PGP: Format for Course Outline (2017-18)

i. Course title: **Working with Networks**

ii. Area to which the course belongs: **Production & Quantitative Methods**

iii. Term in which the course is to be offered: **IV**

iv. Instructors' name(s) with number of sessions by each instructor:

Diptesh Ghosh **20**

v. Course credits: **1**

vi. Course Open for:

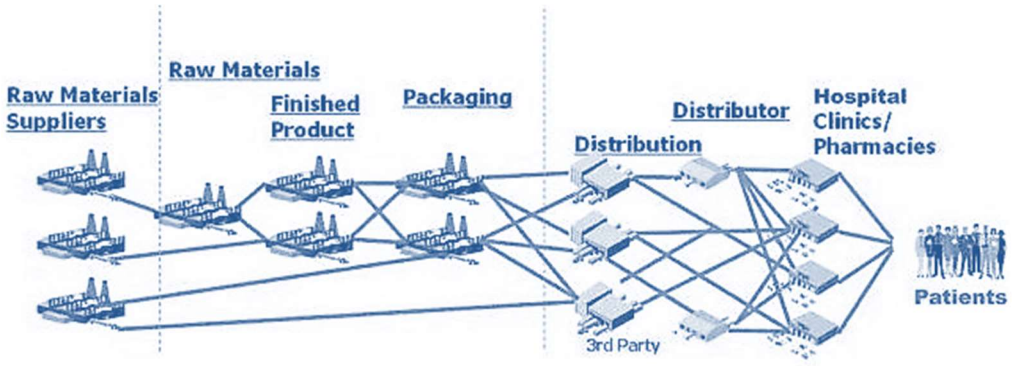
Programme	PGP*	PGP-FABM	PGPX	FPM	Total
# of students	**Yes**	**Yes**	**None**	**None**	**30**

* PGP includes Exchange students on pro-rata basis.

vii. Introduction:

This is a course on analysis of network structures. Whenever entities are interconnected, their interconnection can be represented in structures called networks. These structures are abstractions consisting of nodes which represent the entities, and edges that represent the connections.

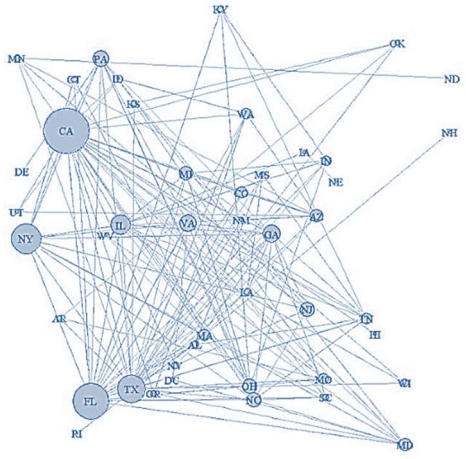
Networks are ubiquitous in present day life. For example, supply chains can be visualized as networks. The diagram below represents a typical supply chain network for a pharmaceutical company.



Trade relations can be also be represented as networks. The next diagram is a network representation of the way in which sugar was traded around the world in 2010-11. (Source: cdn3.vox-cdn.com)

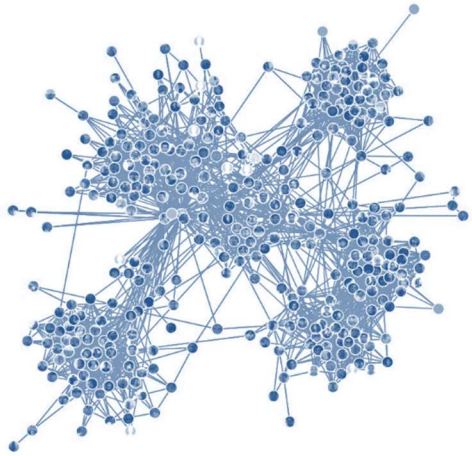
Given these networks, and properties of the entities of the network, one may ask interesting questions. For example, what is the maximum amount of products that can be sent from one point to another through these networks? Or how sensitive is the chain to the disruption of one of its entities (i.e., nodes or connections)?

Interstate migration can be represented by networks. The diagram below shows a network representing migration patterns among different states in the US in 2007. (Source: A. S. Chakrabarti and A. Sengupta, Econ. Mod. 2017)



Based on the data, one can ask questions about the scale of migration in an economy and predict about the populations that individual states may assume after a given time if these patterns continue. There could be questions on the costs and risks of such migration, and the effect of particular government policies on these patterns.

Even one's social media presence can be visualized as a network. The next diagram is a visualization of how my Facebook friends are interconnected on Facebook using the Lost Circles app for Chrome.



Interesting questions here would be to identify the central individuals are in the network, and how close individuals are to other individuals in the network, and to identify communities in the network.

viii. Objective:

The present course equips participants with tools to analyse the structure of networks and algorithms for effective decision making about problems posed on networks.

ix. Pedagogy:

The course will be lecture based. We will also be modeling the problems being discussed and developing computer code to implement the algorithms discussed.

x. Evaluation Scheme:

Individual Assignment(s):	20% (Individual)
Group assignment:	30% (Group)
Endterm (open book, laptops allowed):	50% (Individual)

xi. Course Books/Reference Materials:

There is no specified text books for the course.

Reference books:

R.K. Ahuja, T.L. Magnanti, J.B. Orlin. Network Flows: Theory, Algorithms, and Applications. Prentice Hall NJ. (1993).

T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein. Introduction to Algorithms. The MIT Press MA. (2009).

xii. Session Plan:

Module 1 (Sessions 1 and 2) Basic terminology and results

Covers mathematical preliminaries and mathematical models for networks.

Module 2 (Sessions 3 to 9) Flows through networks

Covers Shortest path, Maximum flow, Minimum cost flow, Transportation, and Transshipment problems.

Module 3 (Sessions 10 to 11) Matchings on networks

Covers bipartite matching including assignment problems.

Module 4 (Sessions 12 to 16) Location and routing in networks

Covers branch and bound techniques for traveling salesman and associated routing problems, and facility location problems.

Module 5 (Sessions 17 to 19) Analyzing network structure

Covers connectivity and centrality measures and detection of communities.

Concluding session 20 Wrapping up

xiii. Pre-requisites & Eligibility:

To be eligible for the course, a participant should

(1) have gone through a mathematical modeling course (e.g. Quantitative Methods II course in PGP I);
(2) be comfortable discussing and working with algorithms; and
(3) be familiar with scientific computer programming (in a language of your choice).

(To evaluate whether you will enjoy this course, think back on whether you liked solving the problems in the case material in the QM-II course. Also check that you can perform the following tasks:

(a) Given a number n, design/write a program to check whether it is prime using a loop with less than $n/2$ iterations.
(b) *Given a $n \times n$ matrix A, and a n-vector b, design/write a program to solve the set of equations $Ax = b$.)*

xiv. Relationship to other courses:

The course builds upon concepts covered in the Quantitative Methods II course in the first year and some topics in the Operations Management Courses. It should complement the material covered in logistics and supply chain management courses in the second year.