Show all your work on the exam paper, legibly and in detail, to receive full credit. The use of a calculator or any other electronic device is prohibited. You may only use techniques discussed to date in class. You must simplify all answers unless you are explicitly instructed not to.

(6 points) Give a vector-valued function $\mathbf{r}(t)$ in 2-space whose graph is the circle centered at $(0,0)$ with radius 2 and is oriented counterclockwise.

(6 points) Give a vector-valued function $\mathbf{r}(t)$ in 3-space whose graph is the parabola $y = x^2$ in the plane $z = 2$.

(8 points) Find the domain of $\mathbf{r}(t) = \cos \pi t \mathbf{i} - \ln (7 - t) \mathbf{j} + \sqrt{1 - t^2} \mathbf{k}$
(2 points each) For each of the following formulas, write the letter of the picture on page 2 which corresponds to it. If there is no match, write No Match. It is possible that some of the pictures do not correspond to any of the formulas.

\[ x^2 + y^2 + \frac{z^2}{9} = 1 \]

\[-x^2 - y^2 + z^2 = 0 \]

\[ x - y^2 - z^2 = 0 \]

\[ \frac{x^2}{9} + y^2 + z^2 = -9 \]

\[-x^2 - y^2 + z^2 = 1 \]

\[ \frac{x^2}{9} + y^2 + z^2 = 1 \]

\[ y + x^2 - z^2 = 0 \]

\[-x^2 - y^2 + z^2 = -1 \]

\[ z - x^2 - y^2 = 0 \]

\[-x^2 + y^2 - z^2 = 1 \]
(20 points) Find all of the second-order partial derivatives of the function

$$f(x, y) = e^{xy} - \frac{3x^2}{y} + \sin y.$$ 

You do not need to simplify your answers.
(13 points) Find the tangent line to the graph of \( \mathbf{r}(t) = \left( t^3, \sqrt{t^2 + 5}, -t \right) \)

at the point \((-8,3,2)\). Express your answer as a vector equation or as a set of parametric equations.

(12 points) For \( t > 0 \), find \( \mathbf{r}(t) \) given that \( \frac{d\mathbf{r}}{dt} = \frac{2}{t} \mathbf{i} + 4t^3 \mathbf{j} \) and \( \mathbf{r}(1) = -3 \mathbf{i} + 2 \mathbf{j} \).
(15 points) For the function $z = x^2 - y^2$, sketch and label the level curves $z = k$ for values of $k = -1, 0, 1$. Use the axes given below.
Space for Extra Work