1. The transformation relating the cartesian coordinates \( x, y, z \) to the parabolic coordinates \( u, v, \theta \) is given by \( x = u \, v \cos \theta, \) \( y = u \, v \sin \theta, \) and \( z = (u^2 - v^2)/2, \) where \((u \geq 0, v \geq 0)\).

\((30\text{ points})\) Verify that the parabolic coordinate system is orthogonal

2. \((40\text{ points})\) Write the following 2nd order differential equation as a system of 1st order, linear differential equations.

\[
2y'' - 5y' + y = 0 \quad y(3) = 6 \quad y'(3) = -1
\]

3. Let \( F = \sin x \, i + \cos y \, j + \ln z \, k \quad (z \neq 0), \) and \( G = e^x \cos y \, i + e^x \sin y \, j. \)

Find

\((a)\) \((10\text{ points})\) \( F + G \)
\((b)\) \((10\text{ points})\) \( F \cdot G \)
\((c)\) \((10\text{ points})\) \( F \times G \)