

**Simplify your final answers. Show organized work. Defend all answers.**

- 1) Find the mass of a wire with density  $\delta = \frac{x + y^2}{\sqrt{1 + \sin^2(y)}}$  grams per cm if it is located on the path  $x = \cos(y)$  from the point  $(0, -\frac{\pi}{2})$  to the point  $(0, \frac{\pi}{2})$ . (10 points)

- 2) Find and evaluate an integral representing the work done by  $\vec{F} = \langle z, y+z, x \rangle$  on a particle that moves on the curve parameterized by  $\vec{r}(t) = \langle \cos t, -\cos t, \sin t \rangle$  from  $t = \frac{-\pi}{2}$  to  $t = \frac{\pi}{2}$ . (10 points)

- 3) Evaluate  $I = \int_C x dx + e^x(y-2) dy$  if C is a line segment from  $(0, 0)$  to  $(0, 2)$  and a curve from  $(0, 2)$  to  $(4, 6)$  on  $y = x + 2$ . (10 points)

4) Prove that  $\hat{u}$  is perpendicular to  $\hat{u}'$  if  $|\hat{u}| = 1$ . (5 points)

5A) Find all the second partial derivatives of  $f(x, y) = \sin(xy)$ . (6 points)

5B) What is  $\nabla f(1, \pi)$  if  $f(x, y) = \sin(xy)$ ? (4 points)

6) Find the equation of the plane that contains the points  $P = (2, 3, 0)$ ,  $Q = (1, 0, 1)$ , and  $R = (0, 1, 1)$ . Write your final answer in standard form. (10 points)

7) Let  $\vec{a} = \langle 2, -1, 2 \rangle$ ,  $\vec{b} = 3\hat{i} - 2\hat{j} + \hat{k}$ , and  $\vec{c} = \langle 1, 1, 1 \rangle$ . (25 points; #7A is 4 points, the others are 3 points)

7A) Find the area of the parallelogram spanned by  $\vec{b}$  and  $\vec{c}$ .

7B) Find the work done on an object with displacement  $\vec{a}$  by force  $\vec{b}$ .

7C) Find the flux of  $\vec{a}$  through the parallelogram spanned by  $\vec{c}$  and  $\vec{b}$ , oriented from  $\vec{c}$  to  $\vec{b}$ .

7D) Find the volume of the box spanned by  $\vec{a}$ ,  $\vec{b}$ , and  $\vec{c}$ .

7E) Find the component of  $\vec{a}$  onto  $\vec{b}$ .

7F) Find the projection of  $\vec{a}$  onto  $\vec{b}$ .

7G) Find an equation for the osculating plane at the point  $r(0) = (1, 0, -1)$  if  $\vec{r}'(0) = \vec{b}$  and  $\vec{r}''(0) = \vec{c}$ .

7H) Find the curvature at  $r(0) = (1, 0, -1)$  if  $\vec{r}'(0) = \vec{b}$  and  $\vec{r}''(0) = \vec{c}$ . Do not simplify your answer.

8) Find the arc length of  $\vec{r}(t) = \langle \cosh t, \sin t, \cos t \rangle$  from  $t = 0$  to  $t = \ln(3)$ . (10 points)

9) Sketch the surface corresponding to  $z = -\sqrt{4 - x^2 - y^2}$ . Label the axes. (5 points)

10) Use the contour plot of  $f(x, y)$  to estimate  $f_x(-7, 6)$ . Draw an appropriate segment. (5 points)

