Second Semester Examination
2021/2022 Academic Session

July/August 2022

EME432 – Internal Combustion Engine
(Enjin Pembakaran Dalam)

Duration: 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of FOUR (4) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi EMPAT (4) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions : Answer **ALL THREE (3)** questions.

*[**Arahan** : Jawab **TIGA (3)** soalan]*

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1. (a) The research and development of Diesel fuel via Nano-Activated Fuel Technology (NAFT) in Malaysia combines diesel and water in equal ratio of 50:50. NAFT Diesel/Water emulsion can be used in Compression-Ignition (CI) engine without any modification on the engine critical components.

(i) State TWO [2] advantages of NAFT Diesel/Water emulsion and discuss how this newly developed fuel can fulfill the Sustainable Development Goal (SDG)?

(ii) Based on the analytical result, the Cetane Number (CN) of NAFT Diesel/Water emulsion is 51.7 and this is lower than the CN of the baseline Diesel fuel which is 54.4. Discuss how the lower CN of NAFT Diesel/Water emulsion will affect the engine in term of the combustion performance?

(40 Marks)

(b) An automobile has a 3.2 litre, five cylinders, four-stroke cycle diesel engine operating at 2400 rpm. Fuel injection occurs from 20^{o} bTDC to 5^{o} aTDC. The engine has a volumetric efficiency of 0.95 and operates with fuel equivalence ratio of 0.80. Light diesel fuel having stoichiometric air-fuel ratio 14.5 is used.

Given:
density of air, ρ_a = 1.181 kg/m^3
mass of air, $m_a = \eta_v \rho_a V_d$
mass of fuel, $m_f = \phi m_a / (AF)_{stoich}$

Where:
η_v is volumetric efficiency
V_d is volume of displacement
ϕ is equivalence ratio
$(AF)_{stoich}$ is stoichiometric air/fuel ratio

Calculate:

(i) time for ONE [1] injection/cycle (sec/cycle)

(40 Marks)

(ii) fuel flow rate through an injector (kg/s)

(20 Marks)

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2. (a) (i) Draw two types of electric hybrid architectures. Other than cost, provide ONE (1) advantage and ONE (1) disadvantage for each architecture.

(15 marks)

(ii) With the emergence of small displacement and turbo engines (like in X50 and Ativa), why do you think car manufacturers are going in that direction and discuss TWO (2) long term issues that come with the engine?

(15 marks)

(b) A 650 cc parallel two, four stroke engine running on wide open throttle (WOT) at a speed of 2500 rpm and consumes 70 g petrol (C_8H_{18}) per minute. The fuel used has lower heating value (Q_{lhv}) of 44.4 MJ/kg. The volumetric efficiency is 85% and density of air is 1.2 kg/m^3. The engine compression ratio is 10.8 and its efficiencies are as follows: $\eta_m = 0.8$, $\eta_c = 0.94$

Molar mass: N = 14 g/mol, O = 16 g/mol, H = 1 g/mol, C= 12 g/mol

Relevant formulas:

$$\text{Brake Power} = \eta_m (0.8\,\eta_{otto}) \eta_c\, \eta_v\, \rho_{air}\, V_d \frac{N}{n} Q_{lhv} \frac{1}{AFR}$$

$$\eta_{otto} = 1 - \left(\frac{1}{CR}\right)^{\Upsilon - 1}$$

$$\Upsilon = 1.3$$

Calculate:

(i) The stoichiometric air fuel ratio (AFR) for the fuel mentioned.

(20 marks)

(ii) The actual AFR and equivalence ratio for the combustion.

(25 marks)

(iii) Indicated power of the engine running at the condition mentioned.

(25 marks)

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3 (a) A diesel truck is initially powered with a natural-aspirated Compression-Ignition diesel engine produces brake power of 100 kW at a mechanical efficiency of 85% and an overall brake thermal efficiency of 35%. This engine was then converted to turbocharged with a boost pressure of 50%. To ease the calculation, you may assume that the frictional power is 17.6kW and no changes before and after the engine conversion. For the engine after the conversion,

(i) Sketch the energy flow diagram
(ii) Calculate the fuel energy input
(iii) Calculate the mechanical efficiency
(iv) Calculate the heat losses
(v) Calculate the brake power
(vi) Calculate the brake thermal efficiency
(vii) Calculate the brake specific fuel consumption (BSFC)

(70marks)

(b) A converted motorcycle with "bi-fuel" system can be operated on either LPG or gasoline. In LPG mode it gets 40km/l in normal usage, in gasoline mode it gets 45km/l. The "bi-fuel" conversion kit costs RM 450. Assuming the vehicle is driven 10,000km annually. In gasoline mode it only burns gasoline. In LPG mode it uses LPG 80% of the time and gasoline 20% of the time (when the LPG tank is run out and needs to be refilled). Use the following data in your calculations:

Fuel	**LPG (butane)**	**Gasoline**
Cost	RM 25/ 15kg	RM 1.95/ liter
Density	590 g/liter	720 g/liter
Composition	C_4H_{10}	C_8H_{18}

Calculate the annual cost for each mode.

(30 marks)

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