A. Computation (20 points each) Solve the following first order differential equations by hand. State what method you are using (for example: linear, separable, exact) and show all steps.

1. $\dfrac{dy}{dx} + 3x^2 y = 0$
2. $(x - t)\,dt + dx = 0$
3. Initial value problem: $\dfrac{dy}{dx} - xy = \dfrac{x}{y}, \qquad y(0) = 1$

B. Problem Solving (15 points each) In the following problems, the words are as important as the numbers. Define the variables that you employ and explain what assumptions you make to arrive at a mathematical model.

4. Consider the differential equation $\dfrac{dx}{dt} = \dfrac{1}{10} - \dfrac{x}{1+t}$. Invent a scenario involving a swimming pool for which this differential equation is an appropriate model. You are not required to solve the equation.
5. When a pie is finished cooking, it is removed from a hot oven at 8:00 PM and set on a kitchen counter to cool. At 8:30 PM, the temperature of the pie is 185°F. At 9:00 PM, the temperature of the pie is 119°F. The temperature of the kitchen is 75°F. What was the temperature of the oven?

C. Theory (10 points) You may do this problem either by hand or with the computer. If you choose to use the computer (for example, to draw direction field plots using Maple's `DEplot` command), first hand in your blue book containing your solutions to the other problems.

6. This problem is personalized. Let A denote your student identification number, expressed as a decimal. (For example, the ID number 987-65-4321 would correspond to $A = 0.987654321$.) Let B denote your group number (which is a whole number between 1 and 12).

   Suppose that the population P of the Puorg marmots in Rebmundi province satisfies the peculiar differential equation $\dfrac{dP}{dt} = AP - B\sin(P)$, where the constants A and B are specified in the preceding paragraph. You cannot expect to solve this nonlinear equation with an explicit formula.

   Discuss the behavior of the population $P(t)$ as $t \to \infty$. In particular, how does the long-term behavior of the population depend on the initial value of the population?