Please work the problems in the white space provided and clearly box your solutions. You are allowed one $3'' \times 5''$ notecard. Enjoy! This quiz has 3pts of bonus credit.

Problem 1 Calculate the limit below (if it doesn't exist then explain why)

$$\lim_{(x,y)\to(0,0)} \frac{2xy}{x^2+y^2}$$

Problem 2 Let $f(x,y) = x^3 + xy^2$. Find the rate of change in f at $(1,2)$ in the $\langle 3,4 \rangle$ direction.

Problem 3 Explain how to express $\frac{\partial f}{\partial x}$ at (x_o, y_o) as a directional derivative of f.

Problem 4 Explain which directions the function $f(x,y) = x^3 + y\sin(y)$ is locally constant at $(1,\pi)$.

Problem 5 Calculate ∇f for $f(x, y, z) = x^y + \cos(z^2)$

Problem 6 Let $z = \cos(xy^2)$. Furthermore, $x = u^2 + v$ and $y = ve^v$. Calculate $\frac{\partial z}{\partial v}$ and $\frac{\partial z}{\partial u}$.

Problem 7 Consider the surface which is the solution set of the equation $x^2 + y^3 + z^4 = 10$. Find the equation of the tangent plane to this surface at $(-1, 2, 1)$.

Problem 8 Let $\vec{r}(s, t) = \langle s\cos(t), s\sin(t), s\rangle$ be the parametrization of a surface M. Find the normal vector field to M.

Problem 9 You are stuck on an ellipitical surface $x^2+y^2+3z^2=5$. At the point $(1,1,1)$ you measure your x-velocity to be $2ft/s$ and your y-velocity is $-3ft/s$. Assuming units of ft and s find $\frac{dz}{dt}$.

Problem 10 Ron Swanson is holding a barbeque of epic size in a heavily misty park. At the same time a bagpipe club is playing at an embarrassing volume. You can't see or hear in effect. The smell of meat is measured to roughly follow $M(x,y)=x^2-2xy$ at $(1,1)$. In which direction should you travel to join the feast?

Problem 11 Suppose $w=x^2+y^3+z^4$ and $xyz=1$. Calculate $\left(\frac{\partial w}{\partial x}\right)_y$ and $\left(\frac{\partial w}{\partial x}\right)_z$

Problem 12 If $dw=(2x^2+3y)dx+(e^z+\cos(y)-4)dy+dz$ then calculate $\frac{\partial w}{\partial x}$, $\frac{\partial w}{\partial y}$ and $\frac{\partial w}{\partial z}$.

Problem 13 Let $\omega = (2xy^2 + e^x)dx + (2x^2y + y\cos(y^2))dy$. Show ω is a closed form on $\mathbb{R}^2$ and show it is exact by finding a function F for which $\omega = dF$.

Problem 14 Solve $(2xy^2 + e^x)dx + (2x^2y + y\cos(y^2))dy = 0$.

Problem 15 Let $\frac{dy}{dx} + Py = Q$ be a differential equation where P, Q are continuous functions of x. Show that the corresponding Pfaffian equation is not exact. Then, assume $I = I(x)$ and find a formula for I for which $I\frac{dy}{dx} + IPy = IQ$ is an exact equation.