Step-1

Suppose one or more eigenvalues of $\hat{I}»_1$, $\hat{I}»_2$, and $\hat{I}»_3$ are zero.

Without loss of generality, let $\lambda_3 = 0$ and other eigenvalues be positive.

Then we get $\lambda_1 y_1^2 + \lambda_2 y_2^2 = 1$

This represents an elliptical cylinder in 3 dimensions. If we consider the plane, which contains the vectors y_1 and y_2, then the cross section of this cylinder with the plane is the ellipse, whose equation is given by $\lambda_1 y_1^2 + \lambda_2 y_2^2 = 1$.

Step-2

Consider the case of two eigenvalues being zero and the third one being positive. Without loss of generality, let $\lambda_2 = 0$, $\lambda_3 = 0$, and $\lambda_1 > 0$.

This gives, $\lambda_1^2 = 1$.

Therefore, $\lambda_1 = \pm 1$.

This represents pair of two planes, perpendicular to the vector y_1, passing through it at a distance of ± 1 from the origin.

Step-3

Suppose we consider the case where all the three eigenvalues are zero. Then we get 0 = 1, which is impossible.