Course Syllabus

Syllabus:

- **Lesson One: What is Network Science?**
  - What is (not) network science?
  - The main premise of network science
  - History and relation to graph theory, physics, sociology, and other disciplines
  - Examples of networks from different application domains

- **Lesson Two: Relevant Concepts From Graph Theory**
  - Undirected, directed, signed, weighted and spatial networks
  - Paths, connected components, random walks, etc
  - Directed Acyclic Graphs
  - Bipartite graphs
  - Max-flow/min-cut

- **Lesson Three: Degree Distribution and ER Graphs**
  - Degree distribution
  - Friendship paradox
  - ER graphs and their degree distribution
  - Giant component size in ER graphs
  - Assortative vs disassortative networks

- **Lesson Four: Random vs. Real Graphs and "Scale Free" Networks**
  - The degree distribution of real-world networks
  - Power-law degree distributions
  - Preferential attachment model
  - How to detect a power-law and estimate the exponent
  - Configuration model and degree-preserving randomization
• **Lesson Five: Network Paths, Clustering and The “Small World” Property**
  - Clustering and transitivity in networks
  - Diameter and characteristic path length
  - Small-world networks and the Watts-Strogatz model
  - Network motifs

• **Lesson Six: Centrality and Network-core Metrics and Algorithms**
  - Link-based centrality metrics
  - Path-based centrality metrics
  - k-core decomposition
  - Core-periphery structure
  - Rich-club set of nodes

• **Lesson Seven: Community Detection and Hierarchical Modularity**
  - Hierarchical clustering in networks
  - Modularity metric
  - Algorithms for modularity maximization
  - Limitations of modularity
  - Hierarchical modularity

• **Lesson Eight: Advanced Topics in Community Detection**
  - Overlapping communities
  - Dynamic communities
  - Comparing community structures
  - The role of nodes within and between communities
  - Applications of community detection

• **Lesson Nine: Network Contagion and Epidemics**
  - Epidemics on networks
  - Epidemic modeling (SI, SIS, SIR, etc) under homogeneous mixing
  - Epidemic modeling under arbitrary degree distributions
  - Basic reproductive number and superspreaders

• **Lesson Ten: Influence Phenomena On Networks**
  - The linear threshold model and the Independent cascades model
- Empirical studies in information and behavior spreading
- Seeding strategies on how to maximize influence
- Cascades and community structure

- **Lesson Eleven: Other Dynamic Processes Of/On Networks**
  - Percolation, random failures, and targeted attacks on networks
  - Search on networks
  - Synchronization on networks
  - Coevolutionary networks

- **Lesson Twelve: Models of Static and Dynamic Networks**
  - Stochastic network models that generate power-law degree distributions
  - Optimization-based network models
  - Stochastic block models
  - Hierarchical Random Graphs

- **Lesson Thirteen: Statistical Analysis of Network Data**
  - Network sampling methods
  - Estimation of network metrics
  - Association networks
  - Network tomography

- **Lesson Fourteen: Machine Learning meets Network Science**
  - Node embeddings
  - Graph neural networks
  - Deep generative network models
  - Limitations and applications of graph neural networks

**Course Summary:**

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<thead>
<tr>
<th>Date</th>
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<tbody>
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<td>Date</td>
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<tr>
<td>Wed Jan 13, 2021</td>
<td>🗓️ BlueJeans Meeting: Office hours for instructor (Constantine) (<a href="https://gatech.instructure.com/calendar?event_id=1620641&amp;include_contexts=course_181718">https://gatech.instructure.com/calendar?event_id=1620641&amp;include_contexts=course_181718</a>) 12:30pm to 1:30pm</td>
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<tr>
<td>Thu Jan 21, 2021</td>
<td>📌 Step 3: Enroll in the Piazza Forums to do: 11:59pm</td>
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<td>Thu Jan 21, 2021</td>
<td>📌 Lesson-1: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673384">https://gatech.instructure.com/courses/181718/assignments/673384</a>) due by 11:59pm</td>
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<tr>
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<td>📌 Step 4: Check Your Canvas Communication Settings to do: 11:59pm</td>
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<tr>
<td>Thu Feb 4, 2021</td>
<td>📌 Lesson-3: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673378">https://gatech.instructure.com/courses/181718/assignments/673378</a>) due by 11:59pm</td>
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<td>Fri Feb 5, 2021</td>
<td>📌 Module One: Project (<a href="https://gatech.instructure.com/courses/181718/assignments/673398">https://gatech.instructure.com/courses/181718/assignments/673398</a>) due by 11:59pm</td>
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<td>Thu Feb 11, 2021</td>
<td>📌 Lesson-4: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673388">https://gatech.instructure.com/courses/181718/assignments/673388</a>) due by 11:59pm</td>
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<td>Thu Feb 18, 2021</td>
<td>📌 Lesson-5: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673382">https://gatech.instructure.com/courses/181718/assignments/673382</a>) due by 11:59pm</td>
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<td>📌 Lesson-6: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673392">https://gatech.instructure.com/courses/181718/assignments/673392</a>) due by 11:59pm</td>
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<td>Fri Feb 26, 2021</td>
<td>📌 Module Two: Project (<a href="https://gatech.instructure.com/courses/181718/assignments/673402">https://gatech.instructure.com/courses/181718/assignments/673402</a>) due by 11:59pm</td>
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<td>Thu Mar 4, 2021</td>
<td>📌 Lesson-7: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673374">https://gatech.instructure.com/courses/181718/assignments/673374</a>) due by 11:59pm</td>
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<td>📌 Lesson-8: Quiz (graded) (<a href="https://gatech.instructure.com/courses/181718/assignments/673368">https://gatech.instructure.com/courses/181718/assignments/673368</a>) due by 11:59pm</td>
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<td>Lesson-9: Quiz (graded) <a href="https://gatech.instructure.com/courses/181718/assignments/673366">Link</a></td>
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<td>Module Three: Project <a href="https://gatech.instructure.com/courses/181718/assignments/673400">Link</a></td>
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<td>Lesson-10: Quiz (graded) <a href="https://gatech.instructure.com/courses/181718/assignments/673376">Link</a></td>
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<td>Thu Apr 1, 2021</td>
<td>Lesson-11: Quiz (graded) <a href="https://gatech.instructure.com/courses/181718/assignments/673386">Link</a></td>
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<td>Lesson-14: Quiz (graded) <a href="https://gatech.instructure.com/courses/181718/assignments/673380">Link</a></td>
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<td>Fri Apr 23, 2021</td>
<td>Module Five: Project <a href="https://gatech.instructure.com/courses/181718/assignments/673394">Link</a></td>
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