NAME (please print legibly): __________________________________________
Your University ID Number: __________________________________________
Circle your Instructor’s Name along with the Lecture Time:

Zokhrab Moustafaev (MWF 9:00 - 9:50)  Carl Mueller (MW 3:25 - 4:40)

- No calculators are allowed on this exam.
- You must do both parts of the final. The first part can make up for a bad midterm grade, but the midterms cannot make up for the first part of the final.
- Please show all your work. You may use back pages if necessary. You may not receive full credit for a correct answer if there is no work shown.
- Please put your final answers in the spaces provided.

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Part A

1. (16 pts) Let

\[ f(x) = \frac{1}{3}x^3 - 2x^2 + 3x \]

(a) (5 points) Find the intervals on which \( f(x) \) is increasing and decreasing.

(b) (5 points) Find the local extrema of \( f(x) \).
(c) (6 points) Find the intervals on which $f$ is concave up and concave down.

2. (14 pts)

Let

$$y = \frac{x^2 - 2x + 2}{2x^2 - 5x + 3}.$$

(a) (7 points) Find the vertical asymptotes.
(b) (7 points) Find the horizontal asymptotes.

3. (20 pts)

A box with a square base and open top must have a volume $32m^3$. Find the dimensions of the box that minimizes the amount of material used.
4. (16 pts)

Differentiate the following functions.

(a) (8 points)

\[ \int_0^x e^{-2t^2} \, dt \]

(b) (8 points)

\[ \int_0^{x^3} \sin(t^2) \, dt \]
5. (24 pts)

Evaluate the following integrals.

(a) (8 points)
\[ \int (x^2 - e^{2x} + \cos(3x)) \, dx \]

(b) (8 points)
\[ \int \frac{dx}{x \ln(2x)} \]

(c) (8 points)
\[ \int_0^{\ln(\pi/4)} e^x \cos(e^x) \, dx \]
6. (20 pts)

Find the area between the curves

\[ y = x^2, \quad y = x, \quad x = 0, \quad x = 2 \]
7. (20 pts)

Find the volume of the solid obtained by rotating about the line \( y = 2 \), the region enclosed by the curves

\[ y = \sqrt{x} \]

and

\[ y = x. \]
8. (20 pts)

A spring has a natural length of 0.1\(m\). If a 20\(N\) force is required to keep it stretched to a length 0.3\(m\), how much work is required to stretch it from 0.1\(m\) to 0.2\(m\)?
Part B

9. (16 pts) Solve the following integrals.

(a) (8 points)
\[ \int x^2 e^{-2x} \, dx \]

(b) (8 points)
\[ \int \frac{\ln x}{x^3} \, dx \]
10. (28 pts)

(a) (9 points) Find 
\[ \int \sin^2(x) \cos^3(x) \, dx \]

(b) (10 points) Find 
\[ \int \sin^2(x) \cos^2(x) \, dx \]

(c) (9 points) Find 
\[ \int \tan(x) \sec^3(x) \, dx \]
11. (18 pts) Solve the following integrals.

(a) (9 points)

\[ \int \frac{x^3}{\sqrt{25 - x^2}} \, dx \]

(b) (9 points)

\[ \int \frac{dx}{x^2 \sqrt{x^2 + 4}} \]
12. (36 pts) Solve the following integrals.

(a) (9 points)
\[ \int \frac{2}{x^2 - x - 6} \, dx \]

(b) (9 points)
\[ \int \frac{x^2 - x + 2}{x + 1} \, dx \]
(c) (9 points)

\[ \int \frac{x + 4}{x^3 + 2x^2} \, dx \]

(d) (9 points)

\[ \int \frac{1}{x^3 + 3x^2 + 2x} \, dx \]
13. (8 pts) Approximate

$$\int_0^4 \sqrt{x^3 + 1} \, dx$$

using 4 intervals of equal length, using the trapezoidal rule. You do not have to evaluate the square roots.
14. (16 pts) Solve the following integrals.

(a) (8 points)
\[ \int_{-1}^{4} \frac{1}{(x - 1)^4} \, dx \]

(b) (8 points)
\[ \int_{-3}^{-1} \frac{1}{(x + 2)^{1/3}} \, dx \]
15. (8 pts) For the following problem, SET UP THE INTEGRAL, BUT DO NOT SOLVE IT. What is the length of the curve $y = x^3 + x$ between $x = -1$ and $x = 3$?
16. (10 pts) Suppose that a cubical tank with 2 meters on each side is full of water. Find the force on one of the vertical sides, in Newtons.
17. (10 pts) Find the center of mass of a right triangle with vertices at (0, 0), (0, 1), and (1, 0).