UNIVERSITI SAINS MALAYSIA

KSCP Semester Examination
Academic Session 2016/2017

August 2017

EMH 441 – Heat Transfer
[Pemindahan Haba]

Duration : 3 hours
[Masa : 3 jam]

INSTRUCTIONS TO CANDIDATE:
ARAHAN KEPADA CALON :

Please check that this paper contains **SEVEN(7)** printed pages, **FOUR(4)** page Appendix and **FIVE(5)** questions before you begin the examination.

*Sila pastikan bahawa kertas soalan ini mengandungi **TUJUH(7)** mukasurat beserta **EMPAT(4)** mukasurat Lampiran dan **LIMA(5)** soalan yang bercetak sebelum anda memulakan peperiksaan.*

Appendix/*Lampiran* :

1.	Heat Exchanger NTU	[**1 page**/mukasurat]
2.	Radiation Heat Transfer Chart	[**1 page**/mukasurat]
3.	Materials Properties	[**2 page**/*mukasurat*]

Answer **ALL** questions.
*Jawab **SEMUA** soalan.*

Answer all questions in **English** OR **Bahasa Malaysia** OR a combination of both.
*Calon boleh menjawab semua soalan dalam **Bahasa Malaysia** ATAU **Bahasa Inggeris** ATAU kombinasi kedua-duanya.*

Each question must begin from a new page.
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 peperikssan, versi Bahasa Inggeris hendalh diguna pakai.

NOTE:
Provided: Formula Booklet
Dibekalkan: Buku formula

Q1. [a] Describe the heat transfer mechanism involving conduction and explain why conduction is less likely to happen in gas, as compared to that in liquid or solid?

Terangkan mekanisme pemindahan haba yang melibatkan konduksi dan jelaskan mengapa konduksi kurang berlaku dalam gas, berbanding dalam cecair atau pepejal?

(20 marks/*markah*)

[b] A 1m high and 1.5m wide glass window consists of two glass sheets of different thicknesses, as shown in Figure Q1[b]. Glass sheet A is of 4mm thickness while glass sheet B is of 6mm thickness. The thermal conductivity of the glass is $k = 0.78 W/m.\ ^0C$. Calculate the steady rate of heat transfer through the glass window when the indoor temperature is 18^0C and the outdoor temperature is 25^0C. The convection heat transfer coefficients in the indoor and outdoor can be assumed to be $h_i = 10 W/m^2.\ ^0C$ and $h_o = 8 W/m^2.\ ^0C$, respectively. State <u>THREE</u> assumptions made.

Tingkap kaca 1m tinggi dan 1.5m lebar terdiri daripada dua kepingan kaca dengan ketebalan yang berlainan, seperti yang ditunjukkan dalam Rajah S1 [b]. Helaian kaca A dengan ketebalan 4mm manakala lembaran kaca B dengan ketebalan 6mm. Kekonduksian haba kaca ialah $k = 0.78 W/m.\ ^0C$. Kirakan kadar pemindahan haba mantap melalui tingkap kaca apabila suhu dalaman ialah 18^0C dan suhu luaran ialah 25^0C. Koefisien pemindahan haba perolakan di dalam dan di luar boleh diandaikan sebagai $h_i = 10 W/m^2.\ ^0C$ dan $h_o = 8 W/m^2.\ ^0C$. Nyatakan <u>TIGA</u> andaian yang dibuat.

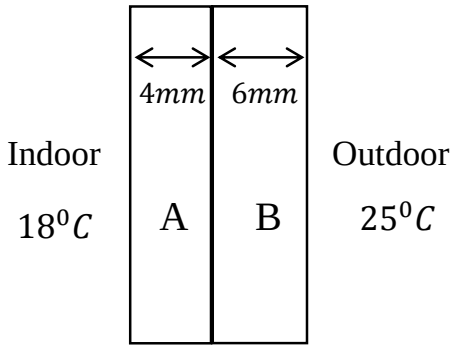

Figure Q1[b]
Rajah S1[b]

(80 marks/*markah*)

Q2. **Water flows at 1m/s in a 8m long tube, as shown in Figure Q2, with outer diameter of 10cm and wall thickness of 0.4cm. Heat is supplied to the water where the tube is subjected to a uniform heat flux along the tube wall. The properties of water are given as follows:**

Air mengalir pada 1m/s *dalam tiub sepanjang 8m, seperti yang ditunjukkan dalam Rajah S2, dengan diameter luar 10cm dan tebal dinding 0.4cm. Haba dibekalkan ke air dimana tiub itu didedahkan kepada fluks haba seragam sepanjang dinding tiub. Sifat-sifat air diberikan seperti berikut:*

Density, $\boldsymbol{\rho_{\text{water}} = 997\text{kg/m}^3}$
Thermal conductivity, $\boldsymbol{k_{water} = 0.607 W/m.\ ^0C}$
Kinematic viscosity, $\boldsymbol{\nu_{water} = 8.937 \times 10^{-7}\text{m}^2/\text{s}}$
Prandtl number, $\boldsymbol{Pr = 6.14}$
Specific heat, $\boldsymbol{c_p = 1007 J/kg.\ ^0C}$

Ketumpatan, $\rho_{air} = 997\, kg/m^3$
Kekonduksian haba, $k_{air} = 0.607 W/m.\ ^0C$
Kelikatan kinematik, $\nu_{air} = 8.937 \times 10^{-7}\, m^2/s$
Nombor Prandtl, $Pr = 6.14$
Haba tentu, $c_p = 1007 J/kg.\ ^0C$

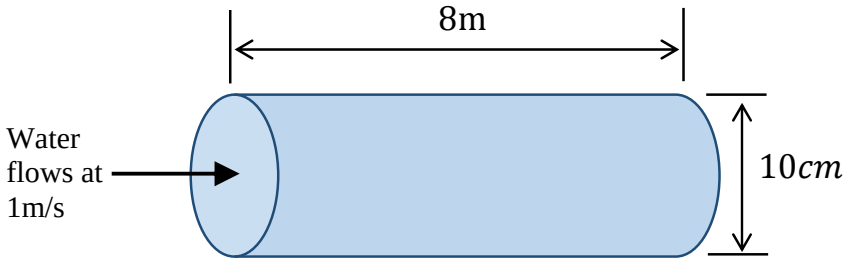

Figure Q2
Rajah S2

[a] **Calculate the convection heat transfer coefficient for the water flow when fully developed flow is assumed. The Dittus-Boelter correlation is given as**

Kirakan koefisien pemindahan haba perolakan untuk aliran air apabila arus terbentuk penuh diandaikan. Korelasi Dittus-Boelter adalah seperti berikut

$$\boldsymbol{Nu = 0.023 Re^{0.8} Pr^n}$$

where $\boldsymbol{n = 0.4}$ **for heating and** $\boldsymbol{0.3}$ **for cooling.**

dimana $n = 0.4$ *untuk memanas dan 0.3 untuk menyejuk.*

(50 marks/*markah*)

[b] Calculate the temperature at the exit of the tube if the inlet temperature is assumed to be 20^0C and the uniform heat flux q''_w is assumed to be $40,000W/m^2$.

Kirakan suhu di bahagian keluar tiub jika suhu di bahagian masuk diandaikan sebagai 20^0C *dan fluks haba seragam* q''_w *diandaikan sebagai* $40{,}000W/m^2$.

(50 marks/*markah*)

Q3. A spherical vessel of 50cm diameter is being completely submerged in a large water-filled tank, as shown in Figure Q3. The temperature of the water in the tank is $35\ ^0C$ and the outer surface of the vessel is $15\ ^0C$. The properties of water at film temperature are given as follows:

Sebuah penakung berbentuk sfera dengan diameter 50cm yang sepenuhnya tenggelam dalam tangki yang dipenuhi dengan air, seperti ditunjukkan dalam Rajah S3. Suhu air dalam tangki adalah $35\ ^0C$ *dan permukaan luar penakung adalah* $15\ ^0C$. *Sifat-sifat air pada suhu tipisan diberikan seperti berikut:*

Density, $\rho_{water} = 997\text{kg/m}^3$
Thermal conductivity, $k_{water} = 0.607W/m.\ ^0C$
Kinematic viscosity, $\nu_{water} = 8.937 \times 10^{-7}\text{m}^2/\text{s}$
Prandtl number, $Pr = 6.14$
Specific heat, $c_p = 1007J/kg.\ ^0C$
Thermal expansion coefficient, $\beta = 0.247 \times 10^{-3}K^{-1}$

Ketumpatan, $\rho_{air} = 997 kg/m^3$
Kekonduksian haba, $k_{air} = 0.607W/m.\ ^0C$
Kelikatan kinematik, $\nu_{air} = 8.937 \times 10^{-7} m^2/s$
Nombor Prandtl, $Pr = 6.14$
Haba tentu, $c_p = 1007J/kg.\ ^0C$
Pekali pengembangan haba, $\beta = 0.247 \times 10^{-3}K^{-1}$

Also, the following equations are given.
Juga, persamaan berikut diberikan

$$Ra = \frac{g\beta(T_s - T_\infty)D^3}{\nu^2}Pr$$

$$Nu = 2 + \frac{0.589Ra^{1/4}}{[1 + (0.469/Pr)^{9/16}]^{4/9}}$$

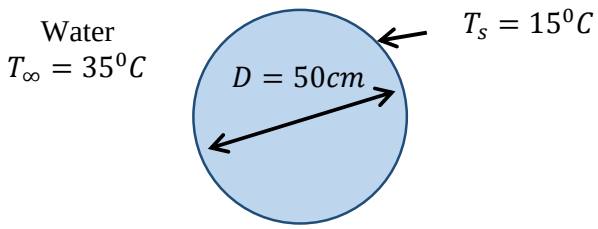

Figure Q3
Rajah S3

[a] **Calculate the rate of heat transfer when the water in the tank is stationary.**

Kirakan kadar pemindahan haba apabila air dalam tangki itu tidak bergerak.

(60 marks/*markah*)

[b] **If the water in the tank remains stationary and the buoyancy force caused by the difference in the water density is assumed to be negligible, calculate the rate of heat transfer.**

Sekiranya air dalam tangki kekal pegun dan daya keapungan yang disebabkan oleh perbezaan ketumpatan air dapat diabaikan, kirakan kadar pemindahan haba.

(40 marks/*markah*)

Q4. **[a]** **How does condensation occur on a surface? List <u>TWO</u> types of condensation.**

Bagaimana pemeluwapan berlaku pada permukaan? Senaraikan <u>DUA</u> jenis pemeluwapan.

(25 marks/*markah*)

[b] **Figure Q4[b] shows that water (c_p=4200 J/kg.K, ρ=1000 kg/m^3) is utilized to cool hot oil (c_p=2100 J/kg.K, ρ=850 kg/m^3) using heat exchanger. The inner tubes are thin with a length of 300m and diameter of 0.05m. The diameter of outer tube are 0.0916m. Water velocity through the inner tubes is 0.5m/s, and the oil velocity through the outer tube is 1 m/s. Neglect the thickness of inner tube and outer tube.**

Rajah S4[b] menunjukkan air (c_p=4200 J/kg.K, ρ=1000 kg/m^3) digunakan untuk menyejukkan minyak panas (c_p=2100 J/kg.K, ρ=850 kg/m^3) menggunakan penukar haba. Tiub dalaman yang nipis mempunyai panjang 300m dan diameter 0.05m. Diameter dan tebal tiub luar ialah 0.0916m. Halaju air melalui tiub dalaman ialah 0.5m/s dan halaju minyak melalui tiub luar ialah 1m/s.

Calculate the cross-sectional area for water and oil, volume flow rate of water and oil, mass flow rate of water and oil, rate of heat transfer, cold water inlet temperature and overall heat transfer coefficient.

Kirakan luas keratan rentas untuk air dan minyak, kadar aliran isipadu air dan minyak, kadar aliran jisim air dan minyak, kadar pemindahan haba, suhu alur masuk air sejuk dan pekali pemindahan haba keseluruhan.

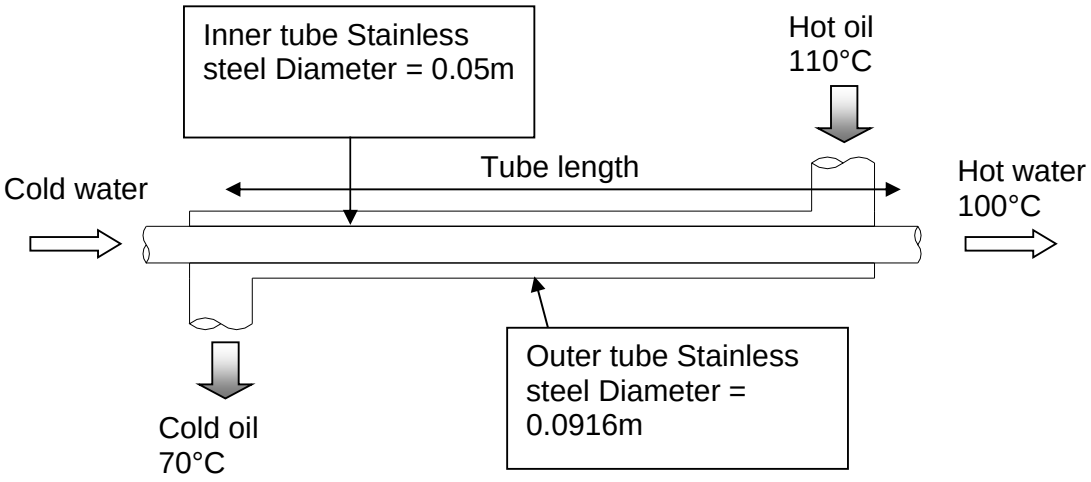

Figure Q4[b]
Rajah S4[b]

(**75 marks**/*markah*)

Q5. [a] **Hot oil (c_p =2100 J/kg.K, ρ = 850 kg/m^3) is to be cooled manometer fluid (c_p =3800 J/kg.K, ρ = 850 kg/m^3) in the heat exchanger as shown in Figure Q5[a]. The tubes have a diameter and length of 2.0cm and 1m, respectively. The overall heat transfer coefficient is 755W/m^2.K. Manometer fluid mass flow rate is 0.2kg/s and oil mass flow rate is 0.4kg/s. Manometer fluid and oil inlet temperatures are 18°C and 160°C, respectively. Calculate the rate of heat transfer in the heat exchanger and outlet temperature of manometer fluid and oil.**

Minyak panas (c_p=2100 J/kg.K, ρ=850 kg/m^3) disejukkan oleh bendalir manometer (c_p=3800 J/kg.K, ρ=850 kg/m^3) dalam penukar haba seperti yang ditunjukkan dalam Rajah S5[a]. Tiub-tiub berketebalan 3mm keluli tahan karat dengan berdiameter 2.0cm dan panjang 1m. Pekali pemindahan haba keseluruhan ialah 755W/m^2.K. Kadar aliran jisim bendalir manometer ialah 0.2kg/s dan kadar aliran jisim minyak ialah 0.4kg/s. Suhu masuk bendalir manometer ialah 18°C dan suhu minyak masuk ialah 160°C. Kirakan kadar pemindahan haba dalam penukar haba dan suhu keluar bendalir manometer dan minyak.

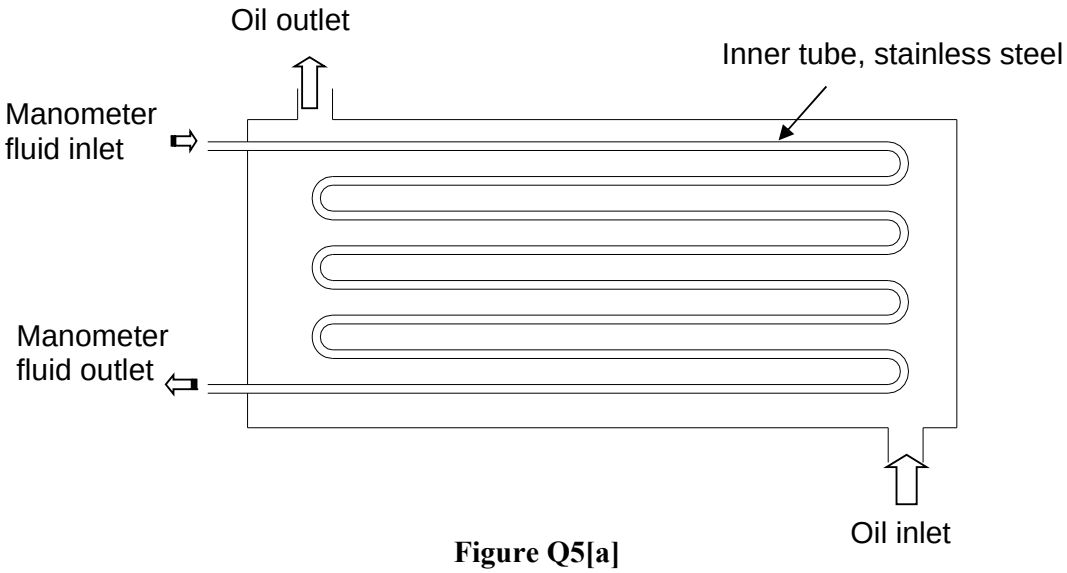

Figure Q5[a]
Rajah S5[a]

(**60 marks**/*markah*)

[b] **All surfaces of 3m x 3m x 3m cubical furnace as shown in Figure Q5[b] are black surface. All surfaces have uniform temperature. Calculate net radiation heat transfer from the bottom surface.**

Semua permukaan 3m x 3m x 3m relau kubus seperti Rajah S5[b] ialah permukaan hitam. Semua permukaan mempunyai suhu sekata. Kirakan pemindahan haba radiasi bersih dari pemukaan bawah.

1 = Bottom surface
2 = Top surface
3 = Sides surface

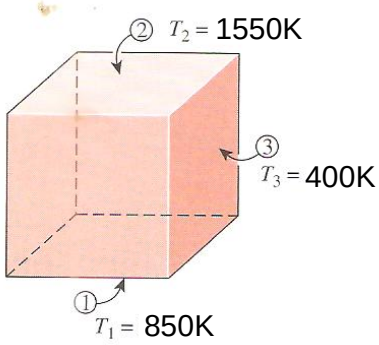

Figure Q5[b]
Rajah S5[b]

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

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