SULIT

POLITEKNIK
Jabatan Pengajian Politeknik

BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENGAJIAN POLITEKNIK
KEMENTERIAN PENGAJIAN TINGGI

JABATAN KEJURUTERAAN MEKANIKAL

PEPERIKSAAN AKHIR

SESI DISEMBER 2012

JJ207 : THERMODYNAMICS 1

TARIKH : 25 APRIL 2013
TEMPOH : 2 JAM (2.30 PM - 4.30 PM)

Kertas ini mengandungi **SEBELAS (11)** halaman bercetak.
Dokumen sokongan yang disertakan : Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SULIT

INSTRUCTION:

This paper consists of **SIX (6)** structured questions. Answer any **FOUR (4)** questions. Table and formulas are given in separate sheets.

ARAHAN:

*Bahagian ini mengandungi **ENAM (6)** soalan berstruktur. Jawab mana-mana **EMPAT (4)** soalan. Jadual dan formula diberikan di dalam kertas berasingan.*

QUESTION 1

SOALAN 1

CLO1 C1 (a) List **FOUR (4)** SI (International Standard) units and their symbols.
*Senaraikan **EMPAT (4)** unit-unit SI (International Standard) dan simbol-simbolnya.*

[4 marks]
[*4 markah*]

CLO1 C2 (b) Explain with the aid of sketch the fundamental concepts of thermodynamics;
Terangkan dengan bantuan gambarajah tentang konsep-konsep asas termodinamik bagi;

i. system
sistem

ii. boundary
sempadan

iii. surroundings
persekitaran

[7 marks]
[*7 markah*]

CLO1 C2 (c) Convert the following units :

Tukarkan unit-unit berikut :

i. 0.15 bar to kN/m^2.

0.15 bar kepada kN/m^2.

ii. 380 km/h to cm/minute

370 km/j kepada cm/minit

iii. $6N/cm^2$ to kN/m^2

6 N/cm^2 kepada kN/m^2

[6 marks]
[*6 markah*]

CLO1 C3 (d) Explain with the aid of sketch of Zeroth Law of thermodynamics

Terangkan dengan bantuan gambarajah Hukum Zeroth termodinamik

[8 marks]
[*8 markah*]

QUESTION 2

SOALAN 2

CLO1 C2 (a) Draw the *P-v* diagram and label the critical point, saturated liquid line, dry saturated steam line, wet steam region and compress liquid region.

Lukiskan gambarajah P-v dan tandakan titik kritikal, garisan cecair tepu, garisan stim tepu, kawasan wap basah dan kawasan cecair termampat.

[7 marks]
[*7 markah*]

CLO1 C3 (b) Steam at 10 bar has the specific internal energy 2480 kJ/kg. Find;

i) dryness fraction
ii) specific volume
iii) specific enthalpy
iv) Sketch and locate the dryness fraction on the *P-v* diagram

Stim pada tekanan 10 bar mempunyai tenaga dalamnya 2480 kJ/kg. Kirakan;

i) pecahan kekeringan
ii) isipadu tentu
iii) entalpi tentu
iv) Lakar dan tandakan titik pecahan kekeringan pada rajah P-v

[10 marks]
[*10 markah*]

CLO1
C3

(c) Steam at 200 bar is at 425°C . Determine :

Stim pada tekanan 200 bar dan suhunya 425°C.Tentukan :

i. the degree of superheat,

Darjah panas lampau,

ii. specific volume,

Isipadu tentu,

iii. specific enthalpy,

Entalpi tentu,

iv. specific internal energy.

Tenaga dalam tentu.

[8 marks]
[*8 markah*]

QUESTION 3

SOALAN 3

CLO2
C2

(a) A certain gas is flowing in a 0.5 m^2 area pipe at a uniform velocity of 0.75 m/s. The temperature and the pressure are 30°C and 120 kPa respectively. Determine the mass flow rate. Given C_p = 1.03 kJ/kgK and C_v = 618 J/kgK.

Suatu gas mengalir di dalam paip berkeluasan 0.5 m^2 pada halaju yang seragam iaitu 0.75 m/s. Suhu dan tekanan masing-masing adalah 30°C dan 120 kPa. Tentukan kadar aliran jisim. Diberi C_p=1.03 kJ/kgK dan C_v=618 J/kgK.

[8 marks]
[*8 markah*]

CLO2 C4 (b) In a steady flow open system a fluid substance flows at the rate of 240 kg/min. It enters the system at a pressure of 550 kPa, a velocity 0.25 km/s, internal energy 2500 kJ/kg and specific volume 0.55 m^3/kg. It leaves the system at a pressure 1.5 bar, a velocity of 140 m/s, internal energy 1.55 MJ/kg and specific volume 1.5 m^3/kg. During its passage through the system, the substance has a loss by heat transfer of 45 kJ/kg to the surroundings. If any change of gravitational potential energy are neglected, determine:

Dalam aliran mantap bagi satu sistem terbuka, bendalir mengalir pada kadar 240 kg/min. Ia memasuki sistem pada tekanan 550 kPa, halaju 0.25 km/s, tenaga dalam tentu 2500 kJ/kg dan isipadu tentu 0.55 m^3/kg. Ia meninggalkan sistem pada tekanan 1.5 bar, halaju 140 m/s, tenaga dalam tentu 1.55 MJ/kg dan isipadu tentu 1.5 m^3/kg. Semasa melalui sistem, bendalir telah kehilangan haba sebanyak 45 kJ/kg ke persekitaran. Jika sebarang perubahan tenaga keupayaan gravity diabaikan, tentukan:

i) power of the system, and state whether it is coming from **OR** to the system.
*kuasa sistem tersebut, dan nyatakan sama ada ia daripada **ATAU** kepada sistem.*

[9 marks]
[9 *markah*]

ii) the inlet and outlet area of the system (in cm^2)
luas di bahagian masuk dan keluar sistem (in cm^2)

[8 marks]
[8 *markah*]

QUESTION 4
SOALAN 4

CLO1 C1 (a) Define close system and open system. Give **ONE (1)** example for each system.

*Takrifkan sistem tertutup dan sistem terbuka. Berikan **SATU (1)** contoh bagi setiap satu sistem.*

[6 marks]
[6 *markah*]

CLO1 C1 (b) Based on the steady flow energy equation below, state the quantity and unit for each equation's symbol.

$$Q - W = \left[(h_2 - h_1) + \left(\frac{C_2^2 - C_1^2}{2} \right) + (gZ_2 - gZ_1) \right]$$

Berdasarkan persamaan tenaga aliran mantap di bawah, nyatakan kuantiti dan unit bagi setiap simbol persamaan.

[7 marks]
[7 *markah*]

CLO2 C3 (c) Gas enters a turbine at a pressure of 7.5 bar with specific internal energy and specific volume of 1657 kJ/kg and 0.56 m^3/kg respectively. The gas exit the turbine with specific enthalpy 1819 kJ/kg while the work energy produced is 30 kJ/s. Assuming the heat transfer, potential energy and kinetic energy is neglected. Determine the mass flow rate of the turbine in kg/hr.

Gas masuk ke dalam turbin pada tekanan 7.5 bar dengan tenaga dalam tentu dan isipadu tentu sebanyak 1657 kJ/kg dan 0.56m^3/kg. Gas keluar daripada turbin dengan entalpi tentu sebanyak 1819 kJ/kg manakala. tenaga kerja yang dihasilkan adalah sebanyak 30 kJ/s. Pemindahan haba, tenaga keupayaan graviti dan tenaga kinetik boleh diabaikan. Tentukan kadar alir jisim dalam kg/hr.

[12 marks]
[12 *markah*]

QUESTION 5
SOALAN 5

CLO1 C1 (a) Define Second Law of Thermodynamics.
Takrifkan Hukum Kedua Termodinamik.

[3 marks]
[*3 markah*]

CLO1 C4 (b) Compare between heat engine and reversible heat engine based on their flow diagram.
Bandingkan enjin haba dengan enjin haba balikan berdasarkan kepada gambarajah alirannya.

[10 marks]
[10 *markah*]

CLO2 C3 (c) A household refrigerator with a COP of 2.2 rejected heat from the refrigerated space at a rate of 75 kJ/min. Determine:
Sebuah peti sejuk dengan COP 2.2 membuang haba dari ruang penyejukkannya pada kadar 75kJ/min. Tentukan:

i. The electric power consumed by the refrigerator.
Kuasa elektrik yang digunakan oleh peti sejuk.

ii. The rate of heat transferred to the kitchen air.
Kadar pemindahan haba ke udara di ruang dapur.

[12 marks]
[*12 markah*]

QUESTION 6
SOALAN 6

CLO1 C1 (a) Define heat engine based on thermodynamics application.
Takrifkan enjin haba berdasarkan kepada aplikasi dalam termodinamik.

[3 marks]
[*3 markah*]

CLO1 C2 (b) Explain **FOUR (4)** characteristics of heat engine.
*Terangkan **EMPAT (4)** sifat enjin haba.*

[8 marks]
[8 *markah*]

CLO2 C3 (c) A Nitrogen (molecular weight 28) expands reversibly in a pneumatic cylinder at a constant pressure of 2.05 bar. The initial temperature was 25°C with a volume of 0.05 m³. The temperature rises to 500°C after the process. Assuming nitrogen to be a perfect gas (Cp = 1.045 kJ/kg K), calculate:

Nitrogen (berat molekul 28) dikembangkan secara boleh balik di dalam silinder pneumatik pada tekanan tetap 2.05 bar. Suhu awal adalah 25°C dengan isipadu 0.05 m³. Suhunya meningkat kepada 500°C selepas proses tersebut. Andaikan nitrogen sebagai gas sempurna (Cp = 1.045 kJ/kg K), kirakan:

i. mass of nitrogen
Jisim nitrogen

ii. work done by nitrogen
Kerja yang dilakukan oleh nitrogen

iii. heat flow during the expansion process
haba yang mengalir sepanjang proses pengembangan

iv. change of entropy.
perubahan entropi.

[14 marks]
[14 markah]

SOALAN TAMAT

POLITEKNIK KEMENTERIAN PENDIDIKAN MALAYSIA
JABATAN KEJURUTERAAN MEKANIKAL
JJ 207 – THERMODYNAMICS 1

1. FIRST LAW OF THERMODYNAMICS

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

2. FLOW PROCESS

$\dot{m} = \rho V A = \rho \dot{V}$ (kg/s) $= \dot{m} = \frac{CA}{V}$

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

$$Q_T - W_T = \left[(h_2 - h_1) + \left(\frac{C_2^2 - C_1^2}{2}\right) + (Z_2 - Z_1)g\right] \qquad h = u + pv$$

3. PROPERTIES OF PURE SUBSTANCE

Steam

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

Ideal Gas

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

Non-Flow Process

1. **Isothermal Process** ($PV = C$)

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

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

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

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

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

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

3. Politropic Process $(PV^{n} = C)$

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

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

4. Isobaric Process

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

5. Isometric Process

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

4. SECOND LAW OF THERMODYNAMICS

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

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

Entropy

$$S_{gen} = \Delta S_{total} = \Delta S_{system} + \Delta S_{surrounding} = 0$$

$$\left(\frac{P_2}{P_1}\right)_{isentropic} = \left(\frac{P_{r2}}{P_{r1}}\right)$$

$$\left(\frac{v_2}{v_1}\right)_{isentropic} = \left(\frac{v_{r2}}{v_{r1}}\right)$$

5. GAS POWER CYCLES

$$r = \frac{V_{max}}{V_{min}} = \frac{V_{BDC}}{V_{TDC}} = \frac{V_1}{V_2} = \frac{v_1}{v_2}$$

$$MEP = \frac{W_{net}}{V_{disp}}$$

$$\eta_{th} = \frac{W_{net}}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$$

Otto Cycle

$$\eta_{th} = 1 - \frac{1}{r^{k-1}}, \quad \text{where } k = c_p / c_v$$

Diesel Cycle

$$\eta_{th} = 1 - \frac{1}{r^{k-1}}\left[\frac{r_c^k - 1}{k(r_c - 1)}\right],$$

where $r_c = \frac{v_3}{v_2}$ (cutoff ratio)

Brayton Cycle

$$\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{in}} = \frac{\dot{W}_t - \dot{W}_c}{\dot{Q}_{in}} = \frac{h_3 - h_4 - h_2 + h_1}{h_3 - h_2}$$

$$r_{bw} = \frac{\dot{W}_{comp}}{\dot{W}_{turb}} = \frac{h_2 - h_1}{h_3 - h_4}$$

$$\eta_{th} = 1 - \frac{1}{r_p^{(k-1)/k}}$$