Math 257/316, Midterm 1, Section 101
9 am on 17 th of October 2018

Instructions. The duration of the exam is 55 minutes. Answer all questions. Calculators are not allowed. A formula sheet is provided.

Maximum score 50.

1. Consider the second order differential equation:

$$Ly = 9x^2y'' + (x+2)y = 0 \tag{1}$$

   (a) Classify the points $0 \leq x < \infty$ as ordinary points, regular singular points, or irregular singular points. For any regular singular points determine the roots of the corresponding indicial equation.

   [7 marks]

   (b) If you were given $y(2) = 1$ and $y'(2) = 0$, what form of series expansion would you assume (**Do not** determine the expansion coefficients of this series)? What would be the minimal radius of convergence of this series?

   [3 marks]

   (c) Use the appropriate series expansion about the point $x = 0$ to determine two independent solutions to (1). You only need to determine the first three non-zero terms in each case. What is the minimal radius of convergence of these series?

   [20 marks]

2. Apply the method of separation of variables to determine the temperature $u(x,t)$ in a conducting circular ring of radius 1 that involves heat loss to the surroundings at a rate γu where $\gamma > 0$. The initial-boundary value problem satisfied by $u(x,t)$ is given by:

$$\begin{aligned} \frac{\partial u}{\partial t} &= \frac{\partial^2 u}{\partial x^2} - \gamma u, \qquad -\pi < x < \pi,\ t > 0 \\ \text{BC} &: \ u(-\pi,t) = u(\pi,t) \text{ and } \frac{\partial u(-\pi,t)}{\partial x} = \frac{\partial u(\pi,t)}{\partial x} \\ \text{IC} &: \ u(x,0) = \cos 2x \end{aligned}$$

   Please show all the cases when solving the appropriate eigenvalue problem.

   Hint: When separating the variables, group the γ term with the time ordinary differential equation.

   [20 marks]