(1) There is no partial credit to the following problems. Check your answer carefully.
(a) Find the volume of the parallelopiped from by:
\[\vec{u} = \langle 1, 0, 2 \rangle, \quad \vec{v} = \langle 2, -1, 0 \rangle, \quad \vec{w} = \langle 4, 1, 1 \rangle\]

(b) Find the parametric equations describing the tangent line to \[\vec{r}(t) = \langle \sqrt{2}t, 4 - t^3, t^2 - 1 \rangle\] at \( (2, -4, 3) \).

(c) Find the equation of the tangent plane to \( z = x^3 - 2\cos(y) + x^2y \) at \( x = 2, y = \pi \).

(d) Write \( w = \left( \frac{1 + \sqrt{3}i}{1 - \sqrt{3}i} \right)^{10} \) in the \( a + bi \) form.

(e) Find the length of the following curve \[\vec{r}(t) = \langle 12t, 8t^{3/2}, 3t^2 \rangle; \quad 0 \leq t \leq 1\]

(2) Let \( f(x, y) = \ln(1 + x^2 + y^2) \).
(a) Compute \( f_{xx} \) and \( f_{xy} \).
(b) Write the unit vector along which \( f \) is increasing fastest at \( x = y = 1 \).
(c) What is the rate of change of \( f \) at \( (1, 1) \) in the direction of \( \langle 1, -2 \rangle \) ?

(3) Find all critical points of \( f(x, y) = 2x^3 + y^3 - 5xy \) and classify them as local minimum, local maximum, saddle points.

(4) Find the absolute maximum and minimum values of \( f(x, y) = xy - 5x^2 + 3 \) on the finite domain \( D \) bounded by \( x \)-axis, \( x = 2 \) and \( y = x^3 \).

(5) Let \( C \) be the curve of intersection of teh following two surfaces
\[ x^2 + y^2 = 1 \]
\[ z = 3 - 2x^2 - 4y^2 \]
Find points on \( C \) which are closest to and farthest from the origin.

(6) A projectile is fired with an initial speed of 100 m/s at an angle of 60 \( ^\circ \).
(a) Write the position \( \vec{r}(t) \) and velocity \( \vec{v}(t) \) of the particle at time \( t \).
(b) At what times is the projectile at the height three quarters of its maximum height?

(7) Assume that \( z \) is implicitly defined as a function of \( x \) and \( y \) by
\[ \cos(yz) + x^2z = 9 \]
If at \( x = 2, \ y = 0 \) and \( z = 2 \), the value of \( x \) starts increasing at the rate of 1 unit per second, and the value of \( y \) starts decreasing at the rate of 2 units per second, compute the rate of change of \( z \).

(8) Let \( \mathbf{r}(t) \) be a parametric curve. Prove that

\[
\frac{d}{dt} \left( \frac{\mathbf{r}'(t)}{||\mathbf{r}(t)||} \right) = \frac{1}{||\mathbf{r}(t)||} \left( \mathbf{r}'(t) - \text{Proj}_{\mathbf{r}(t)}(\mathbf{r}'(t)) \right)
\]

(9) Prove that the curvature \( \kappa(x) \) of a curve \( y = f(x) \) is given by:

\[
\kappa(x) = \frac{|f''(x)|}{(1 + f'(x)^2)^{3/2}}
\]

Use this formula to find the curvature of \( y = x^3 \) at \((2, 8)\).