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GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam - Fall Semester 2000

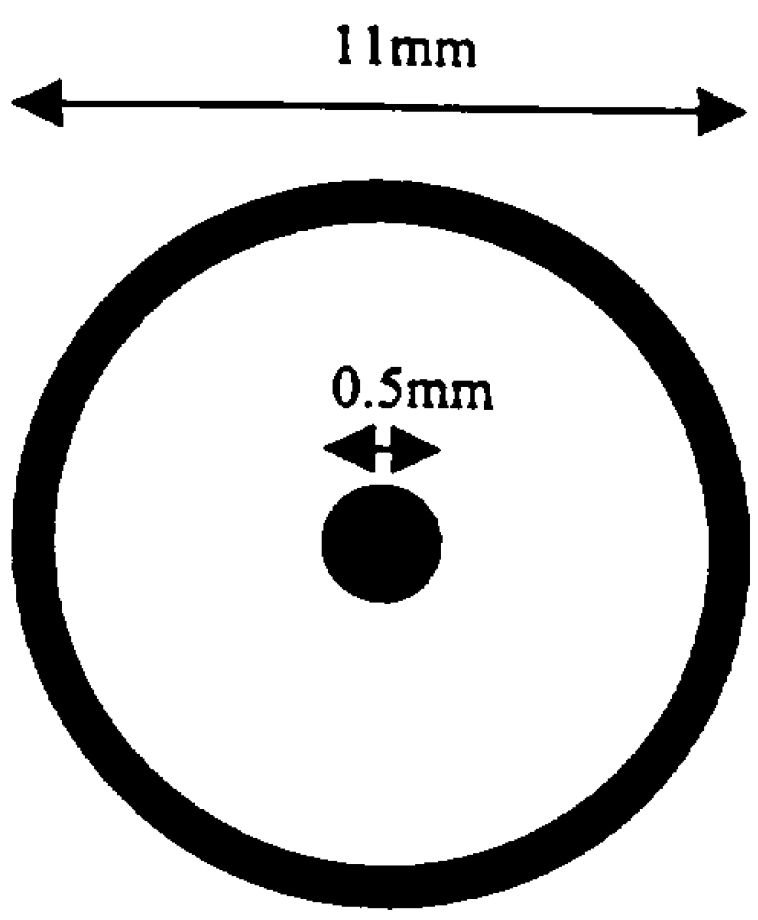
Heat Transfer
EXAM AREA

Assigned Number **(DO NOT SIGN YOUR NAME)**

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

Heat Transfer Written Qualifying Exam
Fall 2000

Problem 1



The electrical wire, dia. 11mm, shown above is carrying a current of 5 amperes in the central conductor, dia. 0.5mm, and 5 amperes in the outer shield. The insulation thickness is 5mm and has a thermal conductivity of 0.3W/mK. Given that the forced convection coefficient from the surface is $0.5 W/cm^2$-K and the ambient temperature is 20°C, calculate the maximum internal surface temperature of the insulating layer. Thermal conductivity of the aluminum wire is 250W/m-K and the resistance per meter of the central conductor is 0.1 ohms/m, the outer conductor is 0.05 ohms/m. (Assume uniform volumetric heat dissipation within each piece of conductor). Clearly state any assumptions that you make.

Problem 2

An estimate of the cyclic heat transfer between a regenerator matrix and a periodic fluid flow during one complete cycle may be obtained via a simple model described as follows:

A uniform stream of hot gas at a velocity $U_{\infty h}$ and a temperature $T_{\infty h}$ flows during its forward pass along the length L of a thin metallic matrix [width W, thickness d] at an initial temperature $T_i < T_{\infty h}$ for one half of the cycle period. At the end of this time, when the matrix temperature is raised to a value T_1, a uniform stream of cold gas at a velocity $U_{\infty c}$ and a temperature $T_{\infty c} < T_i$ flows in the opposite direction during the return pass along the matrix length for the second half of the cycle, lowering the matrix temperature to a value $T_2 < T_i$.

Perform an analysis to relate T_1, T_2, the thermophysical properties of the matrix and the fluid, the hot and cold stream velocities and temperatures and the geometry of the matrix. Comment on the asymptotic behavior of the system.

Problem 3

The schematic below shows an unmanned spacecraft that enters the atmosphere of an unknown planet and travels through it with known velocity V. The atmosphere of the planet consists of unknown gaseous matter and is kept at high temperature (T_s).

To protect the on-board computer from the excessive thermal load, the spacecraft is supplied with a thin highly reflecting radiation shield, which is attached by means of very thin metal rods, and vacuum conditions are imposed in the enclosure between the spacecraft and the radiation shield.

Suppose that the materials of the spacecraft and of the radiation shield are isotropic with known thermophysical and radiative properties. If the initial temperature (i.e., when it just entered the atmosphere) of the spacecraft and of the shield is the same and equal to T_0, find the law that governs the transient temperature evolution of the spacecraft [i.e., $T_2(t)$]?

Don't attempt to obtain the closed-form solution of the problem!!! Only formulate the problem in terms of relevant parameters, make all appropriate assumptions and justify them, state the boundary and initial conditions, and discuss how you'll go about finding the solution (in a few words). Remember, this problem can be solved in many possible ways depending upon the assumptions you make...so be sure to back every step of your analysis by appropriate assumptions.