1) Given \( \vec{v} = <2,1,-2> \) and \( \vec{w} = <3,2,1> \), find the lengths \( a \) and \( b \) pictured below.

\[
\begin{array}{c}
|\vec{v}| = a \\
|\vec{w}| = b
\end{array}
\]

2) a) Find parametric equations for the line through the points \((1,2,3)\) and \((-1,5,4)\).

b) Find an equation for the plane that is perpendicular to the line in a) and passes through the point \((4,0,1)\).

c) At what point do the line in a) and the plane in b) intersect?

3) Given \( f(x,y,z) = \frac{x}{1+x^2+y^2} \):

a) At the point \((1,0,2)\), in what direction does \( f \) increase most rapidly?

b) At the point \((1,0,2)\), what is the rate of change of \( f \) in the direction of \(<3,-4,0>\)?
4) Given \( x = r \cos \theta \) and that \( r \) and \( \theta \) depend on \( t \) in such a way that when \( t = 0 \) : \( r = 2 \), \( \theta = \frac{\pi}{4} \), \( \frac{dr}{dt} = 3 \) and \( \frac{d\theta}{dt} = \pi \). Find \( \frac{dx}{dt} \) at \( t = 0 \).

5) Find the maximum and minimum values of \( f(x, y) = 3x - 2y \) on the ellipse \( 3x^2 + y^2 = 7 \).

6) Change the order of integration and calculate

\[
\int_{0}^{1} \int_{\sqrt{x}}^{1} \sqrt{1+y^2} \, dy \, dx
\]
7) Calculate the total mass of the solid that lies above the cone 
\[ z = \sqrt{x^2 + y^2} \] and below the plane \( z = 1 \), given that the density is \( f(x, y, z) = x^2 + y^2 \).

8) Verify that the field \( \mathbf{F}(x, y, z) = <2xy + z, x^2 + 1, x + 2z> \) is conservative and calculate the work done by \( \mathbf{F} \) in moving an object from \((2,1,1)\) to \((1,1,0)\).
9) Calculate $\int_C -y^2 \, dx + xy \, dy$ where $C$ is the counterclockwise oriented simple closed curve consisting of the piece of the parabola $y = 1 - x^2$ between $(-1, 0)$ and $(1, 0)$ together with the piece of the $x$-axis between $(-1, 0)$ and $(1, 0)$.

10) Find the surface area of the part of the surface $z = 1 - x^2$ that lies above the triangle in the $xy$-plane with vertices $(0,0,0)$, $(1,0,0)$ and $(1,1,0)$. 
11) Let $A$ be the part of the paraboloid $z = 9 - x^2 - y^2$ with $z \geq 0$, oriented with upwards pointing normal vector, and let

$F(x, y, z) = \langle -y, x, z \rangle$. Calculate $\int\int\int (\text{curl} \ F) \cdot d\mathbf{S}$.

12) Let $F(x, y, z) = \langle y, x, z^2 \rangle$ and let $A$ be the closed surface consisting of the cone $z = \sqrt{x^2 + y^2}$, $0 \leq z \leq \sqrt{2}$, and the spherical cap $z = \sqrt{4 - x^2 - y^2}$, $\sqrt{2} \leq z \leq 2$. Calculate the flux, $\int\int\int \mathbf{E} \cdot d\mathbf{S}$, of $\mathbf{F}$ outwards across $A$. 

\[ \int \int\int (\mathbf{F} \cdot \mathbf{n}) \ dS \]