INSTRUCTOR

• There are a total of 8 pages (including this one). Please check to see that you have all 8 pages. Do all your work on this examination.

• A scientific graphics calculator may be used on this final. However, a symbolic calculator, such as a TI-92, may **not** be used.

• Please **simplify** your answers when appropriate.

• Please keep your answers **exact** unless an approximation is called for.

• **You must show your work in appropriate detail to receive credit.**
1. Find the equation of the plane that contains the points $P = (1, 0, 2)$, $Q = (2, 1, -1)$ and $R = (0, 1, 0)$.

2. Find the vector projection of the vector $b = 2i + j - 3k$ onto $a = i - 2j + k$. 
3. Let $C$ be the curve given by $\mathbf{r}(t) = t(t + 3)\mathbf{i} - \sin t\mathbf{j} + e^{2t}\mathbf{k}$. Find the parametric form of the equation of the line tangent to $C$ at $(0, 0, 1)$.

4. Find the equation of the tangent plane to the surface $z = \sqrt{y}e^{-x}$ at the point $(0, 1, 1)$. 


5. Assume $z(s, t) = f(x(s, t), y(s, t))$. Find $z_t(0, 1)$ if

$x(0, 1) = 2, y(0, 1) = 3, x_t(0, 1) = 4, y_t(0, 1) = 5,$

$f_x(0, 1) = 6, f_y(0, 1) = 7, f_x(2, 3) = 8, f_y(2, 3) = 9.$

6. Find and classify the critical points of $f(x, y) = x^3 - 6xy + y^3$. 
7. Express \( \int \int_0^2 x^2 f(x,y) \, dy \, dx \) as an iterated integral with the order of integration reversed.

8. Evaluate \( \int \int_D (y^2 - x^2) \, dA \) where \( D \) is the region bounded by the curves \( y - x = 1 \), \( y - x = 3 \), \( y + x = 2 \) and \( y + x = -1 \). Use the substitution \( u = y + x, v = y - x \).
9. A solid in the first octant is bounded by the planes \( y = x, \) \( y = x/3, \) \( z = 0, \) and the cylinder \( y^2 + z^2 = 1. \) Write the volume of the solid as an iterated triple integral with order of integration \( dzdxdy. \) DO NOT EVALUATE THE INTEGRAL.

10. Evaluate \( \int_0^1 \int_0^\sqrt{1-x^2} \int_0^{\sqrt{x^2+y^2}} dz \, dy \, dx. \)
11. Let \( \mathbf{F}(x, y) = (6xy - y^3)\mathbf{i} + (4y + 3x^2 - 3xy^2)\mathbf{j} \).

(a) Is \( \mathbf{F} \) is a conservative vector field?

(b) Evaluate \( \int_C \mathbf{F} \cdot d\mathbf{r} \) where \( C \) is the straight line joining the point \((1, 2)\) to \((-1, -1)\).
12. Evaluate \( \int_C xy^2 \, dx + 2x^2 \, dy \) where \( C \) is the positively oriented boundary of the region bounded by the curves \( y = 2x \) and \( y = x^2 \).