Question 1

Direct injection gasoline engines are entering the European market in their second-generation version which employs the spray-guided concept

(a) Explain the modes of mixture preparation, (8 marks)
(b) Describe the characteristics of the fuel injection system used in these engines, (8 marks)
(c) Why are these engines more fuel efficient than port-injection engines? (9 marks)

Question 2

Conventional gasoline engines operate with three-way catalysts to reduce all three major pollutants.

(a) Describe the variation of these pollutants with equivalence ratios. (9 marks)
(b) Describe why gasoline particulates are not regulated and provide typical examples of their size distribution. (8 marks)
(c) Describe the link between mixture turbulence and flame propagation speed. (8 marks)

Question 3

A conventional 3.2 litre V6 gasoline engine is producing maximum power of 163KW at about 6000rpm and maximum torque of 310Nm in the range of 3000-5000rpm; it has 3 valves per cylinder.

(a) Calculate the brake mean effective pressure (bmep) at maximum power and maximum torque (9 marks)
(b) Estimate the bore-to-stroke ratio of the engine and the maximum flame speed (9 marks)
(c) Comment on the volumetric efficiency of this engine and the cylinder head arrangement. (7 marks)

Question 4

Diesel engines are becoming increasingly more popular in Europe due to their superior fuel economy and much improved performance.

(a) Describe the advantages of the common-rail fuel injection system. (9 marks)
(b) Describe the combustion stages in a conventional diesel engine operating with single injection per cycle. (8 marks)
(c) Sketch a typical heat release diagram for these engines and link it to the combustion stages. (8 marks)
Question 5

(a) Describe the way soot particles are formed in the engine cylinder and their transformation in the exhaust before they are emitted into the atmosphere.

(6 marks)

(b) Describe a typical exhaust after treatment system for new passenger diesel cars.

(7 marks)

(c) The output shaft of a front-wheel drive transverse engine/transmission system is shown in Figure Q5 below. The torque on the shaft is 120 Nm. Determine the forces at the 2nd Gear and the Final Drive Pinion, and the bearing reactions.

(12 marks)

![Figure Q5](image-url)

**2nd GEAR & FINAL DRIVE PINION PRESSURE ANGLE** \( \psi = 20^\circ \), **HELIX ANGLE** \( \sigma = 35^\circ \)

\[
\begin{align*}
K_{PF2} &= \text{Tangential Force Final Drive} \\
K_{GF2} &= \text{Tangential Force Gear 2} \\
K_{NF2} &= \text{Normal force Final Drive} = \frac{K_{PF2} \tan \psi}{\cos \sigma} \\
K_{NF2} &= \text{Normal force Gear 2} = \frac{K_{GF2} \tan \psi}{\cos \sigma} \\
K_{AF2} &= \text{Axial Force Final Drive} = K_{NF2} \tan \sigma \\
K_{AF2} &= \text{Axial Force Gear 2} = K_{GF2} \tan \sigma
\end{align*}
\]
Question 6

(a) A truck travels at 100 km/hr on a level motorway with zero wind condition. The engine power and fuel consumption map are shown in Figure Q6 and the truck details are listed below. Determine:
(i) the transmission (gearbox) ratio required to give the minimum fuel consumption, (7 marks)
(ii) the fuel flow rate in litres per 100 km. (3 marks)

(b) the same truck now ascends a gradient of 3% at a speed of 55 km/hr with zero wind. Determine:
(i) the new gear ratio required to give minimum fuel consumption, (9 marks)
(ii) the fuel flow rate in litres per 100 km. (3 marks)

(c) Comment on the significance of vehicle mass and gradients on truck fuel consumption and gear ratios. (3 marks)

Mass of Truck = 25 tonnes
Frontal Area = 8.0 m\(^2\)
Drag Coefficient = 0.65
Rolling Resistance Coefficient = 0.006 (constant)
Tyre Rolling Radius = 0.57 m
Final Drive Ratio = 4.5
Air Density = 1.22 kg/m\(^3\)
Overall Transmission Efficiency = 90%
Fuel Density = 0.8 kg/litre
Acceleration due to gravity = 9.81 m/s\(^2\)
Figure Q6