1. (a) (15 points) Find parametric equations for the line in which the planes $3x-6y-2z=3$ and $2x+y-2z=2$ intersect.

   (b) (10 points) Find the distance from the point $(2,-3,4)$ to the plane $x+2y+2z=13$.

2. (a) (10 points) Find the length of the indicated portion of the curve

$$\mathbf{r}(t) = (t\sin t + \cos t)\mathbf{i} + (t\cos t - \sin t)\mathbf{j}, \qquad \sqrt{2} \le t \le 2.$$

   (b) (15 points) Find $\frac{\partial z}{\partial x}$ and $\frac{\partial z}{\partial y}$ at $(1, \ln 2, \ln 3)$ if $xe^y + ye^z + 2\ln x - 2 - 3\ln 2 = 0$.

3. (a) (10 points) Find the directional derivative of $f(x,y,z) = x^3 - xy^2 - z$ at $P_0(1,1,0)$ in the direction of $\mathbf{v} = 2\mathbf{i} - 3\mathbf{j} + 6\mathbf{k}$.

   (b) (15 points) Find equations for the tangent plane and normal lines at the point P_0 on the given surface.

$$\cos \pi x - x^2 y + e^{xz} + yz = 4, \qquad P_0(0,1,2).$$

4. (a) (15 points) Find all the local maxima, local minima, and saddle points of the function

$$f(x,y) = x^4 + y^4 + 4xy$$

   (b) (15 points) Use Lagrange multipliers to find the points on the surface $xyz = 1$ closest to the origin.

5. (a) (15 points) Sketch the region of integration, change to polar coordinates, and evaluate the integral

$$\int_0^{\sqrt{2}} \int_y^{\sqrt{4-y^2}} \cos(x^2+y^2)\, dx\, dy.$$

   (b) (15 points) Find the volume of the region bounded by $z = 4 - 4(x^2+y^2)$ and $z = (x^2+y^2)^2 - 1$.

6. (20 points) Evaluate the line integral $\int_C (x+y+z)\, ds$ over the straight line segment from $(1,2,3)$ to $(0,-1,1)$.

7. (a) (10 points) Show that the vector field $\mathbf{F} = (2x \ln y - yz)\mathbf{i} + \left(\frac{x^2}{y} - xz\right)\mathbf{j} - xy\mathbf{k}$ satisfies the equations in the Component Test.

   (b) (10 points) Find a potential function for this field. Show all your steps.

   (c) (5 points) Evaluate the line integral $\displaystyle\int_{(1,2,1)}^{(2,1,1)} \mathbf{F} \cdot d\mathbf{r}$.

8. (20 points) Apply Green's Theorem to evaluate the counterclockwise circulation of

$$\mathbf{F} = (-y + e^x \ln y)\,\mathbf{i} + \left(\frac{e^x}{y}\right)\mathbf{j}$$

around the boundary of the region that is bounded above by the curve $y = 3 - x^2$ and below by the curve $y = x^4 + 1$.