SULIT

KEMENTERIAN PENDIDIKAN TINGGI
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK DAN KOLEJ KOMUNITI
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN MEKANIKAL

PEPERIKSAAN AKHIR

SESI I : 2025/2026

DJJ20063: THERMODYNAMICS

TARIKH : 26 NOVEMBER 2025
MASA : 8.30 PAGI - 10.30 PAGI (2 JAM)

Kertas ini mengandungi **SEMBILAN (9)** halaman bercetak.

Struktur (4 soalan)

Dokumen sokongan yang disertakan : Formula dan Jadual Steam

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan berstruktur. Jawab **SEMUA** soalan.*

QUESTION 1

SOALAN 1

CLO1

a) Define the terms System, Boundary and Surrounding, aided with a suitable diagram.

Takrifkan istilah Sistem, sempadan dan Sempadan dengan bantuan gambarajah yang sesuai.

[6 marks]

[*6 markah*]

CLO2

b) Steam at pressure of 18 bar has a specific internal energy of 2460 kJ/kg.

Wap pada tekanan 18 bar mempunyai tenaga dalaman tentu sebanyak 2460 kJ/kg

i. Using the steam tables, match the phase of the steam at this state.

Berdasarkan jadual wap, padankan fasa wap pada keadaan ini.

[1 mark]

[*1 markah*]

ii. Justify your answer by comparing the given internal energy with the saturated liquid and saturated vapor values at 18 bar.

Justifikasikan jawapan anda dengan membandingkan tenaga dalaman yang diberi dengan nilai tenaga dalaman bagi cecair tepu dan wap tepu pada tekanan 18 bar.

[3marks]

[*3 markah*]

iii. Based on your answers in (i) and (ii) , locate the internal energy on the P-v diagram and relate its position with respect to the phase region.
Berdasarkan jawapan anda dalam (i) dan (ii), tentukan kedudukan tenaga dalaman ini pada gambarajah P-v dan kaitkan kedudukannya dengan kawasan fasa.

[3 marks]
[*3 markah*]

CLO2

c) Steam at pressure 7 bar and dryness fraction 0.9 expands in a cylinder to a pressure of 1.5 bar and 300ºC. Calculate the
Stim pada tekanan 7 bar dan pecahan kekeringan 0.9 dikembangkan dalam silinder kepada tekanan 1.5 bar dan 300ºC. Kirakan

i. specific internal energy change
perubahan tenaga dalaman tentu

[6 marks]
[*6 markah*]

ii. specific enthalpy change
perubahan entalpi tentu

[6 marks]
[*6 markah*]

QUESTION 2
SOALAN 2

CLO2

a) "Non-Flow process is a process where no mass transfers across the boundary of a system". Based on the definition stated, give **FOUR (4)** examples of non-flow process.
*'Proses tidak alir ialah proses di mana tiada pemindahan jisim merentasi sempadan sistem'. Berdasarkan definisi yang dinyatakan, berikan **EMPAT (4)** contoh proses tidak alir.*

[4 marks]
[*4 markah*]

CLO2

b) In an industrial process, 0.8 kg of oxygen is compressed isothermally from an initial pressure of 2.3 bar and temperature of 42°C to a final pressure of 8.5 bar. Assume oxygen behaves as a perfect gas.
(Take molecular weight of oxygen: M = 32 kg/kmol)
Dalam satu proses industri, 0.8 kg gas oksigen dimampatkan secara isotermal daripada tekanan awal 2.3 bar dan suhu 42°C kepada tekanan akhir 8.5 bar. Anggapkan oksigen sebagai gas sempurna.
(Ambil berat molekul oksigen: M = 32 kg/kmol)

i. Explain what is meant by isothermal compression in the context of an ideal gas process.
Terangkan maksud pemampatan isotermal dalam konteks proses gas ideal.

[2 marks]
[2 markah]

ii. Using the ideal gas law, identify and explain the parameters that would remain constant or change during this isothermal compression.
Dengan menggunakan hukum gas ideal, kenal pasti dan terangkan parameter yang akan kekal malar atau berubah semasa proses pemampatan isotermal ini.

[3 marks]
[3 markah]

iii. Interpret how the work done on the gas would be affected by the pressure ratio, and why temperature remains unchanged.
Huraikan bagaimana kerja yang dilakukan ke atas gas dipengaruhi oleh nisbah tekanan, dan mengapa suhu kekal tidak berubah.

[3 marks]
[*3 markah*]

CLO2

c) 0.018 kg of gas at 1.02 bar, 22°C, initially occupying a cylinder volume of 0.015 m^3, is compressed reversibly and adiabatically by a piston to a pressure of 6.8 bar. If given for gas c_p = 1.040 kJ/kg K and c_v= 0.7429 kJ/kg K, calculate the:
0.018 kg udara pada 1.02 bar, 22°C, pada mulanya mempunyai isipadu silinder 0.015 m^3, dimampatkan secara adiabatik boleh balik oleh omboh kepada tekanan 6.8 bar. Jika di beri untuk udara c_p = 1.040 kJ/kg K dan c_v= 0.7429 kJ/kg K, kirakan:

i. Specific heat ratio
Nisbah haba spesifik

[3 marks]
[*3 markah*]

ii. final temperature (unit K)
suhu akhir (unit K)

[3 marks]
[*3 markah*]

iii. final volume (unit m^3)
isipadu akhir (unit m^3)

[3 marks]
[*3 markah*]

iv. the work done (unit kJ)
kerja dilakukan (unit kJ)

[4 marks]
[*4 markah*]

QUESTION 3
SOALAN 3

CLO2

a) State **FOUR (4)** devices that use the principle of flow process.
*Nyatakan **EMPAT (4)** peralatan yang menggunakan prinsip proses alir.*

[4 marks]
[*4 markah*]

CLO2

b) In a thermodynamic process, air flows steadily through a nozzle, which is an example of an open system. The inlet and outlet conditions involve changes in pressure, velocity, and enthalpy.
Dalam satu proses termodinamik, udara mengalir secara malar melalui sebuah muncung, yang merupakan contoh sistem terbuka. Keadaan di bahagian masuk dan keluar melibatkan perubahan dalam tekanan, halaju dan entalpi.

i. Explain why a nozzle is considered an open system and describe the main assumptions made when analyzing flow through a nozzle.
Terangkan mengapa muncung dianggap sebagai sistem terbuka dan nyatakan andaian utama yang digunakan semasa menganalisis aliran melalui muncung.

[4 marks]
[*4 markah*]

ii. Simplify what happens to the air's properties (enthalpy, pressure, and velocity) as it flows through a nozzle with the aid of a diagram.
Ringkaskan perubahan sifat udara (entalpi, tekanan dan halaju) semasa ia mengalir melalui muncung dengan bantuan gambarajah.

[4 marks]
[*4 markah*]

CLO2

c) Fluid with a specific enthalpy of 2800 kJ/kg enters a horizontal nozzle with negligible velocity at the rate of 840 kg/min. At the outlet from the nozzle the specific enthalpy and specific volume of the fluid are 2250 kJ/kg and 1.25 m^3/kg respectively. Assuming an adiabatic flow, calculate the:

Bendalir dengan entalpi tentu 2800 kJ/kg memasuki muncung mendatar dengan halaju boleh diabaikan pada kadar 840 kg/min. Pada alur keluar dari muncung entalpi tentu dan isipadu tentu bendalir ialah 2250 kJ/kg dan 1.25 m^3/kg masing-masing. Dengan mengandaikan aliran adiabatik, kirakan:

i. velocity of the fluid at exit from the nozzle.
halaju bendalir semasa keluar dari muncung.

[8 marks]
[*8 markah*]

ii. outlet area of the nozzle.
luas kawasan keluaran muncung.

[5 marks]
[*5 markah*]

QUESTION 4
SOALAN 4

CLO2

a) List **FOUR (4)** characteristics of heat engines.
*Senaraikan **EMPAT (4)** ciri enjin haba.*

[4 marks]
[*4 markah*]

CLO2

b) Heat is transferred to a heat engine from a furnace at a rate of 120 MW. If the rate of waste heat rejection to a nearby river is 66 MW, determine the:
Haba dipindahkan ke enjin haba dari relau pada kadar 120 MW. Jika kadar penolakan haba buangan ke sungai berdekatan ialah 66 MW, tentukan:

i. net work done
kerja bersih yang dilakukan

[3 marks]
[*3 markah*]

ii. thermal efficiency for this heat engine.
kecekapan haba untuk enjin haba ini.

[3 marks]
[*3 markah*]

CLO2

c) A steam power plant is operating between a boiler pressure of 40 bar and a condenser pressure of 0.04 bar. Steam enters to the turbine at dry saturated state. For a Rankine cycle, calculate the:
Sebuah loji kuasa wap beroperasi antara tekanan dandang 40 bar dan tekanan pemeluwap 0.04 bar. Stim masuk ke turbin pada keadaan tepu kering. Untuk kitaran Rankine, kirakan:

i. feed pump work
kerja pam suapan

[9 marks]
[*9 markah*]

ii. turbine work
kerja turbin

[2 marks]
[*2 markah*]

ii. Rankine efficiency
Kecekapan Rankine

[2 marks]
[*2 markah*]

iii. specific steam consumption (s.s.c.)
penggunaan stim tertentu (p.s.t.)

[2 marks]
[*2 markah*]

SOALAN TAMAT

1. PROPERTIES OF PURE SUBSTANCE

Steam

$v = xv_g$ $\quad h = h_f + xh_{fg}$ $\quad u = u_f + x(u_g - u_f)$ $\quad s = s_f + xs_{fg}$

Ideal Gas

$PV = mRT$ $\quad R = \frac{R_o}{M}$ $\quad R = C_p - C_v$ $\quad \gamma = \frac{C_p}{C_v}$

2. FIRST LAW OF THERMODYNAMICS

$\Sigma Q = \Sigma W$ $\quad Q - W = U_2 - U_1$

Flow Process

$$\dot{m} = \rho CA = \frac{CA}{V}$$

$$h = u + pv$$

$$h = Cp\,\Delta T$$

$$Q - W = \dot{m}\left[(h_2 - h_1) + \left(\frac{C_2^{\,2} - C_1^{\,2}}{2}\right) + (Z_2 - Z_1)g\right]$$

Non-Flow Process

1. Isothermal Process ($PV = C$)

$U_2 - U_1 = 0$ $\quad Q = W$

$$W = P_1V_1\,ln\left(\frac{V_2}{V_1}\right) \quad @ \quad W = P_1V_1\,ln\left(\frac{P_1}{P_2}\right)$$

$$W = mRT\,ln\left(\frac{V_2}{V_1}\right) \quad @ \quad W = mRT\,ln\left(\frac{P_1}{P_2}\right)$$

2. Adiabatic Process ($PV^{\gamma} = C$)

$U_2 - U_1 = mC_v(T_2 - T_1)$ $\quad W = \frac{P_1V_1 - P_2V_2}{\gamma - 1} = \frac{mR(T_1 - T_2)}{\gamma - 1}$

$Q = 0$ $\quad \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}} = \left(\frac{V_1}{V_2}\right)^{\gamma-1}$

3. Polytropic Process ($PV^n = C$)

$U_2 - U_1 = mC_v(T_2 - T_1)$ $\qquad W = \frac{P_1V_1 - P_2V_2}{n-1} = \frac{mR(T_1 - T_2)}{n-1}$

$Q = \frac{\gamma - n}{\gamma - 1}$ x W $\qquad \frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{V_1}{V_2}\right)^{n-1}$

4. Isobaric Process

$U_2-U_1 = Q - W$
$W = P(V_2 - V_1) = mR(T_2 - T_1)$
$Q = mC_p(T_2-T_1)$

5. Isometric Process

$U_2 - U_1 = Q$
$W = 0$
$Q = mC_v(T_2-T_1)$

3. SECOND LAW OF THERMODYNAMICS

$$W_{net} = Q_H - Q_L$$

Heat Engine

$$\eta_{th} = \frac{W_{net,out}}{Q_H} = 1 - \frac{Q_L}{Q_H}$$

Refrigerator

$$COP_{R,rev} = \frac{T_L}{T_H - T_L} = \frac{1}{T_H/T_L - 1}$$

Heat Pump

$$COP_{HP,rev} = \frac{T_H}{T_H - T_L} = \frac{1}{1 - T_L/T_H}$$

Power Cycle

$$\eta_{Rankine} = \frac{W_T - W_P}{Q_B} = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_4)}$$

$$Work\ ratio = \frac{W_T - W_P}{W_T} = \frac{(h_1 - h_2) - (h_4 - h_3)}{(h_1 - h_2)}$$

$$s.s.c = \frac{3600}{W_T - W_P} = \frac{3600}{(h_1 - h_2) - (h_4 - h_3)}$$