30005

Heat Transfer (ME~~40107~~)

1st Class Test (4th September 2019)

Full marks: 20 **Duration: 60 minutes**

All questions are compulsory and they carry equal marks

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1. A thin electrical heater is inserted between concentric **solid sphere A** and a **hollow sphere B** as shown. The outer radii of A and B are **30 mm and 50 mm**, respectively. The material of sphere A has a thermal conductivity of **15 W/m.K**, while that of sphere B has a thermal conductivity of **1.5 W/m.K**. The outer surface of this assembly is subjected to convection with a convective heat transfer coefficient of **23 W/m².K** and a surrounding fluid temperature of **30°C**. Find a) The electrical heater power required to maintain the outer surface of the sphere B at **60°C** and b) Temperature at the centre of sphere A.

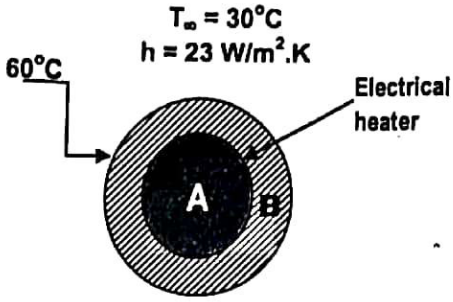

Fig. for Problem 1

2. A plate made of a special alloy 2 is sandwiched between two stainless steel plates 1 and 3 as shown in the figure. One surface of this assembly is maintained at **90°C** while the other surface is at **30°C** as shown. Plates 1 and 3 are **1 cm** thick with a thermal conductivity of **15 W/m.K**, while plate 2 is **2.5 cm** thick and its thermal conductivity is a function of temperature given by the following equation:

$k(T) = 12(1 + 0.2T)$, where k(T) is in W/m.K and T is in °C. Considering heat transfer only in x-direction, find the rate at which heat is transferred through the assembly per unit area.

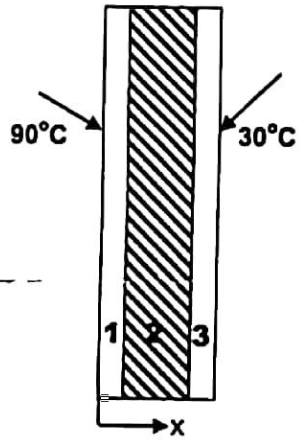

Fig. for Problem 2

3. An electronic chip has to reject **1.0 W** of heat into surrounding air which is at **25°C**. An **array of fins** are provided on the chip surface to enhance the heat transfer. The total heat transfer area of the array which includes both finned and unfinned portions is **5 cm²**, with fins providing **50 %** of the area (**2.5 cm²**). If the efficiency of the individual fins is **90 %**, find the base temperature of the fin array. Take a convective heat transfer coefficient value of **36 W/m².K** for both finned and unfinned portions of the assembly.

4. A thermocouple bead which is spherical in shape with a diameter of **0.5 mm** is used in the measurement of exhaust gas temperature of an automobile. The bead is initially at **30°C** and it records a temperature of **300°C** after **2 seconds**. If the true exhaust gas temperature measured by some other means is **450°C**, find the heat transfer coefficient between the bead and the exhaust gases. The thermal conductivity, density and specific heat of bead material are: **21.8 W/m.K**, **886 kg/m³** and **393 J/kg.K**, respectively. State and verify the assumption(s) made.

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