NOTE: There are 5 problems on this midterm (total of 6 pages). Use of calculators will NOT be permitted. In order to receive full credit for any problem, you must show work leading to your answer. You have 50 minutes to complete this test.

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Problem 1. (20pts) Find the equation of the plane through \((1,1,-1), (2,0,2)\) and \((0,-2,1)\).
Problem 2. (20pts)

(a) (7pts) Find parametric equations for the line \( \ell \) containing \((4, 3, -5)\) and \((3, 5, -2)\).

(b) (7pts) Find the value(s) of the parameter you used in (a) for which the vector from the origin to the point on \( \ell \) determined by the parameter is perpendicular to \( \ell \).

(c) (6pts) Find the distance from the origin to \( \ell \).
Problem 3. (20pts) Let $F(x, y, z) = xyz$ and $u = 2i + j - k$.

(a) (10pts) Compute $D_u F$ at the point $P_0(1, -1, 2)$.

(b) (5pts) How fast is $F$ increasing in the direction of $u$?

(c) (5pts) Find the equation of the plane tangent to the level surface

$$F(x, y, z) = -2$$

at $P_0$. 
Problem 4. (20pts)

(a) (12pts) Find the length of the curve given by
\[ \mathbf{r}(t) = (\cos t)\mathbf{i} + (\sqrt{2}\sin t)\mathbf{j} + (1 - \cos t)\mathbf{k}, \quad -\pi \leq t \leq \pi. \]

(b) (8pts) Find the velocity and acceleration at time \( t = 0 \).

(BONUS: 3pts) Describe the intersection of the infinite elliptic cylinder \( x^2 + \frac{y^2}{2} = 1 \) and the plane \( x + z = 1 \).
Problem 5. (20pts) Find the absolute maxima and minima of the function

\[ f(x, y) = 2x^2 - 4x + y^2 - 4y + 1 \]

on the closed triangular plate bounded by the lines \( x = 0, y = 2, y = 2x \) in the first quadrant.