UPES SAP ID No.: _____

UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
Examination, July 2020

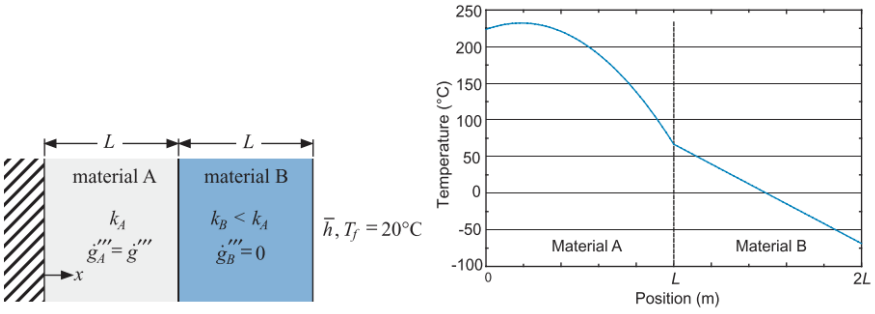
Programme: B.Tech ADE | **Semester: VI**
Course Name: Heat Transfer | **Max. Marks: 100**
Course Code: | **Attempt Duration: 1**
No. of page/s: 04

Note:

1. Read the instruction carefully before attempting.
2. This question paper has two section, Section A and Section B.
3. Answer Sheet to be submitted within 24 hrs from the scheduled time (*exceptional provision due extraordinary circumstance due to COVID-19 and due to internet connectivity issues in the far-flung areas*).
4. No submission of Answer Sheet shall be entertained after 24 Hrs.
5. The answers should be attempted in blank white sheets (hand written) with all the details like programme, semester, course name, course code, name of the student, Sapid at the top (as in the format) and signature at the bottom (right hand side bottom corner)
6. **Each question carry 20 Marks**

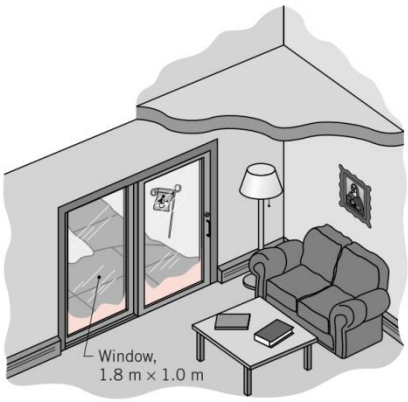
Attempt all questions:

1. One of the engineers that you supervise has been asked to simulate the heat transfer problem shown in Figure. This is a 1-D, plane wall problem (i.e., the temperature varies only in the x-direction and the area for conduction is constant with x). Material A (from $0 < x < L$) has conductivity k_A and experiences a uniform rate of volumetric thermal energy generation, q'''. The left side of material A (at $x = 0$) is completely insulated. Material B (from $L < x < 2L$) has lower conductivity, $k_B < k_A$. The right side of material B (at $x = 2L$) experiences convection with fluid at room temperature (20 °C). Based on the facts above, critically examine the solution that has been provided to you by the engineer and is shown in Figure. There should be a few characteristics of the solution that do not agree with your knowledge of heat transfer; list as many of these characteristics as you can identify and provide a clear reason why you think the engineer's solution must be wrong.



(a) (b)

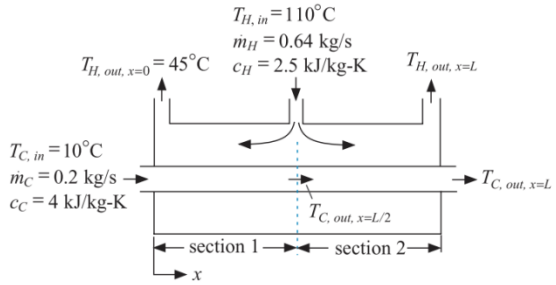
2. During a winter day, the window of a patio door with a height of 1.8 m and width of 1.0 m shows a frost line near its base. The room wall and air temperatures are 15 ^{0}C .



(a) Explain why the window would show a frost layer at the base rather than at the top.
(b) Estimate the heat loss through the window due to free convection and radiation. Assume the window has a uniform temperature of 0 0C and the emissivity of the glass surface is 0.94.

3. You are preparing a spaghetti dinner for guests when you realize that your heat transfer training can be used to answer some fundamental questions about the process. The pot you are using holds four liters of water. The atmospheric pressure is 101 kPa. When on its high setting, the electric stove heating unit consumes 1.8 kW of electrical power of which 20% is transferred to the surroundings, rather than to the water. The pot is made of 4 mm thick polished AISI 304 stainless steel and it has a diameter of 0.25 m. The burner diameter is also 0.25 m.
a.) How much time is required to heat the water from 15 ˚C to its boiling temperature?
b.) What are the temperatures of the outside and inside surfaces of the bottom of pot while the water is boiling?
4. One of your friend is planning to purchase a new oven and he has come to you thinking of you that you are very good in radiative heat transfer. He discussed two model of oven as follow:
Model 1: All six of the oven wall has a dark coating with high value of emissivity 0.95
Model 2: All six of the oven walls are reflective with low value of emissivity 0.15
The manufacturer claims that Model 2 cook food more quickly as compared to Model 1. Both the model has electric resistance heater above the ceiling of both model. The cooking space can be considered cubical with each side of 0.5 m. The top surface has temperature of 200 ^{0}C. Comment on manufacturer claim and help your friend.
5. A concentric tube heat exchanger is built and operated as shown in Figure. The hot stream is a heat transfer fluid with specific heat capacity C_H = 2.5 kJ/kg-K. The hot stream enters at the

axial center of the annular space at $T_{H,in}$ = 110 ˚C with mass flow rate ˙m_H = 0.64 kg/s and then splits; an equal amount flows in both directions. The cold stream has specific heat capacity C_C = 4.0 kJ/kg-K. The cold fluid enters the center pipe at $T_{C,in}$ = 10 ˚C with mass flow rate ˙m_C = 0.2 kg/s. The outlet temperature of the hot-fluid that flows to the left is $T_{H, out, x=0}$ = 45◦C. The two sections of the heat exchanger have the same conductance.



a.) Determine the temperature of the cold stream at the midpoint of the center tube ($T_{C, out, x=L/2}$) and the temperature of the cold-fluid leaving the heat exchanger ($T_{C, out, x=L}$).
b.) Calculate the overall conductance of this heat exchanger.
c.) How will the overall effectiveness be affected if the inlet temperature is increased to 400◦C. (Assume that the properties of the heat transfer fluid are independent of temperature.) Justify your answer.
d.) Is the overall effectiveness of this heat exchanger higher, lower, or the same as a counter-flow heat exchanger having the same inlet conditions? Justify your answer.

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