**ChE 505 Final Exam**
**Administered: Thursday, December 9, 1999**

**Problem (1)**
Classify the following PDEs in terms of (a) linearity vs nonlinearity (b)hyperbolic, elliptic, or parabolic, and (c) spatial dimensionality.

$$\frac{\partial T}{\partial t} = -D\frac{\partial^2 T}{\partial x^2} + v\frac{\partial T}{\partial x} + k\left(T - T_o\right)$$

$$\frac{\partial^2 T}{\partial t^2} - a\frac{\partial T}{\partial t} = -c\frac{\partial^2 T}{\partial x^2} + k\sqrt{\left(T - T_o\right)}$$

$$0 = -c_x\frac{\partial^2 T}{\partial x^2} - c_y\frac{\partial^2 T}{\partial y^2} - c_z\frac{\partial^2 T}{\partial z^2} + kzT$$

**Problem (2)**
For each of the three PDEs in problem (1), give a complete set of initial conditions and boundary conditions.

**Problem (3)**
Describe in words and diagrams and algorithmic flowsheets, how one numerically accounts for a Neumann Boundary Condition of the type:

$$p(x,t)\frac{\partial T}{\partial x} = q(x,t)T + g(x,t)$$

**Problem (4)**
Classify the following order in terms of (i) linearity vs nonlinearity, (ii) Volterra vs Fredholm, (iii) IE of the first kind vs second kind.

$$\phi(x) = f(x) + \lambda\int_0^x K(x,s)\phi(s)ds$$

**Problem (5)**
Numerically integrate using Trapezoidal or Simpson's 1/3, use intervals $n_y = n_x = 2$:

$$I = \int_0^1\int_0^y xydxdy$$

**Problem (6)**
Consider water flowing through a horizontal pipe that is initially empty. If there is not enough flow to fill the pipe cross-section with water, set up the equations to describe the transient flow-system.