A Metro Map-Based Curriculum Visualization for Examining Interrelated Curricula



ASEE 2022, CIT Division Technical Session #9

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- 180+ 3-letter course codes, with 1-100 numbers/courses per code \bullet
- 300+ degree programs*

* includes joint degree programs

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- 180+ 3-letter course codes, with 1-100 numbers/courses per code
- 300+ degree programs*
- 17 degree programs within the Engineering college
- 15 departments within the Engineering college
- Graduation requirements for the College of Engineering
- Graduation requirements for each degree program

* includes joint degree programs

Curricular requirements can be complicated

- information and choice
- Requirements and available courses continue to change

Gestwicki, "Work in progress – curriculum visualization," FIE (2008)

Both students and administrators can be overwhelmed by the amount of

• Even upperclassmen need assistance understanding their path to graduate

Why is this a problem? When students don't understand requirements, they...

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This is a larger issue for students choosing between degree programs



Goal: Help students easily understand commonalities and differences between degree programs

Existing Curriculum Visualizations

- Visualizations that show course pre-requisites/dependencies (Sommaruga & Catenazzi; Kriglstein; Zucker; Gestwicki; Aldrich; Moreno, Bischof & Hoover)
- Visualizations that display recommended course progressions (Zucker; Gestwicki; Auvinen, Paavola & Hartikainen; Nuutinen & Sutinen)
- Visualizations that include course topics and content (Auvinen, Paavola & Hartikainen; Takamatsu; Siirtola)

Computer Science, BS

Overview Degree Requirements

Suggested Sequence

for the degree of Bachelor of Science in Computer Science

Graduation Requirements

Minimum Technical GPA: 2.0

TGPA is required for CS and Math courses. See **Technical GPA** to clarify requirements.

Minimum Overall GPA: 2.0

Minimum hours required for graduation: 128 hours

General education: Students must complete the <u>Campus General Education</u> requirements including the campus general education language requirement.

Orientation and Professional Development

<u>CS 100</u>	Freshman Orientation (optional course highly recommended may be used to help meet free elective requirements) 1	1
<u>CS 210</u>	Ethical & Professional Issues	2
ENG 100	Engineering Orientation ¹	0
Total Hours		3

Foundational Mathematics and Science

Total Hours chosen from the following:		25
MATH 221	Calculus I ²	4
MATH 231	Calculus II	3
MATH 241	Calculus III	4
MATH 415	Applied Linear Algebra	3
PHYS 211	University Physics: Mechanics	4
PHYS 212	University Physics: Elec & Mag	4
Science elective, fr	rom departmentally approved list below:	3
<u>AE 202</u>	Aerospace Flight Mechanics	3
ANTH 249	Evolution and Human Disease	3

Computer Science Technical Core

<u>CS 125</u>	Intro to Computer Science	4
<u>CS 126</u>	Software Design Studio	3
<u>CS 173</u>	Discrete Structures	3
<u>CS 225</u>	Data Structures	4
<u>CS 233</u>	Computer Architecture	4
<u>CS 241</u>	System Programming	4
<u>CS 361</u>	Probability & Statistics for Computer Science	3
<u>CS 357</u>	Numerical Methods I	3
<u>CS 374</u>	Introduction to Algorithms & Models of Computation	4
<u>CS 421</u>	Programming Languages & Compilers	3
Total Hours		35

Technical Electives

select eight courses, a	be chosen from departmentally approved list below. Students at least six of which must be advanced CS courses. Three ated from one area of CS and at least one course should satisfy irement.	
<u>CS 427</u>	Software Engineering I	3 or 4
<u>CS 428</u>	Software Engineering II	3 or 4
<u>CS 429</u>	Software Engineering II, ACP	3
<u>CS 445</u>	Computational Photography (Until Spring 2018)	3 or 4
<u>CS 465</u>	User Interface Design	3 or 4
<u>CS 467</u>	Social Visualization	3 or 4
<u>CS 493</u>	Senior Project II, ACP	-
<u>CS 494</u>	Senior Project II	Sugg
<u>CS 497</u>	CS Team Project	
<u>CS 498</u>	Special Topics (Virtual Reality (Spring 2018 and later); Mobile Interactive Design (Spring 2019 and later); Internet of Things (F 2019 and later))	The curric departme Dynamic a
Three of the CS course	es must be chosen from a single focus area, from among the	_ ,

areas below:

- -

jested Sequence

iculum sequence below is a suggested sequence, as all Grainger Engineering students work with a ent academic advisor to achieve their educational goals, specific to their needs and preparation. and Static curricular maps, which include prerequisite sequencing, can be found here.

First Year		
First Semester		Hours
<u>CS 100¹</u>	Freshman Orientation	1
<u>CS 125</u>	Intro to Computer Science	4
ENG 100	Engineering Orientation	0
MATH 221 ²	Calculus I	4
Science elective ³		3
<u>RHET 105</u> (or General Education elective) ^{4,5}	Writing and Research	4-3
	Semester Hours	16-15
Second Semester		
<u>CS 126</u>	Software Design Studio	3
<u>CS 173</u>	Discrete Structures	3
MATH 231	Calculus II	3
General education elective (or RHET 105)	4,5	3-4
General education elective ⁵		3
	Semester Hours	15-16

CURRICULUM IN MECHANICAL ENGINEERING

The curriculum requires 128 hours for graduation.

Course Rubric	Course Name	Credit	2.25 GPA ⁹	TGPA ¹⁰
ENG 100	ssional Development	0		
Lauren Official Contract	Engineering Orientation Seminar	0		0
ME 290/390 oundational Mathem	A CONTRACT OF A	0		
CHEM 102	General Chemistry I	3		
CHEM 102	General Chemistry Lab I	1		
MATH 221	Calculus I	4		
MATH 221 MATH 231	Calculus II	3		
MATH 241	Calculus III	4	X	0
MATH 285	Intro Differential Equations	3		
MATH 415	Applied Linear Algebra	3		
PHYS 211	University Physics: Mechanics	4		
PHYS 212	University Physics: Elec & Mag	4	×	X
echanical Engineerin		2.24		
CS 101	Intro Computing: Engrg & Sci	3		
ECE 205	Elec & Electronic Circuits	3		
ECE 206	Elec & Electronic Circuits Lab	1		
TAM 210	Introduction to Statics	2		
TAM 212	Introductory Dynamics	3		
TAM 251	Introductory Solid Mechanics	3		
ME 170	Computer-Aided Design	3		
ME 270	Design for Manufacturability	3		\boxtimes
ME 200/300	Thermodynamics	3		\boxtimes
ME 310	Fundamentals of Fluid Dynamics	4		\boxtimes
ME 320	Heat Transfer	4		
ME 330	Engineering Materials	4		
ME 340	Dynamics of Mechanical Systems	3.5		
ME 360	Signal Processing	3.5		
ME 370	Mechanical Design I	3		
ME 371	Mechanical Design II	3		\boxtimes
ME 470	Senior Design Project	3		
ectives and composit			1221	-
RHET 1051	Principles of Composition	4		
Statistics Elective ⁵	IE 300, STAT 400 / MATH 463	3		
Science Elective ³	CHEM 104/105, MCB 150, PHYS 213/214	4		
Technical electives ⁶	Chosen from MechSE approved list	6		
MechSE electives ⁷	TAM and ME courses from MechSE approved list	6		
General education ²		18		
Free electives11		6		

9. To register for third-year Mechanical Engineering (ME) courses, students are required to have a cumulative grade-point average (GPA) of at least 2.25 in the courses marked with an "X". See http://catalog.illinois.edu/undergraduate/engineer/#TechnicalGPA for more information.

10. To remain in good academic standing and to graduate from the ME curriculum, a student must have a cumulative GPA of at least 2.00 in the courses marked with an "X". See http://catalog.illinois.edu/undergraduate/engineer/#TechnicalGPA for more information. 11. Almost any course offered by the University, and most transfer courses, can be used for free electives. Some restrictions apply, visit https://wiki.illinois.edu/wiki/display/ugadvise/Degree+Requirements#DegreeRequirements-FreeElectives for more information.



Curriculum Flow Chart for the Computer Science in Engineering Major

¹ A total of eight electives are required: Six course that total 18hrs of CS Technical, one of the six must satisfy the team project requirement and three from one focus area. Two Advanced courses at the 400-level in any field (CS 397 will count towards advanced courses but not Tech electives). See department website for up to date listings.

²One Science elective. Check the CS website or check with a CS advisor for most up to date list.

³ CS 210 may be taken during semester 3 or later. (CS 225 does not need to be completed first)

⁴ If credit is earned for CS 225 and not yet taken CS 126, students must take CS 242 to meet degree requirements.



----- Prerequisite ----> Corequisite

Mechanical Engineering (ME) Flowsheet



completion.

https://wiki.illinois.edu/wiki/display/ugadvise/Degree+Requirements ⁷Offered in Fall semester only. ¹Rhet 105 is taken the fall by students with even UINs and spring by students with odd UINs in the first year. ME 170 is taken the other semester.

²A total of 18 hours is required to fulfill general education requirements. Of these hours, there is a 6 hour Humanities requirement and 6 hour Social Science requirement, the remaining 6 hours may be from the two preceding categories or the Liberal Education elective list provided by the CoE. For students entering after SU18, a Western (W), Non-Western (NW), and U.S. Minorities (US) cultures course is required. For students entering prior to SU18, a W and NW or US cultures course is required. Among the Social Science courses, ECON 102 or 103 is required for ME students. Students must also complete the university foreign language requirement by completing the 3rd level of a language other than English (LOTE). ³Choose from Chem 104/105, MCB 150 (151 recommended), or Phys 213/214.

(e.g.ME 360, ME 371). Concurrent registration is limited to 2 courses. ME 470 is taken in the fall by students with even UINs and in the spring by students with odd UINs. 5Choose from IE 300 or Stat 400/Math 463.

*Technical electives are generally 400-level courses in engineering, physics, chemistry, and mathematics. One Professional elective of no more than 3 hours can replace a technical elective. See the complete list on the ME undergraduate program website:

http://mechanical.illinois.edu/undergraduate/bs-mechanical-engine ⁷MechSE electives are most 400-level ME and TAM courses. See the list from 6. "[Optional] Three hours of MechSE or technical elective credit can be obtained if ME 199 DES or SAE (1 hr) is taken for three consecutive semesters starting no later than third semester, or second semester for transfer students. A final report must be submitted to the MechSE Undergraduate Programs Office upon



Appendix C: A 4 year suggested curriculum for Chemical Engineering at Uofl

Our visualization requirements

Student should be able to see...

- 1. Which courses must be taken in order to complete a specific degree program
- 2. Which courses are required by multiple curricula, allowing their completion to fulfill requirements in multiple degree programs
- 3. Which courses are prerequisites or corequisites to a specific course



Why a metro map?

- Displays connections between pieces of information
- Promotes exploration of that connected information
- Users of metro maps have been able to better acquire complicated information

Shahaf et al., "Information Cartography," Communications of the ACM (2015)

Creating the Visualization

- Data was collected from university sources
 - With web scraping
 - By hand
- A plot of courses in a metro map format was algorithmically generated

More details on data collection and algorithmic generation can be found in the paper

AEROSPACE ENGINEERING

AGRICULTURAL & BIOLOGICAL ENGINEERING

BIOENGINEERING

CHEMICAL ENGINEERING

CIVIL ENGINEERING

COMPUTER ENGINEERING

COMPUTER SCIENCE

ELECTRICAL ENGINEERING

ENGINEERING MECHANICS

ENGINEERING PHYSICS

INDUSTRIAL ENGINEERING

MATERIALS SCIENCE & ENGINEERING

MECHANICAL ENGINEERING

NUCLEAR, PLASMA, & RADIOLOGICAL ENGINEERING

SYSTEMS ENGINEERING





rb.gy/orkaqs







PHYS 435: Electromagnetic

Fields I

Static electric and magnetic

fields, their interact...

3 hours. •

Limitations

- Only one college at one university represented
- Metro map creation is inefficient
 - Curriculum data must be taken by hand
 - Algorithmic plot generation is slow
- Not particularly useful for independent programs

Future Work

- User evaluation of efficacy with students
 - Particularly those in first-year undeclared programs
- Refining the visualization
 - Option to view only a few degree(s)

Customizing visualization around courses a student has already completed

Some data available on GitHub: https://github.com/illinois/courses-dataset https://github.com/illinois/prerequisites-dataset

Interested in collaborating on your own map? **Contact me!**

tamaranf@umich.edu

Visualization code available (under public license) on GitHub: https://github.com/illinois/eng-metro-map

