1. Let $\mathbf{F} = \langle 2x, 2yz^2, 2y^2z \rangle$.
(a) Show that $\mathbf{F}$ is conservative without actually finding a potential function for $\mathbf{F}$.

(b) Calculate $\nabla \cdot \mathbf{F}$.

2. Let $f(t)$ be a scalar function, $\mathbf{r} = \langle x, y \rangle$ and $r = \|\mathbf{r}\| = \sqrt{x^2 + y^2}$. Show that $\nabla f(r) = f'(r) \frac{\mathbf{r}}{r}$. 
(24) 3. Use the Divergence Theorem to evaluate \( \int \int_S \mathbf{F} \cdot \mathbf{n} dS \), where \( \mathbf{F} = (y^3 - 2x, e^{xz}, 4z) \) and \( S \) is the boundary of the rectangular box \( 0 \leq x \leq 2, 1 \leq y \leq 2, -1 \leq z \leq 2 \), with exterior unit normal.

(24) 4. Use Stokes' Theorem to evaluate \( \oint_C \mathbf{F} \cdot d\mathbf{r} \), where \( \mathbf{F} = (\sin(x^2), y, z - y) \) and curve \( C \) is the horizontal triangle from \((1, 0, 2)\) to \((1, 1, 2)\) to \((0, 0, 2)\) in that order.
(24) 5. Let a surface be given by $z = \sqrt{x^2 + y^2}$ where $(x, y) \in R = \{(x, y) \mid 0 \leq x \leq 1, 0 \leq y \leq 2\}$.
(a) Find formulas for vector and scalar differential surface area $dS$ and $dS$ in terms of $dA$, differential surface area in the $xy$-plane.

(b) Express $\iint_S f(x, y, z) dS$ as an iterated integral in $x$ and $y$ where $f(x, y, z) = \sin(xyz^2)$. Do not work the integral out.

(c) Express $\iint_S \mathbf{F} \cdot d\mathbf{S}$ as a double integral over $R$, where $\mathbf{F} = \langle x, 0, y^2z \rangle$. Do not work the integral out.