Senior CS Electives Guide

How to Use This Guide

You can take five senior CS electives structured as: **one** from the "Select One" bucket (**CS 455**, **CS 468**, **CS 475**, or **CS 487**), plus four additional courses from the broader list (including the four above). This guide organizes courses by area of interest, motivates why they matter, and connects them to real-world jobs. It also offers sample bundles of five courses per track, mixing fundamentals and portfolio-ready depth.

Recommended 5-Course Bundles by Interest

Each bundle includes one course from the Select-One bucket (marked ⋆). Adjust for prerequisites and semester offerings.

A. AI/ML and Data (math-heavy)

- ⋆ CS 475 (Concurrent and Distributed Systems): scalable ML systems and data platforms live on distributed infrastructure.
- CS 450 (Database Concepts): data foundations for features, experiments, and analytics.
- CS 484 (Data Mining): core supervised/unsupervised learning, evaluation, pipelines.
- CS 478 (Natural Language Processing) **or** CS 482 (Computer Vision): domain depth.
- CS 489 (Deep Learning): modern neural networks (CNNs, RNNs/transformers, generative models).

Typical roles: Data Scientist (junior), ML/AI Engineer (associate), Data/Analytics Engineer, Applied Scientist Intern, Recommender Systems Intern.

B. Systems, Performance and Security

- ⋆ CS 468 (Secure Programming and Systems): software security mindset and tooling.
- CS 471 (Operating Systems): core OS mechanisms and concurrency.
- CS 465 (Computer Systems Architecture): hardware/software performance interface.
- CS 475 (Concurrent and Distributed Systems): correctness and scalability.
- CS 469 (Security Engineering) **or** CS 487 (Cryptography): defensive design or formal crypto.

Typical roles: Security Engineer, Systems/Infrastructure Engineer, SRE/Platform Engineer, Performance Engineer, Low-level Developer.

C. Software Engineering and Product Development

- ⋆ CS 455 (Computer Communications and Networking): networked products and cloud back-ends.
- CS 450 (Database Concepts): schema design, SQL proficiency, transactions.
- CS 477 (Mobile Application Development): modern app patterns, UI, and APIs.
- CS 475 (Concurrent and Distributed Systems) **or** CS 468 (Secure Programming): production robustness.

- CS 490 (Design Exhibition) **or** CS 491 (Industry-Sponsored Senior Design): capstone portfolio.

Typical roles: Full-Stack/Backend Developer, Mobile Developer, Product Engineer, SWE Generalist, Solutions Engineer.

D. Graphics, Games and XR

- ⋆ CS 475 (Concurrent and Distributed Systems): real-time multiplayer, asset pipelines.
- CS 451 (Computer Graphics): rendering pipeline, transformations, shading.
- CS 425 → CS 426 (Game Programming I → II): team-based game build.
- CS 452 (Virtual Reality) **and/or** CS 453 (Computational Photography): immersive tech and imaging.

Typical roles: Graphics/Rendering Engineer, Gameplay/Tools Engineer, XR/VR Developer, Technical Artist, Engine Programmer.

E. Robotics, Embedded and Autonomy

- ⋆ CS 475 (Concurrent and Distributed Systems): distributed control, messaging, and reliability.
- CS 471 (Operating Systems): scheduling, memory, and device I/O principles.
- CS 465 (Computer Systems Architecture): memory hierarchy, performance tuning.
- CS 485 (Autonomous Robotics): kinematics, control, planning, and sensor fusion.
- CS 482 (Computer Vision) **or** CS 484 (Data Mining): perception and learning for autonomy.

Typical roles: Robotics Engineer, Embedded/Firmware SWE, Perception Engineer, Autonomy Engineer, Mechatronics/Controls.

F. Programming Languages, Compilers and Theory

- ⋆ CS 487 (Cryptography) **or** CS 475: both emphasize rigor; choose by interest.
- CS 440 (Compilers): front-ends, IR, code generation, optimization.
- CS 463 (Comparative Programming Languages): semantics, types, concurrency models.
- CS 483 (Analysis of Algorithms): *required*, deepens theoretical toolbox.
- MATH 446 (Numerical Analysis) **or** CS 487 (Cryptography): analysis for scientific/crypto workflows.

Typical roles: Compiler/Toolchain Engineer, Language/Runtime Engineer, Research Engineer, Formal Methods/Verification Intern.

Per-Course Overviews: Why Take It and Where It Leads

CS 425/426 Game Programming I/II	**Why:** End-to-end team project using modern engines; builds portfolio pieces.
	Pairs well with: CS 451, CS 452, CS 453, CS 475.
	Typical roles: Gameplay/Tools Engineer, Technical Artist, XR Developer.

	Notes: Strong time management; II builds on I with full implementation.
CS 440 Compilers	**Why:** Understand how languages become executable code; reinforces parsing, IRs, optimization. *Pairs well with:* CS 463, CS 465, CS 471. *Typical roles:* Compiler Engineer, Performance Engineer, Static Analysis/Tooling.
CS 450 Database Concepts	**Why:** Schema design, SQL, normalization, transactions, security; universally useful. *Pairs well with:* CS 455, CS 475, CS 484. *Typical roles:* Backend/Full-Stack SWE, Data Engineer, Analytics Engineer.
CS 451 Computer Graphics	**Why:** Rendering pipeline, transforms, lighting, textures; linear algebra in action. *Pairs well with:* CS 425/426, CS 452, CS 453. *Typical roles:* Graphics/Rendering Engineer, Game/Engine Developer.
CS 452 Virtual Reality	**Why:** VR/AR pipeline (displays, 3D interaction, haptics) and applications. *Pairs well with:* CS 451, CS 425/426. *Typical roles:* XR/VR Developer, Simulation Engineer, Training and Serious Games.
CS 453 Computational Photography	**Why:** Imaging hardware + algorithms; 3D reconstruction, enhancement, generative imaging. *Pairs well with:* CS 451, CS 482, CS 489. *Typical roles:* Imaging/Camera Pipeline Engineer, Vision Engineer.
CS 455 Networking	**Why:** TCP/IP stack, LAN/WAN protocols, performance; foundation for cloud and distributed apps. *Pairs well with:* CS 450, CS 475, CS 468. *Typical roles:* Backend SWE, Network/Systems Engineer, SRE.
CS 463 Comparative Programming Languages	**Why:** Language mechanisms across paradigms; concurrency models and type systems. *Pairs well with:* CS 440, CS 471. *Typical roles:* Language/Runtime Engineer, Tooling/IDE Engineer.
CS 465 Computer Systems Architecture	**Why:** Instruction sets, pipelining, caches, memory hierarchy; performance intuition. *Pairs well with:* CS 471, CS 475, CS 468. *Typical roles:* Systems/Performance Engineer, Embedded SWE.
CS 468 Secure Programming and Systems	**Why:** Vulnerability analysis, secure development, distributed system security. *Pairs well with:* CS 455, CS 475, CS 469. *Typical roles:* Security Engineer, AppSec, Security-minded SWE.

CS 469 Security Engineering	**Why:** End-to-end defense: access control, identity, IDS/forensics, monitoring. *Pairs well with:* CS 468, CS 471, CS 455. *Typical roles:* Security Engineer, Blue Team, Security Architect (junior).
CS 471 Operating Systems	**Why:** Concurrency, scheduling, memory, files, I/O, deadlocks; OS projects build systems skill. *Pairs well with:* CS 465, CS 475, CS 468. *Typical roles:* Systems/Kernel Developer, SRE, Performance Engineer.
CS 475 Concurrent and Distributed Systems	**Why:** Threads, synchronization, distributed protocols, systems integration; highly practical. *Pairs well with:* CS 455, CS 450, CS 471. *Typical roles:* Backend SWE, Distributed Systems Engineer, Cloud/SRE.
CS 477 Mobile App Development	**Why:** UI patterns, event-driven design, IPC, networking, performance on constrained devices. *Pairs well with:* CS 450, CS 455, CS 468, CS 490/491. *Typical roles:* iOS/Android Developer, Full-Stack with Mobile Focus.
CS 478 Natural Language Processing	**Why:** Language modeling, embeddings, tagging, parsing, sentiment and applications. *Pairs well with:* CS 484, CS 489, CS 480. *Typical roles:* NLP Engineer, Applied Scientist Intern, Data Scientist (NLP).
CS 480 Intro to AI	**Why:** Knowledge representation, search, planning, reasoning; breadth across classical AI. *Pairs well with:* CS 484, CS 478, CS 489. *Typical roles:* Generalist SWE with AI literacy, Traditional AI/Planning roles.
CS 482 Computer Vision	**Why:** Early vision, edges/segmentation, representation, understanding; projects with real images. *Pairs well with:* CS 451, CS 484, CS 489. *Typical roles:* Vision/Perception Engineer, Robotics Perception, Imaging.
CS 484 Data Mining	**Why:** Rigorous modeling/prediction, evaluation, clustering, association, BI; end-to-end ML. *Pairs well with:* CS 450, CS 478/482, CS 489. *Typical roles:* ML/AI Engineer, Data Scientist, Recommender Systems.
CS 485 Autonomous Robotics	**Why:** Architectures, kinematics, control, planning, localization, learning, sensor fusion. *Pairs well with:* CS 471, CS 475, CS 482. *Typical roles:* Robotics/Autonomy Engineer, Embedded SWE, Controls.
CS 487 Introduction to Cryptography	**Why:** Formal security definitions; constructions for encryption/authentication; proofs and practice.

	Pairs well with: CS 468, CS 469, CS 483.
	Typical roles: Cryptography/Security Engineer, Protocols/Privacy Engineer.
CS 489 Deep Learning	**Why:** Neural architectures (CNNs, RNNs, Transformers), generative models, training and evaluation.
	Pairs well with: CS 484, CS 478, CS 482.
	Typical roles: ML/AI Engineer, Research Engineer, Vision/NLP Engineer.
CS 490/491 Capstones	**Why:** Portfolio-ready industry or exhibition projects; teamwork, scoping, delivery.
	Pairs well with: Any focused bundle above for a coherent theme.
	Typical roles: Strong interview portfolio; practical experience talking points.
MATH 446 / OR 481 Numerical Analysis/Methods	**Why:** Numerical linear algebra, optimization, ODE/PDE methods; essential in simulation/ML.
	Pairs well with: CS 451, CS 482, CS 489.
	Typical roles: Scientific Computing, Optimization Engineer, Quant/Simulation.

Choosing Your "Select One" Course

- **CS 455** if you lean product/cloud/back-end or want strong networking fundamentals.
- **CS 468** if you want a security-first mindset and hands-on secure development.
- **CS 475** if you care about scale, correctness, and building reliable services or robotics stacks.
- **CS 487** if you enjoy proofs, number theory, and cryptographic protocols.

Two-Semester Sample Plans (Adjust as Needed to Fit Your Unique Interests)

AI/ML	**Fall:** CS 450, CS 484, CS 475 ($\star$)	**Spring:** CS 489, CS 478 or CS 482.
Systems/Security	**Fall:** CS 471, CS 468 ($\star$), CS 465	**Spring:** CS 475, CS 469 or CS 487.
Graphics/Games/XR	**Fall:** CS 451, CS 425, CS 475 ($\star$)	**Spring:** CS 426, CS 452 or CS 453.
Software Eng/Product	**Fall:** CS 450, CS 455 ($\star$), CS 475	**Spring:** CS 477, CS 490/491.
Robotics/Embedded	**Fall:** CS 471, CS 465, CS 475 ($\star$)	**Spring:** CS 485, CS 482 or CS 484.

Prerequisite Awareness

Check prerequisites in advance so you can unlock your target bundle:

- Many advanced courses require **CS 310**, **CS 330**, **CS 367**, **STAT 344**, and for math-heavy courses, **MATH 203**.
- Graphics/vision often rely on **linear algebra** and calculus; security/crypto rely on **discrete math/probability**.

- Some courses (**CS 425→426**, **CS 490/491**) are sequenced or project-intensive—budget time.

Portfolio Tips

- Aim for a coherent theme across projects (like recommender systems + data pipelines + DL capstone).
- For AI/ML: include a full pipeline (data quality, features, model, evaluation, deployment story).
- For systems/security: show concurrency, performance numbers, correctness tests, threat modeling.
- For graphics/games/XR: demonstrate rendering features, tools, or gameplay systems, with short videos.
- For mobile/product: publish an app/TestFlight build or a robust backend + API + docs.

Which Jobs Does This Prepare You For?

- **AI/ML/Data:** ML/AI Engineer, Data Scientist, Data/Analytics Engineer, Recommender Systems.
- **Systems/SRE/Security:** Systems SWE, Platform/SRE, Security Engineer, Performance Engineer.
- **Graphics/Games/XR:** Rendering/Engine/Gameplay Engineer, XR Developer, Simulation Engineer.
- **Robotics/Embedded:** Robotics/Autonomy Engineer, Embedded SWE, Perception/Controls.
- **Compilers/PL/Tools:** Compiler Engineer, Language/Runtime Engineer, Static Analysis/Tooling.
- **Software/Product:** Backend/Full-Stack SWE, Mobile Developer, Product Engineer, Solutions Engineer.

Final Advice

Pick for depth + breadth: one Select-One course that matches your direction, two to three courses that build depth in that area, and one course for complementary breadth (databases for ML, security for product, distributed systems for games/robotics). Tie it all together with a capstone or industry project you can demo during internships and job interviews.

This guide is aligned to the course descriptions you provided; always verify semester offerings and prerequisites in the official catalog.