हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics,

School of Mathematics, Computers and Information Sciences

AGENDA

10th BOARD OF STUDIES MEETING
to be held on **12th May, 2023**

Venue: Seminar Hall, Central University of Himachal Pradesh,
Shahpur Parisar, Shahpur

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206

Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

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AGENDA-INDEX

Agenda Item No.	Particulars	Information
SRDM-BOS-10/23-1	Confirmation and approval of the Minutes of the 9th Board of Studies meeting held on 9th September, 2022.	**Annexure–I**
SRDM-BOS-10/23-2	To approve the List of Courses and Course Contents offered in Spring semester (Semester-I) of Ph.D. Mathematics in 2022 and 2023.	**Annexure – II, II(a)**
SRDM-BOS-10/23-3	To approve the list of Courses and Course Contents offered to the students of M.Sc. Mathematics and Interdisciplinary Courses in Spring Semester, 2023	**Annexure –III, III(a), III(b)**
SRDM-BOS-10/23-4	To approve the list of New Courses (Disciplinary/Interdisciplinary) for M.Sc. and Ph.D. in Mathematics	**Annexure – IV, IV(a)**
SRDM-BOS-10/23-5	To approve the updated list (structure) of Courses to be offered to the M.Sc. and Ph.D. Mathematics	**Annexure – V, V(a)**
SRDM-BOS-10/23-6	To discuss and approve the modalities for the Course "Practical (Paper Publications/Seminar-Conference Presentation at National Level) (MTH 559)" as per NEP 2020 CUHP Guidelines	**Annexure –VI**
SRDM-BOS-10/23-7	To discuss and approve the modalities for the Course "MSc Dissertation & Viva-Voce (MTH 590)" as per NEP 2020 CUHP Guidelines	**Annexure –VII**
SRDM-BOS-10/23-8	To approve the Changes in Course Contents of Course Name: Research Methodology, Course Code: MTH 551.	**Annexure –VIII**
SRDM-BOS-10/23-9	To approve the Course i.e. Linear Algebra and tensors, Course Code: MTH 351T as Interdisciplinary Course for Undergraduate Courses	
SRDM-BOS-10/23-10	Any other item with the permission of the Chair	

Prof. Rakesh Kumar
Head,
Srinivasa Ramanujan Department of Mathematics

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File No.: MTH//5-1BoS/CUHP/23/134 Dated: 12.05.2023

MINUTES OF THE MEETING

The **meeting** of the **10th Board of Studies** of the **Srinivasa Ramanujan Department of Mathematics**, School of Mathematics, Computers and Information Science, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur was **held** on **12th May, 2023** at **02:00 PM** onwards in the **Seminar Hall** of the Central University of Himachal Pradesh, Shahpur Parisar, Shahpur. **Prof. Rakesh Kumar**, Head, Srinivasa Ramanujan Department of Mathematics **chaired** the meeting.

Following members attended the meeting:

1. **Prof. Rakesh Kumar – Head and Convener**
   Head, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
2. **Prof. Jyoti Prakash – Subject Expert**
   Professor, Department of Mathematics and Statistics, Himachal Pradesh University, Shimla.
3. **Dr. Pawan Kumar Sharma – Subject Expert**
   Associate Professor, Department of Mathematics & Scientific Computing, National Institute of Technology, Hamirpur.
4. **Prof. Hum Chand – Vice Chancellor's Nominee**
   Professor, Department of Physics and Astronomical Science, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
5. **Dr. Rajender Kumar – Vice Chancellor's Nominee**
   Associate Professor, Department of Chemical and Chemical Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
6. **Dr. Pradeep Chouksey – Dean's Nominee**
   Associate Professor, Department of Computer Science and Informatics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
7. **Dr. Kranti Kumar – Member**
   Associate Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
8. **Dr. Sachin Kumar Srivastava – Member**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

The **Chairman** welcomed all the **Hon'ble members** and **briefed** about the **past activities** and also about the various **agenda items** to be **discussed** in the **meeting** which were **sent** in **advance** to all the members through **e-mail** including **External Subject Experts**. The **Agenda Items** were **placed** before the **committee** and after **detailed discussions** and **deliberations** on each, the following **decisions** were taken:-

AGENDA ITEM NO. - SRDM-BOS-10/23-1

Confirmation and approval of the Minutes of the 9th Board of Studies meeting held on 9th September, 2022.

Decision:

The Minutes of the 9th meeting of the BoS were Confirmed and Approved attached as Annexure-I.

AGENDA ITEM NO. - SRDM-BOS-10/23-2

To approve the List of Courses and Course Contents offered in Spring Semester (Semester-I) of Ph.D. Mathematics in 2022 and 2023 as per NEP 2020.

Decision:

The List of Courses and Course Contents offered to Ph.D. Mathematics, Semester-I in Spring Semesters of 2022 and 2023 in the light of National Education Policy-2020 were discussed and unanimously approved by the all respective members of the BoS as attached at Annexure-II & II(a).

AGENDA ITEM NO. - SRDM-BOS-10/23-3

To approve the list of Courses and Course Contents offered to the students of M.Sc. Mathematics and Interdisciplinary Courses in Spring Semester, 2023.

Decision:

The List of Courses and Course Contents offered to the students of M.Sc. Mathematics (along with Interdisciplinary Courses) during Spring Semester, 2023 in the light of National Education Policy-2020 were discussed and unanimously approved by the all respective members of the BoS as attached at Annexure-III, III(a) & III(b).

AGENDA ITEM NO. - SRDM-BOS-10/23-4

To approve the list of New Courses (Disciplinary/Interdisciplinary) for M.Sc. and Ph.D. in Mathematics.

Decision:

The list of New Courses (Disciplinary/Interdisciplinary) for M.Sc. and Ph.D. in Mathematics in the light of National Education Policy-2020 were discussed and unanimously approved by the all respective members of the BoS as attached at Annexure-IV & IV(a).

AGENDA ITEM NO. - SRDM-BOS-10/23-5

To approve the updated list (structure) of Courses to be offered to the M.Sc. and Ph.D. Mathematics.

Decision:

All the respective members of BoS unanimously approved the updated list (structure) of courses to be offered to M.Sc. and Ph.D. Mathematics as attached at Annexure-V, V(a).

GENDA ITEM NO. - SRDM-BOS-10/23-6

To discuss and approve the modalities for the Course "Practical (Paper Publications/Seminar-Conference Presentation at National Level) (MTH 559)" as per NEP 2020 CUHP Guidelines.

Decision: After the deliberations of all respective members, the following evaluation criterion for the Course: Practical (Paper Publications/Seminar-Conference Presentation at National Level), Course Code: MTH 559, Course Credit: 02, was approved as recommended/approved by respective Faculty Members of the Department in the Minutes of the Meeting vide no. MTH/1-10/Meeting/CUHP/21/1107 dated 06.02.2023, in the light of NEP-2020 guidelines as attached at Annexure-VI:

Evaluation Criteria*			
Sl. No.	**Category**		**Maximum Marks**
Compulsory Requirement			
1.	**Presentation** (Minimum 01 Paper)	Paper Presentation in a National Seminar/Conference	70
		OR	
		Paper Presentation in an International Seminar/Conference	80
Optional			
2.	**Publication** (Minimum 01 Paper)	Paper Publication in a Seminar/Conference Proceedings/ Peer Reviewed Journal.	10
		OR	
		Paper Publication in a Peer Reviewed Journal (Scopus / Web of Science / SCI / SCIE Indexing).	20
		Total Maximum Marks	**100**

** The concerned Faculty Member/Supervisor will evaluate the respective students, and also prepare the Award list as per above mentioned evaluation criteria.*

AGENDA ITEM NO. - SRDM-BOS-10/23-7

To discuss and approve the modalities for the Course "Dissertation & Viva-Voce (MTH 590)" as per NEP 2020 CUHP Guidelines.

Decision: After the deliberations of all respective members, the following evaluation criterion for the Course: Dissertation & Viva-Voce, Course Code: MTH 590, Course Credit: 08, was approved as recommended/approved by respective Faculty Members of the Department in the Minutes of the Meeting vide no. MTH/1-10/Meeting/CUHP/21/1147 dated 01.03.2023, in the light of NEP-2020 guidelines as attached at Annexure-VII:-

Dissertation Evaluation Criteria*			
Sl. No.	**Category**		**Maximum Marks**
1.	Internal Evaluation **(40% Weightage)**	Dissertation Writing & Presentation/Viva-Voce	160
2.	External Evaluation **(60% Weightage)**	Dissertation Evaluation (30 % Weightage)	120
		Presentation/Viva-Voce (30 % Weightage)	120

	Total	**400**

**** The Soft copy of the Dissertation is to be sent to the approved External Examiner in advance by the Department. The concerned Faculty Member/Supervisor will evaluate the respective students, and also prepare the Award list as per the above mentioned Internal Evaluation Criteria.***

*This evaluation criterion will be followed until the unified CUHP guidelines are issued.

AGENDA ITEM NO. - SRDM-BOS-10/23-8

To approve the Changes in Course Contents of Course Name: Research Methodology, Course Code: MTH 551 for MSc Mathematics students.

Decision: All the respective members of BoS unanimously approved the Changes (about 80%) in the Course Contents of the Course Name: Research Methodology, Course Code: MTH 551, Credits: 04, in the light of National Education Policy-2020 as attached at Annexure-VIII.

AGENDA ITEM NO. - SRDM-BOS-10/23-9

To approve the Course i.e. Linear Algebra and Tensors, Course Code: MTH 351T as Interdisciplinary Course for Undergraduate Courses.

Decision: All the respective members of BoS unanimously approved the Course i.e. Linear Algebra and Tensors, Course Code: MTH 351T, Credits: 02, as Interdisciplinary Course for Undergraduate Courses.

AGENDA ITEM NO. - SRDM-BOS-10/23-10

Any other item with the permission of the Chair

Decision: No item was taken.

The meeting ended with a vote of thanks to the chair.

Sachin 12/5/23
Dr. Sachin Kumar Srivastava
(Member)

Kranti Kumar 12/05/2023
Dr. Kranti Kumar
(Member)

Dr. Pradeep Chouksey
(Dean's Nominee)

Dr. Rajender Kumar 12-5-23
(VC's Nominee)

Hchand 12/5/23
Prof. Hum Chand
(Subject Expert)

Dr. Pawan Kumar Sharma
(Subject Expert)

Prof. Jyoti Prakash
(VC's Nominee)

12.5.23
Prof. Rakesh Kumar
Chairman & Convener

Annexure-I

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics,

School of Mathematics, Computers and Information Sciences

AGENDA

9th BOARD OF STUDIES MEETING
to be held on **09th September, 2022**

Venue: Seminar Hall, Central University of Himachal Pradesh,
Shahpur Parisar, Shahpur

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

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AGENDA-INDEX

Agenda Item No.	PARTICULARS	Information
SRDM-BOS-9/22-1	Confirmation and approval of the Minutes of the 8th Board of Studies meeting held on 27th September, 2021.	**Annexure–I**
SRDM-BOS-9/22-2	To approve the PSOs & POs, of M.Sc. Mathematics	**Annexure – II**
SRDM-BOS-9/22-3	To approve the list of Courses and Course Contents offered to the students of M.Sc. Mathematics in Monsoon Semester, 2021, Spring Semester, 2022 and Monsoon Semester, 2022	
SRDM-BOS-9/22-4	To approve the list of Courses and Course Contents offered to the Ph.D. Scholars in Academic Year 2021-22	**Annexure – III**
SRDM-BOS-9/22-5	To approve the list of New Courses (Disciplinary/Interdisciplinary) and Course Contents to be offered w.e.f. Academic Year 2022-23	**Annexure – IV**
SRDM-BOS-9/22-6	To discuss and approve the modalities for the Course "Research Proposal (MTH 556)" as per NEP 2020 CUHP Guidelines	
SRDM-BOS-9/22-7	To discuss and approve the modalities for the Course "Research Methodology (MTH 551)" as per NEP 2020 CUHP Guidelines	
SRDM-BOS-9/22-8	To discuss and approve the start of Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude" in collaboration with the Department of Computer Science and Informatics in the light of National Education Policy-2022 w.e.f. Academic Year 2022-23.	
SRDM-BOS-9/22-9	To approve the modalities (Course Name, Course duration, eligibility, admission criteria etc.) of the Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude".	**Annexure–V**
SRDM-BOS-9/22-10	To approve the List of Courses & Course Contents for the Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude".	**Annexure–VI**
SRDM-BOS-9/22-11	Any other item with the permission of the Chair	

Prof. Rakesh Kumar
Head,
Srinivasa Ramanujan Department of Mathematics

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
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Website: www.cuhimachal.ac.in

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File No.: MTH/1-5/CUHP/12/429 **Dated:** 09.09.2022

MINUTES OF THE MEETING

The **meeting** of the **9th Board of Studies** of the **Srinivasa Ramanujan Department of Mathematics**, School of Mathematics, Computers and Information Science, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur was held on **09th September, 2022** at **9:30 AM** onwards in the **Seminar Hall** of the Central University of Himachal Pradesh, Shahpur Parisar, Shahpur. Prof. Rakesh Kumar, Head, Srinivasa Ramanujan Department of Mathematics and Dean, School of Mathematics, Computers and Information Sciences chaired the meeting.

Following members attended the meeting:

1. **Prof. Rakesh Kumar – Head and Convener**
   Head, Srinivasa Ramanujan Department of Mathematics and Dean, School of Mathematics, Computers and Information Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
2. **Prof. Jyoti Prakash – Subject Expert**
   Professor, Department of Mathematics and Statistics, Himachal Pradesh University, Shimla.
3. **Dr. Pawan Kumar Sharma – Subject Expert**
   Associate Professor, Department of Mathematics & Scientific Computing, National Institute of Technology, Hamirpur.
4. **Prof. Hum Chand – Vice Chancellor's Nominee**
   Professor, Department of Physics and Astronomical Science, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
5. **Dr. Rajender Kumar – Vice Chancellor's Nominee**
   Associate Professor, Department of Chemical and Chemical Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
6. **Dr. Sachin Kumar Srivastava – Member**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
7. **Dr. Pankaj Kumar S/o Late Sh. Maniram – Special Invitee**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
8. **Dr. Pankaj Kumar S/o Sh. Krishan Singh – Special Invitee**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
9. **Dr. Meenakshi – Special Invitee**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

The **Chairman** welcomed all the **Hon'ble members** & **Special Invitees** and **briefed** about the **past activities** and also about the various **agenda items** to be **discussed** in the **meeting** which were **sent** in **advance** to all the members through **e-mail** including **External Subject Experts**. All the members were **informed** about **the adoption CUHP NEP-2020 guidelines by the Department**. The **Agenda Items** were **placed** before the **committee** and after **detailed discussions** and **deliberations** on each, the **following decisions** were taken:-

AGENDA ITEM NO. - SRDM-BOS-8/21-1

Confirmation and approval of the Minutes of the 8th Board of Studies meeting held on 27th September, 2021.

Decision:

The Minutes of the 8th meeting of the BoS were Confirmed and Approved attached as Annexure-I.

AGENDA ITEM NO. - SRDM-BOS-9/22-2

To approve the PSOs & POs, of M.Sc. Mathematics

Decision:

The PSOs & POs, of M.Sc. Mathematics were **discussed** and **unanimously approved** by the all **respective members** of the **BoS** as **attached** at **Annexure-II(a).**

AGENDA ITEM NO. - SRDM-BOS-9/22-3

To approve the list of Courses and Course Contents offered to the students of M.Sc. Mathematics in Monsoon Semester, 2021, Spring Semester, 2022 and Monsoon Semester, 2022

Decision:

The list of **Courses** and **Course Contents** offered to the students of **M.Sc. Mathematics** (along with interdisciplinary courses) in **Monsoon Semester, 2021**, **Spring Semester, 2022** and **Monsoon Semester, 2022** in the light of **National Education Policy**-2020 were **discussed** and **unanimously approved** by the all **respective members** of the **BoS** as **attached at Annexure-II, II(a), II(b) & II(c).**

AGENDA ITEM NO. - SRDM-BOS-9/22-4

To approve the list of Courses and Course Contents offered to the Ph.D. Scholars in Academic Year 2021-22

Decision:

The list of **Courses** and **Course Contents** offered to the **Ph.D. Scholars** in **Academic Year 2021-22** in the light of **National Education Policy-2020** were **discussed** and **unanimously approved** by the all **respective members** of the **BoS** as **attached at Annexure-III.**

AGENDA ITEM NO. - SRDM-BOS-9/22-5

To approve the list of New Courses (Disciplinary/Interdisciplinary) and Course Contents to be offered w.e.f. Academic Year 2022-23

Decision:

All the respective **members** of BoS unanimously **approved** the **list** of **new courses (Disciplinary/Interdisciplinary)** along with **Course Contents** to be **offered** w.e.f. **Academic Year 2022-23** as **attached** at **Annexure-IV**.

AGENDA ITEM NO. - SRDM-BOS-9/22-6

To discuss and approve the modalities for the Course "Research Proposal (MTH 556)" as per NEP 2020 CUHP Guidelines

Decision: After the **deliberations** of all respective members, the following **evaluation criterion** for the Course: **Research Proposal (MTH 556),** Course Credit: **04**, was **approved** in the light of **NEP-2020** guidelines:

Evaluation Criteria: (Internal: 40%, External: 60%)

S. No.	Examination		Maximum Weightage Assigned 200 Marks (4 Credit Course)
1.	Internal	Internal Assessment by Supervisor	40 Marks
2.		Internal Assessment by the Research Committee (MRC)	40 Marks
3.	External	Evaluation of Research Proposal	60 Marks
4.		Open seminar & Viva-Voce Examination	60 Marks

*This evaluation criterion will be followed until the unified CUHP guidelines are issued.

AGENDA ITEM NO. - SRDM-BOS-9/22-7

To discuss and approve the modalities for the Course "Research Methodology (MTH 551)" as per NEP 2020 CUHP Guidelines

Decision: After the **deliberations** of BoS members, it was **decided** to **follow** the **CUHP** norms for **evaluation criterion** for a normal **course** till specified guidelines are **issued** for the Course: **Research Methodology (MTH 551).**

AGENDA ITEM NO. - SRDM-BOS-9/22-8

To discuss and approve the start of Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude" in collaboration with the Department of Computer Science and Informatics in the light of National Education Policy-2022 w.e.f. Academic Year 2022-23.

Decision: The BoS members unanimously **approved** the **start** of **Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude"** in **collaboration** with the **Department of Computer Science and Informatics** in the light of **National Education Policy-2020** w.e.f. **Academic Year 2022-23**.

AGENDA ITEM NO. - SRDM-BOS-9/22-9

To approve the modalities (Course Name, Course duration, eligibility, admission criteria etc.) of the Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude".

Decision: After the **deliberations**, the BoS members unanimously **approved** the **modalities** (Course Name, Course duration, eligibility, admission criteria etc.) of the Value Added Course **"Certificate in Artificial Intelligence with Quantitative Aptitude"** as **attached** at **Annexure V**.

AGENDA ITEM NO. - SRDM-BOS-9/22-10

To approve the List of Courses & Course Contents for the Value Added Course "Certificate in Artificial Intelligence with Quantitative Aptitude".

Decision: After the **deliberations,** the **course contents** of MTH 451 (Credit:04), MTH 452 (Credit:04) and **MTH 453 (Credit:02)** were unanimously **approved** by the BoS members as **attached** at **Annexure VI**.

AGENDA ITEM NO. - SRDM-BOS-9/22-11

Any other item with the permission of the Chair

Decision: No item was taken.

The meeting ended with a vote of thanks to the chair.

Dr. Meenakshi,
(Special Invitee)

Dr. Pankaj Kumar
S/o Sh. Krishan Singh
(Special Invitee)

Dr. Pankaj Kumar
S/o Late Sh. Maniram,
(Special Invitee)

Dr. Sachin Kumar Srivastava
(Member)

Dr. Rajender Kumar
(VC's Nominee)

Prof. Hum Chand
(VC's Nominee)

09/09/2022

Dr. Pawan Kumar Sharma
(Subject Expert)

Prof. Jyoti Prakash
(Subject Expert)

09/09/2022

Prof. Rakesh Kumar
Chairman & Convener

Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics

School of Mathematics, Computers and Information Science

AGENDA

8th BOARD OF STUDIES MEETING

TO BE HELD ON **27th September, 2021**

Venue: through Online Mode on Google Meet

meet.google.com/msn-aaqh-uvi

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

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AGENDA-INDEX

Agenda Item No.	PARTICULARS	Information
SRDM-BOS-8/21-1	Confirmation and Approval of the Minutes of the 7th Board of Studies meeting held on 15th June, 2021.	Annexure –I
SRDM-BOS-8/21-2	Approval of revised structure (including list of revised courses and list of new courses) of the M.Sc. Mathematics program in light of the National Education Policy-2020. All the revisions made from time to time in the syllabus of different courses of the M.Sc. Mathematics program as per the NEP-2020 guidelines will be reported to the upcoming BOS meetings	Annexure – II, III & IV
SRDM-BOS-8/21-3	To approve the adoption of Blended mode of learning in M.Sc. Mathematics program in the light of National Education Policy-2020.	
SRDM-BOS-8/21-4	To approve the adoption of Multiple Entry-Exit system in M.Sc. Mathematics programme in the light of National Education Policy-2020.	
SRDM-BOS-8/21-5	To approve the list of new courses to be included in the course work of Ph.D. Mathematics in the light of National Education Policy-2020	Annexure - V
SRDM-BOS-8/21-6	Deliberation and Approval of the Ph.D. Synopsis of Mr. Manoj Kumar, CUHP17RDMATH03.	Annexure - VI
SRDM-BOS-8/21-7	Any item with the permission of the Chair	

Prof. Rakesh Kumar
Head,
Srinivasa Ramanujan Department of Mathematics

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File No.: MTH/1-5/CUHP/12/193 Dated: 27.09.2021

MINUTES OF THE 8th BOARD OF STUDIES MEETING

HELD ON 27th September, 2021

The **meeting** of the **7th Board of Studies** of the **Srinivasa Ramanujan Department of Mathematics**, School of Mathematics, Computers and Information Science, Central University of Himachal Pradesh, Temporary Academic Block, Shahpur was held through **online mode** on Google Meet (meet.google.com/hxh-kmrh-fsz) on **27th September, 2021** at **9:30 AM**. During the meeting, all members were available on Google Meet. Prof. Rakesh Kumar, Head, Srinivasa Ramanujan Department of Mathamatics and Dean, School of Mathematics, Computers and Information Sciences chaired the meeting.

Following members attended the meeting:

1. **Prof. Rakesh Kumar – Head and Convener**
   Head, Srinivasa Ramanujan Department of Mathematics and Dean, School of Mathematics, Computers and Information Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
2. **Prof. Jyoti Prakash – Subject Expert**
   Professor, Department of Mathematics and Statistics, Himachal Pradesh University, Shimla.
3. **Dr. Pawan Kumar Sharma – Subject Expert**
   Associate Professor, Department of Mathematics & Scientific Computing, National Institute of Technology, Hamirpur.
4. **Prof. Hum Chand – Vice Chancellor's Nominee**
   Professor, Department of Physics and Astronomical Science, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
5. **Dr. Rajender Kumar – Vice Chancellor's Nominee**
   Associate Professor, Department of Chemical and Chemical Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
6. **Dr. Pankaj Kumar S/o Late Sh. Maniram – Dean's Nominee**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
7. **Dr. Meenakshi – Special Invitee**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.
8. **Dr. Pankaj Kumar S/o Sh. Krishan Singh – Special Invitee**
   Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

The **Chairman** welcomed all the **Hon'ble members** & **Special Invitees** and **briefed** about the **past activities** and also about the various **agenda items** to be **discussed** in the **meeting** which were **sent** in **advance** to all the members through **e-mail** including **External subject experts**. All the members were

informed about the issuance of the University guidelines regarding the implementation of NEP 2020 which are subject to the approval from Academic Council and Executive Council of CUHP. The Agenda Items were placed before the committee and after detailed discussions and deliberations on each, the following decisions were taken:-

AGENDA ITEM NO. - SRDM-BOS-8/21-1

Confirmation and Approval of the Minutes of the 7th Board of Studies meeting held on 15th June, 2021.

Decision:

The Minutes of the 7th meeting of the BoS were Confirmed and Approved attached as Annexure-I.

AGENDA ITEM NO. - SRDM-BOS-8/21-2

Approval of revised course basket (including list of revised courses and list of new courses) of the M.Sc. Mathematics program in light of the National Education Policy-2020. All the revisions made from time to time in the syllabus of different courses of the M.Sc. Mathematics program as per the NEP-2020 guidelines will be reported to the upcoming BOS meetings.

Decision:

All the members of BoS unanimously approved the proposed course basket including the list of revised courses and list of proposed new courses attached respectively as Annexure -II, III and IV. Subject Experts were of the opinion that the revisions made from time to time in the syllabus of different courses of the M.Sc. Mathematics program as well as other modifications as per the NEP-2020 guidelines of the Central University of Himachal Pradesh may be reported to the upcoming BOS meetings.

AGENDA ITEM NO. - SRDM-BOS-8/21-3

To approve the adoption of Blended mode of learning in M.Sc. Mathematics program in the light of National Education Policy-2020.

Decision:

All the members of BoS unanimously approved the adoption of blended/hybrid mode of learning in M.Sc. Mathematics and other programmes of study in the light of National Education Policy-2020.

AGENDA ITEM NO. - SRDM-BOS-8/21-4

To approve the adoption of Multiple Entry-Exit system in M.Sc. Mathematics programme in the light of National Education Policy-2020.

Decision:

All the members of BoS unanimously approved the adoption of Multiple Entry-Exit system in M.Sc. Mathematics program in the light of National Education Policy-2020.

AGENDA ITEM NO. - SRDM-BOS-8/21-5

To approve the list of new courses to be included in the course work of Ph.D. Mathematics in the light of National Education Policy-2020.

Decision:

All the members of BoS unanimously approved the list of new courses for the course work in Ph.D. Mathematics in the light of National Education Policy-2020 attached at Annexure-V.

AGENDA ITEM NO. - SRDM-BOS-8/21-6

Deliberation and Approval of the Ph.D. Synopsis of Mr. Manoj Kumar, CUHP17RDMATH03.

Decision:

All members agreed and approved the Ph.D. Synopsis of Mr. Manoj Kumar, CUHP17RDMATH03 attached at Annexure VI.

AGENDA ITEM NO. - SRDM-BOS-8/21-7

Any item with the permission of the Chair:

All the members were of the opinion that approved CUHP guidelines as per National Education Policy 2020 may be incorporated in the course schemes of different programmes of study of the Srinivasa Ramanujan Department of Mathematics, and advised to report the same in the upcoming BoS meetings.

The meeting ended with a vote of thanks to the chair.

Dr. Pankaj Kumar
S/o Sh. Krishan Singh
(Special Invitee)

Dr. Meenakshi,
(Special Invitee)

(approved through email)
Dr. Pankaj Kumar
S/o Late Sh. Maniram,
(Dean's Nominee)

(approved through email)
Dr. Rajender Kumar
(VC's Nominee)

Prof. Hum Chand
(VC's Nominee)

(approved through E-mail)
Dr. Pawan Kumar Sharma
(Subject Expert)

(approved through E-mail)
Prof. Jyoti Prakash
(Subject Expert)

Prof. Rakesh Kumar
Chairman & Convener

Minutes of 8th BOS Meeting of SRDM held on 27.09.2021

5 messages

Rakesh Kumar <rakesh.lect@gmail.com> 27 September 2021 at 12:10
To: sara712005@gmail.com, jyoti prakash Sharma <jpsmaths67@gmail.com>, PANKAJ THAKUR <pankajthakur28.85@gmail.com>, Pankaj Kumar <pkumar240183@gmail.com>, M T <meenakshithakur490@gmail.com>, rajender.cuhp@gmail.com, Hum Chand <humchand@gmail.com>, humchand@hpcu.ac.in, Rakesh Kumar <rakesh.lect@hpcu.ac.in>
Cc: Gourav Chambyal <gourav.cuhimachal@gmail.com>

Dear Sir/Madam,

Please find attached herewith the minutes (Inclicing necessary Annexures) of the 7th Board of Studies Meeting of the Srinivasa Ramanujan Department of Mathematics held on 27.09.2021.

Kindly approve the minutes.

File No.: MTH/1-5/CUHP/12/ **Dated:**

MINUTES OF THE 8th BOARD OF STUDIES MEETING

HELD ON 27th September, 2021

The **meeting** of the **7th Board of Studies** of the **Srinivasa Ramanujan Department of Mathematics**, School of Mathematics, Computers and Information Science, Central University of Himachal Pradesh, Temporary Academic Block, Shahpur was held through **online mode** on Google Meet (meet.google.com/hxh-kmrh-fsz) on **27th September, 2021** at **9:30 AM**. During the meeting, all members were available on Google Meet. Prof. Rakesh Kumar, Head, Srinivasa Ramanujan Department of Mathamatics and Dean, School of Mathematics, Computers and Information Sciences chaired the meeting.

Following members attended the meeting:

1. **Prof. Rakesh Kumar – Head and Convener**

Head, Srinivasa Ramanujan Department of Mathematics and Dean, School of Mathematics, Computers and Information Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

2. **Prof. Jyoti Prakash – Subject Expert**

Professor, Department of Mathematics and Statistics, Himachal Pradesh University, Shimla.

3. **Dr. Pawan Kumar Sharma – Subject Expert**

Associate Professor, Department of Mathematics & Scientific Computing, National Institute of Technology, Hamirpur.

4. **Prof. Hum Chand – Vice Chancellor's Nominee**

Professor, Department of Physics and Astronomical Science, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

5. **Dr. Rajender Kumar – Vice Chancellor's Nominee**

Associate Professor, Department of Chemical and Chemical Sciences, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

6. **Dr. Pankaj Kumar S/o Late Sh. Maniram – Dean's Nominee**

Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

7. **Dr. Meenakshi – Special Invitee**

Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

8. **Dr. Pankaj Kumar S/o Sh. Krishan Singh – Special Invitee**

Assistant Professor, Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur.

The **Chairman** welcomed all the **Hon'ble members & Special Invitees** and **briefed** about the **past activities** and also about the various **agenda items** to be **discussed** in the **meeting** which were **sent** in **advance** to all the members through **e-mail** including **External subject experts**. All the members were **informed** about the issuance of the **University guidelines** regarding **the implementation of NEP 2020** which are **subject to the approval** from **Academic Council** and **Executive Council** of CUHP. The **Agenda Items** were **placed** before the **committee** and after **detailed discussions** and **deliberations** on each, the **following decisions** were taken:-

AGENDA ITEM NO. - SRDM-BOS-8/21-1

Confirmation and Approval of the Minutes of the 7th Board of Studies meeting held on 15th June, 2021.

Decision:

The Minutes of the 7th meeting of the BoS were Confirmed and Approved attached as Annexure-I.

AGENDA ITEM NO. - SRDM-BOS-8/21-2

Approval of revised course basket (including list of revised courses and list of new courses) of the M.Sc. Mathematics program in light of the National Education Policy-2020. All the revisions made from time to time in the syllabus of different courses of the M.Sc. Mathematics program as per the NEP-2020 guidelines will be reported to the upcoming BOS meetings.

Decision:

All the members of BoS unanimously approved the proposed course basket including the list of revised courses and list of proposed new courses attached respectively as Annexure -II, III and IV. Subject Experts were of the opinion that the revisions made from time to time in the syllabus of different courses of the M.Sc. Mathematics program as well as other modifications as per the NEP-2020 guidelines of the Central University of Himachal Pradesh may be reported to the upcoming BOS meetings.

AGENDA ITEM NO. - SRDM-BOS-8/21-3

To approve the adoption of Blended mode of learning in M.Sc. Mathematics program in the light of National Education Policy-2020.

Decision:

All the members of BoS unanimously approved the adoption of blended/hybrid mode of learning in M.Sc. Mathematics and other programmes of study in the light of National Education Policy-2020.

AGENDA ITEM NO. - SRDM-BOS-8/21-4

To approve the adoption of Multiple Entry-Exit system in M.Sc. Mathematics programme in the light of National Education Policy-2020.

Decision:

All the members of BoS unanimously approved the adoption of Multiple Entry-Exit system in M.Sc. Mathematics program in the light of National Education Policy-2020.

AGENDA ITEM NO. - SRDM-BOS-8/21-5

To approve the list of new courses to be included in the course work of Ph.D. Mathematics in the light of National Education Policy-2020.

Decision:

All the members of BoS unanimously approved the list of new courses for the course work in Ph.D. Mathematics in the light of National Education Policy-2020 attached at Annexure-V.

AGENDA ITEM NO. - SRDM-BOS-8/21-6

Deliberation and Approval of the Ph.D. Synopsis of Mr. Manoj Kumar, CUHP17RDMATH03.

Decision:

All members agreed and approved the Ph.D. Synopsis of Mr. Manoj Kumar, CUHP17RDMATH03 attached at Annexure VI.

AGENDA ITEM NO. - SRDM-BOS-8/21-7

Any item with the permission of the Chair:

All the members were of the opinion that approved CUHP guidelines as per National Education Policy 2020 may be incorporated in the course schemes of different programmes of study of the Srinivasa Ramanujan Department of Mathematics, and advised to report the same in the upcoming BoS meetings.

The meeting ended with a vote of thanks to the chair.

With best regards

Prof. Rakesh Kumar
Head & Dean
Srinivasa Ramanujan Department of Mathematics
Department of Computer Science and Informatics
School of Mathematics, Computers & Information Science
Shahpur Campus, Shahpur Central University of Himachal Pradesh
Dharamshala, India
Mobile No. +919418670200

7 attachments

Minutes of the Meeting of 8th Meeting of SRDM held on 27.09.2021.pdf
929K

Annexure I.pdf
18252K

Annexure II.pdf
685K

Annexure III.pdf
411K

Annexure IV.pdf
245K

Annexure V.pdf
53K

Annexure VI.pdf
743K

Pawan Kumar Sharma <sara712005@gmail.com> 27 September 2021 at 12:12
To: Rakesh Kumar <rakesh.lect@gmail.com>

Approved
[Quoted text hidden]

Hum Chand <humchand@hpcu.ac.in> 27 September 2021 at 12:26
To: Rakesh Kumar <rakesh.lect@gmail.com>
Cc: sara712005@gmail.com, jyoti prakash Sharma <jpsmaths67@gmail.com>, PANKAJ THAKUR <pankajthakur28.85@gmail.com>, Pankaj Kumar <pkumar240183@gmail.com>, M T <meenakshithakur490@gmail.com>, Rajender Kumar <rajender.cuhp@gmail.com>, Hum Chand <humchand@gmail.com>, Rakesh Kumar <rakesh.lect@hpcu.ac.in>, Gourav Chambyal <gourav.cuhimachal@gmail.com>

Approved from my side
With regards
humchand

[Quoted text hidden]
--
Hum Chand
Dean, School of Physical and Material Sciences
Head, Professor, Department of Physics and Astronomical Sciences,

Central University of Himachal Pradesh (CUHP),
Temporary Academic Block, Shahpur,
Kangra, Himachal Pradesh, India. Pin-176206.
Mobile: 6396937743 / 9760154111
email: humchand@hpcu.ac.in & humchand@gmail.com
webpage: http://old.aries.res.in/~hum/ or at this
skype: hum_aries

---

jyoti prakash Sharma <jpsmaths67@gmail.com> 27 September 2021 at 13:05
To: Hum Chand <humchand@hpcu.ac.in>
Cc: Rakesh Kumar <rakesh.lect@gmail.com>, Pawan Kumar Sharma <sara712005@gmail.com>, PANKAJ THAKUR <pankajthakur28.85@gmail.com>, Pankaj Kumar <pkumar240183@gmail.com>, M T <meenakshithakur490@gmail.com>, Rajender Kumar <rajender.cuhp@gmail.com>, Hum Chand <humchand@gmail.com>, Rakesh Kumar <rakesh.lect@hpcu.ac.in>, Gourav Chambyal <gourav.cuhimachal@gmail.com>

Approved.
[Quoted text hidden]

Pankaj Kumar <pkumar240183@gmail.com> 27 September 2021 at 13:08
To: Rakesh Kumar <rakesh.lect@gmail.com>

spected sir,
Approved my side.

On Mon, Sep 27, 2021, 12:10 Rakesh Kumar <rakesh.lect@gmail.com> wrote:
[Quoted text hidden]

[Quoted text hidden]

jender Kumar <rajender.cuhp@gmail.com> Mon, Sep 27, 2021 at 2:59
To: Rakesh Kumar <rakesh.lect@gmail.com>
Cc: "sara712005@gmail.com" <sara712005@gmail.com>, jyoti prakash Sharma <jpsmaths67@gmail.com>, PANKAJ THAKUR <pankajthakur28.85@gmail.com>, Pankaj Kumar <pkumar240183@gmail.com>, M T <meenakshithakur490@gmail.com>, Hum Chand <humchand@gmail.com>, "humchand@hpcu.ac.in" <humchand@hpcu.ac.in>, Rakesh Kumar <rakesh.lect@hpcu.ac.in>, Gourav Chambyal <gourav.cuhimachal@gmail.com>

Approved as attached.
Thanks
[Quoted text hidden]

--
Dr.Rajender Kumar
Associate Professor & Head
Department of Chemistry and Chemical Sciences
School of Physical and Material Sciences
Central University of Himachal Pradesh ,
District Kangra, Himachal Pradesh 176206
Email; rajender@cuhimachal.ac.in, rajender.cuhp@gmail.com,rajender.cuhp@hpcu.ac.in
Mob:+917018623845

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh
(Established under Central Universities Act 2009)
शाहपुर परिसर) ज़िला काँगड़ा ,शाहपुर ,.प्र हि.. - (176206
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics, Shahpur Parisar

Master of Science in Mathematics (MSc Mathematics)

School of Mathematics, Computers & Information Sciences

Batch 2020-22

M.Sc. Mathematics
Semester-III
(Monsoon Semester, 2021)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Sr. No.	Course Name	Course Code	Credit	Course Type
1	Topology	MTH 501	4	Core Compulsory
2	Functional Analysis	IAM 501	4	
3	Finite Element Methods	IAM 506	4	Core Open
4	Mechanics	MTH 504	4	
5	Fundamentals of Statistics	MTH 410	4	
6	Introduction to non-Euclidean Geometry	MTH 412	4	
7	Discrete Mathematics	MTH 503	4	

Note: Students will have to choose three courses out of the five core open courses.

Course Contents

Course Name: Topology
Course Code: MTH-501
Credits: 04
Course Instructor: Dr. Meenakshi
Course Objective: The purpose of this course is to acquaint the students with the fundamental notions of point-set topology.
Course Outcomes: After successful completion of the course, a student will be able to understand the basics of topology, continuity, compactness and connectedness.

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %

ii. Numerical Assignments using programming: 10 %

iii. Presentations and Class Tests: 5 %

Course Contents:

Unit-I: Topological Spaces, Bases for Topology, The Subspace Topology, Sub-basis for Topology, The Order Topology, The Product Topology, Closed Sets, Definition of Topology in terms of Closed Set, Limit Points, the Neighborhood System of a point, Subspace Topology, characterization of Closed Sets in a Subspace, Closure and Interior of a Set, characterization of Closure of a Set in a Subspace.

Unit-II: Definition of a Continuous Function in a Topological Space, various characterizations of Continuous Function in a Topological Space, Quotient Spaces, Homeomorphisms, Definition of a Topological Property, the Product Topology, the Metric Topology, the Connected Spaces, Path Connectedness, Components and Local Connectedness

Unit-III: Compact Spaces, the Image of a Compact Space under a Continuous Function, the Product of finitely many Compact Spaces, the Finite Intersection Property, Limit Point Compactness, Convergence in a Topological Space, Sequential Compactness, Local Compactness

Unit-IV: First Countable Spaces, Second Countable Spaces, Lindelof's Theorem, Separable Spaces, Product of First and Second Countable Spaces, the Separation Axioms: the Regular Spaces, the Normal Spaces, T1, T2, T3 and T4 spaces

Prescribed Text Books:

1. Topology By J. R. Munkres. Second Edition, Prentice Hall
2. General Topology By Stephen Willard, Dover

Suggested Additional Reading:

1. General Topology By J. L. Kelley. Graduate Texts in Mathematics, Springer
2. Basic Topology By M. A. Armstrong. Undergraduate Texts in Mathematics, Springer

Course Name: Functional Analysis
Course Code: IAM-501
Course Credit: 04
Course Instructor: Dr. Meenakshi

Course Objectives:

- To understand and define what functional analysis is
- To use the abstract algebraic/ topological structures in studying spaces of functions
- To create a positive non aversive method in the approach to severe and challenging behaviour

Course Outcomes:

- Appreciate how functional analysis uses and unifies ideas from vector spaces, theory of matrices, and complex analysis.
- Understand and apply ideas from the theory of Hilbert spaces to other areas.

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %

ii. Numerical Assignments using programming: 10 %

iii. Presentations and Class Tests: 5 %

Course Contents:

Unit-I: Metric Space , Examples of Metric Spaces, Open set, Closed set, Neighbourhood, convergence, Cauchy sequence, completeness, completion of metric spaces. **[10 Lectures]**

Unit-II: Normed Linear Spaces, Banach Spaces, Properties of Normed Linear Spaces, Properties of Banach Spaces, Compactness and Finite Dimensions, Linear Operators, Bounded and Continuous Operators. **[10 Lectures]**

Unit-III: Linear Functional, Dual Space, Double Dual Space, Inner Product Spaces, Hilbert Spaces, Properties of Inner Product Spaces, Orthogonal Compliment, Direct Sum, Orthonormal Sets and sequences. **[10 Lectures]**

Unit-IV:, Representation of Functional on Hilbert Spaces, Self-Adjointness, Unitary Operators, Normal Operators, Hahn-Banach, Open mapping and closed Graph Theorems. **[10 Lectures]**

Prescribed Text Book:

1. E. Kreyszig, "Introductory Functional Analysis with Applications", Wiley Classic Library.

Suggested Additional Readings:

1.Bollobas, "Linear Analysis", Second Edition, Cambridge University Press.
2. N. Akhierzer and I. Glazman, "Theory of Linear Operators in Hilbert Spaces", Dover Books.
3. B. Limaye, "Functional Analysis", New Age International.
4. I. J. Maddox, "Elements of Functional Analysis", Cambridge University Press; 2 edition

……

Course Name: Finite Element Methods
Course Code: IAM 506
Credit: 04
Course Instructor: Prof. Rakesh Kumar
Course Objective: The main purpose of this course is to acquaint the students with the analysis and applications of finite element methods.
Course Outcomes:
After this Course the students will be able:

- To define the test and trial function spaces
- To perform the a priori and a postriori error analysis, and stability analysis
- To construct finite element spaces
- To solve complicated problems of interest.

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%
    i. Subjective / Objective Assignment: 10 %
    ii. Numerical Assignments using programming: 10 %
    iii .Presentations and Class Tests :5 %

Course Contents:
Unit I: Basic concepts of function spaces, strong forms, variational or weak forms, minimization forms, equivalence between various forms, Lax-Milgram lemma, Galerkin orthogonality, priori error estimate, posteriori error estimate, stability theorem, discretization of weak and minimization forms in FEM.

Unit II: The energy norm, FEM for model problems; Laplace equation, Poisson equation, biharmonic problem, convection diffusion problem, heat conduction, essential and natural boundary conditions.

Unit III: Finite element space, types of elements (linear, quadratic, cubic) and shape functions, 1D elements, 2D elements (triangles, rectangles, quadrilaterals), 3D elements (tetrahedron, prisms, wedge, pyramidal), iso-parametric mapping.

Unit IV: Assembly of FEM equations and solutions, transport problem, plate problem, Stokes equation, eigenvalue and time dependent problems.

Prescribed Text Book:

1. M.G. Larson, F. Bengzon (2010). The Finite Element Method: Theory, implementation, and Applications, Springer

Suggested Additional Readings:

1. C. Johnson (2009) Numerical solution of partial differential equations by finite element method, Dover publications, INC, New York.
2. S.C. Brenner, L.R. Scott (2008). The Mathematical Theory of Finite Element Methods, Springer.
2. J.N. Reddy (2006). An Introduction to Finite Element Method. McGraw Hill.
3. S.R. Singiresu (2005). The Finite Element Method in Engineering. Fourth Edition. Elsevier Inc.

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Course Name: Mechanics
Course Code: MTH 504
Course Credit: 04
Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Course Objective: To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics, and to develop skills in formulating and solving physics problems.

Course Outcomes
After completing the course satisfactorily, a student will:

- Be able to learn about Lagrangian and Hamiltonian formulation of physical problems in classical mechanics.
- Get familiar with the idea of Euler-Lagrange's differential equations, Hamilton's principle, canonical transformations etc. to solve many physical problems which came across in mechanics.
- Be able to understand the concepts of Lagrange and Poisson's Brackets and their role in mechanics.
- Be skilful to describe and understand the concepts related to mechanical systems.

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %
ii. Numerical Assignments using programming: 10 %
iii. Presentations and Class Tests: 5 %

Course Contents:

Unit I: Generalized coordinates, constraints, work and potential energy, generalized forces, the principle of virtual work, introduction to Lagrange's equation, Lagrange's equation for a

particle in a plane, the classification of dynamical systems, Lagrange's equation for any simple dynamical system.

Unit II: Lagrange's equation for non-holonomic systems with moving constraints, Lagrange's equations for impulsive motion, Hamilton's principle, stationary values of a function, constrained stationary values, stationary value of a definite integral, Hamilton's equation, Derivation of Hamilton's equations.

Unit III: Ignorable coordinates, the Routhian function, the form of Hamiltonian function, modified Hamilton's principle, principle of least action, the Hamilton-Jacobi equation.

Unit IV: Lagrange and Poisson brackets, calculus of variation, the Brachistochrone problem, invariance of Lagrange and Poisson brackets under canonical transformations.

Prescribed Text Books:

1. John L. Synge and Byron A. Griffith Principles of Mechanics, McGraw Hill, 3rd Edition.
2. Donald T. Green and Wood, Classical Dynamics, Prentice Hall of India, 1979.
3. K Sankara Rao, Classical Mechanics, Prentice Hall of India, 2005.

Course Name: Fundamentals of Statistics
Course Code: MTH 410
Credit: 04
Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram
Course Objectives: The prime objective of this course is to make an understanding about the statistics in the students.

Course Outcomes:
After completing the course satisfactory, a student will:

- Be skillful in behaviour statistical properties formally by using the Statistics concept.
- Get experience to use probability theory in details.
- Acquire ability to specify and manipulate basic statistical properties such as descriptive statistics like Central measure of Tendency and measure of Dispersion.
- Able to use various techniques of statistical equalities, convergence in probability, weak law of large numbers with help them to prove simple mathematical properties.
- Be able to apply Markov chain to 11ehavio the problems.
- Get familiar with to construct mathematical problems along with their Mathematical proofs.
- Know how to apply the knowledge they have gain to solve real life problems.

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %
ii. Numerical Assignments using programming: 10 %
iii. Presentations and Class Tests: 5 %

Course Contents

Unit I:

Random variable, probability mass function, probability density function, cumulative distribution function. Expectation of a random variable, properties of expectation, conditional expectation and its properties. Bivariate distributions and the joint probability distribution. Independence of random variables. Marginal and conditional distributions. Discrete and Continuous random variable. Expectation and Variance.

Unit II:

Moment generating function, probability generating function, cumulative generating function, characteristic function and their properties, continuity and uniqueness theorems.

Convergence in probability, almost sure convergence, convergence in distribution and their relationships. Chebyshev's inequality, weak law of large numbers (WLLN), strong law of large numbers (SLLN), central limit theorems.

Unit III:

Karl Pearson's correlation coefficient, Spearman's rank correlation coefficient, principle of least square, lines of regression, simple linear regression, coefficient of determination. Multiple linear regression, coefficient of multiple determination.

Unit IV:

Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, stationary distribution

Prescribed Text Books:

1. Hogg, R.V., McKean, J. & Craig, A.T. (2013). Introduction to Mathematical Statistics, 7th Edition. Pearson
2. Gupta S. C. and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, Delhi.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I & II. World Press.

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Course Code: MTH 412

Course Name: Introduction to non-Euclidean geometry

Credits: 04

Name of Teacher: Dr S. K. Srivastava

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %

ii. Numerical Assignments using programming: 10 %

iii. Presentations and Class Tests: 5 %

Course Contents:

Unit I: The foundation of Euclidean geometry: Introductions, Postulates, Pasch's Axiom, Principle of continuity and Postulate system of Hilbert. The Fifth Postulate: Substitutes for the Fifth Postulate, the Angle-Sum of a Triangle, Attempts to Prove the Fifth Postulate and the Rotation Proof.

Unit II: The Discovery of Non-Euclidean Geometry: Gauss, Bolyai, Lobachewsky, Wachter, Schweikart and Taurinus, Riemann and Further Developments .

Unit III: The Hyperbolic Plane Geometry: The Characteristic Postulate of Hyperbolic Geometry, Elementary Properties of Parallels, the Angle of Parallelism, the Lambert Quadrilateral, Ideal and Ultra-Ideal Points and Circles.

Unit IV: Elliptic Plane Geometry And Trigonometry: The Two Elliptic Geometries, the Trigonometry of the Elliptic Plane, the Trigonometric Functions of an Angle, the Relation among the parts of a Right Triangle and The Consistency of the Non-Euclidean geometries.

Prescribed Text Book:

Harold E. Wolfe: Introduction to Non-Euclidean Geometry, Dover Publications; Reprint edition (26 September 2013)

Suggested Additional Readings:

John Stillwell: The Four Pillars of Geometry, Springer; 2005th edition (December 1, 2010)
Eugene F. Krause: Taxicab Geometry: Adventure in Non-Euclidean Geometry, Dover Publications Inc.; New edition (1 January 1987)

Course Name: Discrete Mathematics
Course Code: MTH 503
Credits: 04
Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: To introduce students to language and methods of the area of Discrete Mathematics. The focus of the module is on basic mathematical concepts in discrete mathematics and on applications of discrete mathematics in algorithms and data structures. To show students how discrete mathematics can be used in modern computer science (with the focus on algorithmic applications) and understand some basic properties of graphs and related discrete structures, and be able to relate these to practical examples.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%
i. Subjective / Objective Assignment: 20 %
ii. Presentations and Class Tests: 5 %

Course Contents:

Unit I: Logic, Propositional Equivalences, Partial Ordered Sets, Lattices and Algebraic Systems, Principle of Duality, Basic Properties of Algebraic Systems defined by Lattices, Distributive and Complemented Lattices, Boolean Lattices and Boolean Algebras.

Unit II: Boolean Functions and Boolean Expressions, Propositional Calculus, Pigeonhole principle: Simple form, Pigeonhole principle: Strong form, A theorem of Ramsey. Two basic counting principles, Permutations of sets, Combinations of Sets, Generating permutations, Inversions in permutations, Generating combinations,

Unit III: Pascal's formula, The binomial theorem, Identities, Unimodality of binomial coefficients, The multinomial theorem, Newton's binomial theorem. The inclusion-exclusion principle, Combinations with repetition, Derangements. Some number sequences, linear homogeneous recurrence relations, Non-homogeneous recurrence relations.

Unit IV: Graph Theory:- Basic properties, Eulerian trails, Hamilton chains and cycles, bipartite multigraphs, Trees, The Shannon switching game, Digraphs and Networks, Chromatic number, Plane and planar graphs, A 5-color theorem.

Prescribed Text Books:

1. CL. Liu and DP. Mohapatra, (2012) Elements of Discrete Mathematics.4th Edition, Tata McGraw Hill Education.
2. Richard A. Brualdi, Introductory Combinatorics, third Edition, (Chapter 2, Chapter 3(3.1, 3.2, 3.3), Chapter 4(4.1, 4.2 ,4.3), Chapter 5(5.1 to 5.6), Chapter6(6.1, 6.2, 6.3), Chapter 7(7.1 to 7.4) and Chapter 11(11.1 to 11.6), Chapter 13(13.1 to 13.3).

Suggested Additional Readings:

1. J. Matousek and J. Nesetril (2005). Invitation to Discrete Mathematics. Oxford University Press.
2. G. Edgar and PM. Michael (2003). Discrete Mathematics with Graph Theory. Prentice Hall.
3. Kenneth H. Rosen, Discrete Mathematics and Its Application, Tata McGraw-Hill, Fourth Edition.

Batch 2020-22

M.Sc. Mathematics
Semester-IV
(Spring Semester, 2022)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

S. No.	Course Name	Course Code	Credit
1	Fluid Dynamics	IAM 405	04
2	Differential Geometry	IAM 407	04
3	Field Theory and Galois Theory	MTH 520	04
4	Mathematical Methods	IAM 404	04
5	M. Sc. Project	MTH 550	04

Course Contents

Course Name: Fluid Dynamics
Course Code: IAM 405
Credits: 04
Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%
    i. Subjective / Objective Assignment: 10 %
    ii. Numerical Assignments using programming: 10 %
    iii. Presentations and Class Tests: 5 %

Course Contents:

Unit I: Basic Concepts, Orthogonal Curvilinear Coordinates, Kinematics of Fluid in Motion, General Theory of Stress and Strain, Equations of Motion of Inviscid Fluids, Bernoulli's Equation and its Applications**.**

Unit II: The Navier-Stokes Equations and the Energy Equation, Dynamical Similarity, Inspection Analysis and Dynamical Analysis:-Rayleigh's Technique and Buckingham π-Theorem.

Unit III: Laminar Flow of Viscous Incompressible Fluids with Temperature Distribution:-Plane Couette Flows, Plane Poiseuille Flows, Generalized Plane Couette Flows, Hagen-Poiseuille Flow, Flow in Tubes of Various Cross-Sections, Jeffery-Hamel Flow, Flow of two Immiscible Fluids, Flow with Constant Fluid Properties and with Variable Viscosity, and Flow in the Neighbourhood of a Stagnation Point.

Unit IV: Boundary Layer Theory: Velocity and Thermal Boundary Layers.

Prescribed Text Books:

1. Bansal J. L. (2004). Viscous Fluid Dynamics. Second Edition. Oxford and IBH Publishing, Delhi.
2. Raisinghania M.D. (2011).Fluid Dynamics. Tenth Edition. S Chand & Company LTD. New Delhi.

Suggested Additional Readings:

1. Schlichting H. and Gersten K. (2000). Boundary Layer Theory. Eighth Edition. Springer Verlag. Germany.
2. Kundu P.K. and Cohen I.M. (2010). Fluid Mechanics. Fourth Edition. Academic Press.

Course Name: **Differential geometry**

Course Code: IAM 407
Credits: 04
Course Instructor: Dr. S.K. Srivastava
Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%
    i. Subjective / Objective Assignment: 10 %
    ii. Numerical Assignments using programming: 10 %
    iii. Presentations and Class Tests: 5 %

Course Contents:
Unit I: Curve, Arc-length, Reparametrization, Level curves, Curvature of Plane curve, Frenet-Formulas.

Unit II: Global Properties of Curves: Simple closed curves, The Isoperimetric Inequality, Four vertex Theorem, Surfaces in Euclidean Spaces, Length of curves on surface, Isometries and conformal mappings of surfaces, Surface area.

Unit III: The Second Fundamental Form, Curvature of curves on surface, Normal and Principal Curvatures, Gaussian and Mean curvatures.

Unit IV: The Pseudosphere, Gauss map, Geodesics: Basic Properties, Theorema Egregium and Gauss-Bonnet Theorem.

Prescribed Text Books:

Andrew Pressley, Elementary Differential Geometry, Springer, 2010.

Suggested Additional Readings:
M.P. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
B. O'Neill, Elementary Differential Geometry, Academic Press, New York, 1966.

Course Name: Field Theory and Galois Theory
Course Code: MTH 520
Credits: 04
Course Instructor: Dr. Meenakshi
Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%
    i. Subjective / Objective Assignment: 10 %
    ii. Numerical Assignments using programming: 10 %
    iii. Presentations and Class Tests: 5 %

Objectives:
- To discuss the Field Theory
- Introduction of Galois Group
- To discuss the related theorems of Galois Field

Outcome:
- An Ability to learn how to write, correct and clear arguments in abstract Mathematics with proofs.
- To solve different polynomials

Course Contents:

Unit I: Polynomial, Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots.

Unit II: Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotonic polynomials, Representation of Elements of Finite Fields, Order of Polynomials

Unit-III: Primitive Polynomials, Irreducible Polynomials, Galois Theory and its Applications, Perfect Field, Separable extensions, Simple extensions

Unit IV: Auto-morphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra.

Text Book
1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, ‘Basic Abstract Algebra’, Second Edition, Cambridge University Press.

Course Code: IAM404
Course Name: Mathematical Methods
Credits: 04
Course Instructor: Dr Pankaj Kumar S/O Late Sh. Maniram

Course Objective: The purpose of this course is to acquaint the students with the integral equations and calculus of variations.

Credits Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Counselling, Activities and Tutorials (CAT): 25%
    i. Subjective / Objective Assignment: 10 %
    ii. Numerical Assignments using programming: 10 %
    iii. Presentations and Class Tests: 5 %

Course Contents:

Unit I: Review the basic concepts for solving ODE: First order and second order Linear differential equations, Series solution for ODE where x=0 is ordinary point, Leibnitz rule for differentiation of integrals, Cauchy formula for reducing multiple integrals to single integral and Laplace transforms. Integral equations: classification of integral equations; conversion from IVP to Volterra integral equations and conversely; conversion from BVP to Fredholm integral equations and conversely, Integral equations with separable kernels. **(10Hours)**

Unit II: Method of successive approximations, eigenvalues and eigenfunctions, Resolvent kernels, Symmetric kernels, Hilbert Schmidt theorem and solution of symmetric integral equations.
(10 Hours)

Unit III: Calculus of Variations: Concept of variation, Linear functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema, Euler-Lagrange differential equation for n-dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables. **(10 Hours)**

Unit IV: Applications of calculus of variations to various problems: Shortest distance, minimum surface of revolution, Brachistochrone problem, geodesic, Isoperimetric problem, Calculus of variations for problems in parametric form, variational problems with moving boundaries. **(10 Hours)**

Prescribed Text Books:

M.D. Raisinghania (2016), Integral equations and boundary value problems, S. Chand Publishing.

I.M. Gelfand and S.V. Fomin (2012): Calculus of Variations, Prentice Hall Inc.

Suggested Additional Readings:

F.G. Tricomi,(1985): Integral Equations, Cambridge University Press.

A. S. Gupta (1996): Calculus of Variations with Applications, Prentice–Hall of India.

Robert Weinstock(1975):CalculusofVariationswithapplicationstoPhysicsandEngineering,DoverPublicationsInc.

Course name: M.Sc. Project
Course Code: MTH 550
Credits: 04
Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Evaluation Criteria: (External: 100%)

S. No.	Examination		Maximum Weightage Assigned 200 Marks (4 Credit Course)
1.	External	Project/ Dissertation Report	100 Marks
2.		Open seminar and Viva-Voce Examination	100 Marks

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh
(Established under Central Universities Act 2009)
शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics, Shahpur Parisar

Program Specific Outcomes

Program Outcomes

Course Outcomes & Course Contents

of

Master of Science in Mathematics (MSc Mathematics)

School of Mathematics, Computers & Information Sciences

Programme Specific Outcomes of Master of Science in Mathematics

PSO[1]: To possess the systematic understanding of the concepts, theories and methods of mathematics at higher education level.

PSO[2]: To deal with the real-world problems and their significance by critical understanding, analyzing and synthesizing the various mathematical concepts.

Programme Outcomes of Master of Science in Mathematics

PO[1]: To comprehend and analyze mathematical theories, methods, and findings in their appropriate contexts.

PO[2]: To learn the generalization of mathematical theories, as well as how to bridge them to broader concepts.

PO[3]: To review the literature related to pure/applied mathematics, and identify the knowledge gaps.

PO[4]: To analyze data critically, prepare scientific reports/papers, and defend the work.

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Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Batch 2021-23

M.Sc. Mathematics
Semester-I
(Monsoon Semester, 2021)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Sr. No.	Course Name	Course Code	Credits
Major Courses (Disciplinary Courses) (10 Credits)			
1	Linear Algebra	MTH 403	04
2	Real Analysis	MTH 406	04
3	One course to be Chosen from the Course basket at University Level which is different and distinct from the programme which s/he is enrolled in.		02
Minor Courses (Disciplinary Courses) (04 Credits)			
4	Mathematical Methods	IAM 404	04
Vocational/Skill Courses (04 Credits)			
5	Operational Research	MTH 502	02
6	Discrete Mathematics	MTH 503	02
Indian Knowledge System Courses (at University Level) (02 Credits)			
8	Indian Knowledge System	IKS	02

Course Contents:

Major Courses (Disciplinary Courses) (10 Credits)

Course Code: MTH-403

Course Name: LINEAR ALGEBRA

Course Credit: 04

Course Instructor: Dr.Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the Numerical analysis which is necessary to develop the basic understanding of numerical algorithms for solving problems in science, engineering and technology.

Course Outcome:

By the end of the course students should be able to understand:

Co^1: The abstract definition of a set theory, and be familiar with the definition of Vector space with examples.

Co^2: All concept of linear transformation.

Co^3: Knowledge about the Eigen vector, Eigen values minimal polynomials.

Co^4: Knowledge about the functional, inner product space and quadratic forms.

Co^5: How apply some underlining and cross-cutting concepts of Vector space and related concepts.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

Unit I:

Vector Spaces, Subspaces, Basis and dimension, Linear Transformations, Quotient spaces, Direct sum, The matrix of a linear transformation, Duality **(12 Hours)**

Unit II:

Eigenvalues and eigenvectors, Annihilating polynomials, Invariant subspaces, Triangulation and diagonalization. **(10 Hours)**

Unit III:

Canonical Forms, Jordan Form, Inner Product Spaces, orthonormal basis, Linear functional and adjoints. **(10 Hours)**

Unit IV:

Bilinear Forms, Definition and examples, Symmetric and skew-symmetric bilinear forms. **(08 Hours)**

Prescribed Text Book:

1. K. Hoffman and R. Kunze : Linear Algebra, Second Edition, Pearson,2015.

Suggested Additional Readings:

1. StrangG.: Linear Algebra and its applications, 4th Edition, CENGAGE LEARNING, 2007.
2. KumaresanS.: Linear Algebra, A Geometric approach, Prentice Hall of India,2000.
3. LipschutzS. and LipsonM. L.: Linear Algebra, 3rd Edition, McGraw Hill Education India, Pvt. Ltd., 2001.
4. AntonH. AndRorresC.: Elementary Linear Algebra, 11th Edition, Wiley,2014.

Course Articulation Matrix MTH-403- Linear Algebra

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	1	2	2	2		1	1	2
CO2	2	2	1	2		1	1	2
CO3	1	2	2	2		2	2	2
CO4	2	1	2	3		2	1	1
CO5	1	2	2	2		2	1	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 406

Course Name: Real Analysis

Course Instructor: Dr Meenakshi

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is:

- To obtain the thorough understanding of the origins of Number System
- To gain the knowledge of sequence and series of real numbers and convergence
- Studying the notions of continuous functions of real number system and their properties

Course Outcomes: After successful completion of the course, a student will be able to:

CO[1]Define and recognize the basic properties of the field of numbers
CO[2]Define and recognize the continuity and differentiability of the functions and their properties
CO[3]Improve and outline the logical thinking of Number system
CO[4] Understand Applications of Integration and Differentiation

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40

2. End Term Examination: 120

3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Real and complex number systems, Basic Topology: Rational Numbers, Dedekind' Theorem, Cantor' Theory of Irrational Numbers, Ordered sets, Fields, The Real field and Complex field, Euclidean spaces, Countable and Uncountable sets, Metric spaces, Compact sets. **(10 Hours)**

Unit-II: Sequence, Series and Continuity: Sequence, subsequence, Convergent sequence, upper and lower limits, Series of non-negative terms, the root and ratio test, Power series and Summation by parts, Absolute

convergence, Continuity and compactness, monotonic functions.

(10 Hours)

Unit-III: Differentiation: Differentiation of a Real valued functions, Mean value theorem, Differentiation of Vector valued functions, L. Hospital Rule, Taylor's Theorem and Derivatives of Higher order.

(10 Hours)

Unit-IV: Sequence, Series of Functions and Functions of several Variables: Uniform Convergence, Equi-continuous Families of Functions, The Stone-Weierstrass Theorem, Differentiations of a Function of Several Real Variables and the Contraction Principle. **(10 Hours)**

Prescribed Text Books:

- Rudin, Walter, "Principles of Mathematical Analysis", 3rd Edition, McGraw Hill.
- Robert G. Bartle, Donald R. Sherbert, "Introduction to Real Analysis" , 3rd Edition, Wiley.

Suggested Additional Readings:

1. G.F. Simmons, "Topology and Modern Analysis", 1st Edition, McGraw Hill.
2. Russell A. Gordon, "Real Analysis: A First Course", Addision-Wesley Higher Mathematics Series.

Course Articulation Matrix of MTH 406- Real Analysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	1		3	3
CO^2	3	2	2	1		3	2
CO^3	3	2	2	1		3	2
CO^4	3	2	2	1		3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Minor Courses (Disciplinary Courses) (04 Credits)

Course Code: IAM 404

Course Name: Mathematical Methods

Credits: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the integral equations and calculus of variations.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO1 The methods of solving Fredholm integral equations.

CO2 The methods of solving Volterra integral equations.

CO3 The notion of variations, Euler Lagrange's equations.

CO4 Applications of calculus of variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

1. MidTermExamination:40
2. EndTermExamination:120
3. ContinuousInternalAssessment:40

Course Contents:

Unit I: Review the basic concepts for solving ODE: First order and second order Linear differential equations, Series solution for ODE where x=0 is ordinary point, Leibnitz rule for differentiation of integrals, Cauchy formula for reducing multiple integrals to single integral and Laplace transforms. Integral equations: classification of integral equations; conversion from IVP to Volterra integral equations and conversely; conversion from BVP to Fredholm integral equations and conversely, Integral equations with separable kernels. **(10Hours)**

Unit II: Method of successive approximations, eigenvalues and eigenfunctions, Resolvent kernels, Symmetric kernels, Hilbert Schmidt theorem and solution of symmetric integral equations.
(10 Hours)

Unit III: Calculus of Variations: Concept of variation, Linear functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema, Euler-Lagrange differential equation for n-dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables. **(10 Hours)**

Unit IV: Applications of calculus of variations to various problems: Shortest distance, minimum surface of revolution, Brachistochrone problem,geodesic, Isoperimetric problem, Calculus of variations for problems in parametric form, variational problems with moving boundaries. (**10 Hours)**

Prescribed Text Books:

M.D. Raisinghania (2016), Integral equations and boundary value problems, S. Chand Publishing.
I.M. Gelfand and S.V. Fomin (2012): Calculus of Variations, Prentice Hall Inc.

Suggested Additional Readings:

F.G. Tricomi,(1985): Integral Equations, Cambridge University Press.
A. S. Gupta (1996): Calculus of Variations with Applications, Prentice–Hall of India.
RobertWeinstock(1975):CalculusofVariationswithapplicationstoPhysicsandEngineering,DoverPublications Inc.

CourseArticulation MatrixofIAM404-MathematicalMethods

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		3	2
CO^2	3	2	1	1		3	2
CO^3	3	2	1	1		3	2
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses (04 Credits)

Course Code: MTH 502

Course Name: Operational Research

Course Instructor: Dr. Khushbu Srivastava &Anuj Kumar

Credits: 02

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with theoperational Research which is mainly concerned with the techniques of applying scientific knowledge, besides the development of science and provides an understanding which gives the expert/manager new insights and capabilities to determine better solutions in his decision–making problems, with great speed, competence and confidence.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1}The formulation and solution to real mathematical models of LPP.
CO^{2}The Graphical and Simplex methods for the solution of LPP.
CO^{3}Degeneracy and dual Simplex methods.
CO^{4}Queueing systems and solution of Queueing Models.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Operations research & its scope, Necessity of operations research in industry .Introductions to Linear programming problems, General linear programming problems, Mathematical Formulation of L.P.P .and examples, Feasible, Basic feasible and optimal solutions, Extreme points, Graphical Methods to solve L.P.P., Simplex Method. **(10 Hour)**

Unit II: Big M Method, Two phase Method, Degeneracy, Unrestricted variables, unbounded solutions, Duality in LPP, fundamental properties of Dual problems, dual simplex method and Revised Simplex method. **(10 Hours)**

Unit III: Queueing systems, Queueing problem, Transient and steady states, Probability Distributions in Queueing systems .Poisson process pure birth process(, Properties of poissons arrivals, Exponential process, Markovian property, Pure death process, Service time distribution, Erlang service time distribution, Solution of Queueing Models. **(10 Hours)**

Prescribed Text Books:

1. Kanti Swarup, P.K .Gupta and Manmohan (2000), Operations Research, Sultan Chand & Sons, 12th Edition.

Suggested Additional Readings:

1. S. D .Sharma (2004), Operations Research, KedarNath Ram Nath & Co .14th Edition.

Course Articulation Matrix of MTH 502- Operational Research

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		2	3
CO^2	3	2	1	1		2	3
CO^3	3	2	1	1		2	3
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 503

Course Name: Discrete Mathematics

Credits: 02

Course Instructor: Dr. Pankaj Kumar S/o Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: To introduce students to language and methods of the area of Discrete Mathematics. The special focus of the module is on basic mathematical concepts in discrete mathematics and on applications of discrete mathematics in algorithms and data structures. To show students how discrete mathematics can be helpful in modern computer science so that they may able to relate these to practical examples.

Course Outcomes: After completing the course satisfactorily, a student will:

CO1: Be skillful in expressing mathematical properties formally by using the formal language of propositional logic.

CO2: Get experience to comprehend formal logical arguments.

CO3: Acquire ability to specify and manipulate basic mathematical objects such as sets, relations and functions.

CO4: Learn to use various techniques of mathematical induction which will help them prove simple mathematical properties of a variety of discrete structures.

CO5: Be able to apply some basic counting techniques to solve permutation and combination problems.

CO6: Get familiar with to construct mathematical problems along with their Mathematical proofs.

CO7: Know how to apply the knowledge they have gained to solve real life problems.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Contents:

Unit I

Logic, Propositional Equivalences, Partial Ordered Sets, Lattices and Algebraic Systems, Principle of Duality, Basic Properties of Algebraic Systems defined by Lattices, Distributive and Complemented Lattices, Boolean Lattices and Boolean Algebras, Boolean Functions and Boolean Expressions, Propositional Calculus, Pigeonhole principle: Simple form, Pigeonhole principle: Strong form, A theorem of Ramsey.

Unit II:

Two basic counting principles, Permutations of sets, Combinations of Sets, Generating permutations, Inversions in permutations, Generating combinations, Pascal's formula, The binomial theorem, Identities, Unimodality of binomial coefficients, The multinomial theorem, Newton's binomial theorem. The inclusion-exclusion principle, Combinations with repetition, Derangements. Some number sequences, linear homogeneous recurrence relations, Non-homogeneous recurrence relations.

Prescribed Text Books:

1. CL. Liu and DP. Mohapatra, (2012) Elements of Discrete Mathematics.4th Edition, Tata McGraw Hill Education.
2. Richard A. Brualdi, Introductory Combinatorics, 3rdEdition.

Suggested Additional Readings:

1. J. Matousek and J. Nesetril (2005). Invitation to Discrete Mathematics. Oxford University Press.
2. G. Edgar and PM. Michael (2003). Discrete Mathematics with Graph Theory. Prentice Hall.
3. Kenneth H. Rosen, Discrete Mathematics and Its Application, Tata McGraw-Hill, Fourth Edition.

Course Articulation Matrix of MTH 503- DISCRETE MATHEMATICS

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	3	1	1		2	2
CO2	2	2	1	1		1	1
CO3	2	2	1	1		2	2
CO4	2	3	1	1		2	2
CO5	1	2	1	1		2	2
CO6	2	2	1	1		3	2
CO7	1	1	1	1		1	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Indian Knowledge System (IKS) Course (02 Credits)

Syllabus is framed centrally as per CUHP Guidelines, and is adopted in totality.

M.Sc. Mathematics
Semester-II
(Spring Semester 2022)

Sr. No.	Course Name	Course Code	Credits
Major Courses (10 Credits)			
1	Abstract Algebra	MTH 404	04
2	Complex Analysis	IAM 401	04
3	Numerical Analysis	IAM 403	02
Major Courses (02 Credits)			
4	To be Chosen from the Course basket at University Level which is different and distinct from the programme which s/he is enrolled in.		02
Minor Courses (04 Credits)			
5	Topology	MTH 501	02
6	Differential Geometry	IAM 407	02
Vocational/Skill Courses (02 Credits)			
7	Basics of Propositional Logic	MTH 529	02
IKS (02 Credits)			
8	Introduction to Rigorous and Precise Thinking	MTH 528	02

Course Contents

Major Courses (12 Credits)

Course Code: MTH-404

Course Name: Abstract Algebra

Course Credits: 04

Course Instructor: Dr. Pankaj Kumar S/o Late Sh. Maniram

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course aims to provide a first approach to the subject of abstract algebra, which is one of the basic pillars of modern mathematics. The focus of the course will be the study of certain structures called groups, rings, fields.

Course Outcome:

By the end of the course students should be able to understand:

Co^1: The abstract definition of a group, and be familiar with the basic types of examples, including numbers, symmetry groups and groups of permutations and matrices.

Co^2: Description of algebraic techniques and basic elements of abstract algebra.

Co^3: The state axioms of groups, rings and fields.

Co^4: How apply some underlining and cross-cutting concepts of groups, rings and fields.

Co^5: The concept of cosets of a subgroup of a group and normal subgroups, symmetric groups, cyclic groups and their properties.

Co^6: The concept of quotient groups, homomorphism and isomorphism.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120

3. Continuous Internal Assessment: 40

Course Contents:

Unit I

Laws of Composition, Groups and Subgroups, Examples of Groups and Subgroups, Groups generated by a Set, Cyclic Groups, Order of an element of a Group, Cosets, Lagrange's theorem, Index of a Subgroup, Cycle decomposition of a Permutation. Homomorphisms, Isomorphisms, Automorphisms, Normal Subgroups, Quotient Groups, The Isomorphism theorems, the Correspondence Theorem, Direct Product of Groups. **(12 hours)**

Unit II

Group Actions, Examples of Group Actions, Orbit and Stabilizer of Group Action, Orbit and Stabilizer Formula, Cayley's theorem, Conjugacy Classes, Center of a Group, Centralizer of a Subset, the Class Equation, Application of the Class Equation, the Center of a p-Group and related results, Simple Groups. **(08 hours)**

Unit III

Stabilizer and Normalizer of a Subgroup, the First Sylow theorem, the Second Sylow theorem, the Third Sylow theorem. Applications of Sylow Theorems, Definition of a Ring, Examples of Rings, Subrings, Homomorphisms of Rings, Kernel of a Homomorphism, Ideals, Ideal Generated by a Set, Principal Ideals. **(08 hours)**

Unit IV

Quotient Ring, Prime Ideals, Maximal Ideals, the Isomorphism theorems for Rings, the Universal Mapping Property of Quotient Rings, The Correspondence theorem, Dircet Product Rings, Integral Domains, Group of Units of a Ring, Associates, Irreducible Elements of Ring, Prime Elements of a Ring, Unique Factorization Domains, An Example of a Non-Unique Factorization Domain.

(12 hours)

Prescribed Text Books:

1. Isaac I.M., *Algebra: A Graduate Course, AMS (Graduate Studies in Mathematics),* Indian Edition.
2. Artin M., *Algebra,* Second Edition, PHI
3. Bhattacharya P. B., Jain S.K., Nagpaul S. R., *Basic Abstract Algebra,* Second Edition, Cambridge University Press.

Additional Text

1. Dummit D. S. and Richard M. Foote, *Abstract Algebra*, Third Edition, Wiley India
2. Jacobson N., *Basic Algebra,* Vol. 1, Hindustan Publishing Corporation, Delhi

Course Articulation Matrix MTH-404- Abstract Algebra

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	1	1	3	2		1	1	2
CO2	2	3	1	1		1	1	2
CO3	1	2	2	3		2	2	2
CO4	2	1	2	3		2	1	1
CO5	1	2	3	1		2	1	2
CO6	1	1	1	1		1	1	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM401

Course Name: Complex Analysis

Credits: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The objectives of this course are to:

- Provide an introduction to the indispensable ideas for the development of the functions of a complex variable and
- equip students with clear understanding of the elementary concepts of the theory of complex analysis and skills to enable them to work with the concepts effectively.

Course Outcomes: After successful completion of the course the student will be able:

$CO^{1:}$ To understand Stereographic projection, analytic functions and singularities.

$CO^{2:}$ To understand Branch point, conformal transformations and homotopic curves.

$CO^{3:}$ To learn basics of complex integrations and Fundamental theorem of algebra.

$CO^{4:}$ To understand Maximum-Modulus theorem and Rouche's theorem etc.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

UNIT-I: Complex Numbers, Geometric description, Stereographic projection, Analytic functions, the Cauchy-Riemann equations, multivalued functions, Branch point. **(10Hours)**

UNIT-II: Complex integration, Cauchy-Goursat theorem, Cauchy integral formula, Derivatives of analytic function. **(10Hours)**

UNIT-III: The Liouville theorem, The Morera theorem, Maximum-Modulus theorem, conformal transformations. **(10Hours)**

UNIT-IV: Taylor's series, Laurent's series, Singularities of complex functions, the Cauchy Residue theorem, Evaluation of integrals. **(10Hours)**

Prescribed text book:

J. B. Conway, Functions of one complex variable, International Student-Edition, Narosa Publishing House, 2000.

Reference books:

- K. Kodaira, Complex Analysis, Cambridge University Press,2007.
- J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill,8thEdition,2008.

CourseArticulationMatrixofIAM401-ComplexAnalysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	ProgrammeOutcomes 4		Programme SpecificOutcomes 1	ProgrammeSpecificOutcomes 2
CO1	3	2	1	1		3	2
CO2	3	2	1	1		3	2
CO3	3	2	1	1		3	2
CO4	3	2	1	1		3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 403

Course Name: Numerical Analysis

Credits: 02

Course Instructor: Prof. Rakesh Kumar

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main objective of this course is to familiarize the students with basic numerical schemes and their applications.

Course Outcomes: After completing the course satisfactorily, the student will be able to:

CO1: Interpolate and approximate functions.

CO2: Perform numerical differential and integration.

CO3: Perform error analysis.

CO4: Apply basic numerical algorithms.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination:20%
End Term Examination:60%
Continuous Internal Assessment: 20%. i.e. 20 marks out of 100

Course Contents:

Unit I: Lagrange and Newton interpolations, interpolations using finite differences, Hermite interpolation, piecewise and spline interpolation, Polynomial approximation: least square approximation, orthogonal polynomials, uniform approximation, rational approximation. **(07 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit II: Numerical Differentiation and Integration: methods based on interpolation, methods based on undetermined coefficients, composite integration methods, Romberg integration. **(07 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit III: Initial and Boundary value problems: Taylor's series method, Runge-Kutta methods, shooting method. **(06 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Prescribed Text Book:

1. M.K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods, 6th Edition, New Age International (P) Limited, Publishers, New Delhi.

Suggested Additional Readings:

1. S. S. Sastri; Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd., 2005.
2. S.C. Chapra: Applied Numerical Methods with MATLAB, McGraw Hill, 2012.

Course Articulation Matrix of IAM 403- Numerical Analysis

Course Outcomes	Programme Specific Outcomes 1	ProgrammeSpecific Outcomes 2	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4
CO1	3	2	2	3	2	1
CO2	3	2	2	3	2	1
CO3	3	3	3	2	2	2
CO4	2	3	3	2	1	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Minor Courses (04 Credits)

Course Code: MTH 501

Course Name: Topology

Credits: 02

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objectives of this course are to:

- To understand the meaning of topology with help of examples
- To make more precise the relationship between geometric translation/ construction and continuous map.

Course Outcomes:

After successful completion of the course the student will be able:

CO^{1} An ability to construct and develop different topologies
CO^{2}An ability to explore applications of topologies
CO^{3}To learn basics of real number system by involving Topology

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: Topological Spaces, Bases for Topology, The Subspace Topology, Sub-basis for Topology, The Order Topology, The Product Topology, Closed Sets, Definition of Topology in terms of Closed Set, Limit Points, the Neighborhood System of a point, Subspace Topology, characterization of Closed Sets in a Subspace, Closure and Interior of a Set, characterization of Closure of a Set in a Subspace.

(10 Hours)

UNIT-II: Definition of a Continuous Function in a Topological Space, various characterizations of Continuous Function in a Topological Space, Quotient Spaces, Homeomorphisms, Definition of a Topological Property, the Product Topology, the Metric Topology, the Connected Spaces, Path Connectedness, Components and Local Connectedness. **(10 Hours)**

Prescribed text book:

J. R. Munkres, Topology, Second Edition, Prentice Hall, 1994.

Reference books:

1. J. L. Kelley, General Topology: Graduate Texts in Mathematics, Springer, 1955
2. M. A. Armstrong, Basic Topology : Undergraduate Texts in Mathematics, Springer, 1955.

Course Articulation Matrix of MTH 501- Topology

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	2		3	2
CO^2	3	2	2	1		3	1
CO^3	3	3	3	3		3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 407

Course Name: Differential Geometry

Credit: 02

Course Instructor: Dr. Pankaj Kumar S/o Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The prime objective of this course is to provide the basic concepts and knowledge of differential geometry by focusing at the various physical aspects through the different solution schemes/ techniques.

Course Outcomes: After completing the course satisfactorily, a student will be able:

CO1 : To know about the distinct kind of curves and their geometry.

CO2 : To know about the distinct techniques/ schemes which are essential in the wide study of curves and surfaces.

CO3 : To know about the famous naming theorems like Egregium theorem, Gauss-Bonnet theorem etc. which are necessary about the basic study of curves/ surfaces.

Learning Outcomes: The deliverables Learning Outcomes of this paper with students are following:

- Can explain about distinct curves and curvature along with their basic terminology which is soul part of the study of differential geometry.
- Will know about the different solution techniques/schemes related to the wide knowledge of curves and surfaces.
- Can explain about the second fundamental form, Gaussian curvatures, Pseudosphere, Geodesics and use of different basic theorems in various physical aspects.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%

3. Continuous Internal Assessment: 20% (i.e. 20 marks out of100).

Course Contents:

UNIT I: The Second Fundamental Form, Curvature of curves on surface, Normal and Principal Curvatures, Gaussian and Mean curvatures. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

UNIT-II: The Pseudosphere, Gauss map, Geodesics: Basic Properties, TheoremaEgregium and Gauss-Bonnet Theorem. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Essential Readings:

- Andrew Pressley, Elementary Differential Geometry, Springer, 2010.

Suggested Additional Readings:

- M.P. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
- B. O'Neill, Elementary Differential Geometry, Academic Press, New York, 1966.

Course Articulation Matrix of IAM 407- DIFFERENTIAL GEOMETRY

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	1	1		2	2
CO2	3	2	1	1		3	3
CO3	2	2	1	1		1	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses (02 Credits)

Course Code: MTH 529

Course Name: Basics of Propositional Logic

Credits: 02

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objective of this course is to develop a rational thinking in statements/decision making/ arguments.

Course Outcomes:

After successful completion of the course the student will be able:

CO[1] State the converse, inverse, contrapositive and negation of a conditional statements including quantified statements
CO[2]Construct the truth tables, and interpret the results
CO[3]To write different types of proofs

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: Set and Proposition, Finite and Infinite set, Mathematical Induction, Principle of Inclusion and Exclusion, Multisets, Propositions, Logical Connectives, Conditional and Biconditional, Well-Formed formulas, Tautologies. **(10 Hours)**

UNIT-II: Logical Equivalence, Theory of Inference for Statement Calculus, Validity using Truth Tables, Rules of Inference, Consistency of Premises, Predicate Calculus, The Statement Function, Variables and Quantifier, Predicate Formula, Free and Bound variable, The Universe of Discourse, Inference Theory of Predicate Calculus, Valid formula and Equivalences, Theory of Inference for Predicate Calculus, Formulas

involving more than one Qualifier, Euclidean Algorithms. **(10 Hours)**

Prescribed text book:
C. L. Liu, "Elements of Discrete Mathematics", McGraw Hill publication.

Reference books:
Kenneth H. Rosen, Discrete Mathematics and its Applications, McGraw Hill

Course Articulation Matrix of MTH 529- Basics of Propositional Logic

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	1	3	2
CO^2	3	3	2	1	3	2
CO^3	3	3	2	1	3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

IKS (02 Credits)

Course Code: MTH 528

Course Name: Introduction to Rigorous and Precise Thinking

Credits: 02

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objectives of this course are:

- To understand what is mathematics and its purpose
- To think for the development of Mathematics
- To know about why we need to learn about Mathematics
- To precise about Mathematical statements
- To perform different types of proofs

Course Outcomes:

After successful completion of the course the student will be able:

CO^1 Explain different definitions of Mathematics

CO^2 Explain the basic ideas for the development of Mathematics

CO^3 Explain logical combinators

CO^4 To possess the knowledge to approach for proofs of Mathematical statements

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: What is mathematics?, More than Arithmetic, Mathematical Notation, Modern college- level mathematics, Getting precise about language, the logical combinators, Implication, Quantifiers. **(10 Hours)**

UNIT-II: Proof, Proof by contradiction, Proving Conditional, Proving Quantified statements, Induction Proofs, Proving results about numbers, Real Numbers, Completeness and Sequences

(10 Hours)

Prescribed text book:

Keith Devlin, Introduction to Mathematical Thinking, Publisher: Keith Devlin, 331 Poe St, Unit 4, Palo Alto, CA 94301, USA

Course Articulation Matrix of MTH 528- Introduction to Rigorous and Precise Thinking

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	1	3	3
CO^2	3	3	2	1	3	2
CO^3	3	3	2	1	3	2
CO^4	3	3	2	2	3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

M.Sc. Mathematics
Semester-III
(Monsoon Semester, 2022)

Sr. No.	Course Name	Course Code	Credits
Major Courses(Disciplinary Courses) (04 Credits)			
1	Mechanics	MTH 504	02
2	Functional Analysis	IAM 501	02
Minor Courses(Disciplinary Courses) (04 Credits)			
3	Research Methodology	MTH 551	04
Vocational/Skill Courses (04 Credits)			
4	Ordinary and Partial Differential Equations	IAM 402A	04
Review of Literature, Research Proposal(08 Credits)			
5	Research Proposal	MTH 556	04
Optional Courses (Review of Literature)			
6	Lebesgue Measure and Integration	MTH 405A	04
7	Dynamical Aspects of Fluid Flows	MTH 557	04
8	Fundamentals of Cryptography	MTH 558	04
9	Galois Theory	MTH 626A	04

Course Contents

Major Courses (Disciplinary Courses) (04 Credits)

Course Code: MTH 504

Course Name: Mechanics

Course Instructors: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits: 02

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: To develop familiarity with the physical concepts and facility with the mathematical methods of classical mechanics, and to develop skills in formulating and solving physics problems.

Course Outcomes: After completing the course satisfactorily, the student will be able to:

CO^1: Understand about the basic concepts related to the Lagrangian and Hamiltonian Mechanics.

CO^2: Understand about the Lagrange and Poisson's brackets and their role in mechanics.

CO^3: Learn about the various useful mathematical techniques/methods used in Lagrangian and Hamiltonian mechanics.

CO^4: Apply the basic concepts of mechanics to the real world problems and their significance.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

Mid Term Examination: 20

End Term Examination: 60 Continuous Internal Assessment: 20

Course Contents:

Unit I: Generalized coordinates, constraints, work and potential energy, generalized forces, the principle of virtual work, introduction to Lagrange's equation, Lagrange's equation for a particle in a plane, the classification of

dynamical systems, Lagrange's equation for any simple dynamical system. Lagrange's equation for non-holonomic systems with moving constraints, Lagrange's equations for impulsive motion, the Branchistochrone problem.

Unit II: Hamilton's principle, stationary values of a function, constrained stationary values, stationary value of a definite integral, Hamilton's equation, Derivation of Hamilton's equations. Ignorable coordinates, the Routhian function, modified Hamilton's principle, principle of least action, the Hamilton-Jacobi equation. Lagrange and Poission brackets, invariance of Lagrange and Poission brackets under canonical transformations.

Prescribed Text Books:

1. John L. Synge and Byron A. Griffith Principles of Mechanics, McGraw Hill, 3rd Edition.

2. Donald T. Green and Wood, Classical Dynamics, Prentice Hall of India, 1979.

Suggested Additional Readings:

1. K Sankara Rao, Classical Mechanics, Prentice Hall of India, 2005.

2. S.L. Gupta, V. Kumar and H.V. Sharma, Classical Mechanics, Pragati Prakashan, 13th Edition, 2019.

Course Articulation Matrix of MTH 504- Mechanics

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	3	2	3	2
CO^2	3	2	3	2	3	2
CO^3	2	3	2	2	3	2
CO^4	2	3	2	2	2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 501

Course Name: Functional Analysis

Course Instructors: Dr. Meenakshi

Credits: 2

Course Objectives:

- To introduce students to the ideas and some fundamental theorems of functional analysis
- To show students the use of the abstract algebraic/ topological structures in studying spaces of functions
- To give students a working knowledge of basic properties of bounded operators between different spaces.

Course Outcomes: After completion of the course, a student will be able to

CO^1 Understand how functional analysis uses and unifies ideas from vector spaces, the theory of metrics and complex analysis

CO^2 Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from operators

CO^3 Appreciate the role of Zorn's Lemma

CO^4 Have the knowledge of central concepts from functional analysis, including the Hahn-Banach Theorem.

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 40

3. Continuous Internal Assessment: 20

Course Contents:

Unit-I: Metric Space , Examples of Metric Spaces, Open set, Closed set, Neighborhood, convergence, Cauchy sequence, completeness, completion of metric spaces, Normed Linear Spaces, Banach Spaces, Properties of Normed Linear Spaces, Properties of Banach Spaces. **[10 Lectures]**

Unit-II: Compactness and Finite Dimensions, Linear Operators, Bounded and Continuous Operators, Linear Functional, Dual Space, Double Dual Space, Inner Product Spaces, Hilbert Spaces, Properties of Inner Product Spaces, Orthogonal Complement, Direct Sum, Orthonormal Sets and sequences. **[10 Lectures]**

Prescribed Text Book:

1. E. Kreyszig, "Introductory Functional Analysis with Applications", Wiley Classic Library.

Suggested Additional Readings:

1. Bollobas, "Linear Analysis", Second Edition, Cambridge University Press.
2. N. Akhierzer and I. Glazman, "Theory of Linear Operators in Hilbert Spaces", Dover Books.

Course Articulation Matrix IAM 501- Functional Analysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	2	2	3	3	1
CO2	2	1	3	3	3	1
CO3	2	2	2	2	2	1
CO4	2	2	3	3	2	1

1. Partially Related
2. Moderately Related
3. Highly Related

Minor Courses (04 Credits)

Course Code: MTH 551
Course Name: Research Methodology
Credits: 04
Course Instructor: Prof. Rakesh Kumar
Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main aim of this course is to develop the research aptitude in the students by acquainting them with the research design, methods and ethics of research.

Course Outcomes: After the successful completion of this course, the student will be able to

CO^1 analyze hypotheses, theories and scientific statements and methods.
CO^2 design the proper research problem.
CO^3 critically analyze the data/solution obtained from research problems.
CO^4 Write scientific paper in proper format and referencing style.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit I: Research: Definition, Concepts and General introduction; Mathematics and science, Hypotheses, theories and laws; scientific statements: Their justification and acceptance, Objectives & types of Research; Attributes of good Research; Research Methods and Research Methodology; Research Process; Time/Effort Management; and Role of a Supervisor; Finding and Solving Research Problems.
Research tools: Searching google (query modifiers), Math. Sci. Net., Zentralblatt Math, Scopus, ISI, Web of Science, Impact factor, Concept of citation index, h-index, Google Scholar, Research Gate, ORCID, JSTOR, JabRef, Mendley, EndNote (Clarivate Analytics), Online and open access journals, National Digital Library Project (NDL), Virtual library of various countries, Introduction to Latex, MathType, Introduction to MS Office, Open Office.

Unit II: Scientific Writing: writing a paper for conference and Journal, communicating research, Publishing a Paper, obtaining offprints of papers, Reviewing a Paper, Scientific Norms and Conventions; Collaborative Work, research grant proposal writing, copyright issues, ethics and plagiarism.

Unit III: Introduction to Computational Software: Maple, Mathematica, Matlab. Research Design Measurement and Scaling; Formulation of Hypothesis: Meaning, Characteristics and various concepts relating to research design; classification of research design and Importance; Graphical presentations (Bar-chart, Histograms, Pie-chart, Table-chart and Line-chart, surface plots).

Unit IV: Data types Nominal, Ordinal and Ratio scale; scaling techniques- meaning, characteristics and concepts relating to testing of Hypothesis (parameter and statistic, standard error, level of significance, type-I and type-II errors, critical region, one tail and two tail tests); procedure of testing hypothesis; Numerical problems based on chi-square test and Ftest (variance ratio test only). Data analysis and interpretation: introduction to multivariate analysis-multiple and partial correlation, multiple regression analysis (with two independent variables), specification of regression models and estimation of parameters, and interpretation of results.

Prescribed Text Books:

1. P. Pruzan, Research Methodology, Springer, 2016.

2. R. Kumar, Research Methodology, Pearson Education, 2009.

3. C.R. Kothari, Research Methodology Methods & Techniques, Second Edition, New Age International publisher, 2004.

Additional Suggested Readings:

1. J.N. Kapoor, Research Methodology for Scientists and Engineers, Mathematical Science Trust Society, 1997.

2. Robert A. Day, How to write and Publish a scientific Paper, University Press, Fourth Edition 1996.

3. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C. Rowley, The LaTeX Companion (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004.

4. T. Tantau, The BEAMER class: User Guide for version 3.49, 12th Media Services, 2016.

Course Articulation Matrix of MTH 551- Research Methodology

Course Outcomes	Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4
CO1	3	2	3	3	2	2
CO2	3	2	3	3	2	3
CO3	2	3	3	2	3	3
CO4	2	3	2	2	3	3

1. Partially Related
2. Moderately Related
3. Highly Related

Vocational/Skill Courses (04 Credits)

Course Code: IAM 402A

Course Name: Ordinary and Partial Differential Equations

Course Instructors: Dr S. K. Srivastava and Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with introductory-ODEs, PDEs and their applications.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1} Existence and Uniqueness Theorem
CO^{2} Sturm-Liouville Boundary Value Problem
CO^{3} Charpit and Jacobi Methods for solving first order nonlinear PDEs
CO^{4} Classification of second order PDEs

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Existence and uniqueness theorem; dependence of solutions on initial conditions and on the function; existence and uniqueness theorems for systems and higher order equations. **(10 Hours)**

Unit-II: The theory of linear differential equations; homogeneous and non-homogeneous systems, nth order homogeneous and non-homogeneous linear differential equations, Sturm theory, Sturm-Liouville boundary value problems. **(10 Hours)**

Unit-III: Surfaces and curves in three dimensions, simultaneous differential equations, orthogonal trajectories, Pfaffian differential equations, First order PDEs, Cauchy's method of characteristics, compatible system of first order equations, Charpit's and Jacobi's methods.

(10 Hours)

Unit-IV: Classification of second order PDEs, first General solution of higher order PDEs with constant and variable coefficients, Method of separation of variables. **(10 Hours)**

Prescribed Text Books:

1. Ross S.L. (1984). Differential Equations. Third Edition. John Wiley & Sons Inc.
2. Ian N. Sneddon (2006), Elements of Partial Differential Equations, Dover Publications Inc.

Suggested Additional Readings:

1. W.E. Boyce and R.C. Diprima (2013). Elementary Differential Equations and Boundary Value Problems, Ninth Edition, Wiley.
2. W.A. Strauss; Partial differential equations an introduction, John Wiley & Sons, 2008.

Course Articulation Matrix of IAM 402A- Ordinary and Partial Differential Equations

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	1		3	3
CO^2	3	2	2	1		3	2
CO^3	3	2	2	1		3	2
CO^4	3	2	2	1		3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Review of Literature, Research Proposal (08 Credits)

Course Code: MTH 556

Course Name: Research Proposal

Course Credit: 04

Course Instructor: All Faculty Members

Course Contents and Evaluation Criteria as finalized in the BoS meeting vide Agenda Item No. SRDM-BOS-9/22-6

Review of Literature (08 Credits) (Optional Courses)

Course Code: MTH 405A

Course Name: Lebesgue Measure and Integration

Course Credit: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours such as independent individual/ group work; obligatory/ optional work placement; literature survey/ urs of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other work load library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the concept of measure, a means for comparing the size of sets and generalizing intuitive notions such as length and area, and moves on to describe the elements of the Lebesgue theory of integration. Lebesgue integration is a fundamental tool for advanced study in areas of mathematics such as functional analysis and potential theory, and provides the foundation for the axiomatic treatment of probability theory.

Course Outcome: By the end of the course students will be able to understand:

CO^1: Countability and Cantor's like sets.

CO^2: Measurable sets, Borel sets and their measurability.

CO^3: Convergence in measure and Lebesgue Integrals.

CO^4: Dini's derivatives and functions of bounded variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40

End Term Examination: 120

Continuous Internal Assessment: 40

Course Contents:

Unit I: Set theory, Topological ideas, sequence and limits, functions and mapping, cardinal number and Countability, properties of open sets and Cantor's like sets. **(10 Hours)**

Unit II: Lebesgue outer measure, measurable sets, properties of measurable sets, Borel sets and their measurability, characterizations of measurable sets, measurable functions and their properties. **(10 Hours)**

Unit III: Borel measurable functions, convergence in measure, Lebesgue Integrals and integral of non-negative measurable functions. **(10 Hours)**

Unit IV: The four derivatives, Continuous and Non- differentiable functions, functions of bounded variation, Lebesgue's differentiation theorem, differentiation, integration and the Lebesgue set.**(10 Hours)**

Prescribed Text Book:

1. P.K. Jain, V.P. Gupta and P. Jain (2012), Lebesgue measure and integration, Anshan Publishers, 2nd Edition.

Suggested Additional Readings:

1. P. R. Halmos, Measure Theory, Graduate Text in Mathematics, Springer-Verlag, 1979.
2. G. De Barra (2003), Measure theory and Integration, Horwood Publishing.

Course Articulation Matrix MTH 405A- Lebesgue Measure and Integration

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	1	1	1	1
CO2	3	3	1	1	1	1
CO3	3	3	2	2	2	2
CO4	3	3	2	2	2	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 557

Course Name: Dynamical Aspects of Fluid Flows

Credits: 04

Course Instructor: Dr. Pankaj Kumar (s/o Sh. Krishan Singh)

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main purpose of this course is to acquaint the students with the fundamental concepts fluid dynamics and enable them to search the gaps in the literature related to fluid flow patterns.

Course Outcomes: After completing the course satisfactorily, a student will be able:

CO1: To identify the key fluid properties used in the analysis of fluid behavior.

CO2: To apply the Reynolds transport theorem.

CO3: To apply conservation of mass and energy and Newton's second law of motion to the contents of a finite control volume to get important answers.

CO4: To analyze certain types of flows using the Navier–Stokes equations.

CO5: To develop a set of dimensionless variables for a given flow situation.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of 200

Course Contents:

UNIT I: Basic concepts and definitions, continuum hypothesis, basic algebra with vectors and tensors, fluid statics, Bernoulli equation, fluid kinematics; velocity field, acceleration field.

(Chapters 1-4) (12 HRS)

UNIT-II: Reynolds transport theorem, Control volume analysis: continuity equation, momentum equation, First law of thermodynamics-energy equation, Second law of thermodynamics-irreversible flow.

(Chapters 4-5) (08 HRS)

UNIT-III: Differential analysis: fluid element kinematics, conservation of mass and momentum, inviscid flow, plane potential flows, viscous flow, some simple solutions for viscous incompressible fluids.

(Chapter 6) (12 HRS)

UNIT-IV: Dimensional analysis, similitude and modelling: dimensional analysis, Buckingham Pi theorem, correlation of experimental data, modelling and similitude. **(Chapter 7) (08 HRS)**

Text Book:

1. B.R. Munson, D.F. Young, T.H. Okiishi, W.W. Huebsch, (2009). Fundamentals of Fluid Mechanics, Sixth Edition, John Wiley & Sons, Inc.

Reference Books

1. Ronald L. Panton, (2014). Incompressible flow, Third Edition, Wiley.

2. Edward J. Shaughnessy, Jr. Ira M. Katz James P. Schaffer, (2005). Introduction to Fluid Mechanics and Fluid Machines, Oxford University Press.

Course Articulation Matrix of MTH 557- Dynamical Aspects of Fluid Flows

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	3	2	2	3	2
CO2	3	3	2	3	2	3
CO3	2	3	3	2	2	3
CO4	3	2	2	3	3	2
CO5	3	3	2	2	3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 558

Course Name: Fundamentals of Cryptography

Course Instructor: Dr Pankaj Kumar S/o Late Sh. Maniram

Credits: 04

Credits Equivalent:

Credits Equivalent: 02 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Outcomes

After completing the course satisfactorily, a student will be able:

CO^1 To understand the basics of Cryptography.

CO^2 To be able to secure a message over an insecure channel by various means.

CO^3 To learn about how to maintain the Confidentiality, Integrity and Availability of a data.

CO^4 To understand various protocols for network security to protect against the threats in the networks.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%

2. End Term Examination: 50%

3. Counseling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %

ii. Numerical Assignments using programming: 10 %

iii. Presentations and Class Tests: 5 %

Course Contents:

UNIT I:

Group, Rings, Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem(statement only), Chinese Remainder theorem, Discrete logarithm-Hallman problem, Need of security, Security attacks, Security services. (8 Hours)

Unit II:

Symmetric Key Cryptography: Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques, Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES). (8 Hours)

UNIT III:

Asymmetric Key Cryptography: Introduction to public key cryptography, RSA algorithm and security of RSA, Key distribution – Key management, Introduction to elliptic curve cryptography. Introduction to chaos-based cryptography, Identity Based Public key Cryptography, Certificateless Public Key Cryptography, Provable Security, Security against Chosen-Ciphertext Attacks, Random Oracle Model. (12 Hours)

UNIT IV:

Advance in Cryptography: Diffie Hellman key exchange, Digital signature, Elgamal signature, Digital signature standards. Digital Signatures: Proxy Signature, Aggregate Signature, Multi-signature, Partially Blind Signature and Blind Signature.

Authentication requirement, Authentication function, MAC, Hash function, Security of hash function and MAC, SHA –Digital signature and authentication protocols, DSS- Entity Authentication: Biometrics, Passwords, Challenge Response protocols- Authentication applications - Kerberos, X.509 (12 Hours)

Prescribed books:

1. William Stallings, "Cryptography and Network Security", Principles and Practise, Fifth Edition, Pearson Education, 2012.

2. H. Xiong, Z. Q. Athanasios V. Vasilakos, "Introduction to Certificateless Cryptography", CRC Press Taylor & Francis Group

Reference Book:

1. Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

Course Articulation Matrix MTH 558- Fundamentals of Cryptography

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	2	2	2	2
CO2	2	3	3	3	1	2
CO3	1	3	2	2	2	2
CO4	2	2	2	3	2	2

1. Partially Related

2. Moderately Related

3. Highly Related

Course Code: MTH 626A

Course Name: Galois Theory

Course Instructor: Dr. Meenakshi

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The purpose of this course are

- To discuss the Field Theory
- To introduce Galois Groups
- To explore the application area of Galois Theory

Course Outcomes: After successful completion of the course, a student will be able to:

CO^1 Understand how to write, correct and clear arguments in abstract Mathematics with proofs.

CO^2 Have the knowledge about Field Extensions

CO^3 Solve polynomials having different degrees

CO^4 Understand the basis of Galois's Criterion for solvability of an equation by radicals.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Polynomial, Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots. **(10 Hours)**

Unit-II: Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotonic polynomials, Representation of Elements of Finite Fields, Order of Polynomials **(10 Hours)**

Unit-III: Primitive Polynomials, Irreducible Polynomials, Galois Theory and its Applications, Perfect Field, Separable extensions, Simple extensions

(10 Hours)

Unit-IV: Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra. **(10 Hours)**

Prescribed Text Book:

P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, 'Basic Abstract Algebra', Second Edition, Cambridge University Press.

Suggested Additional Readings:

1. I.N. Herstein, "Topics in Algebra", 2nd Edition (1975) (Wiley International Editions).
2. M. Artin, "Algebra", 2nd Edition (1991)(PHI).

Course Articulation Matrix of MTH 626A- Galois Theory

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	3	3	2
CO^2	3	2	2	3	3	1
CO^3	3	2	2	3	3	2
CO^4	3	2	2	3	3	1

1. Partially Related
2. Moderately Relate
3. Highly Related

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206

Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics, Shahpur Parisar

Program Specific Outcomes

Program Outcomes

Course Outcomes & Course Contents

of

Master of Science in Mathematics (MSc Mathematics)

School of Mathematics, Computers & Information Sciences

Programme Specific Outcomes of Master of Science in Mathematics

PSO[1]: To possess the systematic understanding of the concepts, theories and methods of mathematics at higher education level.

PSO[2]: To deal with the real-world problems and their significance by critical understanding, analyzing and synthesizing the various mathematical concepts.

Programme Outcomes of Master of Science in Mathematics

PO[1]: To comprehend and analyze mathematical theories, methods, and findings in their appropriate contexts.

PO[2]: To learn the generalization of mathematical theories, as well as how to bridge them to broader concepts.

PO[3]: To review the literature related to pure/applied mathematics, and identify the knowledge gaps.

PO[4]: To analyze data critically, prepare scientific reports/papers, and defend the work.

Batch 2022-24

M.Sc. Mathematics
Semester-I
(Monsoon Semester, 2022)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Sr. No.	Course Name	Course Code	Credits
Major Courses(Disciplinary Courses) (10 Credits)			
1	Ordinary Differential Equations	MTH 401	02
2	Linear Algebra	MTH 403	04
3	Real Analysis	MTH 406	04
Minor Courses(Disciplinary Courses) (04 Credits)			
4	Calculus of Variations	MTH 431	02
5	To be Chosen from the Course basket at University Level which is different and distinct from the programme which s/he is enrolled in.		02
Vocational/Skill Courses (04 Credits)			
6	Operational Research	MTH 502	02
7	Cryptography	MTH 548	02
Indian Knowledge System Courses (at University Level)(02 Credits)			
8	Indian Knowledge System	IKS	02

Major Disciplinary Courses (10 Credits)

Course Code: MTH-401

Course Name: Ordinary Differential Equations

Credits: 02

Course Instructor: Prof. Rakesh Kumar

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Outcomes: After completing the course satisfactorily, a student will be able:

CO1: Comprehend general theory of first order differential equations.

CO2: To analyze autonomous systems, bifurcation points and limit cycle.

CO3: To get familiar with Sturm-Liouville problems and the Riccati equation.

Learning Outcomes: The deliverables Learning Outcomes of this paper with students are following:

1) Can formulate differential equations.
2) Can check the existence and uniqueness of solutions.
3) Can check the independence and dependence of solutions of second order equations.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Contents:

UNIT I: First order differential equations: Basic results, Autonomous equations, generalized logistic equation, Bifurcation, Linear systems, Floquet theory, Autonomous systems: phase plane, stability of nonlinear systems, and linearization of nonlinear systems, existence and nonexistence of periodic solutions.

(Chapters - 1, 2 and 3) (10 HRS)

UNIT-II: Self-Adjoint Second Order Differential Equations: Basic definitions, Cauchy function and variation of constants formula, Sturm-Liouville Problems, Zeros of solutions and Disconjugacy, Factorizations and recessive and dominant solutions, The Riccati equation. **(Chapter - 5) (10 HRS)**

Text Book:

1. W.G. Kelley, A.C. Peterson, (2010). The Theory of Differential equations, Second Edition, Springer.

Reference Books

1. S. Ahmad, A. Ambrosetti, (2015). A Textbook on Ordinary Differential Equations, Second Edition, Springer Nature.

Course Articulation Matrix of MTH 401- ORDINARY DIFFERENTIAL EQUATIONS

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	2	2	3	3	2
CO2	1	2	1	2	1	2
CO3	2	3	2	1	2	3

1. Partially Related
2. Moderately Related
3. Highly Related

Course Code: MTH 403

Course Name: LINEAR ALGEBRA

Course Credit: 04

Course Instructor: Dr Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main aim of this course is to introduce basic ideas and techniques of linear algebra which are used to solve systems of linear equations using various methods by appropriate proof-writing techniques.

Course Outcome:

By the end of the course students will be able to understand:

CO^1: The abstract definition of a set theory, and be familiar with the definition of Vector space with examples.

CO^2: All concepts of linear transformation.

CO^3: About the Eigenvector, Eigenvalues minimal polynomials.

CO^4: About the functional, inner product space and quadratic forms.

CO^5: How to apply some underlining and cross-cutting concepts of Vector space and related concepts.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40

End Term Examination: 120

Continuous Internal Assessment: 40

Course Contents:

Unit I:

Vector Spaces, Subspaces, Basis and dimension, Linear Transformations, Quotient spaces, Direct sum, The matrix of a linear transformation, Duality **(12 Hours)**

Unit II:

Eigenvalues and eigenvectors, Annihilating polynomials, Invariant subspaces, Triangulation and diagonalization.

(10 Hours)

Unit III:

Canonical Forms, Jordan Form, Inner Product Spaces, orthonormal basis, Linear functional and adjoints.

(10 Hours)

Unit IV:

Bilinear Forms, Definition and examples, Symmetric and skew-symmetric bilinear forms.

(08 Hours)

Prescribed Text Book:

1. K. Hoffman and R. Kunze : Linear Algebra, Second Edition, Pearson,2015.

Suggested Additional Readings:

1. Strang G.: Linear Algebra and its Applications, 4th Edition, CENGAGE LEARNING, 2007.
2. Kumaresan S.: Linear Algebra, A Geometric approach, Prentice Hall of India,2000.
3. Lipschutz S. and Lipson M. L.: Linear Algebra, 3rd Edition, McGraw Hill Education India, Pvt. Ltd., 2001.
4. Anton H. and Rorres C.: Elementary Linear Algebra, 11th Edition, Wiley,2014.

Course Articulation Matrix MTH 403- Linear Algebra

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	1	2	2	2	1	1
CO2	2	2	1	2	1	1
CO3	1	2	2	2	2	2
CO4	2	1	2	3	2	1
CO5	1	2	2	2	2	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 406

Course Name: Real Analysis

Credits: 04

Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is

- To obtain the thorough understanding of the origins of Number System
- To gain the knowledge of sequence and series of real numbers and convergence
- Studying the notions of continuous functions of real number system and their properties

Course Outcomes: After successful completion of the course, a student will be able to:

CO^{1} Define and recognize the basic properties of the field of numbers
CO^{2} Define and recognize the continuity and differentiability of the functions and their properties
CO^{3} Improve and outline the logical thinking of Number system
CO^{4} Understand Applications of Integration and Differentiation

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40

2. End Term Examination: 120

3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Real and complex number systems, Basic Topology: Rational Numbers, Dedekind' Theorem, Cantor' Theory of Irrational Numbers, Ordered sets, Fields, The Real field and Complex field, Euclidean spaces, Countable and Uncountable sets, Metric spaces, Compact sets. **(10 Hours)**

Unit-II: Sequence, Series and Continuity: Sequence, subsequence, Convergent sequence, upper and lower limits, Series of non-negative terms, the root and ratio test, Power series and Summation by parts, Absolute convergence, Continuity and compactness, monotonic functions. **(10 Hours)**

Unit-III: Differentiation: Differentiation of a Real valued function, Mean value theorem, Differentiation of Vector valued functions, L. Hospital Rule, Taylor's Theorem and Derivatives of Higher order.

(10 Hours)

Unit-IV: Sequence, Series of Functions and Functions of several Variables: Uniform Convergence, Equi-continuous Families of Functions, The Stone-Weierstrass Theorem, Differentiations of a Function of Several Real Variables and the Contraction Principle. **(10 Hours)**

Prescribed Text Books:

1. Rudin, Walter, "Principles of Mathematical Analysis", 3rd Edition, McGraw Hill.
2. Robert G. Bartle, Donald R. Sherbert, "Introduction to Real Analysis" ,3rd Edition, Wiley.

Suggested Additional Readings:

1. G.F. Simmons, "Topology and Modern Analysis", 1st Edition, McGraw Hill.
2. RussellA. Gordon, "Real Analysis: A First Course", Addision-Wesley Higher Mathematics Series.

Course Articulation Matrix of MTH 406- Real Analysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	1		3	3
CO^2	3	2	2	1		3	2
CO^3	3	2	2	1		3	2
CO^4	3	2	2	1		3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Minor Courses (4 Credits : 2 Credits from Department & 2 Credits from other Departments)

Course Code: MTH 431

Course Name: Calculus of Variations

Credits: 02

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures/organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work /Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/ dissertation/ thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the calculus of variations.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO[1] The notion of variations.

CO[2] The Brachistochrone problem and Isoperimetric problem.

CO[3] The Euler Lagrange's equations.

CO[4] Applications of calculus of variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Calculus of Variations: Concept of variation, Linear functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema, Euler-Lagrange differential equation for n-dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables.

(10 Hours)

Unit II: Applications of calculus of variations to various problems: Shortest distance, minimum surface of revolution, Brachistochrone problem, geodesic, Isoperimetric problem, Calculus of variations for problems in parametric form, Variational problems with moving boundaries. **(10 Hours)**

Prescribed Text Books:

I.M. Gelfand and S.V. Fom in (2012): Calculus of Variations, Prentice Hall Inc.

Suggested Additional Readings:

A. S. Gupta (1996): Calculus of Variations with Applications, Prentice–Hall of India.

Robert Weinstock (1975): Calculus of Variations with applications to Physics and Engineering, Dover Publications Inc.

Course Articulation Matrix of MTH 431 - Calculus of Variations

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		3	2
CO^2	3	2	1	1		3	2
CO^3	3	2	1	1		3	2
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses

Course Code: MTH 502

Course Name: Operational Research

Credits: 02

Course Instructor: Dr. Pankaj Kumar S/o Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the operational Research which is mainly concerned with the techniques of applying scientific knowledge, besides the development of science and provides an understanding which gives the expert/manager new insights and capabilities to determine better solutions in his decision–making problems, with great speed, competence and confidence.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1} The formulation and solution to real mathematical models of LPP.
CO^{2} The Graphical and Simplex methods for the solution of LPP.
CO^{3} Degeneracy and dual Simplex methods.
CO^{4} Queueing systems and solution of Queueing Models.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Operations research & its scope, Necessity of operations research in industry. Introductions to Linear programming problems, General linear programming problems, Mathematical Formulation of L.P.P. and examples, Feasible, Basic feasible and optimal solutions, Extreme points, Graphical Methods to solve L.P.P., Simplex Method. Big M Method, Two phase Method, Degeneracy, Unrestricted variables, unbounded solutions, Duality in LPP, fundamental properties of Dual problems, dual simplex method and Revised Simplex method.

(10 Hours)

Unit II: Queueing systems, Queueing problem, Transient and steady states, Probability Distributions in Queueing systems. Poisson process (pure birth process), Properties of Poisson's arrivals, Exponential process, Markovian property, Pure death process, Service time distribution, Erlang service time distribution, Solution of Queueing Models. **(10 Hours)**

Prescribed Text Books:

1. Kanti Swarup, P.K. Gupta and Manmohan (2004), Operations Research, Sultan Chand & Sons, 12th Edition.

Suggested Additional Readings:

1. S. D. Sharma (2004), Operations Research, KedarNath Ram Nath & Co. 14th Edition.

Course Articulation Matrix of MTH 502- Operational Research

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1	2	3
CO^2	3	2	1	1	2	3
CO^3	3	2	1	1	2	3
CO^4	3	2	1	1	2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH-548

Course Name: Cryptography

Course Credit: 02

Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with basics of Cryptography and Network security.

Course Outcomes

After completing the course satisfactorily, a student will be able:

CO^1 To calculate probabilities by applying probability laws and theoretical results.

CO^2 To understand the axiomatic formulation of modern Probability Theory.

CO^3 To understand the Conditional Probability including the concept of Bayes' Theorem.

CO^4 To characterize probability models and function of random variables based on single & multiples random variables.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 40
3. Continuous Internal Assessment: 20

Course Contents:

Unit I:

Definition of a cryptosystem, Security attacks, Security services, Symmetric cipher model, Classical encryption techniques, Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES).

UNIT II:

Introduction to public key cryptography, Identity Based Public key Cryptography, RSA algorithm and security of RSA, Hash based security, Introduction to elliptic curve cryptography. Lattices based cryptography, Digital signature, Elgamal signature, Authentication, Key exchange protocols.

Prescribed books:

1. William Stallings, "Cryptography and Network Security", Principles and Practice, Fifth Edition, Pearson Education, 2012.

Reference books :

1. Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

Course Articulation Matrix MTH 548- Cryptography and Network Security

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	2	2	2	2	2
CO2	2	2	3	3	1	2
CO3	1	3	2	2	2	2
CO4	2	1	2	3	2	1

1. Partially Related
2. Moderately Related
3. Highly Related

Indian Knowledge System (IKS) Course (02 Credits)

Syllabus is framed centrally as per CUHP Guidelines, and is adopted in totality.

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206

Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

INTERDISCIPLINARY COURSES OFFERED BY THE SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Monsoon Semester 2021

Sr. No.	Course Name	Course Code	Credit
1.	Ordinary Differential Equations	MTH 401	02
2.	Numerical Analysis	IAM 403	02

Course Contents

Course Name: Ordinary Differential Equations
Course Code: MTH-401
Credits: 02
Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Course Objective: The prime aim of this course is to provide the interdisciplinary relevance of ordinary differential equations by focusing at the various physical aspects of the equations through the different solution schemes.

Course Outcomes
After completing the course satisfactorily, a student will be able:

- To analyse the real world problems and transform them into the corresponding mathematical form
- To understand the fundamental concepts of differential equations and qualitative interpretation of solutions
- To get familiar with some pre-existing distinct techniques/methods of differential equations to solve different kinds of differential equations.
- To understand and apply the series solution approach to various types of problems encountered in differential equations.

Course Contents:

UNIT I: First order differential equations, existence and uniqueness, higher order linear differential equations, homogeneous and non-homogeneous differential equations with constant coefficients, Wronskian, fundamental solutions, variation of parameters, method of reduction of order, method of undetermined coefficients. **(Chapter - 2, 3 and 4)**

UNIT-II: Series solutions of linear equations: power series, series solutions near an ordinary point, regular singular points, Euler equations, series solutions near regular singular point, Bessel's equation.

(Chapter - 5)

Prescribed Text Book:

1. W.E. Boyace and R.C. Diprima (2013). Elementary Differential Equations and Boundary Value Problems, Ninth Edition, Wiley.

Suggested Additional Readings:

1. Fred Brauer, John A. Nohel (1989). The Qualitative Theory of Ordinary Differential Equations, Dover Publications, INC, New York.
2. S.L. Ross (1984). Differential Equations. Third Edition. John Wiley & Sons Inc.

Course Name: Numerical Analysis
Course Code: IAM 403
Credits: 02
Course Instructor: Dr. Rakesh Kumar

Course Objective: The purpose of this course is to develop the basic understanding of numerical approximations and algorithms which are necessary for solving real world problems in Science, Engineering and Technology.

Course Outcomes
After completing the course satisfactorily, a student will be able:

- To interpolate and approximate functions
- To perform numerical differential and integration
- To apply basic numerical algorithms
- To perform error analysis

Course Contents:
Unit I: Lagrange and Newton interpolations, interpolations using finite differences, Hermite interpolation, piecewise and spline interpolation, Polynomial approximation: least square approximation, orthogonal polynomials, uniform approximation, rational approximation.

Unit II: Numerical Differentiation and Integration: methods based on interpolation, methods based on undetermined coefficients, composite integration methods, Romberg integration.

Unit III: Initial and Boundary value problems: Taylor's series method, Runge-Kutta methods, shooting method.

Prescribed Text Books:
1. M.K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods, 6th Edition, New Age International (P) Limited, Publishers, New Delhi.

Suggested Additional Readings:
1. S. S. Sastri; Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd., 2005.
2. S.C. Chapra: Applied Numerical Methods with MATLAB, McGraw Hill, 2012.

INTERDISCIPLINARY COURSES OFFERED BY THE SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Spring Semester 2022

Sr. No.	Course Name	Course Code	Credit
1.	Partial Differential Equation and Integral Equations	MTH 408	02
2.	Probability Theory	MTH 413	02

Course Contents

Course Name: Partial Differential Equation and Integral Equations
Course Code: MTH 408
Credits: 02
Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh
Credits Equivalent:
(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Course Outcomes:
After completing the course satisfactorily, a student will be able:
- To know about the origin/ form the general partial differential equations.
- To solve the basic Linear and Non Linear partial differential equations of order one.
- To know about the Homogeneous linear partial differential equations with constant coefficients and their solution.
- To know about the integral equations, their types and their solution.

Learning Outcomes:
The deliverables Learning Outcomes of this paper with students are following:
- Can explain about the Linear and Non Linear partial differential equations and their solution.
- Will know about the Lagrange's and Charpit's method to solve the Partial differential equations.
- Can explain about the basic integral equations especially some special kind of integral equations and their solution.
- Will know about the conversion of ordinary differential equations into integral equations.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:
1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Objective: The prime objective of this course is to provide the basic knowledge ofpartial differential equations and integral equations by focussing at the various physical aspects of the equations through the different solution schemes/ techniques.

Course Contents:
Unit I: Origin of partial differential equations, Linear partial differential equations of order one: Lagrange's method, Non linear partial differential equations of order one: Charpit's method, Homogeneous linear partial differential equations with constant coefficients. **(10 Hrs)**
Practicum
- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

UNIT-II: Integral Equations: Preliminary concepts, Conversion of ordinary differential equations into integral equations, Homogeneous Fredholm Integral equations of the second kind with separable

(degenerate) kernels, Fredholm Integral equations of the second kind with separable (degenerate) kernels. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Essential Readings:

1. M.D. Raisinghania (2013). Ordinary and Partial Differential Equations, Eighteenth Edition, S. Chand.
2. M.D. Raisinghania (2013). Integral equations and Boundary value problems, Sixth Edition, S. Chand.

Suggested Additional Readings:

1. A.D. Polyanin, A.V. Manzhirov. Handbook of Integral equations, Second Edition, Chapman & Hall/ CRC.

Course Name: Probability Theory
Course Code: MTH 413
Credits: 02
Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram
Credits Equivalent:
(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:
1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Outcomes
After completing the course satisfactorily, a student will be able:
- To calculate probabilities by applying probability laws and theoretical results.
- To understand the axiomatic formulation of modern Probability Theory.
- To understand the Conditional Probability including the concept of Bayes' Theorem.
- To characterize probability models and function of random variables based on single & multiples random variables.

Learning Outcomes
The deliverables Learning Outcomes of this paper with students are following:
- Ability to distinguish between random and non-random experiments.
- To calculate probabilities by applying probability laws and theoretical results.
- Gain knowledge to conceptualise the probabilities of events including frequentist and axiomatic approach.
- Can explain the conditional probability including the concept of Bayes' Theorem,
- Will possess the knowledge related to discrete and continuous random variable and its probability distribution including expectations.

Unit I
Classical Approach to Probability: Random Experiment an Events, Exhaustive Events, Favorable Events, Mutually Exclusive Events, Equally Likely Events, Classical Theory of Probability, Theorem of Total Probability, Compound Events, Theorem of Compound Events. **(10 HRS)**
Practicum
- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit II
Classical Approach to Probability: Set Theoretic Concepts, Function, Algebra and Sigma- Algebra, Sample Space, Events, Events Space, Probability Function, Probability Space, Conditional Probability, Independent Events, Bayes Theorem, Multiple Rule. Distribution function and Expectation. **(10 HRS)**
Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Reference Books:

i. Miller, I. and Miller, Marylees. John E. Freund's :Mathematical Statistics with Application, 7th ed, New Jersey: Prentice Hall, 2010.
ii. S. C. Gupta , V. K. Kapoor, : Fundamentals of Mathematical Statistics, 12th Edition, Sultan Chand and Sons, 2020.

INTERDISCIPLINARY COURSES OFFERED BY THE SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Monsoon Semester, 2022

Sr. No.	Course Name	Course Code	Credits
1	Vedic Mathematics	IAM 412	02
2	Linear Algebra and Tensors	MTH 351	04

Course Contents

Course Code: IAM 412

Course Name: Vedic Mathematics

Course credit: 02

Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent:
(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:
1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Outcomes: On completion of the course, the students will be able:

- To understand the idea of different vedic sutras and sub-sutras.
- To apply 16 sutras and 13 sub-sutras.

Learning Outcomes

The deliverables Learning Outcomes of this paper with students are following:

- Can explain the idea of sixteen sutras of Vedic Tradition.
- Can also explain the idea of sub-sutras of Vedic Tradition.
- Can take quick decisions through the use of Sutras and their corollaries.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: The 16 Sutras: Ekadhikina Purvena, Nikhilam Navatashcaramam Dashatah, Urdhva-Tiryagbyham, Paraavartya Yojayet, Shunyam Saamyasamuccaye, (Anurupye) Shunyamanyat, Sankalana-vyavakalanabhyam, Puranapuranabyham, Chalana-Kalanabyham, Yaavadunam, Vyashtisamanstih, Shesanyankena Cha.ramena, Sopaantyadvayamantyam, Ekanyunena Purvena, Gunitasamuchyah, Gunakasamuchyah **(10 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems

Unit II: Corollary: Anurupyena, Sisyate Sesasamjnah, Adyamadyenantyamantyena, Kevalaih Saptakam Gunyat, Vestanam, Yavadunam Tavadunam, Yavadunam Tavadunikritya Varga Yojayet, Antyayordashake'pi, Antyayoreva, Samuccayagunitah, Lopanasthapanabhyam, Vilokanam, Gunitasamuccayah Samuccayagunitah, Dhvajanka, Dwandwa Yoga, Adyam Antyam Madhyam.

(10 HRS)

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Essential Reading:

1. Bharati Krishna Tirtha, Vedic Mathematics, Motilal Banarsidass, New Delhi, (2001).

Course Code: MTH 351

Course Name: Linear Algebra and Tensors

Course credit: 04

Course Instructor: Dr Meenakshi

Course Objectives:

- To introduce student to the ideas and some fundamental concepts of Matrices
- To give students a working knowledge of basic properties of Vector Spaces, Matrices and Cartesian Tensors and General Tensors

Credits Equivalent:
(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)
Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.
Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Outcomes: After completion of the course, a student will be able to

CO^1 Understand how linear transformations are used to preserve the structure of a vector space

CO^2 Understand how Matrices are extensively used in solving the simultaneous system of equations

CO^3 Understand the use of Cartesian Tensors

CO^4 Have the knowledge of central concepts of Algebra of Tensors

Course Contents:

Unit I: Linear Vector Spaces: Abstract Systems, Binary Operations and Relations, Introduction to Groups and Fields, Vector Spaces and Subspaces, Linear Independence and Dependence of Vectors, Change of Basis, Homomorphism and Isomorphism of Vector Spaces, Linear Transformations, Representation of Linear Transformations by Matrices.

Unit II: Matrices: Addition and Multiplication of Matrices, Null Matrices, Diagonal, Scalar and Unit Matrices, Upper-Triangular and Lower- Triangular Matrices, Transpose of Matrix, Symmetric and

Skew-Symmetric Matrices, Conjugate of a Matrix, Hermitian and Skew-Hermitian Matrices, Singular and Non-Singular matrices, Orthogonal and Unitary Matrices, Trace of a Matrix, Inner Product.

Eigen- values and Eigenvectors, Cayley- Hamilton Theorem, Diagonalization of Matrices, Solutions of Coupled Linear Ordinary Differential Equations, Functions of a Matrix.

Unit III : Cartesian Tensors: Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Antisymmetric Tensors, Invariant Tensors: Kronecker and Alternating Tensors, Association of Antisymmetric Tensor of Order Two and Vectors, Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products, Differentiation. Gradient, Divergence and Curl of Tensor Fields, Vector Identities, Tensorial Formulation of Analytical Solid Geometry: Equation of a Line, Angle Between Lines, Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation), Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor, Stress and Strain Tensors: Symmetric Nature, Elasticity Tensor, Generalized Hooke's Law.

Unit IV: General Tensors: Transformation of Coordinates. Minkowski Space, Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

Prescribed Text Books:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publication.
2. Mathematical Methods for Physicists and Engineers, C.D, Cantrell, 2011, Cambridge University Press.
3. Introduction to Matrices and Linear Transformation, D.T. Finkbeiner, 1978, Dover Pub.
4. Linear Algebra, W. Cheney, E.W Cheney & D.R Kincaid, 2012, Jones & Bartlett Learning.
5. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
6. Mathematical Methods for Physics & Engineers, K.F.Riley, M.P.Hobson, S.J. Bence, 3rd Ed, 2006, Cambridge University Press.

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

शाहपुर परिसरप्र.हि) ज़िला काँगड़ा ,शाहपुर ,. - (176206

Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

Central University of Himachal Pradesh

Srinivasa Ramanujan Department of Mathematics, Shahpur Parisar

Ph.D. Mathematics

School of Mathematics, Computers & Information Sciences

Ph.D. Mathematics
Semester-I

(Spring Semester, 2022)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Course Code	Course Name	Credits
Compulsory Courses (10 Credits)		
MTH 601	Research Methodology	04
CPE-RPE	Research and Publication Ethics	02
MTH 651	Indian Traditional Knowledge and Practices	02
TTR 622 / PTLP	Pedagogy of Teaching-Learning Process ***(Offered and taught by the Department of Education)***	02
Optional Courses (Specialisation) (08 Credits) (The students will have to choose two courses from the optional course list according to their specialisation)		
IAM 603	Applied Functional Analysis	04
MTH 611	Advanced Topics in Topology and Analysis	04
MTH 624	Commutative Algebra	04
MTH 643	Cryptography and Network Security	04
MTH 644	Advanced Fluid Dynamics	04

Course Contents

Compulsory Courses (10 credits)

Course Code: MTH 601
Course Name: Research Methodology
Credits: 04 Credits
Course Instructor: Dr. S.K. Srivastava
Course Contents:
Unit I: Fundamentals of Research: Objectives, Motivation, General Characteristics, Criterion of good research and Literature Review.
Unit II: Mathematics and its History, Identification and Evaluation of Research Problems.

Unit III: Scientific Writing: Writing a survey article, research paper, survey article and thesis writing.
Unit IV: Research Tools: LaTeX, Beamer, Reference Manager like Zotero & Mendeley, Plagiarism detection software.

References:

1. C.R. Kothari, **Research Methodology** Methods & Techniques, Second Edition, New Age International publisher, 2004.
2. J. Stillwell, **Mathematics and its History**, 3rd Edition, Springer, 2010.
3. N. E. Steenrod, P. R. Halmos, M. M. Schiffer& J. A. Dieudonné,
How to Write Mathematics, American Mathematical Society, 1973.
4. N. J. Higham, **Handbook of Writing for the Mathematical Sciences**, 2nd edition, Society for Industrial and Applied Mathematics, 1998.
5. D. E. Knuth, T. Larrabee& P. M. Roberts, **Mathematical Writing**,
Mathematical Association of America, 1989.
6. L. Lamport, LaTeX, **a Document Preparation System**, Pearson, 2008.
7. M. Goossens, F. Mittelbach, S. Rahtz, D. Roegel& H. Voss, **The LaTeX Graphics Companion**, Addison-Wesley, 2008.
8. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C.
Rowley, **TheLaTeX Companion** (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004.
9. T. Tantau, **The BEAMER class**: User Guide for version 3.49, 12th Media Services, 2016.
10. N. R. Glassman, **Citation Management Tools: A Practical Guide for Librarians**, Rowman& Littlefield, 2018.

Course Code: CPE-RPE
Course Name: Research and Publication Ethics
Credits: 02 Credits
Course Instructor: Dr. Rakesh Kumar

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: Philosophy and Ethics: Introduction to philosophy: definition, nature and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgements and reactions;

Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data;

Publication Ethics: Publication ethics: definition, introduction and importance, Best practices / standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

Unit II: Open Access Publishing: Open access publications and initiatives, SHERPA/RoME0 online resource to check publisher copyright & self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.;

Publication Misconduct:

A. Group Discussions: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad

B. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Databases and Research Metrics:

A. Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.

B. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score 2. Metrics: h-index, g index, I10 index, altmetrics.

References:

Refer UGC Website / Internet : https://www.ugc.ac.in/pdfnews/9836633_Research-and-Publication-Ethics.pdf

Course Code: MTH 651
Course Name: Indian Traditional Knowledge and Practices
Credits :02
Course Instructor: Dr. Pankaj Kumar & Dr. Pankaj Kumar

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%**Course Outcomes:**

After completing the course satisfactorily, a student will be able:

- To familiar with Indian thought.
- To familiar with major Indian thinkers.
- To familiar with the primary texts of Indian thought through an organized study of short Extracts in translation of those texts.
- To develop a better appreciation and understanding of not only the Knowledge Traditions and Practices of India but also of many contemporary questions.

Learning Outcomes:

- Identify the concept of Traditional knowledge and its importance.
- Explain the need and importance of protecting traditional knowledge.
- Illustrate the various enactments related to the protection of traditional knowledge.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Objectives: To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.

Course Contents:

Unit 1:

Life of Jagadguru Śaṅkarācārya Svāmī Bhāratīkṛṣṇa Tīrtha Mahararaja, Introduction of 16 Sutra and Subsutras**.** **(10 Hrs)**

Unit 2:

Life of Srinivasa Ramanujan, Some finding of Srinivasa Ramanujan Magie Squares, Sums Related to the Harmonie Series or the Inverse Tangent Function. **(10 Hrs)**

Prescribed Text Books:

1. Bharatiya Krishna Teerth : Vedic Mathematics (Motilal Banarasidas New Delhi, 2001)
2. Bruce C. Berndt," Ramanujan's Notebooks Part 1 ", Springer (1985)

Optional Courses (08 credits)

Course Name: Applied Functional Analysis
Course Code: IAM 603
Credits: 04
Course Instructor: Dr. Rakesh Kumar

Course Objective: The purpose of this course is to acquaint the students with those advanced applications of functional analysis in the various fields of science, engineering and technology which are modeled by differential/integral equations.

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: Linear spaces, operators and functionals: Basic concepts of Linear Spaces, Spaces of continuously differentiable functions, the geometric series theorem and its variants, integral operators, convergence of numerical quadratures, linear functionals and adjoint operators, weak convergence and compact convergence, the Fredholm alternative theorem.

Chapters-1&2

Unit II: Approximation theory: Interpolation theory, best approximations, orthogonal polynomials, projection operators, uniform error bounds, uniform error bounds for L^2-approximations, interpolatory projections and their convergence. **Chapter-3**

Unit III: Fourier analysis, wavelets and nonlinear equations: Continuous and discrete Fourier transforms, types and properties of wavelets, continuous and discrete wavelet transforms, multiresolution analysis; wavelets decomposition and reconstruction, the Banach fixed point theorem and iterative methods, differential calculus for nonlinear operators, the finite difference method.

Chapters-4, 5 & 6

Unit IV: Sobolev Spaces and numerical solutions: Weak derivatives, traces, periodic spaces, weak formulations of BVP, the Galerkin method and its variants.**Chapters-7, 8 & 9**

Prescribed Text Book:

1. K. Atkinson, W. Han, (2009) Theoretical Numerical Analysis: A Functional Analysis Framework, Third Edition, Springer.

Suggested Additional Reading:

1. A.H. Siddiqi, (2018) Functional Analysis and Applications, Springer.
2. S. Kesavan, (2019) Topics in Functional Analysis and Applications, New Age International Publishers.
3. H. Brezis (2011) Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer.
4. Svetlin G. Georgiev, Khaled Zennir, (2019) Functional Analysis with Applications, Walter de Gruyter GmbH, Berlin/Boston.

Course Code: MTH 611

Course Name: Advanced Topics in Topology and Analysis

Course Instructor: Dr S. K. Srivastava

Credits: 04

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: Curvature of Plane curve, Frenet-Formulas, Vector Fields, Orientation, Gaussian curvature, Mean curvature.

Unit II: Smooth manifold, Tangent space, Integral curves, Tensor Fields, Lie bracket, sub-manifold, Connection.

Unit III: Riemannian metric, Levi-Civita Connection, Parallel Transport, Geodesic, Exponential map, geodesic coordinates, first variation of arc length.

Unit IV: Isometry, Curvature Tensor, Ricci curvature, Sectional curvature, Jacobi fields, Differential forms, Poincare's Lemma, Stokes theorem.

Prescribed Text Books:

1. M.P. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
2. M.P. doCarmo, Riemannian Geometry, Birkhauser, 1992.
3. M.P. doCarmo, Differential Forms and Applications, Universitext, 1998.
4. M. Spivak, Comprensive Introduction to Differential Geometry I-V, Publish or Perish, 1999.

Suggested Additional Readings:

1. J.A. Thorpe, Elementary Topics in Differential Geometry, Springer (India), 2004.
2. S. Kumaresan, A Course on Differential Geometry and Lie Groups, HBA.
3. S. Gallot, D. Hulin and J. Lafontaine, Riemannian Geometry, Universitext, 2004.
4. B. O'Neill, Elementary Differential Geometry, Academic Press, New York, 1966.

Course Code: MTH 624
Course Name: Commutative Algebra
Course Credit: 04
Course Instructor: Dr. Meenakshi

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:
Unit-I: Rings and Ring Homomorphisms, Ideals, Quotient Rings, Prime and Maximal Ideals, Nilradical and Jacobson Radical, Sum and Product of Ideals, Extension and Contraction of Ideals, The Prime Spectrum of a Ring, the Zariski Topology on the Prime Spectrum.

Unit-II: Modules and Module Homomorphisms, Submodules and Quotient Modules, Sum, Product and Annihilator of a Module, Exact Sequences, Free Modules, Tensor Product of Modules, Restriction and Extension of Scalars, Exactness Properties of the Tensor Product, Alegbras , Projective Modules, Flat Modules

Unit-III: Multiplicatively Closed Sets, the Ring of Fractions (Localisation), and Module of Fractions, Examples of Localisation, Exactness of Localisation Operation, Local Properties, Extended and contracted Ideals in Rings of Fractions, Notherian Rings and Modules, Hilbert's Basis Theorem.

Unit-IV: Primary Ideal, Primary Decomposition of and Ideal, the First Uniqueness Theorem, the Second Uniqueness Theorem. Integral Dependence, The Going-Up Theorem, Integrally Closed Domains, the Going -Down Theorem, Valuation Rings

Prescribed Text Book:
(i) Introduction to Commutative Algebra by Atiyah and Macdonald, Addison-Wesley Publishing Company
(ii) Commutative Algebra by N.S. Gopala Krishnan, Second Edition, University Press

Course Code: **MTH 643**
Course Name: **Cryptography and Network Security**
Credits: **04 Credits**
Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Objectives of the Course:

1. To understand basics of Cryptography and Network Security.
2. To be able to secure a message over insecure channel by various means.
3. To learn about how to maintain the Confidentiality, Integrity and Availability of a data.
4. To understand various protocols for network security to protect against the threats in the networks.

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I:

Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques, Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES).

UNIT II:

Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem(statement only), Chinese Remainder theorem, Discrete logarithm.

UNIT III:

Advanced Encryption Standard(AES), Stream ciphers . Introduction to public key cryptography, RSA algorithm and security of RSA, Introduction to elliptic curve cryptography.

UNIT IV:

Information/Computer Security: Basic security objectives, security attacks, security services, Network security model, Cryptographic Hash functions, Secure Hash algorithm, SHA-3, Digital signature, Elgamal signature, Digital signature standards, Authentication.

Prescribed books:

1. William Stallings, “Cryptography and Network Security”, Principles and Practise, Fifth Edition, Pearson Education, 2012.

Reference books :

1. Douglas R. Stinson, “Cryptography theory and practice”, CRC Press, Third edition, 2005.

Course Code: MTH 644
Course Name: Advanced Fluid Dynamics
Credits: 04
Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh
Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)
Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.
Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%
Course Contents:
Unit-I: Basic concepts, The thermal instability of a layer of fluid heated from below: The Benard problem: Introduction, The nature of the physical problem, The basic hydrodynamic equations, The Boussinesq approximation, The perturbation equations, The analysis into normal modes, The principle of exchange of stabilities, The equations governing the marginal state and the reduction to a characteristic value problem, Exact solutions of the characteristic value problem, the case of two free boundaries.
Unit-II: The thermal Instability of a layer of fluid heated from below: The effect of rotation: The problem of thermal instability in a rotating fluid, The perturbation equations, The case when instability sets in as stationary convection, A variational principle, Solutions for the case when instability sets in as stationary convection, the case of two free boundaries, On the onset of convection as overstability, The solution for the case of two free boundaries.
Unit-III: The thermal instability of a layer of fluid heated from below: The effect of a magnetic field: The problem of thermal instability in the presence of a magnetic field, The perturbation equations, The case when instability sets in as stationary convection, A variational principle, Solutions for the case when instability sets in as stationary convection, the case of two free boundaries, On the onset of convection as overstability.
Unit-IV: The stability of superposed fluids: The Rayleigh Taylor instability: Introduction, The characteristic of the equilibrium of a stratified heterogeneous fluid, The perturbation equations, the inviscid case, the effect of rotation, the effect of vertical magnetic field.
Prescribed Text Books:
S. Chandrasekhar: Hydrodynamic and Hydromagnetic Stability, Dover Publication, New York, 1981.

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New Courses (Disciplinary/Interdisciplinary) and Course Contents to be offered w.e.f. Academic Year 2022-23

Sr. No.	Course Name	Course Code	Credit
	M.Sc. Mathematics		
	Minor Courses(Disciplinary Courses)		
1	Calculus of Variations	MTH 431 02	02
	Vocational/Skill Courses		
2	Ordinary and Partial Differential Equations	IAM 402A	04
	Review of Literature, Research Proposal		
3	Lebesgue Measure and Integration	MTH 405A	04
4	Dynamical Aspects of Fluid Flows	MTH 557	04
5	Fundamentals of Cryptography	MTH 558	04
6	Galois Theory	MTH 626A	04
	Interdisciplinary Course (University wide)		
7	Linear Algebra and Tensors	MTH 351	04

Course Contents

Minor Courses (Disciplinary Courses)

Course Code: MTH 431

Course Name: Calculus of Variations

Credits: 02

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures/organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work /Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/ dissertation/ thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the calculus of variations.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^1 The notion of variations.

CO^2 The Brachistochrone problem and Isoperimetric problem.

CO^3 The Euler Lagrange's equations.

CO^4 Applications of calculus of variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Calculus of Variations: Concept of variation, Linear functional, Euler-Lagrange equation, Necessary and sufficient conditions for extrema, Euler-Lagrange differential equation for n-dependent variables, Functional dependent on higher order derivatives, Functional dependent on functions of several variables.

(10 Hours)

Unit II: Applications of calculus of variations to various problems: Shortest distance, minimum surface of revolution, Brachistochrone problem, geodesic, Isoperimetric problem, Calculus of variations for problems in parametric form, Variational problems with moving boundaries. (**10 Hours)**

Prescribed Text Books:

I.M. Gelfand and S.V. Fom in (2012): Calculus of Variations, Prentice Hall Inc.

Suggested Additional Readings:

A. S. Gupta (1996): Calculus of Variations with Applications, Prentice–Hall of India.
Robert Weinstock (1975): Calculus of Variations with applications to Physics and Engineering, Dover Publications Inc.

Course Articulation Matrix of MTH 431 - Calculus of Variations

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		3	2
CO^2	3	2	1	1		3	2
CO^3	3	2	1	1		3	2
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses

Course Code: IAM 402A

Course Name: Ordinary and Partial Differential Equations

Course Instructors: Dr S. K. Srivastava and Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with introductory-ODEs, PDEs and their applications.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1} Existence and Uniqueness Theorem
CO^{2} Sturm-Liouville Boundary Value Problem
CO^{3} Charpit and Jacobi Methods for solving first order nonlinear PDEs
CO^{4} Classification of second order PDEs

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Existence and uniqueness theorem; dependence of solutions on initial conditions and on the function; existence and uniqueness theorems for systems and higher order equations. **(10 Hours)**

Unit-II: The theory of linear differential equations; homogeneous and non-homogeneous systems, nth order homogeneous and non-homogeneous linear differential equations, Sturm theory, Sturm-Liouville boundary value problems. **(10 Hours)**

Unit-III: Surfaces and curves in three dimensions, simultaneous differential equations, orthogonal trajectories, Pfaffian differential equations, First order PDEs, Cauchy's method of characteristics, compatible system of first order equations, Charpit's and Jacobi's methods.

(10 Hours)

Unit-IV: Classification of second order PDEs, first General solution of higher order PDEs with constant and variable coefficients, Method of separation of variables. **(10 Hours)**

Prescribed Text Books:

- Ross S.L. (1984). Differential Equations. Third Edition. John Wiley & Sons Inc.
- Ian N. Sneddon (2006), Elements of Partial Differential Equations, Dover Publications Inc.

Suggested Additional Readings:

1. W.E. Boyce and R.C. Diprima (2013). Elementary Differential Equations and Boundary Value Problems, Ninth Edition, Wiley.
2. W.A. Strauss; Partial differential equations an introduction, John Wiley & Sons, 2008.

Course Articulation Matrix of IAM 402- Ordinary and Partial Differential Equations

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	2	1		3	3
CO^2	3	2	2	1		3	2
CO^3	3	2	2	1		3	2
CO^4	3	2	2	1		3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Review of Literature, Research Proposal

Course Code: MTH 405A

Course Name: Lebesgue Measure and Integration

Course Credit: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours such as independent individual/ group work; obligatory/ optional work placement; literature survey/ urs of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other work load library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the concept of measure, a means for comparing the size of sets and generalizing intuitive notions such as length and area, and moves on to describe the elements of the Lebesgue theory of integration. Lebesgue integration is a fundamental tool for advanced study in areas of mathematics such as functional analysis and potential theory, and provides the foundation for the axiomatic treatment of probability theory.

Course Outcome: By the end of the course students will be able to understand:

CO^1: Countability and Cantor's like sets.

CO^2: Measurable sets, Borel sets and their measurability.

CO^3: Convergence in measure and Lebesgue Integrals.

CO^4: Dini's derivatives and functions of bounded variations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

Unit I: Set theory, Topological ideas, sequence and limits, functions and mapping, cardinal number and Countability, properties of open sets and Cantor's like sets. **(10 Hours)**

Unit II: Lebesgue outer measure, measurable sets, properties of measurable sets, Borel sets and their

measurability, characterizations of measurable sets, measurable functions and their properties. **(10 Hours)**

Unit III: Borel measurable functions, convergence in measure, Lebesgue Integrals and integral of non-negative measurable functions. **(10 Hours)**

Unit IV: The four derivatives, Continuous and Non- differentiable functions, functions of bounded variation, Lebesgue's differentiation theorem, differentiation, integration and the Lebesgue set.**(10 Hours)**

Prescribed Text Book:

1. P.K. Jain, V.P. Gupta and P. Jain (2012), Lebesgue measure and integration, Anshan Publishers, 2nd Edition.

Suggested Additional Readings:

1. P. R. Halmos, Measure Theory, Graduate Text in Mathematics, Springer-Verlag, 1979.
2. G. De Barra (2003), Measure theory and Integration, Horwood Publishing.

Course Articulation Matrix MTH 405A- Lebesgue Measure and Integration

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	1	1	1	1
CO2	3	3	1	1	1	1
CO3	3	3	2	2	2	2
CO4	3	3	2	2	2	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 557

Course Name: Dynamical Aspects of Fluid Flows

Credits: 04

Course Instructor: Dr. Pankaj Kumar (s/o Sh. Krishan Singh)

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main purpose of this course is to acquaint the students with the fundamental concepts fluid dynamics and enable them to search the gaps in the literature related to fluid flow patterns.

Course Outcomes: After completing the course satisfactorily, a student will be able:

CO1: To identify the key fluid properties used in the analysis of fluid behavior.

CO2: To apply the Reynolds transport theorem.

CO3: To apply conservation of mass and energy and Newton's second law of motion to the contents of a finite control volume to get important answers.

CO4: To analyze certain types of flows using the Navier–Stokes equations.

CO5: To develop a set of dimensionless variables for a given flow situation.

Attendance Requirements: Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of 200

Course Contents:

UNIT I: Basic concepts and definitions, continuum hypothesis, basic algebra with vectors and tensors, fluid statics, Bernoulli equation, fluid kinematics; velocity field, acceleration field.
(Chapters 1-4) (12 HRS)

UNIT-II: Reynolds transport theorem, Control volume analysis: continuity equation, momentum equation, First law of thermodynamics-energy equation, Second law of thermodynamics-irreversible flow.
(Chapters 4-5) (08 HRS)

UNIT-III: Differential analysis: fluid element kinematics, conservation of mass and momentum, inviscid flow, plane potential flows, viscous flow, some simple solutions for viscous incompressible fluids.
(Chapter 6) (12 HRS)

UNIT-IV: Dimensional analysis, similitude and modelling: dimensional analysis, Buckingham Pi theorem, correlation of experimental data, modelling and similitude. **(Chapter 7) (08 HRS)**

Text Book:

1. B.R. Munson, D.F. Young, T.H. Okiishi, W.W. Huebsch, (2009). Fundamentals of Fluid Mechanics, Sixth Edition, John Wiley & Sons, Inc.

Reference Books

1. Ronald L. Panton, (2014). Incompressible flow, Third Edition, Wiley.

2. Edward J. Shaughnessy, Jr. Ira M. Katz James P. Schaffer, (2005). Introduction to Fluid Mechanics and Fluid Machines, Oxford University Press.

Course Articulation Matrix of MTH 557- Dynamical Aspects of Fluid Flows

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	3	2	2	3	2
CO2	3	3	2	3	2	3
CO3	2	3	3	2	2	3
CO4	3	2	2	3	3	2
CO5	3	3	2	2	3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 558

Course Name: Fundamentals of Cryptography

Course Instructor: Dr Pankaj Kumar S/o Late Sh. Maniram

Credits: 04

Credits Equivalent:

Credits Equivalent: 02 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity /contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Outcomes

After completing the course satisfactorily, a student will be able:

CO^1 To understand the basics of Cryptography.

CO^2 To be able to secure a message over an insecure channel by various means.

CO^3 To learn about how to maintain the Confidentiality, Integrity and Availability of a data.

CO^4 To understand various protocols for network security to protect against the threats in the networks.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%

2. End Term Examination: 50%

3. Counseling, Activities and Tutorials (CAT): 25%

i. Subjective / Objective Assignment: 10 %

ii. Numerical Assignments using programming: 10 %

iii. Presentations and Class Tests: 5 %

Course Contents:

UNIT I:

Group, Rings, Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem(statement only), Chinese Remainder theorem, Discrete logarithm-Hallman problem, Need of security, Security attacks, Security services. (8 Hours)

Unit II:

Symmetric Key Cryptography: Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques, Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES). (8 Hours)

UNIT III:

Asymmetric Key Cryptography: Introduction to public key cryptography, RSA algorithm and security of RSA, Key distribution – Key management, Introduction to elliptic curve cryptography. Introduction to chaos-based cryptography, Identity Based Public key Cryptography, Certificateless Public Key Cryptography, Provable Security, Security against Chosen-Ciphertext Attacks, Random Oracle Model. (12 Hours)

UNIT IV:

Advance in Cryptography: Diffie Hellman key exchange, Digital signature, Elgamal signature, Digital signature standards. Digital Signatures: Proxy Signature, Aggregate Signature, Multi-signature, Partially Blind Signature and Blind Signature.

Authentication requirement, Authentication function, MAC, Hash function, Security of hash function and MAC, SHA –Digital signature and authentication protocols, DSS- Entity Authentication: Biometrics, Passwords, Challenge Response protocols- Authentication applications - Kerberos, X.509 (12 Hours)

Prescribed books:

1. William Stallings, "Cryptography and Network Security", Principles and Practise, Fifth Edition, Pearson Education, 2012.

2. H. Xiong, Z. Q. Athanasios V. Vasilakos, "Introduction to Certificateless Cryptography", CRC Press Taylor & Francis Group

Reference Book :

1. Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

Course Articulation Matrix MTH 558- Fundamentals of Cryptography

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	3	2	2	2	2
CO2	2	3	3	3	1	2
CO3	1	3	2	2	2	2
CO4	2	2	2	3	2	2

1. Partially Related

2. Moderately Related

3. Highly Related

Course Code: MTH 626A

Course Name: Galois Theory

Course Instructor: Dr Meenakshi

Credits: 4

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The purpose of this course is

- To discuss the Field Theory
- To introduce Galois Groups
- To explore the application area of Galois Theory

Course Outcomes: After successful completion of the course, a student will be able to:

CO^1 Understand how to write, correct and clear arguments in abstract Mathematics with proofs.

CO^2 Have the knowledge about Field Extensions

CO^3 Solve polynomials having different degrees

CO^4 Understand the basis of Galois's Criterion for solvability of an equation by radicals.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit-I: Polynomial, Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots

(10 Hours)

Unit-II: Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotomic polynomials, Representation of Elements of Finite Fields, Order of Polynomials **(10 Hours)**

Unit-III: Primitive Polynomials, Irreducible Polynomials, Galois Theory and its Applications, Perfect Field, Separable extensions, Simple extensions

(10 Hours)

Unit-IV: Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra. **(10 Hours)**

Prescribed Text Book:

P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, 'Basic Abstract Algebra', Second Edition, Cambridge University Press.

Suggested Additional Readings:

1. I.N. Herstein, "Topics in Algebra", 2nd Edition (1975) (Wiley International Editions).
2. M. Artin, "Algebra", 2nd Edition (1991)(PHI).

Course Articulation Matrix of MTH 626A- Galois Theory

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	3	3	2
CO^2	3	2	2	3	3	1
CO^3	3	2	2	3	3	2
CO^4	3	2	2	3	3	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Interdisciplinary Course (University wide)

Course Code: MTH 351

Course Name: Linear Algebra and Tensors

Course credit: 04

Course Instructor: Dr Meenakshi

Course Objectives:

To introduce student to the ideas and some fundamental concepts of Matrices

To give students a working knowledge of basic properties of Vector Spaces, Matrices and Cartesian Tensors and General Tensors

Course Outcomes: After completion of the course, a student will be able to

CO^1 Understand how linear transformations are used to preserve the structure of a vector space
CO^2 Understand how Matrices are extensively used in solving the simultaneous system of equations
CO^3 Understand the use of Cartesian Tensors
CO^4 Have the knowledge of central concepts of Algebra of Tensors

Credit Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Continuous Internal Assessment: 25%
4. Assignment 10%
5. Class participation 10%
6. Class tests 5%

Course Contents:

Unit I: Linear Vector Spaces: Abstract Systems, Binary Operations and Relations, Introduction to Groups and Fields, Vector Spaces and Subspaces, Linear Independence and Dependence of Vectors, Change of Basis, Homomorphism and Isomorphism of Vector Spaces, Linear Transformations, Representation of Linear Transformations by Matrices.

Unit II: Matrices: Addition and Multiplication of Matrices, Null Matrices, Diagonal, Scalar and Unit Matrices, Upper-Triangular and Lower- Triangular Matrices, Transpose of Matrix, Symmetric and Skew-Symmetric Matrices, Conjugate of a Matrix, Hermitian and Skew-Hermitian Matrices, Singular and Non-Singular matrices, Orthogonal and Unitary Matrices, Trace of a Matrix, Inner Product.

Eigen- values and Eigenvectors, Cayley- Hamilton Theorem, Diagonalization of Matrices, Solutions of Coupled Linear Ordinary Differential Equations, Functions of a Matrix.

Unit III : Cartesian Tensors: Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors, Contraction, Quotient Law of Tensors, Symmetric and Antisymmetric Tensors, Invariant Tensors: Kronecker and Alternating Tensors, Association of Antisymmetric Tensor of Order Two and Vectors, Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products, Differentiation. Gradient, Divergence and Curl of Tensor Fields, Vector Identities, Tensorial Formulation of Analytical Solid Geometry: Equation of a Line, Angle Between Lines, Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation), Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor, Stress and Strain Tensors: Symmetric Nature, Elasticity Tensor, Generalized Hooke's Law.

Unit IV: General Tensors: Transformation of Coordinates. Minkowski Space, Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

Prescribed Text Books :

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publication.
2. Mathematical Methods for Physicists and Engineers, C.D, Cantrell, 2011, Cambridge University Press.
3. Introduction to Matrices and Linear Transformation, D.T. Finkbeiner, 1978, Dover Pub.
4. Linear Algebra, W. Cheney, E.W Cheney & D.R Kincaid, 2012, Jones & Bartlett Learning.
5. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
6. Mathematical Methods for Physics & Engineers, K.F.Riley, M.P.Hobson, S.J. Bence, 3rd Ed, 2006, Cambridge University Press.

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Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

MINIMUM ELIGIBILITY REQUIREMENTS, CRITERIA FOR SELECTION OF STUDENTS FOR ADMISSION, CREDIT REQUIREMENTS FOR COMPLETION AND CONDITIONS FOR AWARD OF VALUE ADDED COURSE "CERTIFICATE IN ARTIFICIAL INTELLIGENCE WITH QUANTITATIVE APTITUDE"

1. **Name of Programme: Certificate in Artificial Intelligence with Quantitative Aptitude**

2. **Programme Duration:**
   a. **Minimum:** Six Months (01Semester)
   b. **Maximum:** Two Years (04 Semesters)
   c. **Intake:** 30+3 = **33**

3. **Minimum Eligibility Conditions:**

   A minimum of 50% Marks or an equivalent grade in Graduation from a recognized University/Institute.

4. **Relaxation in Minimum Qualifying Marks:**

   Relaxation in minimum qualifying marks up to a maximum of 5% shall be made in case of candidates belonging to the SC, ST and Persons with Disabilities categories.

5. **Selection Criteria for Admission:**

   All candidates seeking admission to Value Added Course "**Certificate in Artificial Intelligence with Quantitative Aptitude"** shall be admitted on the basis of merit in Graduation or as decided by the University time to time.

6. **Credit Requirement for Value Added Course "**Certificate in Artificial Intelligence with Quantitative Aptitude" **(01 Semester):**

   a. For the successful completion of the Programme, a student shall be required to accumulate a total of **20 credits** as per course structure.
   b. The maximum number of credits that a student may earn in a Semester shall not exceed 20, and he/she shall be required to register for such number of courses accordingly.

7. **Conditions for the award of Certificate in Artificial Intelligence with Quantitative Aptitude:**

   The students will have the option to complete this Value Added Course within the duration of 02 years from the date of enrollment in the course. After successful completion of the said Value Added Course, the student will be awarded a Certificate by the University. This Certificate may be of 10 Credits (for 03 months) or 20 Credits (for 06 months), which the student has to earn during the stipulated time period.

8. **Evaluation Criteria:** As per CUHP Norms

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List of Courses for "Certificate in Artificial Intelligence with Quantitative Aptitude" jointly offered by Department of Computer Science & Informatics, and Srinivasa Ramanujan Department of Mathematics for Monsoon Semester 2022 (Total Credits: 20):-

Mathematics Section[$] (10 Credits):			
Sr. No.	**Course Name**	**Course Code**	**Credits**
1	Mathematical Aptitude-I	MTH 451	04
2	Mathematical Aptitude-II	MTH 452	04
3	Verbal and Non-Verbal Reasoning	MTH 453	02
Computer Section[$] (10 Credits):			
4	Python Programming	CSI 451	04
5	Machine Learning	CSI 452	04
6	Data Mining	CSI 453	02

[$]The student will have to choose at least one course from each Section to get a certificate of 10 Credits (for 03 months) or 20 Credits (for 06 months).

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CERTIFICATE IN ARTIFICIAL INTELLIGENCE WITH QUANTITATIVE APTITUDE

Course Contents

Course Code: MTH 451

Course Name: MATHEMATICAL APTITUDE-I

Course Instructor: Dr S. K. Srivastava

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: This course's objective is to familiarize the students with mathematical aptitude and its many uses. In almost every competitive examination, aptitude tests include quantitative aptitude as a mandatory component. Along with logical and analytical abilities, it also assesses mathematical capabilities.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^1 the number system, H.C.F. and L.C.M.

CO^2 Average, Logarithms, surds and Indices.

CO^3 Profit and Loss, Partnership and Chain Rule.

CO^4 the problems on Time, work, Distance and Trains.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40

End Term Examination: 120

Continuous Internal Assessment: 40

Course Contents:

Unit-I: Number system, H.C.F. and L.C.M. of Numbers, Decimal Fractions, Simplifications, Square roots and cube roots.

Unit-II: Average, Problems on Numbers, Problems on ages, Surds and Indices, Logarithms.

Unit-III: Percentage, Profit and Loss, Ratio and Proportion, Partnership, Chain Rule.

Unit-IV: Pipes and Cisterns, Time and work, Time and Distance, Boats and Streams, Problems on Trains.

Prescribed Text Books:

Aggarwal R.S. (2017). Quantitative Aptitude, S. Chand & Company Ltd.

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Website: www.cuhimachal.ac.in

Course Code: MTH 452

Course Name: MATHEMATICAL APTITUDE-II

Course Instructor: Dr Pankaj Kumar (S/o Sh. Krishan Singh)

Credits: 04

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: This course's objective is to familiarize the students with mathematical aptitude and its many uses. In almost every competitive examination, aptitude tests include quantitative aptitude as a mandatory component. Along with logical and analytical abilities, it also assesses mathematical capabilities.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1} Simple Interest and Compound Interest.

CO^{2} Stocks and Shares, Permutations and Combinations.

CO^{3} Probability, Odd Man Out and Series.

CO^{4} the data Interpretation.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40

End Term Examination: 120

Continuous Internal Assessment: 40

Course Contents:

Unit-I: Alligation or Mixture, Simple Interest, Compound Interest, Area, Volume and Surface area.

Unit-II: Races and Games of Skill, Calendar, Clocks, Stocks and Shares, Permutations and Combinations.

Unit-III: Probability, True Discount, Banker's Discount, Heights and Distances, Odd Man Out and Series.

Unit-IV: Data Interpretation: Tabulation, Bar Graphs, Pie Chart, Line Graphs.

Prescribed Text Book:

- Aggarwal R.S. (2017). Quantitative Aptitude, S. Chand & Company Ltd.

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Website: www.cuhimachal.ac.in

Course Code: MTH 453

Course Name: Verbal and Non-Verbal Reasoning

Course Instructor: Dr Pankaj Kumar (S/o Sh. Late Mani Ram)

Credits: 02

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the Mathematical aptitude and its various applications.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^{1} coding/decoding.

CO^{2} Logical Venn Diagrams & arithmetical reasoning.

CO^{3} Figure formation and analysis.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 20

End Term Examination: 60

Continuous Internal Assessment: 20

Course Contents:

Unit-I: Analogy, Classification and Series Completion, Coding-Decoding, Blood Relations, Puzzle Test, Direction Sense Test, Logical Venn Diagrams, Arithmetical Reasoning, Data Sufficiency and Decision Making, Assertion and Reason, Situation Reaction Test, Logic, Arguments, Assumptions, Course of action and conclusions from the statement.

Unit-II: Series, Classification, Analytical Reasoning, Images, Embedded figures, Completion of Incomplete pattern, Paper folding and cutting, Rule Detection, Figures, Cubes and Dice, Construction of squares and triangles, Dot situation, Figure formation and analysis.

Prescribed Text Book:

- Aggarwal R.S. (2007). A Modern Approach to Verbal and Non-Verbal Reasoning, S. Chand & Company Ltd.

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Annexure-II

Central University of Himachal Pradesh

Ph.D. Mathematics

School of Mathematics, Computers & Information Sciences

Ph.D. Mathematics
Semester-I

(Spring Semester, 2022)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Compulsory Courses (10 Credits)					
S. No.	**Course Name**	**Course Code**	**Credit**	**Lecture & Tutorial**	**Name of Faculty**
1	Research Methodology	MTH 601	04	2L, 1T	Dr S K Srivastava
2	Research and Publication Ethics	CPE-RPE	02	2L, 1T	Dr Rakesh Kumar
3	Indian Traditional Knowledge and Practice	MTH 651	02	2L, 1T	Dr Pankaj Kumar S/O Late Sh. Maniram
4	Pedagogy of Teaching-Learning Process*	TTR 622	02		
Optional Courses (Specialisation#) (08 Credits)					
5	Applied Functional Analysis	IAM 603	04	4L, 2T	Dr Rakesh Kumar
6	Commutative Algebra	MTH 624	04	4L, 2T	Dr Meenakshi
7	Advanced Fluid Dynamics	MTH 644	04	4L, 2T	Dr Pankaj Kumar S/O Sh. Krishan Singh
8	Cryptography and Network Security	MTH 643	04	4L, 2T	Dr Pankaj Kumar S/O Late Sh. Maniram
9	Advanced Topics in Topology and Analysis	MTH 611	04	4L, 2T	Dr S K Srivastava

*The course Pedagogy of Teaching-Learning Process will be offered and taught by the Department of Education.

#The students will have two choose at least two (maximum three) courses from the optional course list according to their specialisation.

Course Contents

Compulsory Courses (10 credits)

Course Code: MTH 601
Course Name: Research Methodology
Credits: 04 Credits
Course Instructor: Dr. Meenakshi
Course Contents:
Unit I: Fundamentals of Research: Objectives, Motivation, General Characteristics, Criterion of good research and Literature Review.
Unit II: Mathematics and its History, Identification and Evaluation of Research Problems.

Unit III: Scientific Writing: Writing a survey article, research paper, survey article and thesis writing.
Unit IV: Research Tools: LaTeX, Beamer, Reference Manager like Zotero & Mendeley, Plagiarism detection software.

References:

1. C.R. Kothari, **Research Methodology** Methods & Techniques, Second Edition, New Age International publisher, 2004.
2. J. Stillwell, **Mathematics and its History**, 3rd Edition, Springer, 2010.
3. N. E. Steenrod, P. R. Halmos, M. M. Schiffer& J. A. Dieudonné,
How to Write Mathematics, American Mathematical Society, 1973.
4. N. J. Higham, **Handbook of Writing for the Mathematical Sciences**, 2nd edition, Society for Industrial and Applied Mathematics, 1998.
5. D. E. Knuth, T. Larrabee& P. M. Roberts, **Mathematical Writing**,
Mathematical Association of America, 1989.
6. L. Lamport, LaTeX, **a Document Preparation System**, Pearson, 2008.
7. M. Goossens, F. Mittelbach, S. Rahtz, D. Roegel& H. Voss, **The LaTeX Graphics Companion**, Addison-Wesley, 2008.
8. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C.
Rowley, **TheLaTeX Companion** (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004.
9. T. Tantau, **The BEAMER class**: User Guide for version 3.49, 12th Media Services, 2016.
10. N. R. Glassman, **Citation Management Tools: A Practical Guide for Librarians**, Rowman& Littlefield, 2018.

Course Code: CPE-RPE
Course Name: Research and Publication Ethics
Credits: 02 Credits
Course Instructor: Dr. Rakesh Kumar

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: Philosophy and Ethics: Introduction to philosophy: definition, nature and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgements and reactions;

Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data;

Publication Ethics: Publication ethics: definition, introduction and importance, Best practices / standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

Unit II: Open Access Publishing: Open access publications and initiatives, SHERPA/RoME0 online resource to check publisher copyright & self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.;

Publication Misconduct:

A. Group Discussions: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad
B. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Databases and Research Metrics:

A. Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.
B. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score 2. Metrics: h-index, g index, I10 index, altmetrics.

References:

Refer UGC Website / Internet : https://www.ugc.ac.in/pdfnews/9836633_Research-and-Publication-Ethics.pdf

Course Code: MTH 651
Course Name: Indian Traditional Knowledge and Practices
Credits: 02
Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%**Course Outcomes:**

After completing the course satisfactorily, a student will be able:

- To familiar with Indian thought.
- To familiar with major Indian thinkers.
- To familiar with the primary texts of Indian thought through an organized study of short Extracts in translation of those texts.
- To develop a better appreciation and understanding of not only the Knowledge Traditions and Practices of India but also of many contemporary questions.

Learning Outcomes:

- Identify the concept of Traditional knowledge and its importance.
- Explain the need and importance of protecting traditional knowledge.
- Illustrate the various enactments related to the protection of traditional knowledge.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Objectives: To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.

Course Contents:

Unit 1:

Life of Jagadguru Śaṅkarācārya Svāmī Bhāratīkṛṣṇa Tīrtha Mahararaja, Introduction of 16 Sutra and Subsutras**.** **(10 Hrs)**

Unit 2:

Life of Srinivasa Ramanujan, Some finding of Srinivasa Ramanujan Magie Squares, Sums Related to the Harmonie Series or the Inverse Tangent Function. **(10 Hrs)**

Prescribed Text Books:

1. Bharatiya Krishna Teerth : Vedic Mathematics (Motilal Banarasidas New Delhi, 2001)
2. Bruce C. Berndt," Ramanujan's Notebooks Part 1 ", Springer (1985)

Optional Courses (08 credits)

Course Code: MTH 611
Course Name: Advanced Topics in Topology and Analysis
Course Instructor: Dr S. K. Srivastava
Credits: 04
Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)
Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.
Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:
Unit I: Curvature of Plane curve, Frenet-Formulas, Vector Fields, Orientation, Gaussian curvature, Mean curvature.
Unit II: Smooth manifold, Tangent space, Integral curves, Tensor Fields, Lie bracket, sub-manifold, Connection.
Unit III: Riemannian metric, Levi-Civita Connection, Parallel Transport, Geodesic, Exponential map, geodesic coordinates, first variation of arc length.
Unit IV: Isometry, Curvature Tensor, Ricci curvature, Sectional curvature, Jacobi fields, Differential forms, Poincare's Lemma, Stokes theorem.
Prescribed Text Books:

1. M.P. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
2. M.P. doCarmo, Riemannian Geometry, Birkhauser, 1992.
3. M.P. doCarmo, Differential Forms and Applications, Universitext, 1998.
4. M. Spivak, Comprensive Introduction to Differential Geometry I-V, Publish or Perish, 1999.

Suggested Additional Readings:

1. J.A. Thorpe, Elementary Topics in Differential Geometry, Springer (India), 2004.
2. S. Kumaresan, A Course on Differential Geometry and Lie Groups, HBA.
3. S. Gallot, D. Hulin and J. Lafontaine, Riemannian Geometry, Universitext, 2004.
4. B. O'Neill, Elementary Differential Geometry, Academic Press, New York, 1966.

Course Code: MTH 643

Course Name: Cryptography and Network Security

Credits: 04 Credits

Objectives of the Course:

1. To understand basics of Cryptography and Network Security.
2. To be able to secure a message over insecure channel by various means.
3. To learn about how to maintain the Confidentiality, Integrity and Availability of a data.
4. To understand various protocols for network security to protect against the threats in the networks.

Course Contents:

Unit I:

Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques, Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES).

UNIT II:

Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2n), Fermat theorem and Euler's theorem(statement only), Chinese Remainder theorem, Discrete logarithm.

UNIT III:

Advanced Encryption Standard(AES), Stream ciphers . Introduction to public key cryptography, RSA algorithm and security of RSA, Introduction to elliptic curve cryptography.

UNIT IV:

Information/Computer Security: Basic security objectives, security attacks, security services, Network security model, Cryptographic Hash functions, Secure Hash algorithm, SHA-3, Digital signature, Elgamal signature, Digital signature standards, Authentication.

Prescribed book:

1. William Stallings, "Cryptography and Network Security", Principles and Practise, Fifth Edition, Pearson Education, 2012.

Reference book :

1. Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

Course Name: Applied Functional Analysis

Course Code: IAM 603

Credits: 04

Course Objective: The purpose of this course is to acquaint the students with thoseadvanced applicationsof functional analysis in the various fields of science, engineering and technology which are modeled by differential/integral equations.

Course Contents:

Unit I: Linear spaces, operators and functionals: Basic concepts of Linear Spaces, Spaces of continuously differentiable functions, the geometric series theorem and its variants, integral operators, convergence of numerical quadratures, linear functionals and adjoint operators, weak convergence and compact convergence, the Fredholm alternative theorem. **Chapters-1&2**

Unit II: Approximation theory: Interpolation theory, best approximations, orthogonal polynomials, projection operators, uniform error bounds, uniform error bounds for L^2-approximations, interpolatory projections and their convergence. **Chapter-3**

Unit III: Fourier analysis, wavelets and nonlinear equations: Continuous and discrete Fourier transforms, types and properties of wavelets, continuous and discrete wavelet transforms, multiresolution analysis; wavelets decomposition and reconstruction, the Banach fixed point theorem and iterative methods, differential calculus for nonlinear operators, the finite difference method**.** **Chapters-4, 5 & 6**

Unit IV: Sobolev Spaces and numerical solutions: Weak derivatives, traces, periodic spaces, weak formulations of BVP, the Galerkin method and its variants.**Chapters-7, 8 & 9**

Prescribed Text Book:

1. K. Atkinson, W. Han, (2009) Theoretical Numerical Analysis: A Functional Analysis Framework,Third Edition, Springer.

Suggested Additional Reading:

1. A.H. Siddiqi, (2018) Functional Analysis and Applications, Springer.
2. S. Kesavan, (2019) Topics in Functional Analysis and Applications, New Age International Publishers.
3. H. Brezis (2011) Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer.
4. Svetlin G. Georgiev, Khaled Zennir, (2019) Functional Analysis with Applications, Walter de Gruyter GmbH, Berlin/Boston.

Course Code: MTH 624

Course Name: Commutative Algebra

Course Credit: 04

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual /group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.) Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course.A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Mid Term Examination: 25%
2. End Term Examination: 50%
3. Continuous Internal Assessment: 25%

i) Assignments 20%
ii) Class participation 5%

Course Contents:

Unit-I: Rings and Ring Homomorphisms, Ideals, Quotient Rings, Prime and Maximal Ideals,Nilradical and Jacobson Radical, Sum and Product of Ideals, Extension and Contraction of Ideals, The Prime Spectrum of a Ring, the Zariski Topology on the Prime Spectrum.

Unit-II: Modules and Module Homomorphisms, Submodules and Quotient Modules, Sum, Productand Annihilator of a Module, Exact Sequences, Free Modules, Tensor Product of Modules, Restriction and Extension of Scalars, Exactness Properties of the Tensor Product, Alegbras , Projective Modules, Flat Modules

Unit-III: Multiplicatively Closed Sets, the Ring of Fractions (Localisation), and Module of Fractions, Examples of Localisation, Exactness of Localisation Operation, Local Properties, Extended and contracted Ideals in Rings of Fractions, Notherian Rings and Modules, Hilbert's Basis Theorem.

Unit-IV: Primary Ideal, Primary Decomposition of and Ideal, the First Uniqueness Theorem, the Second Uniqueness Theorem. Integral Dependence, The Going-Up Theorem, Integrally Closed Domains, the Going -Down Theorem, Valuation Rings

Prescribed Text Book:

(i) Introduction to Commutative Algebra by Atiyah and Macdonald, Addison-WesleyPublishing Company
(ii) Commutative Algebra by N.S. Gopala Krishnan, Second Edition, University Press

Course Code: MTH 644

Course Name: Advanced Fluid Dynamics

Credits: 04

Course Contents:

Unit-I: Basic concepts, The thermal instability of a layer of fluid heated from below: The Benard problem: Introduction, The nature of the physical problem, The basic hydrodynamic equations, The Boussinesq approximation, The perturbation equations, The analysis into normal modes, The principle of exchange of stabilities, The equations governing the marginal state and the reduction to a characteristic value problem, Exact solutions of the characteristic value problem, the case of two free boundaries.

Unit-II: The thermal Instability of a layer of fluid heated from below: The effect of rotation: The problem of thermal instability in a rotating fluid, The perturbation equations, The case when instability sets in as stationary convection, A variational principle, Solutions for the case when instability sets in as stationary convection, the case of two free boundaries, On the onset of convection as overstability, The solution for thecase of two free boundaries.

Unit-III: The thermal instability of a layer of fluid heated from below: The effect of a magnetic field: The problem of thermal instability in the presence of a magnetic field, The perturbation equations, The case when instability sets in as stationary convection, A variational principle, Solutions for the case when instability sets in as stationary convection, the case of two free boundaries, On the onset of convection as overstability.

Unit-IV: The stability of superposed fluids: The Rayleigh Taylor instability: Introduction, The characteristic of the equilibrium of a stratified heterogeneous fluid, The perturbation equations, the inviscid case, the effect of rotation, the effect of vertical magnetic field.

Prescribed Text Book:

S. Chandrasekhar: Hydrodynamic and Hydromagnetic Stability, Dover Publication, New York, 1981.

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Annexure-II (a)

Central University of Himachal Pradesh

Ph.D. Mathematics

School of Mathematics, Computers & Information Sciences

Ph.D. Mathematics
Semester-I

(Spring Semester, 2023)

COURSES OFFERED BY SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Course Code	Course Name	Credits
Compulsory Courses (10 Credits)		
MTH 601	Research Methodology	04
CPE-RPE	Research and Publication Ethics	02
MTH 651	Indian Traditional Knowledge and Practices	02
TTR 622 / PTLP	Pedagogy of Teaching-Learning Process ***(Offered and taught by the Department of Education)***	02
Optional Courses (Specialisation) (08 Credits) (The students will have to choose two courses (maximum three) from the optional course list according to their specialisation)		
IAM 602	Computational Methods	04
MTH 611	Advanced Topics in Topology and Analysis	04
MTH 644	Advanced Fluid Dynamics	04

Course Contents

Compulsory Courses (10 credits)

Course Code: MTH 601
Course Name: Research Methodology
Credits: 04 Credits
Course Instructor: Dr. Meenakshi
Course Contents:
Unit I: Fundamentals of Research: Objectives, Motivation, General Characteristics, Criterion of good research and Literature Review.
Unit II: Mathematics and its History, Identification and Evaluation of Research Problems.

Unit III: Scientific Writing: Writing a survey article, research paper, survey article and thesis writing.
Unit IV: Research Tools: LaTeX, Beamer, Reference Manager like Zotero & Mendeley, Plagiarism detection software.

References:

1. C.R. Kothari, **Research Methodology** Methods & Techniques, Second Edition, New Age International publisher, 2004.
2. J. Stillwell, **Mathematics and its History**, 3rd Edition, Springer, 2010.
3. N. E. Steenrod, P. R. Halmos, M. M. Schiffer& J. A. Dieudonné,
How to Write Mathematics, American Mathematical Society, 1973.
4. N. J. Higham, **Handbook of Writing for the Mathematical Sciences**, 2nd edition, Society for Industrial and Applied Mathematics, 1998.
5. D. E. Knuth, T. Larrabee& P. M. Roberts, **Mathematical Writing**,
Mathematical Association of America, 1989.
6. L. Lamport, LaTeX, **a Document Preparation System**, Pearson, 2008.
7. M. Goossens, F. Mittelbach, S. Rahtz, D. Roegel& H. Voss, **The LaTeX Graphics Companion**, Addison-Wesley, 2008.
8. F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C.
Rowley, **TheLaTeX Companion** (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004.
9. T. Tantau, **The BEAMER class**: User Guide for version 3.49, 12th Media Services, 2016.
10. N. R. Glassman, **Citation Management Tools: A Practical Guide for Librarians**, Rowman& Littlefield, 2018.

Course Code: CPE-RPE
Course Name: Research and Publication Ethics
Credits: 02 Credits
Course Instructor: Dr. Rakesh Kumar

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: Philosophy and Ethics: Introduction to philosophy: definition, nature and scope, concept, branches Ethics: definition, moral philosophy, nature of moral judgements and reactions;

Scientific Conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP), redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data;

Publication Ethics: Publication ethics: definition, introduction and importance, Best practices / standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

Unit II: Open Access Publishing: Open access publications and initiatives, SHERPA/RoME0 online resource to check publisher copyright & self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.;

Publication Misconduct:

A. Group Discussions: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad
B. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

Databases and Research Metrics:

A. Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.
B. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score 2. Metrics: h-index, g index, I10 index, altmetrics.

References:

Refer UGC Website / Internet : https://www.ugc.ac.in/pdfnews/9836633_Research-and-Publication-Ethics.pdf

Course Code: MTH 651
Course Name: Indian Traditional Knowledge and Practices
Credits: 02
Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%**Course Outcomes:**

After completing the course satisfactorily, a student will be able:

- To familiar with Indian thought.
- To familiar with major Indian thinkers.
- To familiar with the primary texts of Indian thought through an organized study of short Extracts in translation of those texts.
- To develop a better appreciation and understanding of not only the Knowledge Traditions and Practices of India but also of many contemporary questions.

Learning Outcomes:

- Identify the concept of Traditional knowledge and its importance.
- Explain the need and importance of protecting traditional knowledge.
- Illustrate the various enactments related to the protection of traditional knowledge.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Objectives: To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the Importance of roots of knowledge system.

Course Contents:

Unit 1:

Life of Jagadguru Śaṅkarācārya Svāmī Bhāratīkṛṣṇa Tīrtha Mahararaja, Introduction of 16 Sutra and Subsutras**.** **(10 Hrs)**

Unit 2:

Life of Srinivasa Ramanujan, Some finding of Srinivasa Ramanujan Magie Squares, Sums Related to the Harmonie Series or the Inverse Tangent Function. **(10 Hrs)**

Prescribed Text Books:

1. Bharatiya Krishna Teerth : Vedic Mathematics (Motilal Banarasidas New Delhi, 2001)
2. Bruce C. Berndt," Ramanujan's Notebooks Part 1 ", Springer (1985)

Optional Courses (08 credits)

Course Name: Computational Methods
Course Code: IAM 602
Credits: 04
Course Instructor: Prof. Rakesh Kumar
Course Objective: The purpose of this course is to acquaint the students with the advanced computational methods which can effectively treat the problems of real world phenomena.
Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)
Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.
Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%
Course Contents:

Unit I: Preliminaries of Artificial Neural Network, Multilayer Artificial Neural Network, Regression-Based ANN, Single-Layer Functional Link Artificial Neural Network, Single-Layer Functional Link Artificial Neural Network with Regression-Based Weights
Unit II: Back propagation, Recurrent Neural Networks, Convolutional Networks, Stability of Neural Networks.

Unit III: Wavelets: Preliminaries, Multiresolution analysis and the construction of wavelets; Band-limited wavelets; Other constructions of wavelets; Representation of functions by wavelets; Characterizations of function spaces using wavelets.

Unit IV: Weighted Residual methods: collocation approach, Galerkin Approach, Least Square Approach, Tau Approach; **Finite volume methods**; **Finite element methods.**

Prescribed Text Books:

1. S. Chakraverty, S.K. Jeswal, Applied Artificial Neural Network Methods for Engineers and Scientists, World Scientific, 2021.

2. S. Chakraverty, Mall, Artificial Neural Networks for Engineers and Scientists, CRC Press, 2017.

3. E. Hernhdez, G. Weis, A First Course on Wavelets, CRC Press, 1996.

4. George F. Pinder, Numerical Methods for Solving Partial Differential Equations, Wiley, 2018.

Course Code: MTH 611
Course Name: Advanced Topics in Topology and Analysis
Course Instructor: Dr S. K. Srivastava
Credits: 04
Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)
Attendance Requirement:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.
Evaluation Criteria:
1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:
Unit I: Curvature of Plane curve, Frenet-Formulas, Vector Fields, Orientation, Gaussian curvature, Mean curvature.
Unit II: Smooth manifold, Tangent space, Integral curves, Tensor Fields, Lie bracket, sub-manifold, Connection.
Unit III: Riemannian metric, Levi-Civita Connection, Parallel Transport, Geodesic, Exponential map, geodesic coordinates, first variation of arc length.
Unit IV: Isometry, Curvature Tensor, Ricci curvature, Sectional curvature, Jacobi fields, Differential forms, Poincare's Lemma, Stokes theorem.
Prescribed Text Books:

1. M.P. doCarmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
2. M.P. doCarmo, Riemannian Geometry, Birkhauser, 1992.
3. M.P. doCarmo, Differential Forms and Applications, Universitext, 1998.
4. M. Spivak, Comprensive Introduction to Differential Geometry I-V, Publish or Perish, 1999.

Suggested Additional Readings:

1. J.A. Thorpe, Elementary Topics in Differential Geometry, Springer (India), 2004.
2. S. Kumaresan, A Course on Differential Geometry and Lie Groups, HBA.
3. S. Gallot, D. Hulin and J. Lafontaine, Riemannian Geometry, Universitext, 2004.
4. B. O'Neill, Elementary Differential Geometry, Academic Press, New York, 1966.

Course Code: MTH 644

Course Name: Advanced Fluid Dynamics

Credits: 04

Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credit Equivalent: Credits (One credit is equivalent to 10 hours of lectures / organised classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Attendance Requirement:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in the examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit-I: Basic concepts and definitions; Kinematics of Fluids in Motion; Equations of Motion of Inviscid Fluid; Motion in two dimensions Sources and Sinks.

(Book 2: Chapters 1, 2, 3, 5) 12 Hrs

Unit-II: General Theory of Irrotational Motion; General theory of stress and rate of strain; The Navier-Stokes equations and the Energy equation; Dimensional similarity, Inspection Analysis and Dimensional Analysis. **(Book 2: Chapters 6, 13, 14, 15) 12 Hrs**

Unit-III: Flow Instabilities: Local Analysis of Instabilities, Linear Analysis of Global Instabilities, Some Examples of Famous Instabilities, Waves Interaction, Nonlinear Development of Instability, Optimal Perturbations. **(Book 1: Chpater 6) 8 Hrs**

Unit-IV: Thermal Convection: Introduction, Conductive Equilibrium, Two Approximations, Rayleigh-Benard Instability, Convection Patterns, Weakly Nonlinear Amplitude Range, Route to Turbulent Convection. **(Book 1: Chpater 7) 8 Hrs**

Prescribed Text Books:

1. Rieutord M (2015). Fluid Dynamics- An Introduction. Springer International Publishing, Switzerland.
2. Raisinghania M.D. (2011).Fluid Dynamics. Tenth Edition. S Chand & Company LTD. New Delhi.

Suggested Additional Books:

a. S. Chandrasekhar: Hydrodynamic and Hydromagnetic Stability (1981), Dover Publication, New York.
b. Bansal J. L. (2004). Viscous Fluid Dynamics. Second Edition. Oxford and IBH Publishing,Delhi.
c. Kundu P.K. and Cohen I.M. (2010). Fluid Mechanics. Fourth Edition. Academic Press.

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh
(Established under Central Universities Act 2009)
शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

Annexure-III

Batch 2022-24

M.Sc. Mathematics
Semester-II
(Spring Semester 2023)

Sr. No.	Course Name	Course Code	Credits
Major Courses (Disciplinary Courses) (12 Credits)			
1	Complex Analysis	IAM 401	04
2	Abstract Algebra	MTH 404	04
3	Numerical Analysis	IAM 403	02
4	Partial Differential Equations	MTH 402	02
Minor Courses (Disciplinary Courses) (02 Credits)			
5	Linear Integral Equations	MTH 432	02
Minor Courses (Inter-Disciplinary Courses) (02 Credits)			
6	To be Chosen from the Course basket at University Level which is different and distinct from the programme which s/he is enrolled in.		02
Vocational/Skill Courses (02 Credits)			
7	Basics of Fluid Dynamics	MTH 433	02
IKS (02 Credits)			
8	Introduction to Rigorous and Precise Thinking	MTH 528	02

Course Contents

Major Courses (12 Credits)

Course Code: MTH-404

Course Name: Abstract Algebra

Course Credits: 04

Course Instructor: Dr. Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

This course aims to provide a first approach to the subject of abstract algebra, which is one of the basic pillars of modern mathematics. The focus of the course will be the study of certain structures called groups, rings, fields.

Course Outcome:

By the end of the course students should be able to understand:

Co^1: The abstract definition of a group, and be familiar with the basic types of examples, including numbers, symmetry groups and groups of permutations and matrices.

Co^2: Description of algebraic techniques and basic elements of abstract algebra.

Co^3: The state axioms of groups, rings and fields.

Co^4: How apply some underlining and cross-cutting concepts of groups, rings and fields.

Co^5: The concept of cosets of a subgroup of a group and normal subgroups, symmetric groups, cyclic groups and their properties.

Co^6: The concept of quotient groups, homomorphism and isomorphism.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 40
2. End Term Examination: 120

3. Continuous Internal Assessment: 40

Course Contents:

Unit I

Laws of Composition, Groups and Subgroups, Examples of Groups and Subgroups, Groups generated by a Set, Cyclic Groups, Order of an element of a Group, Cosets, Lagrange's theorem, Index of a Subgroup, Cycle decomposition of a Permutation. Homomorphisms, Isomorphisms, Automorphisms, Normal Subgroups, Quotient Groups, The Isomorphism theorems, the Correspondence Theorem, Direct Product of Groups. **(12 hours)**

Unit II

Group Actions, Examples of Group Actions, Orbit and Stabilizer of Group Action, Orbit and Stabilizer Formula, Cayley's theorem, Conjugacy Classes, Center of a Group, Centralizer of a Subset, the Class Equation, Application of the Class Equation, the Center of a p-Group and related results, Simple Groups. **(08 hours)**

Unit III

Stabilizer and Normalizer of a Subgroup, the First Sylow theorem, the Second Sylow theorem, the Third Sylow theorem. Applications of Sylow Theorems, Definition of a Ring, Examples of Rings, Subrings, Homomorphisms of Rings, Kernel of a Homomorphism, Ideals, Ideal Generated by a Set, Principal Ideals. **(08 hours)**

Unit IV

Quotient Ring, Prime Ideals, Maximal Ideals, the Isomorphism theorems for Rings, the Universal Mapping Property of Quotient Rings, The Correspondence theorem, Dircet Product Rings, Integral Domains, Group of Units of a Ring, Associates, Irreducible Elements of Ring, Prime Elements of a Ring, Unique Factorization Domains, An Example of a Non-Unique Factorization Domain.

(12 hours)

Prescribed Text Books:

1. Isaac I.M., *Algebra: A Graduate Course, AMS (Graduate Studies in Mathematics),* Indian Edition.
2. Artin M., *Algebra,* Second Edition, PHI
3. Bhattacharya P. B., Jain S.K., Nagpaul S. R., *Basic Abstract Algebra,* Second Edition, Cambridge University Press.

Additional Text

1. Dummit D. S. and Richard M. Foote, *Abstract Algebra*, Third Edition, Wiley India
2. Jacobson N., *Basic Algebra,* Vol. 1, Hindustan Publishing Corporation, Delhi

Course Articulation Matrix MTH-404- Abstract Algebra

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3
CO1	1	1	3	2		1	1	2
CO2	2	3	1	1		1	1	2
CO3	1	2	2	3		2	2	2
CO4	2	1	2	3		2	1	1
CO5	1	2	3	1		2	1	2
CO6	1	1	1	1		1	1	1

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 401

Course Name: Complex Analysis

Credits: 04

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives: The objectives of this course are to:

- Provide an introduction to the indispensable ideas for the development of the functions of a complex variable and
- equip students with clear understanding of the elementary concepts of the theory of complex analysis and skills to enable them to work with the concepts effectively.

Course Outcomes: After successful completion of the course the student will be able:

CO$^{1:}$ To understand Stereographic projection, analytic functions and singularities.

CO$^{2:}$ To understand Branch point, conformal transformations and homotopic curves.

CO$^{3:}$ To learn basics of complex integrations and Fundamental theorem of algebra.

CO$^{4:}$ To understand Maximum-Modulus theorem and Rouche's theorem etc.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40
End Term Examination: 120
Continuous Internal Assessment: 40

Course Contents:

UNIT-I: Complex Numbers, Geometric description, Stereographic projection, Analytic functions, the Cauchy-Riemann equations, multivalued functions, Branch point. **(10 Hours)**

UNIT-II: Complex integration, Cauchy-Goursat theorem, Cauchy integral formula, Derivatives of analytic

function. **(10 Hours)**

UNIT-III: The Liouville theorem, The Morera theorem, Maximum-Modulus theorem, conformal transformations. **(10 Hours)**

UNIT-IV: Taylor's series, Laurent's series, Singularities of complex functions, the Cauchy Residue theorem, Evaluation of integrals. **(10 Hours)**

Prescribed text book:

J. B. Conway, Functions of one complex variable, International Student-Edition, Narosa Publishing House, 2000.

Reference books:

- K. Kodaira, Complex Analysis, Cambridge University Press,2007.
- J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill,8thEdition,2008.

CourseArticulationMatrixofIAM401-ComplexAnalysis

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	ProgrammeOutcomes 4		Programme SpecificOutcomes 1	ProgrammeSpecificOutcomes 2
CO^1	3	2	1	1		3	2
CO^2	3	2	1	1		3	2
CO^3	3	2	1	1		3	2
CO^4	3	2	1	1		3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: IAM 403

Course Name: Numerical Analysis

Credits: 02

Course Instructor: Prof. Rakesh Kumar

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main objective of this course is to familiarize the students with basic numerical schemes and their applications.

Course Outcomes: After completing the course satisfactorily, the student will be able to:

CO1: Interpolate and approximate functions.
CO2: Perform numerical differential and integration.
CO3: Perform error analysis.
CO4: Apply basic numerical algorithms.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination:20%
End Term Examination:60%
Continuous Internal Assessment: 20%. i.e. 20 marks out of 100

Course Contents:

Unit I: Lagrange and Newton interpolations, interpolations using finite differences, Hermite interpolation, piecewise and spline interpolation, Polynomial approximation: least square approximation, orthogonal polynomials, uniform approximation, rational approximation. **(07 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit II: Numerical Differentiation and Integration: methods based on interpolation, methods based on undetermined coefficients, composite integration methods, Romberg integration. **(07 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

Unit III: Initial and Boundary value problems: Taylor's series method, Runge-Kutta methods, shooting method. **(06 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems
- Performing simulations for the pattern of solutions

General Practicum:

i. Class Room Presentation
ii. Model/Chart/PowerPoint based presentations
iii. Assignment/ Write Up/Creative work
iv. Books/Journals Readings
v. Tutorials/PBL

Prescribed Text Book:

1. M.K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods, 6th Edition, New Age International (P) Limited, Publishers, New Delhi.

Suggested Additional Readings:

1. S. S. Sastri; Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd., 2005.
2. S.C. Chapra: Applied Numerical Methods with MATLAB, McGraw Hill, 2012.

Course Articulation Matrix of IAM 403- Numerical Analysis

Course Outcomes	Programme Specific Outcomes 1	ProgrammeSpecific Outcomes 2	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4
CO1	3	2	2	3	2	1
CO2	3	2	2	3	2	1
CO3	3	3	3	2	2	2
CO4	2	3	3	2	1	1

1. Partially Related 2. Moderately Related 3. Highly Related

Course Code: MTH 402

Course Name: Partial Differential Equations

Credits: 02

Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main objective of this course is to familiarize the students with the basic idea of Partial Differential Equations, their formation and different solution techniques along with numerous applications.

Course Outcomes: After completing the course satisfactorily, the student will be able:

CO1: To form partial differential equations for different configurations.

CO2: To Classify the distinct types of partial differential equations.

CO3: To Understand the various mathematical techniques to handle the partial differential equations.

CO4: To apply the knowledge of partial differential equations in some physical problems.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 20%
End Term Examination: 60%
Continuous Internal Assessment: 20%. i.e. 20 marks out of 100

Course Contents:

Unit I: Partial Differential equations of first order: Formation of Partial Differential Equation; Solution of Partial Differential Equations of First Order; Integral Surfaces Passing Through a Given Curve; The Cauchy Problem for First Order Equations; Surfaces Orthogonal to a Given System of Surfaces; First Order Nonlinear Equations; Cauchy Method of Characteristics; Compatible Systems of First Order Equations; Charpit's Method.

Fundamental concepts: Classification of second order partial differential equations, Canonical forms, adjoint operators**. (10 Hrs)**

Unit II: Elliptic partial differential equations: maximum-minimum principle, separation of variables; Parabolic partial differential equations: maximum-minimum principle, separation of variables; and hyperbolic partial differential equations: separation of variables. **(10 Hrs)**

Prescribed Text Books:

1. K. Sankara Rao: Introduction to partial differential equations, PHI Learning Private limited, Delhi, 2011.

2. W.A. Strauss; Partial differential equations an introduction, John Wiley & Sons, 2008.

Suggested Additional Readings:

1. D. Bleecker & G. Csordas; Basic partial differential equations, VAN NOSTRAND REINHOLD NewYork, 1992 .

2. M. Renardy & R.C. Rogers: An introduction to partial differential equations, Springer, 2009.

3. H.F. Weinberger: A first course in partial differential equations, Dover, 1995.

Course Articulation Matrix of MTH 402- Partial Differential Equations

Course Outcomes	Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4
CO1	2	1	2	2	1	1
CO2	1	1	2	2	1	1
CO3	3	2	3	3	2	1
CO4	2	3	2	3	2	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Minor Courses (04 Credits)

Course Code: MTH 432

Course Name: Linear Integral Equations

Credits: 02

Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures/organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work /Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/ dissertation/ thesis; seminars, etc.)

Course Objective: The purpose of this course is to acquaint the students with the linear integral equations.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^1 The methods of solving Fredholm integral equations.

CO^2 The methods of solving Volterra integral equations.

CO^3 The eigenvalues and eigenfunctions.

CO^4 Resolvent kernels and Symmetric kernels.

AttendanceRequirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Review the basic concepts for solving ODE: First order and second order Linear differential equations, Series solution for ODE where x=0 is ordinary point, Leibnitz rule for differentiation of integrals, Cauchy formula for reducing multiple integrals to single integral and Laplace transforms. Integral equations: classification of integral equations; conversion from IVP to Volterra integral equations and conversely; conversion from BVP to Fredholm integral equations and conversely, Integral equations with separable kernels. **(10 Hours)**

Unit II: Method of successive approximations, eigenvalues and eigenfunctions, Resolvent kernels, Symmetric kernels, Hilbert Schmidt theorem and solution of symmetric integral equations. **(10 Hours)**

Prescribed Text Book:

M.D. Raisinghania (2016), Integral equations and boundary value problems, S. Chand Publishing.

Suggested Additional Reading:

F.G. Tricomi, (1985): Integral Equations, Cambridge University Press.

Course Articulation Matrix of MTH 432 - Linear Integral Equations

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	2	1	1		3	2
CO^2	3	2	1	1		3	2
CO^3	3	2	1	1		3	2
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Vocational/Skill Courses (02 Credits)

Course Code: MTH 433

Course Name: Basics of Fluid Dynamics

Credits: 02

Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The purpose of this course is to acquaint the students with the basics of fluid dynamics.

Course Outcomes:

After successful completion of the course, a student will be able to understand:

CO^1 The basic knowledge of various kinds of fluid flows.
CO^2 Basic laws and hypotheses observed in the dynamics of distinct fluids.
CO^3 Basic hydrodynamical equations related to different fluid flow problems.
CO^4 The knowledge of different basic mathematical tools which are important to analyze fluid flow.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Basic concepts: Types of fluids and flows, continuum hypothesis, Newton's law of

viscosity, thermal conductivity, rotation and circulation, stress and rate of strain.

Unit II: Kinematics of flow field: Lagrangian and Eulerian approach, streamlines, pathlines,

streaklines, material derivative, stream function and its physical significance, vorticity vector, complex velocity potential, Kelvin's minimum energy theorem, source, sink, doublet and images in two dimensions drag and lift force, Kutta-Jukowski theorem.

Unit III: Basic hydrodynamic equations: Equation of continuity; Euler's equation; Kelvin's circulation theorem; Bernoulli equation; The Navier-Stokes equations and the equation of energy.

Unit IV: Dynamical similarity: Inspection and dimensional analysis; Rayleigh's technique; Buckingham theorem.

Prescribed Text Books:

1. Raisinghania M.D. (2011).Fluid Dynamics. Tenth Edition. S Chand & Company LTD. New Delhi.

2. Bansal J. L. (2004). Viscous Fluid Dynamics. Second Edition. Oxford and IBH Publishing, Delhi.

Suggested Additional Readings:

1. Kundu P.K. and Cohen I.M. (2010). Fluid Mechanics. Fourth Edition. Academic Press.

Course Articulation Matrix of MTH 433 - Basics of Fluid Dynamics

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4		Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	2	3	1	1		2	2
CO^2	3	3	1	1		3	2
CO^3	3	2	1	1		3	3
CO^4	3	2	1	1		2	3

1. Partially Related
2. Moderately Relate
3. Highly Related

IKS (02 Credits)

Course Code: MTH 528

Course Name: Introduction to Rigorous and Precise Thinking

Credits: 02

Course Instructor: **Dr. Pankaj Kumar S/O Late Sh. Maniram**

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objectives:

The objectives of this course are:

- To understand what is mathematics and its purpose
- To think for the development of Mathematics
- To know about why we need to learn about Mathematics
- To precise about mathematical statements
- To perform different types of proofs

Course Outcomes:

After successful completion of the course the student will be able:

CO^1 Explain different definitions of Mathematics

CO^2 Explain the basic ideas for the development of Mathematics

CO^3 Explain logical combinatorics

CO^4 To possess the knowledge to approach for proofs of Mathematical statements

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

UNIT-I: Rigorous Thinking, Types of Thinking, procedure of thinking, Getting precise about language, the logical combinatorics, Implication, Quantifiers. **(10 Hours)**

UNIT-II: Rigorous Mathematical Thinking, Computational Thinking, Reasoning, Logics, Arguments, Predicate, Quantifier, assertion and reason. Language and Grammar. **(10 Hours)**

Prescribed text book:

Keith Devlin, Introduction to Mathematical Thinking, Publisher: Keith Devlin, 331 Poe St, Unit 4, Palo Alto, CA 94301, USA

Course Articulation Matrix of MTH 528- Introduction to Rigorous and Precise Thinking

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	1	3	3
CO^2	3	3	2	1	3	2
CO^3	3	3	2	1	3	2
CO^4	3	3	2	2	3	3

1. Partially Related
2. Moderately Relate
3. Highly Related

Annexure-III (a)

M.Sc. Mathematics
Semester-IV
(Spring Semester, 2023)

Sr. No.	Course Name	Course Code	Credits
Major Courses (Disciplinary Courses) (04 Credits)			
1	Number Theory	MTH 510	04
Minor Courses (Disciplinary Courses) (04 Credits)			
2	The Basics of Scientific Writing	MTH 552	02
3	Practical (Paper Publications/Seminar-Conference Presentation at National Level)	MTH 559	02
Vocational/Skill Courses (04 Credits)			
4	Fundamentals of Statistics	MTH 410	04
Dissertation & Viva-Voce (08 Credits)			
5	Dissertation and Viva-Voce	MTH 590	08

Major Courses (Disciplinary Courses) (04 Credits)

Course Code: MTH 510

Course Name: NUMBER THEORY

Course Credit: 04

Course Instructor: Dr Meenakshi

Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom

activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main aim of this course is to introduce the basic concepts of Number Theory, certain number theoretic functions and their properties

Course Outcome:

By the end of the course students will be able:

CO^1: To work on the solution of algebraic equations and on the theory of numbers.
CO^2: To know a more efficient avenue for testing whether certain numbers are roots of polynomials
CO^3 : To understand how Wilson's Theorem is used to construct formulas for primes
CO^4: To understand primitive roots and learn how to use them in proofs and explicit constructions
CO^5: To explore Prime number theory

Attendance Requirements

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must, failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

Mid Term Examination: 40

End Term Examination: 120

Continuous Internal Assessment: 40

Course Contents:

Unit I:

Mathematical Induction and Binomial Theorem , The Integers, The Division Algorithm, The Greatest Common Divisor, The Euclidean Algorithm, The Diophantine Equation. **(10 Hours)**

Unit II:

The Fundamental Theorem of Arithmetic, Basic Properties of Congruence, Binary and Decimal Representation of Integers, Line**ar Congruences and the Chinese Remainder Theorem (10 Hours)**

Unit III:

Fermat's Little Theorem and Pseudoprimes, Wilson's Theorem, The Fermat-Kraittchik Factorization Method, The Sum and Number of Divisors, The Mobius Inversion Formula, the Greatest Integer Function **(10 Hours)**

Unit IV:

Leonard Euler, Euler's Phi-Function, Euler's Theorem, Properties of the Phi-Function, The order of an Integer Modulo , Primitive Roots of Primes, Composite Numbers Having Primitive Roots, The Theory of Indices

(10 Hours)

Prescribed Text Books:

1. David M. Burton : Elementary Number Theory, Seventh Edition, McGraw Hill, 2009.
2. Kenneth H. Rosen, Elementary Number Theory and its Applications, 6th ed., Pearson, 2014

Suggested Additional Readings:

1. Baker A.: A Concise Introduction to the Theory of Numbers, First Edition, Cambridge University Press, 1984.

Course Articulation Matrix MTH 510- NUMBER THEORY

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	3	2	2	1	2	3
CO2	2	2	1	1	2	1
CO3	1	2	1	2	2	2
CO4	2	2	2	3	2	2
CO5	2	2	2	3	2	3

1. Partially Related
2. Moderately Related
3. Highly Related

Minor Courses (Disciplinary Courses) (04 Credits)

Course Code: **MTH 552**
Course Name: **The Basics of Scientific Writing**
Course Credit: **02**
Course Instructor: Dr S. K. Srivastava

Credits Equivalent: (One credit is equivalent to 10 hours of lectures/organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work /Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/ dissertation/ thesis; seminars, etc.)

Course Objective: The purpose of this course is to develop a research orientation among the Students of Mathematics and to acquaint them with the Fundamentals of Scientific writings and Research Tools.

Course Outcomes: After successful completion of the course, a student will be able to understand:

CO^1 Scientific Writing

CO^2 Latex

CO^3 Beamer

CO^4 Plagiarism

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examinations.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20

Course Contents:

Unit I: Scientific Writing: Writing a survey article, research paper, dissertation, and thesis writing. **(10 Hours)**

Unit II: Research Tools: LaTeX, Beamer, Reference Manager like Zotero & Mendeley, Plagiarism detection software.
(10 Hours)

Prescribed Text Book:

[1] N. J. Higham, **Handbook of Writing for the Mathematical Sciences**, 2nd edition, Society for Industrial and Applied Mathematics, 1998.

[2] D. E. Knuth, T. Larrabee & P. M. Roberts, **Mathematical Writing**, Mathematical Association of America, 1989.

[3] L. Lamport, LaTeX, **a Document Preparation System**, Pearson, 2008.

Suggested Additional Reading:

[1] M. Alley, **The Craft of Scientific Writing** Fourth Edition, Springer, 2018.

[2] M. Goossens, F. Mittelbach, S. Rahtz, D. Roegel & H. Voss, **The LaTeX Graphics Companion**, Addison-Wesley, 2008.

[3] F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C. Rowley, **The LaTeX Companion** (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004.

[4] T. Tantau, **The BEAMER class**: User Guide for version 3.49, 12th Media Services, 2016.

[5] N. R. Glassman, **Citation Management Tools: A Practical Guide for Librarians**, Rowman &

Littlefield, 2018.

Course Articulation Matrix of MTH 552 - The Basics of Scientific Writing

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO^1	3	3	2	2	3	2
CO^2	3	2	2	2	3	2
CO^3	3	2	2	2	3	2
CO^4	3	2	2	2	3	2

1. Partially Related
2. Moderately Relate
3. Highly Related

Course Code: MTH 559

Course Name: Practical (Paper Publications / Seminar-Conference Presentation at National Level)

Course Credit: 02

Course Instructor: All Faculty Members

The evaluation criteria will be adopted as per the necessary directions from the University or as per approval from BoS.

Vocational/Skill Courses (04 Credits)

Course Code: MTH 410

Course credit: 04

Course Name: Fundamentals of Statistics

Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credit Equivalent: 04 Credits (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual / group work; obligatory / optional work placement; literature survey / library work; data collection / field work; writing of papers / projects / dissertation / thesis; seminars, etc.)

Course Objectives: The prime objective of this course is to make an understanding about the statistics in the students.

Course Outcomes

After completing the course satisfactorily, a student will be able:

CO^1 To characterize probability models and function of random variables based on single & multiples random variables.

CO^2 To understand the Basic Statistical Laws and Theoretical results.

CO^3 To understand advanced topics like WLLN, SLLN and others.

CO^4 To understand the concept of correlation.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Unit 1

Random Variable, Probability Mass Function, Probability Density Function, Cumulative Distribution Function. Expectation of a Random Variable, Properties of Expectation, Conditional Expectation And Its Properties, Bivariate Distributions and the Joint Probability Distribution, Independence of random variables, Marginal and Conditional Distributions, Discrete and Continuous Random Variable.

Unit 2

Expectation and Variance, Moment Generating Function, Probability Generating Function, Cumulative Generating Function, Characteristic Function and Their Properties, Continuity and Uniqueness Theorems.

Unit 3

Standard Discrete and Continuous Univariate Distributions. Convergence in Probability, Almost Sure Convergence, Convergence in Distribution and Their Relationships. Chebyshev's Inequality, Weak Law of Large Numbers (WLLN), Strong Law of Large Numbers (SLLN), Central Limit Theorems.

Unit 4

Karl Pearson's Correlation Coefficient, Spearman's Rank Correlation Coefficient, Principle of Least Square, Lines Of Regression, Simple Linear Regression, Coefficient Of Determination, Multiple Linear Regression, Coefficient of Multiple Determination.

Prescribed Text Book:

1. Hogg, R.V., McKean, J. & Craig, A.T. (2013). Introduction to Mathematical Statistics, 7th Edition. Pearson
2. Gupta S. C. and V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, Delhi.
3. Goon, A.M., Gupta, M.K. & Dasgupta, B. (2016). Fundamentals of Statistics, Vol. I & II. World Press.

Course Articulation Matrix MTH-410 Fundamentals of statistics

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Outcomes 3	Programme Outcomes 4	Programme Specific Outcomes 1	Programme Specific Outcomes 2
CO1	2	2	2	2	2	2
CO2	2	2	3	2	2	2
CO3	2	2	2	2	2	2
CO4	2	3	2	2	2	2

1. Partially Related

2. Moderately Related

3. Highly Related

Dissertation & Viva-Voce (08 Credits)

Course Code: MTH 590

Course Name: Dissertation and Viva-Voce

Course Credit: 08

Course Instructor: All Faculty Members

The evaluation criteria will be adopted as per the necessary directions from the University or as per approval from BoS.

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय

Central University of Himachal Pradesh

(Established under Central Universities Act 2009)

शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206

Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206

Website: www.cuhimachal.ac.in

Annexure-III (b)

INTERDISCIPLINARY COURSES OFFERED BY THE SRINIVASA RAMANUJAN DEPARTMENT OF MATHEMATICS

Spring Semester 2023

Sr. No.	Course Name	Course Code	Credit
1.	Partial Differential Equation and Integral Equations	MTH 408	02
2.	Vedic Mathematics	IAM 412	02

Course Name: Partial Differential Equation and Integral Equations

Course Code: MTH 408

Credits: 02

Course Instructor: Dr. Pankaj Kumar S/O Sh. Krishan Singh

Credits Equivalent:

(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The prime objective of this course is to provide the basic knowledge of partial differential equations and integral equations by focussing at the various physical aspects of the equations through the different solution schemes/ techniques.

Course Outcomes:

After completing the course satisfactorily, a student will be able:

CO1 To explain about the Linear and Non Linear partial differential equations (of particular order and degree) and their formation along with their solution.

CO2 To know about Lagrange's method, Charpit's method along with their distinct approach to solve the Partial differential equations.

CO3 To explain about the basic integral equations, especially some special kind of integral equations and their solutions.

CO4 To convert the ordinary differential equations (of specific order and degree) into their respective integral equations.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20
2. End Term Examination: 60
3. Continuous Internal Assessment: 20**.**

Course Contents:

Unit I: Origin of partial differential equations, Linear partial differential equations of order one: Lagrange's method, Non linear partial differential equations of order one: Charpit's method, Homogeneous linear partial differential equations with constant coefficients. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

UNIT-II: Integral Equations: Preliminary concepts, Conversion of ordinary differential equations into integral equations, Homogeneous Fredholm Integral equations of the second kind with separable (degenerate) kernels, Fredholm Integral equations of the second kind with separable (degenerate) kernels. **(10 Hrs)**

Practicum

- Solving the Exercises of the selected Chapters.
- Implementation on the selected real world problems.

General Practicum:

i. Classroom Presentation

ii. Model/Chart/PowerPoint based presentations

iii. Assignment/ Write Up/Creative work

iv. Books/Journals Readings

v. Tutorials/PBL

Essential Readings:

1. M.D. Raisinghania (2013). Ordinary and Partial Differential Equations, Eighteenth Edition, S. Chand.

2. M.D. Raisinghania (2013). Integral equations and Boundary value problems, Sixth Edition, S. Chand.

Suggested Additional Readings:

1. A.D. Polyanin, A.V. Manzhirov. Handbook of Integral equations, Second Edition, Chapman & Hall/ CRC.

Course Code: IAM 412

Course Name: Vedic Mathematics

Course credit: 02

Course Instructor: Dr. Pankaj Kumar S/O Late Sh. Maniram

Credits Equivalent:

(One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination:20%
2. End Term Examination:60%
3. Continuous Internal Assessment: 20%. i.e. 20 marks out of100

Course Outcomes: On completion of the course, the students will be able:

- To understand the idea of different vedic sutras and sub-sutras.
- To apply 16 sutras and 13 sub-sutras.

Learning Outcomes

The deliverables Learning Outcomes of this paper with students are following:

- Can explain the idea of sixteen sutras of Vedic Tradition.
- Can also explain the idea of sub-sutras of Vedic Tradition.
- Can take quick decisions through the use of Sutras and their corollaries.

Attendance Requirements:

Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:

1. Mid Term Examination: 20%
2. End Term Examination: 60%
3. Continuous Internal Assessment: 20%

Course Contents:

Unit I: The 16 Sutras: Ekadhikina Purvena, Nikhilam Navatashcaramam Dashatah, Urdhva-Tiryagbyham, Paraavartya Yojayet, Shunyam Saamyasamuccaye, (Anurupye) Shunyamanyat, Sankalana-vyavakalanabhyam, Puranapuranabyham, Chalana-Kalanabyham, Yaavadunam, Vyashtisamanstih, Shesanyankena Cha.ramena, Sopaantyadvayamantyam, Ekanyunena Purvena, Gunitasamuchyah, Gunakasamuchyah **(10 HRS)**

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems

Unit II: Corollary: Anurupyena, Sisyate Sesasamjnah, Adyamadyenantyamantyena, Kevalaih Saptakam Gunyat, Vestanam, Yavadunam Tavadunam, Yavadunam Tavadunikritya Varga Yojayet, Antyayordashake'pi, Antyayoreva, Samuccayagunitah, Lopanasthapanabhyam, Vilokanam, Gunitasamuccayah Samuccayagunitah, Dhvajanka, Dwandwa Yoga, Adyam Antyam Madhyam.

(10 HRS)

Practicum

- Solving the Exercises of the selected Chapters
- Implementation on the selected real world problems

General Practicum:

i. Class Room Presentation

ii. Model/Chart/PowerPoint based presentations

iii. Assignment/ Write Up/Creative work

iv. Books/Journals Readings

v. Tutorials/PBL

Essential Reading :

1. Bharati Krishna Tirtha, Vedic Mathematics, Motilal Banarsidass, New Delhi, (2001).

Annexure-IV

List of New Courses to be offered to MSc Mathematics w.e.f. Academic Year 2022-23

Minor Courses (16 credits)

S. No.	Course Code	Course Name	Credit	Pre-requisite/ Remarks
1.	MTH 431	Calculus of Variations	02	
2.	MTH 432	Linear Integral Equations	02	
3.	MTH 559	Practical (Paper Publications / Seminar-Conference Presentation at National Level)	02	

Vocational/ Skill Courses (14 credits)

S. No.	Course Code	Course Name	Credit	Pre-requisite/ Remarks
1.	IAM 402A	Ordinary and Partial differential Equations	04	
2.	MTH 433	Basics of Fluid Dynamics	02	

Review of Literature, Research Proposal (Credit 08)

S. No.	Course Code	Course Name	Credit	Pre-requisite/ Remarks
1.	MTH 405A	Lebesgue Measure and Integration	04	
2.	MTH 557	Dynamical Aspects of Fluid Flows	04	
3.	MTH 558	Fundamentals of Cryptography	04	
4.	MTH 626A	Galois Theory	04	
5.	MTH 560	Introduction to Artificial Neural Network	04	

[$]University has issued the guidelines for the implementation of NEP 2020 which are subject to the approval from Academic Council and Executive Council, CUHP.

Annexure-IV (a)

Updated Comprehensive Approved List of PhD Courses

Proposed list of new courses for Ph.D. course work in the Srinivasa Ramanujan Department of Mathematics

S. No.	Course Code	Course Name	Course Credits	Remarks
1.	MTH 644	Advanced Fluid Dynamics	4	
2.	MTH 645	Hydrodynamic Stability Theory	4	

Annexure-V

Approved Course Scheme for Master Degree Programme of Two Years duration (Four Semeters) [$]

2 YEARS MASTER'S DEGREE PROGRAMME
Total Credits: 80
Credit per Semester: 20
Eligibility: 3 Year Bachelor's Degree Programme

Semester	Disciplinary/ Interdisciplinary : Major Course	Disciplinary/ Interdisciplinary : Minor Course	Vocational / Skill	IKS	Review of Literature, Research Proposal	Dissertation & Viva-Voce	Total
1st	10	04	04	02+	0	0	20
2nd	12	04	02	02#	0	0	20
3rd	04 Elective Specialization (*Course basket is to be offered)*	04* (Research Methodology)	04* Software based Data Analysis (Available in the concerned subject / field)	0	08*	00	20
4th	04 Elective Specialization (*Course basket is to be offered)*	02 **Theory** (Academic Writings) 02 **Practical** (Paper Publications / Seminar - Conference Presentation at National Level)	04* Subject based Data Analysis and Interpretation	0	0	08 50% Dissertation 50% Presentation & Viva-Voce	20
Total	**30**	**16**	**14**	**04**	**08**	**08**	**80**

+02 Credits Course Developed by University Level Committee and uniform for all the programmes.
 # 02 Credits Course Developed by the Department concerned.
** 50% Theory and 50% Practical.*

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Updated Course Basket for Master Degree Programme (MSc Mathematics) of Two Years duration (Four Semeters) in Srinivasa Ramanujan Department of Mathematics as Per NEP 2020 Guidelines of CUHP[$]

Name of Programme: M.Sc. Mathematics
Duration: Two Years (Four Semester)
Total Credits: 80
Credit per Semester: 20

Major Courses (30 credits)

S. No.	Course Code	Course Name	Credit	Pre-requisite/Remarks
1.	MTH 401	Ordinary Differential Equations	02	
2.	MTH 402	Partial Differential Equations	02	
3.	MTH 403	Linear Algebra	04	
4.	MTH 404	Abstract Algebra	04	
5.	MTH 406	Real Analysis	04	
6.	IAM 401	Complex Analysis	04	
7.	IAM 403	Numerical Analysis	02	
Elective Specialization				
1.	MTH 405	Lebesgue Measure and Integration	02	MTH 406
2.	MTH 408	Partial Differential Equation and Integral Equations	02	
3.	MTH 413	Probability Theory	02	
4.	MTH 504	Mechanics	02	
5.	MTH 505	Fuzzy Sets and Fuzzy Systems	04	
6.	MTH 508	Graph Theory	02	
7.	MTH 510	Number Theory	04	
8.	MTH 512	Introduction to Algebraic Topology	04	
9.	MTH 514	Global Differential Geometry	04	
10.	MTH 515	Non-Commutative Rings	04	
11.	MTH 516	Introduction to Representation Theory	04	
12.	MTH 517	Stochastic Differential Equations	04	
13.	MTH 519	Introduction to Commutative Algebra	04	
14.	MTH 520	Field Theory and Galois Theory	04	
15.	MTH 521	Introduction to Elliptic Curve	02	
16.	MTH 607	Coding Theory & Applications	04	
17.	MTH 608	Advanced Complex Analysis	04	
18.	MTH 609	Advanced Algebra	04	MTH 404
19.	MTH 610	Algebraic Number Theory	04	
20.	MTH 611	Advanced Topics in Topology and Analysis	04	MTH 501
21.	MTH 613	Category Theory	04	
22.	MTH 614	Differentiable Structures on Manifolds	04	

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23.	MTH 615	Algebraic Curves	04	
24.	MTH 616	Projective Representations of the Symmetric Groups	04	
25.	MTH 617	Banach Algebras	04	
26.	MTH 618	Differentiable Manifolds and Lie groups	04	MTH 403, MTH 501
27.	MTH 619	Mechanics of Fluids	04	
28.	MTH 620	Group Analysis of Differential Equations	04	
29.	MTH 621	Categories and Modules	04	
30.	MTH 623	Introduction to Algebraic Geometry	04	
31.	MTH 624	Commutative Algebra	04	
32.	MTH 625	Introduction to Homological Algebra	04	
33.	IAM 406	Theory of Elasticity	02	
34.	IAM 410	General Relativity and Cosmology	02	
35.	IAM 413	Introduction to Fourier Analysis	02	
36.	IAM 501	Functional Analysis	02	
37.	IAM 502	Advanced Numerical Analysis	04	
38.	IAM 503	Mathematical Analysis	02	
39.	IAM 506	Finite Element Methods	04	
40.	IAM 512	Queues and Reliability	04	
41.	IAM 513	Computer Graphics	04	
42.	IAM 516	Spectral Methods	04	
43.	IAM 517	Mesh Free Methods	04	
44.	IAM 520	Theory of Vibrations	04	
45.	IAM 521	Advanced Fluid Dynamics	04	
46.	IAM 602	Computational Methods	04	
47.	IAM 603	Applied Functional Analysis	04	
48.	IAM 604	Advanced Mathematical Methods	04	
49.	IAM 606	Fractional Differential Equations	04	

Minor Courses (16 credits)

S. No.	Course Code	Course Name	Credit	Pre-requisite/Remarks
1.	MTH 501	Topology	02	MTH 406
2.	IAM 404	Mathematical Methods	04	
3.	IAM 407	Differential Geometry	02	
4.	MTH 550	M.Sc. Project	04	
5.	MTH 551	Research Methodology	04	
6.	MTH 552	The basics of Scientific Writing	02	
7.	MTH 553	Term Paper	02	
8.	IAM 550	Project and Seminar Based on Practical Training with Industry	04	
9.	MTH 431	Calculus of Variations	02	New Course

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10.	MTH 432	Linear Integral Equations	02	New Course
11.	MTH 559	Practical (Paper Publications / Seminar-Conference Presentation at National Level)	02	New Course

Vocational/ Skill Courses (14 credits)

S. No.	Course Code	Course Name	Credit	Pre-requisite/Remarks
1.	MTH 410	Fundamentals of Statistics	04	
2.	MTH 411	Introduction to Projective Geometry	02	
3.	MTH 412	Introduction to Non-Euclidean Geometry	02	
4.	MTH 420	Basics of Python Programming	02	
5.	MTH 421	Programming in C	02	
6.	MTH 422	Programming in C++	02	
7.	MTH 423	Android Programming	02	
8.	MTH 424	Cyber Security	02	
9.	MTH 425	Internet of Things	02	
10.	MTH 430	Cyber Laws	02	
11.	MTH 502	Operational Research	02	
12.	MTH 503	Discrete Mathematics	02	
13.	MTH 506	Software Lab	02	
14.	MTH 507	Approximation Theory	02	
15.	MTH 511	Numerical Mathematical Analysis	02	
16.	MTH 522	Analytic Number Theory	02	
17.	MTH 527	Introduction to Mathematical Statistics	02	
18.	MTH 529	Basics of Propositional Logic	02	
19.	MTH 545	Introduction to Latex Programming	02	
20.	MTH 548	Cryptography	02	
21.	MTH 549	Community Lab	02	
22.	MTH 606	Principle of Mathematics and Techniques	04	
23.	MTH 626	Galois Theory	02	
24.	IAM 402	Ordinary and Partial differential Equations	02	
25.	IAM 405	Fluid Dynamics	04	
26.	IAM 408	Mathematical Modelling	02	
27.	IAM 409	Applied Algebra	04	
28.	IAM 414	Introduction to Geometry	02	
29.	IAM 416	Computational Number Theory	02	
30.	IAM 504	Computer Applications	02	
31.	IAM 505	Mathematical Modelling and Simulations	04	
32.	IAM 507	Wavelet Theory	04	
33.	IAM 508	Image Processing	02	
34.	IAM 509	Robotics and Control	02	
35.	IAM 510	Artificial Intelligence	02	
36.	IAM 511	Computer Aided Design	02	

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37.	IAM 514	Data Base Management	02	
38.	IAM 515	Bio-Mathematics	02	
39.	IAM 518	Optimization Techniques	02	
40.	IAM 519	Data Structure Techniques	02	
41.	IAM 523	Special Functions	02	
42.	IAM 524	Mathematical Packages	02	
43.	IAM 525	Financial Mathematics	02	
44.	IAM 526	Integral Equations and Boundary Value Problems	02	
45.	IAM 402A	Ordinary and Partial differential Equations	04	New Course
46.	MTH 433	Basics of Fluid Dynamics	02	New Course

Indian Knowledge System Courses (Credit 04)

Courses at Department Level (Credit 02)				
S. No.	**Course**	**Course Name**	**Credit**	**Pre-requisite/Remarks**
1.	MTH 426	Mathematics in Ancient India	02	
2.	MTH 427	Mathematics in Medieval India	02	
3.	MTH 428	Contributions of Bhaskaracharya	02	
4.	MTH 429	Geometry in Ancient India	02	
5.	MTH 528	Introduction to Rigorous and Precise Thinking	02	
6.	IAM 411	Mathematics for Social Sciences	02	
7.	IAM 412	Vedic Mathematics	02	
8.	IAM 415	Elementary Number Theory	02	
Courses at University Level (Credit 02)				
S. No.	**Course**	**Course Name**	**Credit**	**Pre-requisite/Remarks**
	IKS	Indian Knowledge System	02	

Review of Literature, Research Proposal (Credit 08)

S. No.	Course Code	Course Name	Credit	Pre-requisite/Remarks
1.	MTH 555	Review of Literature	04	
2.	MTH 556	Research Proposal	04	
3.	MTH 405A	Lebesgue Measure and Integration	04	New Course
4.	MTH 557	Dynamical Aspects of Fluid Flows	04	New Course
5.	MTH 558	Fundamentals of Cryptography	04	New Course
6.	MTH 626A	Galois Theory	04	New Course
7.	MTH 560	Introduction to Artificial Neural Network	04	New Course

Dissertation and Viva-Voce (Credit 08)

[$]University has issued the guidelines for the implementation of NEP 2020 which are subject to the approval from Academic Council and Executive Council, CUHP.

S. No.	Course	Course Name	Credit	Pre-requisite/Remarks
1.	MTH 590	Dissertation & Viva-Voce	08	

[$]University has issued the guidelines for the implementation of NEP 2020 which are subject to the approval from Academic Council and Executive Council, CUHP.

Annexure V(a)

Updated Comprehensive Approved List of Ph.D. course work in the Srinivasa Ramanujan Department of Mathematics

S. No.	Course Code	Course Name	Course Credits	Remarks
1.	MTH 601	Research Methodology	4	
2.	MTH 606	Principle of Mathematics and Techniques	4	
3.	MTH 607	Coding Theory & Applications	4	
4.	MTH 608	Advanced Complex Analysis	4	
5.	MTH 609	Advanced Algebra	4	
6.	MTH 610	Algebraic Number Theory	4	
7.	MTH 611	Advanced Topics in Topology and Analysis	4	
8.	MTH 614	Differentiable Structures on Manifolds	4	
9.	MTH 615	Algebraic Curves	4	
10.	MTH 616	Projective Representations of the Symmetric Groups	4	
11.	MTH 617	Banach Algebras	4	
12.	MTH 618	Differentiable Manifolds and Lie groups	4	
13.	MTH 619	Mechanics of Fluids	4	
14.	MTH 620	Group Analysis of Differential Equations	4	
15.	MTH 621	Categories and Modules	4	
16.	MTH 623	Introduction Algebraic Geometry	4	
17.	MTH 624	Commutative Algebra	4	
18.	MTH 625	Introduction to Homological Algebra	4	
19.	MTH 626	Galois Theory	4	
20.	IAM 602	Computational Methods	4	
21.	IAM 603	Applied Functional Analysis	4	

22.	IAM 604	Advanced Mathematical Methods	4	
23.	IAM 606	Fractional Differential Equations	4	
24.	CPE RPE	Research and Publication Ethics	2	
25.	MTH 641	Cloud Computing	4	
26.	MTH 642	Advances in Internet of Things (IoT)	4	
27.	MTH 643	Cryptography and Network Security	4	
28.	MTH 644	Advanced Fluid Dynamics	4	New Course
29.	MTH 651	Indian Traditional Knowledge and Practices	2	
30.	MTH 652	Pedagogy of Teaching and Learning Process	2	
31.	MTH 645	Hydrodynamic Stability Theory	4	New Course

Annexure-VI

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh
(Established under Central Universities Act 2009)
शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

File No.: MTH/1-10/Meeting/CUHP/21/1107 Dated: 16.02.2023

MINUTES OF THE MEETING

A **meeting** of all **Faculty Members** of the **Srinivasa Ramanujan Department of Mathematics**, School of Mathematics, Computers and Information Sciences was **held** on **16th February, 2023** at **04:00 PM** onwards in the **Chamber** of the **Head,** Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur (**Room No. 303**) to **discuss** on the below **agenda** items and **decided** as under:-

Agenda Item 1: To discuss and prepare the list of External Examiners for the End Term Examinations of M.Sc. Mathematics, 4th semester, 2021 batch.

Decision: The List of External Examiners for the End Term Examinations of M.Sc. Mathematics, 4th semester, 2021 batch is prepared and finalized as attached at Annexure-1.

Agenda Item 2: To discuss and finalize the evaluation criteria for the Practical Course i.e. MTH 559.

Decision: The following evaluation criteria for the Course Code: MTH 559, Course Name: Practical, Credits: 02 will be finalized subject to the approval of the upcoming meeting of Board of Studies as well as School Board:-

Evaluation Criteria*			
Sl. No.	**Category**		**Maximum Marks**
Compulsory Requirement			
1.	**Presentation** (Minimum 01 Paper)	Paper Presentation in a National Seminar/Conference	70
		OR	
		Paper Presentation in an International Seminar/Conference	80
Optional			
2.	**Publication** (Minimum 01 Paper)	Paper Publication in a Seminar/Conference Proceedings/ Peer Reviewed Journal.	10
		OR	
		Paper Publication in a Peer Reviewed Journal (Scopus / Web of Science / SCI / SCIE Indexing).	20
		Total Maximum Marks	**100**

** The concerned Faculty Member/Supervisor will evaluate the respective students, and also prepare the Award list as per above mentioned evaluation criteria.*

Agenda Item 3: To discuss the preparation for NAAC visit.

Decision: The preparation for NAAC visit was discussed.

Agenda Item 4: To discuss the mechanism for the attendance record of students.

Decision: It was decided that Dr. Pankaj Kumar S/o Lt. Sh. Maniram, Assistant Professor, will prepare the mechanism for the attendance record of the students.

Agenda Item 5: Any other item.

Decision: The Department proposes to organize the following events in upcoming time:-

1. Two Day Workshop on "Analysis of the Mathematical Models in Biology".
2. Two Day Workshop on "Riemannian Geometry and its Applications"
3. Two Day International Conference on "Historical Mathematical Perspectives of Indian Knowledge System".

Dr. Meenakshi
Assistant Professor

Dr. Pankaj Kumar
S/o Sh. Krishan Singh
Assistant Professor

Dr. Pankaj Kumar
S/o Lt. Sh. Maniram
Assistant Professor

Dr. Sachin Kumar Srivastava
Assistant Professor

Prof. Rakesh Kumar
Professor, and, Head,
Srinivasa Ramanujan Department of Mathematics

Annexure-VII

हिमाचल प्रदेश केंद्रीय विश्वविद्यालय
Central University of Himachal Pradesh

(Established under Central Universities Act 2009)
शाहपुर परिसर, शाहपुर, ज़िला काँगड़ा (हि.प्र.) - 176206
Shahpur Parisar, Shahpur, Distt. Kangra (HP) - 176206
Website: www.cuhimachal.ac.in

File No.: MTH/1-10/Meeting/CUHP/21/1147 Dated: 01.03.2023

MINUTES OF THE MEETING

A **meeting** of all **Faculty Members** of the **Srinivasa Ramanujan Department of Mathematics**, School of Mathematics, Computers and Information Sciences was **held** on 1st **March, 2023** at **11:30 AM** onwards in the **Chamber** of the **Head,** Srinivasa Ramanujan Department of Mathematics, Central University of Himachal Pradesh, Shahpur Parisar, Shahpur (**Room No. 303**) to **discuss** on the below **agenda** items and **decided** as under:-

Agenda Item 1: To discuss the Course Structure of M.Sc. Mathematics, Academic Session 2021-23.

Decision: The Course Structure of M.Sc. Mathematics, Academic Session 2021-23 was discussed and finalized as per NEP-2020 as attached at Annexure-1.

Agenda Item 2: To discuss and finalize the evaluation criteria for the Dissertation and Viva Voce i.e. MTH 590 for M.Sc. Mathematics, 4th semester, Academic Session 2021-23.

Decision: The following evaluation criteria for the Course Code: MTH 590, Course Name: Dissertation and Viva Voce, Credits: 08, was finalized subject to the approval of the upcoming meeting of Board of Studies as well as School Board:-

Dissertation Evaluation Criteria*			
Sl. No.	**Category**		**Maximum Marks**
1.	Internal Evaluation **(40% Weightage)**	Dissertation Writing & Presentation/Viva-Voce	160
2.	External Evaluation **(60% Weightage)**	Dissertation Evaluation (30 % Weightage)	120
		Presentation/Viva-Voce (30 % Weightage)	120
		Total	**400**

The Soft copy of the Dissertation is to be sent to the approved External Examiner in advance by the Department. The concerned Faculty Member/Supervisor will evaluate the respective students, and also prepare the Award list as per the above mentioned Internal Evaluation Criteria.

Agenda Item 3: To redistribute the faculty workload for the Spring Semester – 2023.

Decision: The workload of the Faculty Members of the Srinivasa Ramanujan Department of Mathematics was revised as attached at Annexure-II

Agenda Item 4: To discuss the preparation for NAAC visit.

Decision: It was decided that the Faculty Members will document the contents of their respective NAAC Criteria, and prepare the interactive slides to be merged with the Final presentation later on.

Agenda Item 5: Any other item.

Decision: Nil

Dr. Meenakshi
Assistant Professor

Dr. Pankaj Kumar
S/o Sh. Krishan Singh
Assistant Professor

Dr. Pankaj Kumar
S/o Lt. Sh. Maniram
Assistant Professor

Dr. Sachin Kumar Srivastava
Assistant Professor

Dr. Kranti Kumar
Associate Professor

01/03/2023

Prof. Rakesh Kumar
Professor, and, Head,
Srinivasa Ramanujan Department
of Mathematics

Annexure-VIII

Course Code: MTH 551
Course Name: Research Methodology
Credits: 04
Course Instructor: Prof. Rakesh Kumar
Credits Equivalent: (One credit is equivalent to 10 hours of lectures / organized classroom activity / contact hours; 5 hours of laboratory work / practical / field work / Tutorial / teacher-led activity and 15 hours of other workload such as independent individual/ group work; obligatory/ optional work placement; literature survey/ library work; data collection/ field work; writing of papers/ projects/dissertation/thesis; seminars, etc.)

Course Objective: The main aim of this course is to develop the research aptitude in the students by acquainting them with the research design, methods and ethics of research.

Course Outcomes: After the successful completion of this course, the student will be able to

CO1 analyze hypotheses, theories and scientific statements and methods.
CO2 design and critically analyse the proper research problems.
CO3 mathematically simulate the biological problems.
CO4 ~~write scientific paper in proper format and referencing style~~ understand, and apply the Finite Element Methods and Artificial Neural networks.

Attendance Requirements:
Students are expected to attend all lectures in order to be able to fully benefit from the course. A minimum of 75% attendance is a must failing which a student may not be permitted to appear in examination.

Evaluation Criteria:
1. Mid Term Examination: 40
2. End Term Examination: 120
3. Continuous Internal Assessment: 40

Course Contents:

Unit I: Research: Definition, Concepts and General introduction; Mathematics and science, Hypotheses, theories and laws; scientific statements: Their justification and acceptance, Objectives & types of Research; Attributes of good Research; Research Methods and Research Methodology; Research Process; Time/Effort Management; and Role of a Supervisor; Research methods in mathematics; Finding and Solving Research Problems.
~~**Research tools:** Searching google (query modifiers), Math. Sci. Net., Zentralblatt Math, Scopus, ISI, Web of Science, Impact factor, Concept of citation index, h-index, Google Scholar, Research Gate, ORCID, JSTOR, JabRef, Mendley, EndNote (Clarivate Analytics), Online and open access journals, National Digital Library Project (NDL), Virtual library of various countries, Introduction to Latex, MathType, Introduction to MS Office, Open Office.~~

Unit II: ~~**Scientific Writing:** writing a paper for conference and Journal, communicating research, Publishing a Paper, obtaining offprints of papers, Reviewing a Paper, Scientific Norms and Conventions; Collaborative Work, research grant proposal writing, copyright issues, ethics and plagiarism.~~

Mathematical Models in Biology: Nonlinear models of interactions- Predator-Prey model; equilibria of multi-population models; Linearization and stability; Positive and negative interactions.
Infectious Disease Modeling: Elementary epidemic models-The SIR model; Threshold values and critical parameters; SI and SIS model, Multiple population and differentiated infectivity.

Unit III: ~~Introduction to Computational Software: Maple, Mathematica, Matlab. Research Design Measurement and Scaling; Formulation of Hypothesis: Meaning, Characteristics and various concepts relating to research design; classification of research design and Importance; Graphical presentations (Bar-chart, Histograms, Pie-chart, Table-chart and Line-chart, surface plots)~~
Finite Element Methods: Shape functions; 1D elements (linear, quadratic); 2D elements (triangles); strong forms; variational or weak forms; minimization forms; equivalence between various forms; Lax-Milgram lemma; Galerkin orthogonality; priori error estimate; posteriori error estimate; stability theorem; discretization of weak and minimization forms in FEM; FEM for model problems- Laplace equation; Poisson equation; convection diffusion problem and heat conduction equation.

Unit IV: ~~Data types Nominal, Ordinal and Ratio scale; scaling techniques- meaning, characteristics and concepts relating to testing of Hypothesis (parameter and statistic, standard error, level of significance, type-I and type-II errors, critical region, one tail and two tail tests); procedure of testing hypothesis; Numerical problems based on chi-square test and Ftest (variance ratio test only). Data analysis and interpretation: introduction to multivariate analysis-multiple and partial correlation, multiple regression analysis (with two independent variables), specification of regression models and estimation of parameters, and interpretation of results~~.
Artificial Neural network(ANN): Neural Network-an overview, Historical Development of Neural Network, Neural network architecture, weights, activation function, bias, threshold, training/learning algorithms types, Delta learning rule, McCulloch Pitts neuron model, Hebb Net, Gradient Descent Algorithm, Single and Multilayer Perceptron.

Prescribed Text Books:

1. P. Pruzan, Research Methodology, Springer, 2016.
2. C.R. Kothari, Research Methodology Methods & Techniques, Second Edition, New Age International publisher, 2004.
3. ~~R. Kumar, Research Methodology, Pearson Education, 2009.~~ E.S Allman, J.A. Rhodes, Mathematical Models in Biology An Introduction, Cambridge University Press, New York, 2004.
4. M.G. Larson, F. Bengzon, The finite element: Theory, implementation, and practice, Springer, 2010.
5. S.N. Sivanandam S. Sumathi, S.N. Deepa, Introduction to Neural Networks Using Matlab 6.0. Tata McGraw Hill Publishing Company, 2017.

Additional Suggested Readings:

1. J.N. Kapoor, Research Methodology for Scientists and Engineers, Mathematical Science Trust Society, 1997.

2. ~~Robert A. Day, How to write and Publish a scientific Paper, University Press, Fourth Edition 1996.~~ F. Brauer, C.C. Chavez, Mathematical Modelsin Population Biology and Epidemiology, Springer, 2nd Edition, 2012.

3. ~~F. Mittelbach, M. Goossens, J. Braams, D. Carlisle & C. Rowley, The LaTeX Companion (Tools and Techniques for Computer Typesetting) 2nd Edition, Addison-Wesley Professional, 2004~~. C. Johnson, Numerical solution of partial differential equations by finite element method. Dover publications, INC, New York, 2009.

4. ~~T. Tantau, The BEAMER class: User Guide for version 3.49, 12th Media Services, 2016~~. S. Haykin, Neural Networks and Learning Machines. Pearson, Third Edition, 2016.

5. C.C. Agarwal, Neural Networks and Deep Learning, Springer, 2019.

Course Articulation Matrix of MTH 551- Research Methodology

Course Outcomes	Programme Outcomes 1	Programme Outcomes 2	Programme Specific Outcomes 1	Programme Specific Outcomes 2	Programme Specific Outcomes 3	Programme Specific Outcomes 4
CO1	3	2	3	3	2	2
CO2	3	2	3	3	2	3
CO3	2	3	3	2	3	3
CO4	2	3	2	2	3	3

1. Partially Related
2. Moderately Related
3. Highly Related