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GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Spring Quarter 1999

Heat Transfer
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

- **Please sign your name on the back of this page—**

Please **p r i n t** your name here.

The Exam Committee will get a copy of this exam and will not be notified whose paper it is until it is graded.

Ph.D. Qualifying Exams
Heat Transfer
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All problems are equal credit

1. It is proposed to model heat transfer in the core of nucle reactor.

A long solid cylindrical nuclear reactor core (thermal co uctivity k_c) made o uranium oxide is covered with a concentric shield (therm conductivity k_s; $k_s > k$ The unit is subjected to forced convection using pressu zed water. The rea core develops uniform volumetric heat generation whi is constant througl the core. There is no energy generation in the shield.

a. Draw a sketch of the steady state temperature di ibution in the core, shield and surrounding water.

b. Write the boundary conditions for the shi d/water interface, core/shield interface and the center of the core.

c. Write the form of differential equation(s) for the emperature distribu proposed in part (a).

d. Develop a solution for the differential equation plicable to the nuc reactor core.

e. How is the volumetric heat generation in the e related to core down.

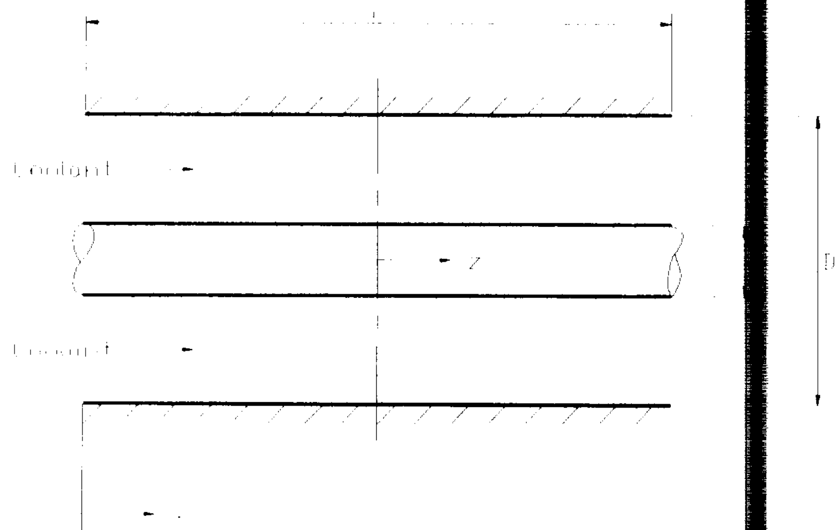
2.

In an experiment a metallic rod is placed along the axis of an nsulated pipe, as sh the figure. The rod is volumetrically heated at the rate of:

$$q = q_0 \cos(\pi z / L)$$

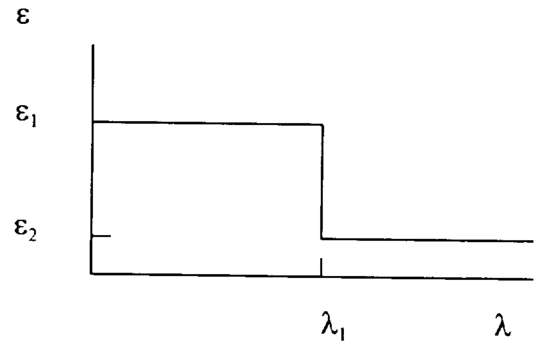
where q is the heat generation rate, per unit length. Axial co uction in the rod is negligible. The rod is cooled by an incompressible fluid that ows at a mass flow $\dot{m}$, and has constant density, ρ, and specific heat, C_p. The onvection heat trans coefficient between the rod and the coolant, h, is also assume constant. The cool inlet temperature is $T_{f,in}$.

Derive expressions for the axial variations of: a) the coolan emperature, $T_f(x)$ heated rod surface temperature, $T_s(x)$. Also, determine the l ation where the rod surface temperature is maximum.



3.

A disk-shaped heating element of diameter D and thickness t is ell-insulated on all su
except the top surface. The heating element is placed outside, nd its top surface e
irradiation from the sun. Outdoor air (temperature T_∞) flows ove the top surface cau i
convective heat transfer coefficient to be h. The top surface is diff e and its spectral em i
is shown below.



Assume that the power input to the heating element is known. Sh w how one should
the equilibrium temperature of the top surface of the heater. Justi all additional assum p
Develop your solution from fundamental principles and energy bala es, as appropriate.