UNIVERSITI SAINS MALAYSIA

First Semester Examination
2012/2013 Academic Session

January 2013

EMH 332/3 – Applied Thermodynamics
[Termodinamik Gunaan]

Duration : 3 hours
Masa : 3 jam

Please check that this paper contains **SIX (6)** printed pages, **ONE (1)** page appendix and **SIX (6)** questions before you begin the examination.

*[Sila pastikan bahawa kertas soalan ini mengandungi **ENAM (6)** mukasurat bercetak, **SATU (1)** mukasurat lampiran dan **ENAM (6)** soalan sebelum anda memulakan peperiksaan.]*

Appendix/*Lampiran :*

1. Formula for Internal Combustion Engine [3 pages/mukasurat]

INSTRUCTIONS : Answer **FIVE (5)** questions only. You may answer all questions in **English** OR **Bahasa Malaysia** OR a combination of both.

***[ARAHAN :** Jawab **LIMA (5)** soalan sahaja. Calon boleh menjawab semua soalan dalam **Bahasa Malaysia** ATAU **Bahasa Inggeris** ATAU kombinasi kedua-duanya.]*

Answer to each question must begin from a new page.
[Jawapan untuk setiap soalan mestilah dimulakan pada mukasurat yang baru.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

Table for Property Tables Booklet is provided.
Jadual Sifat Bendalir Termodinamik adalah dibekalkan.

Q1. [a] Due to some leakages of air into condenser of the steam plant, explain briefly how these problems being solved and the losses involved.

Disebabkan kebocoran udara memasuki penyejuk bagi loji stim, terangkan secara ringkas bagaimana masalah diatasi dan kehilangan yang terlibat.

(30 marks/*markah***)**

[b] A vessel of 0.3 m^3 capacity contains a mixture of air and steam which is 75% dry. If the pressure is 700 kPa and the temperature is 117°C, determine the mass of water present, the mass of dry saturated vapor, and the mass of air.

Sebuah kebuk berkapasiti 0.3 m^3 mengandungi campuran udara dan wap yang mana 75% kering. Jika tekanan adalah 700 kPa dan suhu adalah 117°C, tentukan jisim air wujud, jisim bagi wap tepu, dan jisim air.

(30 marks/*markah***)**

[c] 0.5 kg of saturated air is contained in a rigid tank along with water vapor at 160°C and 1 MPa. Calculate the amount of heat required to be transferred to cool the mixture to 80°C, and the moisture will be condensed in this process.

0.5 kg bagi udara tepu terkandung dalam sebuah tangki tetap bersama dengan wap pada 160°C dan 1 MPa. Kirakan jumlah haba yang diperlukan bagi menyejuk campuran kepada 80°C, dan lembapan yang akan tersejuk di dalam proses ini.

(40 marks/*markah***)**

Q2. [a] Compare and explain briefly a sweating phenomena occurs on the glass surface filled by ice cubes at 50% and 90% relative humidity respectively with the atmospheric condition of 101 kPa and 25°C.

Banding dan terangkan secara ringkas fenomena berpeluh berlaku pada permukaan gelas yang diisi oleh kiub ais masing-masing pada kelembapan relatif 50% dan 90% dengan keadaan atmosfera 101 kPa dan 25°C.

(20 marks/*markah***)**

[b] Using the schematic, propose five (5) criteria required in design an effective air conditioning system for a medium sized factory floor that mainly assembles sensitive electronic products.

Menggunakan skematik, cadangkan lima (5) kreteria yang diperlukan dalam reka bentuk sebuah sistem penyaman udara untuk sebuah kilang bersaiz sederhana terutamanya bagi memasang produk elektronik yang peka.

(40 marks/*markah***)**

[c] Cold air at 30% relative humidity, 8°C, is heated to 31°C and the pass through humidifier cooler until it reaches 21°C. Determine:

(i) The heat input

(ii) The mass of water added

(iii) The final relative humidity

(iv) If the cold air as at 35% relative humidity, 8°C, estimate the percentage different of heat input.

Udara sejuk pada kelembapan relatif 30%, 8°C, dipanaskan kepada 31°C dan di alir melalui penyejuk lembapan sehingga mencapai 21°C. Tentukan:

(i) Haba masukan

(ii) Jisim air yang ditambah

(iii) Kelembapan relatif akhir

(iv) Jika udara sejuk pada kelembapan relatif 35%, 8°C

(40 marks/*markah***)**

Q3. [a] Samples X and Y is the liquid and gas fuels respectively. Propose and explain how the calorific values of these fuels are determined.

Sampel X dan Y masing-masing adalah cecair dan gas. Cadang dan terangkan bagaimana nilai kalori bagi bahan api ini ditentukan.

(30 marks/*markah***)**

[b] A 500 g of Kerosene ($C_{12}H_{26}$) is used in the combustion, calculate both the stoichiometric air-fuel ratio required and for the combustion with 20% access air.

500 g kerosin ($C_{12}H_{26}$) digunakan dalam pembakaran, kirakan kedua-dua nisbah udara-bahan api stoikhiometrik dan bagi pembakaran dengan 20% lebihan udara.

(30 marks/*markah***)**

[c] Methane and air enter a combustor at atmospheric pressure and 25°C in the ratio 7.933 mole air/mole methane. After combustion the products, including carbon dioxide and carbon monoxide, are at 227°C and the water formed in the vapor state. Calculate the heat absorbed or released in kJ/kmol methane.

Metana dan udara memasuki sebuah pembakar pada tekanan atmosfera dan 25°C dengan nisbah 7.933 mol udara/mol metana. Selepas pembakaran produk, termasuk karbon dioksida dan karbon monoksida adalah pada 227°C dan air terbentuk dalam keadaan wap. Kirakan haba terbekal atau terbebas dalam kJ/kmol methan.

(40 marks/*markah***)**

Q4. [a] Using the diagram, differentiate the four-stroke and two-stroke spark ignition engines.

Menggunakan gambarajah, bezakan enjin cucuhan bunga api lenjang-empat dan lenjang-dua.

(30 marks/*markah***)**

[b] Briefly discuss the phenomena is known as 'knock' in a gasoline engine.

Bincangkan dengan ringkas fenomena yang dikenali sebagai 'knock' di dalam sebuah enjin gasoline.

(20 marks/*markah***)**

[c] A Mitsubishi truck used an air Diesel engine cycle with a compression ratio of 17. Air is at 30 ºC and 100 kPa at the beginning of the compression process and at 1800 K at the end of the heat addition process. Accounting for the variation of specific heats with temperature, determine:

(i) The cut-off ratio
(ii) The heat rejection per unit mass, and
(iii) The thermal efficiency.

Sebuah trak Mitsubishi menggunakan kitar enjin udara Diesel dengan nisbah mampatan adalah 17. Udara adalah pada 30 ºC dan 100 kPa pada permulaan proses mampatan dan pada 1800 K diakhir proses penambahan haba. Mengambil kira bagi perubahan haba tentu dengan suhu, tentukan:

(i) Nisbah cut-off
(ii) Haba terbebas per unit jisim, dan
(iii) Kecekapan terma

(50 marks/*markah***)**

Q5. [a] In the indicated diagram, briefly discuss the performance map at different piston speed for Diesel engine.

Dalam gambarajah penunjukkan, bincang secara ringkas peta prestasi pada perbezaan halaju piston bagi enjin Diesel.

(30 marks/*markah***)**

[b] A three-liter V6 four-stroke spark ignition engine has compression ratio of 9.0. During a test at 3700 rev/min, the brake torque reading from a dynamometer is 200 Nm. At this speed, air enters the cylinders at 101 kPa and 30ºC. The air-fuel ratio measured is 14.5:1 and the mechanical efficiency of the engine is 92%. The engine cylinder bore is the same as the stroke length. The fuel calorific value is 44 MJ/kg, calculate the

(i) Cylinder bore and stroke length
(ii) Mean piston speed
(iii) Clearance volume for one cylinder
(iv) Brake power
(v) Indicated power
(vi) Brake mean effective pressure
(vii) Indicated mean effective pressure
(viii) Mass flow rate of fuel into the engine
(ix) Brake thermal efficiency

Sebuah enjin empat lenjang V6 cucuhan bunga api tiga-liter mempunyai nisbah mampatan 9.0. Semasa ujian dijalankan ke atas enjin pada kelajuan 3700 pusingan/min, bacaan tork brek yang diperolehi daripada dynamometer ialah 200 Nm. Pada kelajuan ini, udara memasuki selinder pada 101 kPa dan 30ºC. Nisbah udara-bahan api yang diukur adalah 14.5:1 dan kecekapan mekanikal ialah 92%. Jara bagi enjin silinder adalah sama dengan lejang. Nilai kalori bahan api adalah 44 MJ/kg, kirakan:

(i) Jara dan lejang
(ii) Halaju purata omboh
(iii) Isipadu kelegaan bagi sebuah silinder
(iv) Kuasa brek
(v) Kuasa tertunjuk
(vi) Tekanan berkesan purata brek
(vii) Tekanan berkesan purata tertunjuk
(viii) Kadar aliran jisim bahan api ke dalam enjin
(ix) Kecekapan terma brek

(70 marks/*markah***)**

Q6. [a] Using the diagram, differentiate the reciprocating and rotary positive displacement air compressor.

Menggunakan gambarajah, bezakan pemampat udara sesaran positif berlejang dan putaran sesaran positif.

(20 marks/*markah***)**

[b] In the indicated diagram, briefly discuss the correlation between the volumetric efficiency and pressure ratio for a multi stage compressor.

Dalam gambarajah petunjuk, bincangkan secara ringkas korelasi antara kecekapan isipadu dan nisbah tekanan bagi sebuah pemampat pelbagai peringkat.

(30 marks/*markah***)**

[c] A two stage air compressor consists of three cylinders having the same bore and stroke. The delivery pressure is 707 kPa and the FAD is 4.2 m^3/min. Air is drawn in at 101 kPa, 15°C and intercooler cools the air to 38°C. The index of compression is 1.3 for all three cylinders. Neglecting clearance, calculate:

(i) the intermediate pressure

(ii) the power required to drive the compressor

(iii) the isothermal efficiency

Sebuah pemampat udara dua peringkat terdiri daripada tiga silinder yang mempunyai jara dan lejang yang sama. Tekanan hantaran adalah 707 kPa dan FAD adalah 4.2 m^3/min. Udara disedut masuk pada 101 kPa, 15°C dan penyejuk antara peringkat menyejuk udara kepada 38°C. Indeks mampatan adalah 1.3 bagi kesemua tiga silinder. Abaikan had ruang, kirakan:

(i) Tekanan perantaraan

(ii) Kuasa yang diperlukan bagi memandu pemampat

(iii) Kecekapan isoterma

(50 marks/*markah***)**

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APPENDIX 1/*LAMPIRAN 1*

Formula for Internal Combustion Engine

The compression ratio, r:

$$r = \frac{V_{\max}}{V_{\min}}$$

The mean effective pressure, MEP

$$MEP = \frac{W_{net}}{V_{\max} - V_{\min}} = \frac{w_{net}}{v_{\max} - v_{\min}}$$

The indicated mean effective pressure, pi

$$p_i = \frac{net\_area\_of\_diagram}{length\_diagram} \times cons\tan t$$

Work done per cycle = $p_i \times A \times L$

The indicated power, ip:

$$ip = p_i AL \times (cycles/time)$$

For four-stroke engine:

$$ip = \frac{p_i ALNn}{2}$$

For two-stroke engine:

$$ip = p_i ALNn$$

Where n is the no. of cylinders.

Brake power (bp)

This is to measure the engine output. The engine is connected to the break or dynamometer.

T= WR

The brake power is then given by

$$bp = 2\pi NT$$

Friction power (fp) and mechanical efficiency, η_m

The difference between ip and bp:

Fp = ip – bp

The mechanical efficiency:

$$\eta_m = \frac{bp}{ip}$$

For multi cylinder engines such as four cylinder engine, the bp

$$bp = (ip_1 - L_1) + (ip_2 - L_2) + (ip_3 - L_3) + (ip_4 - L_4)$$

Break mean effective pressure (bmep)

The bp is obtained using dynamometer,

$$bp = \eta_m \times ip$$

For a four-stroke engine,

$$bp = \frac{\eta_m \times p_i ALNn}{2} \quad \text{or}$$

$$bp = \frac{p_b ALNn}{2} \quad \text{where} \quad p_b = \eta_m \times p_i$$

For the frictionless engine, the bmep

$$\frac{p_b ALNn}{2} = 2\pi NT$$

Thus, $p_b = K \times T$ where K = constant

The overall efficiency of the engine is given by the brake thermal efficiency,

$$\eta_{BT} = \frac{bp}{m_{fuel} \times Q_{net,v}}$$

Specific fuel consumption, sfc

The specific fuel consumption (sfc) is the mass flow rate of fuel consumed per unit power output,

$$sfc = \frac{m_{fuel}}{bp}$$

The indicated thermal efficiency, η_{IT} is defined as

$$\eta_{IT} = \frac{ip}{m_{fuel} \times Q_{net,v}}$$

Volumetric Efficiency, η_V

$$\eta_V = \frac{V}{V_S}$$