CURRICULUM VITAE

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Present Position: Lecturer
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Educational Qualifications:

- **Ph.D. (Mathematics):** Indian Institute of Technology Kanpur, INDIA, (2003).
  Thesis Title: Investigation of Certain Differential and Integro-differential Equations in Abstract Spaces
  Summary: Given in Appendix A-1
  Thesis Supervisors: Prof. D. Bahuguna

  Courses Studied for Ph.D. Program:
  (i) Applied Mathematical Method
  (ii) PDE and their Applications
  (iii) Numerical Solutions of PDE
  (iv) Functional Analysis
  (v) PDE of Parabolic type
  (vi) Numerical Linear Algebra
  C.P.I. in Course Work: 9.33 in 10.0 scale.
  Courses Attended:
  (i) Finite Element Method to Fluid Dynamics
  (ii) Computer Programming
  (iii) Measure Theory

- **M.Sc. (Mathematics):** Lucknow University, Lucknow. (1997), 65%.
  Div: 1st.
  Courses Studied:
  First Year
  (i) Real and Complex Analysis
  (ii) Topology
  (iii) Differential Geometry
  (iv) Modern Algebra
  (v) Partial Differential and Integral Equations
  Second Year
  (i) Distributions with Applications
  (ii) Applied Functional Analysis
  (iii) Special Functions
  (iv) Approximation Theory
  (v) Fluid Dynamics

- **B.Sc. (PCM Group):** Mahila Vidyalaya Degree College, Lucknow, Lucknow University. (1995), 66.22%.
  Div: 1st.

- **Intermediate (PCM Group):** Mahila Vidyalaya Inter College, Lucknow, U.P. Board. (1992), 72.20%, Distinction in Mathematics (91/100) and Physics (83/100).
  Div: 1st.

- **High School (Science group):** Mahila Vidyalaya Inter College, Lucknow, U.P. Board. (1990), 69.71%, Distinction in Mathematics (83/100) and Science (77/100).
  Div: 1st.

Field of Specialization and Research Interests:

- Differential Equations in Abstract Spaces (34G20) and Application to Partial Differential Equations
- Approximation in normed linear spaces and other abstract spaces (41A65)
- Integrodifferential and Functional Differential Equations (34K20)
- Semigroups of Operators and Non-linear Analysis
- Finite Element Method

Research and Teaching Experience:

- Working as a lecturer in Mathematics Group BITS Pilani - Goa Campus since June 28, 2004
  Courses Taught:
  1. MATH GC191 Mathematics I
  2. MATH GC192 Mathematics II
  3. MATH GC241 Mathematics III
  4. AAOC GC111 Probability and Statistics (Instructor in Charge)
  5. AAOC GC222 Optimization

- Worked as a lecturer in Mathematics Group BITS Pilani - Pilani Campus from February 20, 2003 to June 2004
  Courses Taught/Handled:
  1. MATH C191 Mathematics I
  2. MATH C192 Mathematics II
  3. MATH C241 Mathematics III
  4. MATH ZC161 Engineering Mathematics I
  5. MATH ZC232 Engineering Mathematics II

- Worked as Senior Research Fellow of CSIR in the Department of Mathematics, I.I.T. Kanpur from January 2002 to February 2003.

- Worked as Junior Research Fellow of CSIR in the Department of Mathematics, I.I.T. Kanpur from December 1999 to December 2001.

- Worked as Teaching Assistant in Core Course (MTH 203) Partial Differential Equations, Complex Analysis and Statistics (twice) in the Department of Mathematics I.I.T. Kanpur.

- Worked as a Lecturer in Mathematics and Physics at Intermediate level from July 1998 to May 1999 at Mahatma Gandhi Inter College, Chowk, Lucknow.

Computer Experience:

- Operating System Known: Unix, Linux, Windows/98/NT.
- Knowledge of FORTRAN 90 and C.

- Familiar with MATHEMATICA, gnuplot, xfig.
- Word processing: Latex, MS-word.

Scholastic Achievements:

- Selected for **"Young Scientist Award"** in 'Fifth Conference of the International Academy of Physical Sciences (CONIAPS-V, 2002)' held on April 07-09, 2002 at Department of Mathematical Sciences and Computer Applications, Bundelkhand University, Jhansi.

- Qualified Joint CSIR-UGC Test for Junior Research Fellowship (JRF) and Eligibility for Lectureship (NET) held on June 20, 1999:
  1. JRF(CSIR) from January 2000 to December 2001
  2. SRF(CSIR) from January 2002 to February 2003

- Post Doctoral Fellowship from The Institute of Mathematical Sciences, Chennai in March 2003

- Scholarship for High School from U.P. Board

Membership in Scientific Societies:

- Life Member of Bharata Ganita Parishad (BGP).

List of Publications:

- **Published/Accepted Papers:**

  [1] 'Approximations of solutions to nonlinear Sobolev type evolution equations' (with D. Bahuguna), *Electronic J. Differential Equations*, Vol. 2003(2003), No. 31, pp. 1-16.
  Abstract: Given in Appendix A-2

  [2] 'Approximations of Solutions to Second Order Semilinear Integrodifferential Equations' (with D. Bahuguna), *NUMER. FUNCT. ANAL. AND OPTIMIZ.*, Vol. 24, Nos. 3 and 4, pp. 365-390, 2003.
  Abstract: Given in Appendix A-3

  [3] Method of semidiscretization in time to quasilinear integrodifferential equations' (with D. Bahuguna), *International Journal of Mathematics and Mathematical Sciences*, Vol. 2004, No. 9, pp. 469-478.
  Abstract: Given in Appendix A-4

  [4] 'Approximations of solutions to second order semilinear evolution equations' (with D. Bahuguna) *Differential Equations and Dynamical Systems*, Narosa 2004, pp. 179-203.
  Abstract: Given in Appendix A-5

  [5] 'Application of Method of Semidiscretization in Time to Semilinear Viscoelastic Systems' (with D. Bahuguna and S. Singh), *Differential Equations and Dynamical Systems*, Vol. 13, October 2005, pp. 323-341.
  Abstract: Given in Appendix A-6

  [6] 'Existence of A Regular Solution to Quasilinear Implicit Integrodifferential Equations in Banach Spaces'. *Global Journal of Mathematics and Mathematical Sciences*, to appear.
  Abstract: Given in Appendix A-7

- **Manuscripts under preparation:**

[1] 'Application of Rothe Method to Abstract Quasilinear Implicit Integrodifferential Equations in Reflexive Banach Space'
Abstract: Given in Appendix A-8

[2] 'Abstract Second Order Semilinear Integrodifferential Equation in Banach Space'.
Abstract: Given in Appendix A-9

[3] 'Global solutions of Abstract Nonhomogeneous Quasilinear Evolution Equations of the "Hyperbolic" Type'
Abstract: Given in Appendix A-10

- **Conference Proceedings:**

[1] 'Application of Rothe Method to Abstract Quasilinear Implicit Integrodifferential Equations in Reflexive Banach Space' (with D. Bahuguna), Pre-Conference Proceedings of National Seminar on Recent trends in Mathematics and its Applications organized by Visva-Bharati Santiniketan, 25-26, 2002

- **Conference Presentations:**

[1] 'Regular Solution to Quasilinear Implicit Integrodifferential Equations in Banach Spaces' (with D. Bahuguna) presented at the 'International Conference on Current Trades in Differential Equations and Dynamical Systems' held during December 15-17, 2001 at the Department of Mathematics, I.I.T. Kanpur.

[2] 'Method of Semidiscretization in Time to Implicit Quasilinear Integrodifferential Equations in Banach Space' (with D. Bahuguna) presented at 'Joint 9th National Conference of The Vigyan Parishad of India on Applied and Industrial Mathematics and 5th Annual Conference of Indian Society of Information Theory and Applications' held during February 22-24, 2002 at the Department of Mathematics, School of Applied Sciences, NSIT Delhi.

[3] 'Application of Rothe Method to Abstract Quasilinear Implicit Integrodifferential Equations in Reflexive Banach Space' (with D. Bahuguna) presented at 'National Seminar on Recent trends in Mathematics and its Applications' held during February 25-26, 2002 at the Department of Mathematics, Siksha-Bhavana, Visva-Bharati, Santiniketan.

[4] 'Global solutions of Abstract Inhomogeneous Quasilinear Evolution Equations of the "Hyperbolic" Type' (with D. Bahuguna) presented for **"Young Scientist Award"** at 'Fifth Conference of the International Academy of Physical Sciences (CONI APS-V, 2002)' to be held on April 07-09, 2002 at Department of Mathematical Sciences and Computer Applications, Bundelkhand University, Jhansi.

[5] 'Approximations of solutions to second order semilinear evolution equations' (with D. Bahuguna) presented at "Annual Conference of the Ramanujan Mathematical Society" held on June 10-13, 2002, at Department of Applied Mathematics IT-BHU, Varanasi.

[6] Approximations of solutions to nonlinear Sobolev type evolution equations (with D. Bahuguna) presented at "International Conference & Instructional Workshop on Industrial Mathematics" held on December 2-9 2002 at Department of Mathematics IIT Bombay, INDIA.

Participation:

- **Conference**

Participated in the 'Golden Jubilee International Conference on Mathematics' held during December 31, 1999 to January 3, 2000 at the Department of Mathematics and Astronomy, Lucknow University, INDIA.

- **Workshop**
  - Participated in the 'UNESCO Regional Instructional Workshop on Industrial Mathematics' held during December 2-6, 2002 at the Department of Mathematics IIT Bombay, INDIA and worked on problem "Efficient Heat Transition Coefficient of a Window Construction".
  - Worked as a resource person in a workshop for higher secondary teachers organized by directorate of science and technology of Goa Government in BITS Pilani Goa Campus in 2005

Other Achievements:

- Visited Department of Mathematics, Indian Institute of Sciences, Bangalore under **IISc-TIFR Short Term Visitors Program** during the period from April 22, 2002 to May 22, 2002 and worked with Prof. Phoolan Prasad on "Singularities in Level Set Theory and Kinks in solution of Kinematical Conservation Law".
- Attended N.C.C. Annual Training Camp held at U.P. Sainik School, Lucknow during May 12-23 1989.
- Passed the N.C.C. certificate 'A' Examination held in 1990 under the authority of Ministry of Defense, Government of India.

References:

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  Department of Mathematics and Statistics,
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Father's Name	:	Mr. Kaushal Kishore Shukla
Mother's Name	:	L/o Mrs. Suresh Kumari Shukla
Nationality	:	Indian
Date of Birth	:	December 8, 1974
Sex	:	Female
Marital Status	:	Married
Husband's Name	:	Capt. Abhijeet Dubey
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Appendix A-1

The governing partial differential equations of many physical phenomena can be modelled as evolution equations in Hilbert or more generally, in Banach spaces and may be viewed as ordinary differential equations in infinite dimensional spaces of functions. The work presented in this thesis demonstrates the applications of rich theory of functional analysis to study problems. By considering such problems in abstract spaces not only we establish the results for the problems under consideration, but also for the whole class of problems to which these prototype of problems belong. We concentrate on basic features those remain invariant when we switch from one problem to another belonging to the same class.

We first analyze the well-posedness of a solution of an evolution equation and then aim to find, the exact solution if possible, otherwise the approximate solution. We consider certain approximate equations in finite dimensional spaces associated with an evolution equation under consideration and establish the existence and uniqueness of solutions to these approximate equations. The convergence of the solutions of the approximate equations to the solution of the evolution equation is then established. Our tools for this are the theory of analytic semigroups and the contraction mapping theorem. We consider analytic semigroups generated by the operators appearing in evolution equations under consideration.

Although, our study concerns some special type of evolution equations, namely the Sobolev type equations and certain classes of second order semi-linear differential and integro-differential equations but the techniques are quite general which are extendable to other type of problems.

The thesis has seven chapters.

In **Chapter 1**, we give the introduction to the problems discussed in the subsequent chapters providing a motivation to the study carried out in this thesis. Then, we give a review of related works in the literature and the significance of the problems considered. Next, we mention some of the results required for the analysis in the ensuing chapters.

In **Chapter 2**, we consider the Sobolev type evolution equations in a separable Hilbert space and study the approximations of the solutions. The Sobolev type evolution equations are implicit evolution equations in which time derivatives of the unknown function appear implicitly and these type of equations arise in many diffusion and fluid flow models. We consider an associated integral equation and a sequence of approximate integral equations using projection operators. Then we establish the existence of a unique solution to every approximate integral equation using the contraction mapping theorem. After proving some estimates for the solutions of approximate integral equations, we prove the convergence of the solutions of the approximate integral equations to the solution of the associated integral equation. Further, we show that the solution of associated integral equation can be extended

to the maximal interval of existence and it is unique. Finally, we consider the Faedo-Galerkin approximations of solutions and prove some convergence results.

In **Chapter 3**, we consider a strongly damped semi-linear wave equation and reformulate it as a second order semi-linear evolution equation. We study the convergence of approximation of the solution to a second order semi-linear evolution equation in a separable Hilbert space by using similar techniques which are used in Chapter 2. First, with the help of a pair of associated integral equations and projection operators, we consider a pair of approximate integral equations and prove the existence and uniqueness of the solution to this pair. We then establish the convergence of the pair of approximate integral equations to the pair of associated integral equations and limit of the solution of approximate integral equations being the solution of associated integral equation.equations. Further, we show that the solution of the pair of associated integral equations can be extended to the maximal interval of existence and it is unique. Finally, we consider the Faedo-Galerkin approximations of the solutions and prove some convergence results.

In nuclear dynamics and thermo-elasticity, there is a need to reflect the effects of the "memory" of the system. This results in the inclusion of an integral term into the governing partial differential equation yielding a partial integro-differential equation (PIDE). This provides us a motivation to study the partial integro-differential equations. In the next two Chapters, we study a class of second order semi-linear integro-differential equations arising in the study of viscoelastic material with memory.

In **Chapter 4**, we consider an abstract second order semi-linear integro-differential equation in a Banach space and first prove the existence and uniqueness of a local classical solution with the help of the semigroup theory and the contraction mapping theorem. Further, under some additional growth conditions on the nonlinear maps we establish the continuation of this solution, the maximum interval of existence and the global existence.

In **Chapter 5**, we consider a strongly damped semi-linear integro-differential equation and reformulate it as a second order semi-linear integro-differential equation in a separable Hilbert space and study the convergence of the approximation of the solution using similar techniques which are used in Chapters 2 and 3.

In **Chapter 6**, we consider a first order quasi-linear implicit integro-differential equation in a Banach space. First, we prove the existence, uniqueness and continuous dependence on the initial data of a strong solution by using the method of semi-discretization in time in which we discretize the time axis and replace the time derivatives by the correspond difference quotients. Then, we show that these discrete points lies in a ball whose radius is independent of the discretization parameters and prove some estimates. After defining the approximate solution in terms of these discrete points, we prove its convergence. Next, we establish the existence of a unique local mild solution and its regularity under some additional condition with the help of the semigroup theory and the contraction mapping theorem.

In **Chapter 7**, we conclude the thesis with some remarks and provide some insight into further research work in this and related areas.

Appendix A-2

In this paper we study the approximations of solutions to a class of nonlinear Sobolev type evolution equations in a Hilbert space. These equations arise in the analysis of the partial neutral functional differential equations with unbounded delay. We consider an associated integral equation and a sequence of approximate integral equations. We establish the existence and uniqueness of the solutions to every approximate integral equation using the fixed point arguments. We then prove the convergence of the solutions of the approximate integral equations to the solution of the associated integral equation. Next we consider the Faedo-Galerkin approximations of the solutions and prove some convergence results. Finally we demonstrate some of the applications of the results established.

Appendix A-3

In this paper we study the approximations of solutions to a class of second order semilinear integrodifferential equations in a Hilbert space. These equations arise in the study of viscoelasticity of materials with memory. Using a pair of associated nonlinear integral equations and projection operators we consider a pair of approximate nonlinear integral equations. We first show the existence and uniqueness of solutions to the pair of approximate integral equations. We then establish the convergence of solutions and convergence of the pair of approximate integral equations to the pair of associated integral equations. We finally consider the Faedo-Galerkin approximations of solutions and prove some convergence results.

Appendix A-4

In this paper we consider a class of quasilinear integrodifferential equations in a reflexive Banach space. We apply the method of semidiscretization in time to establish the existence, uniqueness and continuous dependence on the initial data of strong solutions.

Appendix A-5

In this paper we consider the Faedo-Galerkin approximations of a strongly damped semilinear equation. We reformulate the initial boundary value problem as an abstract second order initial value problem in a Hilbert space. Using a pair of associated nonlinear integral equations and projection operators we consider a pair of approximate nonlinear integral equations. We first show the existence and uniqueness of solutions to the pair of approximate integral equations. We establish the convergence of solutions and convergence of the pair of approximate integral equations to the pair of associated integral equations, limit of the solutions to the pair of approximate integral equations being the solution of the pair of associated integral equations. We then consider the Faedo-Galerkin approximations of solutions and prove some convergence results.

Appendix A-6

In this paper we consider the application of the method of semidiscretization in time to a class of problems arising in the mathematical formulation of viscoelastic systems with small strains. We reformulate the problem as a second order abstract Cauchy problem in a reflexive Banach space. We establish existence uniqueness of solutions to the abstract Cauchy problem. The results established for the abstract Cauchy problem are then used to conclude existence and uniqueness of the solutions to the physical problem under consideration.

Appendix A-7

In this paper first we establish the existence of a unique local mild solution using contraction mapping theorem and after that the existence of a local classical solution to a class of quasilinear implicit integrodifferential equations in a general Banach space.

Appendix A-8

In this paper we have established the existence, uniqueness and continuous dependence on initial data of the strong solution of abstract quasi-linear implicit integrodifferential equation in real reflexive Banach space X whose dual is uniformly convex by using Rothe method which is also known as method of lines or method of semidiscritization in time. In this case quasilinear operator also depends on time.

Appendix A-9

In this paper we consider a strongly damped semilinear integrodifferential equation and formulate it as a second order integrodifferential equation in a Banach space. We establish the local existence and uniqueness of a classical solution. We also study the continuation, the maximal interval of the existence and the global existence of the classical solution.

Appendix A-10

In this Paper we are interested in discussing the problem of existence and uniqueness of global classical solution of abstract inhomogeneous quasilinear evolution equations of the hyperbolic type

$$\frac{du}{dt}(t) = A(u(t))u(t) + F(t, u(t)), \quad t \geq 0, \quad u(0) = u_0.$$

in a real Banach space Z, where $\{A(w) : w \in Y\}$ is a family of closed linear operators in Z and Y is another real Banach space which is densely and continuously embedded in Z and $F(t, w)$ depends on t and certain $w \in Y$.

This equation may have only local classical solutions provided that $A(w)$ is local quasi-dissipative for each $w \in Y$, and it is necessary to consider the growth of classical solutions. In this paper we employ a nonnegative continuous functional φ on Y to define the local quasi-dissipativity of $A(w)$ and specify the growth of a classical solution u of this equation in terms of the real-valued function $\varphi(u(.))$.