(15 pts)   1) If $f(x, y, z) = xy + z^2$ find

        a) ∇f at $(1, 2, 1)$,

        b)   the direction in which f changes most rapidly at $(1, 2, 1)$,

        c)   the equation of the tangent plane to $xy + z^2 = 4$ at $(1, 2, 1)$,

        d)   the normal line to $xy + z^2 = 4$ at $(1, 2, 1)$.

(15 pts)   2)   a) Find the maxima, minima, and points of inflection of $f(x, y) = x^3 - y^3 - 2xy + 6$.

        b) Find $\dfrac{\partial w}{\partial x}$, at $(x, y) = (0, 0)$, if $w = u^2 + \dfrac{u}{v}$, $u = x + 2y + 1$, and $v = 2x - y + 2$.

(20 pts)   3) Set up but do not evaluate integrals for the following:

        a) The mass of the plate bounded by $y = 4 - x^2$ and $y = 3x$ if the density $\rho = 2xy$,

        b) the average distance from a point p, on the disk $x^2 + y^2 = 1$, to the origin,

        c) the volume bounded by $x^2 + y^2 + z^2 = 9$, $x^2 + y^2 + z^2 = 4$, inside the case $z = \sqrt{x^2 + y^2}$,

        d) the center of mass of the area bounded by $y = 2\cos x$, $y = 0$, $0 \le x \le \dfrac{\pi}{2}$ if the density $\rho = xe^y$.

(15 pts)   4)   a) Evaluate by changing the order of integration

$$\int_0^\infty \int_{x^{\frac{1}{3}}}^2 \frac{dy\, dx}{y^4 + 1},$$

        b) Find the volume of the smaller region cut from $x^2 + y^2 + z^2 \le 4$ by the plane $z = 1$.

(15 pts)   5) If $f(x, y, z) = e^x \cos(y + z)$ find

        a) the linearization of f at $(0, \frac{\pi}{2}, 0)$,

        b) the error if the function is replaced by its linearization provided $|x| < \dfrac{1}{100}$, $|y - \dfrac{\pi}{2}| \le \dfrac{1}{100}$, and $|z| \le \dfrac{1}{100}$.

(10 pts)   6) Find the absolute maximum and minimum of $f(x, y) = x^2 + xy + y^2 - 6x + 2$ on $\{(x, y) | 0 \le x \le 5, -3 \le y \le 0\}$.

(10 pts)   7) Find the maximum value of

$$f(x, y, z) = x - 2y + 5z \text{ on } x^2 + y^2 + z^2 = 30.$$