Name:—————————————————   **Score:**—————————

Instructions: Show your work in the spaces provided below for full credit. Use the reverse side for additional space, *but clearly so indicate.* You must clearly identify answers and show supporting work to receive any credit. Exact answers (e.g., π) are preferred to inexact (e.g., 3.14). Point values of problems are given in parentheses. Notes or text in *any* form not allowed. Calculator is required.

(30) **1.** A projectile is launched on level ground due north from ground level at an angle of $\pi/6$ above the horizontal with an initial speed of 100 ft/sec. The only force on the projectile is gravity. (a) Find the acceleration, velocity and position as functions of time in a three dimensional coordinate system.

(b) Use (a) to find the time to impact and the velocity of the projectile at impact.

(c) Suppose that the projectile is launched into a steady wind which blows the projectile due east at 20 miles per hour. What are the new position, velocity and acceleration vectors for the projectile?

(30) **2.** A function is defined by $f(x, y) = \ln(x^2 + 2x + 1 - y)$.

(a) Sketch the domain of $f(x, y)$ and one contour of $f(x, y)$ in the xy-plane. Where is $f(x, y)$ continuous? Explain.

(b) Find all first and second partials of $f(x, y)$.

(c) Find an equation for the tangent plane to the surface $z = f(x, y)$ at the point $(0, 0, 0)$.

(10) **3.** Show that $\displaystyle\lim_{(x,y)\to(0,0)} \frac{x^2 - y}{x^2 + y^2}$ does not exist.

(20) **4.** Let $z = f(x, y) = x^2 + y^2 - 1$.

(a) Find the total differential dz for $f(x, y)$ at the point $(2, 1)$.

(b) Use differentials to estimate the maximum variance of $f(x, y)$ from $f(2, 1)$ (this means $|f(x, y) - f(2, 1)|$) given that $|x - 2| \leq 0.2$ and $|y - 1| \leq 0.1$.

(10) **5.** A smooth function $f(x, y)$ (this means f and its first partials are continuous) has the following contour graph. Use the contour graph to estimate $\partial f/\partial x$ and $\partial f/\partial y$ at $(2, 2)$.