1. Consider the curve defined parametrically by $x(t) = t^3 - 3t^2 - t$ and $y(t) = 2t^3 - 3t^2 - 2t$.
   (a) (10 pts.) Find the point where the curve intersects itself.
   (b) (10 pts.) Determine the equation of each line tangent to the curve at the point you found in part (a).

2. (20 pts.) Do the points (1,2,1), (2,-3,1), (-2,2,4) and (3,-3,0) all lie in the same plane? Explain.

3. Consider the polar curve $r = e^{2\theta}$ for $-\pi/2 \leq \theta \leq \pi/2$.
   (a) (10 pts.) Find the length of the curve.
   (b) (10 pts.) Find the values of θ that correspond to a point on the curve having a horizontal or vertical tangent line.

4. Consider the function $f(x, y) = \sqrt{x} \cos y$.
   (a) (10 pts.) Calculate the rate of change of $f(x, y)$ at the point $(2, \pi/4)$ in the direction of the vector $\langle 3, 4 \rangle$.
   (b) (10 pts.) Find the maximum rate of change of $f(x, y)$ at the point $(2, \pi/4)$ and the direction in which it occurs.

5. (25 pts.) Find all local and absolute maxima and minima of $f(x, y) = x^2 - xy + y^2 - 3y + 2$ on the region bounded by the lines $y = x$, $y = -x$ and $y = 3$.

6. (20 pts.) Find the maximum and minimum of $f(x, y, z) = xyz^2$ subject to the constraint $5x^2 + 3y^2 + 2z^2 = 20$.

7. Let $\mathcal{D}$ denote the region of the xy-plane that is bounded by the curve $x = y^2$ and the line $y = 6 - x$.
   (a) (10 pts.) Calculate the area of $\mathcal{D}$.
   (b) (10 pts.) Find the surface area of the portion of the plane $2x + 2y - z = -1$ which lies directly above $\mathcal{D}$.

8. (a) (10 pts.) Evaluate $\iint_D e^{x^2+y^2} dA$ where D is the region in the xy-plane such that $x^2 + y^2 \leq 1$.
   (b) (15 pts.) Find the volume of the solid region bounded by the parabolic cylinder $x = 1 - y^2$ and the planes $z + y = 2$, $x = 0$ and $z = 0$.

9. (30 pts.) Circle your answer for each of the following questions.

(a) Two vectors u and v are perpendicular if

i. $u \times v = 0$ ii. $u \cdot v = 1$ iii. $u \cdot v = 0$ iv. none of the above

(b) Two vectors u and v are parallel if

i. $u \times v = 0$ ii. $u \times v = 1$ iii. $u \cdot v = 0$ iv. none of the above

(c) The vector $u \times v$ is always perpendicular to

i. $v \times u$ ii. $u \cdot v$ iii. $(u \cdot v)u$ iv. $(u - v) \times (u + v)$

(d) The point (0,1,1) in rectangular coordinates is the same as which of the following points given in cylindrical coordinates

i. $(\sqrt{2}, \pi/2, \pi/2)$ ii. $(1, \pi/2, 1)$ iii. $(\sqrt{2}, \pi/2, 1)$ iv. $(1, \pi, 1)$

(e) The point (1,1,$\sqrt{2}$) in rectangular coordinates is the same as which of the following points given in spherical coordinates

i. $(\sqrt{2}, \pi/4, \pi/4)$ ii. $(\sqrt{3}, \pi/2, \pi/4)$ iii. $(2, \pi/4, \pi/4)$ iv. $(\sqrt{3}, \pi/4, \pi/2)$

(f) The surface $x^2 = -1 - z^2 + y^2$ is a

i. ellipsoid
ii. hyperboloid of one sheet
iii. cone
iv. hyperboloid of two sheets

(g) The surface $z^2 + x = y^2$ is a

i. hyperbolic paraboloid
ii. ellipsoid
iii. hyperboloid of one sheet
iv. parabolic cylinder

(h) Horizontal cross-sections of the surface $x^2 = 3z^2 + 2y^2$ are most generally

i. circles ii. ellipses iii. hyperbolas iv. parabolas

(i) Vertical cross-sections of the surface $z = y^2 - x^2$ are most generally

i. circles ii. ellipses iii. hyperbolas iv. parabolas

(j) The surface $\rho \sin\phi(\cos\theta + 5\sin\theta) + 2\rho\cos\phi = 1$ is a

i. cylinder ii. plane iii. paraboloid iv. hyperboloid