INSTRUCTIONS:
1. To receive credit you must:
   (a) work in a logical fashion, show all your work, indicate your reasoning
   (b) when applicable put your answer on/in the line/box provided
   (c) if no such line/box is provided, then box your answer
   (d) if you use your calculator on a particular problem, then indicate so.
2. The MARK BOX indicates the problems along with their points.
   Check that your copy of the exam has all of the problems.
3. As indicated on the syllabus:
   (a) allowed is a calculator (but not a computer)
   (b) allowed are the class handouts: table of integrals, calculus formula sheet, and Spring 2000 informal summary (along with your personal scribbles on them)
   (c) not allowed are books and other notes.
4. During this exam, do not leave your seat. If you have a question, raise your hand. When you finish: turn your exam over, put your pencil down, and raise your hand.
5. This exam covers (from Vector Calculus by Marsden&Tromba, 4th ed.):
   Chs. 1, 2, § 3.1, 4.1, 4.2.

Problem Inspiration:
1. an example from class
2. homework problem ch 1 review # 9 and quiz 2 problem 2
3. homework problem ch 2 review # 7
4. quiz 3 problem 4
5. an example from class, § 2.6 # 21
6. 1997 exam 1 # 5.
1. A parameterization of the line \( \mathcal{L} \) parallel to the intersection of the two planes

\[
\mathcal{P}_1 : 3x + y + z = 5 \\
\mathcal{P}_2 : x - 2y + 3z = 1
\]

and passing through the point \((4, 2, 1)\) is:

\[
\vec{R}(t) = \langle \ , \ , \ \rangle + t \langle \ , \ , \ \rangle
\]

where \( t \) varies as: ________________________.
2. Consider the surface $S$ described using Cartesian coordinates by:

$$S = \{ (x, y, z) \in \mathbb{R}^3 : x^2 + y^2 = 4 \text{ and } 0 \leq z \leq 5 \}.$$ 

Thus you can think of $S$ as the curved side metal part of a soup can with radius 2 and height 5. One can describe $S$ using vector notation as:

$$\mathbf{R}(\theta, h) = \hspace{1cm}$$

$\theta$ varies as: ______________ and $h$ varies as: ______________.
3. An equation of the plane tangent to the graph of

\[ f(x, y) = x^2 + y^4 + e^{xy} \]

at the point \((1, 0, f(1, 0))\) is:

Remark: your solution should be of the form \(ax + by + cz = d\).
4. Captain Ralph is out for a flight in his space ship again, traveling at a constant speed of $e^6$ meters per second. The temperature of the ship’s hull when he is at location $(x, y, z)$ will be given by

$$T(x, y, z) = \exp (-x^2 - y^2 - z^2)$$

where $x, y, \text{and } z$ are measured in meters. He is currently at $(1, 2, 1)$. Describe the set of possible directions in which he may proceed to bring the ship’s hull temperature \textit{down} at exactly a rate of $3\sqrt{2}$ degrees per second. Box your answer.
5. Mount Calc has the shape of the paraboloid

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

where \( x \) and \( y \) are the east-west and north-south map coordinates and \( z \) is the altitude above sea level (\( x, y, z \) are all measured in kilometers). If a puffo is at the point \( \left( \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} \right) \) and heads up Mount Calc in the direction of \( \langle 11, -13 \rangle \), then he is climbing Mount Calc at approximately a \_________ \% grade. Round your answer to a whole number. Recall from an example in class that a 3\% grade means that

\[
\frac{\text{change in vertical distance traveled}}{\text{change in horizontal distance traveled}} = \frac{3}{100}.
\]
6. Houston, we have a problem. The space shuttle Atlantis is traveling along with position vector

\[ \mathbf{r}(t) = \langle t^2, 3t^2, 4t \rangle. \]

If the power thrusters are turned off at time \( t \), the Atlantis will coast off, with constant speed along a straight path tangent to the vector \( \mathbf{r}(t) \). The Atlantis is almost out of fuel when astronaut John Grunsfeld notices the Mir space station off ahead of them at the position \((220, 660, 64)\). John realizes that their only hope is to turn the thrusters off, just at the proper time, so that the Atlantis will safely coast to dock with the Mir; but, John is not sure if his plan will work. So John quickly calls Tom and Ray for advice. Tom claims that John’s plan will work; Ray claims that John’s plan will not work. Who is right: Tom or Ray? Why? Be sure to mathematically support your answer, explaining your thought process. If so needed, continue on the next (blank) page.
MORE SPACE FOR PROBLEM 6: