There are 10 problems. Each problem is worth 10 points. SHOW your work. $\boxed{CIRCLE}$ your answer. **NO CALCULATORS!** Write your name on the front of the first page of your solution **AND** on the back of the last page of your solution.

1. Find the equation of the plane which contains $(1,1,1)$, $(2,2,3)$, and $(1,3,4)$. Be sure to check your answer.

2. Find the equation of the plane which is tangent to $z = x^2 + y^2$ at $x = 1$ and $y = 2$.

3. Find the equations of the line tangent to $\vec{\boldsymbol{c}}(t) = (t, t^2, t^3)$ at $(2,4,8)$.

4. Find $\lim\limits_{(x,y)\to(0,0)} \frac{xy}{x^2+y^2}$. (If the limit does not exist, be sure to explain why it does not exist.)

5. Suppose that $\vec{\boldsymbol{c}}(t)$ is a path with constant speed. Prove that this path has the property that velocity is always perpendicular to acceleration.

6. Find the length of $\vec{\boldsymbol{c}}(t) = (2t, t^2, \ln t)$ between $(2,1,0)$ and $(4,4,\ln 2)$.

7. Find the curvature of $\vec{\boldsymbol{c}}(t) = (\cos t, \sin t, t)$.

8. Let $w = f(x,y,z)$. View the rectangular coordinates (x,y,z) in terms of the spherical coordinates (ρ, ϕ, θ). Express $\frac{\partial w}{\partial \phi}$ in terms of $\frac{\partial w}{\partial x}$, $\frac{\partial w}{\partial y}$, $\frac{\partial w}{\partial z}$, ρ, ϕ, and θ.

9. Parametrize $\frac{x^2}{4} + \frac{y^2}{9} = 1$. (In other words, find a path $\vec{\boldsymbol{c}}(t) = (x(t), y(t))$ so that the curve traced out by $\vec{\boldsymbol{c}}(t)$ is $\frac{x^2}{4} + \frac{y^2}{9} = 1$.)

10. Consider the function $f(x,y) = y^2 - x^2$.
    (a) Graph the level set of value 9 for this function.
    (b) Calculate $\vec{\nabla} f|_{(0,3)}$. Graph $-\frac{1}{10}\vec{\nabla} f|_{(0,3)}$ on your graph of part (a) starting at $(0,3)$.
    (c) Calculate $\vec{\nabla} f|_{(4,5)}$. Graph $-\frac{1}{10}\vec{\nabla} f|_{(4,5)}$ on your graph of part (a) starting at $(4,5)$.