discharge opening to form a fine spray pattern that has a cone shape.	04



Electronic Fuel Injector

04

b) Write eight properties of C.I. engine fuel. 08

Answer: 01 each (8 points)

(1) *Flash point*: - flash point is the temperature at which a flammable liquid will produce, with a standardized apparatus and procedure, a mixture of its vapour and air which will ignite to give a visible flash by contact with an open flame.

(2) *Fire point:* - Fire point is the temperature at which the flash will sustain itself as a steady flame for at least five seconds.

3) *Viscosity*: - Viscosity of a fuel is a measure of its resistance to flow.

(4) *Cloud point*: - The temperature below which the wax content of the petroleum oil separates out in the form of a solid is called cloud point. Such waxy solid can clog fuel lines and fuel filters.

(5) *Pour point*: - Pour point is the temperature below which the entire mass of fuel, solid or liquid together, freeze and thus cause flow of fuel impossible. Pour point is usually 5 to 10 °C below the cloud point.

(6)Volatility: - The fuel should be sufficiently volatile in the operating range of temperature to produce good mixing and combustion.

(7) Cetane number: - The Cetane rating of a diesel fuel is measure of its ability to auto-ignite quickly when it is injected into the compressed and heated air in the engine.

(8) Contamination: - the contents of sand and rust particles can clog small openings and abrasive particles can damage injector surface piston rings and cylinder walls.

(9) Sulphur:- A high sulphur content in diesel fuel causes corrosion, wear of engine parts, especially the cylinder walls, and tends to increase the rate of sticky and sludge –like deposits.

c) Name the pollutants present in diesel fuel and state the effect of pollutant on human being. — 08

Answer: The pollutants present in diesel engine emission and their effect on human being are as follows. — 08

Sr. No.	Pollutant	Effect on human being
1	Sulphur dioxide(SO_2)	It affects mucous membrane when inhaled. Tends to cause Bronchitis and asthma.
2	Carbon Monoxide (CO)	When inhaled, replaces the oxygen in the blood stream so that the body's metabolism cannot function correctly. Small amounts of CO concentrations, when breathed in, slow down physical and mental activity and produces headaches. It affects the central nervous system. It is also responsible for heart attacks and a high mortality rate. (Large concentration will kill).
3	Oxides of Nitrogen	It causes eye and nasal irritation when exposed to 15 parts per million (p.p.m.) of nitrogen oxide and pulmonary discomfort after brief exposure to 25 p.p.m. of nitrogen oxide. It tends to cause Bronchitis and asthma.
4	Hydrocarbons (HC)	They cause eye and respiratory irritation caused by photochemical smog.
5	Smoke/ Particulate matter	It causes irritation in eyes and lungs, and visibility reduction. It also causes other respiratory diseases.
6	Compounds of incomplete combustion (polycyclic organic compounds and aliphatic hydrocarbons)	They act as carcinogenic agents and are responsible for lung cancer.

Any four points (02 marks for each point)

6. Attempt any four of the following. — 16

a) What are basic requirements considered for designing the combustion chamber? Explain in brief. — 4

Answer: The basic requirements considered for designing the combustion chamber are as follows- (1 mark for each point)

1. High power output: It can be achieved by using highest useful compression ratio, small or no excess air, complete utilization of air, optimum turbulence and high volumetric efficiency.
2. High thermal efficiency: It can be achieved by a small heat loss during combustion, good scavenging of exhaust gases.
3. Smooth engine operation: It can be achieved by moderate rate of pressure rise, normal combustion (appropriate ignition delay), compact combustion chamber, proper location of spark plug / injector and valves, proper engine cooling.
4. Proper mixing of fuel and air in a short time: It can be achieved by adopting proper fuel injection strategy, optimized induction system design and air swirl.

b) Explain the effect of engine variables on ignition lag. — 4

Answer: — 1 each (any four)

The duration of ignition lag depend on

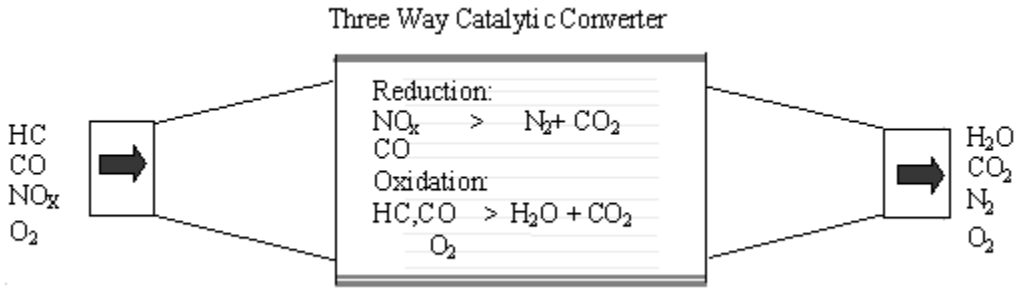
1) Fuel- it is depend on chemical nature of fuel. The higher, the self-ignition temp of fuel, the longer, the ignition lag.

2) Mixture Ratio-The ignition lag is smallest for the mixture ratio which gives the maximum temperature this mixture ratio is somewhat richer than the stoichiometric ratio.

3) Initial pressure and temperature –increasing the intake temp, pressure, compression ratio and retarding spark, all reduce the ignition lag.

4) Electrode gap- It affects establishment of the nucleus of flame. If the gap is too small, quenching of the flame nucleus may occur & rang of fuel –air ratio for the development of a flame nucleus is reduced.

5) Turbulence- measured in degree of crank-rotation the ignition lag increases almost linearly with engine speed. For this reason. It becomes necessary to advance the spark timing at higher speed.	
c) Write four advantages of CRDI system over conventional fuel ignition system.	4
Answer: Advantages: 1. Separation of pressure generation and injection allowing flexibility in controlling both the injection rates and timing of CRDI. 2. In CRDI system, Fuel pressure does not depend on the engine speed and load conditions. 3. In CRDI, High injection pressures (about 1500 bar) and good spray preparations are possible even at low engine speeds and loads. Finely atomized fuel results in efficient air-fuel mixing & reduced particulate emissions. 4. Less engine noise and reduced NOx emission (Pilot injection prior to main injection increases compression pressure, thus reducing the noise). 5. In CRDI system, Fuel pump operates with low drive torque. 6. Low emission at all engine speeds (due to optimum air-fuel ratio).	1 each (any four point)
d) State four inputs and outputs of electronics control module.	4
Answer: The ECM (Electronic control module) / ECU (Electronic Control Unit) evaluates the sensor inputs using data tables and calculations to determine the output of the actuating devices. Inputs of Electronic Control Module: 1. The Ignition (Engine Speed Sensor). 2. Temperature Sensor (Coolant Temperature). 3. Throttle Potentiometer (Intake Air Flow). 4. Throttle Switch (Idle and Overrun, WOT- Wide Open Throttle), Starter Switch. 5. Lambda (O2) Sensor. 6. Pressure Sensor (Manifold Pressure) and other sensors. The Outputs of ECM are: 1. Injection Volume Control. 2. Injection Timing Control. 3. Ignition Timing Control. 4. Evaporative Emission Control. 5. Turbocharger Boost Pressure Control (Diesel). 6. Engine / Vehicle Speed Control. 7. EGR Control. 8. Glow Plug Control (Diesel).	2 (any four) 2 (any four)
e) What is catalytic converter? Draw sketch of three way catalyst system and write its working.	4
Answer: Catalytic Converter: It is a device with porous ceramic structure fitted in the engine exhaust system to process harmful gases into harmless ones. Working: The catalytic converter's conversion rate is largely a function of operating temperature; no meaningful treatment of pollutants takes place until the converter has reached an operating temperature of approx. 400…800^{0}C provide ideal conditions for maximum efficiency and extended service life. The catalytic converter works with its best conversion efficiency with λ= 0.99 to 1. (λ = excess air factor. λ = actual air supplied/ theoretical air requirement). Catalyst Reduction First, nitrogen oxide gives up its oxygen. This only occurs when a sufficient amount of carbon monoxide is available for the oxygen to bond with. This chemical reaction results in reduction of nitrogen oxide to pure nitrogen and oxidation of carbon monoxide to form carbon dioxide. Catalyst Oxidation.	02

Second, hydrocarbon and carbon monoxide continue to burn. This occurs only if there is a sufficient amount of oxygen available for the hydrogen and carbon to bond with. This chemical reaction results in oxidation of hydrogen and carbon to form water vapour (H_2O) and carbon dioxide (CO_2).  	02