1. Let $P$ be the plane and $Q$ the point in $\mathbb{R}^3$ described by

$P: \ 2x - 3y + 5z = 10; \quad Q = (1\ -2\ 2)^*.$

Find the point $R \in P$ which lies closest to $Q$.

2. Let $X(t)$ be the curve in $\mathbb{R}^3$ given by the formulae:

$x(t) = \cos 3t, \quad y(t) = -\sin 3t, \quad z(t) = 2t^2 - t.$

Find the velocity vector, speed, acceleration vector and scalar acceleration as functions of $t$ and give the vector $X''(2)$.

3. Let $\phi(x, y, z) = 2x - 2(x+y)^2 + 3(y-z)^3$. Compute the gradient vector function $\nabla \phi(x, y, z)$ and find the formula for the tangent plane to the surface $\phi(x, y, z) = 10$ at $X_0 = (2, 1, -1)^*$.

4. a) Let $f(x, y) = -x/y + (x-y)^2$. Find the linear approximation to $f(x, y)$ at the point $x = 1, y = 2$ and use it to obtain an estimate for $f(1.1, 1.9)$. Compare with the actual value $\phi(1.1, 1.9)$.

b) Compute the directional derivative $\frac{\partial f}{\partial U}(2, 1)$ where $U = \frac{1}{\sqrt{5}}(1, 2)^*$.

5. Let $g(x, y) = (x - y)^4 - 4(x-y)^2 + (x+y)^2$. Using the change of variables $u = x+y, \ v = x-y$, find all stationary points of $g(x, y)$.

6. Let $\phi(x, y, z)$ be the function in Problem 3 and let $X(t)$ be the curve in $\mathbb{R}^3$ described by $X(t) = (1+t, \ -t, \ t^2)^*$. Use the Chain Rule to compute the derivative $\frac{d}{dt} \phi(X(t))$ as a function of $t$ and give its numerical value when $t = 2.$