



Center for Academic Resources in Engineering (CARE) Peer Exam Review Session

Math 231 — Calculus II

Midterm 2 Worksheet Solutions

The problems in this review are designed to help prepare you for your upcoming exam. Questions pertain to material covered in the course and are intended to reflect the topics likely to appear in the exam. Keep in mind that this worksheet was created by CARE tutors, and while it is thorough, it is not comprehensive. In addition to exam review sessions, CARE also hosts regularly scheduled tutoring hours.

Tutors are available to answer questions, review problems, and help you feel prepared for your exam during these times:

Session 1: October 26th, 4:00 - 5:20 pm Maya and Hriday

Can't make it to a session? Here's our schedule by course:

<https://care.grainger.illinois.edu/tutoring/schedule-by-subject>

Solutions will be available on our website after the last review session that we host.

Step-by-step login for exam review session:

1. Log into Queue @ Illinois: <https://queue.illinois.edu/q/queue/844>
2. Click "New Question"
3. Add your NetID and Name
4. Press "Add to Queue"

Please be sure to follow the above steps to add yourself to the Queue.

Good luck with your exam!

1. Determine whether the integral converges or diverges. If so, what value does the integral converge to?

$$\int_5^{\infty} \frac{1}{n(\ln(n))^2}$$

$$= \int_5^{\infty} \frac{1}{x(\ln(x))^2} dx \quad [u = \ln(x), du = \frac{1}{x}]$$

$$= \frac{-1}{\ln(x)} \Big|_5^{\infty} = \frac{1}{\ln(5)} \rightarrow \text{so the integral converges.}$$

2. We want to evaluate

$$\int_0^2 x^2 dx$$

using a Riemann sum of $n = 3$ terms. Let us define L_3 as the Riemann Sum if we choose the left endpoints and R_3 if we choose the right endpoints. Then:

(a) $L_3 = \frac{9}{32}, R_3 = \frac{15}{32}$

(b) $L_3 = \frac{40}{27}, R_3 = \frac{112}{27}$

(c) $L_3 = \frac{15}{81}, R_3 = \frac{41}{81}$

(d) $L_3 = \frac{7}{32}, R_3 = \frac{55}{36}$

(e) $L_3 = \frac{53}{36}, R_3 = \frac{55}{36}$

We have $\Delta x = \frac{2}{3}$

Choose the left-hand endpoints

$$x_1 = 0, x_2 = \frac{2}{3}, x_3 = \frac{4}{3}$$

$$L_3 = f(x_1)\Delta x + f(x_2)\Delta x + f(x_3)\Delta x$$

$$0^2\left(\frac{2}{3}\right) + \left(\frac{2}{3}\right)^2\left(\frac{2}{3}\right) + \left(\frac{4}{3}\right)^2\left(\frac{2}{3}\right)$$

$$L_3 = \frac{40}{27}$$

Now, choose the right endpoints

$$x_1 = \frac{2}{3}, x_2 = \frac{4}{3}, x_3 = 2$$

$$R_3 = f(x_1)\Delta x + f(x_2)\Delta x + f(x_3)\Delta x$$

$$\left(\frac{2}{3}\right)^2 \left(\frac{2}{3}\right) + \left(\frac{4}{3}\right)^2 \left(\frac{2}{3}\right) + (2)^2 \left(\frac{2}{3}\right)$$

$$R_3 = \frac{112}{27}$$

3. Test the following improper integral for convergence. If it converges, find the value

$$\int_0^{\infty} e^{-\frac{4}{3}y} dy$$

- (a) Diverges
- (b) Converges, value is $-\frac{3}{4}$
- (c) Converges, value is $\frac{4}{3}$
- (d) Converges, value is $\frac{3}{4}$
- (e) None of the above

This is an improper integral, so we need to check for convergence.

$$\lim_{t \rightarrow \infty} \int_0^t e^{-\frac{4}{3}y} dy$$

$$\lim_{t \rightarrow \infty} \left(\frac{-3}{4} e^{-\frac{4}{3}y} \right) \Big|_0^t$$

$$\lim_{t \rightarrow \infty} \left(\left(\frac{-3}{4} e^{-\frac{4}{3}t} \right) - \left(-\frac{3}{4} e^0 \right) \right)$$

$$\lim_{t \rightarrow \infty} \frac{-3}{4e^{\frac{4}{3}t}} + \frac{3}{4}$$

$$\frac{-3}{\infty} + \frac{3}{4} = \boxed{\frac{3}{4}}$$

4. Determine if the following integral is convergent or divergent:

$$\int_2^{\infty} \frac{\cos^2 x}{x^2} dx$$

To solve this we must use the comparison test. Note that the numerator is bounded by:

$$0 \leq \cos^2 x \leq 1$$

Therefore the behavior of the denominator will determine the convergence/divergence. The integral

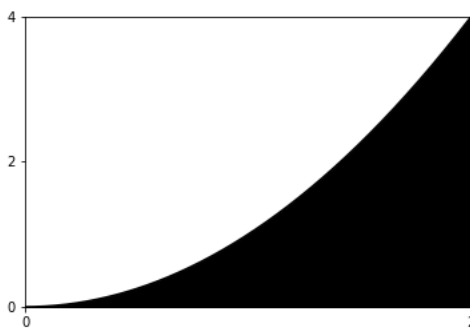
$$\int_2^{\infty} \frac{1}{x^2} dx$$

must converge via the p -test since $p = 2 > 1$. Putting these two facts together, we see that

$$\frac{\cos^2 x}{x^2} \leq \frac{1}{x^2}$$

, as the numerator of $\cos^2 x$ will always be ≤ 1 . Since $\int_2^{\infty} \frac{1}{x^2} dx$ converges, then our original integral $\int_2^{\infty} \frac{\cos^2 x}{x^2} dx$ must converge.

5. Find the M_x , M_y , and the centroid of $y = x^2$ with density λ on $x \in [0, 2]$.



$$mass = \lambda \int_0^2 x^2 dx = \frac{\lambda}{3} x^3 \Big|_0^2 = \frac{8\lambda}{3}$$

$$M_x = \frac{\lambda}{2} \int_0^2 (x^2)^2 dx = \frac{\lambda}{10} x^5 \Big|_0^2 = \frac{16\lambda}{5}$$

$$M_y = \lambda \int_0^2 x(x^2) dx = \frac{\lambda}{4} x^4 \Big|_0^2 = 4\lambda$$

$$\text{Centroid } (x, y) = \left(\frac{M_y}{mass}, \frac{M_x}{mass} \right) = \left(\frac{3}{2}, \frac{6}{5} \right)$$

6. Consider the curve $y = 5\ln(x)$ between the points $(1, 0)$ and $(e, 5)$.
- SET UP, BUT DO NOT EVALUATE, a dx -integral which represents the arc length of the curve.
 - SET UP, BUT DO NOT EVALUATE, a dy -integral which represents the arc length of the curve.
 - SET UP, BUT DO NOT EVALUATE, a definite integral which represents the surface area of the surface obtained by rotating the curve around the line $y = 10$.

$$\text{A. } ds = \sqrt{1 + \left(\frac{dy}{dx}\right)^2} dx, \quad y' = \frac{5}{x}, \quad ds = \int_1^e \sqrt{1 + \left(\frac{5}{x}\right)^2}$$

B. $y = 5 \ln(x)$, $e^{\frac{y}{5}} = e^{\ln(x)}$, $x = e^{\frac{y}{5}}$, $x' = \frac{e^{\frac{y}{5}}}{5}$, $ds = \int_0^5 \sqrt{1 + \left(\frac{e^{\frac{y}{5}}}{5}\right)^2} dy$

C. $SA = \int 2\pi y ds$, $ds = \sqrt{1 + \left(\frac{e^{\frac{y}{5}}}{5}\right)^2} dy$, $SA = 2\pi \int_0^5 (10 - y) \sqrt{1 + \left(\frac{e^{\frac{y}{5}}}{5}\right)^2} dy$

7. The profile $y = \sqrt{4 - x^2}$ on the interval $x \in [-1, 1]$ is revolved around the x -axis. Find the surface area of this surface.

Use the following formula to find the surface area of an arc rotated about the x -axis:

$$S = \int 2\pi y ds$$

$$\text{where } ds = \sqrt{1 + \left(\frac{dy}{dx}\right)^2} dx$$

We choose to integrate with respect to x since we are given that interval.

$$S = \int_{-1}^1 2\pi y \sqrt{1 + \left(\frac{-x}{\sqrt{4 - x^2}}\right)^2} dx$$

We can simplify the square root term from the ds .

$$\sqrt{1 + \left(\frac{-x}{\sqrt{4 - x^2}}\right)^2} = \sqrt{1 + \frac{x^2}{4 - x^2}} = \sqrt{\frac{4 - x^2}{4 - x^2} + \frac{x^2}{4 - x^2}} = \sqrt{\frac{4}{4 - x^2}} = \frac{2}{\sqrt{4 - x^2}}$$

$$S = \int_{-1}^1 2\pi y \frac{2}{\sqrt{4 - x^2}} dx$$

We can then write y in terms of x and simplify.

$$S = \int_{-1}^1 2\pi \sqrt{4 - x^2} \frac{2}{\sqrt{4 - x^2}} dx$$

$$S = \int_{-1}^1 4\pi dx = \boxed{8\pi}$$

8. Compute the arc length of the function $y = 1 + 2x^{\frac{3}{2}}$ between $x = 0$ and $x = 1$

- (a) $\frac{14}{9}$
- (b) $\frac{10}{9}$
- (c) $\frac{2}{9}\sqrt{10}$
- (d) $\frac{2}{27}(10\sqrt{10} + 1)$
- (e) None of the above

$$ds = \sqrt{1 + \left(\frac{dy}{dx}\right)^2}$$

$$y = 1 + 2x^{\frac{3}{2}}, \frac{dy}{dx} = 3x^{\frac{1}{2}}$$

$$S = \int_0^1 \sqrt{1 + (3x^{\frac{1}{2}})^2} dx$$

$$S = \int_0^1 \sqrt{1 + 9x} dx$$

$$u = 1 + 9x, du = 9dx, dx = \frac{1}{9}du$$

The u-bounds are: $u = 1 + 9(1) = 10$, $u = 1 + 9(0) = 1$

$$S = \sqrt{u} \frac{1}{9} du$$

$$S = \frac{1}{9} \left(\frac{2}{3}\right) u^{\frac{3}{2}} \Big|_1^{10}$$

$$\left(\frac{2}{27}\right) (10^{\frac{3}{2}} - 1^{\frac{3}{2}})$$

$$S = \left(\frac{2}{27}\right) (10\sqrt{10} - 1)$$

The answer is therefore **(e)**.

9. Come up with your own series problem! Have a partner answer it and explain what test you would use.