INSTRUCTIONS:

1. NO TABLES, BOOKS, NOTES, HEADPHONES, CALCULATORS, OR COMPUTERS MAY BE USED.

2. Show ALL of your Work on the Exam itself.

1. _____(10)  2. _____(10)  3. _____(10)  4. _____(10)  5. _____(10)
6. _____(10)  7. _____(10)  8. _____(10)  9. _____(10)  10. _____(10)

TOTAL:_______(100)
1. (a) (5 points) Find the unit tangent and unit normal vectors $\mathbf{T}$ and $\mathbf{N}$ to the curve 
\[ \mathbf{r}(t) = \langle 3 \cos t, 4t, 3 \sin t \rangle \]
at the point $P = \left( -\frac{3}{\sqrt{2}}, 3\pi, \frac{3}{\sqrt{2}} \right)$.

(b) (5 points) Find curvature of the curve at the point $P$.

2. (10 points) Use LINEAR approximation to approximate the number 
\[ \sqrt{3.04} + e^{-0.08} \]

3. (10 points) Find all critical points of the function $f(x, y) = 4x - 3x^3 - 2xy^2$. For each critical point determine if it is a local maximum, local minimum or a saddle point.

4. (10 points) Find the volume of the solid $E$ bounded by $y = x^2$, $x = y^2$, $z = x + y + 5$, and $z = 0$.

5. (10 points) Find the $y$ coordinate of the center of mass of a lamina that occupies the region bounded by $y^2 = x + 4$, $x = 0$, and $y \geq 0$ and has density $\rho(x, y) = y$. Simplify your answer as much as possible.

6. (10 points) Evaluate the integral 
\[ \iint_{R} e^{x-2y} \, dA \]
where $R$ is the parallelogram $ABCD$ with vertices $A = (0,0)$, $B = (4,1)$, $C = (7,4)$, and $D = (3,3)$ using the transformation $x = 4u + 3v$ and $y = u + 3v$. Simplify your answer as much as possible.
7. (10 points) Evaluate the line integral

\[ \oint_C e^{2x+y} \, dx + e^{-y} \, dy \]

along the **negatively** oriented closed curve \( C \), where \( C \) is the boundary of the triangle with the vertices \((0,0), (0,1), \) and \((1,0)\).

8. (10 points) Evaluate the integral

\[ \iint_S (10 - 2z) \, dS, \]

where \( S \) is the part of the surface \( z = 5 - \frac{x^2}{2} - \frac{y^2}{2} \) inside the cylinder \( x^2 + y^2 = 1 \).

9. (10 points) Evaluate the line integral

\[ \oint_C \mathbf{F} \cdot d\mathbf{r} \]

for the vector field \( \mathbf{F}(x, y, z) = -y \mathbf{i} + x \mathbf{j} - z \mathbf{k} \), where the closed curve \( C \) is the boundary of the triangle with vertices \((0,0,5), (2,0,1), \) and \((0,3,2)\) traced in this order.

10. (10 points) Evaluate the flux of \( \mathbf{F}(x, y, z) = z^2y \mathbf{i} + x^2y \mathbf{j} + (x + y) \mathbf{k} \) over \( S \), where \( S \) is the closed surface consisting of the coordinate planes and the part of the sphere \( x^2 + y^2 + z^2 = 4 \) in the first octant \( x \geq 0, \ y \geq 0, \ z \geq 0 \), with the normal pointing outward.