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
C1

a) Heat is a form of energy that can be transferred from one system to another system as a result of temperature difference.
Haba adalah satu bentuk tenaga yang boleh dipindahkan dari satu sistem kepada sistem lain akibat dari perbezaan suhu.

i. List **THREE (3)** elements of energy.
*Senaraikan **TIGA (3)** elemen tenaga.*

[3 Marks]
[*3 Markah*]

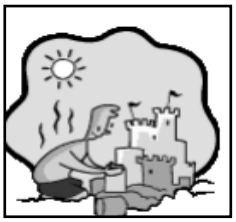
ii. Select **TWO (2)** elements and write down its SI unit.
*Pilih **DUA (2)** elemen dan nyatakan dalam unit SI.*

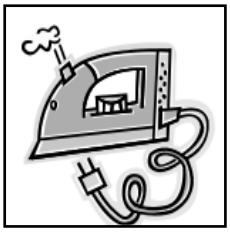
[2 Marks]
[*2 Markah]*

CLO1
C2

b) Identify the main method of heat transfer that takes place in each illustration or situation.
Kenal pasti kaedah pemindahan haba utama yang berlaku dalam setiap ilustrasi atau situasi.

i. 

ii. 

iii. 

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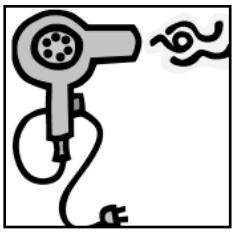
v. 

vi. 

vii. Hot coffee is stirred with a spoon, the spoon gets hot.
Sudu digunakan untuk mengacau kopi yang panas, kemudian sudu menjadi panas.

viii. During a sunny day, the water in a swimming pool near the surface is slightly warmer since the warm water rises to the surface.
Pada pagi yang panas, air di dalam kolam renang yang berhampiran permukaan lebih panas sedikit disebabkan air yang panas bergerak ke permukaan.

[8 Marks]
[*8 Markah*]

CLO2
C3

c) A 1.25 m high and 2.5 m wide double pane window consisting of two thick layers of glass that is 3.25 mm (k = 0.78 W/m·°C) and separated by a 12.5 mm wide stagnant air space (k = 0.026 W/m·°C). The air resistance is 0.1538 °C/W. Calculate each of the individual thermal resistance. Take the convection heat transfer coefficient on the inner and outer surfaces of the window to be h_1 = 10 W/m^2·°C and h_2 = 25 W/m^2·°C, and disregard any heat transfer by radiation.

Satu tingkap dua panel 1.25 m tinggi dan 2.5 m lebar yang terdiri daripada dua lapisan kaca berketebalan 3.25 mm (k = 0.78 W/m·°C) dan dipisahkan oleh 12.5 mm ruang udara tetap (k = 0.026 W/m·°C). Rintangan udara ialah 0.1538 °C/W. Kirakan setiap rintangan terma. Pekali pemindahan haba bagi permukaan dalaman dan luaran ialah h_1 = 10 W/m^2·°C dan h_2 = 25 W/m^2·°C dan abaikan sebarang pemindahan haba oleh radiasi.

[12 Marks]

[*12 Markah*]

QUESTION 2

SOALAN 2

CLO1
C2

a) Convection heat transfer is closely tied with fluid mechanics, which is the science that deals with the behavior of fluids at rest or in motion, and the interaction of fluids with solids or other fluids at the boundaries.

Pemindahan haba melalui perolakan berkait rapat dengan mekanik bendalir, iaitu sains yang berkaitan dengan tingkah laku bendalir dalam keadaan pegun mahupun dalam pergerakan dan interaksi cecair dengan pepejal atau dengan cecair lain di sempadan.

i) State **THREE (3)** types of flow.

*Nyatakan **TIGA (3)** jenis aliran.*

[3 Marks]

[*3 Markah*]

ii) State the Reynold number for the **TWO (2)** chosen flows.

*Nyatakan nombor Reynold bagi **DUA (2)** aliran dipilih.*

[2 Marks]

[*2 Markah*]

CLO2
C3

b) Sketch velocity boundary layer with complete labelling.
Lakarkan lapisan sempadan halaju dengan label yang lengkap.

[10 Marks]
[10 Markah]

CLO2
C4

c) A long 10 cm diameter steam pipe whose external surface temperature is 110 °C passes through some open area that is not protected against the winds is shown on Diagram 3 (c). Calculate the rate of heat loss from the pipe per unit of its length when the air is 1 atm pressure with temperature 10°C and the wind is blowing across the pipe at a velocity of 8 m/s.
Paip stim berdiameter 10 cm panjang yang suhu permukaan luarannya 110 ° C melalui beberapa kawasan terbuka yang tidak dilindungi daripada angin yang ditunjukkan dalam Gambarajah 3(c). Kirakan kadar kehilangan haba dari paip per unit dari panjangnya apabila tekanan udara ialah 1 atm tekanan dengan suhu 10 ° C serta angin meniup merentasi paip pada halaju 8 m/ s.

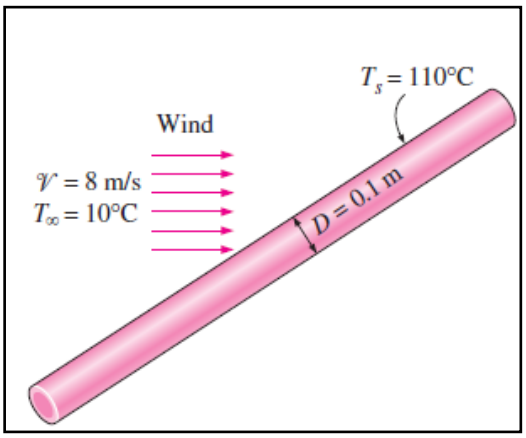


Diagram 3(c) / *Gambarajah 3(c)*

[10 Marks]
[*10 Markah*]

QUESTION 3

SOALAN 3

CLO1 C2

a) Identify **SEVEN (7)** examples of radiation process application in daily life or industry.

*Kenalpasti **TUJUH (7)** contoh aplikasi proses radiasi dalam kehidupan seharian atau industri.*

[7 Marks]

[*7 Markah*]

CLO2 C3

b) The spectral emissivity of an opaque surface at 1200K is approximated as:

Fungsi bagi keberpancaran spectrum pada suhu 1200K bagi permukaan legap dianggarkan seperti berikut:

$$\varepsilon_1 = 0, \quad \lambda < 2\mu m$$

$$\varepsilon_2 = 0.85\,, \quad 2 \leq \lambda \leq 6\mu m$$

$$\varepsilon_3 = 0, \quad \lambda > 6\mu m$$

Determine:

Tentukan:

(i) The total emissivity of the surface.

Jumlah keberpancaran permukaan.

[7 Marks]

[*7 Markah*]

(ii) The emissive flux from the surface, in W/m^2.

Kuasa pancaran dari permukaan dalam unit W/m^2.

[3 Marks]

[*3 Markah]*

CLO2 C4

c) Radiation offers a lot in terms of treating patient in medical field. On the other hand, this type of treatment does bring good and bad in someone life. Analyze **FOUR (4)** advantages and disadvantages of treatment from radiation (in table form). *Radiasi menawarkan banyak dari segi merawat pesakit dalam bidang perubatan. Sebaliknya, rawatan jenis ini turut membawa kebaikan dan keburukan dalam kehidupan seseorang. Analisa **EMPAT (4)** kebaikan dan keburukan rawatan daripada radiasi (dalam bentuk jadual).*

[8 Marks]

[*8 Markah*]

QUESTION 4
SOALAN 4

CLO1 C2

a) An engineer that browse through the manufacturers catalogues of heat exchanger will be overwhelmed by the types and choices readily available in the market. The proper selection depends on several factors. Identify **FIVE (5)** factors. *Seorang jurutera yang meneliti katalog pengeluar penukar haba akan kagum dengan jenis dan pilihan sedia ada di pasaran. Pemilihan yang betul bergantung kepada beberapa faktor. Kenalpasti **LIMA (5)** faktor.*

[5 Marks]

[*5 Markah*]

CLO2 C3

b) A long thin-walled double-pipe heat exchanger with tube and shell diameters of 1.0 cm and 2.5 cm respectively as shown in Diagram 4(b), is used to condense refrigerant 134a by water at 20°C. The refrigerant flows through the tube, with a convection heat transfer coefficient of h_i = 5000 W /$m^2 \cdot °$ C. Water flows through the shell at a rate of 0.3 kg/s. Determine the overall heat transfer.

Penukar haba paip panjang berganda dan berdinding nipis dengan tiub serta diameter shell 1.0 cm dan 2.5 cm seperti yang ditunjukkan dalam gambarajah 4(b), masing-masing digunakan untuk menyejatkan penyejuk 134a dengan air pada suhu 20°C. Aliran penyejuk melalui tiub, dengan pekali pemindahan haba konveksi h_i = 5000 W/$m^2 \cdot$°C. Air mengalir melalui shell pada kadar 0.3 kg/s. Tentukan pemindahan haba keseluruhan.

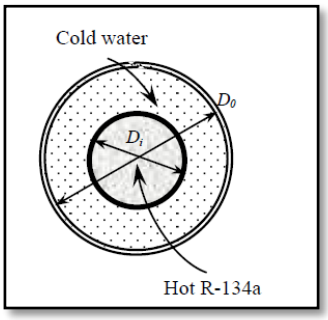


Diagram 4(b) / *Gambarajah 4(b)*

[10 marks]

[*10 markah*]

CLO2
C4

c) Hot oil is to be cooled in a shell-and-tube heat exchanger by water. The oil flows through the shell, with a heat transfer coefficient of h_o = 35 W/m^2·°C, and the water flows through the tube with an average velocity of 3 m/s. The tube is made of brass (k = 110 W/m·°C) with internal and external diameters of 1.3 cm and 1.5 cm, respectively. Using water properties at 25°C, determine the overall heat transfer coefficient of this heat exchanger based on the inner surface.

Minyak panas disejukkan dalam penukar haba shell-dan-tiub dengan air. Minyak mengalir melalui shell, dengan pekali pemindahan haba konduksi 35 W / m^2 ° C, dan air mengalir melalui tiub dengan kelajuan purata 3 m/s. Tiub ini diperbuat daripada tembaga (k= 110/m·°C) dengan diameter dalam dan luar masing-masing 1.3cm dan 1.5cm. Dengan menggunakan sifat air pada 25 ° C, tentukan pekali pemindahan haba keseluruhan penukar haba ini berdasarkan permukaan dalam.

[10 marks]

[*10 markah*]

SOALAN TAMAT

Formula list / *Senarai formula*

CONDUCTION

The elementary thermal resistance relations:

Conduction resistance (plane wall): $R_{\text{wall}} = \dfrac{L}{kA}$

Conduction resistance (cylinder): $R_{\text{cyl}} = \dfrac{\ln(r_2/r_1)}{2\pi Lk}$

Conduction resistance (sphere): $R_{\text{sph}} = \dfrac{r_2 - r_1}{4\pi r_1 r_2 k}$

Convection resistance: $R_{\text{conv}} = \dfrac{1}{hA}$

CONVECTION

The average friction coefficient relations for flow over a flat plate:

Laminar: $C_f = \dfrac{1.328}{\text{Re}_L^{1/2}} \qquad \text{Re}_L < 5 \times 10^5$

Turbulent: $C_f = \dfrac{0.074}{\text{Re}_L^{1/5}} \qquad 5 \times 10^5 \le \text{Re}_L \le 10^7$

Combined: $C_f = \dfrac{0.074}{\text{Re}_L^{1/5}} - \dfrac{1742}{\text{Re}_L} \qquad 5 \times 10^5 \le \text{Re}_L \le 10^7$

Rough surface, turbulent: $C_f = \left(1.89 - 1.62 \log \dfrac{\varepsilon}{L}\right)^{-2.5}$

The average Nusselt number relations for flow over a flat plate:

Laminar: $\text{Nu} = \dfrac{hL}{k} = 0.664\, \text{Re}_L^{0.5}\, \text{Pr}^{1/3} \qquad \text{Re}_L < 5 \times 10^5$

Turbulent:

$$\text{Nu} = \frac{hL}{k} = 0.037\, \text{Re}_L^{0.8}\, \text{Pr}^{1/3} \qquad \begin{matrix} 0.6 \le \text{Pr} \le 60 \\ 5 \times 10^5 \le \text{Re}_L \le 10^7 \end{matrix}$$

Combined:

$$\text{Nu} = \frac{hL}{k} = (0.037\, \text{Re}_L^{0.8} - 871)\, \text{Pr}^{1/3}, \qquad \begin{matrix} 0.6 \le \text{Pr} \le 60 \\ 5 \times 10^5 \le \text{Re}_L \le 10^7 \end{matrix}$$

The average Nusselt number for cross flow over a cylinder and sphere:

$$\text{Nu}_{\text{cyl}} = \frac{hD}{k} = 0.3 + \frac{0.62\, \text{Re}^{1/2}\, \text{Pr}^{1/3}}{[1 + (0.4/\text{Pr})^{2/3}]^{1/4}} \left[1 + \left(\frac{\text{Re}}{282{,}000}\right)^{5/8}\right]^{4/5}$$

which is valid for $\text{Re Pr} > 0.2$, and

$$\text{Nu}_{\text{sph}} = \frac{hD}{k} = 2 + [0.4\, \text{Re}^{1/2} + 0.06\, \text{Re}^{2/3}]\text{Pr}^{0.4} \left(\frac{\mu_\infty}{\mu_s}\right)^{1/4}$$

which is valid for $3.5 \le \text{Re} \le 80{,}000$ and $0.7 \le \text{Pr} \le 380$

RADIATION

Stefan–Boltzmann law: $E_b(T) = \sigma T^4$; $\sigma = 5.670 \times 10^{-8}$ W/m^2·K^4

Spectral blackbody emmisive power;

$$E_{b\lambda}(\lambda, T) = \frac{C_1}{\lambda^5[\exp(C_2/\lambda T) - 1]} \qquad (\text{W/m}^2 \cdot \mu\text{m})$$

where

$$C_1 = 2\pi hc_0^2 = 3.742 \times 10^8\ \text{W} \cdot \mu\text{m}^4/\text{m}^2$$
$$C_2 = hc_0/k = 1.439 \times 10^4\ \mu\text{m} \cdot \text{K}$$

Wien's displacement law:

$$(\lambda T)_{\text{max power}} = 2897.8\ \mu\text{m} \cdot \text{K}$$

HEAT EXCHANGER

Overall heat transfer coefficient U or a total thermal resistance R, expressed as:

$$\frac{1}{UA_s} = \frac{1}{U_iA_i} = \frac{1}{U_oA_o} = R = \frac{1}{h_iA_i} + R_{\text{wall}} + \frac{1}{h_oA_o}$$

The effects of fouling on both the inner and the outer surfaces of the tubes of a heat exchanger can be accounted for by:

$$\frac{1}{UA_s} = \frac{1}{U_iA_i} = \frac{1}{U_oA_o} = R$$
$$= \frac{1}{h_iA_i} + \frac{R_{f,i}}{A_i} + \frac{\ln(D_o/D_i)}{2\pi kL} + \frac{R_{f,o}}{A_o} + \frac{1}{h_oA_o}$$

LMTD method, the rate of heat transfer

$$\dot{Q} = UA_s\,\Delta T_{\text{lm}}$$

where

$$\Delta T_{\text{lm}} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)}$$