Question #1

A thin wire dissipating 500W is suspended in a duct to heat air passing through it. The duct has a square cross section with width and height of 150 mm and is 0.5 m long. It is considered isothermal. Air enters the duct (fully developed) at 25°C with a volumetric flow rate of 0.02 m^3/s. The outer surface of the duct is also exposed to a cross flow of air at 25°C and 0.02 m/s and radiates to a very large room at 25°C as shown. Determine:

- Surface temperature of the duct?
- Mean temperature of the air at the exit of the duct?
- Quantity of heat transferred to the air?
- Discuss the implications of the assumptions used in this problem on the accuracy of your results

NOTE: *Estimate reasonable heat transfer coefficients if correlations can not be remembered.*

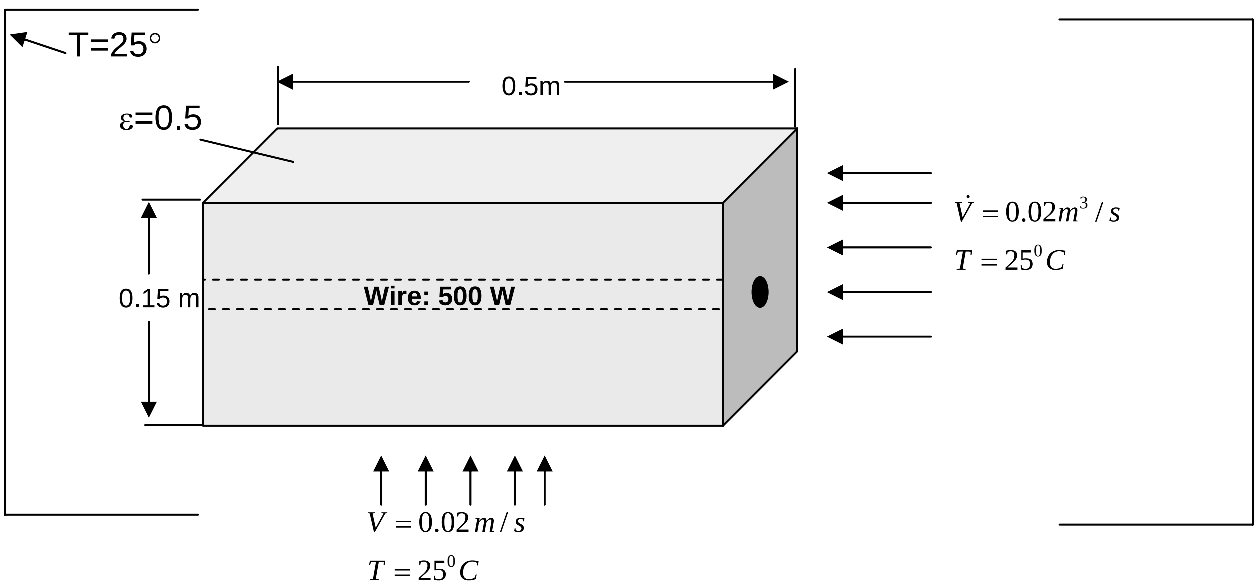
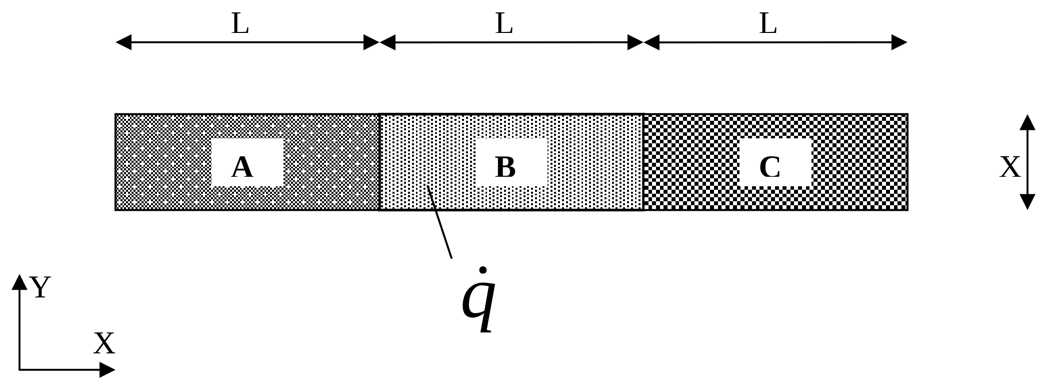


Table A.7 Gases[a]: Thermal properties

Gas	T K	k W/m K	ρ kg/m^3	c_p J/kg K	$\mu \times 10^{6\,b}$ kg/m s	$\nu \times 10^{6\,b}$ m^2/s	Pr
Air	150	0.0158	2.355	1017	10.64	4.52	0.69
(82 K BP)	200	0.0197	1.767	1009	13.59	7.69	0.69
	250	0.0235	1.413	1009	16.14	11.42	0.69
	260	0.0242	1.360	1009	16.63	12.23	0.69
	270	0.0249	1.311	1009	17.12	13.06	0.69
	280	0.0255	1.265	1008	17.60	13.91	0.69
	290	0.0261	1.220	1007	18.02	14.77	0.69
	300	0.0267	1.177	1005	18.43	15.66	0.69
	310	0.0274	1.141	1005	18.87	16.54	0.69
	320	0.0281	1.106	1006	19.29	17.44	0.69
	330	0.0287	1.073	1006	19.71	18.37	0.69
	340	0.0294	1.042	1007	20.13	19.32	0.69
	350	0.0300	1.012	1007	20.54	20.30	0.69
	360	0.0306	0.983	1007	20.94	21.30	0.69
	370	0.0313	0.956	1008	21.34	22.32	0.69
	380	0.0319	0.931	1008	21.75	23.36	0.69
	390	0.0325	0.906	1009	22.12	24.42	0.69
	400	0.0331	0.883	1009	22.52	25.50	0.69
	500	0.0389	0.706	1017	26.33	37.30	0.69

Question #2



Consider the above composite material of dimensions shown and unit depth, initially at temperature Θ = 0. The middle section receives uniform volumetric heating at a rate $\dot{q}$ beginning at time t = 0 and continuously thereafter.

The three sections of the composite, A, B, and C are homogeneous but each have different thermal conductivity (k_A, k_B, k_C), heat capacity (C_A, C_B, C_C),, and density (ρ_A, ρ_B, ρ_C). There is no thermal resistance at the A/B interface or at the B/C interface. The composite is suspended in fluid such that there is a uniform, constant convection coefficient h.

1. What condition(s) must be satisfied in order to assume that the temperature does not vary in the y-direction?

2. What condition(s) must be satisfied in order to assume that the entire composite material is at uniform temperature at any instant in time?

3. If the condition(s) for #2 are satisfied, approximately how long must we wait for the system to reach steady state?

4. If temperature does not vary in the y-direction and all of the thermophysical properties are the same for materials A, B and C except for $k_B >> k_A$, $k_B >> k_C$, and $k_A = 3\ k_C$, sketch Θ(x) immediately after the heating begins, at some later time but before steady state, and at steady state.

5. If temperature does not vary in the y-direction and all of the thermal properties are the same for materials A, B and C, in terms of the parameters given, what are the condition(s) such that no heat leaves the leftmost face of section A or the rightmost face of section C?

Question #3

The gray annulus shown in the Figure with the dimensions indicated is heated to 1000K. The total directional emissivity is indicated in the figure below. Calculate the following:

(a) Total emissive power and radiosity of the annulus.
(b) Solid angle corresponding to the annulus as viewed from the small disk located at the distance 1 m normal to the plain of the annulus (see
(c) The view (angle) factor from the annulus to the disk. Please evaluate using integration.
(d) The radiation intensity incident on the disk.
(e) The temperature of the disk assuming $T_{surroundings}$ is 300K.

State any assumptions you make clearly.