TÉCNICO LISBOA

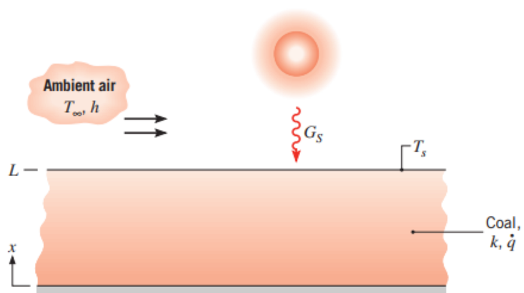
TEM – Transferência de Energia e Massa 2017/18

(22th June 2018)

Group 1.1 (Exam : 8/20; Test 16/20)

Justify every answer, using equations if convenient

A plane layer of coal of thickness L = 1m experiences uniform volumetric heat generation at a rate of q=20W/m^3 due to slow oxidation of the coal particles. The top surface of the layer transfers heat by convection to ambient air for which h=5 W/m^2 K and daily average temperature is T_a =25 C, while receiving solar irradiation in the amount G_S 400 W/m^2. Irradiation from and to the atmosphere may be neglected. The solar absorptivity and emissivity of the surface are equal to 0.95. The soil, under the coal can be considered a perfect insulator.



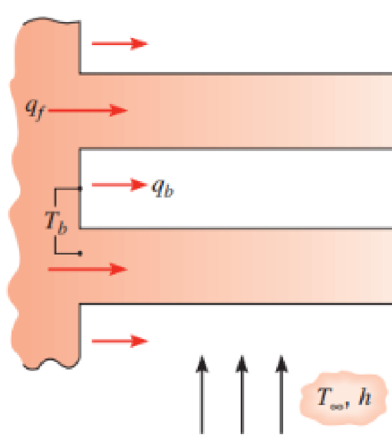
a) Why is it reasonable to assume the soil interface as adiabatic?
b) Draft the heat flux across the coal layer.
c) Write the equation of the heat flux across the interface with the atmosphere and compute the surface temperature, assuming that radiation at the surface is negligible.
d) Write the differential equation for the temperature in the layer and the boundary conditions. Verify that the temperature distribution is of the form:

$$T(x) = T_s + \frac{qL^2}{2k}\left(1 - \frac{x^2}{L^2}\right)$$

e) In fact, the solar radiation varies along the day. Sketch physically plausible temperature profiles across the coal layer at sunset and at sunrise (the issue is the difference between them)
f) Write the equation for the coal mass loss rate, relating the coal calorific power and the energy generated per unit of volume.
g) If the coal layer was covered with an insulator impermeable to heat and gas, how would the temperature of the coal layer change (increase, decrease, get uniform, …)?
h) If porosity of the coal decreases (e.g. compressing the layer) how will the rate of heat generated change?

Group 1.2 (Exam : 2/20; Test 4/20)

The figure below represents two fins belonging to a set with a large number of fins.



Comment the following sentences saying if they are true or false. (Try to support your rationale with a sketch of the temperature along the fin)

a) "Fins with very high ratio length/thickness are inappropriate"
b) "The heat lost through the top edge of the fin is more important in longer fins than in short fins"

TEM – Transferência de Energia e Massa 2017/18 Exame 1 – Part 2, 22th June 2018

Grupo 2.1: About evolution equations **(4 marks/20)**

The Temperature evolution equation written below aims to describe the temperature in a river of depth "h".

$$\frac{dT_w}{dt} = \frac{\partial T_w}{\partial t} + u\frac{\partial T_w}{\partial x} = \frac{\partial}{\partial t}\left(\vartheta \frac{\partial T_w}{\partial x}\right) + \frac{1}{h}h_s(T_{air} - T_w) + \frac{1}{h}h_L\left(e_{s,T_w} - r * e_{s,T_{air}}\right)$$

a) This equation misses an important term to simulate the surface heat flux during the day light period. Which term is this?
b) What are the "non-differential" terms representing? Why are they divided by the water depth?
c) Physically what is the difference between the total time-derivative and the partial time-derivative?
d) In fact, the equation that we have solved in the Assignment II was (plus the missing term):

$$\frac{\partial(\iiint T_w d_{Vol})}{\partial t} + \iint T_w(\vec{u}.\vec{n})\,dA = \iint \left(-\vartheta\vec{\nabla}T_w.\vec{n}\right) dA + A_H * h_s(T_{air} - T_w) + A_H * h_L\left(e_{s,T_w} - r * e_{s,T_{air}}\right)$$

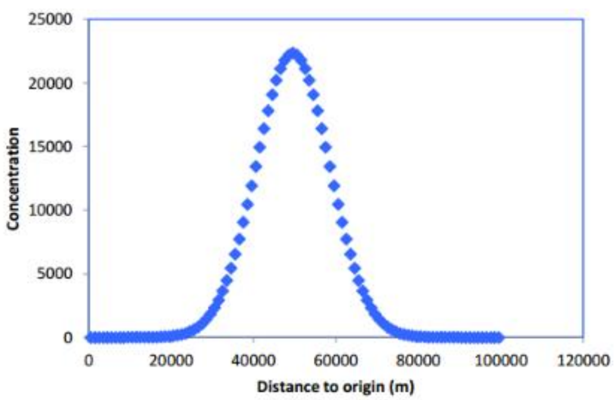
e) When are the two equations equivalent? (A_H is the surface area of the water volume Vol and A is the "wet" surface of the volume, i.e. the river cross section.

Grupo 2.2: Numerics **(3 marks/20)**

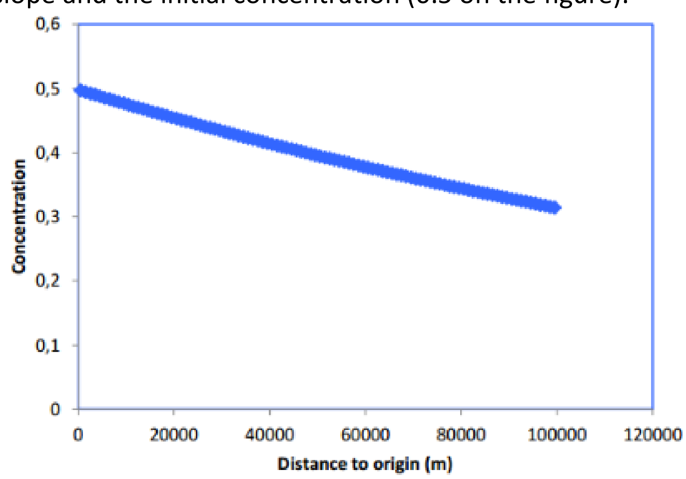
a) Taylor's series are used to compute differentials, transforming partial differential equations into algebraic equations, and providing information about truncation errors. What is the truncation error?
b) How is numerical diffusion related with spatial step?
c) How does violation of transportive property of advection contribute to generate negative concentrations?

Grupo 2.3: Model Results **3 marks/20)**

a) The figure below shows a permanent spatial distribution of a property in a 1D geometry. Tell if advection, diffusion or decay are present. Is there a permanent discharge?



b) The figure below represents another steady state spatial distribution. What can generate the gradient? How would the distribution change if the velocity increased? (think about the slope and the initial concentration (0.5 on the figure).



c) If we add a continuous discharge to solution b) at meter 60000 of the same substance how would the new profile look like? (you can plot on the same image).