Course template for IT 454 Introduction to Complex Networks

1. **Title:** Introduction to Complex Networks

2. **Credit Structure (L-T-P-Cr):** 3 0 0 3

3. **Course Code:** IT454

4. **Semester:** SEM VII

5. **Category:** Technical elective

6. **Prerequisites:** Undergraduate Calculus, Undergraduate Probability theory, background in graph theory would be beneficial but not essential

7. Foundation for: Nil

8. **Abstract Content:**

   This course aims to introduce students to the rapidly emergent field of complex networks. Complex networks crucially underpin much of real and synthetic world. In the past decade building on the work of a wide range of disciplines, many (but certainly not all) advances have been made in understanding complex networks such as world wide web, social and organizational networks, biochemical networks and transportation networks. Many complex systems are hard to describe and understand because they are composed of large number of elements interacting in a non-ordered way. A good example is cellular biology: diverse cellular components (genes, proteins, enzymes) participate in various reactions and regulatory interactions forming a robust system. A very useful representation of complex systems is given by graphs (or networks), where we denote the component with nodes and their interaction by edges. The properties of these interaction graphs can then be analyzed by graph theoretic and statistical mechanics techniques which can lead to important conclusions about the dynamics of the system.

   In this special topic course we will explore the evolving field of complex networks by looking at the basics of complex networks and furthermore by reading and discussing seminal and recent papers. In this process we will also be developing mathematical and algorithmic results where they exist.

   **The level will be advanced undergraduate.**

**Grading and Course policy:** There will be continuous evaluation throughout the semester for a total of 100%.
**Exams:**
There will be one in-sem exam of 30% weightage. There is **NO** provision of any make-up exam so make sure that you take the exam. Any request for re-exam can only come through the office of Dean Academics.

**Quizzes & assignments:** 30% of the points will be divided between quiz and assignment. The quizzes will be surprise and will test the students on their understanding of the covered material. If you miss a quiz you can not request for a make up quiz. **Once** in the semester if pre-excused from attending the lecture the student can have a make up quiz in case there was a surprise quiz in that lecture.

**Assignments:** While the students are encouraged to discuss the assignment copying or late submissions would lead to cancellation of the assignment.

**Project:** The project will be of 40% weightage. It will consist of a written report and presentation. The projects would be decided in the first couple of weeks of the semester. The project will require the students to understand and present an applied area of their choice which should fall within the framework of the course. The students have to submit a term paper before a given deadline. Failure to do so will result in loss of 50% of the allotted points.

**The grading will be relative but failure to obtain 30% of the total points would lead to FAIL grade.**

9. **Suggested Text/s:** The lectures will be self contained but some of the references are:
1. Dynamical processes on complex networks: Alain Barrat, Marc Barthelemy, Alessandro Vespignany.
2. Complex Networks Eli Ben-Naim.
4. The structure and Dynamics of networks: Marc Newmann, Barabsi, Duncan Watts.
5. Complex webs in nature and technology: Guido Calderelli

10. **Detailed Contents:**
The course commences with and overview of the nascent field of complex networks dividing it into three related but distinct strands: Statistical description of large scale networks; the dynamic evolution of networks, where now the structure of networks is understood in terms of a growth process; and dynamical process that take place on fixed networks that is networked dynamical systems. The remainder of the course treats each of the three strands in greater detail, introducing technical knowledge as required, summarizing the research papers that have introduced the principal ideas and pointing out directions for further development.

Briefly some of the topics that will cover the major portion of the course are:
1. Elements of graph theory, node degree, distances between nodes, clustering, node betweenness, subgraphs, directed graphs etc.
2. Random graph theory.
4. Network robustness and vulnerability.
5. Percolation and flow processes on networks.
6. Modeling reaction networks, elements of kinetic theory.
7. Some topics from biological networks for example cellular networks, gene regulatory networks, metabolic networks etc.

11. Outcomes and Objectives: The primary objective of the course is to provide students with substantial introduction and background in complex networks. Since this is an area of widespread applicability the fundamentals learnt can either be directly applied to solve problems in their own area of research or gain a better understanding in their current research area.