

A Metro Map-Based Curriculum Visualization for Examining Interrelated Curricula

Tamara Nelson-Fromm and Wade Fagen-Ulmschneider



ASEE 2022, CIT Division Technical Session #9

Get the slides: nelsonfromm.com/files/asee2022-slides.pdf

**Curricular requirements can be complicated
at a large university**

Curricular requirements can be complicated

At the time of this project, the **University of Illinois** had...

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

* includes joint degree programs

Curricular requirements can be complicated

At the time of this project, the **University of Illinois** had...

- 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

- Both students and administrators can be overwhelmed by the amount of information and choice
- Even upperclassmen need assistance understanding their path to graduate
- Requirements and available courses continue to change

Why is this a problem?

When students don't understand requirements, they...

- Might have to extend their time in a degree program



Why is this a problem?

When students don't understand requirements, they...

- Might have to extend their time in a degree program
- May miss pre-requisite information



Why is this a problem?

When students don't understand requirements, they...

- Might have to extend their time in a degree program
 - May miss pre-requisite information
 - May take rudimentary courses later in the curriculum
-

Why is this a problem?

When students don't understand requirements, they...

- Might have to extend their time in a degree program
 - May miss pre-requisite information
 - May take rudimentary courses later in the curriculum
 - Increased burden on advisors
-

Why is this a problem?

When students don't understand requirements, they...

- Might have to extend their time in a degree program
- May miss pre-requisite information
- May take rudimentary courses later in the curriculum
- Increased burden on advisors

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 Campus General Education 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
<u>ENG 100</u>	Engineering Orientation ¹	0
Total Hours		3

Foundational Mathematics and Science

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

Computer Science Technical Core

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

Technical Electives

Technical electives to be chosen from departmentally approved list below. Students select eight courses, at least six of which must be advanced CS courses. Three courses must be selected from one area of CS and at least one course should satisfy the team project requirement.		
<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	
<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 (Fall 2019 and later))	
Three of the CS courses must be chosen from a single focus area, from among the areas below:		

Suggested Sequence

The curriculum sequence below is a suggested sequence, as all Grainger Engineering students work with a department academic advisor to achieve their educational goals, specific to their needs and preparation. Dynamic and Static curricular maps, which include prerequisite sequencing, can be found [here](#).

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

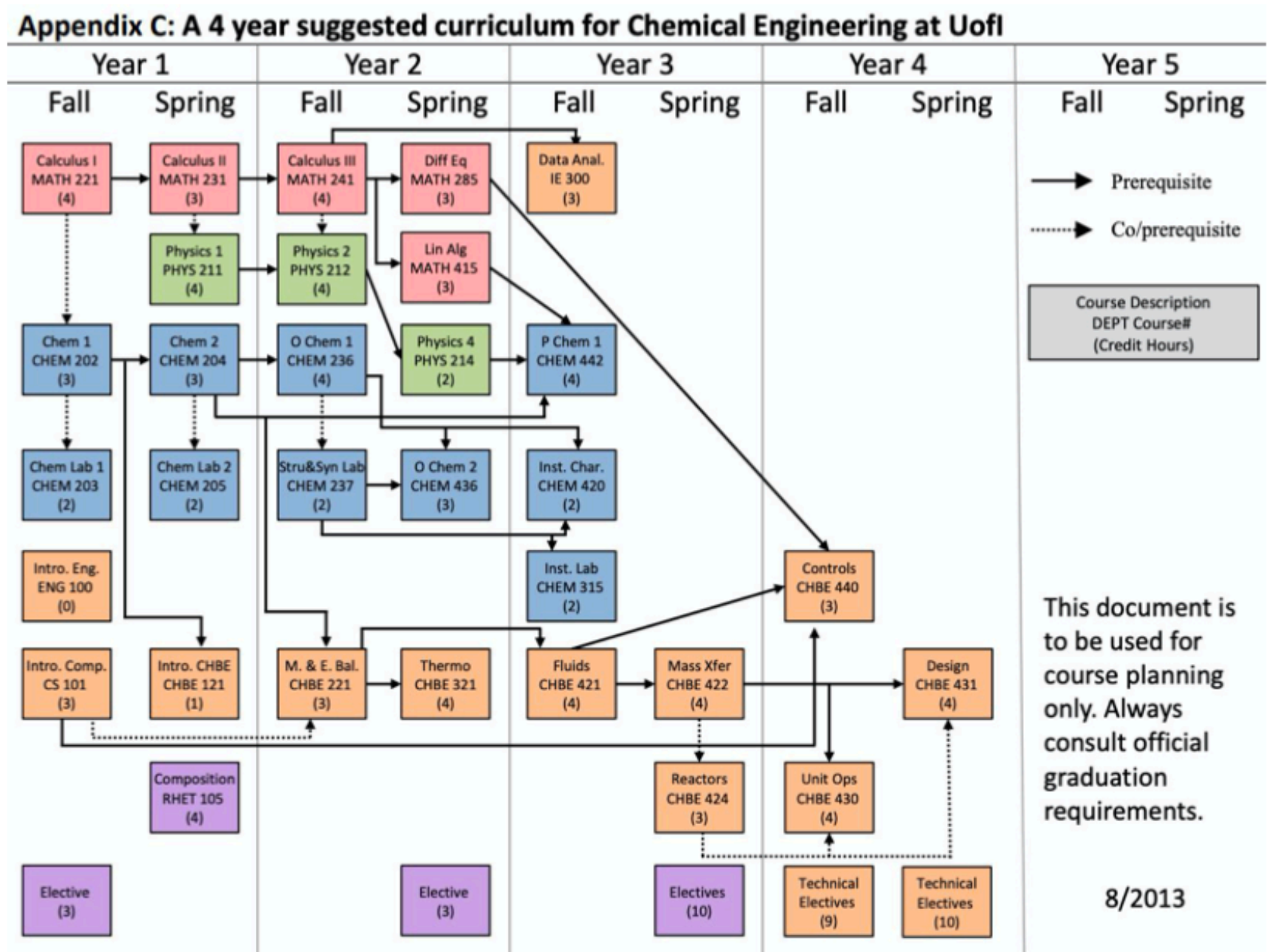
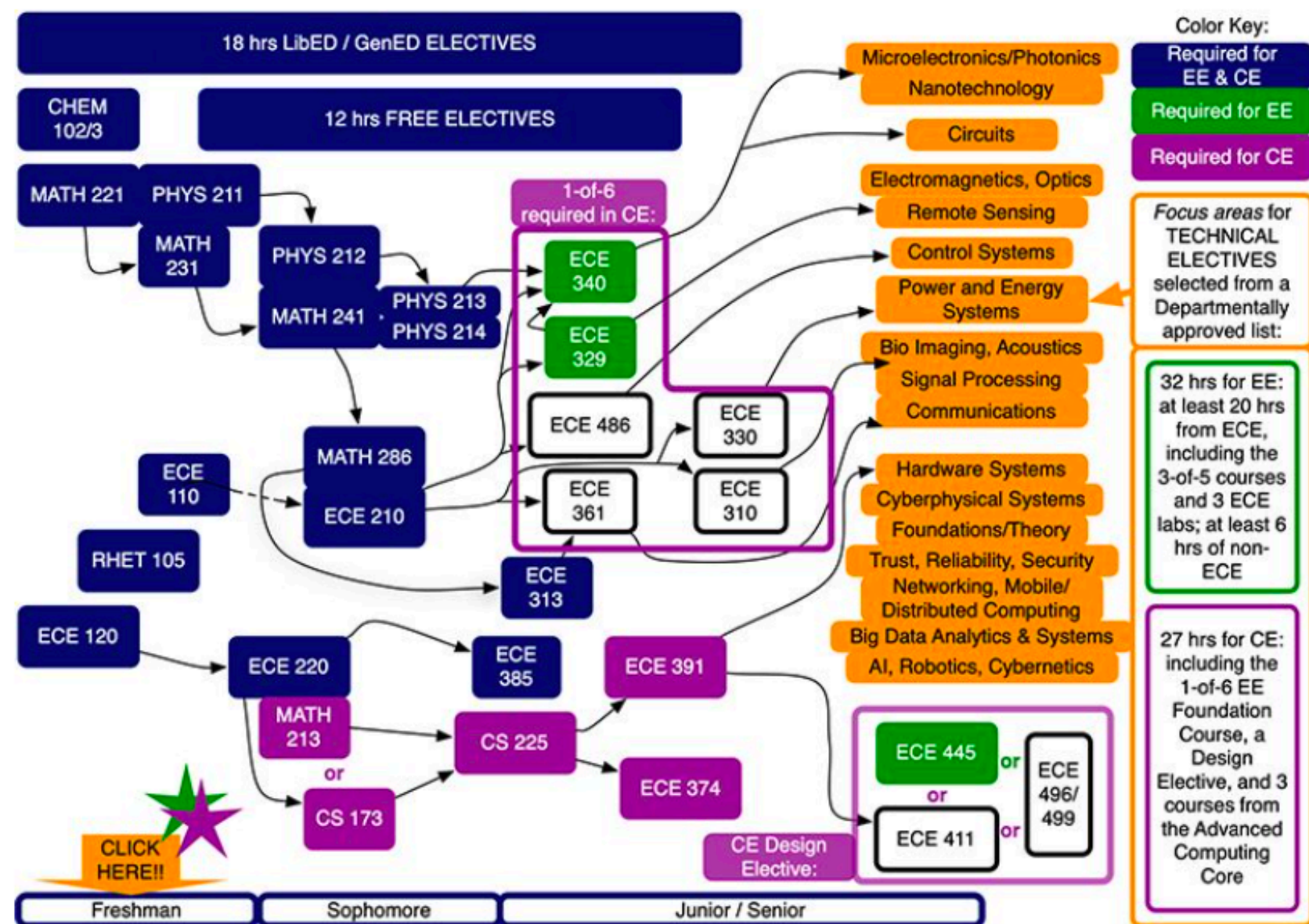
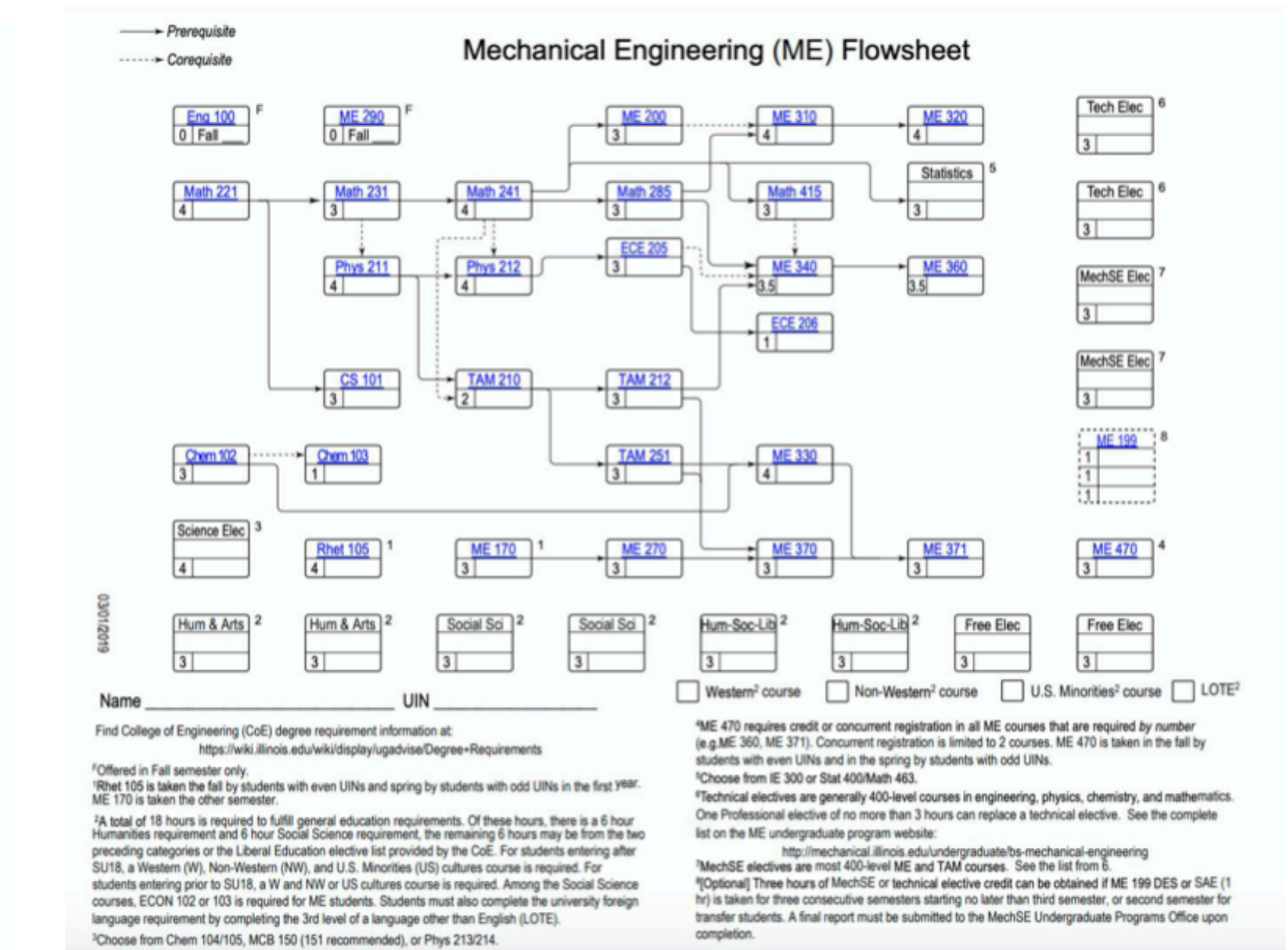
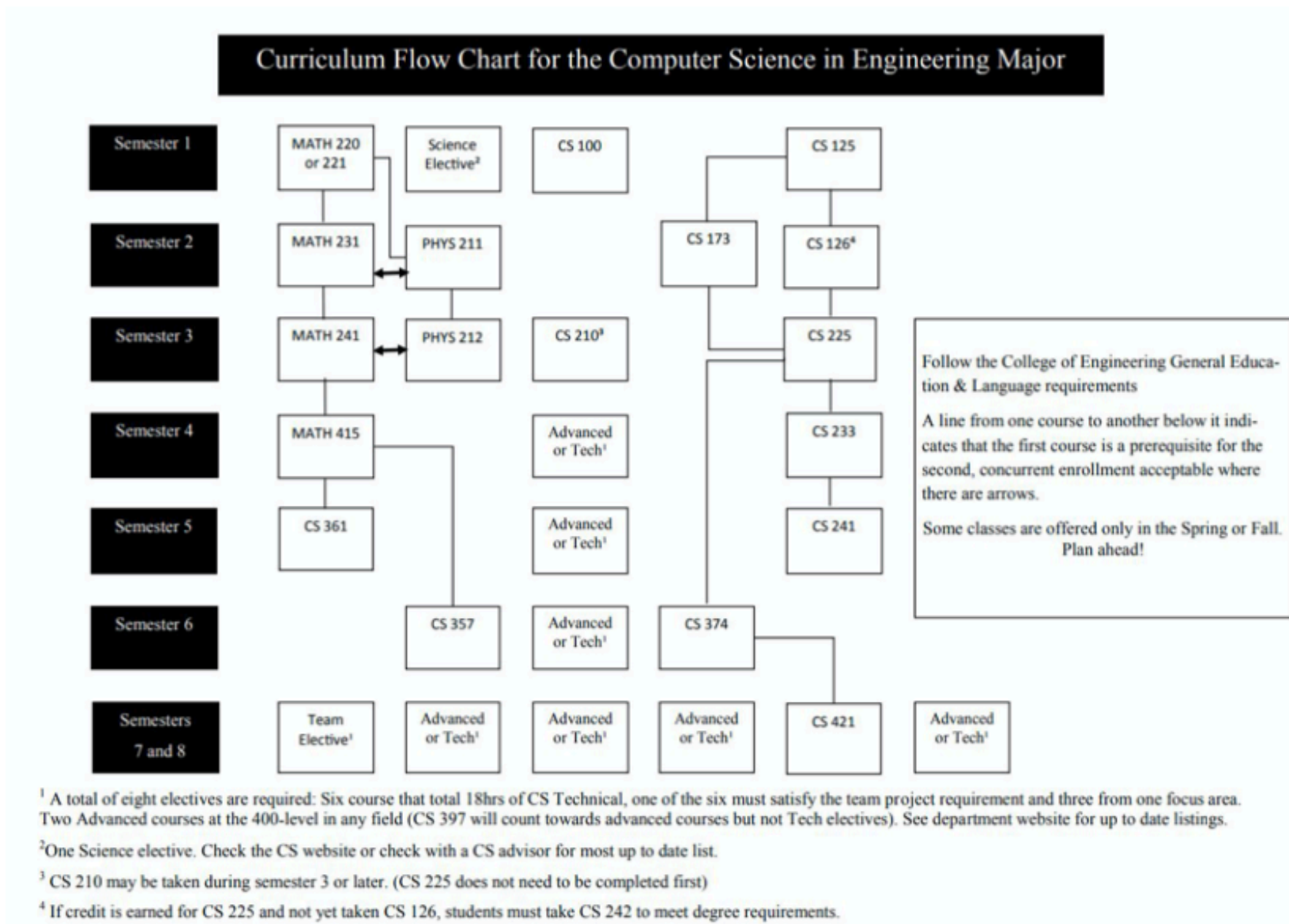
The curriculum requires 128 hours for graduation.

Course Rubric	Course Name	Credit	2.25 GPA ⁹	TGPA ¹⁰
Orientation and Professional Development				
ENG 100	Engineering Orientation	0	<input type="checkbox"/>	<input type="checkbox"/>
ME 290/390	Seminar	0	<input type="checkbox"/>	<input type="checkbox"/>
Foundational Mathematics and Science				
CHEM 102	General Chemistry I	3	<input checked="" type="checkbox"/>	<input type="checkbox"/>
CHEM 103	General Chemistry Lab I	1	<input checked="" type="checkbox"/>	<input type="checkbox"/>
MATH 221	Calculus I	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
MATH 231	Calculus II	3	<input checked="" type="checkbox"/>	<input type="checkbox"/>
MATH 241	Calculus III	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
MATH 285	Intro Differential Equations	3	<input checked="" type="checkbox"/>	<input type="checkbox"/>
MATH 415	Applied Linear Algebra	3	<input type="checkbox"/>	<input checked="" type="checkbox"/>
PHYS 211	University Physics: Mechanics	4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
PHYS 212	University Physics: Elec & Mag	4	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Mechanical Engineering Technical Core				
CS 101	Intro Computing: Engrg & Sci	3	<input checked="" type="checkbox"/>	<input type="checkbox"/>
ECE 205	Elec & Electronic Circuits	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ECE 206	Elec & Electronic Circuits Lab	1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TAM 210	Introduction to Statics	2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TAM 212	Introductory Dynamics	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
TAM 251	Introductory Solid Mechanics	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME 170	Computer-Aided Design	3	<input checked="" type="checkbox"/>	<input type="checkbox"/>
ME 270	Design for Manufacturability	3	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 200/300	Thermodynamics	3	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
ME 310	Fundamentals of Fluid Dynamics	4	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 320	Heat Transfer	4	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 330	Engineering Materials	4	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 340	Dynamics of Mechanical Systems	3.5	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 360	Signal Processing	3.5	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 370	Mechanical Design I	3	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 371	Mechanical Design II	3	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ME 470	Senior Design Project	3	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Electives and composition				
RHET 105 ¹	Principles of Composition	4	<input type="checkbox"/>	<input type="checkbox"/>
Statistics Elective ⁵	IE 300, STAT 400 / MATH 463	3	<input type="checkbox"/>	<input type="checkbox"/>
Science Elective ³	CHEM 104/105, MCB 150, PHYS 213/214	4	<input checked="" type="checkbox"/> <input checked="" type="checkbox"/>	<input type="checkbox"/> <input checked="" type="checkbox"/>
Technical electives ⁶	Chosen from MechSE approved list	6	<input type="checkbox"/>	<input checked="" type="checkbox"/>
MechSE electives ⁷	TAM and ME courses from MechSE approved list	6	<input type="checkbox"/>	<input checked="" type="checkbox"/>
General education ²		18	<input type="checkbox"/>	<input type="checkbox"/>
Free electives ¹¹		6	<input type="checkbox"/>	<input type="checkbox"/>

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.



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?

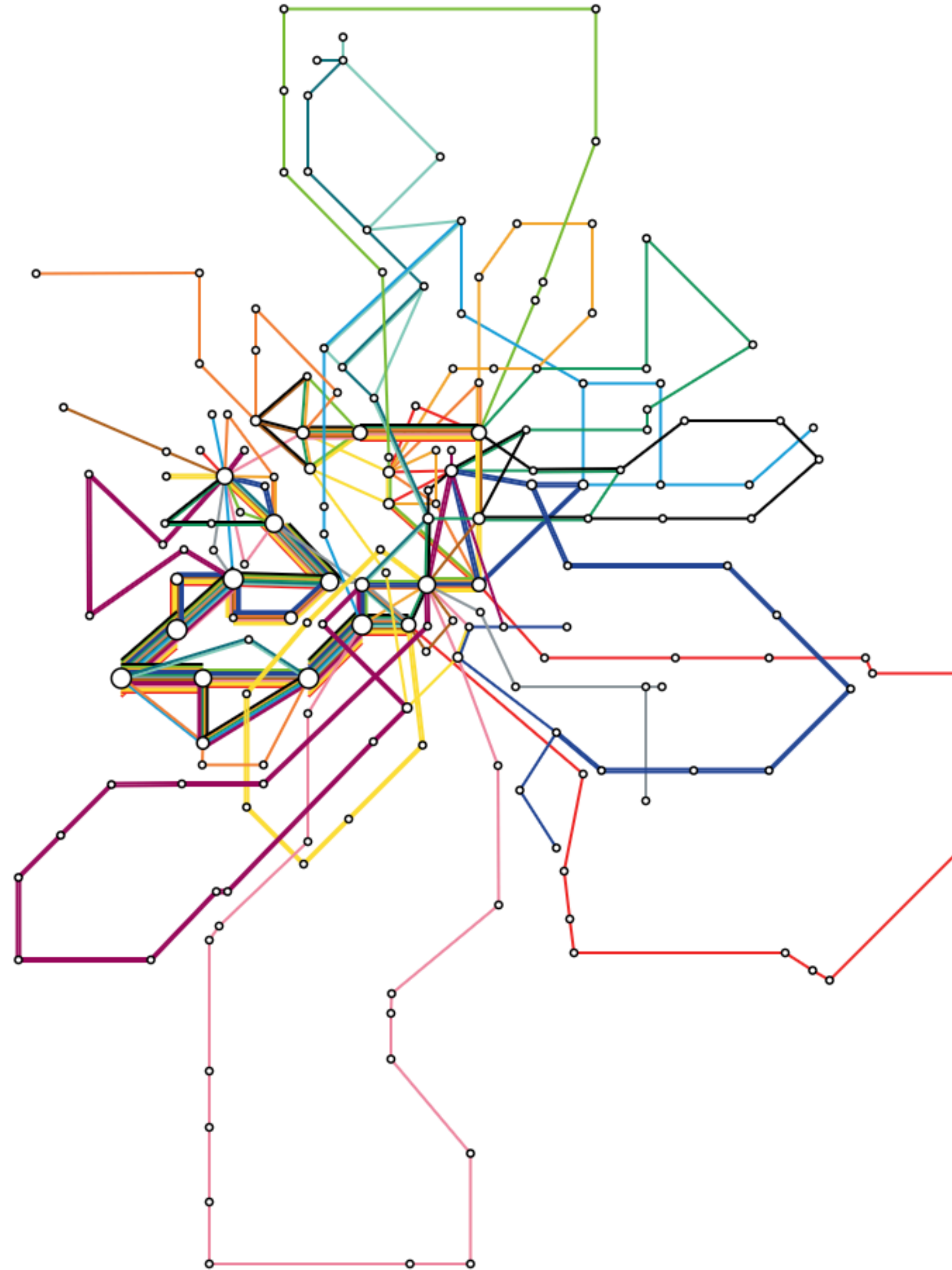
- Displays connections between pieces of information
- Promotes exploration of that connected information
- Users of metro maps have been able to better acquire complicated information

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

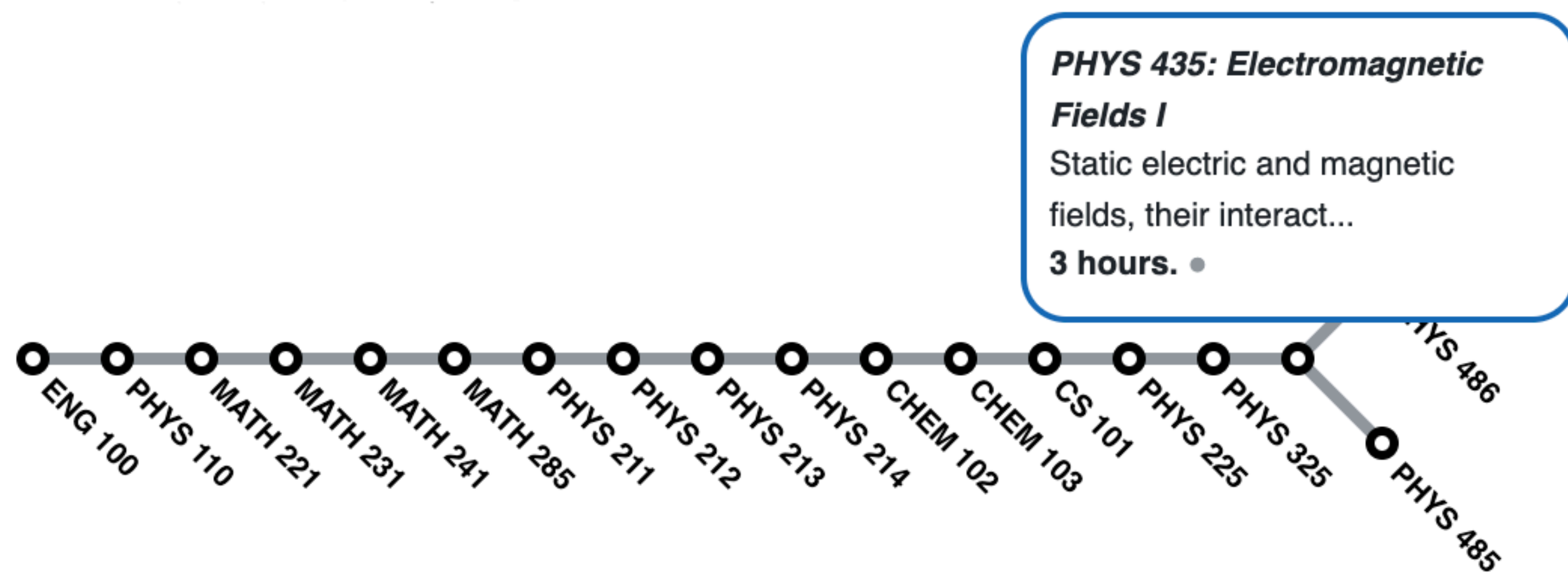
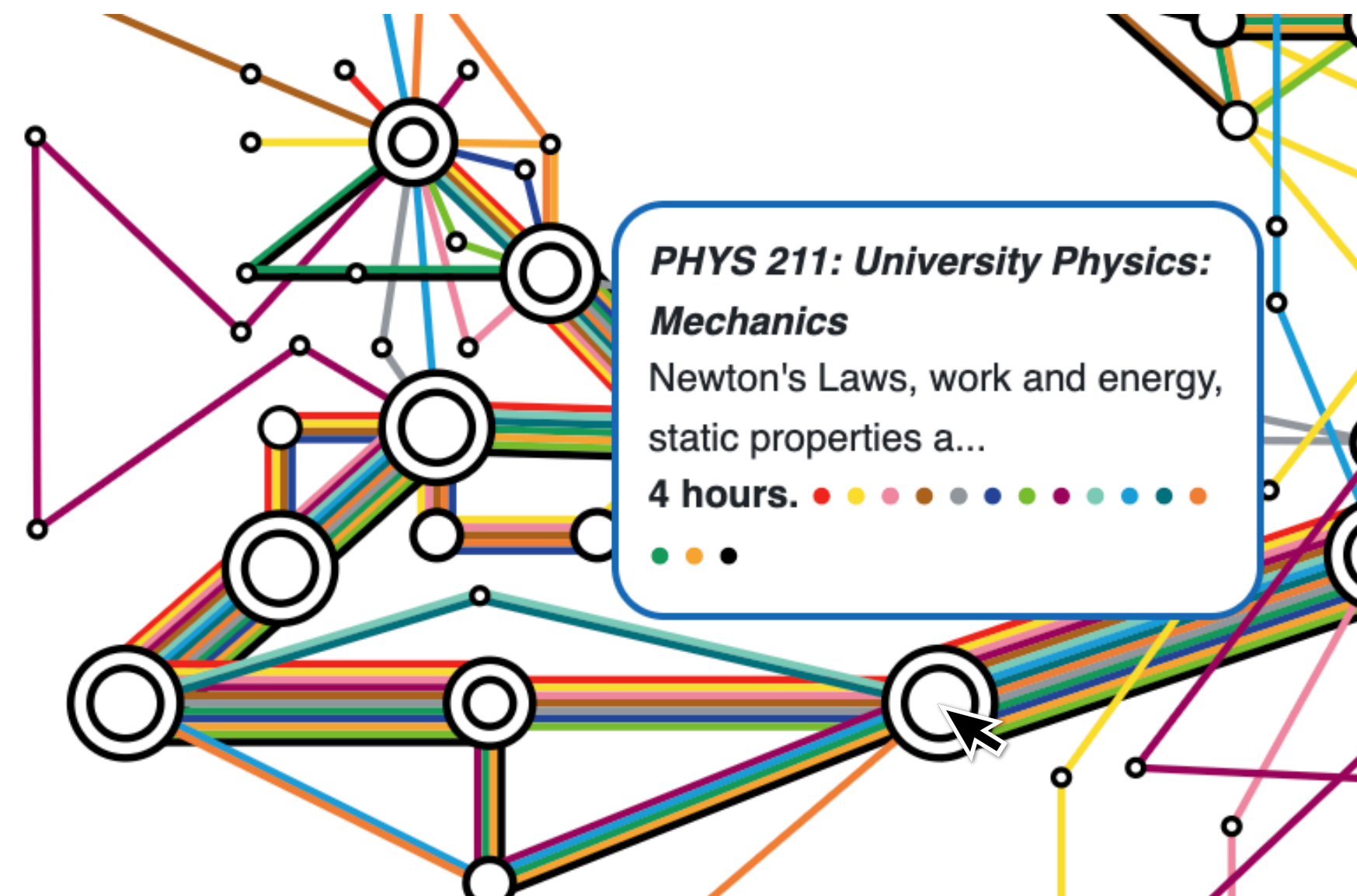
More details on data collection and algorithmic generation can be found in the paper

- 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





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
-

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

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

