Linear Systems on Graphs

Controllability of Structured Networks

Course Introduction

Orientation

Course Information · How It Runs · Weekly Plan

Fall 2026 · Graduate Program in Intelligent Robot Engineering
Department of Control & Instrumentation Engineering
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Orientation. Course Information

Course	Linear System (A05470, section 001)
Credits	3 (3-3-0) · graduate elective
Time	Wednesday, periods 7–9 (15:00–18:00)
Room	B21-219
Instructor	Nam-Jin Park / Control & Instrumentation Eng.
Office hours	by e-mail appointment pnj@pknu.ac.kr
Course page	https://pknu-507.github.io/MARS/

MARS Lab — slides and lecture notes are posted here

[Course goal] Master linear system theory from the **state-space viewpoint** and extend it to **networks**.

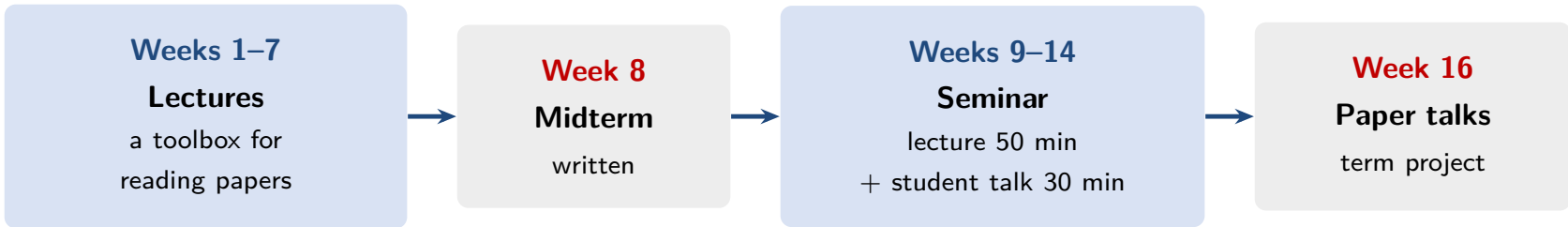
Decide and design the controllability of networks with unknown weights **from the graph alone**.

Orientation. Textbook and Tools

- **Main text — lecture notes by the instructor**
  - N.-J. Park, *Linear Systems on Graphs: Controllability of Structured Networks*
  - Three parts, ten chapters, plus proof appendices A · B
  - Free PDF on the course page — https://pknu-507.github.io/MARS/
  - Text and slides in English; lectures delivered in Korean
- **Reference**
  - C.-T. Chen, *Linear System Theory and Design*, 4th ed.
- **Tool — MATLAB only (free under the PKNU site license)**
  - Rank, eigenvalues, Gramians · `digraph` for reachability and matchings · symbolic determinants (Symbolic Math Toolbox)
- **Prerequisites**
  - Linear algebra · differential equations · basic programming

[In one line] The first half **trusts the numbers** in A; the second asks what can be certified when only the **zero/non-zero pattern** is known.

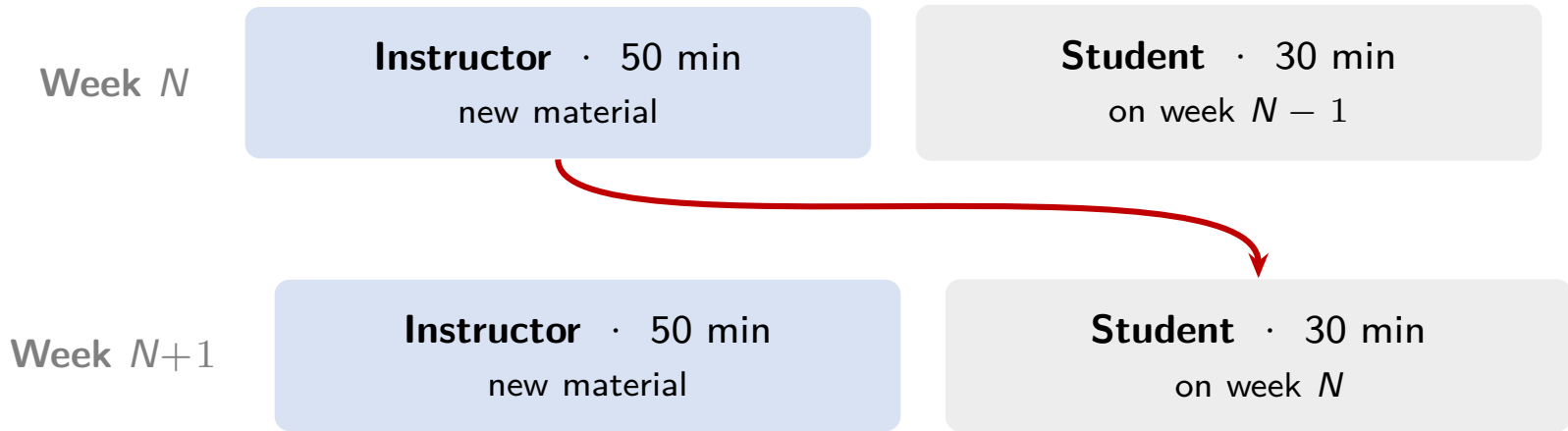
Orientation. How This Course Runs



- **First half** (weeks 1–7) — instructor lectures, Ch.1–Ch.6: **basic concepts, graph vocabulary, and the state-space → graph correspondence**. Deep proofs are left out.
- **Midterm** (week 8) — written exam, Ch.1–Ch.6.
- **Second half** (weeks 9–14) — each week opens with a **50-minute lecture**; a student then re-presents part of the **previous** week's material.
- **Week 16** — individual talks on a **paper each student picks** from a list handed out in week 9.

[The point] Learn **how to read** in the first half; **read and present** on your own in the second.

Orientation. Presentation Format (Weeks 9–14)

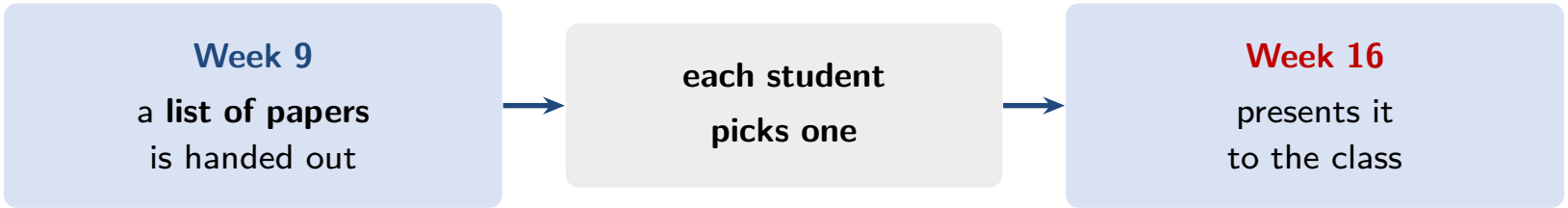


what the instructor covers in one week, a student re-presents in the next

- **50 min** — the instructor states the key definitions and theorems of the week.
- **30 min** — a student re-presents part of it: **20 min talk + 10 min Q & A**.
- Speakers and topics are announced in **week 9**.

[Why present] You find out what you did *not* understand only when you have to **say it back**.

Orientation. Term Project (Week 16)



- The list comes **right after the midterm**, so you choose knowing what the course has already covered.
- Talk length, report format, and what to cover are announced in **week 9**.

[Intent] Can you **read an unfamiliar paper on your own** with one semester's worth of tools?

Orientation. Evaluation

Item	Attendance	Midterm	Term project
Weight	10 %	40 %	50 %
When · scope	all weeks	week 8 · Ch.1–Ch.6	week 16 · paper talk

- **Midterm** — week 8, written: stating definitions, running the tests, constructing counterexamples.
- **Term project** — the week-16 paper talk and the technical report.
- Presentation work in weeks 9–14 counts **within the project score**.

[Attendance] Missing **1/4 or more** of the class hours results in an **F** under university regulations.

Orientation. Curriculum Map (I)

[Turning point] Part I trusts **every number** in A — Part II keeps only its **zero / non-zero pattern**.

Orientation. Curriculum Map (II)

▶ Part III Input Placement: Synthesis — student talks

Ch. 9 Minimum Input Problem *how many inputs* — wk 13

Ch. 10 Optimal Input Placement and Outlook *where inputs go* — wk 14

▶ Appendix Proofs — deep-dive topics

Ch. A Proofs: Structural Side *Hosoe · Lin* — optional

Ch. B Proofs: Strong Structural Side *Mayeda · zero forcing* — optional

▶ Milestones

- Midterm (written) — wk 8
- Paper list handed out · speakers announced — wk 9
- Student talks begin — wk 10
- Term-project talks — wk 16

[In one line] From **deciding** (Part II) to **designing** (Part III) — and then to the literature.

Orientation. Weekly Schedule

First half wk 1–8 lectures			
Wk	**Date**	**Topic**	**Note**
1	9/2	Orientation · Ch.1 Introduction	
2	9/9	Ch.2 (I) Models and graphs	
3	9/16	Ch.2 (II) Solutions · stability	
4	9/23	Ch.3 Controllability · PBH	
5	9/30	Ch.4 Pattern graphs · vocabulary	
6	10/7	Ch.5 Determinant view · SC, SSC	
7	10/14	Ch.6 Two controllable subspaces	
8	10/21	**Midterm**	Ch.1–6

Second half wk 9–16 seminar			
Wk	**Date**	**Topic**	**Note**
9	10/28	Ch.7 (I) Lin · matching	papers
10	11/4	Ch.7 (II) Mayeda · zero forcing	talk
11	11/11	Ch.8 (I) Fixed subspaces, nodes	talk
12	11/18	Ch.8 (II) Input-addition test	talk
13	11/25	Ch.9 Minimum input problem	talk
14	12/2	Ch.10 Optimal input placement	talk
15	12/9	**Make-up week**	
16	12/16	**Term-project talks**	

[Academic calendar] midterm period **10/20–26** · make-up week **12/8–11** · final period **12/14–20** **[No class]**
10/28 (Wed) official trip — made up in the make-up week

Orientation. What to Prepare

- **This week**
  - Download the lecture-note PDF — skim **Ch.1 and Ch.2**
  - Install **MATLAB** — free for students under the **PKNU site license**
- **Week 2 (9/9) — Ch.2 State-Space Models and Their Graphs**
  - One question will run through the whole semester:

    "*If you do not know the numbers in A — only **where it is zero and where it is not** — can you control this network?*"
  - Answering it needs, first, a way to **move a system onto a graph**.

[The promise] By the end of this course you can **read and present a paper on structural controllability** on your own.

Thank you

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