NAME:_____

This exam should have 4 pages; please check that it does. Calculators (or any other electronic devices) are not allowed. **Show all work that you want considered for grading. An answer will only be counted if it is supported by all the work necessary to get that answer.** Give exact answers; for instance, don't give 3.14159 when the answer is π. Simplify as much as you can except if stated otherwise. No cheating.

---

1. (12 points) Let $P = (1, 0, 1)$, $Q = (2, -1, 3)$ and $R = (0, 0, 3)$.

   (a) Find parametric equations for the line between P and Q.

   (b) Find a normal vector to the plane containing P, Q and R. (Hint: first find two vectors in the plane)

   (c) What is the area of the triangle with vertices P, Q and R.

2. (5 points) Find all vectors in 2 dimensions having $\|\vec{v}\| = 8$ where the $\vec{j}$-component is $4\vec{j}$.

3. (18 points) Match the surfaces with the verbal description of the level curves by placing the letter of the verbal description to the left of the number of the surface.

   (a) $z = 2x^2 + 3y^2$

   (b) $z = x^2 + y^2$

   (c) $z = \frac{1}{x+1}$

   (d) $z = 2x + 3y$

   (e) $z = \sqrt{x^2 + y^2}$

   (f) $z = xy$

   - A. a collection of unequally spaced concentric circles ~~vskip .08in~~
   - B. a collection of unequally spaced parallel lines ~~vskip .08in~~
   - C. a collection of equally spaced concentric circles ~~vskip .08in~~
   - D. two straight lines and a collection of hyperbolas ~~vskip .08in~~
   - E. a collection of concentric ellipses ~~vskip .08in~~
   - F. a collection of equally spaced parallel lines

4. (12 points) Let $w = x^2 + 3y^2 + 2z^2$, $x = t^2 + 2$, $y = \frac{1}{t+1}$, $z = e^{2t}$.

   (a) Write down the chain rule for $\frac{dw}{dt}$.

   (b) Find $\frac{dw}{dt}$ when $t = 0$.

5. (25 points) Let $g(x, y) = x^3y^2$.

   (a) Write down the local linear approximation for g near $(1, 3)$.

   (b) Approximate $g(.8, 3.1)$ using the local linear approximation. You do not need to simplify your answer.

   (c) The equation $z = g(x, y)$ describes a surface S which contains the point $(1, 3, 9)$. Find an equation of the tangent plane to the surface S at $(1, 3, 9)$.

   (d) What is the value of the directional derivative $D_{\vec{u}}g(\cancel{0,1})$, where the unit vector $\vec{u}$ is in the direction of $-3\vec{i} + \vec{j}$.

6. (10 points)

   (a) For all values of the scalar a is $< 3a, -2 >$ parallel to $< a^2, 1 >$.

   (b) Suppose $\|\vec{v}\| = 3$, $\|\vec{w}\| = 4$ and the angle between $\vec{v}$ and $\vec{w}$ is $2\pi/3$. Find $\vec{v} \cdot \vec{w}$.

7. (18 points) Let

$$f(x, y) = \frac{x^3}{3} + \frac{y^2}{2} - xy - 2y + 5.$$

   (a) Find all critical points of $f(x, y)$.

   (b) Classify each critical point as a local maximum, a local minimum, or a saddle point.