(10) I. Give a parametrization of

A. the line segment that connects the points \((1, 0, 3)\) and \((4, 5, 5)\) in \(\mathbb{R}^3\).

B. the surface bounded by the triangle in \(\mathbb{R}^3\) located in the first octant and cut off by the plane whose equation is \(x + y + z = 1\).

(5) II. Compute the area of the triangle in \(\mathbb{R}^3\) which has vertices \((1, 1, 1)\), \((4, 5, 6)\), and \((3, 7, 5)\).
(25) III. Let $M$ be the surface in $\mathbb{R}^3$ parametrized by $\mathbf{f}(s,t) = (s, s \cos t, s \sin t)$ for $0 \leq s \leq 2$ and $0 \leq t \leq \pi$.

A. Give a coordinate equation for $M$ in terms of $x$, $y$, and $z$. Describe $M$ in words.

B. Calculate a unit normal to $M$ at the point $(1, 0, 1)$.

C. Give an equation of the tangent plane to $M$ at the point $(1, 0, 1)$. 
(This continues the problem from the previous page . . .)

D. Calculate the surface area of $M$.

E. If $\mathbf{F}(x, y, z) = xi + yj + zk$, calculate the value of the surface integral $\iint_M \mathbf{F} \cdot \mathbf{n} d\sigma$. 
IV. The curve $C$ is parametrized by $f(t) = (t^2 - 1, t^2 + 1, t^2)$ starting at $t = 0$ and ending at $t = 1$.

A. Compute the length of $C$.

B. Compute the line integral of $\mathbf{F}(x, y, z) = y^4 \mathbf{i} + 4xy^3 \mathbf{j} + 2z \mathbf{k}$ over $C$.

C. Compute the line integral of $\mathbf{F}(x, y, z) = y^4 \mathbf{i} + 4xy^3 \mathbf{j} + 2z \mathbf{k}$ over the curve that is the ellipse obtained by intersecting the cylinder $x^2 + y^2 = 1$ with the plane $3x + 5y - 2z = 0$. 
(5) V. Compute \[ \int_0^2 \int_0^4 \int_0^{\sqrt{4-x^2}} \sqrt{4-x^2-y^2} \, dz \, dy \, dx \]
by converting to spherical coordinates.

(5) VI. \( f(t) = (\cos t, \sin t, t) \) with \( 0 \leq t \) is a parametrization of a helix in 3-space. Give the equation of the tangent line to this path at the point where \( t = \frac{\pi}{2} \).
VII. Suppose \( f(x, y, z) = (xy^2z, xz(y + l)) \) and \( a = (1, 1, 1) \)

A) Calculate the Jacobian matrix of \( f \) at \( a \).

B) Calculate the total derivative of \( f \) at \( a \).

VIII. For the quadratic form \( p(x, y) = x^2 + 3xy + y^2 \)

A. Give a symmetric matrix \( S \) that is a matrix of this quadratic form.

B. Calculate the Hessian for \( p \) at \( (0, 0) \).

C. Give the second degree Taylor polynomial for \( p \) at \( (0, 0) \).
(10) IX. Let $F(x, y) = (y^2, y + 2x)$. Let $R$ be the triangular region in the first quadrant bounded by the curves $y = 0$, $x = 1$, and $y = x$. Use Green's Theorem to calculate $\int_{\partial R} F \cdot dx$.

(10) X. Use the Divergence theorem to calculate $\int_{\partial S} F \cdot n\, d\sigma$, where $F = 2xi + 3yj + 5zk$ and $S$ is the unit cube in the first octant. ($S = [0,1] \times [0,1] \times [0,1]$).