

Question 1

- a) Draw and label a P-V diagram for a standard 'ideal' Otto cycle. (4 marks)
- b) Explain the differences between the following thermodynamic processes:
- i. Isothermal
 - ii. Adiabatic
 - iii. Isochoric
 - iv. Polytropic
- (2 marks)
- c) Describe the 3 principle processes of heat transfer. You should explain the mechanisms by which the transfer occurs, the mediums in which heat transfer is possible in each case and an example of where each type is the main source of heat transfer. (6 marks)
- d) Draw a P-V diagram for a real engine, labelling the 4 different parts of the four stroke cycle and the important parameters of the cycle. (4 marks)
- e) If during combustion, the fuel releases an average of 18 Joules per degree during combustion, calculate the increase in pressure in the cylinder over 10 degrees of crank rotation if the volume changes from 44.1 cc to 38.88 cc and the initial pressure at the start of the 10 degree change is 24.15 Bar? You may assume that the polytropic index is 1.38, that the air/fuel ratio is 13.2:1 and that γ is 1.35. (4 marks)

Question 2

You are required to carry out calculations on a Land Rover TDV6 compression ignition engine with a cylinder displacement of 450cc and a compression ratio of 18:1.

Assume that the cycle is an ideal constant pressure combustion diesel cycle. Assume that the intake stroke is complete at Bottom Dead Centre (BDC) and that the exhaust valve opens at BDC. The engine is not quite adiabatic but has a polytropic index of 1.35 during compression and 1.28 during the expansion stroke. Assuming that the air intake temperature is 4°C, Calculate:

- a. The air mass trapped in the cylinder if the volumetric efficiency is 92%.
- b. The fuel mass trapped in the cylinder.
- c. The heat output from the burning fuel assuming 90% combustion efficiency.
- d. The temperature of the air/fuel gas just before the start of combustion.
- e. The rise in temperature of the air/fuel mixture during combustion.
- f. The temperature of the exhaust gas.
- g. The peak pressure in the cylinder.
- h. The work done during expansion.
- i. The potential energy recoverable from the exhaust gas per cycle if the ambient temperature is 4°C.
- j. What assumptions are being made in this questions that are not applicable for a real engine?

You may use the following information:

Density of air at 4°C = 1.27 kg m^{-3}

Calorific value of fuel = $44.8 \times 10^6 \text{ J kg}^{-1}$

Fuel Ratio = 14.6:1

Cut Off Ratio = 1.65:1

Specific heat of air/fuel of exhaust gas at constant pressure = $1087 \text{ J kg}^{-1} \text{ K}^{-1}$

(20 marks, 2 for each part)



EXAMINATION SOLUTIONS

(to accompany the examination paper sent to the external examiner
but NOT to be seen by students)

Programme:	BEng Engineering	Level:	5
Module:	Mock Question		
Author:	Cwa	Page:	

Q	Question	Marks
1a		(4)
1b	Descriptive explanation of thermodynamic processes	(2)
1c	Explain conduction, Convection and Radiation including mechanisms, mechanisms (atomic/molecular K.E transfer etc) also an example for each	(6)
1d		(6)



1e Looking at heat release over $10^\circ \rightarrow 185 \times 10 = 180 \text{ J}$
during Combustion

To find Pressure we use

$$P_2 = P_1 \left(\frac{V_1}{V_2} \right)^{\gamma} + \frac{dQ_r (\gamma - 1)}{V_2}$$

$$P_2 = 24.15 \left(\frac{44.1}{38.88} \right)^{1.38} + \frac{180(0.35)}{38.88 \times 10^{-6}} \times \frac{1}{10^5}$$

$$P_2 = 28.74 + 16.2$$

$$P_2 = \underline{44.94 \text{ Bar}}$$

(4)

Total	20 Marks
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- 2a Air mass = $\rho \times Vol \times Vol_{eff}$
 $= 1.27 \times 450 \times 10^{-6} \times 0.92$
 $= \underline{5.26 \times 10^{-4} \text{ Kg}}$ (2)
- b fuel mass = $\frac{5.26 \times 10^{-4}}{14.6} = 3.6 \times 10^{-5} \text{ Kg}$ (2)
- c Heat = Calorific val $\times$ Mass $\times$ Combustion eff
 $= 44.8 \times 10^6 \times 3.6 \times 10^{-5} \times 0.9$
 $= \underline{14525}$ (2)
- d $T_2 = T_1 \left(\frac{V_1}{V_2} \right)^{\gamma-1} = 277(18)^{0.35} = 761.7 \text{ K}$ (2)
- e $Q = MC\Delta T$ so $\Delta T = \frac{Q}{(3.6 \times 10^{-5} + 5.26 \times 10^{-4}) \times 1087}$
 $\Delta T = \underline{2376.8 \text{ K}}$ (2)
- f $T_4 = T_3 \left(\frac{V_3}{V_4} \right)^{\gamma-1} = (2376.8 + 761.7) \left(\frac{1.65}{18} \right)^{0.28}$
 $T_4 = 1607.5 \text{ K}$ (2)
- g $P_2 = P_1 \left(\frac{18}{1} \right)^{1.35} = \underline{49.5 \text{ Bar}}$ (2)



h To make life easier calc all volumes.

$$V_1 = 450 \text{ cc}$$

$$V_2 = \frac{450}{18} = 25 \text{ cc}$$

$$V_3 = 25 \times 1.65 = 41.25 \text{ cc}$$

$$\text{work during expansion} = -P \Delta V + \frac{P_1 V_1 - P_2 V_2}{n-1} \quad (\text{WD})$$

$$\text{WD} = 49.5 \times 10^5 (25 - 41.25) \times 10^{-6} \quad (P \Delta V)$$
$$= -80.4 \text{ J}$$

$$\text{WD}(2) = \frac{49.5 \times 10^5 (41.25 \times 10^{-6}) - 1 \times 10^5 (450 \times 10^{-6})}{0.28}$$
$$= \frac{159.19}{0.28} = 568.5 \text{ J}$$

$$\text{So WD during expansion} = 568.5 + 80.4 = 649.9 \text{ J} \quad (2)$$

(i) Potential Energy recovery = $m C \Delta T$

$$\Delta = (36 \times 10^{-5} + 5.26 \times 10^{-4}) \times 1087 \Delta T$$

$$Q = 0.61 \Delta T = 0.61 (761.7 - 277)$$

$$Q = 295 \text{ J}$$

j Assumptions are:

Value timings are overlooked

Simplistic Combustion model

No turbo considered

No intake heating effects

etc

Total 20