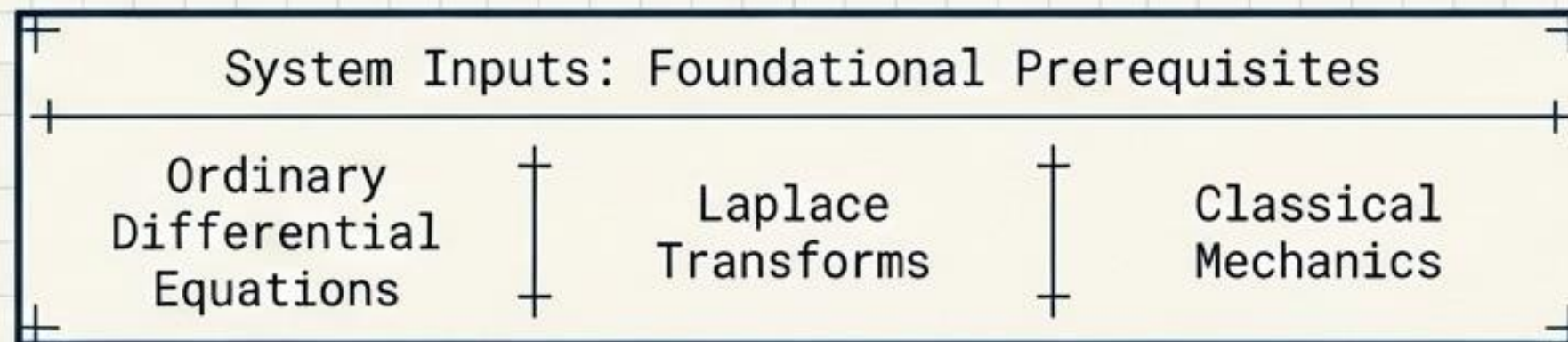
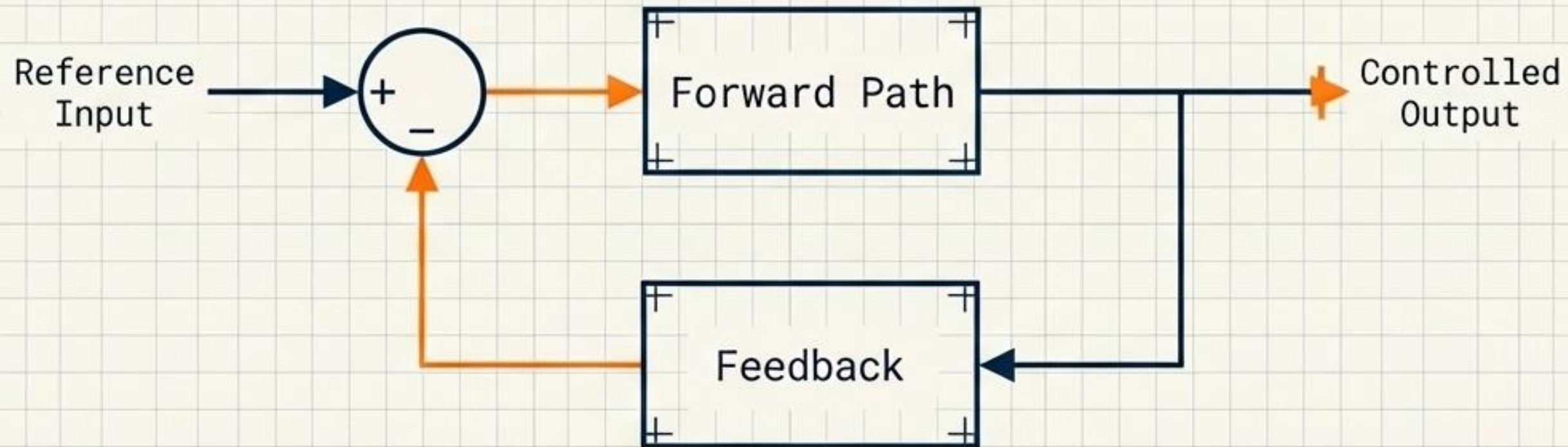


MEC524 Course Outline

Course Architecture and Roadmap for MEC524 (3 Credit Hours)



Course Outcomes: The Competency Architecture



Pillar 1: Theory & Math

- Derive mathematical models of dynamic systems.
- Understand classical Control Engineering principles.
- Design controllers specifically for second-order systems.



Pillar 2: Analysis & Tools

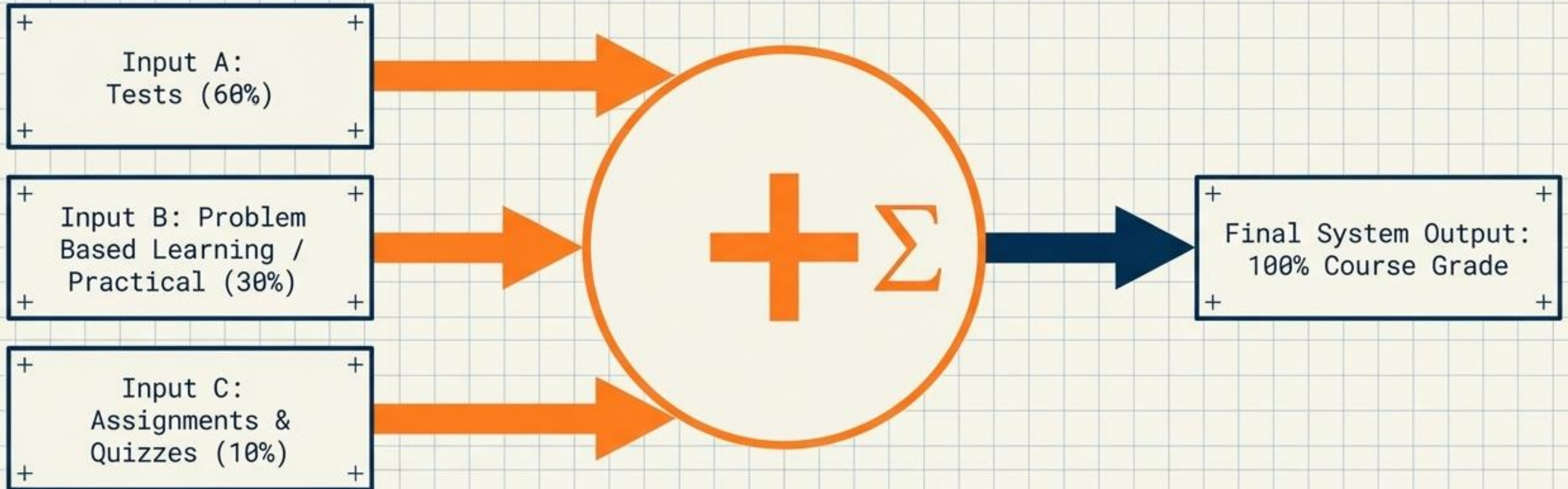
- Evaluate performance and stability using analytical methods.
- Master computational tools like MATLAB® and SIMULINK® for system design.



Pillar 3: Design & Communication

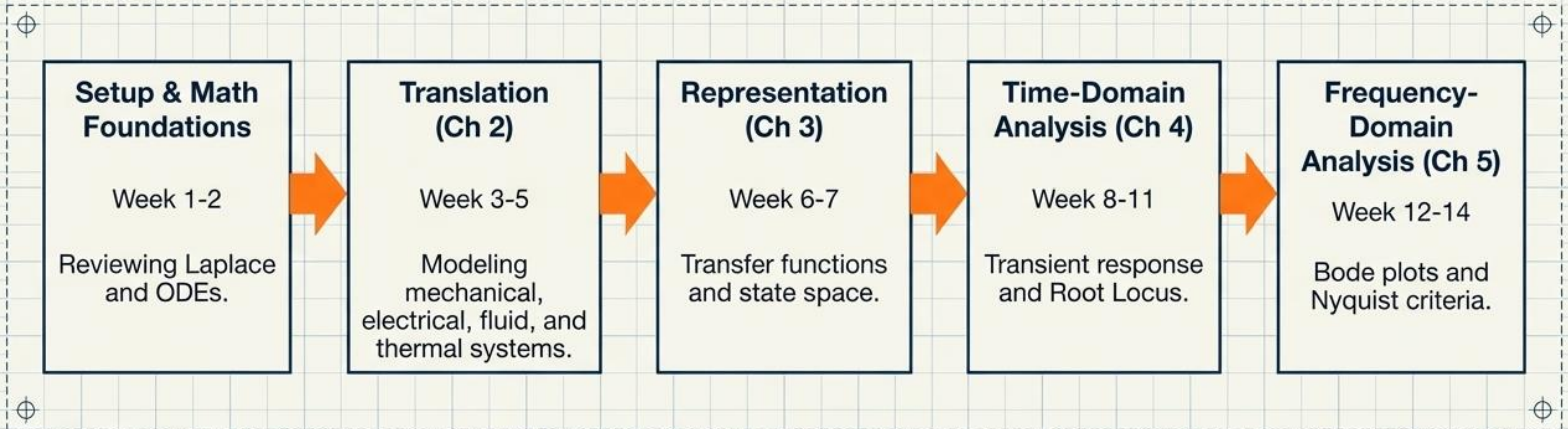
- Translate theoretical knowledge to practical control applications.
- Create technical documentation and presentations.
- Develop a foundation for lifelong learning in control advancements.

The Grading Feedback Loop



Diagnostic Note: Total Course Work comprises 40% of the grade, while summative Tests provide the remaining 60% stability check.

The Control Engineer's Journey: Master Roadmap

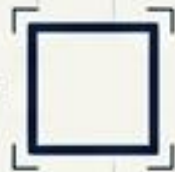


Phase 1: Foundations & Translation (Weeks 1-5)

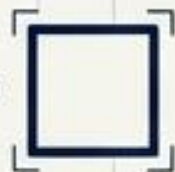
Chronological Milestones



Week 1: Complete Entrance Survey (by **03/05/2026**).



Week 2: Submit Homework 1 (ODE/Laplace conversion, **due 20/04**).



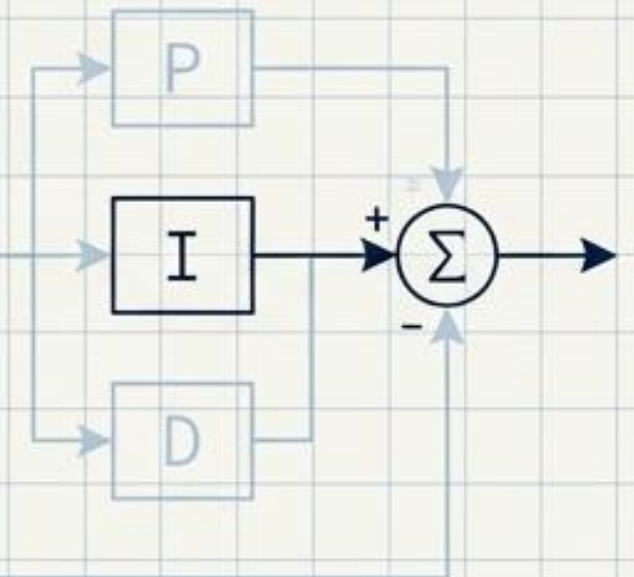
Week 4: Complete Quiz 1 (System mathematical models) via Ufuture platform.

Conceptual Objectives (Ch 1 & 2)

Introduction to open-loop vs. closed-loop systems.


Basic PID Controller concepts.

Mathematical modeling of diverse engineering systems.



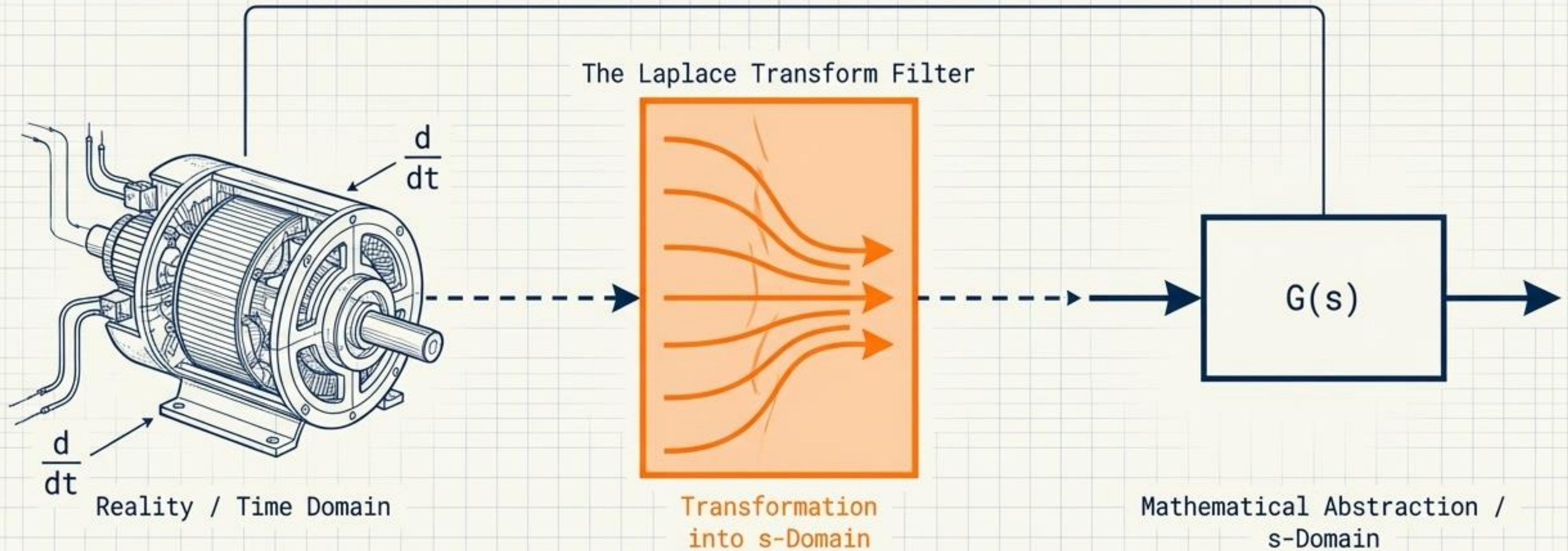
The Unification of Physical Domains

Domain	Physical Components	Mathematical Analysis
Mechanical Systems	Mass, springs, and dampers	Equations of Motion
Electrical & Electromechanical	RLC circuits and motors (DC/Brushless)	Kirchhoff's Laws
Fluid Systems	Fluid resistance and capacitance	Pressure drops and flow rates
Thermal Systems	Thermal resistance and capacitance	Heat flow and temperature gradients



All domains reduce to Ordinary Differential Equations (ODEs) for control analysis.

The Cognitive Bridge: Week 6 Concept



Prerequisite Viewing (Week 4): Review the required YouTube materials on DC/Brushless motor working principles before attempting this transformation.

Phase 2: System Representation (Weeks 6-7)

Transfer Functions: The ratio of output to input in the s-domain.

State Space Representation: Matrix-based modeling for complex systems.

Block Diagrams & Signal Flow: Visualizing system architecture and reducing complexity.

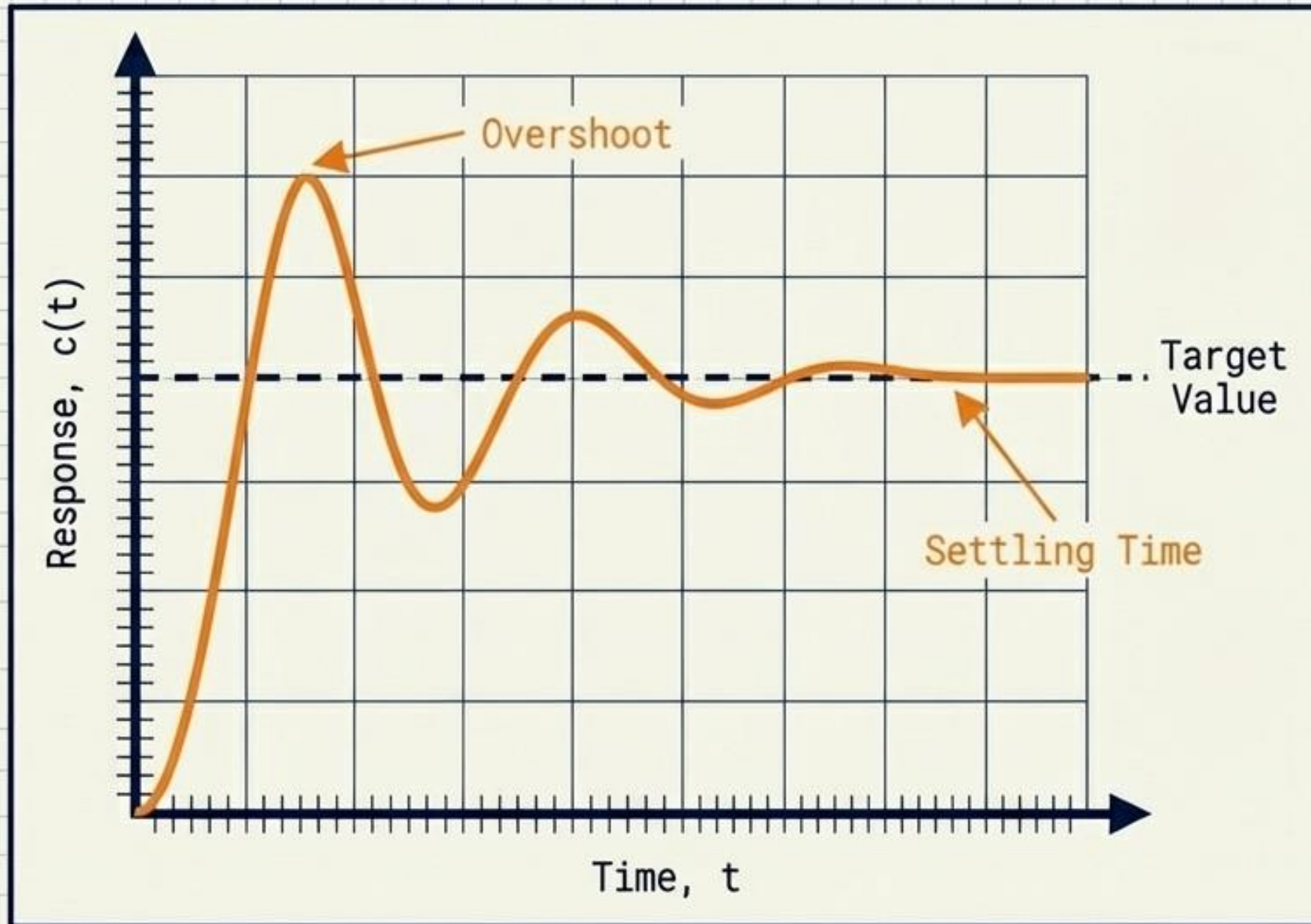
Execution Milestones

Week 6: Watch three specific e-Content modules on establishing Transfer Functions

Week 6: Submit **Homework 2** (ODE, Laplace, and Transfer Functions, due 17/05).

Week 7: Complete GeeksforGeeks reading on Block Diagram Reduction Concepts.

Phase 3: Time-Domain Analysis (Weeks 8-11)



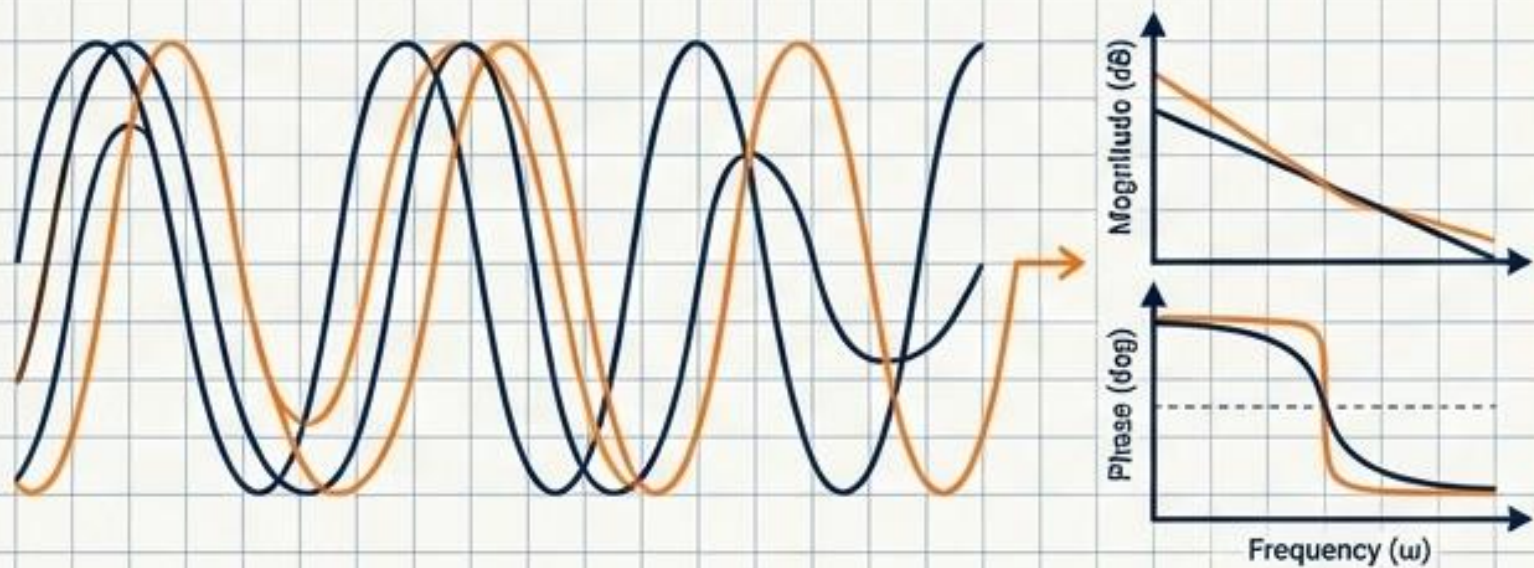
Core Analytical Topics

- Transient and Steady-State response for 1st & 2nd Order Systems.
- BIBO (Bounded-Input Bounded-Output) Stability Criterion.
- Routh-Hurwitz Stability Criteria and Root Locus Method.

Execution Milestones

- **Week 8:** Submit Homework 3 (First Order System response equations, due 14/06).
- **Week 9 & 10:** Complete Exercise Sheets 1 & 2. Engage with Webex e-Content on System Performance and Root Locus.
- **Week 11:** Complete Quiz 2 (1-hour stability analysis assessment via Ufuture).

Phase 4: Frequency-Domain Analysis (Weeks 12-14)



Core Topics

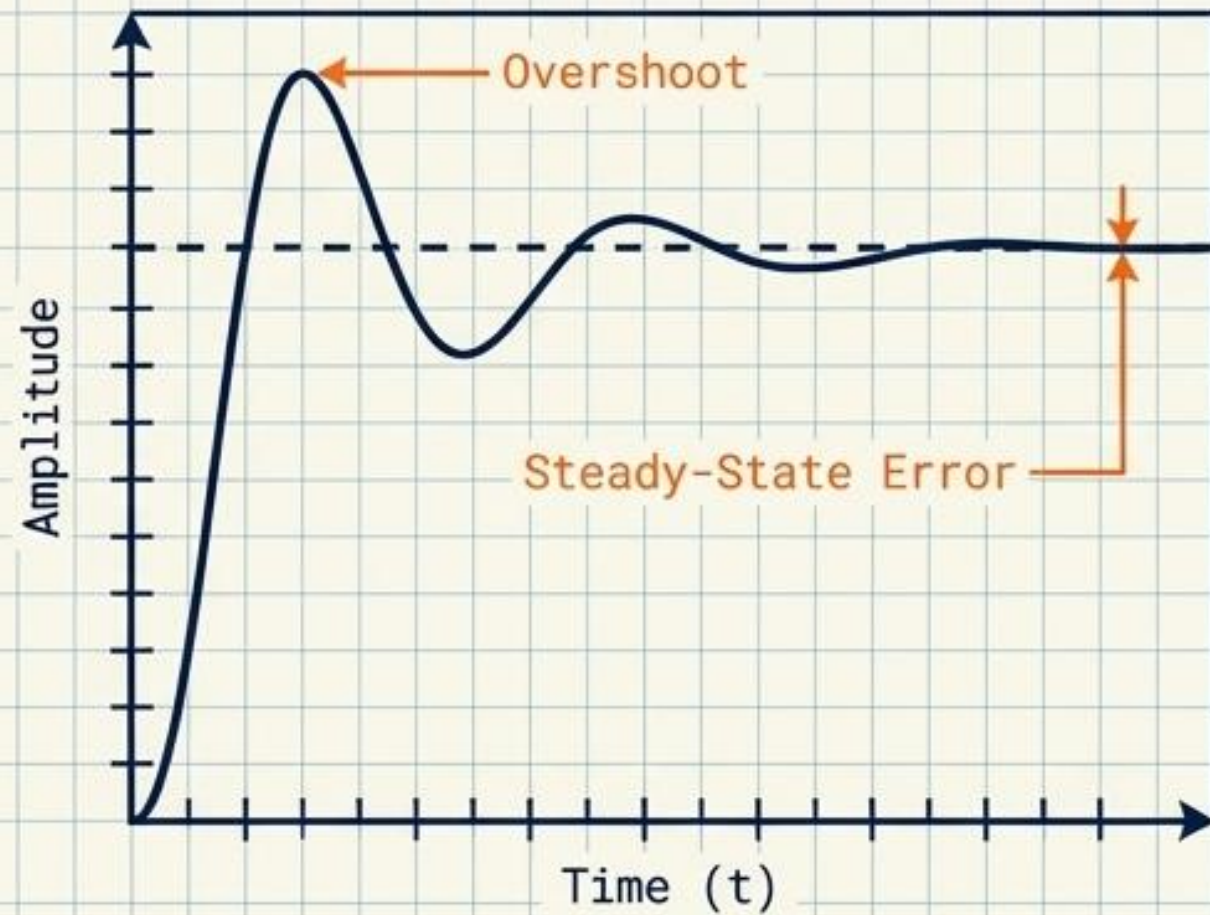
- **Bode Diagrams**: Analyzing system magnitude and phase over a spectrum of frequencies.
- **Nyquist Stability Analysis**: Advanced polar plotting for theoretical and numerical stability.

Execution Milestones

- **Weeks 12 & 13**: Deep dive into four specific Webex e-Content streaming recordings dedicated exclusively to Bode Diagrams.
- **Week 14**: Complete **Exercise Sheet 3** (Theoretical analysis via Nyquist Diagram and numerical approaches).

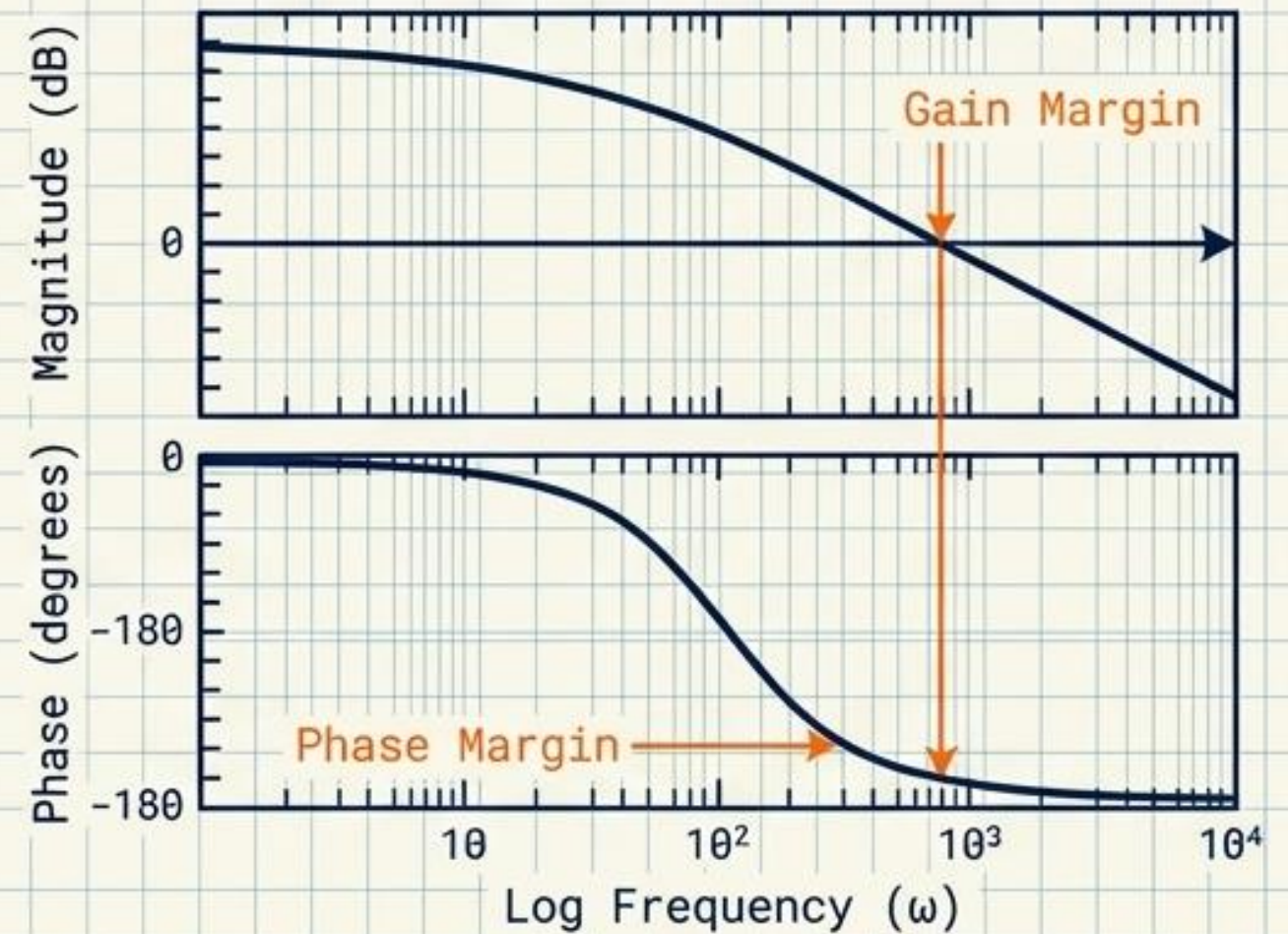
The Paradigm Shift: Time vs. Frequency Domains

Time Domain / Ch 4



How the system behaves over seconds and minutes.

Frequency Domain / Ch 5



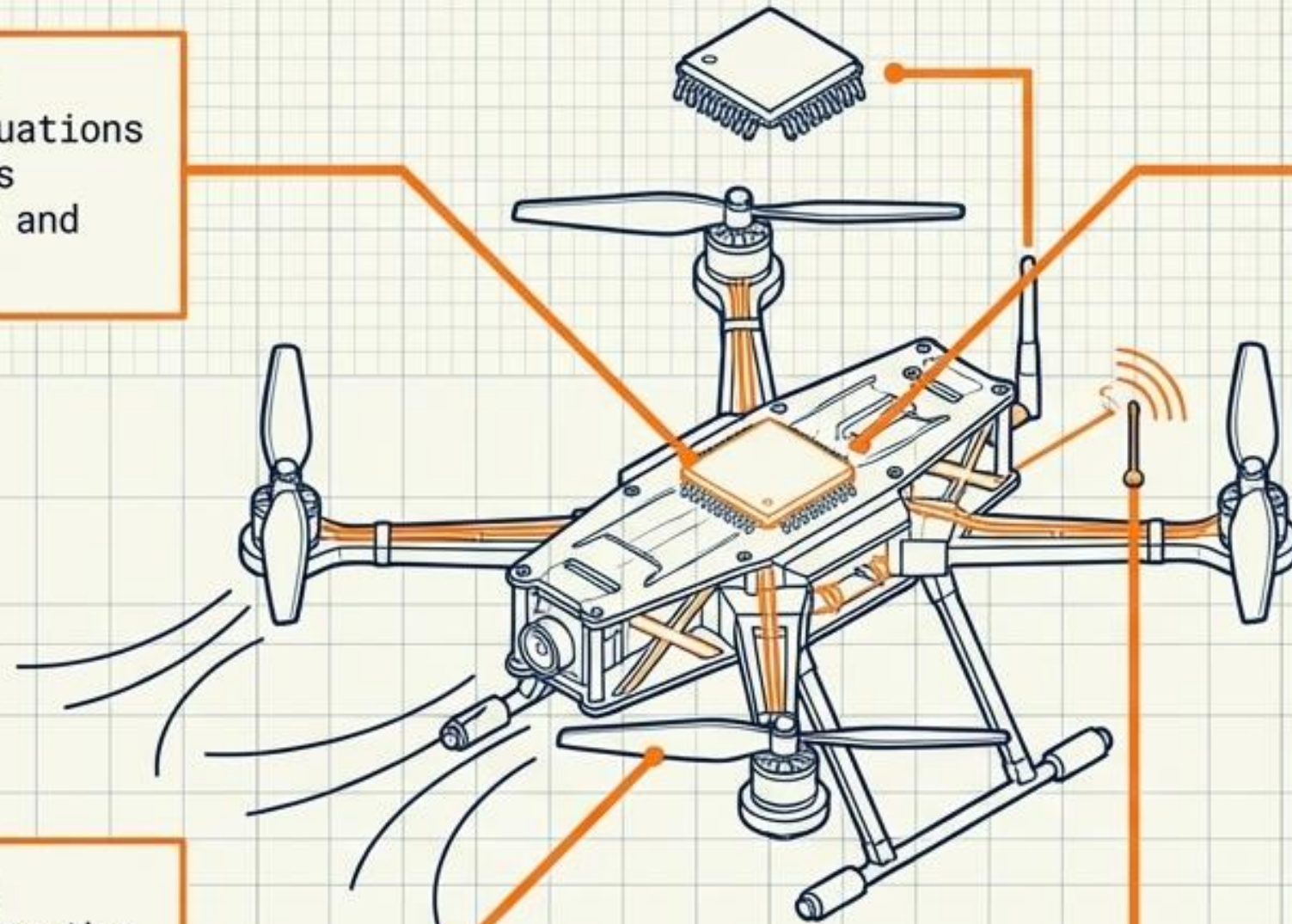
How the system responds to different input frequencies.

The Stability Analysis Toolkit

Routh-Hurwitz	Root Locus	Bode Plots	Nyquist Criterion
Domain: Mathematical / Algebraic	Domain: Time Domain / Graphical	Domain: Frequency Domain / Logarithmic	Domain: Frequency Domain / Polar
Use Case: Quick check for absolute stability without solving roots.	Use Case: Visualizing how roots move as system gain changes; tuning transient response.	Use Case: Designing for specific phase and gain margins; steady-state accuracy.	Use Case: Determining absolute and relative stability from open-loop frequency response.

Synthesis: Engineering the Quadcopter (PBL Group Assignment due 14/06)

Chapter 2 - Translation:
Deriving the physical equations of motion for the drone's electromechanical rotors and aerodynamic chassis.

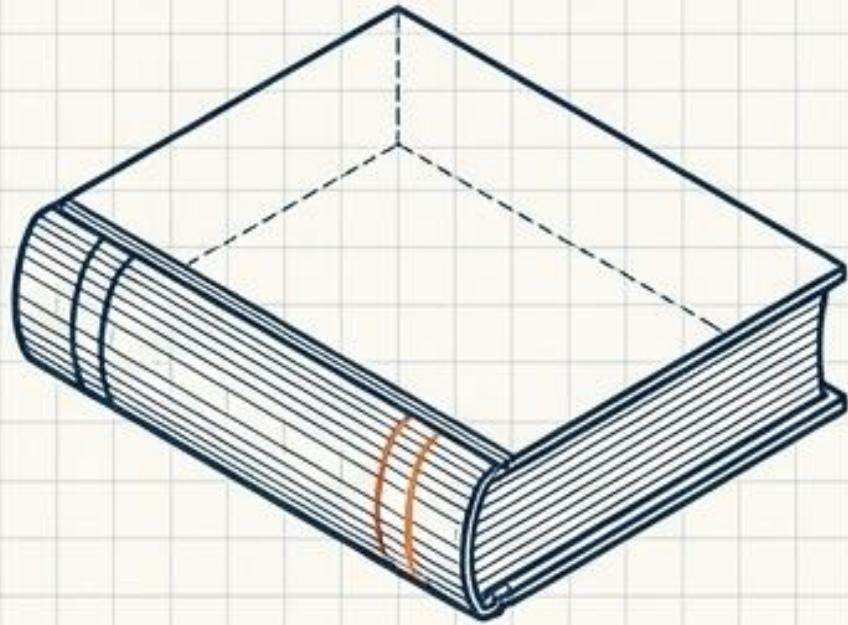


Chapter 3 - Representation:
Building the multi-variable block diagram that links rotor speed to altitude and pitch.

Chapter 4 - Time Domain:
Using Root Locus to ensure the drone doesn't crash from severe transient overshoot when a gust of wind hits.

Chapter 5 - Frequency Domain:
Utilizing Bode plots to tune the drone's responsiveness to rapid remote-control inputs.

Core Toolsets & Foundational Texts

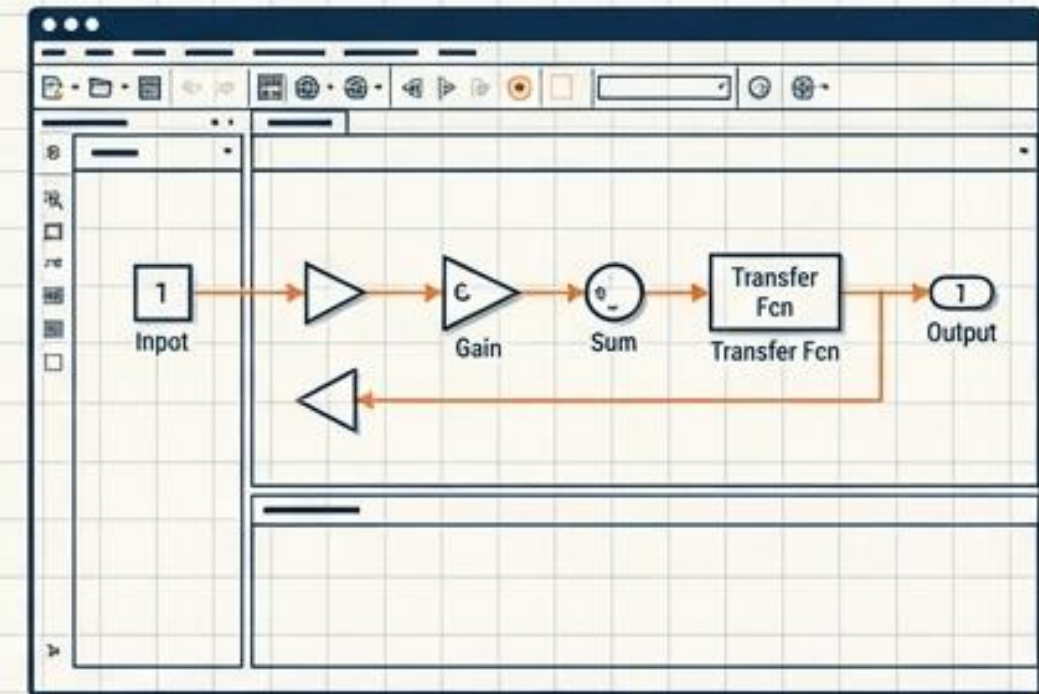


The Text

Primary Text: Norman Nise, Control Systems Engineering, 8th Edition (2019).
ISBN: 978-1-119-47422-7.

Secondary References:

- Ogata K. (System Dynamics, 4th Ed)
- William J. Palm III (System Dynamics, 2nd Ed)
- A. Anand Kumar (Control Systems)



MATLAB® & SIMULINK®

The industry-standard computational environments required for the analysis, design, and simulation of control systems in MEC524.