CIV-E1050 Heat and Mass Transfer in Buildings

Final Exam

9:00-12:00, 09.12.2020

(It's forbidden to post exam questions publicly or share with others.)

1. Answer the following questions briefly (hit the points and use max 2-3 sentences for each question).

(1) Consider fluid flow in pipe, what does it mean by a fully developed flow profile?

(2) What is the reciprocity rule in the calculation of radiant heat transfer? Provide an example.

(3) Under what circumstances a 'semi-infinite heat transfer' can be assumed or used in calculating heat transfer problem, provide an example.

(4) Under what circumstances "lumped system" can be assumed or used in calculating heat transfer problem, provide an example.

2. See Figure below. Steam is flowing inside a pipe with the diameter 57mm and outer surface temperature 100℃. An insulation layer with k = 50 W/m·K is used to reduce the heat loss. Calculate the thickness of insulation layer if the outer surface temperature of insulation and heat loss per meter do not exceed 40℃ and 70 W respectively.

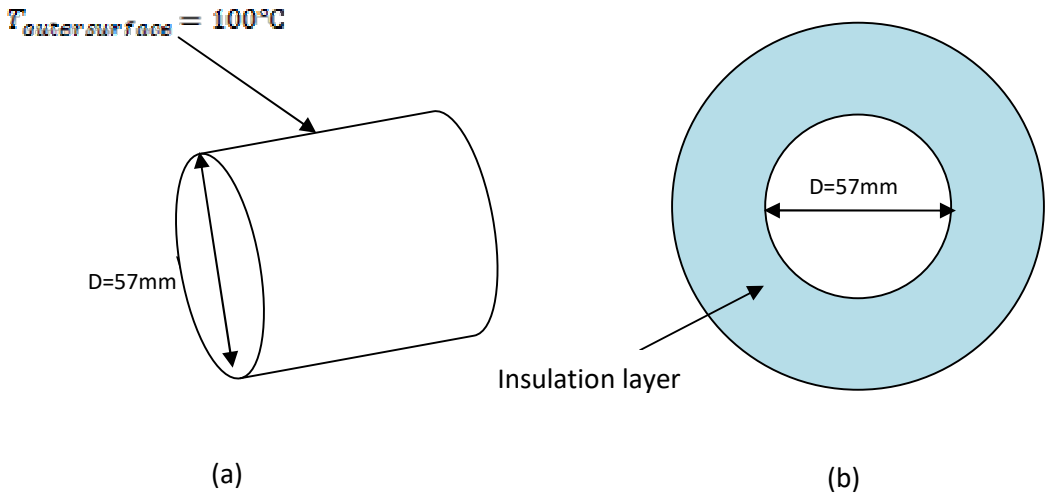


Figure 1. (a) Pipe in 3D (without insulation layer). (b) Section of pipe with insulation layer.

3. See Figure below. A solar collector with size 1m x 1m is installed on the roof horizontally.

(a) The environment temperature is 20℃. The surface temperature of solar collector is 90℃. Calculate the convective heat loss from the surface of solar collector.

(b) To reduce the heat loss, a glazing cover is installed on the top of this solar collector. The height from the bottom of collector to glazing cover is 10 cm. The inner surface temperature of glazing cover is 30℃. Calculate the convective heat loss of this solar collector.

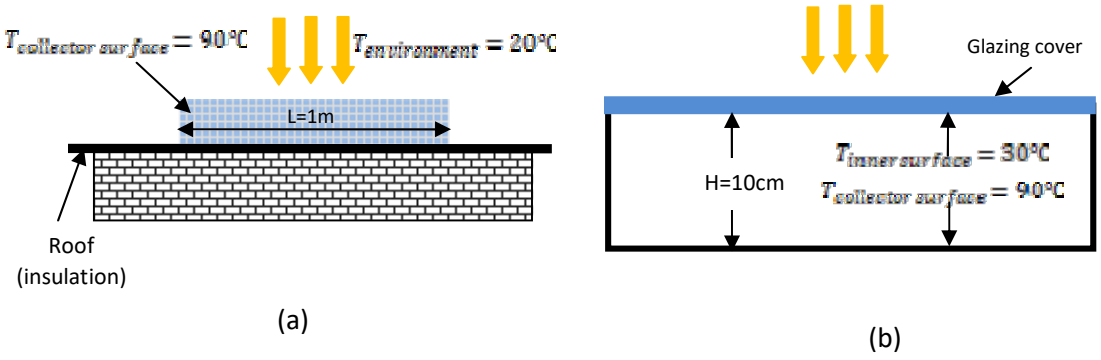
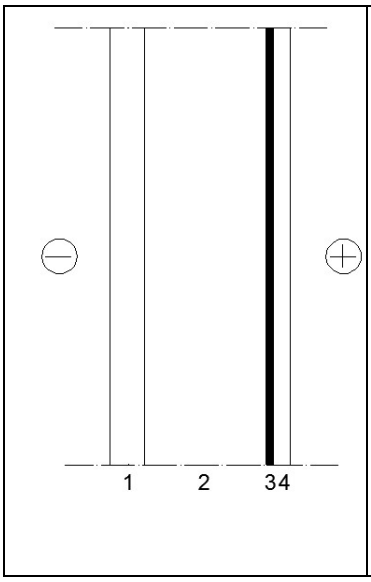


Figure 2. (a) Solar collector placed on the roof. (b) Solar collector with glazing cover.

4. See Figure below. This problem is about moisture design for a wall construction. The wall consists of interior gypsum board, vapour barrier, insulation, and siding. Assuming moisture transports with vapor diffusion at steady state with indoor 20 °C and 30 % RH and outdoor -15 °C and 85 % RH, calculate relative humidity for all the structural interfaces. Assume convective resistance for inside and outside air are both 0.13 [m^2K/W]. Please show all steps.



Material	d [m]	k [W/mK]	$Rv10^{-12}$ [s.m2.Pa/kg]
Outside		-	-
1	0.025	0.065	0.00023
2	0.191	0.037	0.001
3	-	-	0.0365
4	0.013	0.23	0.0005
Inside		-	-

Figure 3. Wall structure and material property data.

5. Consider a duct with length 10m as shown in the following figure. The emissivity of these surfaces is 0.9. The surface temperatures are $T_{ABB'A'} = T_{ACC'A'} = 300°C$ and $T_{BCC'B'} = 500°C$. Calculate the radiation heat transfer from surface BCC'B' to ABB'A' and ACC'A'.

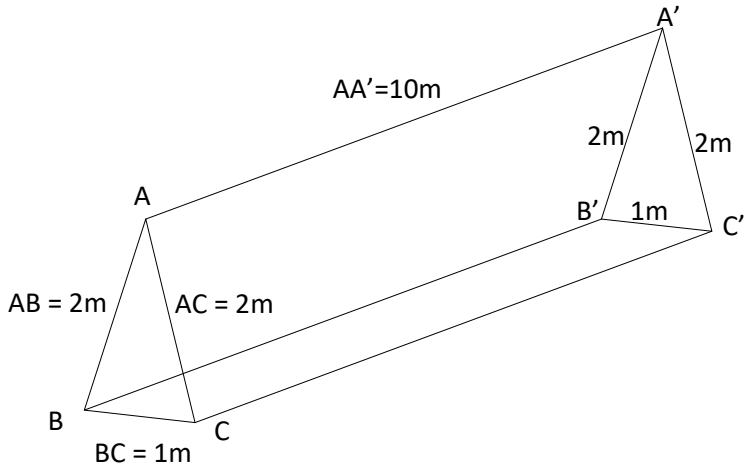


Figure 4. Long duct with triangular section.

6. Consider the stationary heat transfer by the differential method in the chimney shown in the figure. The calculation nodes selected based on the symmetry conditions are shown in the figure. The outer and inner surfaces of the chimney have a convection boundary condition with heat transfer coefficients h1 and h0. The corresponding boundary temperature temperatures are T1 and T2. Node spacing Lx = Ly = L and thermal conductivity is k. Using finite difference scheme to express the temperatures at node 1 to node 9 (you don't need to solve the system of the equations).

.

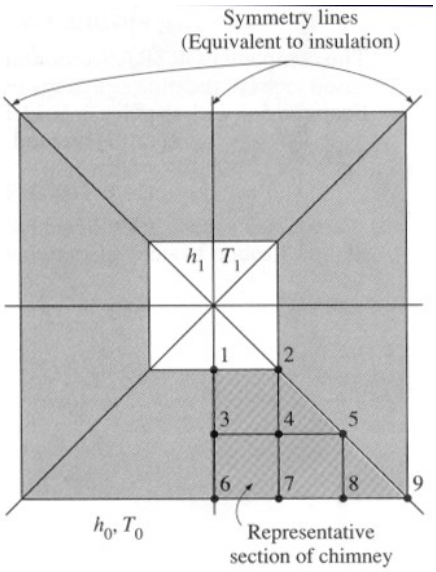


Figure 5. Nodal network of the chimney section.