

Department of Mechanical Engineering
Indian Institute of Technology Delhi

MEL 802 -- II Semester 2009-2010

30th April, 2010

Major

Duration: 2 hrs

Full marks: 40

1. *You should clearly indicate the assumptions you make.*
2. *If you are unable to complete the detailed solution to a problem, outline the remaining steps unambiguously.*

Part A: Open notes. Photocopied notes are not allowed

1. For liquid metals (very low Prandtl number) the thermal boundary layers fill the tube near the entrance while the velocity distribution is still very nearly uniform (slug flow). An approximation for this case can be obtained by solving the energy equation with a uniform velocity. Show that under these conditions for a laminar flow in a circular pipe with constant heat flux rate, $Nu = 8.0$.

Note that thermal diffusion along the tube can be important with liquid metals but is ignored in this question. [12 marks]

2. A constant property fluid is in fully developed laminar flow in a circular tube with negligible dissipation. The fluid is initially at temperature T_i , and at a point in the flow it undergoes a step change in wall temperature to T_0 . At a distance downstream of this point, the fluid achieves a fully-developed temperature profile (*i.e.*, the dimensionless shape of the temperature profile has become invariant in x). This profile is given by:

$$\frac{T - T_0}{T_{CL} - T_0} = 1 - \left(\frac{r}{R}\right)^2$$

where T_{CL} is the local centerline temperature, r is the radial variable, and R is the tube radius.

Find the Nusselt number (using the tube diameter as the length dimension) associated with this profile. [6 marks]