

## CSC 641 Network Science Fall 2017

**Instructor:** Dr. Natarajan Meghanathan, Professor of Computer Science

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**Class Time:** TR 6 PM to 7.20 PM

**Office Hours:** TR 4.30 to 6 PM

### Catalog Description

CSC 641 (3 Hours) Network Science. Topics covered include the measurement and structure of networks, methods for analyzing network data, including methods developed in physics, statistics, and sociology, graph theory, computer algorithms, mathematical models of networks, including random graph models and generative models, and theories of dynamical processes taking place on networks.

**Pre-requisite:** Graduate student status in Computer Science, Computer Engineering or CDSE

### Course Outcomes

Each student who successfully completes this course should be able to:

**CO-1:** Analyze the characteristics of complex networks using graph theoretic metrics and paradigms

**CO-2:** Generate simulated networks from theoretical models and evaluate their characteristics in comparison with real-world networks

**CO-3:** Apply various centrality metrics and related algorithms to determine the topological significance of the nodes in a network

**CO-4:** Extract clusters of related nodes using efficient community detection algorithms and evaluate the effectiveness of the partitioning

**CO-5:** Use hands-on tools and spectral analysis techniques to analyze datasets corresponding to complex real-world networks

### Required Textbook

A. L. Barabasi, "Network Science," 1<sup>st</sup> Edition, Cambridge University Press, ISBN: 1107076269. August 2016.  
Available Online: <http://barabasi.com/networksciencebook/>

### Course Modules (Tentative)

Module 1: Graph Theory

Module 2: Spectral Analysis

Module 3: Centrality Metrics

Module 4: Community Detection Algorithms

Module 5: Theoretical Network Models

**Evaluation:** Exams – 60% (4 Exams); Assignments (2) – 10%; Quizzes (3) – 15%; Term Project – 15%

*Tentative Quiz Dates:* 09/19, 10/17 and 11/07

*Tentative Exam Dates:* 09/26, 10/24, 11/14 and 12/05

### Grading

90 - 100: A

80 - 89: B

70 - 79: C

60 - 69: D

Below 60: F

**Course Website:** <http://www.jsums.edu/nmeghanathan/csc641-fall2017/>

### Dropping a course

The last day to drop a course with no grade:

September 5, 2017

The last day to drop a course with "W" grade:

October 23, 2017

### Term Project:

The term project is a team project of 2-3 students. Each team would have to select a different network visualization and analysis tool (other than Gephi) that can be used for analyzing large real-world network graphs (of size 1000 nodes or higher) and give a demo of its working in class as well as submit a desktop recorded demo video (that runs for at least 20 minutes) covering different features of the chosen tool and explanation for using those features with appropriate examples. Your tool could be applied for any field: Social Networks, Biology, Finance, Chemistry, etc.

The deadline for choosing the tool and informing the instructor is October 19, 2017 (each team would have to work on a different tool; the team that informs the earliest will be given the permission to use a particular tool). The class presentations have been tentatively scheduled for November 28 and 30, 2017.

### Course Outline (Tentative)

Week #	Topics to be Covered	Course Outcomes
Week 1	Module 1: Degree Distribution Analysis, Maximal Assortative and Dissortative Matching	CO-1
Week 2	Module 1: Cocitation and Bibliographic Coupling, # Walks in a Graph, Bipartite Graphs	CO-1
Week 3	Module 1: Breadth First Search, # Components Module 2: Eigenvectors and Eigenvalues, Spectral Radius Ratio for Node Degree, Bipartivity Index and its Computation	CO-1 CO-5
Week 4	Module 2: Protein Folding and Algebraic Connectivity	CO-5
Week 5	Module 2: Modularity, Community Detection using Spectral Analysis	CO-5
Week 6	Module 3: Degree Centrality, Eigenvector Centrality, Closeness Centrality Module 3: Betweenness Centrality	CO-3
Week 7	Module 3: Local Clustering Coefficient-based Degree Centrality, Correlation Coefficient Measures; HITS Algorithm	CO-3
Week 8	Module 3: PageRank Algorithm	CO-3
Week 9	Module 4: Modularity Maximization, Hierarchical Clustering Algorithm	CO-4
Week 10	Spring Break	
Week 11	Module 4: Edge Betweenness and Girvan Newman Algorithm	CO-4
Week 12	Module 4: Neighborhood Overlap-based Community Detection and Homophily	CO-4
Week 13	Module 5: Random Network Model and Simulations	CO-2
Week 14	Module 5: Scale-free Network Model, BA Model and BB Model and Simulations	CO-2
Week 15	Term Project Presentations	CO-5
Week 16	Final Exam Week	

### Quiz and Exam Calendar

	Tuesday	Thursday
<b>Week 1</b>	08/22	08/24
<b>Week 2</b>	08/29	08/31
<b>Week 3</b>	09/05	09/07
<b>Week 4</b>	09/12	09/14
<b>Week 5</b>	09/19, Quiz 1	09/21
<b>Week 6</b>	09/26, Exam 1	09/28
<b>Week 7</b>	10/03	10/05
<b>Week 8</b>	10/10, Assignment 1 due	10/12
<b>Week 9</b>	10/17, Quiz 2	10/19
<b>Week 10</b>	10/24, Exam 2	10/26
<b>Week 11</b>	10/31, Assignment 2 due	11/02
<b>Week 12</b>	11/07, Quiz 3	11/09
<b>Week 13</b>	11/14, Exam 3	11/16
<b>Week 14</b>	11/21, Thanksgiving Break	11/23, Thanksgiving Break
<b>Week 15</b>	11/28, Term Project Presentations	11/30, Term Project Presentations
<b>Week 16</b>	12/05: Final Exam (Exam 4): 6 PM to 7.50 PM	

### ***Make-up Exams***

- **No make-up quizzes.**
- **No make-up examinations will be given except for emergencies such as death in the family or serious illness. The instructor must be informed, through e-mail or a written request, BEFORE the time of the examination that is to be missed.** The instructor will make a decision on the make-up examination after verifying the appropriate written documentation. Failure to furnish, written, verifiable documentation will result in a grade of zero for the missed examination.
- **Any make-up exam for a missed exam has to be taken before the next class meeting time.**
- **A make-up exam will be different and will be relatively tough compared to the actual missed exam.**

### **Reference Books**

- [1] Newman, Mark. 2010. *Networks: An Introduction*. 1<sup>st</sup> ed. Cary, NC: Oxford University Press.
- [2] Barrat, Alain., Barthelemy, Marc., and Vespignani, Alessandro. 2008. *Dynamical Processes on Complex Networks*. 1<sup>st</sup> ed. Cambridge, UK: Cambridge University Press.
- [3] Nooy, Wouter De., Mrvar, Andrej., and Batagelj, Valdimir. 2011. *Exploratory Social Network Analysis with Pajek*. 1<sup>st</sup> ed. Cambridge, UK: Cambridge University Press.
- [4] Junker, Bjorn. and Schreiber, Falk. 2008. *Analysis of Biological Networks*. 1<sup>st</sup> ed. Hoboken, NJ: Wiley.
- [5] Levitin, Anany. 2011. *Introduction to the Design and Analysis of Algorithms*. 3<sup>rd</sup> ed. Boston, MA: Addison-Wesley.
- [6] Estrada, Ernesto. 2011. *The Structure of Complex Networks*. 1<sup>st</sup> ed. Cary, NC: Oxford University Press.
- [7] Newman, Mark, G., Barabasi, Albert-Laszlo., and Watts, Duncan, J. 2006. *The Structure and Dynamics of Networks*. Princeton, NJ: Princeton University Press.
- [8] Easley, David. and Kleinberg, Jon. 2010. *Networks, Crowds, and Markets: Reasoning About a Highly Connected World*. 1<sup>st</sup> ed. Cambridge, UK: Cambridge University Press.
- [9] Nielsen, Michael. 2013. *Reinventing Discovery: The New Era of Networked Science*. 1<sup>st</sup> ed. Princeton, NJ: Princeton University Press.
- [10] Scott, John, G. 2011. *Social Network Analysis*. 3<sup>rd</sup> ed. Thousand Oaks, CA: SAGE Publications.

### **ADA Statement**

**Compliance with the Americans with Disabilities Act:** If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and ADA Coordinator (as early as possible in the term) located in the Jacob L. Reddix Building (old student union), rooms 101 and 102. The office hours are: 8:00 a. m. to 5:00 p.m., Monday through Friday. The telephone number is (601) 979-3704 or (601) 979-6919 (TTY) and the facsimile number is (601) 979-6918. The mailing address is: Office of Support Services for Students and Employees with Disabilities, P.O. Box 17156, Jackson State University, Jackson, MS 39217.

### **Diversity Statement**

Jackson State University is committed to creating a community that affirms and welcomes persons from diverse backgrounds and experiences and support the realization of their potential. We recognize that there are differences among groups of people and individuals based on ethnicity, race, socioeconomic status, gender, exceptionalities, language, religion, sexual orientation, and geographical area. All persons are encouraged to respect the individual difference of others.

### **Collegiate Code of Conduct**

Jackson State University students are expected to dress in a manner representative of higher education institution. More information on Dress Code; Verbal and/or Physical Harassment; Indecent, Obscene, Immoral Behavior and/or Profanity is available in the JSU Student Handbook. The most recent version of JSU Student Handbook is available at <http://www.jsums.edu/studentlife/pdf/2010book.pdf>

### **Student Conduct and Class Attendance Policy**

Students at Jackson State University must fully commit themselves to their program of study. One hundred percent (100%) punctual class attendance is expected of all students in all scheduled classes and activities. Instructors keep attendance records and any absence for which a student does not provide written official excuse is counted as an

unexcused absence. Students must understand that even with an official excuse of absence, they (students) are responsible for the work required during their absence.

Students may be officially excused from class for attendance at University approved functions, provided the sponsor properly executes a Student Affairs Leave Form. Such excuses shall be accepted by the instructor. Students may also be officially excused by the Dean of their School or the Vice President for Academic Affairs for certain campus activities. Students must submit written documentation to Student Affairs to obtain official excuses for absences due to illness or other emergency situations.

Students who willfully miss class face serious consequences. After being absent three times in a 50-minute class, three hours in a class that meets longer than one hour, or one time immediately before or after a scheduled recess/holiday, the instructor shall report the next unexcused absence to the Dean of University College for freshman and sophomores and to the school dean and department chair for juniors and seniors. The dean/chair or designee will counsel with the student and in concert with the instructor, may require the student to complete complementary course assignments. If a student does not respond well to the counsel or with the assignments, the instructor may impose a grade penalty on the student. Unexcused absences that exceed the equivalency of six 50-minute Sessions may lead to an "F" for the course.