UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For the following qualifications :-

B.Eng. *M.Eng.*

Biochemical Eng E124: Biotransport Processes II

COURSE CODE	:	**BENGE124**
UNIT VALUE	:	**0.25**
DATE	:	**30-APR-02**
TIME	:	**10.00**
TIME ALLOWED	:	**2 hours**

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Biochemical Engineering

E124

Bioheat Transfer Processes

ANSWER ***FOUR QUESTIONS***
Examination time: 2 hours
Additional information provided: *Graph paper*

1. A steam condenser contains 30 parallel straight tubes of 2cm outside diameter and 2mm wall thickness. Water flows through them in parallel at 30 cm/s. The inside film coefficient is given by:

$$Nu = 0.023\,\mathrm{Re}^{0.8}\,\mathrm{Pr}^{0.4}$$

and the outside film coefficient is 22.7×10^3 W/m^{2}K. If the inlet water temperature is 10°C, the outlet temperature 40°C and steam is condensing at 80°C, what is the effective surface area for heat transfer? [25]

For water, density=1000 kg/m^3; viscosity =10^{-3} Ns/m^2;
Specific heat capacity = 4.2×10^3 J/kg°C and
Thermal conductivity = 0.6 W/m°C
The thermal conductivity of steel = 45 W/m°C

2. Saturated steam free from air at 57.83 kPa condenses on the outer surface of 225 horizontal tubes of 0.0127 m outside diameter arranged in a 15-by-15 array. Tube surfaces are maintained at a uniform temperature T_w=75°C. Calculate the total condensation rate per meter length of the tube bundle using the following physical properties for the condensate. [15]

Thermal conductivity, k_l = 0.668 W/m°C
Liquid density, ρ_L = 974 kg/m^3
Liquid viscosity, μ_L = 0.335×10^{-3} kg/ms
Latent heat of steam at 57.83 kPa, h_{fg} = 2309×10^3 J/kg
Saturated temperature, T_s, of steam at 57.83 kPa = 85°C

Verify your results. [5]

The average heat transfer coefficient, h_L, for a horizontal array of N tubes each of diameter, D, and length L is given by:

$$h_L = 0.725\left[\frac{g\rho_L^2 h_{fg} k_L^3}{\mu_L (T_s - T_w) D}\right]^{1/4}\left[\frac{1}{N^{1/4}}\right]$$

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3. An 8cm thick slab having large dimensions in the plane normal to the thickness is initially at a uniform temperature of 20°C. Both surfaces of the slab are suddenly raised to and held at 100°C. The thermal diffusivity of slab is 0.0694×10^{-5} m^2/s. using a nodal spacing of 1cm numerically determine by the explicit method the temperature history in the slab during the first 0.1 hour period. [25]

4. A spherical metal object has a diameter of 50 mm and is initially at a uniform temperature of 450°C. It is suddenly placed in a oil bath maintained at a uniform and constant temperature of 100°C. The convection heat transfer coefficient may be assumed to be 10 W/m^2 °C. Using the lumped parameter approach calculate the time required for the ball to attain a temperature of 150°C. The physical and thermal properties of the object are as follows:

   Specific heat capacity = 0.46 kJ/kg °C; thermal conductivity = 35 W/m °C; density = 7800 kg/m^3.

   Verify the assumption that the lumped parameter method is applicable to this problem. [25]

5. A solid bar with a rectangular cross section, 50mm by 40 mm, is initially at a uniform temperature of 225°C. Suddenly the surfaces of the bar are subjected to a convective cooling environment with a heat transfer coefficient of 500 W/m^2 °C and a temperature of 25°C. Using the chart provided calculate the centre temperature of the bar after 2 min of exposure to the cooling environment. The thermal diffusivity of the bar is 1.6×10^{-5} m^2/s, its thermal conductivity is 60 W/m°C. [25]

END OF PAPER

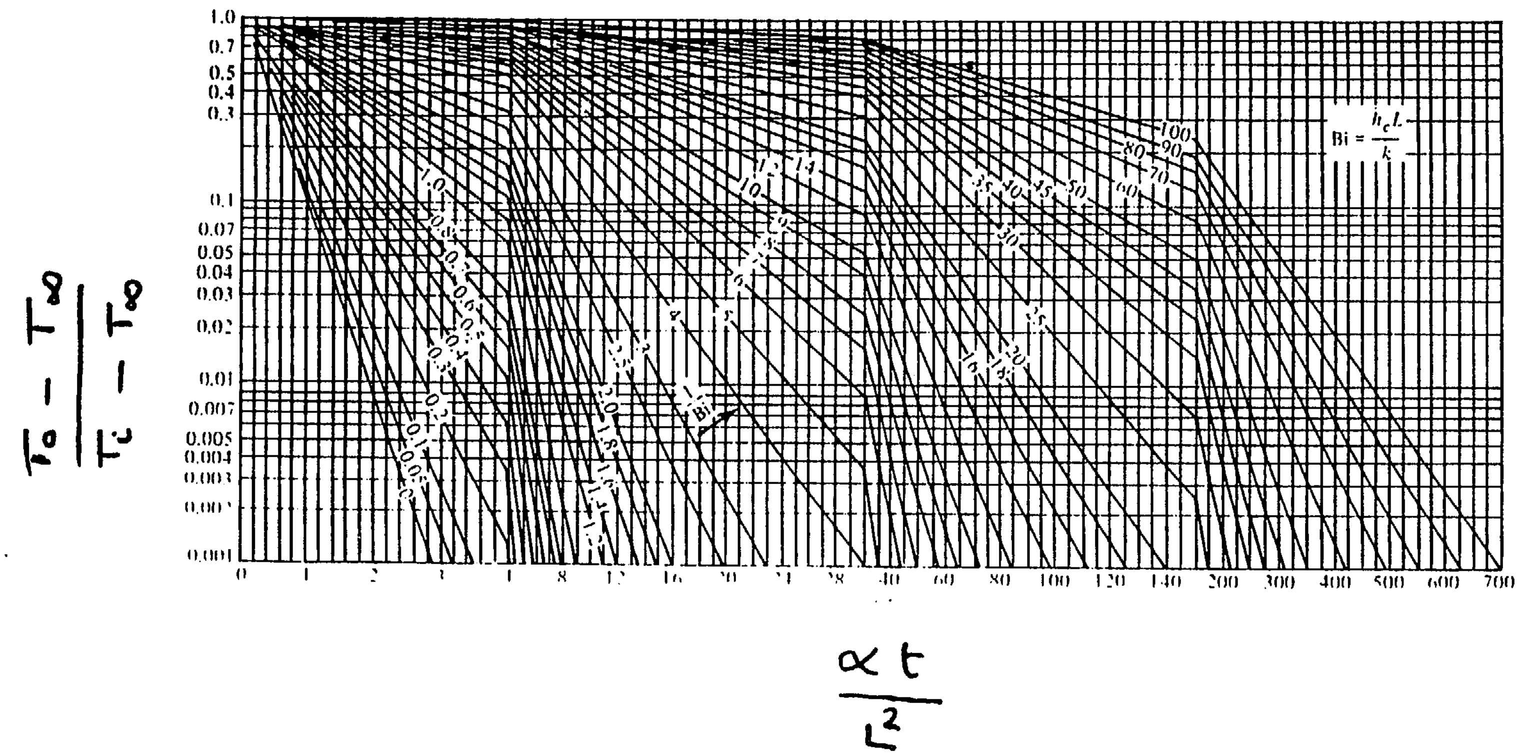

Chart for Q. 5

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