**More Tutorial Problems for Exam 1**

**ABE 30800**

**Problem 1**

Radioactive wastes are packed in a thin-walled spherical container. The wastes generate thermal energy non-uniformly according to the following relationship:



where *Q* is the local rate of energy generation per unit volume, *Qo* is a constant and *ro* is the radius of the container. Steady state conditions are maintained by submerging the container in a liquid that is at  and provides a uniform convection coefficient *h*. Determine the temperature distribution, *T(r)*, in the container. Express your result in terms of *Qo, ro,  h* and the thermal conductivity of the radioactive wastes.

**Problem 2**

The air inside a chamber at  = 50oC is heated convectively with *hi*= 20 W/m2.K by a 200mm thick wall having a thermal conductivity of 4W/m.K and uniform heat generation of 1000 W/m3. To prevent any heat generated within the wall from being lost to the outside of the chamber at ** = 25oC with *ho*= 5 W/m2.K, a very thin electrical strip heater is placed on the outer wall to provide a uniform heat flow, *q”o.*

(a) Sketch the temperature distribution in the wall on *T – x* coordinates for the condition where no heat generated within the wall is lost to the outside of the chamber.

(b) What are the temperatures at the wall boundaries *T(0)* and *T(L)*, for the conditions of part (a).

(c) Determine the value of *q”o* that must be supplied by the strip heater so that heat generated within the wall is transferred to the inside of the chamber.

(d) If the heat generation is the wall was switched off while the heat flux to the strip heater remained constant, what would be the steady-state temperature *T(0)* of the outer wall surface?

**Problem 3**

One modality for destroying malignant tissue involves imbedding a small spherical heat source of *ro* within the tissue and maintaining local temperatures above a critical value *Tc* for an extended period. Tissue that is well removed from the source may be assumed to remain at normal body temperature (*Tb* = 37oC). Obtain a general expression for the radial temperature distribution in the tissue under steady-state conditions for which heat is dissipated at a rate *q*. If *ro* = 0.5mm what heat rate must be supplied to maintain a tissue temperature of  in the domain ? The tissue thermal conductivity is approximately 0.5 W/m.K.

**Problem 4**

A spherical, cryosurgical probe may be imbedded in diseased tissue for purpose of freezing, and thereby, destroying the tissue. Consider a probe of 3mm diameter whose surface is maintained at -30oC when imbedded in tissue that is at 37oC. A spherical layer of frozen tissue forms around the probe, with a temperature of 0oC existing at the phase front (interface) between the frozen and normal tissue. If the thermal conductivity of frozen tissue is approximately 1.5W/m.K and heat transfer at the phase front may be characterized by an effective convection coefficient of 50W/m2.K, what is the thickness of the layers of frozen tissue?