# MANIPAL UNIVERSITY JAIPUR

Faculty of Engineering | School of Computer Science Engineering

**Department of Artificial Intelligence & Machine Learning**

Course Hand-out Recommender

Systems | AIM 3143 | 3 0 0 3

**Session:** Jul – Nov 25 | **Program:** B. Tech (AI & ML) | **Semester:** V

**Course Coordinator:** Dr. Sonia

**Instructor:** Dr.Shivendra Dubey, Ms Simran & Ms. Akanksha Mrinali

## A. Introduction:

This course provides a comprehensive introduction to Recommender Systems, essential in machine learning and data analytics for predicting user preferences from large datasets. Widely used in e-commerce, social media, and content streaming, these systems enhance user experience and engagement. The course covers fundamental concepts and techniques in designing and evaluating recommender systems, exploring collaborative filtering, content- based, knowledge-based, and hybrid approaches.

a) Core functions include understanding linear algebra foundations like matrix operations.
b) Apply user-based and item-based collaborative filtering and learn about their vulnerabilities.
c) Explore content-based systems' architecture, feature extraction, and classification algorithms.
d) Gain insights into knowledge-based systems, examining representation and reasoning techniques.
e) Investigate hybrid approaches, understanding design strategies and limitations.

## B. Course Outcomes: At the end of the course, students will be able to

| CO Statement | CO | Bloom's Level | Target Attainment % | Target Attainment Level |
|---|---|---|---|---|
| Understand the core functions and applications of recommender systems, including related linear algebra concepts like matrix operations | **AIM3143.1** | Understand | >= 70% <80% | Level 2 |
| Apply the techniques of user-based and item-based collaborative filtering | **AIM3143.2** | Apply | >=80% | Level 3 |
| Apply principles of content-based recommendation, including system architecture and methods for item profile representation, feature extraction, and user profile learning | **AIM3143.3** | Apply | >=80% | Level 4 |
| Analyze various techniques used in knowledge-based recommendation systems, focusing on knowledge representation and reasoning, and understanding the difference between constraint-based and case-based recommenders | **AIM3143.4** | Analyze | >=80% | Level 5 |

| | | | | |
|---|---|---|---|---|
| Evaluate the opportunities and challenges in hybrid recommender systems, design strategies for implementing hybrid approaches, and analyze their potential to meet market needs and promote entrepreneurship | AIM3143.5 | Evaluate | >=80% | Level 6 |

## C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

**PO 1:** Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization is to the solution of complex engineering problems.

**PO 2:** Problem Analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO 3:** Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

**PO 4:** Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

**PO 5:** Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

**PO 6:** The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.

**PO 7:** Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO 8:** Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

**PO 9:** Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO 10:** Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO 11:** Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO 12:** Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**PSO 1:** Graduates will be able to examine the applications of Artificial Intelligence and Machine Learning in real-life problems.

**PSO 2:** Graduates will be able to design and implement intelligent systems for

multidisciplinary problems.

## D. Assessment Plan:

| Criteria | Description | Maximum Marks |
|---|---|---|
| Internal Assessment (Summative) | Mid-Term Examination (Close Book) | 30 |
| | Class Work Sessional (CWS):<br>1 Quiz/Technical Seminar: 10<br>3 Assignment/Problem Statement: 15<br>Attendance: 05 | 30 |
| End Term Exam (Summative) | End Term Exam (Close Book) | 40 |
| | Total | 100 |
| Attendance (Formative) | A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. | |
| Make up Assignments (Formative) | Students who miss a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester. | |
| Homework/ Home Assignment/ Activity Assignment (Formative) | There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded. | |

## E. Syllabus

Introduction: Recommender system functions, Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system. Collaborative Filtering: User-based nearest neighbor recommendation, Item-based nearest neighbor recommendation, Model based and pre-processing based approaches, Attacks on collaborative recommender systems. Content-based recommendation: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, obtaining item features from tags, representing item profiles, Methods for learning user profiles, Similarity based retrieval, Classification algorithms. Knowledge based recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders. Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies. Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics.

### References:

1. C.C. Aggarwal, Recommender Systems: The Textbook (1e), Springer, 2016.
2. N Manouselis, H. Drachsler, K. Verbert and E. Duval., Recommender Systems for Learning (1e), Springer 2013.
3. F. Ricci, L. Rokach, D. Shapira and B.P. Kantor, Recommender Systems Handbook (1e), Springer ,2011.

**F. Lecture Plan:**

| Lect. | Topics | Session Outcome | Corresponding CO | Mode of delivery | Mode of Assessing CO |
|---|---|---|---|---|---|
| 1 | Introduction to Recommender System Functions | Understand system functions | AIM3143.1 | Slides / Blackboard | MTE, Quiz |
| 2 | Linear Algebra Notation: Matrix Addition and Multiplication | Analyze matrix operations | AIM3143.1 | Slides / Blackboard | |
| 3 | Linear Algebra Notation: Matrix Transposition and Inverses | Evaluate transposition and inversion | AIM3143.1 | Slides / Blackboard | |
| 4 | Linear Algebra Notation: Covariance Matrices | Examine covariance matrices | AIM3143.1 | Slides / Blackboard | |
| 5 | Revision | Review linear algebra | AIM3143.1 | Slides / Blackboard | |
| 6 | Understanding Ratings in Recommender Systems | Explore rating mechanisms | AIM3143.1 | Slides / Blackboard | |
| 7 | Applications of Recommender Systems | Identify system applications | AIM3143.1 | Slides / Blackboard | |
| 8 | Issues with Recommender Systems | Discuss system challenges | AIM3143.1 | Slides / Blackboard | |
| 9 | Collaborative Filtering: Overview and Concepts | Understand filtering concepts | AIM3143.2 | Slides / Blackboard | |
| 10 | Revision | Review filtering concepts | AIM3143.2 | Slides / Blackboard | |
| 11 | Collaborative Filtering: User-Based Nearest Neighbor Recommendation | Analyze user-based algorithms | AIM3143.2 | Slides / Blackboard | |
| 12 | Collaborative Filtering: Item-Based Nearest Neighbor Recommendation | Evaluate item-based algorithms | AIM3143.2 | Slides / Blackboard | |
| 13 | Collaborative Filtering: Model-Based Approaches | Examine model-based methods | AIM3143.2 | Slides / Blackboard | |
| 14 | Collaborative Filtering: Pre-Processing Based Approaches | Explore pre-processing methods | AIM3143.2 | Slides / Blackboard | |
| 15 | Revision | Review collaborative filtering | AIM3143.2 | Slides / Blackboard | Quiz MTE, Quiz & ETE |
| 16 | Attacks on Collaborative Recommender Systems | Identify security vulnerabilities | AIM3143.2 | Slides / Blackboard | |
| 17 | Content-Based Recommendation: Overview and Architecture | Understand system architecture | AIM3143.3 | Slides / Blackboard | |

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| 18 | Content-Based Recommendation: Advantages and Drawbacks | Evaluate system pros and cons | AIM3143.3 | Slides / Blackboard | |
| 19 | Content-Based Recommendation: Item Profiles and Features | Analyze item profile methods | AIM3143.3 | Slides / Blackboard | |
| 20 | Content-Based Recommendation: Discovering Features from Documents | Explore feature extraction | AIM3143.3 | Slides / Blackboard | |
| 21 | Content-Based Recommendation: Obtaining Item Features from Tags | Examine tag-based features | AIM3143.3 | Slides / Blackboard | |
| 22 | Revision | Review content-based methods | AIM3143.3 | Slides / Blackboard | |
| 23 | Methods for Learning User Profiles | Explore user profile methods | AIM3143.3 | Slides / Blackboard | |
| 24 | Content-Based Recommendation: Similarity-Based Retrieval | Understand similarity retrieval | AIM3143.3 | Slides / Blackboard | |
| 25 | Content-Based Recommendation: Classification Algorithms | Analyze classification in systems | AIM3143.3 | Slides / Blackboard | |
| 26 | Knowledge-Based Recommendation: Overview and Concepts | Understand knowledge-based concepts | AIM3143.4 | Slides / Blackboard | Technical Project & ETE |
| 27 | Knowledge Representation and Reasoning in Recommender Systems | Examine representation techniques | AIM3143.4 | Slides / Blackboard | |
| 28 | Knowledge-Based Recommendation: Constraint-Based Recommenders | Analyze constraint-based methods | AIM3143.4 | Slides / Blackboard | |
| 29 | Knowledge-Based Recommendation: Case-Based Recommenders | Explore case-based methods | AIM3143.4 | Slides / Blackboard | |
| 30 | Technical Project | Review Practical Implementation | AIM3143.4 | Slides / Blackboard | |
| 31 | Hybrid Approaches: Overview and Opportunities | Explore hybrid system benefits | AIM3143.5 | Slides / Blackboard | |
| 32 | Monolithic Hybridization Design: Feature Combination | Understand feature combination | AIM3143.5 | Slides / Blackboard | |
| 33 | Monolithic Hybridization Design: Feature Augmentation | Explore feature augmentation | AIM3143.5 | Slides / Blackboard | |
| 34 | Revision | Review Hybridization Design | AIM3143.5 | Slides / Blackboard | |
| 35 | Parallelized Hybridization Design: Weighted Approach | Analyze weighted hybridization | AIM3143.5 | Slides / Blackboard | |

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| 36 | Parallelized Hybridization Design: Switching Approach | Examine switching hybridization | AIM3143.5 | Slides / Blackboard | |
| 37 | Parallelized Hybridization Design: Mixed Approach | Understand mixed hybridization | AIM3143.5 | Slides / Blackboard | |
| 38 | Pipelined Hybridization Design: Cascade Approach | Explore cascade hybridization | AIM3143.5 | Slides / Blackboard | |
| 39 | Pipelined Hybridization Design: Meta-Level Approach | Analyze meta-level hybridization | AIM3143.5 | Slides / Blackboard | |
| 40 | Revision | Review hybridization strategies | AIM3143.5 | Slides / Blackboard | |
| 41 | Limitations of Hybridization Strategies | Discuss hybridization challenges | AIM3143.5 | Slides / Blackboard | |
| 42 | Evaluating Recommender Systems: Introduction and Importance | Understand evaluation importance | AIM3143.5 | Slides / Blackboard | |
| 43 | General Properties of Evaluation Research | Examine evaluation research | AIM3143.5 | Slides / Blackboard | |
| 44 | Evaluation Designs for Recommender Systems | Analyze evaluation designs | AIM3143.5 | Slides / Blackboard | |
| 45 | Evaluation on Historical Datasets | Explore evaluation on datasets | AIM3143.5 | Slides / Blackboard | |
| 46 | Revision | Review evaluation methodologies | AIM3143.5 | Slides / Blackboard | |
| 47 | Error Metrics in Recommender System Evaluation | Understand error metrics | AIM3143.5 | Slides / Blackboard | Assignment & ETE |
| 48 | Decision-Support and User-Centered Metrics | Analyze decision-support metrics | AIM3143.5 | Slides / Blackboard | |
| **End Term Examination** | | | | | |

**G. Target attainment (%) for course outcomes:**

| CO | Target attainment (%) |
|---|---|
| 1 | 80% |
| 2 | 80% |
| 3 | 80% |
| 4 | 80% |
| 5 | 80% |

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(University under Section 2(f) of the UGC Act)

**H. Course Articulation Matrix: (Mapping of COs with POs and PSOs)**

| CO | Statement | Correlation with Program Outcomes | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO 10 | PO 11 | PO 12 | PSO 1 | PSO 2 |
| AIM3143.1 | Understand the core functions and applications of recommender systems, including related linear algebra concepts like matrix operations. | 2 | | | | | | | | | 1 | | 1 | | |
| AIM3143.2 | Apply the techniques of user-based and item-based collaborative filtering | 2 | | | | | | 1 | | | | | 2 | | |
| AIM3143.3 | Apply principles of content-based recommendation, including system architecture and methods for item profile representation, feature extraction, and user profile learning. | | 2 | | | | | | | | | | | | |
| AIM3143.4 | Analyze various techniques used in knowledge-based recommendation systems, focusing on knowledge representation and reasoning, and understanding the difference between constraint-based and case-based recommenders. | | 2 | | 3 | 1 | | | | 2 | | | | 2 | 2 |
| AIM3143.5 | Evaluate the opportunities and challenges in hybrid recommender systems, design strategies for implementing hybrid approaches, and analyze their potential to meet market needs and promote entrepreneurship | | | | 2 | | | | 2 | | 2 | | | | 2 |

Sonia 5/8/25

**Course Coordinator**

**Name:** Dr. Sonia

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