Electrified Transportation Systems

A Multi-Campus Course

Spring 2022

Course Syllabus

ASPIRE

NSF Engineering Research Center

ASPIRE – Electrified Transportation Systems Class Time: TR 4:30 -6:00 PM (Mountain Time)

Introduction: Vehicles drive the nation's economy by transporting over 11 billion tons of freight and travel over 3 trillion miles per year. Transportation accounts for 50% of air pollution and 70% of petroleum use in the U.S. and claims 20% of household incomes. Looking to the future, electrification offers zero tailpipe emissions and reduced energy consumption. At 50% adoption, an electrified transportation system would cut the use of oil by 6 million barrels per day. It could also cut lifecycle ownership costs in half and reduce vehicle fuel costs by $150 billion per year. Realizing these transformations depends strongly on how EVs are charged.

Electrified Transportation System (ETS) operates at the nexus of several critical industries (such as Transportation, Power, and Information Technology) that have historically operated independently, and the existing overlap among them has little to no strategic coordination. A coherent understanding of these complex interactions is required to capture and harness convergence across these industries and scientific communities and to reshape forever the future.

The vision of the Advancing Sustainability through Powered Infrastructure for Roadway Electrification Engineering Research Center (ASPIRE ERC) funded by the National Science Foundation (NSF) is a sustainable and equitable future for transportation with widespread electrification of the roadway for all classes of passenger cars to heavy-duty trucks. This will be accomplished through seamless integration of wireless and wired charging solutions and co-optimized grid and vehicle networks that bring power to where vehicles operate, both parked and in motion. Achieving this vision requires entirely new lines of thinking on how city, highway, and electric grid infrastructure are designed, how vehicles and operators interact with those systems, and how to integrate private sector partners and public resources.

The goal of this course is to provide a survey of a large number of areas of knowledge needed to implement successfully ETS as a first step to convey competencies in the concepts of (1) systems of systems, (2) trans-disciplinarity, and (3) leadership. All senior-level or graduate students in the engineering field or areas relevant to ASPIRE are welcomed to this course.

***Schedule*:** Tentative schedule of the lectures is included in Appendix A. We will use a seminar approach in this course. Lectures are delivered by subject matter experts through webinars. We have recruited about two dozen renowned experts that will lecture on their topics of expertise. Essentially, from the first week of the class until the end, you will spend about 75 minutes learning from and engaging with each expert.

Deliverables: You will choose a specific topic to understand deeply, document thoroughly, and teach effectively to others based on a "deep dive" in the existing literature. There are no exams in this class. The final deliverables by the end of the semester are the following items about your assigned topic:

1. A PowerPoint presentation to teach to others on the topic of your choice
2. A report similar to a chapter of a book

As in any other aspect of ASPIRE, we encourage multi-disciplinary, multi-campus joint projects.

PowerPoint Presentation (1st draft due April 15 and final draft due May 15): The last three weeks of the class are dedicated to your presentations. The duration of the presentation should be about 15 minutes. Your instructor will review the presentation and will provide feedback to you to improve it before delivering it. Your presentation should follow the sections of your report discussed below. The grading of PowerPoint is based on the following criteria:

- Completeness and appropriateness of the preliminary presentation submitted before April 15.
- Your classmates' impressions based on the criteria detailed in Table 1. Based on the feedback provided by the faculty and students you will modify and finalize (but not present) your PowerPoint presentation.
- Quality of your final presentation submitted by May 15.

Table 1 – Criteria for Evaluating Presentations

Grade	5	3	1
Content	Shows a full understanding of the topic.	Shows a good understanding of parts of the topic.	Does not seem to understand the topic very well.
Comprehension	Can accurately answer almost all questions posed about the topic.	Can accurately answer a few questions posed about the topic.	Unable to accurately answer questions posed about the topic.
Enthusiasm	Facial expressions and body language generate a strong interest and enthusiasm about the topic in others.	Facial expressions and body language are used to try to generate enthusiasm but seem somewhat faked.	Very little use of facial expressions or body language. Did not generate much interest in the topic being presented.
Preparedness	Completely prepared and have rehearsed.	Somewhat prepared, but clear that rehearsal was lacking.	Do not seem at all prepared to present.
Stays on Topic	Stays on topic all (100%) the time.	Stays on the topic some (90%-75%) of the time.	It was hard to tell what the topic was.

Project Report (1st draft due April 15, final draft due May 15): The project report is a comprehensive explanation of the topic that is assigned to you. The paper should contain the following sections.

- Title Page
- Table of Content
- List of Figures
- List of Tables
- Introduction
- Review and Analysis of Literature
- Gaps in the State of the Art
- Future Trends
- References
- Bibliography

The format to follow is provided in Appendix B. The text should be carefully written and the tables and figures should be of the highest quality. Your instructor of the record will review your draft report and will provide feedback on how to improve the report. We will follow the timetable in Table 2 for this deliverable. The grading of the report is based on the following criteria:

- Timeliness and comprehensiveness of your intermediate deliverables.
- Completeness and appropriateness of the preliminary draft submitted by April 15.
- The quality of your final report submitted by May 15.

Homework: The homework problems consists of the following two parts:

- Summarizing the presentation provided by each speaker in an organized manner in two pages or less in the form included in Appendix D.
- Summarizing the paper provided by each speaker in an organized manner in the form included in Appendix E.

The homework problems have to be typed and should be submitted electronically before 11:59 PM on Sunday the following week. Please use complete sentences in preparing your homework problems. There is no partial credit for incoherent or incomplete homework problems.

Grading: Handing in homework on time and class participation will count a maximum of 40% toward your grade. The PowerPoint presentation will count as 20% of your grade. The final report will count as 40% of your grade.

Class Attendance: Students are expected to attend all class periods. Those who fail to attend class regularly are inviting scholastic difficulty and, with the approval of the Dean of the College of Engineering, may be dropped from the course with a grade of F for repeated (5 or more) unexcused absences.

Cell Phones and Laptops: It is disrespectful and to be on social media or doing your homework during the lectures. For that reason and although some of you use your laptops to take notes, the use of laptops during the lectures is not permitted. Please turn off your cell phones during class lectures.

Table 2 – Timetable for Delivery of Deliverables[1]

Week	Tuesday	Thursday
0 1/10	Try to choose a topic	
1 1/17	Try to put multi-disciplinary/ multi-institutional team together, if you wish	
2 1/24	Choose your topic	
3 1/31	Provide 10 keywords for literature search	Conduct literature search at a minimum using TRID, Google Scholar, and other sources
4 2/7	• Download and organize abstracts from your search. • Download the papers and save them electronically in a folder. • Use interlibrary loans to obtain those that you cannot download.	• Provide a document that contains the list of references in the format discussed in Appendix C. • Include at least ten unique papers, three theses or dissertations, and ten other sources. At least half of the documents should be from the year 2010 and later.
5 2/14	Start reading, extracting relevant information, and organizing your papers in the format shown in Appendix C.	
6 2/21		
7 2/28	Organize your literature search in an organize fashion (see Appendix C as an example)	
8* 3/7	Start working on your report and presentation	
9* 3/14		
10* 3/21		
11 3/28	Deliver "Introduction" and "Review and Analysis of Literature" sections of your report.	
12 4/4	Deliver "Gaps in the State of the Art," and "Future Trends" sections of your report	
13 4/11	Deliver your PowerPoint Presentation and Draft Report	
14 4/18	Work on finalizing your report and prepare for your presentations	
15 4/25		
16 5/2	Work on finalizing your three deliverables	
17 5/9	Deliver all your deliverables and celebrate that we are all done!!	

Policy on Cheating: Students are expected to be above reproach in all scholastic activities. Students who engage in scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and dismissal from the university. Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give an unfair advantage to a student, or the attempt to commit such acts (Regents' Rules and Regulations, Part One,

[1] https://library.sacredheart.edu/c.php?g=29803&p=185901 may be a good source of information before starting your work.

Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22). Scholastic dishonesty harms the individual, all students, and the integrity of the university. Policies on scholastic dishonesty will be strictly enforced.

Final Comment: Good luck to all of you in this course. Please do not hesitate to ask questions in class, or, if necessary, to see me outside of class. Any specific comments that students may have on how the course might be improved are particularly welcome.

Appendix A - Lecture Schedule

Week	*Session 1*		*Session 2*	
	Topic	*Instructor*	*Topic*	*Instructor*
0 1/10	Campus Specific (when applicable)		Campus Specific (when applicable)	
1 1/17	Introduction	Soheil Nazarian, UTEP	Systems of Systems Concept	Regan Zane, USU
2 1/24	Introduction to Electrical System Components	Dragan Maksimovic, UCB	Role of Battery Management in EVs	Scott Trimboli, UCCS
3 1/31	Traditional Plugin Charging	Abhilash Kamineni, USU	Inductive Charging	Steve Pekarek, Dionysios Aliprantis Purdue
4 2/7	Capacitive Charging	Khurram Afridi, Cornell	Generation and Optimization of Power Grid	Yuanrui Sang, UTEP
5 2/14	Basic Transportation Planning	Kelvin Cheu, UTEP	Analysis and Optimization of Transportation Network	Ziqi Song, USU
6 2/21	Power System Impacts of EVs	Bri-Mathias Hodge, UCB	Basic Pavement Design as related to EV technology	John Haddock, Purdue
7 2/28	Basic EV Structural Design	Marv Halling, USU	Construction and Constructability of EV Facility	Adeeba Raheem, UTEP
8* 3/7	Basic Life Cycle Analysis of EV technology	Bill Tseng, UTEP	Basic Sustainability Aspects of EV technology	Jason Quinn, CSU
9* 3/14				
10* 3/21	Environmental Aspects of EV technology	Jana Milford, UCB	Environmental Justice and Equity of EV technology	Ivonne Santiago, UTEP
11 3/28	Economical Aspect of EV technology	Chris Fawson, USU	Marketing Aspects of EV technology	Antje Graul, USU
12 4/4	Pricing Strategies for Charging EVs	Mandal Paras, UTEP	Strategy to Accelerate Adoption	Chris Fawson, USU
13 4/11	Role of Data Science in Electrified Transportation	Christine Lv, UCB	SWOT Analysis by DOT Representative	IIB Member
14 4/18	SWOT Analysis by Car Manufacturers	IIB Member	SWOT Analysis by Contractors	IIB Member
15 4/25	Student Term Project Presentations		Student Term Project Presentations	
16 5/2	Student Term Project Presentations		Student Term Project Presentations	
17 5/9	Student Term Project Presentations		Student Term Project Presentations	

*** Asynchronous Classes (participate in four lectures during these three weeks)**

Appendix B: Format of Report[2]

Ethical Standards

These ethical standards derive from the American Society of Civil Engineers (ASCE)'s definition of the scope of the journal and the community's perception of standards of quality for engineering and scientific work, and its presentation. The ethical standards that follow reflect a conviction that the observance of high ethical standards is so vital to the entire engineering and scientific enterprise that a definition of those standards should be brought to the attention of all concerned.

Obligations of Authors

1. An author's central obligation is to present a concise account of the research, work, or project completed, together with an objective discussion of its significance.
2. A submitted manuscript shall contain detail and reference to public sources of information sufficient to permit the author's peers to repeat the work or otherwise verify its accuracy.
3. An author shall cite and give appropriate attribution to those publications influential in determining the nature of the reported work sufficient to guide the reader quickly to earlier work essential to an understanding of the present work. Information obtained by an author privately, from the conversation, correspondence, or discussion with third parties shall not be used or reported in the author's work without explicit permission from the persons from whom the information was obtained.
4. The submitted manuscript shall not contain plagiarized material or falsified research data. ASCE defines plagiarism as the use of the ideas or words of another person without giving appropriate credit to that source. The Society views any similar misappropriation of intellectual property, which may include data or interpretation, as plagiarism. [This definition is based on one used by the National Academy of Science, National Academy of Engineering, and the Institute of Medicine. ASCE added the sentence on misappropriation of intellectual property.]
5. Fragmentation of research papers shall be avoided. An engineer or scientist who has done extensive work on a system or group of related systems shall organize publication so that each paper gives a complete account of a particular aspect of the general study.
6. It is inappropriate for an author to submit for review more than one paper describing essentially the same research or project to more than one journal or primary publication.
7. Scholarly criticism of a published paper may sometimes be justified; however, personal criticism is never appropriate.
8. To protect the integrity of authorship, only persons who have significantly contributed to the research or project and manuscript preparation shall be listed as co-authors. The corresponding author attests to the fact that any others named as co-authors have seen the final version of the manuscript and have agreed to its submission for publication. Deceased persons who meet the criterion for co-authorship shall be included, with a footnote reporting date of death. No fictitious name shall be given as an author or co-author. An author who submits a manuscript for publication accepts responsibility for having properly included all, and only, qualified co-authors.
9. It is inappropriate to submit manuscripts with obvious commercial intent.

Manuscript Requirements

Typescript. Type the manuscript using Times New Roman font no smaller than 10 points, SINGLE-SPACED, single-column (including references and abstract) with at least 1-in. margins.

[2] The information provided is heavily borrowed from http://engineering.missouri.edu/civil/files/asce-author-guide-journals.pdf and modified to fit the nature of this course. Please review the original document if you are going to submit a paper in the future.

Title. Make sure the title is not more than 100 characters long including spaces between words. Avoid titles beginning with "Analysis of ...," "A Note on ...," "Theory of ...," "On the ...," "Some ...," and "Toward a ...."

Mathematics. Type all mathematics and make sure special characters and super- and subscripts are distinguishable. In-text, write single-level expressions, e.g., 1/(a + b), not stacked equations. In numbered (displayed) equations, stack numerators over denominators. All displayed equations should be numbered sequentially throughout the entire manuscript, including appendixes. Equations should be in the body of a manuscript; complex equations in tables and figures are to be avoided.

Units. The use of Systéme International (SI) units as primary units of measure is mandatory. The customary unit should be given in parentheses after the SI unit. More information about SI units can be found from NIST at http://physics.nist.gov/cuu/Units/index.html. SI units are constructed from seven base units for independent physical quantities (A, cd, K, kg, m, mol, and s), and two supplementary units for plane angle (rad) and solid angle (sr) as shown in Table 1. Derived SI units whose names and symbols are approved by the International General Conference on Weights and Measures are listed in Table 2. Other common derived units with generic or complex names are listed in Table 3. A wide range of SI unit sizes is available through the use of prefixes to form decimal multiples and submultiples of units. Prefixes generally applicable to engineering are listed in Table 4.

In engineering applications, there is a preference for use of prefixes representing only the ternary powers of 10 (10^3, 10^6, etc.). For example, statements of pressure, stress, and elastic modulus are preferably given in kPa, MPa, GPa. Prefixes are applied directly to unit symbols (e.g., millimeter, mm; megawatt, MW; kilonewton, kN; gigapascal, GPa) except in the case of the kilogram, for which all prefixes are applied directly to the gram; thus, for example, Mg (megagram) is 10^3 kg. The precise use of uppercase and lowercase letters is essential. Authors using word processors should not put SI and other metric units in italics, and there should be a space between numerals and SI units (e.g., 2 N). When quantities are converted from one system of units to another, care must be taken to retain a sufficient number of digits to reflect the accuracy of the original quantity. Converted quantities should not imply a degree of accuracy greater than that of the original values; they should be rounded to an appropriate level of accuracy and number of significant digits.

Table 1. Base and Supplementary Units in SI System

Quantity name	Unit name	Unit symbol[a]
Base units		
Amount of substance	Mole	mol
Electric current	Ampere	A
Length	Meter	m
Luminous intensity	Candela	cd
Mass	Kilogram	kg
Thermodynamic temperature	Kelvin	K
Time	Second	s
Supplementary units		
Plane angle	Radian	rad
Solid angle	Steradian	sr

[a] Unit symbol to be used only when preceded by a numeral

Table 2. SI Units Approved by the International General Conference on Weights and Measures

Qantity	Unit	Symbol[a]	Formula
Absorbed dose	Gray	Gy	J/kg
Activity (of a radionuclide)	Becquerel	Bq	1/s
Celsius temperature	Degree Celsius	°C	K
Dose equivalent	Sievert	Sv	J/kg
Electric capacitance	Farad	F	C/V
Electric conductance	Siemens	S	A/V
Electric resistance	Ohm	Ω	V/A
Electric potential, potential difference, electromotive force	Volt	V	W/A
Energy, work, quantity of heat	Joule	J	N•m
Force	Newton	N	kg•m/s^2
Frequency (of a periodic phenomenon)	Hertz	Hz	1/s
Illuminance	Lux	lx	lm/m^2
Inductance	Henry	H	Wb/A
Luminous flux	Lumen	lm	cd•sr
Magnetic flux	Weber	Wb	V•s
Magnetic flux density	Tesla	T	Wb/m^2
Power, radiant flux	Watt	W	J/s
Pressure, stress	Pascal	Pa	N/m^2
Quantity of electric, electric charge	Coulomb	C	A•s

[a] Symbol to be used only when preceded by a numeral.

Table 3. Other Common Derived SI Units

Quantity	Unit	Unit symbol[a]
Acceleration	Meters per second squared	m/s^2
Angular acceleration	Radians per second squared	rad/s^2
Angular velocity	Radian per second	rad/s
Area	Meters squared	m^2
Concentration[a]	Mole per cubic meter	mol/m^3
Current density	Ampere per meter squared	A/m^2
Density (mass)	Kilogram per cubic meter	kg/m^3
Electric field strength	Volt per meter	V/m
Electric flux density	Coulomb per meter squared	C/m^2
Energy density	Joule per cubic meter	J/m^3
Entropy	Joule per kelvin	J/K
Heat capacity	Joule per kelvin	J/K
Heat flux density (irradiance)	Watt per meter squared	W/m^2
Luminance	Candela per meter squared	cd/m^2
Magnetic filed strength	Ampere per meter	A/m
Molar energy	Joule per mole	J/mol
Molar entropy (heat capacity)	Joule per mole kelvin	J/mol•K
Moment of force	Newton meter	N•m
Permeability (magnetic)	Henry per meter	H/m
Permittivity	Farad per meter	F/m
Radiance	Watt per meter squared steradian	$W/(m^2 \bullet sr)$
Radiant intensity	Watt per steradian	W/sr
Specific heat capacity	Joule per kilogram kelvin	J/(kg•K)
Specific energy	Joule per kilogram	J/kg
Specific entropy	Joule per kilogram kelvin	J/(kg•K)
Specific volume	Cubic meter per kilogram	m^3/kg
Surface tension	Newton per meter	N/m
Thermal conductivity	Watt per meter kelvin	W/(m•K)
Velocity	Meter per second	m/s
Viscosity (dynamic)	Pascal second	Pa•s
Viscosity (kinematic)	Meters squared per second	m^2/s
Volume	Cubic meter	m^3
Wave number	One per meter	1/m

[a] Unit symbol used only when preceded by a numeral.

Table 4. SI Prefixes Applicable to Engineering

Factor	Prefix	Symbol[a]
10^9	Giga	G
10^6	Mega	M
10^3	Kilo	k
10^2	Hecto	h
10^1	Deka	da
10^{-1}	Deci	d
10^{-2}	Centi	c
10^{-3}	Milli	m
10^{-6}	Micro	μ
10^{-9}	Nano	n

[a] Unit symbols used only when preceded by a numeral.

References

To cite sources in the text, use the author-date method; list the last names of the authors, then the year. The formats are as follows: one author—(Smith 2004); two authors—(Smith and Jones 2004); three or more authors—(Smith et al. 2004). Prepare a reference section listing all references alphabetically by the last name of the first author. For anonymous reports and standards, alphabetize by the issuing institution. Below are samples of properly formatted and complete references:

Journals: King, S., and Delatte, N. J. (2004). "Collapse of 2000 Commonwealth Avenue: Punching shear case study." J. Perf. Constr. Facil., 18(1), 54-61. Double-check the year, journal title, volume and issue numbers, and page numbers. ASCE reference information can be verified using our CE Database at www.pubs.asce.org.

Conference Proceedings and Symposia: Fwa, T. F., Liu, S. B., Teng, K. J. (2004). "Airport pavement condition rating and maintenance-needs assessment using fuzzy logic." Proc., Airport Pavements: Challenges and New Technologies, ASCE, Reston, Va., 29-38. Include the sponsor of the conference or publisher of the proceedings, AND that entity's location— city and state or city and country.

Books and Reports: Feld, J., and Carper, K. (1997). Construction failure, 2nd Ed., Wiley, New York. Book references must include author, book title, publisher, and the publisher's location. If a specific chapter is being used, list the chapter title and inclusive page numbers. For reports, include the full institution name (not just the acronym) and its location.

Unpublished Material: Unpublished material is not included in the references. It may be cited in the text in the following forms: (John Smith, personal communication, May 16, 1999) or (Jones et al., unpublished manuscript, 2002). As an exception to the rule, articles that are accepted for publication may be included in the references as follows: Gibson, W. (2003). "Cyberspace: The postmodern frontier." J. Comp. in Fiction, in press.

Web Pages and On-line Material: Burka, L. P. (2002). "A hypertext history of multiuser dimensions." MUD history, (Dec. 5, 2003). Include an author if possible, a copyright date, a title, the Web address, and the date the material was accessed or downloaded (in parentheses at the end).

CD-ROM: Liggett, J. A., and Caughey, D. A. (1998). "Fluid statics." Fluid mechanics (CD-Rom), ASCE, Reston, Va. Include authors, copyright date, titles, medium, and producer/publisher and their location.

Tables

Every table must be called out in the text and must be in sequential order. The tables will be placed in the pages as close to the first reference to that table (call-out) as possible. For example, do not mention Table 3 on Page 1 when no other tables have been mentioned. Also, make sure that your table call-outs match the actual tables provided.

Table format. Tables should follow the guidelines below. See sample Table A follow for an example of a properly formatted table.

- All tables should be typed with clear columns.
- Each table must be called out in text; it will be placed on a page as close to the first mention as possible.
- Tables must have a table number, a title, and be numbered sequentially. Do not number tables as 1, 1a, 1b, etc. If there are individual tables, please number them 1, 2, 3, etc.
- Tables must have more than one column with each column having a unique heading; do not repeat column heads to create more than one column (see sample Tables B and C).
- Tables cannot be simple lists. Simple lists should be added to the body of the text (see sample Table C).
- Each table can have only one set of column heads within the body of the table (see sample Tables D and E).
- Avoid using equations in tables. The font size is smaller in tables than in the text, and super and subscripts tend to get lost.
- Notes are acceptable in tables and should be represented by superscript letters. Do not use numbers as they could be confused as math.
- Divide tables into two or more when data are sizable. (Note: Avoid redundancy of data in figures, tables, and text. Select the format that presents data in the clearest form for readers.)
- **Figures**
- ***Figure Captions***. Brief figure captions (which are to serve as identifying labels) must be typed. Place explanations, descriptions, and other expository prose in the text, not the figure captions.
- ***Figures.*** Figures, whether line art or photographs, should be numbered sequentially in the order to which they are referred in the text.

Table. A. Properly Formatted Table—Every Table Needs a Table Number and Title[a]

Heading level 3[b]		Heading level 2	
Heading level 2	Heading level 2		
Heading level 1	Heading level 1	Heading level 1	Heading level 1
Subsection identifier			
Body text entry	Body text entry	Body text entry	Body text entry
Body text entry	Body text entry	Body text entry	Body text entry
Body text entry	Body text entry	Body text entry	Body text entry
Subsection identifier			
Body text entry	Body text entry	Body text entry	Body text entry
Body text entry	Body text entry	Body text entry	Body text entry
Body text entry	Body text entry	Body text entry	Body text entry

[a] All tables must have clear columns. Each column must have a heading. Repeated columns will be combined and repeated headings will be deleted. All vertical rules will be deleted as will most horizontal rules within the body of the text.

[b] Try to avoid having a lot of levels of headings in a table. Combine headings if you can.

TABLE B. INCORRECT Table Format- Repeated Headings

Action	Result	Action	Result
Go to the beach	Have fun	Take a walk	Get exercise
Go swimming	Stay cool	Put up umbrella	Stay in shade
Go fishing	Catch fish	Drink water	Stay hydrated

Column Headings should not be repeated. This table should only have two columns.

TABLE C. INCORRECT Table Format- Simple List

Skills	Skills
Leadership	Negotiation
Delegation	Ability to compromise
Compassion	Integrity
Discipline	Management

This is not a table but rather a simple list. It does not have at least two unique columns and should be eliminated or included in the text.

The first column needs to have a heading.

The second column has information unnecessarily repeated and there are more columns on the top portion than the bottom portion.

There are two levels of headings within the body of the table.

TABLE D. INCORRECT Table Format- Multiple Headings in Columns

	Activity	Managers		Editors	Vendors		Proofreaders
Requirements	Editing	2		10	5		0
	Composition	3		4	1		10
	Proofreading	1		6	1		10
	Activity	Pens	Pencils	Rulers	Dictionaries	Computers	Printers
Equipment	Editing	10	25	10	15	5	2
	Composition	10	0	20	3	10	5
	Proofreading	10	25	10	10	0	0

TABLE E. Properly Formatted Version of Table D

	Activity		
Resources	Editing	Composition	Proofreading
Managers	2	3	1
Editors	10	4	6
Vendors	5	1	1
Proofreaders	0	10	0
Pens	10	10	10
Pencils	25	0	25
Rulers	10	20	10
Dictionaries	15	3	10
Computers	5	10	0
Printers	2	5	0

This shows the same information as Table D above. The format conforms to the ASCE style and is easier to read.

Appendix C: Format for Literature Search[3]

To summarize others work you may want to follow these four items:

1. In a single coherent sentence give the following:
   a. name of the author, date in parenthesis;
   b. a rhetorically accurate verb such as "assert," "argue," "deny," "refute," "prove," disprove," "explain,"
   c. -a, that clause containing the major claim (thesis statement) of the work.
2. In a single coherent sentence explain how the author develops and supports the major claim (thesis statement).
3. In a single coherent sentence state the author's purpose, followed by an "in order" phrase.
4. In a single coherent sentence give a description of the intended audience and/or the relationship the author establishes with the audience.

Example: Nazarian et al. (2014) stated that the precision of the ultrasonic surface wave method is 7%.......

Another way that I have found to be useful for students is summarizing the papers in a table like the following:

Reference	Objective and Scope	Key Findings/Comments
Petersen and Peterson, 2006	Compared CMV with the point test measurements such as LWD, DCP and Geogauge	The roller measurements vary greatly with point measurements. The variation in the roller measurements is due to the difference in the area of the measurements between drum and sensors of spot tests, and the response is influenced by moisture, material and support.
Rahman et al., 2007	Studied the use of subgrade stiffness obtained from the IC technology using Bomag single smooth steel drum variocontrol intelligent roller. Three sections were considered in Kansas.	Demonstrated the potential benefits of the IC technology in identifying less stiff areas. Revealed the sensitivity of the roller measurements to moisture content variation.

Do not forget to keep the complete reference for the List of References. I usually place them as endnotes as soon as I finish summarizing the paper.

[3] Copied from http://www.raulpacheco.org/2016/10/using-the-rhetorical-precis-for-literature-reviews-and-conceptual-syntheses/, accessed August 20, 2017

Appendix D: Format of Presentation Summary

Your Name	
Title of Presentation	
Presenter	
Date of Presentation	
Main Idea	
Main Take Aways	
Gaps Identified	
Future Directions	
Final Thoughts	

Please see https://pressbooks.bccampus.ca/technicalwriting/chapter/appendixb-writingsummary/ for helpful hints in taking notes and turning it to an academic summary

Appendix E: Format for Paper Review Summary

Your Name	
Title of Paper	
Author(s)	
Date	
Main Idea	
Main Take Aways	
Gaps Identified	
Future Directions	
Final Thoughts	

Please see https://pressbooks.bccampus.ca/technicalwriting/chapter/appendixb-writingsummary/ for helpful hints in taking notes and turning it to an academic summary

Lecture Information 1-1

Lecture Title	Introduction to Class
Instructor	Soheil Nazarian
Lecture Description	This lecture presents the information about the course, the expectations and the processes associated with the course requirements.
Lecture Outcome	By the end of this lecture, you will be provided with: • Topics covered in the course • Assignments and due dates • Formats and procedures to be followed
Required Reading	• N/A
Relevant References	• Course Syllabus

Lecture Information 1-2

Lecture Title	Systems of Systems Concept
Instructor	Regan Zane, USU
Lecture Description	This lecture introduces the systems associated with electrified transportation and the concept of taking a systems of systems approach to understanding and leveraging their interdependencies. These include electric vehicles (from passenger to delivery and freight), charging equipment and network providers, charging site locations, electric utility (from generation to delivery), roads and parking, traffic and traffic management, end users and fleet operators, and the environment and society.
Lecture Outcome	By the end of this lecture, you will be able to: • Recognize the systems associated with electrified transportation and their interdependencies • Understand the meaning of a systems of systems approach to considering the transition to electrified transportation • Explain at the conceptual level how the interdependencies among the systems in electrified transportation may impact adoption, the environment, and society
Required Reading	TBD
Suggested Term Project Topics	• Design a system based on long range vehicles with 15 minute charge capability and consider the impacts on the grid and use of renewable energy
Relevant References	• TBD • • • •

Lecture Information 2-1

Lecture Title	Introduction to Electrical System Components
Instructor	Dragan Maksimovic
Lecture Description	This lecture presents an introduction to electric-vehicle drivetrain components, including battery systems, power electronic converters, and variable-speed ac drives. Operation of the vehicle over standard drive cycles is discussed using an EV system model. Vehicle specifications in terms of acceleration performance, maximum velocity, gradeability, and EV range, together with relationships among electrical and mechanical quantities are used to develop the EV system component constraints and ratings. The system components are characterized in terms of loss mechanisms and efficiency. The lecture ends with an overview of charging requirements, charging standards, and the charging infrastructure tied to the electric power grid.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand architectures EV drivetrains • Develop basic EV component and system models and study EV operation over standard drive cycles • Size EV system components in terms of electrical and mechanical quantities (voltage, current, power, energy, torque, velocity) based on the EV performance specifications • Gain familiarity with charging requirements and standards, as well as the issues related to the development of the charging infrastructure tied to the electric power grid
Required Reading	• B. Bilgin et al., "Making the Case for Electrified Transportation," in IEEE Transactions on Transportation Electrification, vol. 1, no. 1, pp. 4-17, June 2015
Suggested Term Project Topics	• E-Truck Design, Modeling and Simulations, and Impact • E-Bike Design, Modeling, Simulations, and Impact • E-Rickshaw Design, Modeling, Simulations, and Impact • E-Aircraft Design, Modeling, Simulations, and Impact
Relevant References	• B. Bilgin et al., "Making the Case for Electrified Transportation," in IEEE Transactions on Transportation Electrification, vol. 1, no. 1, pp. 4-17, June 2015 • Afonso JL, Cardoso LAL, Pedrosa D, Sousa TJC, Machado L, Tanta M, Monteiro V. A Review on Power Electronics Technologies for Electric Mobility. Energies. 2020; 13(23):6343. https://doi.org/10.3390/en13236343 • U.S. Department of Energy U.S. DRIVE Electrical and Electronics Technical Team Roadmap, Oct 2017, https://www.energy.gov/sites/prod/files/2017/11/f39/EETT%20Roadmap%2010-27-17.pdf • L. Wang, Z. Qin, T. Slangen, P. Bauer and T. van Wijk, "Grid Impact of Electric Vehicle Fast Charging Stations: Trends, Standards, Issues and Mitigation Measures - An Overview," in IEEE Open Journal of Power Electronics, vol. 2, pp. 56-74, 2021. • H. Tu, H. Feng, S. Srdic and S. Lukic, "Extreme Fast Charging of Electric Vehicles: A Technology Overview," in IEEE Transactions on Transportation Electrification, vol. 5, no. 4, pp. 861-878, Dec. 2019

Lecture Information 2-2

Lecture Title	"The Role of Battery Management in Electric Vehicles"
Instructor	M. Scott Trimboli
Lecture Description	The lecture provides a basic introduction to the operation and function of lithium-ion batteries and discusses how systems must carefully manage these batteries in operation. Mathematical modeling of battery cells is introduced with a focus on empirical, equivalent circuit models. Physics-based models are briefly introduced. The lecture addresses the important role of a battery management system (BMS) in enabling the safe and reliable operation of lithium-ion battery packs.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the basic operation and function of lithium-ion batteries. • Describe battery dynamic behavior in terms of an empirical equivalent circuit model. • Understand the basic approach to physics-based modeling of battery dynamics. • Describe the various requirements of a battery management system, to include sensing, control, protection, state and health estimation, and communications.
Required Reading	"Algorithms for Advanced Battery Management Systems," Chaturvedi, N. et al., IEEE Control Systems Magazine, June 2010.
Suggested Term Project Topics	• MATLAB simulation of an equivalent circuit model of a battery cell. • Term paper addressing a survey of methods used for state-of-charge estimation.
Relevant References	• G.Plett, *Battery Management Systems Volume I: Battery Modeling* (Artech House) (2015). • G.Plett, *Battery Management Systems Volume II: Battery Modeling* (Artech House) (2015). • D. Andrea, *Battery Management Systems for Large Lithium Ion Battery Packs* (Artech House)

Lecture Information 3-1

Lecture Title	Traditional Plug in EV Charging
Instructor	Abhilash Kamineni
Lecture Description	This lecture introduces the plug in chargers for electric vehicles. This lecture will outline the objectives of an EV charger before diving into the structure of EV chargers. It will introduce the different classes of plugin EV chargers that are commonly used today, the various standards surrounding EV chargers and go into a high level discussion about the structure and tradeoffs surrounding the different types of plugin chargers. Finally, we will discuss upcoming standards that are being developed to predict future developments in this space.
Lecture Outcome	By the end of this lecture, you will be able to: • Discuss what an EV charger does • Discuss the differences between different types of EV chargers • Discuss the tradeoffs between different types of charger technologies
Required Reading	This paper is a little technical and electrical focused which not everyone might understand but there are lots of other details like standards, etc that a broader will understand: M. R. Khalid, I. A. Khan, S. Hameed, M. S. J. Asghar and J. -S. Ro, "A Comprehensive Review on Structural Topologies, Power Levels, Energy Storage Systems, and Standards for Electric Vehicle Charging Stations and Their Impacts on Grid," in IEEE Access, vol. 9, pp. 128069-128094, 2021, doi: 10.1109/ACCESS.2021.3112189. https://ieeexplore.ieee.org/abstract/document/9536577
Suggested Term Project Topics	• We can look at developing a simple enough model for an EV charger to use as part of a broader systems of systems optimization style project to determine ideal charger sizing, number of chargers required, etc.
Relevant References	• Refer to the references from the required reading paper

Lecture Information 3-2

Lecture Title	Inductive-Based Wireless Charging
Instructor	Steve Pekarek, Dionysios Aliprantis, Purdue University
Lecture Description	The lecture will focus on several parts. First, a description of some basics of magnetic fields and electromagnetic coupling will be provided. Subsequently, a focus will be to describe the purpose and topologies of components, including dc-ac and ac-dc converters, cables, and compensation circuits used in inductive wireless power transfer systems. Coil topologies for several static and dynamic wireless chargers will be shown. Finally, a focus will be to highlight ongoing research, mostly along the lines of high-power wireless power transfer for heavy-duty vehicles, that is taking place within ASPIRE.
Lecture Outcome	By the end of this lecture, you will be able to: • Describe the role that coil turns/current level play in creating magnetic flux • Describe how time-varying magnetic flux is used to provide coupling between circuits • Identify and explain the key components used in wireless power transfer systems • Describe key problems that are being considered in static and dynamic wireless power transfer
Required Reading	Ali Abdolkhani (June 29th 2016). Fundamentals of Inductively Coupled Wireless Power Transfer Systems, Wireless Power Transfer - Fundamentals and Technologies, Eugen Coca, IntechOpen, DOI: 10.5772/63013. Available from: https://www.intechopen.com/chapters/50520
Suggested Term Project Topics	• Determine the sizing layout/placement of components of an interstate-based DWPT system (including cabling, connections, compensation circuit components, dc-ac, ac-dc converters) • Simulate the structural behavior of a roadway segment that includes the coils and magnetic components of a DWPT system. • Use the modeling tools available at website to determine the efficacy of installing a DWPT system on a roadway of your choice.
Relevant References	• “IPT PRIMOVE Dynamic Wireless Charging of Electric Vehicles in Motion.” IPT Technology, https://ipt-technology.com/e-mobility-wireless-dynamic-charging/. Accessed 30 Nov. 2021. • “Technology | Electreon.” Electreon, 15 Oct. 2020, https://www.electreon.com/technology. • “OLEV Technologies’ Dynamic Wireless Inductive System Charges Vehicles While in Motion - Charged EVs.” Charged EVs, 1 May 2014, https://chargedevs.com/features/olev-technologies-dynamic-wireless-inductive-system-charges-vehicles-while-in-motion/. • R. Tavakoli, E. M. Dede, C. Chou and Z. Pantic, "Cost-Efficiency Optimization of Ground Assemblies for Dynamic Wireless Charging of Electric Vehicles," in IEEE Transactions on Transportation Electrification, doi: 10.1109/TTE.2021.3105573. • R. Bosshard and J. W. Kolar, "Multi-Objective Optimization of 50 kW/85 kHz IPT System for Public Transport," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 4, no. 4, pp. 1370-1382, Dec. 2016, doi: 10.1109/JESTPE.2016.2598755. • Z. Luo, X. Wei, M. G. S. Pearce and G. A. Covic, "Multiobjective Optimization of Inductive Power Transfer Double-D Pads for Electric Vehicles," in IEEE Transactions on Power Electronics, vol. 36, no. 5, pp. 5135-5146, May 2021, doi: 10.1109/TPEL.2020.3029789. • D. Haddad et al., "Data-Driven Design and Assessment of Dynamic Wireless Charging Systems," 2019 IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW), 2019, pp. 59-64, doi: 10.1109/WoW45936.2019.9030612. • M. G. S. Pearce, H. Gao, A. Ramadugu, G. A. Covic and J. T. Boys, "Robust double D topology for roadway IPT applications," 2017 IEEE Energy Conversion Congress and Exposition (ECCE), 2017, pp. 2734-2741, doi: 10.1109/ECCE.2017.8096512. • R. Bosshard, U. Iruretagoyena and J. W. Kolar, "Comprehensive Evaluation of Rectangular and Double-D Coil Geometry for 50 kW/85 kHz IPT System," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 4, no. 4, pp. 1406-1415, Dec. 2016, doi: 10.1109/JESTPE.2016.2600162. • S. Li, W. Li, J. Deng, T. D. Nguyen and C. C. Mi, "A Double-Sided LCC Compensation Network and Its Tuning Method for Wireless Power Transfer," in IEEE Transactions on Vehicular Technology, vol. 64, no. 6, pp. 2261-2273, June 2015, doi: 10.1109/TVT.2014.2347006. • Konstantinou, T., Haddad, D., Prasad, A., Wright, E., Gkritza, K., Aliprantis, D., Pekarek, S., & Haddock, J. E. (2021). Feasibility study and design of in-road electric vehicle charging technologies (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2021/25). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317353

Lecture Information 4-1

Lecture Title	Capacitive Wireless Charging
Instructor	Khurram Afridi (Cornell)
Lecture Description	Wireless charging systems are of two types: inductive, which use magnetic field coupling between conducting coils, and capacitive, which use electric field coupling between conducting plates to transfer energy. For electric vehicle charging, inductive systems have traditionally been preferred. However, capacitive systems have potential advantages over inductive systems because of the relatively directed nature of electric fields, which reduces the need for electromagnetic field shielding. Furthermore, because capacitive wireless charging systems do not use ferrites, they can be operated at higher frequencies, allowing them to be smaller and lighter. Capacitive systems also have other potential benefits. However, there are also challenges associated with capacitive wireless charging. This lecture will cover the fundamentals of capacitive wireless charging, including the design of couplers, matching networks and high-frequency inverter/rectifiers, and will use results from prototyped systems to highlight the opportunities and challenges associated with capacitive wireless charging.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the principles behind capacitive wireless charging • Describe the function of various components of a capacitive wireless charging system • Describe the advantages of capacitive wireless charging over its inductive counterpart • Describe the challenges in the development of capacitive wireless charging systems • Partially describe the state of the art of capacitive wireless charging systems
Required Reading	S. Sinha, B. Regensburger, A. Kumar and K.K. Afridi, "A New Design Approach to Mitigating the Effect of Parasitics in Capacitive Wireless Power Transfer Systems for Electric Vehicle Charging," *IEEE Transactions on Transportation Electrification*, vol. 5, no. 4, pp. 1040-1059, December 2019.
Suggested Term Project Topics	• Literature search to determine the state of the art of capacitive wireless charging systems for electric vehicle applications.
Relevant References	• S. Sinha, A. Kumar, B. Regensburger and K.K. Afridi, "Design of High-Efficiency Matching Networks for Capacitive Wireless Power Transfer Systems," *IEEE Journal of Emerging and Selected Topics in Power Electronics*, (early access). • B. Regensburger, S. Sinha, A. Kumar, S. Maji and K.K. Afridi, "High-Performance Multi-MHz Capacitive Wireless Power Transfer System for EV Charging Utilizing Interleaved-Foil Coupled Inductors," *IEEE Journal of Emerging and Selected Topics in Power Electronics*, (early access). • S. Sinha, A. Kumar, B. Regensburger and K.K. Afridi, "Active Variable Reactance Rectifier – A New Approach to Compensating for Coupling Variations in Wireless Power Transfer Systems," *IEEE Journal of Emerging and Selected Topics in Power Electronics*, vol. 8, no. 3, pp. 2022-2040, September 2020.

Lecture Information 4-2

Lecture Title	Generation and Transmission Optimization of the Power Grid
Instructor	Yuanrui Sang
Lecture Description	This lecture introduces fundamentals of power system optimization based on direct-current optimal power flow (DCOPF) models. In this lecture, the students will learn about the optimal decision-making process in power system operations and planning, including how to choose the topology and other parameters for the electric power transmission network and dispatch the generation to reduce congestions in power systems and improve the cost-efficiency in power system operations and planning.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the basics of optimal power flow • Understand how generation dispatch decisions are made • Understand how to adjust parameters of the transmission systems for reduced congestion • Understand how to operate power systems with high cost-efficiency
Required Reading	E. B. Fisher, R. P. O'Neill and M. C. Ferris, "Optimal Transmission Switching," *IEEE Transactions on Power Systems*, vol. 23, no. 3, pp. 1346-1355, Aug. 2008, doi: 10.1109/TPWRS.2008.922256.
Suggested Term Project Topics	• Develop an optimal power flow (OPF) model using C++ and Gurobi • Develop an optimal power flow (OPF) model using Python Pyomo • Develop an optimal power flow (OPF) model using Julia JuMP
Relevant References	• M. Sahraei-Ardakani and K. W. Hedman, "A Fast LP Approach for Enhanced Utilization of Variable Impedance Based FACTS Devices," in *IEEE Transactions on Power Systems*, vol. 31, no. 3, pp. 2204-2213, May 2016, doi: 10.1109/TPWRS.2015.2447453. • Y. Sang and M. Sahraei-Ardakani, "The Interdependence Between Transmission Switching and Variable-Impedance Series FACTS Devices," in *IEEE Transactions on Power Systems*, vol. 33, no. 3, pp. 2792-2803, May 2018, doi: 10.1109/TPWRS.2017.2756074.

Lecture Information 5-1

Lecture Title	Basic Transportation Planning
Instructor	Kelvin Cheu
Lecture Description	This lecture covers the basics of transportation planning. It starts by defining transportation planning and its purpose. A brief discussion about Metropolitan Planning Organization and its functions is provided. The lecture then focuses on the transportation planning model, starting from demographic and economic forecasting, followed by the four-step urban transportation planning system process. Towards the end of this lecture, the uses of the outputs of transportation planning models are discussed.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the transportation planning process, the roles of MPO. • Acquire basic knowledge on the urban transportation planning model
Required Reading	Cheu, R.L. (2021) Transportation Engineering FE+. Chapter 21. 978-1-09839-155-3.
Suggested Term Project Topics	• A literature survey on the traffic assignment model with applications to electric vehicles. • A literature survey on trip generation, destination and route choice models for electric vehicles.
Relevant References	• Planning. Office of Planning, Environment and Safety. Federal Highway Administration. https://www.fhwa.dot.gov/planning • TransCAD User Guide, Caliper Corp, Newton, MA. https://www.caliper.com • What the Heck is an MPO. Slide presentation by Association of Metropolitan Planning Organization.https://ampo.org › 1813_ampo2012whattheheck

Lecture Information 5-2

Lecture Title	Analysis and Optimization of Electrified Transportation Networks
Instructor	Ziqi Song
Lecture Description	This lecture will provide an overview of the analysis and optimization models for electrified transportation networks, including both private vehicles and public transit. For the electrification of private vehicles, the main focus will be on public charging station deployment and private vehicle route choice (user equilibrium) models. In addition, basic transportation network equilibrium models will be introduced. For public transportation electrification, topics such as fleet battery sizing, charging scheduling and management, and charging station deployment will be discussed.
Lecture Outcome	By the end of this lecture, you will be able to: • Recognize the trends in urban transportation electrification • Construct basic route choice (user equilibrium) models for simple transportation networks • Explain the importance of transportation network equilibrium in modeling private vehicle electrification • Identify critical challenges for public transportation electrification
Required Reading	S. Li, Y. Huang, S.J. Mason. A multi-period optimization model for the deployment of public electric vehicle charging stations on network Transport. Res. Part C, 65 (2016), pp. 128-143
Suggested Term Project Topics	• Public charging station deployment for electric vehicles • Charging scheduling for battery electric bus systems
Relevant References	• N. Jiang, C. Xie, S.T. Waller. Path-constrained traffic assignment. Transport. Res. Rec J. Transport. Res. Board, 2283 (2012), pp. 25-33 • Y. He, Z. Song, Z. Liu. Fast-charging station deployment for battery electric bus systems considering electricity demand charges. Sustain. Cities Soc., 48 (2019), p. 101530

Lecture Information 6-1

Lecture Title	Power System Impacts of EVs
Instructor	Bri-Mathias Hodge
Lecture Description	This lecture will focus on the impact of electric vehicles on the power system. This will include aspects related to both the distribution and transmission systems. Critical aspects of charging impacts include: charging type, power draws, charging timing, and potential controllability of charging.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the coupling of the two large infrastructure systems: power systems and transportation systems • Estimate EV charging impacts on distribution systems • Estimate EV charging impacts on transmission systems • Understand the different impacts of charging location and type, as well as the potential ramifications for current and future power systems
Required Reading	Muratori, Impact of uncoordinated plug-in electric vehicle charging on residential power demand, 2018, Nature Energy. https://www.nature.com/articles/s41560-017-0074-z
Suggested Term Project Topics	• A distribution system planning study for EV charging increases • Estimating the bulk power impacts from different types of charging
Relevant References	• Electric Vehicle Integration into Modern Power Networks, edited by Rodrigo Garcia-Valle, João A. Peças

Lecture Information 6-2

Lecture Title	Basic Pavement Design as Related to EV Technology
Instructor	John E. Haddock
Lecture Description	Basic design of highway pavements, how EV charging technology might be designed and constructed within such pavements, along with a discussion of the possible advantages and disadvantages that might result from including such technology in pavements.
Lecture Outcome	By the end of this lecture, you will be able to: • Identify and distinguish the components of various pavement structures. • Distinguish the differences between structural and functional pavement performance and give examples of both. • Describe failure mechanisms in flexible, rigid, and composite pavements. • Explain the behavior of materials incorporated into pavement structures. • Explain possible adverse effects of incorporating wireless charging mechanisms in pavements.
Required Reading	Amirpour, Maedeh, Seho Kim, Matthew P. Battley, Piaras Kelly, Simon Bickerton, and Grant Covic, "Coupled Electromagnetic-thermal Analysis of Roadway Indictive Power Transfer Pads Within a Model Pavement," *Applied Thermal Engineering*, Vol. 189, 2021, https://doi.org/10.1016/j.applthermaleng.2021.116710.
Suggested Term Project Topics*	• Determine methods for using pavement-embedded charging units in continuously reinforced concrete pavements. • Investigate thermal aspects of pavement-embedded charging systems. • Develop methods for construction of pavement-embedded charging systems.
Relevant References	• Yoder, E.J and M.W. Witczak, *Principles of Pavement Design*, John Wiley and Sons, Inc., 2nd ed., 1975. • Mallick and El-Korchi, *Pavement Engineering: Principles and Practice*, 3rd ed., CRC Press, 2017. • Konstantinou, T., Haddad, D., Prasad, A., Wright, E., Gkritza, K., Aliprantis, D., Pekarek, S., & Haddock, J. E. (2021). *Feasibility study and design of in-road electric vehicle charging technologies* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2021/25). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317353 • Halling, Marvin W. and Trevor Gardner, *Infrastructure Issues Related to In-Motion Wireless Power Transfer*, CAIT-UTC-NC30, Logan, Utah, 2017.

Lecture Information 7-1

Lecture Title	Structural Considerations of Pavement Embedded Wireless Power Transfer Components
Instructor	Marv Halling, PhD, PE, SE; Utah State University
Lecture Description	This discussion will focus on the issues related to analysis and design of concrete pavements with embedded electronics. The technology of wireless power transfer is covered elsewhere in this course. This lecture will focus on the practical issues related to design, construction, durability and maintenance of actual systems in concrete and their interaction with the harsh environment of the transportation infrastructure.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand differences in pre-cast and cast-in-place construction • Understand the differences between strength and durability in concrete • Understand relationships between bending, stress, and reinforcing in concrete • Understand concrete "cover" and why it is important
Required Reading	TBD
Suggested Term Project Topics	• Consider design configuration alternatives for concrete vs asphalt wireless systems
Relevant References	• TBD • • • •

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Lecture Information 7-2

Lecture Title	Construction of an Electric Road System (ERS) - Concepts and Challenges
Instructor	Adeeba A. Raheem
Lecture Description	Most of the existing ERS examples are in the test phase, and large-scale implementation can be challenging due to varying site, design/structural and weather conditions. The lecture will cover the construction and maintenance concepts and associated potential challenges of an Electric Road System. The role and importance of digital information management infrastructure will also be discussed.
Lecture Outcome	By the end of this lecture, you will be able to: • Define an Electric Road System • Understand Structural Components of an Electrified Road System • Differentiate the Construction Process of Electric vs. Traditional Roads • Potential Challenges associated with Construction and Maintenance • Describe the need for Digital Information Management for the Electric Road Infrastructure
Required Reading	• Chen, F. (2016). Sustainable Implementation of Electrified Roads: Structural and Material Analyses. https://www.diva-portal.org/smash/get/diva2:1044961/FULLTEXT02.pdf
Suggested Term Project Topics*	• Systemically evaluate various deployment scenarios of Electric Road Systems based on existing literature • Conduct risk assessment of various Electric Road Systems in terms of construction and maintenance safety
Relevant References	• American Association of State Highway, Transportation Officials. AASHTO Guide for Design of Pavement Structures, 1993. AASHTO, 1993. • Feasibility analysis and development of on-road charging solutions for future electric vehicles, https://www.fabric-project.eu/www.fabric-project.eu/index.html • Swedish ICT Viktoria. Slide-in Electric Road System-Inductive project report. Project report, Phase 1. https://www.viktoria.se/publications/Slide-in-ERS-Inductive-project-report

Lecture Information 8-1

Lecture Title	Basic Life Cycle Assessment (LCA) from the Perspective of EV Components
Instructor	Dr. Bill Tseng & Dr. Md Fashiar Rahman
Lecture Description	Basic theory Life Cycle Assessment Introduction with GaBi LCA software Conducting Life Cycle Assessment using GaBi Software – Use case example Impact analysis using GaBi balance and dashboard
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the basic concept of LCA • Work with Gabi software • Create a LCA model in GaBi • Analyze the environmental impact
Required Reading	Gabi Manual Lecture handout
Suggested Term Project Topics	• Exploring the impact on Global Warming Potential (GWP) through LCA of Lithium-ion battery
Relevant References	• Kupfer, T., et. al., "GaBi Databases and Modeling Principles 2020" (Sphera) (Online resource) • Klöpffer, Walter, and Birgit Grahl. Life cycle assessment (LCA): a guide to best practice. John Wiley & Sons, 2014.

Lecture Information 8-2

Lecture Title	Life Cycle Assessment Applied to Electric Vehicles
Instructor	Jason Quinn
Lecture Description	Life cycle assessment or carbon footprint analysis will be introduced. This will include the basics of performing a life cycle assessment (functional units, system boundary, life cycle inventory data). The lecture will go over LCA in electric vehicles with detailed data presented on emissions from electricity production.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the basics of LCA • Read and compare two different LCA studies • Talk intelligently about the metrics of LCA
Required Reading	I am generating a text book next semester. It will be one chapter from that document
Suggested Term Project Topics	• LCA applied to electrified transportation
Relevant References	• CMU open source LCA text book

Lecture Information 9-1

Lecture Title	Environmental Aspects of EV Technology
Instructor	Jana Milford
Lecture Description	Air quality and climate benefits are commonly cited as reasons to transition from internal combustion engine (ICE) to electric vehicles (EV). This lecture will describe the sources and types of pollution associated with ICE and EVs across their respective life cycles, as well as corresponding health and environmental effects. Participants will be asked to consider how alternative pathways for EV technology and deployment might influence the health and environmental benefits that are realized from the EV transition.
Lecture Outcome	By the end of this lecture, you will be able to: • Recognize the magnitude and scope of impacts of air pollution on human health and the environment • Appreciate the types of evidence that link air pollution with health and environmental effects, from local to global scales • Identify the sources of air pollution across the well-to-wheels life cycle of internal combustion engine vehicles and electric vehicles • Recognize factors that will influence how the EV transition affects human health and the environment and consider how they could be addressed in EV research
Required Reading	Choma, E. F., Evans, J. S., Hammitt, J. K., Gómez-Ibáñez, J. A., and Spengler, J. D. (2020). “Assessing the health impacts of electric vehicles through air pollution in the United States.” Environment International, Elsevier, 144(February), 106015.
Suggested Term Project Topics	• Map sources and air pollutant emissions from transportation and electricity generation in the community of your choice and use this data to suggest priorities for staging the EV transition • Select a medium or heavy-duty vehicle class or type of use and estimate the contribution it makes to pollutant emissions and exposures in your community • Access historical load and emissions data for your electricity provider and assess how the fleet mix and emissions vary by time of day to evaluate the best times for charging from an emissions perspective
Relevant References	• Tessum, C. W., Hill, J. D., and Marshall, J. D. (2014), “Life cycle air quality impacts of conventional and alternative light-duty transportation in the United States.” Proceedings of the National Academy of Sciences of the United States of America, 111(52), 18490–18495. • Davidson, K., Fann, N., Zawacki, M., Fulcher, C., and Baker, K.R. (2020), “The recent and future health burden of the US mobile sector apportioned by source.” Environmental Research Letters. IOP Publishing, 15(7), DOI:10.1088/1748-9326/ab83a8.

Lecture Information 9-2

Lecture Title	Environmental Justice and equity in Transportation: What does it mean?
Instructor	Ivonne Santiago
Lecture Description	This lecture will help understand environmental justice and existing disparities in transportation, including electric vehicle technology and public charger access.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand what environmental justice and what environmental injustices in transportation are • Learn what different agencies such as DOT and DOE are doing to promote environmental justice • The different of roles that faculty, researchers, and students in ASPIRE can play in environmental justice work and community engagement
Required Reading	Parris, C. L., Hegtvedt, K. A., Watson, L. A., & Johnson, C. (2014). Justice for all? Factors affecting perceptions of environmental and ecological injustice. *Social Justice Research*, *27*(1), 67-98.
Suggested Term Project Topics	• Disparities in access of residents of multi-unit dwellings to public charging stations in your area • Disparities in modes of transportation
Relevant References	• Fuller, Christina, and Frugge, Doug. Environmental Justice: Disproportionate Impacts of Transportation on Vulnerable Communities. Elsevier Inc, 2020. • Taylor, Dorceta. Toxic communities. New York University Press, 2014. • Mohai, Paul, David Pellow, and J. Timmons Roberts. "Environmental justice." Annual review of environment and resources 34 (2009): 405-430. • Agyeman, Julian, et al. "Trends and directions in environmental justice: from inequity to everyday life, community, and just sustainabilities." Annual Review of Environment and Resources 41 (2016): 321-340. • Lucas, John Randolph. "Justice." Philosophy 47.181 (1972): 229-248. • Rawls, John. "A theory of justice/Revised Edition." (1971). • Young, Iris Marion. Justice and the Politics of Difference. Princeton University Press, 2011. • Karner, Alex, et al. "From transportation equity to transportation justice: within, through, and beyond the state." journal of planning literature 35.4 (2020): 440-459. • National Academies of Sciences, Engineering, and Medicine (2020) • Bullard, R. D. (2004) Addressing urban transportation equity in the United States, Fordham Urban Law Journal, 31(5), 1183-1210. • Fuller, C. H. & Brugge, D. (2020) Chapter 20 - environmental justice: Disproportionate impacts of transportation on vulnerable communities. In H. Khreis, M. Nieuwenhuijsen, J. Zietsman & T. Ramani (Eds.), Traffic-Related Air Pollution, pp. 495-510, Elsevier. • Mohai, P., Pellow, D., & Roberts, J.T. (2009) Environmental Justice, Annu. Rev. Environ. Resour. 34, 405-430. • Nardone, A., Chiang, J., & Corburn, J. (2020) Historic redlining and urban health today in U.S. cities. Environmental Justice, 13(4), 109-119, doi:10.1089/env.2020.0011. • Hsu, C-W & Fingerman, K. (2021) Public electric vehicle charger access disparities across race and income in California, Transport Policy, 100, 59-67. • Tessum, C.W. et al. (2021) PM2.5 polluters disproportionately and systemically affect people of color in the United States, Science Advances 7: eabf4491.

There are no information for Lectures 10-1 and 10-2 since they are related to Spring Break Gap

Lecture Information 11-1

Lecture Title	Economic Aspects of EV technology
Instructor	Chris Fawson
Lecture Description	This lecture will introduce students to the basic economic principles that are associated with the emergence and dissemination of EV technology within the economy.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand how economic principles can be used to better understand the complexity of EV technology diffusion within market institutions and the core issues driving EV adoption. • Apply economic principles in analyzing market structures that are emerging within the EV market space.
Required Reading	The Economics of Electric Vehicles by David S. Rapson and Erich Muehlegger. (University of California-Davis working paper – 7/21/2021)
Suggested Term Project Topics	• Confronting the challenges of applying conventional technology adoption models to the electric vehicle market. • An evaluation of intersecting interests within the EV market space—and how those impact optimal policy design.
Relevant References	• Any good Microeconomics Principles textbook.

Lecture Information 11-2

Lecture Title	Understanding Sustainability Marketing as related to EV technology
Instructor	Dr. Antje Graul, Assistant Professor of Marketing at Utah State University
Lecture Description	This lecture will talk about sustainability marketing as related to EV technology.
Lecture Outcome	By the end of this Lecture, you will be able to: • Understand the concept and basic principles of marketing and consumer behavior • Discuss what a sustainability-oriented version of marketing would look like • Understand the latest trends in sustainable and electrified transportation from a consumer perspective • Apply marketing communication strategies currently used by leading companies to market green products/ services
Required Reading	https://www.liebertpub.com/doi/full/10.1089/sus.2020.29178.ers https://hbr.org/2019/07/the-elusive-green-consumer
Relevant References	• Lancaster, G., and Withey, F. (2006). Marketing Fundamentals. Routledge. • Kotler, P. and Keller, K. (2011). Marketing Management (14th edition). London Pearson Education. • icct 2020; Cleantechnica.com 2019 • Ward, Singleton, Graul & Garrison, 2020

Lecture Information 12-1

Lecture Title	Pricing Strategies for Charging EVs
Instructor	Paras Mandal, UTEP
Lecture Description	This lecture will provide a transactive energy (TE) approach through a transactive control (TC) mechanism for an efficient EV management with a goal of minimizing the charging cost of EVs and mitigating the adverse effects on the distribution grid. Charging EVs can present undesirable effects, e.g., overload components, in the distribution grid. We will discuss a case study of a distribution transformer located at a distribution feeder test system in addition to the following: (1) distribution locational marginal price calculation, (2) Electric vehicle modeling, (3) Case studies on when all EVs (i) charge at the same time, (ii) at different times, and (iii) at the least cost. Moreover, this lecture will provide information about how EV owners can minimize their electricity bills while charging their EVs efficiently.
Lecture Outcome	By the end of this lecture, you will be able to understand: • Mathematical modeling of EV • Concept of electricity pricing at power distribution grid and EVs charging • Transactive energy • Transactive control • Smart grid
Required Reading	• E. Galvan, P. Mandal, M. Velez-Reyes, and S. Kamalasadan, "Transactive Control Mechanism for Efficient Management of EVs Charging in Transactive Energy Environment," *in Proc.* 2016 North American Power Symposium (NAPS2016), September 18-20, 2016.
Suggested Term Project Topics	• EVs and demand response • EVs and pricing mechanism • EVs charging and technology
Relevant References	• GridWise Architecture Council, "GridWise transactive energy framework (draft)," Oct. 2013. • J. A. P. Lopes, F. J. Soares, and P. M. R. Almeida, "Integration of electric vehicles in the electric power system," *in Proc.* IEEE, Vol. 99, No. 1, pp. 168–183, Jan. 2011. • K. J. Dyke, N. Schofield, and M. Barnes, "The impact of transport electrification on electrical networks," *IEEE Trans. Ind. Electron.,* Vol. 57, No. 12, pp. 3917–3926, Dec. 2010. • O. Sundstrom and C. Binding, "Flexible Charging Optimization for Electric Vehicles Considering Distribution Grid Constraints," *IEEE Transactions on Smart Grid,* Vol. 3, No. 1, pp. 26–37, 2012.

Lecture Information 12-2

Lecture Title	Accelerating EV Adoption Rates – An Economists Perspective
Instructor	Chris Fawson
Lecture Description	This lecture will introduce students to the basic suite of interconnected market challenges presented to policy makers and EV manufacturers as they seek to accelerate EV adoption rates.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand how economic principles can be used to better understand the complexity of EV technology diffusion within market institutions and the core issues driving EV adoption. • Apply economic principles in analyzing market structures that are emerging within the EV market space. • Explore the complex set of market issues that confront policy makers and EV manufacturers as they try to strategically accelerate EV adoption rates.
Required Reading	Future Paths of Electric Vehicle Adoption in the United States: Predictable Determinants, Obstacles and Opportunities. By James Archsmith, Erich Muehlegger and David Rapson. National Bureau of Economic Research Technical Report 2021
Suggested Term Project Topics	• Confronting the challenges of applying conventional technology adoption models to the electric vehicle market. • An evaluation of intersecting interests within the EV market space—and how those impact optimal policy design.
Relevant References	• Any good Microeconomics Principles textbook.

Lecture Information 13-1

Lecture Title	Role of Data Science in Electrified Transportation
Instructor	Qin (Christine) Lv, Department of Computer Science, University of Colorado Boulder
Lecture Description	This lecture gives an overview of ASPIRE's data research thrust and how it connects to other research thrusts within ASPIRE. It introduces the core concepts and techniques in data science that can be leveraged in the research of electrified transportation.
Lecture Outcome	By the end of this lecture, you will be able to: • Understand the main focuses of the ASPIRE data research thrust. • Identify potential collaborations between the data thrust and other research thrusts. • Understand the core concepts and techniques in data science. • Identify potential applications of data science methods in electrified transportation.
Required Reading O	None.
Suggested Term Project Topics	• Data-driven analysis and modeling of battery systems, vehicle performance, transportation demand, charging demand, power and energy systems, user perspectives and adoption, sustainability impact, charging system security and optimization.
Relevant References	• Q. Wang, X. Liu, J. Du and F. Kong, "Smart Charging for Electric Vehicles: A Survey From the Algorithmic Perspective," in *IEEE Communications Surveys & Tutorials*, vol. 18, no. 2, pp. 1500-1517, Secondquarter 2016, doi: 10.1109/COMST.2016.2518628. • Guang Wang, Yongfeng Zhang, Zhihan Fang, Shuai Wang, Fan Zhang, and Desheng Zhang. 2020. FairCharge: A Data-Driven Fairness-Aware Charging Recommendation System for Large-Scale Electric Taxi Fleets. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol. 4, 1, Article 28 (March 2020), 25 pages. https://doi.org/10.1145/3381003 • N. I. Nimalsiri, C. P. Mediwaththe, E. L. Ratnam, M. Shaw, D. B. Smith and S. K. Halgamuge, "A Survey of Algorithms for Distributed Charging Control of Electric Vehicles in Smart Grid," in *IEEE Transactions on Intelligent Transportation Systems*, vol. 21, no. 11, pp. 4497-4515, Nov. 2020, doi: 10.1109/TITS.2019.2943620. • A. Ospina, A. Simonetto, and E. Dall'Anese, "Personalized Demand Response via Shape-Constrained Online Learning," IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids, Nov. 2020