Closed book, closed notes. Simple calculators are allowed. Work all problems. The first 2 problems are multiple choice. Please circle the correct answer. Only the correct answer will receive credit -- there is no partial credit. Problems 3-7 are free response. Please work the problem in the space provided, and show all work. Partial credit will be given. A correct answer may receive less than full credit if the work is incomplete or incorrect. If you need extra space, work on the back of the pages, or attach extra sheets. Please clearly label all work.

(10) 1. What is $\dfrac{d^2}{dx^2}\left(e^{-3x}\right)$?

      (a) $-3e^{-3x}$

      (b) $-6e^{-3x}$

      (c) $-9e^{-3x}$

      (d) $9e^{-3x}$

      (e) None of the above.

(10) 2. Suppose that the functions $f(x)$ and $g(x)$ are differentiable and that $g(1)=2$, $f(2)=4$, $g'(1)=3$, $f'(2)=5$. Let $h(x)=f\circ g(x)$. Which of the following statements is true?

      (a) $h'(1)=8$

      (b) $h'(1)=15$

      (c) $h'(2)=8$

      (d) $h'(2)=15$

      (e) None of the above.

(15) 3. Compute the following limits.

(5)   a. $\lim\limits_{x\to 0}(1+x)^{2/x}$

(5)   b. $\lim\limits_{x\to\infty}\dfrac{e^x-e^{-x}}{e^x+e^{-x}}$

(5)   c. $\lim\limits_{x\to 1+}\dfrac{1+x}{1-x}$

(20) 4. Suppose that you start an experiment with 1 kg of the radioactive element Rn^{222}. Let $W(t)$ be the total mass of the remaining quantity of Rn^{222}, measured in kg, where t is the elapsed time since the beginning of the experiment, measured in days. Assume that Rn^{222} has a half-life of exactly 4 days.

    (10) a. Compute $\dfrac{dW}{dt}$ exactly one week after the beginning of the experiment.

    (10) b. Compute $\dfrac{dW}{dt}$ when the total mass of the remaining quantity of Rn^{222} reaches 1 mg.

        (1 mg $= 10^{-6}$ kg).

(15) 5. Consider the curve $x^2 + y^2 + \sin y = 2x$. Compute $\dfrac{dy}{dx}$ and $\dfrac{d^2 y}{dx^2}$ when $(x, y) = (0,0)$.

(15) 6. Use the method of linear approximation to estimate $\cot(46°)$. Hint: $\cot(45°) = 1$.

(15) 7. Compute the following derivatives. Simplify your answer.

    (5) a. $\dfrac{d}{d\theta}\left(\dfrac{\tan\theta}{1 + \tan\theta}\right)$

    (5) b. $\dfrac{d}{dx}\left(\dfrac{2}{e^x - e^{-x}}\right)$

    (5) c. $\dfrac{d}{dx}\left(e^x \sqrt{\sin x}\right)$