

# Abstract

In this thesis, we define  $l$ - fractional difference operator using  $l$ - Pochhammer symbol. The  $l$ - fractional difference operator is further used to introduce some difference sequence spaces. Some properties and duals of the newly defined spaces are studied. We also introduce some difference sequence spaces in bigeometric calculus. We determine the  $\alpha$ -duals of these bigeometric sequence spaces and study their matrix transformations. We develop an interpolating polynomial in bigeometric calculus, which is analogous to the classical Hermite interpolating polynomial.

Further, we consider a lower triangular infinite matrix  $\mathbb{B}$  on  $c_0$ . The diagonal and sub-diagonal entries of this matrix consist of oscillatory sequences with the different numbers of limit points and the rest of the entries of the matrix are zero. We show that the matrix  $\mathbb{B}$  is a bounded linear operator and discuss the spectrum and its subdivisions, namely point spectrum, continuous spectrum, residual spectrum, etc for this matrix. Then, we consider a lower triangular infinite matrix  $A$  with three non zero bands formed by oscillatory sequences, where each of the oscillatory sequences has two distinct limit points. We show that the matrix  $A$  is a bounded linear operator on  $c_0$ . We discuss the spectrum and its subdivisions of the matrix  $A$  on  $c_0$ . We also generalize the matrix  $A$  to a  $(p + 1)$ -banded lower triangular infinite matrix  $A_1$  and we determine inclusion relation for the spectrum of this generalized matrix.

Next, we study the numerical solutions of two-dimensional Volterra integral equations with weakly singular kernels by Galerkin, iterated Galerkin, multi-Galerkin and iterated multi-Galerkin methods using Jacobi polynomials. We obtain improved rates of convergence in iterated Jacobi spectral Galerkin and iterated Jacobi spectral multi Galerkin methods. Subsequently, some numerical examples are given in support of the results.

**Keywords:** Spectrum; Point spectrum; Continuous spectrum; Residual spectrum; Goldberg classification; Sequence space; Difference operator; Duals; Matrix transformation; Bigeometric calculus; Hermite interpolation; Volterra integral equations; Galerkin and multi - Galerkin spectral methods.