Question 1

(a) Describe the mode of mixture preparation and combustion in conventional port-injected gasoline engines. [13 marks]

(b) Link, in clear terms, the mode of combustion with
   (i) the exhaust after-treatment system used in production gasoline engines, [6 marks]
   (ii) the prevailing gasoline composition. [6 marks]

Question 2

(a) Describe the advantages offered by the new generation direct-injection gasoline engines. [7 marks]

(b) Describe the different modes of operation of direct-injection gasoline engines in terms of injection timing and mixture preparation. [9 marks]

(c) Explain why these engines emit NOx and particulates under stratified mixture conditions. [9 marks]
Question 3

Renault is one of the few European automotive companies that produces direct-injection gasoline engines. The engine is a 2L, 16-valve unit producing a maximum power of 103kW at 5,500 rev/min and maximum torque of 200Nm. The company is claiming 20% reduction in fuel consumption but without compromising emissions performance especially in terms of NOx levels.

(a) Describe a mode of operation that can achieve simultaneously high power and low emissions. [13 marks]

(b) Calculate the brake mean effective pressure (bmep) at maximum power and torque. [12 marks]

Question 4

(a) Describe the advantages offered by the introduction of the common-rail injection system in new generation diesel engines. [10 marks]

(b) Describe the mechanism of swirl and swish in diesel engines and explain the advantages offered by each of these two large scale motions (a schematic presentation could be very helpful). [15 marks]
Question 5

(a) Explain clearly the reasons for employing exhaust gas recirculation (EGR) in reducing the nitrogen oxide gas emissions in diesel engines and the types of EGR mechanism. [12 marks]

(b) The diagram shown as Figure Q5 shows a 4-speed front wheel drive transmission. The synchronisers are positioned on the output shaft with the output gears free to rotate on the output shaft. Selecting a gear via the synchroniser locks a particular gear to the output shaft. The inertias of the various components are shown. For example, the inertia of the first gear wheel on the input shaft is $I_{1i}$, and the first gear wheel on the output shaft is $I_{1o}$. Similarly for the inertias of the input, output and clutch are indicated. The ratios of the gears are first gear $r_1$, second gear $r_2$ etc.

(i) Determine the effective inertia at the first gear synchroniser in terms of the individual inertias and gear ratios, [8 marks]

(ii) If the synchronisers are moved to the input shaft, describe how this will affect the effective inertias at the synchronisers. Indicate the advantage of placing the synchronisers on the input shaft and explain the changes to the various components that will be necessary, and indicate why this cannot always be achieved. [5 marks]
Figure Q5
Question 6

(a) A small city car with the design parameters listed below is fitted with a continuously variable transmission (CVT) that can be controlled to operate the engine at maximum power during acceleration. Calculate the time to accelerate from 0 km/h to 60 km/h assuming the acceleration is constant at the value attainable in the middle of this speed range. [8 marks]

(b) During constant speed driving at 90 km/h the transmission control system maintains the engine speed to obtain the minimum fuel consumption. Determine the required engine speed, fuel flow rate and the fuel consumption in litres/100km. [7 marks]

(c) Briefly describe how you would develop the method used in (a) above to determine a more accurate method of calculating the time to accelerate over the whole speed range (from zero speed to maximum speed). Include the basic equations you will use. Explain including sketch graphs why a manual shift transmission will take longer to achieve maximum speed that CVT controlled for maximum engine power. [5 marks]

(d) Assuming you know engine, transmission and vehicle parameters, briefly describe how you would calculate the fuel consumption for a vehicle driven over the ECE-15 Urban Driving Cycle. [5 marks]

Vehicle mass $M = 800$ kg
Equivalent mass of rotating parts $m_r = 0.04M$
Frontal area $A = 1.7$ m$^2$
Drag coefficient $C_D = 0.3$
Rolling Resistance Coefficient $f = (0.01 + 0.0005v)$
Air density $= 1.22$ kg/m$^3$
Transmission efficiency $= 0.90$
Fuel density $= 0.75$ kg/litre
Engine power and fuel map is shown in Figure Q6.
Figure Q6: Small Car Engine Power/Speed

Power kW

0 5 10 15 20 25

Speed Rev/min

0 2000 4000 6000 8000