Brij Mohan, Ph.D. Research Scholar, P2109, Department of Mathematics, University of Delhi.

Question 1: **What do you understand by scientific research? Discuss the different types of scientific research.**

Answer:

Scientific Research

Scientific research can be defined as a scientific and systematic study of the pertinent information on a specific topic using systematic methods of collecting, analyzing, and interpreting data or information. It is often referred to as a creative process because it involves novel ways to test ideas that can lead to new ideas and information.

A **scientific study** is a method of obtaining information to address a previously identified problem or question. It often involves forming and testing a hypothesis or an explanation for something based on prior knowledge or research. Scientists study various topics, including medicine, psychology, chemistry, mathematics, physics, and environmental sciences. People can even conduct scientific research investigating aspects of their daily lives.

Scientists or researchers use a variety of methods to study their topics of interest:

- **Scientific method**: This is a general framework for how scientists approach various types of problems. They identify the problem or question, propose a hypothesis (i.e., a potential explanation), gather information about their topic, apply the appropriate methodology and make a conclusion based on the data they obtained.
- **Observational studies**: This involves watching a particular phenomenon as a way to look for specific effects, relationships, or outcomes. For example, researchers may observe married couples to learn how they deal with marital stress when they encounter different types of relationship problems.
- **Scientific experiments**: This involves systematically manipulating factors in a controlled environment to establish a causal relationship between the variables of interest. For example, researchers may administer a drug to a group of rats and compare their behaviour to another group that received no drug to determine whether or not the drug has an effect.

Steps of doing scientific research:

1. Identify the problem
2. Selecting the topic of research
3. Literature review
4. Objective of Research
5. Selecting methods
6. Obtaining the results
7. Analyzing the results
8. Concluding the work and finding the future scope of work
9. Writing research paper

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Types/Classification of Scientific Research:

1. **Descriptive Research and Analytical Research**

   Descriptive Research: In this type of research, the researcher studies the subject's current state and describes and interprets the existing conditions and relationships. In other words, descriptive research examines a phenomenon by expressing a complete definition and contrasting it with other phenomena. The primary purpose of this type of research is to provide an objective, realistic description of the characteristics of a situation or a topic. It focuses on answering a research problem's *how, what, when, and where* questions rather than the *why.*

   Analytical Research: This is a specific type of research that involves critical thinking skills and the evaluation of facts and information relative to the research being conducted. Various people, including students, doctors, and psychologists, use analytical research during studies to find the most relevant information.
   Analytical research focuses on understanding the cause-effect relationships between two or more variables. In an analytical study, the researcher tries to explain why and how the trade deficit has moved in a specific direction within the given time.

2. **Applied Research and Fundamental or Basic Research**

   Applied research: It refers to scientific study and research that seeks to solve practical problems. Applied research is used to find solutions to everyday problems, cure illnesses, and develop innovative technologies rather than to acquire knowledge for knowledge's sake. For example, applied researchers may investigate ways to:
   • Improve agricultural crop production
   • Treat or cure a specific disease
   • Improve the energy efficiency of homes, offices, or modes of transportation

   Fundamental Research: It is driven by a scientist's curiosity or interest in a scientific question. The primary motivation is to expand man's knowledge, not to create or invent something. There is no apparent commercial value to the discoveries that result from basic research.
   For example, basic science investigations probe for answers to questions such as
   - How did the universe begin?
   - What are protons, neutrons, and electrons composed of?
   - How do slime molds reproduce?
   - What is the specific genetic code of the fruit fly?

3. **Quantitative Research and Qualitative Research**

   Qualitative Research: This research deals with phenomena that are difficult or impossible to quantify mathematically, such as beliefs, meanings, attributes, and symbols. Qualitative researchers aim to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour. Generally, it addresses argumentative descriptions, discovering the meanings and changes of social actors. This research, above all, describes everyday realities in social life and, through common sense and inductive analyses and interpretations, makes a hypothesis that was unpredictable before doing research or not predetermined.

Quantitative Research: This refers to the systematic empirical investigation of any phenomena via statistical, mathematical, or computational techniques. The objective of quantitative research is to develop and employ mathematical models, theories, and hypotheses about phenomena.
In quantitative methods, everything is inspired by crucial and predetermined concepts, such as hypothesis, operational definition, validity, significance, statistics, reliability, deductive analysis, and repeatability.
To put it simply, the findings of quantitative research are the result of systematic studies that are achieved by top-down methods.
Quantitative research is generally made using scientific methods, which can include:

- The generation of models, theories, and hypotheses
- The development of instruments and methods for measurement
- Experimental control and manipulation of variables
- Collection of empirical data
- Modelling and analysis of data
- Evaluation of results

4. **Conceptual Research and Experimental Research**

Conceptual Research: It is defined as a methodology wherein research is conducted by observing and analysing already present information on a given topic. Conceptual research doesn't involve conducting any practical experiments. It is related to abstract concepts or ideas. Philosophers have long used conceptual research to develop new theories or interpret existing theories in a different light.

Experimental Research: This is a study that strictly adheres to a scientific research design. It includes a hypothesis, a variable that can be manipulated by the researcher, and variables that can be measured, calculated and compared. Most importantly, experimental research is completed in a controlled environment. The researcher collects data and results will either support or reject the hypothesis.

5. **Others**:

a. One-time Research
b. Laboratory Research
c. Clinical Research
d. Diagnostic Research

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Question 2: **Distinguish between research topic and a research problem. Choose a research problem in your area of research and discuss its objectives.**

Answer:

Research topic:
Research topic is the topic of our research/study. Topic should be strict and focussed, i.e. it must be explicit or definite.

For example basic research topics in mathematics are:

1. **Algebra**:
   Abstract Algebra, Modern Algebra, Linear Algebra
2. **Analysis**:
   Functional Analysis, Complex Analysis, Metric Spaces
3. **Topology**:
   Point Set Topology (General Topology), Algebraic Topology, Combinatorial Topology
4. **Geometry**:
   Differential Geometry, Complex Geometry, Discrete Geometry, Computational Geometry
5. **Applied Mathematics**:
   ODE and PDE (Linear and Nonlinear), Fluid Dynamics, Optimization, Space Dynamics
6. **Others**:
   Machine Learning, Game Theory, Mathematical Modelling, Data Analysis

Research problem:

The whole research work comprises different research problems, and it is an assertion for which we want to find the answer.

Remark:

1. All questions cannot be transformed into research problems.
2. There always exists a research topic in which a research problem is included. i.e., Every research problem comes from a research topic.

Steps in formulating the research problem:

1. Identify the broad field or subject.
2. Dissect the wide-area into a sub-area.
3. Select what is of most interest to us.
4. Raise research question.
5. Formulate objective.
6. Access your objective.

The basic steps associated with finding and solving a research problem:

1. Finding the study which is related to our research topic.
2. Arranging our study materials from good sources.
3. Learning/studying from organized data/information.
4. Collecting necessary information/data which can be used in the selected problem.
5. Finding the methodology or steps that can be applied to get novel results.
6. Analysing the obtained results and concluding.

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My Research problem and its objective:

My research topic is nonlinear partial differential equations (NLPDE), and my research problem is "A study of multi-soliton solutions, breather, lumps, and their interactions for Kadomtsev-Petviashvili equation with variable time coefficient using Hirota method."

General Objective:

To study the dynamics of obtained analytical/exact solutions for the KP equation, a nonlinear partial differential equation. We apply the Hirota method to get the exact solutions for the considered KP equation and use symbolic software such as Mathematica to show the dynamics of the obtained solutions in 2D and 3D.

Specific Objective:

- We investigate the integrability of nonlinear evolution equations that can help to accomplish the objective of obtaining multiple soliton solutions as well as analytical solutions. Complete integrability for an NLPDE can be confirmed using the Painlevé test.
- We seek specific solutions to correctly apprehend the characteristic of varied facts in different aspects of natural sciences.
- We seek the dynamical behaviour of soliton solutions derived from NLPDEs has been a fascinating area of study due to its potential relevance in demonstrating realistic features in the dimensions of engineering sciences, nonlinear dynamics, and complex physical systems.
- We obtain multiple soliton solutions, rogue waves, breathers, lump solutions, and their interactions using the Hirota bilinear method.
- We investigate multiple soliton solutions up to fourth-order.
- We illustrate our solutions using three-dimensional postures and contour plots depending on the graphical suitability.
- Due to the arbitrariness of the time-dependent coefficient g(t), we show graphical representations of the solutions in (x-t-u) coordination using erratic choices of the same.

Brij Mohan, Ph.D. Research Scholar, P2109, Department of Mathematics, University of Delhi.

Question 3: **Discuss the duties of student and supervisor in the scientific research. Describe the method of publishing a research paper.**

Answer:

Research Supervisor:

Supervision (in general) is the action or process of watching and directing what someone does or how something is done.

A research supervisor is an advanced member of a university/faculty whose role is to guide students who are the candidates for a doctorate. He helps them select course work, shape, refine and direct the student choice of sub-discipline in which they will be examined or on which they will write a dissertation or research work.

A good supervisor is a guide and mentor, not an encyclopedia or a self-help book. Without the help of a supervisor experienced in the area, it is virtually impossible to do proper research (unless the student is a self-taught genius).

In one sentence, a promising Ph.D. supervisor is the one who spends time with the student not only at the university but follows the student, in the searching area, helps the student with appropriate journals, meets and discusses, and communicates regularly with the student. Most importantly, who encourages and appreciates the student for their efforts and who understands student's problems, including personal. The Ph.D. supervisor should not be a threat to the student, but a friend, which will make a good Ph.D. outcome in the long run.

To avoid misunderstanding between supervisor and the student, individual students and their supervisors may find it helpful to draw up a written agreement or memorandum of understanding which can be referred to if difficulties arise and reviewed regularly in the light of changing circumstances.

Roles and Responsibilities of a Supervisor:

The role is the function assumed or part played by a person or thing in a particular situation, and responsibility is the state or fact of being accountable or to blame for something.

ROLE OF THE SUPERVISOR (GENERAL)

The supervisor should be available to guide the student at every stage:

1. Formulation of the study,
2. Establishing the methods,
3. Discussing the results of the study,
4. Presentation (seminars or conferences),

5. Publication of journal articles,
6. and writing of the thesis.

Stages in PhD supervision:

1. Proposal Writing
2. Provisional Registration
3. Full Registration
4. Progress Report
5. Thesis Writing, Seminars, Conferences
6. Publications, Thesis submission
7. Defence

ROLES IN PROPOSAL WRITING

- The supervisor should assist the student with the selection and planning of a suitable and manageable research topic.
- The supervisor should be sufficiently familiar with the field of study to provide guidance and/or has a willingness to gain that familiarity before agreeing to act as a supervisor.
- The student should assume the leading role in writing the proposal to internalize the subject of the study.

ROLES IN PROVISIONAL REGISTRATION

- The supervisor ensures that the student files the application, provides certified academic transcripts and certificates (BSc and MSc) and pays application fee and submits a proposal.
- The supervisors sign the proposal as their commitment to guide the student.
- The supervisor checks the progress that the Department/School/University receives application and processes to grant preliminary admission.

ROLES IN FULL REGISTRATION

- The supervisor guides the student refines the proposal using the library services of the university.
- The supervisors sign/approve the proposal after ascertaining its adherence to format and its quality.
- The supervisor ensures that the student submits the refined proposal to the Departmental committee for evaluation.
- The supervisor checks that the student gives a Departmental seminar on the proposal. The Department/School receives and evaluates and BPS processes the proposal to grant full registration.

ROLES IN RESEARCH/PROGRESS REPORTING

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- The supervisor should be accessible to the student for consultation and discussion of the student's academic progress and research.
- The supervisor must provide complete, prompt, and honest feedback on their research progress.
- The supervisor should meet the student one-on-one in a conducive environment. The student should not be embarrassed in front of peers.
- The supervisor should ensure:
  a) that the research environment is safe, healthy and free from harassment, discrimination and conflict.
  b) compliance with the university requirements of submitting reports as a means of monitoring student progress.

ROLES IN THESIS WRITING

- The student should be the primary writer of the thesis. The supervisor should not be the editor of the thesis, but provide guidance on structure of the thesis.
- He should read the student's thesis thoroughly and make constructive comments on both style and intellectual content.
- The supervisor should verify the accuracy of the discussions and conclusions.
- The supervisor should ensure the university guidelines are followed. The university should provide library services.
- The supervisor should respond timely and thoroughly to written work submitted by the student, with constructive suggestions for improvement and continuation. The turnaround time for comments should not exceed three weeks.
- The supervisors must also ensure that their students' work meets the standards of the University and the academic discipline.
- The supervisor should ensure the students are fully aware of plagiarism, its consequences, and the need for academic integrity/honesty in undertaking and writing research.

ROLES IN SEMINARS & CONFERENCES

- The supervisor should encourage the student to make presentations of research findings within the university and outside at scholarly or professional forums as appropriate.
- The supervisor should guide the student to prepare and deliver a quality presentation.
- The supervisor should ensure that the venue of the seminar that is equipped with audio-visual facilities.

ROLES IN PUBLICATIONS

- The supervisor/student identifies the important themes of the study to be formulated in the article.
- The student drafts the paper in consultation with the supervisor.

- The supervisor should acknowledge the contributions of the student via joint authorship.
- The supervisor identifies the relevant journal for the article and guides the student in formatting the article based on the guidelines of authors.
- He should encourage the students to discipline writing conventions (the mechanics of writing, like capitals, punctuation, and handwriting), referencing, and citations.

ROLES IN THESIS SUBMISSION/EXAMINATION/DEFENCE

- Supervisors assess the quality of the thesis and approve for submission.
- Supervisor identifies the internal and external examiners.
- The student submits the thesis to BRS (Board of Research Studies).
- Supervisor examines the thesis and submits a report to BPS.

Research Student:

A research student means a person duly admitted and pursuing a programme of study, including a research programme in any mode of study.

Roles and Responsibilities:

1. The student should take responsibility for his/her own personal and professional development.
2. The student should maintain regular contact with his supervisor.
3. The student should prepare adequately for meetings with the supervisor and other advisory committee members.
4. The student should make supervisors aware of any specific needs or circumstances likely to affect their work.
5. The student should ensure that appropriate ethical approval is obtained before research commence.
6. The student should conduct research with integrity, following the university's policy framework.

Method of publishing a research paper:

Step 1: Evaluating a work:

Before submitting a paper, one should evaluate the research paperwork. For this, one should try to find answers to the questions such as its significance, originality/novelty, completeness, and correctness.

Step 2: Now the question arises where to submit?

It can be challenging to find up-to-date guidance when choosing where to publish. One should

publish in a journal for which

- it is easy to discover the latest papers in the journal.
- quickly identify and contact the publisher.
- journal belongs to the COPE (Committee on Publication Ethics)
- if the journal is open access, then check for listed in DOAJ.

Choosing a relevant journal makes the manuscript more likely to be accepted. Some factors to consider are

- see the topics the journal publishes.
- see the journal audience.
- the types of articles the journal publishes.
- the reputation of the journal.

Besides these, one should keep the following is the mind

- A good starting point is the journals that published the papers what we reference in our work. Each issue of the journal should explain where to send the submission.
- One cannot submit the same paper to two journals simultaneously.

Step 3: Once we submit our paper to a journal, it goes through the journal's review process. It passes through an editorial phase. Based on the reviewers' reports, the editor recommends acceptance, minor revisions, a major revision, or rejection. This decision is made by the editor-in-chief and sent to the contributing authors by email.

Step 4: Try to believe that the reviewer's comments will help to improve the manuscript.

Step 5: Revised manuscript should be submitted within the time given by the journal with appropriate revisions suggested by the reviewers.

Step 6: At the end, we get an email of acceptance by the journal if our paper is accepted for publication.

Brij Mohan, Ph.D. Research Scholar, P2109, Department of Mathematics, University of Delhi.

Question 4: **Discuss different funding agencies for scientific research in Mathematics. Write a brief research proposal for getting financial support from the University of Delhi.**

Answer:

We need to write a research proposal to get funds from the agencies. Funding agencies and potential supervisors use research proposals to assess the quality and originality of your ideas, your critical thinking skills, and the research project's feasibility.

We have funding agencies at the national, local, and international levels.

At national level

1. NBHM (National Board for Higher Mathematics)
2. CSIR (Council Of Scientific And Industrial Research)
3. UGC (University Grants Commission)
4. DST-SERB (Department of Science and Technology-Science and Engineering Research Board)
5. Ministry of Education
6. DRDO (Defence Research and Development Organisation)
7. ISRO (Indian Space Research Organisation)

At local level, we have universities/institutions. There is a research council in the university of Delhi to take care of such matter.

At international level

1. ICIAM (International congress on Industrial & Applied Mathematics)
   It is an international congress in the field of applied mathematics that is hold every four years. The next event will be hold on 20-25 August, 2023 in Tokyo, Japan.
2. DAAD (or German Academic Exchange Service, Germany)
3. IMU (International Mathematical Union, USA)
4. NSF (National Since Foundation, USA)
5. SIAM (Society of International Applied Mathematics, USA)

Brief example of Research Proposal:

1. **Details of the Applicant**:
   Principal Investigator: Brij Mohan
   Designation: Assistant Professor
   Department/Centre: Department of Mathematics
   University: University of Delhi
   Email: brijmohan6414@gmail.com
   Phone: +91-9711216414

Project Overview

2. **Broad Area/Discipline**: Nonlinear Partial Differential Equations
3. **Project Title**: Analytical solutions and dynamical behaviour for nonlinear evolution equations using Hirota method.
4. **Abstract**:
   This project proposal aims to investigate the nonlinear PDEs of higher-order or higher dimensions or both and achieve the different types of exact solutions. The exact solutions such as multiple soliton, lumps, breathers, rouge waves, and their interactions are to be

obtained with the dynamical behaviour of the solutions to understand their peculiar properties in shallow water waves, plasma physics, oceanography, ion-acoustic waves, and other nonlinear sciences.

5. **Duration of Project**: 2 Years
   Total Budget: 2 Lakh
   Fund requested from DU: 2 Lakh

6. **Project Details**:

(i) **Introduction**:
It has always been challenging to comprehend the nonlinearity in PDEs. To learn about the same aspects, a wide range of theories have come up in the past decade. Numerous mathematicians and physicists have got influenced by the richness in the structures of nonlinear PDEs. The higher-order and higher-dimensional nonlinear PDEs have become an essential part of various science and engineering domains that own a more notable characteristic required to learn about the dynamical behaviour of a wide range of applied sciences.
This research proposal involves the literature review activities to study and understand the nonlinear partial differential equations and utilize the Hirota bilinear method to obtain analytical and exact solutions to the studied PDEs. Using symbolic system software Mathematica/Matlab/Maple, the dynamical behaviour of the acquired solutions of the given equations is being illustrated and gathering the research data to formulate the final research papers for the fulfilled objectives.

(ii) **Objective**:
After finding the complex nonlinear problem through literature review, we have our objectives as
F**irst objective** is to check the integrability of the nonlinear evolution equation selected as the problem. Painlevé analysis test is used to check the integrability of the nonlinear PDEs. Due to the complexity of the test, symbolic software such as Mathematica/Matlab/Maple is used.
Second objective is to do bilinearization. We apply a dependent variable transformation to get a bilinear form for the selected problem. A dependent variable transformation converts the nonlinear PDEs to a quadratic or quartic equation with an auxiliary function demonstrated in the form of Hirota D-operators.
Third objective is to obtain the solutions as soliton, lump, breather, rogue wave or their interactions. Hirota proposed the N-soliton solution form to establish the single, double, and triple soliton solutions.
Fourth and last objective is fulfilled by creating the 2D and 3D dynamics for the obtained solutions using the computer algebra system software Mathematica/Matlab/Maple.

(iii) **Research Design and Method**:
In 2004, Hirota offered an algebraic approach to finding exact soliton solutions to nonlinear PDEs, formally known as the Hirota bilinear method. The first challenge in applying this method is to check the integrability of a nonlinear PDE. The second is to modify the equation into a bilinear form known as bilinearization. The bilinearization of a nonlinear PDE is achieved by changing the PDE to a quadratic or quartic equation for an auxiliary function using dependent variable transformation. Modifying a nonlinear PDE into the bilinear form becomes tedious even if the corresponding dependent variable transformation

is known. Hirota bilinear method is one of the most productive, powerful, and efficient tools for generating single soliton, multiple soliton solutions, breather, and lump solutions of integrable nonlinear PDEs. This methodology is proposed to describe and apply approaches relevant to nonlinear integrable PDEs. The above-said method provides practical outcomes in multiple soliton solutions for a wide range of nonlinear PDEs.

(iv) **Description of the result chain of the project**:
The Hirota bilinear method needs highly computational work to obtain exact closed-form solutions and showcase their dynamical structures. Therefore, using symbolic system software Mathematica/Maple/Matlab, the Hirota bilinear method can provide profoundly feasible exact solutions to nonlinear PDEs. The **primary goal** of this project is to obtain multiple soliton solutions, rogue waves, breathers, lumps, and their interactions for the integrable nonlinear PDEs with constant or time-dependent coefficients. The **secondary goal** of this proposal is to exhibit the evolutionary dynamics of obtained exact closed-form solutions by taking the best suitable values of arbitrary functions or constants through three-dimensional graphics and corresponding contour plots.

7. **Significance of the Project**
The obtained exact solutions using the Hirota bilinear method will be very advantageous, practical, and valuable in the dynamics of mathematical physics, natural science, and different fields of applied sciences.
The master/research students will be trained during the project and after the project in whatever facility provided by this project. The research students would also be encouraged to pursue further research in the same or related area.

8. **List of references**
Sachin Kumar, Brij Mohan, Raj Kumar 2022 Lump, soliton, and interaction solutions to a generalized two-mode higher-order nonlinear evolution equation in plasma physics, Nonlinear Dynamics, Q1, IF: 5.741, SCIE.
https://doi.org/10.1007/s11071-022-07647-5
Sachin Kumar, Brij Mohan 2022 A novel and efficient method for obtaining Hirota's bilinear form for the nonlinear evolution equation in (n+1) dimensions, Partial Differential Equations in Applied Mathematics, DOAJ, 5:100274.
https://doi.org/10.1016/j.padiff.2022.100274
Sachin Kumar, Brij Mohan, Amit Kumar 2022 Generalized fifth-order nonlinear evolution equation for the Sawada-Kotera, Lax, and Caudrey-Dodd-Gibbon equations in plasma physics: Painleve analysis and multi-soliton solutions, Physica Scripta, Q2, IF: 3.081, SCIE, 97(3):035201.
https://doi.org/10.1088/1402-4896/ac4f9d
Sachin Kumar, Brij Mohan 2021 A study of multi-soliton solutions, breather, lumps, and their interactions for Kadomtsev-Petviashvili equation with variable time coefficient using Hirota method, Physica Scripta, Q2, IF: 3.081, SCIE, 96(12):125255.
https://doi.org/10.1088/1402-4896/ac3879

9. **Date of Submission**
11th July, 2022
Brij Mohan

Brij Mohan, Ph.D. Research Scholar, P2109, Department of Mathematics, University of Delhi.

Question 5: **Distinguish between oral and poster presentations. Select one paper of your interest and describe how you present it in oral and poster format.**

Answer:

Oral presentation:
For oral presentation the time generally allocated for

1. Field Medal talks - 1 Hour
2. Plenary talks - 45 Min
3. Invited talks - 30 Min
4. Keynote speaker - 25 Min
5. Contributory Speaker - 20 Min

Steps for oral presentation:

1. Introduce yourself, your advisor and committee members.
2. Give an introduction and background information on your topic. What relevant research has been performed previously?
3. State the problems that remain unanswered.
4. State your objectives clearly and give the specific hypothesis, you wish to show.
5. Describe the methodology. Be sure you fully understand your chosen methods. Give reasons why you chose these methods over other approaches.
6. Present any data you have collected.
7. Explain the significance of your findings or potential future findings.

Poster presentation:

1. The presenter should stand beside the poster for about 1-2 hours during the display period.
2. Poster presentation is a casual demonstration of a novel and applicable idea in a simple and concise manner.
3. It is displayed during a conference.
4. It should fit within an offered area.

Example of Poster presentation:

<table>
<tr><td colspan="2">A study of multi-soliton solutions, breather, lumps, and their interactions for Kadomtsev-Petviashvili equation with variable time coefficient using Hirota method
Brij Mohan
Department of Mathematics, Hansraj College,
University of Delhi – 110007, India.</td></tr>
<tr><td>Objective:
To study the dynamics of obtained analytical solutions for the KP nonlinear partial differential equation using Hirota method.</td><td rowspan="2">Result & Discussion:
We obtained only multiple soliton solutions using the simplified Hirota method, while our research findings showed multiple soliton solutions, rogue waves, breathers, lump solutions, and their interactions using the Hirota bilinear method.

We obtained multiple soliton solutions up to fourth-order whereas ref. [1] came up with third-order multiple soliton solutions.

We have illustrated our solutions by using both</td></tr>
<tr><td>Introduction:
Investigating the integrability of nonlinear evolution equations can help to accomplish the objective of obtaining multiple soliton solutions as well as analytical solutions. Complete integrability for an NLPDE can be confirmed using the Painlevé test. We seek specific solutions to correctly apprehend the characteristic</td></tr>
</table>

of varied facts in different aspects of natural sciences. The dynamical behaviour of soliton solutions derived from NLPDE's has been a fascinating area of study due to its potential relevance in demonstrating realistic features in the dimensions of engineering sciences, nonlinear dynamics, and complex physical systems.

three-dimensional postures and contour plots depending upon the graphical suitability.

Due to the arbitrariness of the time-dependent coefficient g(t), we have shown graphical representations of the solutions in (x-t-u) coordination using erratic choices of the same.

Model:
To investigate the steady-state of two-dimensional KdV soliton, Kadomtsev–Petviashvili (KP) proposed the equation as in normalized form as
$(u_t+uu_x+u_{xxx})_x+3u_{yy}=0$,
where u is the wave-amplitude function of (x,y,t) and represents the nonlinear restoring forces and frequency dispersion of water-waves which are weakly in nature; u_{var} denotes partial derivatives with respect to independent variable var: x,y,t. This KP equation achieved substantial interest in different dimensions of research due to its integrability and dispersal property.

Conclusion:
In this study, we used Hirota bilinear method to calculate the results of multiple soliton solutions up to fourth-order solutions, rogue waves, breather, lump solutions, and their interactions by making methodical choices of time-dependent coefficients in the integrable KP equation. Subsequently, we demonstrated various dynamical structures by numerically simulating specific values of arbitrary functions and constants. Furthermore, the analytical findings of this study have applicability in terms of their influence on a broad class of nonlinear KP equations and several nonlinear PDEs.

References:
[1] Wazwaz, A.M.: Two new integrable Kadomtsev–Petviashvili equations with time-dependent coefficients: multiple real and complex soliton solutions, Waves in Random and Complex Media, 30:4, 776-786, (2020).
[2] Tian Y., Liu J.G., Bao T.: Study on dynamical behavior of multiple lump solutions and interaction between solitons and lump wave. Nonlinear Dyn. 104, 507–1517 (2021).
[3] Baldwin D. and Hereman W.: Symbolic software for the Painlev\'e test of nonlinear differential ordinary and partial equations, Journal of Nonlinear Mathematical Physics, vol. 13 (1), pp. 90-110 (2006).

Brij Mohan, Ph.D. Research Scholar, P2109, Department of Mathematics, University of Delhi.

Question 6: **Write the Latex type set for the title, author affiliations, abstract, introduction and references. What is built-in function in MATLAB? Write the syntax for different built-in functions in MATLAB.**

Answer:

```
\documentclass [11pt, reqno] {article}
\usepackage{amssymb, latexsym}
\usepackage{hyperref}
\usepachage{amsmath}
\usepachage{graphicx}
\usepachage{caption}
\usepachage{cite}
\date{}

\begin{document}

\title{\textbf{A study of multi-soliton solutions, breather, lumps, and their interactions for Kadomtsev-Petviashvili equation with variable time coefficient using Hirota method}}

\author{\textbf{ Brij Mohan} \footnote{\it brijmohan6414@gmail.com}\\
\small Department of Mathematics, Hansraj College, University of Delhi, Delhi -110007, India\\
}

\maketitle

\begin{abstract}
We write here the abstract of our paper.
\end{abstract}

\section{Introduction}
We write here the very first section of our manuscript, that is introduction. We discussed here our chosen model with literature reviews. This section brief about the methodology and findings, and at the end we give the structure of the paper.

\begin{thebibliography}{}

\bibitem{Wazwaz}
Wazwaz, A.M.: Two new integrable Kadomtsev–Petviashvili equations with time-dependent coefficients: multiple real and complex soliton solutions, Waves in Random and Complex Media, 30:4, 776-786, (2020).

\bibitem{Liu}
Tian Y., Liu J.G., Bao T.: Study on dynamical behavior of multiple lump solutions and interaction between solitons and lump wave. Nonlinear Dyn. 104, 507–1517 (2021).
\end{thebibliography}

\end{document}
```

Brij Mohan, Ph.D. Research Scholar, P2109, Department of Mathematics, University of Delhi.

MATLAB provides a large number of standard elementary mathematical functions.
To get a list of elementary mathematical functions, we type
> **help elfun**
To get a list of more advanced mathematical and matrix functions, we type
>**help specfun**
>**help elmat**
OR we can press **shift +F1** key to browse the functions.

Functions that are frequently used or that can take more time to execute are often implemented as executable files. These functions are called built-in functions.
Many functions are programmed inside MATLAB as built-in functions, and can be used in Mathematical expressions by typing their name with the arguments.

Syntax is: ***function_name(arguments)***

Different built-in functions in Matlab are:

	Syntax	**Function**
1.	sqrt(x)	Square root of x
2.	exp(x)	Exponential of x
3.	log(x)	Natural logarithm of x
4.	sin(x), cos(x), tan(x)	Trigonometric functions with arguments in radian
5.	asin(x), acos(x), atan(x)	Inverse trigonometric functions with arguments in radian
6.	factorial(x)	Factorial of n
7.	abs(x)	Absolute value of x
8.	mod(n,m)	Remainder on division of n by m
9.	eye(x)	Returns an n-by-n identity matrix
10.	zeros(m,n)	Provides an m-by-n matrix of zeros
11.	diag(v)	Returns a square diagonal matrix with the elements of vector v on the main diagonal
12.	solve(eqn, var)	Solves the equation eqn for the variables var
13.	dsolve(eqn)	Solves the differential equation eqn
14.	dsolve(eqn, cond)	Solves equation eqn with the initial or boundary condition cond
15.	power(a,b)	Returns A^B