# Instructions for Final Presentations and Reports

UCSB Mechanical Engineering, Spring 2026, ME/ECE 269
Course Title: **Network Systems: Dynamics and Control**

Francesco Bullo
Mechanical Engineering, ECE, CS and CCDC, UC Santa Barbara

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## General instructions

- Decide topic for your Final Report and Final Presentation and email me:
  1. your topic
  2. which paper or two papers you will present
  3. if you are working alone or in a team (and if so, with whom).
- Work in groups: I strongly recommend the formation of groups of two students per topic. Individual students are welcome but should expect the same report length, presentation time, and evaluation criteria.
- Topic selection: A list of possible topics is given below. Topics are assigned on a "first come first serve". I will share a google document with the list of selected projects.
- Requirement: your topic needs to be related to the material covered in class.
- I collected some advice on how to review a paper, how to write in a precise, concise, and well-structured manner, and how to organize, practise and deliver your presentation. Please download and read http://motion.me.ucsb.edu/pdf/FBullo-GettingItWrite.pdf

## Final Report

The report should contain a meaningful review, explanation, and elaboration of one or multiple paper(s) in the literature. Simply copy/pasting + light revision of the paper(s) is not sufficient.

Requested report length = 10 pages (excluding title page and bibliography), single column, single space between rows, 11 points, and .75in margin. Recommended structure and instructions:

1. Title, author(s) (your name, not the names of the paper you are reviewing), date, subtitle with course number and quarter/year
2. Section 1: Introduction with three subsections (at-least one paragraph each) containing (a) problem description and motivation, (b) literature review (at least 1 sentence per bibliographical item, at least 6 bibliographical items), (c) summary of content in the report.
3. Section 2: Preliminaries/review of notation (consistent with the book)
4. Section 3: Actual content, possibly with lemmas, theorems, examples, and tutorial graphics
5. Section 4: Simulation results. You are expected to write your own code and produce your own simulation figures. Simply reproducing figures from the literature (cut and paste) is not acceptable.
6. Conclusion with critical analysis of selected paper(s).

7. Bibliography: mandatory, at least 5 items. Feel free to use: https://fbullo.github.io/lns/LecturesNetworkSystems-Biblio-FB.bib

Please refer to references in your bibliography for each important point you make. Please include images: if you re-use images (previously generated by yourself or others), then cite the source and the copyright information carefully. Otherwise clarify that you generated them.

## Final Presentation

- Length: 25+5 minutes each.
- Consider this presentation your opportunity to teach some important concepts to your colleagues.
- You will grade each other's presentation performance
- I expect everybody to attend and evaluate everybody else's presentation.
- Instructions: Please do not cut and paste parts of papers and reports. I expect you to actually write your own slides. It is okay to include a few selected graphics from the literature (with attribution).

## Document writing using LaTeX or Word/Powerpoint

My suggestion is to use LaTeX, but ultimately I leave it up to you to choose software for the report and presentation. To learn about LaTeX, I suggest having a copy of `The-not-so-short-introduction-to-latex.pdf` at https://tobi.oetiker.ch/lshort/lshort.pdf

For LaTeXslides, I recommend using Beamer (this is the LaTeXpackage I use for my talks).

Regarding slides in powerpoint, I recommend the template for the UCSB College of Engineering.

## Evaluation criteria for final report and presentation

These are the criteria with which I will evaluate your report and presentation (about your selected paper(s)):

1. *Technical comprehension and accuracy:* Understanding and accurate presentation of the technical content, methodologies, results, and conclusions of the assigned research papers.
2. *Critical analysis and evaluation of the selected paper(s):* Critical analysis of methods and findings (practicality, efficiency, and potential applications)
3. *Clarity and organization:* Adherence to the structure presented above. Clear concise language and accurate technical terms. Logical structure. The report should logically flow from problem definition to main results and conclusions. Effective communication of complex ideas. Use of diagrams or models where helpful.
4. *Ethical use of sources:* Accurate use of citations and clear explanation of the key related literature.
5. *Relationship with course material:* Identify and emphasize connections and overlap with course material and text.
6. *Presentation delivery* (presentations only): Time management (25+5 min), clarity of oral explanations, quality of slides, and ability to answer questions from the audience.

Peer evaluation: each student will fill out a brief evaluation form for every presentation, rating clarity, technical content, and delivery. These peer evaluations will contribute to the final presentation grade.

## Schedule for final report and slides

- Communicate your topic to me by Friday May 1st, 2026 (end of week 5).
- The final report is due on Friday of week 9, i.e., Friday May 29th at 11:59pm, via email to me.
- The final slides (revised version incorporating any feedback received during your presentation) are due on Friday June 12th at 11:59pm, via an email to me.

## Schedule for final presentations

We will have final presentations during the two official lectures on week 10 (Mon Jun 1 and Wed Jun 3) and during the final exam (date/time to be determined). (Recall: Final exam week is Mon Jun 8 – Friday Jun 12.)

Schedule of presentations: final presentations will be assigned by alphabetical order, starting with a randomly selected letter in class. https://randomwordgenerator.com/letter.php

## Possible Topics for Final Presentations and Report

For topics with a single listed reference, you are expected to supplement it with additional related papers found through your own literature search.

1. Cooperative systems theory, compartmental systems and examples

   - H. L. Smith. Systems of ordinary differential equations which generate an order preserving flow. A survey of results. *SIAM Review*, 30(1):87–113, 1988. doi:10.1137/1030003
   - G. Bastin and V. Guffens. Congestion control in compartmental network systems. *Systems & Control Letters*, 55(8):689–696, 2006. doi:10.1016/j.sysconle.2005.09.015

2. Dissipativity for control design in network systems

   - M. Arcak, C. Meissen, and A. Packard. *Networks of Dissipative Systems: Compositional Certification of Stability, Performance, and Safety*. Springer, 2016, ISBN 978-3-319-29928-0. doi:10.1007/978-3-319-29928-0 (I can explain which sections/chapters)

3. Epidemic models over digraphs:

   - highly influential: P. V. den Driessche and J. Watmough. Reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission. *Mathematical Biosciences*, 180(1):29–48, 2002. doi:10.1016/S0025-5564(02)00108-6
   - Lyapunov functions with SEIR with vital dynamics: H. Guo, M. Y. Li, and Z. Shuai. A graph-theoretic approach to the method of global Lyapunov functions. *Proceedings of the American Mathematical Society*, 136(8):2793–2802, 2008. doi:10.1090/S0002-9939-08-09341-6
   - SI/SIS/SIR network models: W. Mei, S. Mohagheghi, S. Zampieri, and F. Bullo. On the dynamics of deterministic epidemic propagation over networks. *Annual Reviews in Control*, 44:116–128, 2017. doi:10.1016/j.arcontrol.2017.09.002
   - connection with degree-based models: A. d'Onofrio. A note on the global behaviour of the network-based SIS epidemic model. *Nonlinear Analysis: Real World Applications*, 9(4):1567–1572, 2008. doi:10.1016/j.nonrwa.2007.04.001

4. Collective motions in planar robotic systems:

   - R. Sepulchre, D. A. Paley, and N. E. Leonard. Stabilization of planar collective motion: All-to-all communication. *IEEE Transactions on Automatic Control*, 52(5):811–824, 2007. doi:10.1109/TAC.2007.898077
   - R. Sepulchre, D. A. Paley, and N. E. Leonard. Stabilization of planar collective motion with limited communication. *IEEE Transactions on Automatic Control*, 53(3):706–719, 2008. doi:10.1109/TAC.2008.919857

5. Master stability analysis and network optimization for synchronized oscillators:

   - G. Russo and M. Di Bernardo. Contraction theory and master stability function: Linking two approaches to study synchronization of complex networks. *IEEE Transactions on Circuits and Systems II: Express Briefs*, 56(2):177–181, 2009. doi:10.1109/TCSII.2008.2011611
   - T. Nishikawa and A. E. Motter. Maximum performance at minimum cost in network synchronization. *Physica D: Nonlinear Phenomena*, 224(1-2):77–89, 2006. doi:10.1016/j.physd.2006.09.007

6. Randomized consensus algorithms:

   - A. Tahbaz-Salehi and A. Jadbabaie. A necessary and sufficient condition for consensus over random networks. *IEEE Transactions on Automatic Control*, 53(3):791–795, 2008. doi:10.1109/TAC.2008.917743

- D. Acemoglu, G. Como, F. Fagnani, and A. Ozdaglar. Opinion fluctuations and disagreement in social networks. *Mathematics of Operation Research*, 38(1):1–27, 2013. doi:10.1287/moor.1120.0570

7. Impulsively-coupled oscillators:
   A. Mauroy, P. Sacré, and R. J. Sepulchre. Kick synchronization versus diffusive synchronization. In *IEEE Conf. on Decision and Control*, pages 7171–7183, Maui, HI, USA, December 2012. doi:10.1109/CDC.2012.6425821

8. Distributed Kalman filter:
   - R. Carli, A. Chiuso, L. Schenato, and S. Zampieri. Distributed Kalman filtering based on consensus strategies. *IEEE Journal on Selected Areas in Communications*, 26(4):622–633, 2008. doi:10.1109/JSAC.2008.080505
   - F. S. Cattivelli and A. H. Sayed. Diffusion strategies for distributed Kalman filtering and smoothing. *IEEE Transactions on Automatic Control*, 55(9):2069–2084, 2010. doi:10.1109/TAC.2010.2042987

9. Coherence in large-scale networks:
   - B. Bamieh, M. R. Jovanovic, P. Mitra, and S. Patterson. Coherence in large-scale networks: Dimension-dependent limitations of local feedback. *IEEE Transactions on Automatic Control*, 57(9):2235–2249, 2012. doi:10.1109/TAC.2012.2202052

10. Network Small Gain Theorem
    - Z.-P. Jiang, A. R. Teel, and L. Praly. Small-gain theorem for ISS systems and applications. *Mathematics of Control, Signals and Systems*, 7:95–120, 1994. doi:10.1007/BF01211469
    - T. Liu, D. J. Hill, and Z.-P. Jiang. Lyapunov formulation of ISS cyclic-small-gain in continuous-time dynamical networks. *Automatica*, 47(9):2088–2093, 2011. doi:10.1016/j.automatica.2011.06.018
    - S. N. Dashkovskiy, B. S. Rüffer, and F. R. Wirth. Small gain theorems for large scale systems and construction of ISS Lyapunov functions. *SIAM Journal on Control and Optimization*, 48(6):4089–4118, 2010. doi:10.1137/090746483
    - X. Duan, S. Jafarpour, and F. Bullo. Graph-theoretic stability conditions for Metzler matrices and monotone systems. *SIAM Journal on Control and Optimization*, 59(5):3447–3471, 2021. doi:10.1137/20M131802X

11. Random walks on graphs (Thomson principle, conductance, hitting times):
    - Chapter 9 "Random Walks on Graphs" in: B. Bollobás. *Modern Graph Theory*. Springer, 1998, ISBN 0387984887
    - L. Lovász. Random walks on graphs: A survey. In T. S. D. Miklós, V. T. Sós, editor, *Combinatorics: Paul Erdős is Eighty*, volume 2, pages 353–398. János Bolyai Mathematical Society, 1993

12. Financial networks, stability and risk
    - D. Acemoglu, A. Ozdaglar, and A. Tahbaz-Salehi. Systemic risk and stability in financial networks. *American Economic Review*, 105(2):564–608, 2015. doi:10.1257/aer.20130456
    - M. Elliott, B. Golub, and M. O. Jackson. Financial networks and contagion. *American Economic Review*, 104(10):3115–53, 2014. doi:10.1257/aer.104.10.3115

13. Network formation games
    - M. O. Jackson. A survey of models of network formation: Stability and efficiency. In G. Demange and M. Wooders, editors, *Group Formation in Economics; Networks, Clubs and Coalitions*. Cambridge University Press, 2005. URL: https://web.stanford.edu/~jacksonm/netsurv.pdf
    - V. Bala and S. Goyal. A noncooperative model of network formation. *Econometrica*, 68(5):1181–1229, 2000. doi:10.1111/1468-0262.00155

14. Distributed optimization
    - A. Nedić and A. Ozdaglar. Distributed subgradient methods for multi-agent optimization. *IEEE Transactions on Automatic Control*, 54(1):48–61, 2009. doi:10.1109/TAC.2008.2009515
    - W. Shi, Q. Ling, G. Wu, and W. Yin. EXTRA: An exact first-order algorithm for decentralized consensus optimization. 25(2):944–966, 2015. doi:10.1137/14096668x
    - G. Qu and N. Li. Harnessing smoothness to accelerate distributed optimization. *IEEE Transactions on Control of Network Systems*, 5(3):1245–1260, 2018. doi:10.1109/tcns.2017.2698261
    - T. Yang, X. Yi, J. Wu, Y. Yuan, D. Wu, Z. Meng, Y. Hong, H. Wang, Z. Lin, and K. H. Johansson. A survey of distributed optimization. *Annual Reviews in Control*, 47:278–305, 2019. doi:10.1016/j.arcontrol.2019.05.006
15. Contraction Analysis of Monotone Systems (for students who took the Contraction Theory course)
    - Y. Kawano, B. Besselink, and M. Cao. Contraction analysis of monotone systems via separable functions. *IEEE Transactions on Automatic Control*, 65(8):3486–3501, 2020. doi:10.1109/TAC.2019.2944923
16. Energy and Dissipation in Consensus Systems
    - H. Mangesius. *Energy and dissipation in consensus systems*. PhD thesis, Technische Universität München, 2021. URL: https://mediatum.ub.tum.de/doc/1585119/document.pdf (wonderful recent PhD thesis)
17. Dynamic average consensus
    - S. S. Kia, B. V. Scoy, J. Cortes, R. A. Freeman, K. M. Lynch, and S. Martinez. Tutorial on dynamic average consensus: The problem, its applications, and the algorithms. *IEEE Control Systems*, 39(3):40–72, June 2019. doi:10.1109/mcs.2019.2900783
18. Dynamic programming via Perron-Frobenius
    - E. Todorov. Linearly-solvable Markov decision problems. In *Advances in Neural Information Processing Systems*, pages 1369–1376, Cambridge, MA, USA, 2006. MIT Press
    - E. Todorov. Efficient computation of optimal actions. *Proceedings of the National Academy of Sciences*, 106(28):11478–11483, 2009. doi:10.1073/pnas.0710743106
19. Kuramoto oscillators on spheres
    - M. A. Lohe. Non-Abelian Kuramoto models and synchronization. *Journal of Physics A: Mathematical and Theoretical*, 42(39):395101, 2009. doi:10.1088/1751-8113/42/39/395101
    - J. Markdahl, J. Thunberg, and J. Gonçalves. Almost global consensus on the $n$-sphere. *IEEE Transactions on Automatic Control*, 63(6):1664–1675, 2018. doi:10.1109/TAC.2017.2752799
20. Higher order networks
    - S. Majhi, M. Perc, and D. Ghosh. Dynamics on higher-order networks: a review. *Journal of The Royal Society Interface*, 19(188), 2022. doi:10.1098/rsif.2022.0043
    - P. S. Skardal and A. Arenas. Abrupt desynchronization and extensive multistability in globally coupled oscillator simplexes. *Physical Review Letters*, 122:248301, 2019. doi:10.1103/PhysRevLett.122.248301