Family Name	
Given Names	
Student Number	
Teaching Period	Semester 2, 2016

FINAL EXAMINATION	DURATION
ENG481 – Applied Heat and Mass Transfer	Reading Time: **10** minutes Writing Time: **180** minutes

INSTRUCTIONS TO CANDIDATES

The examination has **FOUR** questions. Please answer **ALL** questions.

Note that all questions are of equal value.

The total marks for this examination is **100 marks**.

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
none	1 x 20 Page Book Manuscript Paper

THIS EXAMINATION IS PRINTED

DOUBLE-SIDED.

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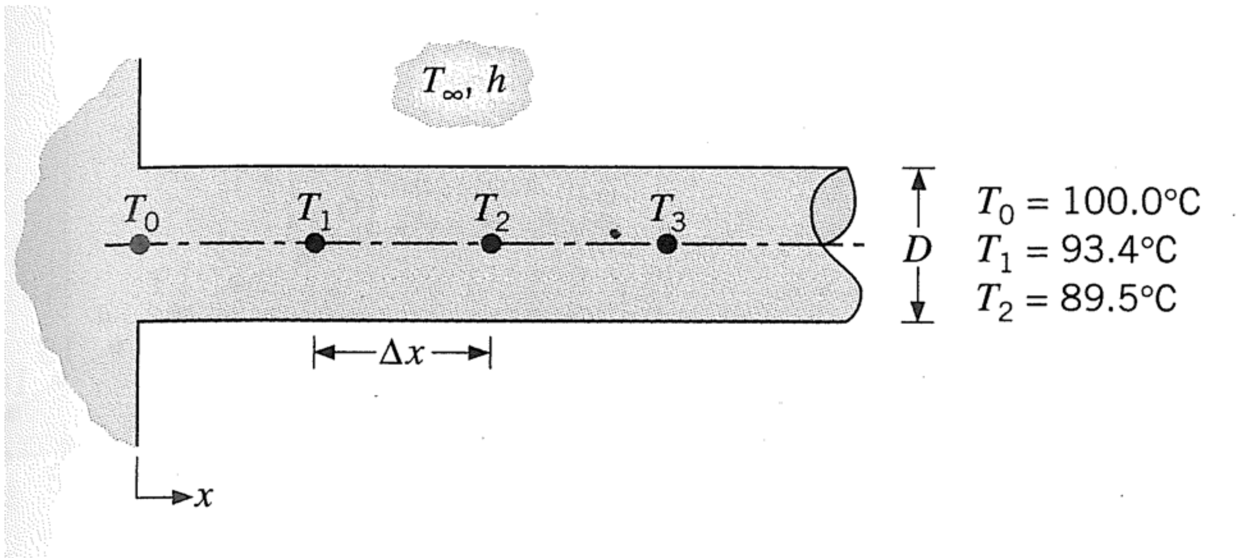
Question 1 **(25 marks)**

A steady-state, finite-difference analysis has been performed on a cylindrical fin with a diameter of 12 mm, and a thermal conductivity of 15 W/m·K. The convection process is characterized by a fluid temperature of 25 °C and a heat transfer coefficient of 25 $W/m^2 \cdot K$.

a) The temperature for the first three nodes, separated by a spatial increment of x = 10 mm, are given as shown. Determine the fin heat rate. *(15 marks)*

b) Determine the temperature at node 3, T_3. *(10 marks)*



Question 2 **(25 marks)**

On a cool day in April a scantily clothed runner is known to lose heat at a rate of 500 W because of convection to the surrounding air at $T_\infty = 10$ °C. The runner's skin remains dry and at a temperature of $T_s = 30$ °C. Three months after, the runner is moving at the same speed, but the day is warm and humid with a temperature of $T_\infty = 30$ °C and a relative humidity of $\varphi_\infty = 60$ %. The runner is now drenched in sweat and has a uniform surface temperature of 35 °C. Under both conditions, constant air properties may be assumed with $v = 1.6 \times 10^{-5}$ m^2/s, k = 0.026 W/m·K, Pr = 0.7 and D_{AB} (water vapor-air) = 2.3×10^{-5} m^2/s.

a) What is the rate of water loss due to evaporation on the summer day? *(15 marks)*

b) What is the total convective heat loss on the summer day? *(10 marks)*

[For saturated water vapor (T_∞ = 303 K): $\rho_{A,sat}$ = 0.030 kg/m^3; (T_s = 308 K): $\rho_{A,sat}$ = 0.039 kg/m^3, h_{fg} = 2419 kJ/kg]

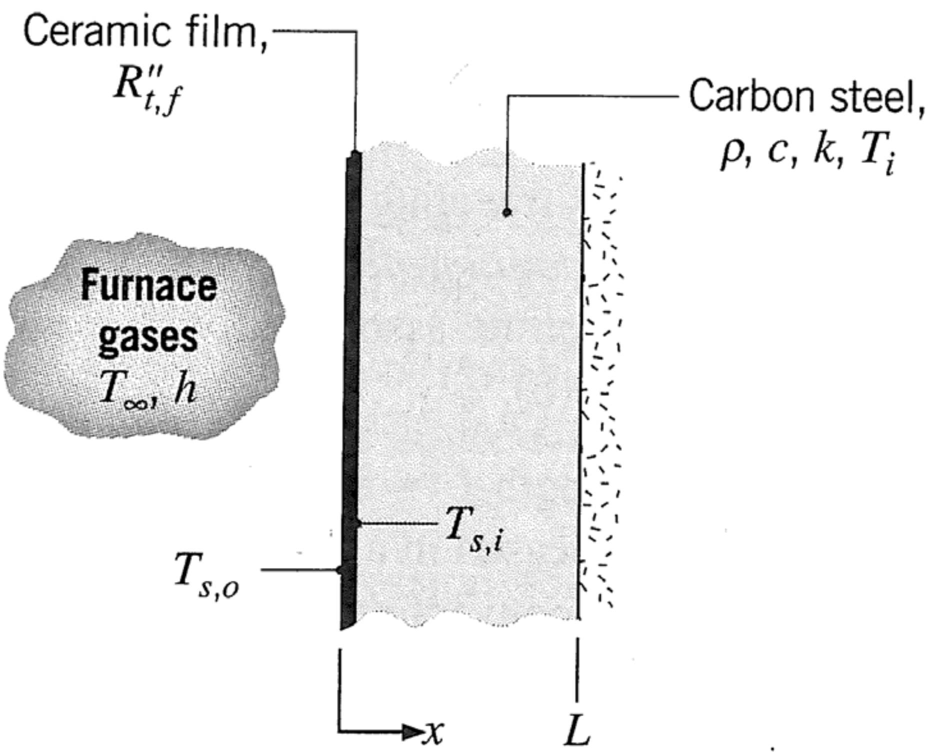
Question 3 **(25 marks)**

A plane wall of a furnace is fabricated from plain carbon steel (k = 60 W/m·K, ρ = 7850 kg/m^3, c = 430 J/kg·K) and is of thickness L = 10 mm. To protect it from the corrosive effects, one surface wall is coated with a thin ceramic film that has a thermal resistance of $R''_{t,f}$ = 0.01 m^2·K/W. The opposite surface is well insulated from the surroundings.

At the furnace start-up, the wall is at an initial temperature of T_i = 300 K, and combustion gases at T_∞ = 1300 K enter the furnace, providing a convection coefficient of h = 25 W/m^2·K at the ceramic film. Assuming the film has negligible thermal capacitance:

a) How long will it take for the inner surface of the steel to achieve a temperature of $T_{s,i}$ = 1200 K? *(15 marks)*

b) What is the temperature $T_{s,o}$ of the exposed surface of the ceramic film at this time? *(10 marks)*



Question 4 **(25 marks)**

Consider atmospheric air at U_∞ = 2 m/s and T_∞ = 300 K in parallel flow over an isothermal flat plate of length L = 1 m and temperature T_s = 350 K.

a) Compute the local convection coefficient at the leading and trailing edges of the heated plate with and without an unheated starting length of ξ = 1 m. *(18 marks)*

b) Compute the average convection coefficient for the plate for the same condition as part (a). *(7 marks)*

[For air at T_f = 325 K and 1 atm: v = 18.4 x 10^6 m^2/s, Pr = 0.703, k = 0.0282 W/m·K]