1. (8 points) (a) (4 points) Find the equation for the plane containing the lines $r_1(t) = (1, 2 + t, -1 - 2t)$ and $r_2(t) = (1 - t, 2, -1 + t)$

(b) (2 points) Calculate the area of the parallelogram determined by the two vectors $\mathbf{j} - 2\mathbf{k}$ and $-\mathbf{i} + \mathbf{k}$
(c) (2 points) Find the line of intersection between the planes $y - 2z = 0$
and $-x + z = 0$
2. (10 points) Evaluate the following integrals

(a) (4 points)
\[
\int \int_{R} e^{2x-3y} \, dA \quad \text{where} \ R = [0, 1] \times [1, 2]
\]

(b) (6 points)
\[
\int_{0}^{4} \int_{\sqrt{x}}^{2} \sin(y^3) \, dy \, dx
\]
3. (8 points) Let \( f(x, y, z) = x^2 + 2y^2 - z \)

(a) (3 points) In which direction from the point \((1,1,0)\) does \( f \) increase the fastest?

(b) (3 points) What is the rate of change of \( f \) in the direction of the vector \( \mathbf{i} - \mathbf{k} \) at the point \((1,1,0)\)
(c) (2 points) Find the equation of the tangent plane to the surface
\[ z = x^2 + 2y^2 - 3 \] at (1,1,0)
4. (6 points) Let $f(u, v) = (v^2, u^2 - v)$ and $g(x, y, z) = (xz, y^2 z)$.

Calculate

$$\mathbf{D}(f \circ g)(-1, 1, -1)$$
5. (10 points) A particle in space follows a helix-shaped path given by

\[ \mathbf{c}(t) = (\cos(t), \sin(t), t) \]

(a) (3 points) Calculate the velocity vector function \( \mathbf{c}'(t) \)

(b) (2 points) Show that the speed of the particle is constant
(c) (3 points) Find the equation of the tangent line to the path at $t = \pi$

(d) (2 points) If the particle follows the path $\mathbf{c}(t)$ until it flies off on a tangent at $t = \pi$, where is the particle at $t = 2\pi$?
6. (10 points) Let $W$ be the region inside the sphere $x^2 + y^2 + z^2 = 4$ and above the plane $z = 0$.

(a) (5 points) Describe $W$ as an elementary region of the form:

\[
  a \leq x \leq b, \quad \phi_1(x) \leq y \leq \phi_2(x), \quad \gamma_1(x, y) \leq z \leq \gamma_2(x, y)
\]

(You need to determine $a, b, \phi_1(x), \phi_2(x), \gamma_1(x, y), \gamma_2(x, y)$)
(b) (3 points) Rewrite the triple integral

\[ \iiint_W 1 \, dV \]

as an iterated integral (you do not have to evaluate it).

(c) (2 points) What does the triple integral in part (b) calculate?