

**DEPARTMENT OF ELECTRICAL ENGINEERING**

**EE STUDENT  
HANDBOOK**

**SWENSON COLLEGE OF SCIENCE & ENGINEERING  
UNIVERSITY OF MINNESOTA DULUTH**

**FALL 2021**

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**Individuals who have any disability, either permanent or temporary, which might affect their ability to perform in class are encouraged to inform the instructor at the start of the semester. Adaptation of methods, materials, or testing may be made as required to provide for equitable participation.**

*The University of Minnesota is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, religion, color, sex, national origin, handicap, age, veteran status or sexual orientation.*

# UNIVERSITY OF MINNESOTA

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Fall 2021

Dear EE student:

Welcome to the Electrical Engineering Department of the University of Minnesota Duluth! All of our faculty and staff here are well prepared to support you through each step of this exciting educational journey of you.

We strive to provide an excellent undergraduate and graduate education to Electrical Engineering students with solid experience and dedication of our faculty and staff, as well as our state-of-art lab facilities. Our graduates usually have close to 100% job placement rate. In addition, we have very active extracurricular activities, such as the IEEE club, Rocketry club, Robotics club and Society of Women Engineers (SWE). These activities provide students with opportunities to learn about engineering outside the classroom.

We are very excited that we can meet all of you in person this fall. The social distancing and separation during the past three semesters made us value more the social connections, face-to-face communications and active campus life that we had pre-COVID, even though we tried our best and well survived through the online mode. In this upcoming year, we aim to serve all of you more effectively for your learning with the new campus operation mode. At the same time, as we have learned from the pandemic, we will keep placing everyone's safety and health as the highest priority. I am confident that students, faculty and staff together can do this and do it well.

This handbook has been assembled to provide you with important information, so please read it carefully. You can also check our updated EE Web page at <http://www.d.umn.edu/ee/>. Feel free to contact me via email.

Again, I welcome you to the EE Department and offer the best wishes for this academic year.

Sincerely,



Jing Bai  
Professor and Department Head  
Phone: (218) 726-8606  
Email: [jingbai@d.umn.edu](mailto:jingbai@d.umn.edu)

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## **PART I: EE DEPARTMENT INFORMATION**

## EE FACULTY AND STAFF

| NAME  | POSITION                                  | MWAH ROOM # | OFFICE TELEPHONE |
|---|---|-------------|------------------|
| <b>Bai, Dr. Jing</b><br><a href="mailto:jingbai@d.umn.edu">jingbai@d.umn.edu</a>                | Professor and Department Head             | 272         | 8606             |
| <b>Burns, Dr. Stanley</b><br><a href="mailto:sburns@d.umn.edu">sburns@d.umn.edu</a>             | Professor                                 | 252         | 7506             |
| <b>Chen, Mr. Xiaogang</b><br><a href="mailto:chen1557@d.umn.edu">chen1557@d.umn.edu</a>         | Laboratory Services Coordinator           | 189E        | 6153             |
| <b>Fang, Dr. Peng</b><br><a href="mailto:fangp@d.umn.edu">fangp@d.umn.edu</a>                   | Assistant Professor                       | 257         | 8410             |
| <b>Hasan, Dr. Mohammed</b><br><a href="mailto:mhasan@d.umn.edu">mhasan@d.umn.edu</a>            | Associate Professor                       | 254         | 6150             |
| <b>Hayajna, Dr. Tareq</b><br><a href="mailto:tareqmsh@yahoo.com">tareqmsh@yahoo.com</a>         | Assistant Professor                       | 255         | 6658             |
| <b>Hayee, Dr. Imran</b><br><a href="mailto:ihayee@d.umn.edu">ihayee@d.umn.edu</a>               | Professor                                 | 278         | 6743             |
| <b>Kochmann, Mr. Todd</b><br><a href="mailto:kochm006@d.umn.edu">kochm006@d.umn.edu</a>         | Finance Professional II (EE & Physics)    | 147         | 7123             |
| <b>Kwon, Dr. Taek</b><br><a href="mailto:tkwon@d.umn.edu">tkwon@d.umn.edu</a>                   | Professor                                 | 253         | 8211             |
| <b>Naidu, Dr. Desineni Subbaram</b><br><a href="mailto:dsnaidu@d.umn.edu">dsnaidu@d.umn.edu</a> | Professor, Jack Rowe Chair                | 273         | 6531             |
| <b>Norr, Mr. Scott</b><br><a href="mailto:snorr@d.umn.edu">snorr@d.umn.edu</a>                  | Instructor                                | 154         | 8947             |
| <b>Peterson, Shey</b><br><a href="mailto:speters1@d.umn.edu">speters1@d.umn.edu</a>             | Executive Secretary                       | 271         | 6830             |
| <b>Tang, Dr. Hua</b><br><a href="mailto:htang@d.umn.edu">htang@d.umn.edu</a>                    | Professor                                 | 276         | 7095             |
| <b>Yang, Dr. Jiann-Shiou</b><br><a href="mailto:jyang@d.umn.edu">jyang@d.umn.edu</a>            | Professor<br>Director of Graduate Studies | 274         | 6290             |
| <b>Zimmerman, Dr. Lee</b><br><a href="mailto:lzimmerm@d.umn.edu">lzimmerm@d.umn.edu</a>         | Adjunct Assistant Professor               | 153         | 6385             |

## ELECTRICAL ENGINEERING FACULTY PROFILES

The electrical engineering curriculum is presented by faculty members who bring a wide range of research, industrial and consulting experience to their teaching assignments. Each is well aware of the national goals that must be met in order to produce graduates who are prepared to compete in an international technical market place. Faculty work together to evolve a curriculum that is challenging to the student, a curriculum that reflects the scope of the faculty expertise and training. A brief summary of the research areas in which faculty members are involved follows.

**Dr. Jing Bai, Professor and Department Head:** Dr. Bai joined the EE Department in Fall 2007. She received her Bachelor of Engineering degree from Tsinghua University, China, and M.S. and Ph.D. degrees in Electrical and Computer Engineering from Georgia Institute of Technology. Her research interests include optoelectronic devices, semiconductor nanostructures, nonlinear optics, quantum optics and micro-electro-mechanical system (MEMS).

**Dr. Stanley G. Burns, Professor and DGS:** Dr. Burns joined EE as Department Head in 1998. He received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from the University of Wisconsin-Madison. Dr. Burns' research interests include microelectronics, semiconductor device processing, and high frequency analog circuit design. He is a senior member of the IEEE, and a member of ASEE and ECS. Dr. Burns is a registered Professional Engineer in Minnesota and Iowa.

**Dr. Peng Fang, Assistant Professor:** Dr. Fang joined the EE Department in Fall 2018. He received his B. Eng. degree in Information and Computer Science from Chong Qing University of Post and Telecommunication, China, in 2006, the MSEE degree from Hong Kong University of Science and Technology, Hong Kong, China, in 2007, and his Ph.D. in Electrical Engineering from Queens's University, Ontario, Canada in 2016. Dr. Fang's research interests are in the area of power electronics technology for EV charger, distributed renewable energy integration, solar energy harvesting technology, and power converter design.

**Dr. Mohammed Hasan, Associate Professor:** Dr. Hasan began with the EE Department in September 1997. He received his B.S. degree in Mathematics from the University of Baghdad, Iraq, and the M.S. degree in Electrical Engineering from Colorado State University. Dr. Hasan has a Ph.D. in Applied Mathematics and a Ph.D. in Electrical Engineering both from Colorado State University. His research interests include modeling and estimation of random processes and their applications to signal processing and biomedical research, adaptive filtering and sinusoidal estimation.

**Dr. Tareq Hayajna, Assistant Professor:** Dr. Hayajna joined the department in Fall 2021 as an Assistant Professor. He holds a PhD in Electrical Engineering from École de Technologie Supérieure (University of Quebec), Canada in 2017, a Master of Engineering in Electrical and Computer Engineering, Concordia University, Canada in 2011, and a Bachelor of Science in Electrical Engineering with a specialization in Communications and Electronics Engineering, Jordan University of Science and Technology, Jordan in 2004. He also has the experience of being an instructor and lab teaching assistant in electrical engineering courses. His research focuses computer network and wireless communications.

**Dr. Imran Hayee, Professor:** Dr. Hayee joined the EE Department in Fall 2004. He received a B.Sc.E.E. at UET Pakistan, and his M.S.E.E. and Ph.D. degrees at the University of Southern California in Los Angeles. Dr. Hayee's research interests are in the field of state-of-the-art optical fiber communication products, cabled and wireless communication regimes.

**Dr. Taek Mu Kwon, Professor:** Dr. Kwon has been in the department since Fall 1988. He received his B.S. degree in Electrical Engineering from Sung-Jun University, Seoul, Korea, and his M.S. and Ph.D. degrees from the Florida Institute of Technology, Melbourne. Dr. Kwon's research interests include neural networks, neural nets and fuzzy controllers, genetic algorithms, digital signal processing, computer networks, and intelligent transportation systems..

**Dr. Desineni Subbaram Naidu, Professor, Minnesota Power Jack Rowe Chair:** Dr. Naidu joined the EE Department as Minnesota Power Jack Rowe Endowed Chair in August 2014. He received his M.S. and Ph.D. degrees

from the Indian Institute of Technology (IIT), Kharagpur, India. Before joining UMD, Dr. Naidu was Professor with the EE Department at Idaho State University, Pocatello. His area of teaching and research include electrical engineering, industrial control systems and cyber security, biomedical engineering and time scales in engineering and life sciences. Dr. Naidu is an IEEE Fellow.

**Mr. Scott Norr, Instructor:** Mr. Norr has 13 years of industry experience in the areas of power systems and electrical consulting. He is especially interested in dynamic stability of power systems, voltage collapse phenomena and power quality. Mr. Norr received his B.S.E.E. from North Dakota State University in 1986 and his M.S.E.E degree from University of Minnesota Duluth in 2017. He is a registered Professional Engineer in the State of Minnesota.

**Dr. Hua Tang, Professor** joined the department in Fall 2005. He received his B.E. in Electrical Engineering from North China Electric Power University (Beijing), Beijing, P.R. China, and M.S. and Ph.D. in Electrical Engineering from State University of New York at Stony Brook, Stony Brook, NY in 2002 and 2005 respectively. Dr. Tang's research interests include high-performance analog, digital and mixed-signal VLSI circuit design and computer aided design. He is a member of IEEE.

**Dr. Jiann-Shiou Yang, Professor:** Dr. Yang began teaching at UMD in the fall of 1988. He received his B.S. and M.S. degrees in Control Engineering from National Chiao-Tung University, Taiwan and his M.S. and Ph.D. degrees in Electrical Engineering from the University of Maryland at College Park. Dr. Yang's research interests include robust control, system theory, computer-aided control system design, optimization, intelligent transportation systems, biped locomotion, and control applications. He is a senior member of the IEEE.

**Dr. Lee Zimmerman, Adjunct Assistant Professor:** Dr. Zimmerman joined the Department in the Fall of 2012. He received the B.S.E.E. degree from the University of Utah and his Ph.D. in Electrical Engineering from the University of Minnesota, Twin Cities. He was Assistant Professor with Tulane University, New Orleans, from 1991 to 1998 and adjunct Assistant Professor with the EE Department at UMD from 1999 to 2008. Dr. Zimmerman's research interest is computer vision, neurobiology and experimental psychology.

## ELECTRICAL ENGINEERING STAFF PROFILES

**Xiaogang Chen, Laboratory Services Coordinator:** As lab services coordinator, Xiaogang provides equipment, maintenance, and support for the EE laboratories. He received his B.S.M.E. degree from Dalian Jiaotong University in China and his M.S.E.E. from the University of Minnesota Duluth and. See Xiaogang if you need materials, supplies, or equipment for use in laboratory instruction.

**Shey Peterson, Executive Secretary:** As department secretary, Shey provides administrative support for the EE office. See Shey for information on grant expenses, payroll, course permission, advisement, etc.

**Todd Kochmann, Accountant:** As accountant for EE and Physics, Todd prepares purchase orders, requisitions and processes invoices. In addition, he also prepares employee reimbursement, travel expenses and purchasing card reports.

## IEEE STUDENT BRANCH

The UMD branch chapter of the IEEE Computer Society is a student organization for EE students, as well as other students majoring in technical/engineering fields. The UMD IEEE Computer Society is affiliated with the Institute of Electrical and Electronics Engineers (IEEE), an international professional organization.

New members are always welcome. To join, application forms are available (during the academic year only) in the IEEE office (102 MWAH), or in the EE Department office (271 MWAH). There is an annual membership fee. IEEE membership includes subscriptions to two national IEEE publications. Members are eligible for scholarships and can participate in national and regional professional conferences. The EE student group sponsors student-faculty feedback forums, arranges tours to industries, and plans recreational activities.

Meetings are held starting late September, with regular meetings to follow. Check your email for meeting announcements. Faculty advisor is Dr. Imran Hayee.

E-mail contacts for the IEEE Student Branch are: [ieee\\_officers@d.umn.edu](mailto:ieee_officers@d.umn.edu)

President: Ivan Herrlich

Vice President: Liam D Fife

Treasurer: Andrew Hachten

Secretary: Sydney Nguyen

Social Media: Brock Anderson

Public Relations: Kaleb Krush

## GENERAL INFORMATION ABOUT THE DEPARTMENT OF ELECTRICAL ENGINEERING

**EE DEPARTMENT OFFICE HOURS** - The EE department office (271 MWAH) is working remotely, but can meet at the office via appointment. Office staff Shey Peterson can be reached via email [speters1@d.umn.edu](mailto:speters1@d.umn.edu) or phone – 218-726-6830.

**GRADUATE SCHOOL AND CAREER INFORMATION** is available on the bulletin board outside 157 MWAH. Please do not remove these materials from the area. (FYI: Employment, internship, and undergraduate opportunities are also sent via UMD email to EE majors and minors.)

**EMAIL** is routinely used to inform students of course changes, seminar announcements, employment, internships, undergraduate opportunities and other pertinent information. Please be sure to check your email on a regular basis. When sending email to the department office, you will receive the quickest response if you address it to [umdee@d.umn.edu](mailto:umdee@d.umn.edu). You should use only your UMD email address for resumes and communicating with potential employers.

### **EE BULLETIN BOARDS**

**Department Bulletin Boards** are for EE announcements only. Please check with Shey if you wish to post something on any department bulletin board.

**Employment Board** is located next to MWAH 157. Information on internships and employment for graduates is posted here. This information is also sent via email. Please check with Shey to post information on the employment board.

**Miscellaneous/Student Group Board** is next to the 295 MWAH; University and miscellaneous announcements are placed here. Please check with Shey to post information on the miscellaneous board.

**PHOTOCOPYING** is available in the Library or Kirby Student Center. The photocopier in the EE Office is not available for student use.

**102 MWAH STUDENT ACTIVITY AND LEARNING CENTER** See page 10

**EE TEACHING LABS** - Labs in 41, 60, 141, 291, 291A, 293, 295, 391, 393 MWAH have swipe card access which is available through filling out an online form found at [z.umn.edu/eekeylink](http://z.umn.edu/eekeylink). Upon obtaining code(s)/key card, you will be responsible for the following:

1. You must not give this code/key card to any other student, not even another EE student.
2. You are responsible for locking the lab and closing the windows when you leave.
3. Equipment, program manuals and other supplies are not to be removed from any lab. Anyone found removing such items will have their lab privileges revoked.
4. You must not work alone after business hours in any of the departmental laboratories.
5. Please keep the labs clean; dispose of food wrappers, recycle scrap paper and pop cans, etc.

**SENIOR DESIGN PROJECT GUIDELINES** – For information and resources on Senior Design projects, please visit the website: <https://sites.google.com/d.umn.edu/senior-design/home>. For the format of Senior Design project report, please visit: [https://scse.d.umn.edu/sites/scse.d.umn.edu/files/sr\\_report\\_guidelines\\_0.pdf](https://scse.d.umn.edu/sites/scse.d.umn.edu/files/sr_report_guidelines_0.pdf)

**SENIOR DESIGN PROJECT/INDEPENDENT STUDY PERMISSION NUMBERS** - You need to have permission from the faculty member with whom you are going to do your senior project or independent study. To receive your permission, please send your student ID and faculty name to the EE office via email. You send one email for all your team members; if you list their names and student ID, the department will give the permission to each.

**FORMS AND INFORMATION AVAILABLE ONLINE – for assistance contact EE Office staff**

|  |              |
|--|--------------|
| Application to Upper Division                      | EE Electives |
| APAS, Transcripts                                  | Lab Access   |
| Student Handbook, Resume Book, Senior Design Book  |              |
| EE Senior Design Project Permission Number Request |              |

**ITEMS AVAILABLE VIA SCSE STUDENT AFFAIRS, also online.**

|                                |  |
|--------------------------------|--|
| SCSE Amendment Forms           | Registration Materials/Class Schedules |
| Change of College Request Form | Petition forms                         |
| Change of Advisor/Major        | Transcripts                            |

**ADVISEMENT AND REGISTRATION**

EE majors are required to attend one of the group advising sessions held by the department each semester. **Registration hold release is based on the attendance of group advising.** The department will offer multiple advising sessions with the same coverage to accommodate students' schedules. Topics covered include general registration questions, curriculum updates, elective courses, credits transfer, scholarship information, co-op and internship opportunities, student clubs, etc. Each student will be assigned an individual advisor. In addition to participating group advising, students are strongly encouraged to meet with their individual advisor to further discuss their academic plans/curriculum choices, professional interests, and especially unusual circumstances if any. **Students on probation are required to meet with an individual advisor.**

**GRADES**

A "D" is the minimum grade required in an EE course. Although it is not required, students receiving a D in an EE course are encouraged to retake the course.

**EXIT INTERVIEW**

You will receive an email from the EE Department before the end of the semester in which you graduate giving information on the exit interview process. The exit interview is an EE graduation requirement.

## EE LABORATORY SAFETY RULES

During COVID-19 pandemic, some of EE labs are closed and lab sessions are taught with remote or online modalities. For those labs which are open, please maintain social distance and wear masks when working in the lab. Please also follow the "COVID-19: Cleaning Computers and Electronics for All Users" attached in the handbook for necessary cleaning after using labs.. Other than that, the following general guidelines for EE labs still apply:

1. No horseplay or running is allowed in the labs.
2. No bare feet or open sandals are permitted.
3. Before energizing any equipment, check whether anyone is in a position to be injured by your actions.
4. When working on equipment where more than 120 volts exist between circuit points and/or ground, get your lab instructor's approval before energizing the circuit.
5. Read the appropriate equipment instruction manual sections or consult with your instructor before applying power or connecting unfamiliar equipment or instruments into any circuits.
6. Position all equipment on benches in a safe and stable manner.
7. Do not make circuit connections by hand while circuits are energized. This is especially dangerous with high voltage and current circuits.
8. Do not work alone in the lab if equipment is energized; at least one other person is to be present. You must not work alone after normal business hours.
9. The use of 110 volts, 60 Hz plug-in cords with open wire or alligator clip ends is hazardous; use them only with the permission and direction of your instructor.
10. For safety reasons, metal cases of instruments and appliances are usually grounded through the third wire ground. Do not consider any departure from the use of the third wire ground. e.g., "cheater plugs", without the instruction and supervision of your instructor. Failure to know whether or not an instrument case is grounded can lead to hazardous circuit conditions.
11. Tag instruments with badly frayed or broken power leads and deliver them to the shop (189E) for repair. Notify your instructor. Also notify your instructor if equipment is not working correctly.
12. Do not bring food or beverages near the work areas in the labs.
13. Do not attempt chemical or electro-chemical experiments or activities, e.g., printed circuit board etching, without proper supervision, or in areas other than those designated for that purpose.
14. When using equipment with high voltage, e.g., color television circuits, take precautions to guard against radiation, primarily x-rays.
15. Remove metal rings and metal watch bands when working around energized, especially high voltage and current, circuits.
16. Treat high voltages with care to avoid endangering your life or the lives of your lab partners.

## **RULES FOR USE OF EE LABORATORIES**

1. Labs are maintained for use not only by you but also by others. Do not treat equipment as your personal property. It is a resource made available for specific purposes. Whether for class work or for research, be sure that your use of equipment does not diminish its value to others.
2. Some labs are equipped with combination locks to allow authorized people to use those facilities at their convenience. If you are such an authorized person in one or more of these labs, treat that access as a privilege, not a right. Do not disclose the combination to unauthorized persons. Only authorized lab users should enter such rooms. Labs are crowded enough ... don't bring your friends. Labs are places to work and learn, not to socialize.
3. The equipment on lab benches is organized into lab "stations," where each station is properly configured to support the class(es) using that room. Do not reconfigure the lab stations by moving instruments from one station to another, or by taking an instrument from a lab station for use elsewhere. Doing so makes life difficult for the next user of that lab station. If additional equipment is needed for a particular experiment, see your lab TA or research advisor and s/he will either find it for you or show you how to work around its absence.

Some spare instruments are stored in cabinets in the above lab rooms for temporary use within that lab when additional equipment is required. For long-term needs, such as senior project use, please check out instruments from the EE Lab Coordinator. Such instruments will be your responsibility until you personally check them back in to the Lab Coordinator.

4. Be observant and security-minded. You could buy a nice house with the equipment in many of our labs. If you see someone engaged in questionable activities please call 911 from the public telephone in the ground-floor hall of MWAH and report it. False alarms are better than suffering a loss that might seriously impair your educational opportunities.

## COVID-19: CLEANING COMPUTERS AND ELECTRONICS FOR ALL USERS

The following information provides guidance on how to clean high-touch electronics. Examples include computers, computer accessories, touchscreen devices, printers and copiers (hereinafter referred to as “electronics”). All electronics in shared and public locations should be frequently cleaned and disinfected. When cleaning electronics, it is important to follow the manufacturer recommendations for specific cleaning requirements. The guidance below was adapted from the CDC: Cleaning & Disinfecting Schools, Apple “How to Clean your Apple Products”, and Microsoft “Clean and Care for your Surface”.

### General cleaning tips

- Use a lint-free cloth, such as a screen wipe or a cloth made from microfiber.
- Avoid excessive wiping and submerging item in cleanser to avoid damage.
- Unplug all external power sources and cables.
- Do not use aerosol sprays, bleach or abrasive cleaners.
- Ensure moisture does not get into any openings to avoid damage.
- Never spray cleaner directly on an item.
- Approved COVID-19 disinfectants safe for computers, accessories and electronics
- Using a Clorox disinfectant wipe or a wipe containing 70% alcohol, gently and carefully wipe the hard, nonporous surface of the item. This includes the display, touchscreen keyboard, mouse and the exterior surface of the item. If you have concerns about the cleaning product being used, please refer to the manufacturer’s recommendations and warning label.
- When using a disinfectant wipe, it is important to follow the contact time found on the label. It may be necessary to use more than one wipe to keep the surface wet for the recommended contact time.
- Do not use fabric or leather surfaces on items, as this can scratch or damage to the items.
- Do not use bleach to disinfect computers and electronics.
- Resources:
  - CDC: Cleaning & Disinfecting Schools
  - Apple: How to Clean your Apple Products
  - Microsoft: Clean and Care for your Surface

## Student Activity and Learning Center (MWAH 102)

### Access

MWAH 102 is intended for EE students and faculty as a venue for studying/research, meetings, and events. Access cards are available through an online form found at [z.umn.edu/eekeylink](http://z.umn.edu/eekeylink). Since these cards are available, the door should not be propped open except during events. Visitors should be accompanied at all times. Please do not abuse the room or its resources. **Please maintain social distance and wear face masks when work in MWAH 102 during the COVID-19 pandemic.**

### Food/Drink

Food and drink are allowed in MWAH 102. This is a privilege that can be taken away, so guidelines must be followed. Students bring their own lunches, and the IEEE provides light refreshments for purchase by students. A refrigerator and microwave are provided for safe storage and preparation of food. The food purchasing is handled on the honor system, so payments must be made in full and on time to prevent the IEEE from losing money in this service. When finished, food scraps and food containers must be removed or disposed of properly. Drinks and foods such as candy, chips, or other packaged snack foods may be disposed of in a bag-lined garbage can. Other foods (i.e. greasy foods) cannot be thrown away with regular garbage. An example would be pizza boxes (even empty). If this food is served at an event, one of the following means of disposal will be used: 1) Make arrangements with Facilities Management for pickup immediately following said event; 2) Bring garbage to a food dumpster (get access from Facilities Mgmt); 3) Take garbage out of the building and away after said event. The university's policy can be found following this link: <http://www.d.umn.edu/ehso/events/serving.html>

### Computers/Equipment

MWAH 102 serves as a departmental personal computer lab, used in several EE courses. The PC's in this room are maintained to support educational activities in course work and beyond. Feel free to use the equipment as needed. However, the equipment is meant for serious work, and such work takes priority over game playing or just "surfing" the Internet. Please be considerate of others and realize that these machines are not your personal workstations. Do not leave your stuff cluttered with programs or data that are of no use to others, and if you are using the computers for frivolous games or other such activities, yield to students who need the computers for course work.

The IEEE will also post procedures for security and file storage.

Be sensitive to the feelings of your colleagues. Inappropriate screen savers or related materials on the computers is strictly prohibited.

MWAH 102 is also a student presentation area, both for developing presentations and for making the presentations to small audiences. All students participate in oral presentations that are part of the senior project or design workshop experience.

In summary, MWAH 102 serves the EE department in many ways. It is a room focused on student activities, whether for presentations, computer use, meetings, or general student gatherings. This is a room designed for you. Please take the responsibility of keeping it neat and orderly so that its use in the above functions is not impeded.

## **PART II: EE CURRICULUM INFORMATION**

<http://www.d.umn.edu/courseinfo/>

## **EE PROGRAM DESCRIPTION**

The electrical engineering B.S.E.E. program combines traditional electrical engineering topics with current computer design and analysis topics. The program is concerned with the theory, design, and application of electrical phenomena and digital computers, including electronic circuits, signal analysis, system design, and computer architecture. The department displays strengths in such diverse areas as electronics, signal processing, electromagnetics, digital computer systems, communications, and controls. Individual faculty members specialize in areas such as VLSI design, microprocessor systems, image processing, automatic control, solid state devices, optoelectronics, nanostructures, medical instrumentation and neural networks. The program balances theoretical and practical experience in electrical engineering through analysis, synthesis, and experimentation, using facilities that include major instructional laboratories and research laboratories.

### **EE MISSION STATEMENT**

The Mission of the Department of Electrical Engineering is to provide high quality education for students through a program that offers challenging hands-on laboratory and design components in conjunction with a thorough foundation in theory, and to equip students with the skills to be life-long major contributors to their profession and society.

### **EE PROGRAM OBJECTIVES AND OUTCOMES**

Using the EE Mission Statement for guidance, the EE Program Educational Objectives are given below (The resultant Outcomes are listed in Table 1).

#### EE Program Educational Objectives

Consistent with the mission of the University, the Duluth campus, and the College, the Electrical Engineering program educational objectives are to produce graduates who will ....

1. Develop a productive career.
2. Advance knowledge in their field through technical innovations and scholarly research.
3. Integrate the imparted ethical foundation, creative purpose, and technical knowledge into responsible citizenship.
4. Contribute to the well-being of their community.
5. Pursue life-long learning.

## EE MAJOR: GENERAL INFORMATION

**Honors Requirements:** To receive department honors upon graduation, students must finish the program with an overall GPA of at least 3.50, satisfactorily complete a research project under the guidance of a faculty member, and convey the results in an oral and written presentation to the department.

**Advising:** EE majors are required to attend one of the group advising sessions held by the department each semester. Registration hold release is based on the attendance of group advising. The department will offer multiple advising sessions with the same coverage to accommodate students' schedules. Topics covered include general registration questions, curriculum updates, elective courses, credits transfer, scholarship information, co-op and internship opportunities, student clubs, etc. Each student will be assigned an individual advisor. In addition to participating group advising, students are strongly encouraged to meet with their individual advisor to further discuss their academic plans/curriculum choices, professional interests, and especially unusual circumstances if any. **Students on probation are required to meet with individual advisor.**

### EE MAJOR - DEGREE REQUIREMENTS (127)

Requirements for the B.S.E.E. in electrical engineering (127 credits) include:

- UMD liberal education requirements - courses listed within the major or minor indicated by \* may be used to fulfill this requirement
- Advanced writing requirement: WRIT 3130 Advanced writing: engineering (3 credits)
- Twenty one EE technical elective credits to achieve breadth and depth in the major
- Enough required math, science, engineering science, engineering design, and writing credits to meet or exceed accreditation requirements

#### Required Courses for the EE Major:

##### *Lower Division (22)*

EE 1001 – Intro. to Electrical Engineering (2)  
EE 1315 - Digital Logic (4)  
EE 2006 - Electrical Circuit Analysis (4)  
EE 2111 - Linear Systems and Signal Analysis (4)  
EE 2212 - Electronics I (4)  
EE 2325 - Microprocessor Systems (4)

##### *Upper Division (36)*

EE 3151 - Control Systems (4)  
EE 3235 - Electronics II (4)  
EE 3445 - Electromagnetic Fields (3)  
EE Technical Electives (21)  
EE 4899 - Senior Design Project I (1)  
and EE 4999 - Senior Design Project II (3)  
Or EE 4951- Design Workshop (4)

#### Required Courses from Other Programs:

##### *Lower Division (40)*

WRIT 1120 - College Writing (3)\*  
Chem 1153 (lect; 4) & Chem 1154 (lab; 1) - General Chemistry I (5)\*

CS 1511 - Computer Science 1 (5)\*  
Math 1296 - Calculus I (5)\*  
Math 1297 - Calculus II (5)  
Math 3280 - Differential Equations (4)  
Phys 2013 (lect; 4) & Phys 2014 (lab; 1) - General Physics I (5)\*  
Phys 2015 (lect; 4) & Phys 2016 (lab; 1) - General Physics II (5)  
Econ 1022 - Principles of Economics: Macro (3)\*  
Or  
Econ 1023 - Principles of Economics: Micro (3)\*

*Upper Division (29)*

Engineering "Breadth" elective (3)<sup>‡</sup>  
WRIT 3130 - Adv Writing: Engineering (3)  
Math 3298 - Calculus III (4)  
Phil 3242 – Values and Technology (3)\*  
Or Phil 3325 Environmental Ethics (3)\*  
Or CS 3111 Computer Ethics (3)\*  
Stat 3611 - Intro to Probability and Statistics (4)  
Lib. Ed. Elective (12)

Liberal education electives (18) must include the following:

- Econ 1022 or Econ 1023
- Writ 1120 and Writ 3130
- Phil 3242 or Phil 3325 or CS 3111
- At least one course from LE - OCL
- At least one course from each of the following categories: LE - SS, LE - H, LE - FA
- At least one course emphasizing GP (Global Perspectives)
- At least one course emphasizing CD (Cultural Diversity in the US)
- At least one course emphasizing S (Sustainability)

Liberal Education (LE) Requirement Abbreviations: Writing & Information Literacy - WL; Oral Communication & Language - OCL; Logic & Quantitative Reasoning - LQR; Natural Sciences - NS; Natural Sciences with lab - NS W/LAB; Social Sciences - SS; Humanities - H; Fine Arts - FA; Global Perspectives - GP; Cultural Diversity in the US - CD; Sustainability - S.

\* Courses that may be used to fulfill UMD liberal education program requirements

<sup>‡</sup> Engineering-outside-EE requirement is met by taking one of the following courses:  
CE 2017, ChE 2001, ChE 2111 or ChE2211, IE 3115, ME 2105.

Final Project: Electrical Engineering students must complete a capstone design project integrating the knowledge from their academic career. This team project must involve the design of hardware or software to meet specifications agreed upon by the student and the faculty project advisor. Oral and written reports are required.

# Electrical Engineering (127 cr)

## 1. Non-Engineering Courses (66 cr)

### A. Required (48)

Chem 1153 – General Chemistry I (4)  
Chem 1154 – General Chemistry Lab I (1)  
CS 1511 – Computer Science I (5)  
Math 1296 – Calculus I (5)  
Math 1297 – Calculus II (5)  
Math 3280 – Differential Equations (4)  
Math 3298 – Calculus III (4)  
Phys 2013 – General Physics I (4)  
Phys 2014 – General Physics Lab I (1)  
Phys 2015 – General Physics II (4)  
Phys 2016 – General Physics Lab II (1)  
Stat 3611 – Probability and Statistics (4)  
Writ 1120 – College Writing (3)  
Writ 3130 – Advanced Writing (3)

### B. Lib Ed Electives (18)

Must meet global perspective, cultural diversity in the US, and sustainability requirements.

- \* 6 credits of Humanities (including Phil 3242 or Phil 3325 or CS 3111)
- \* 6 credits of Social Science (including either Econ 1022 or Econ 1023)
- \* 3 credits of Fine Arts
- \* 3 credits of oral communication

## 2. Engineering Courses (61 cr)

### A. EE Required (37)

EE 1001 – Intro to Electrical Engineering (2)  
EE 1315 – Digital Logic (4)  
EE 2006 – Electric Circuit Analysis (4)  
EE 2111 – Linear Systems and Signal Analysis (4)  
EE 2212 – Electronics I (4)  
EE 2325 – Microprocessor Systems (4)  
EE 3151 – Control Systems (4)  
EE 3235 – Electronics II (4)  
EE 3445 – Electromagnetics (3)  
EE 4899 – Senior Design Project I (1) \*\*  
EE 4999 – Senior Design Project II (3) \*\*

\*\*EE 4951 (4) can replace (EE 4899 + EE 4999)

† For undergraduate students only

\* 5xxx/4xxx dual listed elective courses. Different requirement between 5xxx and 4xxx credit is determined by each course instructor.

### B. EE Electives (21)

Minimum one course from four out of five areas of specialization. The rest of credits can be filled from any five areas.

#### Communications and Signal Processing

EE 5477/4477 – Antennas and Transmission Lines (3)\*  
EE 5479 – Antennas and Transmission Lines Laboratory (1)  
EE 5741 – Digital Signal Processing (3)  
EE 5745 – Medical Imaging (3)  
EE 5765/4765 – Modern Communication (4)\*

#### Controls and Robotics

EE 5151/4151 – Digital Control System Design (3)\*  
EE 5161/4161 – Linear State-Space Control Systems (3)\*  
EE 5351/4351 – Robotics and Mobile Robot Control (3)\*  
EE 5742 – Pattern Recognition/Machine Learning (3)  
EE 5801 – Intro to Neural Networks (3)

#### Power and Energy

EE 4501 – Power Systems (4)  
EE 5501 – Energy Conversion Systems (3)  
EE 5522/4522 – Power Electronics (3)\*  
EE 5533/4533 – Grid-Resiliency, Efficiency & Technology (3)\*

#### Microelectronics and VLSI

EE 4611 – Intro. to Solid State Semiconductors (3)  
EE 5311/4311 – Design of VLSI Circuits (4)\*  
EE 5621/4621 – Microelectronics Technology (3)\*

#### Digital Systems

EE 4305 – Computer Architecture (4)  
EE 4321 – Computer Networks (3)  
EE 4341 – Digital Systems (4)†  
EE 5315 – Multiprocessor Based System Design (3)

#### Group depends on Topic

EE 5995 – Special Topics (1-3)

### C. Non-EE Engineering Electives (3)

Minimum 3 credits from:

CE 2017 – Engineering Mechanics (5)  
CHE 2001 – Intro to Environmental Eng (3)  
CHE 2111 – Material and Energy Balances (3)  
Or CHE 2211 – Material and Energy Balances (4)  
IE 3115 – Operations Research (4)  
ME 2105 – Intro. to Material Science for Engineers (3)

## **DEGREE REQUIREMENTS FOR THE CpE MINOR (36)**

### Computer Engineering (CpE) Minor

#### *Lower Division (32)*

Math 1296 – Calculus I (5)\*  
Math 1297 – Calculus II (5)  
CS 1511 – Computer Science I (5)  
CS 1521 – Computer Science II (5)  
CS 2511 – Software Analysis and Design (4)  
EE 1315 – Digital Logic (4)  
EE 2325 – Microprocessor Systems (4)\*\* Or  
CS 2521 – Computer Organization and Architecture (4)

#### *Upper Division (4)*

EE 4305 – Computer Architecture (4) or CS 4412 Computer Architecture (4)

\* Courses that may be used to fulfill UMD liberal education program requirements

\*\* For computer science majors: CS 2521 - Computer Organization and Architecture (4) may be substituted for EE 2325 Microprocessor Systems (4)

## **DEGREE REQUIREMENTS FOR THE EE MINOR (41-42)**

### Electrical Engineering (EE) Minor

#### *Lower Division (38)*

Math 1296 – Calculus I (5)\*  
Math 1297 – Calculus II (5)  
Math 3280 – Differential Equations (4)  
Phys 2013 – General Physics I (4)  
Phys 2015 – General Physics II (4)  
EE 1315 – Digital Logic (4)  
EE 2006 – Electrical Circuit Analysis (4)  
EE 2111 – Linear Systems and Signal Analysis (4)  
EE 2212 – Electronics I (4)

#### *Upper Division (3-4)*

Choose one course from the following list:

EE 3151 – Control Systems (4)  
EE 3235 – Electronics II (4)  
EE 3445 – Electromagnetic Fields (3)  
EE 4501 – Power Systems (4)  
EE 4611 – Introduction to Solid-State Semiconductors (3)

## REQUIREMENTS FOR THE B.S.E.E.

- (1) Completion of at least of 127 degree credits.
- (2) Completion of at least 30 degree credits at UMD.
- (3) Completion of at least 20 of the last 30 credits earned before graduation at UMD.
- (4) Completion of the electrical engineering major. A minimum GPA of 2.0 in all work attempted at UMD, successful completion (with grades of A through D, or S) of all lower division courses listed on page 14, and a minimum GPA of 2.0 overall (including transfer credits) are required for admission to the EE upper division program.
- (5) Completion of UMD and ABET liberal education requirements. Liberal education elective choices must include the following:
  - Econ 1022 or Econ 1023
  - Writ 1120 and Writ 3130
  - Phil 3242 or Phil 3325 or CS 3111
  - At least one course from LE - OCL
  - At least one course from each of the following categories: LE - SS, LE - H, LE - FA
  - At least one course emphasizing LE - GP
  - At least one course emphasizing LE - CD
  - At least one course emphasizing LE – S
- (6) A minimum GPA of 2.00 in all courses taken in the major including required supporting courses is required for graduation. This average applies to all courses in the major taken at UMD and calculated separately and also to all courses in the major when transfer credits are included.
- (7) Completion of the Electrical Engineering “Exit Survey”, and a one-to-one exit interview with the EE Department Head.
- (8) Compliance with the general regulations governing the granting of degrees.

## ELECTRICAL ENGINEERING

### Typical Program of Undergraduate Study

*Fall sester*

*Spring Semester*

**First Year**

|                            |          |                                  |          |
|----------------------------|----------|----------------------------------|----------|
| MATH 1296-CALCULUS I       | 5        | MATH 1297-CALCULUS II            | 5        |
| EE 1001-INTRO TO EE        | 2        | EE 1315-DIGITAL LOGIC            | 4        |
| WRIT 1120 COLLEGE WRITING  | 3        | PHYS 2013/2014-GENERAL PHYSICS I | 5        |
| CS 1511-COMPUTER SCIENCE I | <u>5</u> | ECON 1023 -PRIN. OF ECON: MICRO  | <u>3</u> |
|                            | 15       |                                  | 17       |

**Second Year**

|                                      |          |                                    |          |
|--------------------------------------|----------|------------------------------------|----------|
| MATH 3280-DIFF EQUATIONS LIN ALGEBRA | 4        | MATH 3298-CALCULUS III             | 4        |
| EE 2006-ELEC CIRCUIT ANALYSIS        | 4        | CHEM 1153/1154 GENERAL CHEMISTRY I | 5        |
| EE 2325-MICROPROCESSOR SYS           | 4        | EE 2111-LIN SYSTEMS & SIGNALS      | 4        |
| PHYS 2015/2016-GENERAL PHYSICS II    | <u>5</u> | EE 2212-ELECTRONICS I              | <u>4</u> |
|                                      | 17       |                                    | 17       |

**Third Year**

|                               |          |                              |          |
|-------------------------------|----------|------------------------------|----------|
| EE 3151-CONTROL SYSTEMS       | 4        | EE TECHNICAL ELECTIVE        | 3        |
| EE 3235-ELECTRONICS II        | 4        | EE TECHNICAL ELECTIVE        | 3        |
| EE 3445-ELECTROMAGNETICS      | 3        | EE TECHNICAL ELECTIVE        | 3        |
| STAT 3611-INTRO TO STATISTICS | 4        | LIB ED ELECTIVE <sup>1</sup> | 3        |
| LIB ED ELECTIVE <sup>1</sup>  | <u>3</u> | WRIT 3130 ADV WRITING – ENGR | <u>3</u> |
|                               | 18       |                              | 15       |

**Fourth Year**

|  |          |   |          |
|--|----------|---|----------|
| EE 4899-SENIOR DESIGN PROJECT I <sup>2</sup> | 1        | EE 4999-SENIOR DESIGN PROJECT II <sup>2</sup> | 3        |
| EE TECHNICAL ELECTIVE                        | 3        | EE TECHNICAL ELECTIVE                         | 3        |
| PHIL 3242 or PHIL 3325 or CS 3111            | 3        | EE TECHNICAL ELECTIVE                         | 3        |
| ENGINEERING “BREADTH” ELECTIVE <sup>3</sup>  | 3        | EE TECHNICAL ELECTIVE                         | 3        |
| LIB ED ELECTIVE <sup>1</sup>                 | <u>3</u> | LIB ED ELECTIVE <sup>1</sup>                  | <u>3</u> |
|  | 13       |   | 15       |

1. Lib Ed electives (plus [Phil 3242 or Phil 3325 or CS 3111], [Econ 1022 or Econ 1023], Writ 1120 and Writ 3130) must include the following:

- At least one course from LE - OCL
- At least one course from each of the following categories: LE - SS, LE - H, LE - FA
- At least one course emphasizing LE - GP
- At least one course emphasizing LE - CD
- At least one course emphasizing LE – S

2. EE 4951-Design Workshop may be taken in place of EE 4899 and EE 4999

3. Engineering “Breadth” elective must include one course from the following list: CE 2017, ChE 2001, ChE 2111/ChE2211, IE 3115, ME 2105.

**NOTE** Liberal Education (LE) Requirement Abbreviations: Writing & Information Literacy - WL; Oral Communication & Language - OCL; Logic & Quantitative Reasoning - LQR; Natural Sciences - NS; Natural Sciences with lab - NS W/LAB; Social Sciences - SS; Humanities - H; Fine Arts - FA; Global Perspectives - GP; Cultural Diversity in the US - CD; Sustainability - S.

## ELECTRICAL ENGINEERING UNDERGRADUATE COURSES

KEY TO SYMBOLS: § = Credit will not be granted if credit has been received for the course listed after this symbol  
¶ = Concurrent registration is allowed in the course listed after this symbol  
# = Consent of the instructor is required for registration  
  
□ = Consent of the department is required for registration

### EE 1001. INTRODUCTION TO ELECTRICAL ENGINEERING.

(2 cr; prereq Pre-engr, ChE, CS, EE, IE majors only; A-F only)

Definition and description of electrical and computer engineering. Digital and analog systems. Electrical and computer engineering lab equipment and software. Selected specialties. (2 hrs lect)

### EE 1315. DIGITAL LOGIC.

(4 cr; prereq Pre-engr, ChE, CS, EE, IE majors only; A-F only)

Binary number system and digital coding techniques. Boolean algebra, combinational logic circuits, and minimization techniques. Synchronous sequential circuits and state reduction techniques. Medium Scale Integration (MSI) combinational components. (3 hrs lect, 3 hrs lab)

### EE 2006. ELECTRICAL CIRCUIT ANALYSIS.

(4 cr; prereq ¶Math 3280, ¶Phys 2012; A-F only)

Basic circuit analysis: resistive circuits, voltage and current sources - independent and dependent. Nodal and mesh analysis. Network theorems. Energy storage elements. RC, RL, and RLC transient and steady state analysis, phasors. SPICE analysis. (3 hrs lect, 3 hrs lab)

### EE 2111. LINEAR SYSTEMS AND SIGNAL ANALYSIS.

(4 cr; prereq 2006; A-F only)

Signal and system modeling concepts, system analysis in time domain, Fourier series and Fourier transform. Discrete time domain signals and systems, Z transform, applications. (3 hrs lect, 3 hrs lab)

### EE 2212. ELECTRONICS I.

(4 cr; prereq 2006; A-F only)

Diodes, BJTs, FETs, ideal operational amplifiers, DC analysis, small signal models and analysis; single-stage circuits design; power amplifiers. (3 hrs lect, 3 hrs lab)

### EE 2325. MICROPROCESSOR SYSTEMS.

(4 cr; prereq 1315; A-F only)

Microcomputer components. Instruction set, machine and assembly language programming. Addressing modes. Signed/unsigned arithmetic. Stack uses. Assembly-level translation of high level language constructions. Input/Output interfacing. Interrupt programming. Microcomputer system hardware. (3 hrs lect, 3 hrs lab)

### EE 3151. CONTROL SYSTEMS.

(4 cr; prereq 2111; A-F only)

System mathematical modeling: differential equations, Laplace transform, block diagrams, signal flow graphs. System performance characteristics: time response, sensitivity, steady-state error. Stability analysis: Routh-Hurwitz, root locus and Nyquist. State variables. Compensation design, software tools. (3 hrs lect, 3 hrs lab)

### EE 3235. ELECTRONICS II.

(4 cr; prereq 2212; A-F only)

Multistage circuits, frequency analysis, non-ideal operational amplifiers, feedback and stability, oscillators, filters. (3 hrs lect, 3 hrs lab)

### EE 3445. ELECTROMAGNETIC FIELDS.

(3 cr; prereq Math 3280, Math 3298, Phys 2012; A-F only)

Fundamentals of electromagnetic analysis. Electrostatic and Magnetostatic fields. Introductory numerical analysis of electromagnetic fields. Time-varying fields and potentials. Maxwell's equations and their applications. (3 hrs lect)

## EE ELECTIVES

### EE 4305. COMPUTER ARCHITECTURE.

(4 cr; prereq 2325; A-F only)

Advanced assembly language programming techniques. Memory design principles. Virtual memory. Cache memory. Processor design. Pipelined

and Reduced Instruction Set Computers (RISC). Advanced microprocessor features. (3 hrs lect, 3 hrs lab)

EE 4321. COMPUTER NETWORKS.

(3 cr; prereq 3341, Stat 3611; A-F only)

Network classification and services. Protocol and communication architectures. Hardware components: multiplexers, concentrators, bridges, routers, access servers. (3 hrs lect)

EE 4341. DIGITAL SYSTEMS.

(4 cr; prereq 2325; A-F only)

Digital logic family characteristics. Medium Scale Integration (MSI) components and applications. Programmable Logic Devices (PLDs). Alternative clocking techniques. Computer arithmetic circuits and memory design. Fundamental mode asynchronous finite-state machine design. (3 hrs lect, 3 hrs lab)

EE 4501. POWER SYSTEMS.

(4 cr; prereq 2006; no Grad School credit; A-F only)

Fundamentals of rotating machines: DC, synchronous, and induction machines. Transformers. Power system representation. Transmission lines. Power system analysis: stability and dynamic performance. Balanced and unbalanced faults. Power system protection. (3 hrs lect, 3 hrs lab)

EE 4611. INTRODUCTION TO SOLID STATE SEMICONDUCTORS.

(3 cr; prereq Phys 2012; A-F only)

Fundamentals of solid-state semiconductors and devices. Quantum mechanical concepts and atomic states, solid state structure, band structure, semiconductor statistics, and transport. (3 hrs lect)

EE 4896. CO-OP IN ELECTRICAL ENGINEERING

(1 cr; BSEE or MSEE standing in Electrical Engineering, or department consent; S-N only)

Career-related work experience with employer closely associated with student's academic area. Students must have department approval for the course prior to starting the Co-Op or the internship. Midterm status report and final written report with employer survey must be submitted to the EE department. This course cannot be counted towards EE degree requirements or EE technical electives.

EE 4899. SENIOR DESIGN PROJECT I.

(1 cr; prereq §4951; 3341, BSEE candidate, #; no Grad School credit; A-F only)

Selection and completion of team project approved and supervised by faculty. (See also EE 4999.)

EE 4951. SENIOR DESIGN WORKSHOP.

(4 cr; ¶ WRIT 3130; §4899, §4999; Comp 3130, BSEE candidate, #; no Grad School credit; A-F only)

Study of a selected topic; its application to a design project, completed in a small group. Focuses on a different method each semester offered. Completion satisfies the requirement for a senior design project.

EE 4991. INDEPENDENT STUDY.

(1-3 cr; prereq #; does not qualify as EE technical elective; A-F only)

Special projects not available in regular curriculum. Independent investigation, research studies, or survey of selected projects or problems.

EE 4999. SENIOR DESIGN PROJECT II.

(3 cr; ¶ WRIT 3130; §4951; 4899, BSEE candidate, #; no Grad School credit; A-F only)

Students present senior design project results in formal written and oral reports after making refinements. Complete documentation of results in professional manner required. Results must be presented in an oral report with other senior project team members. EE 4899 and EE 4999 must be completed within one year for credit.

EE 5151/4151. DIGITAL CONTROL SYSTEM DESIGN.

(3.0 cr; prereq 3151, 3341, § 4151; A-F only)

Digital control system characteristics: transient and steady-state responses, frequency response, stability. Digital control system design using transform techniques. Controllability and observability. Design of digital control systems using state-space methods: pole placement and observer design, multivariable optimal control. Implementation issues in digital control.

EE 5161/4161. LINEAR STATE-SPACE CONTROL SYSTEMS.

(3.0 cr; prereq 3151; A-F only)

State space representations of control systems and analysis and design. Stability, controllability, observability, realizations, state estimator or observer design and state feedback design.

EE 5311/4311. DESIGN OF VERY LARGE-SCALE INTEGRATED CIRCUITS.

(4 cr; prereq 3235, 3341 or #; A-F only)

Philosophy of and techniques for designing VLSI circuits in CMOS technology. Full- and semi-custom design techniques. Digital, analog, and hybrid CMOS circuits and systems. Substantial design project required. (3 hrs lect)

EE 5315. MULTIPROCESSOR-BASED SYSTEM DESIGN.

(3.0 cr; prereq 4305, § 4315 ; A-F only)

Parallelism, interconnection networks, shared memory architecture, principles of scalable performance, vector computers, multiprocessors, multicomputers, dataflow architectures, and supercomputers.

EE 5351/4351. INTRODUCTION TO ROBOTICS AND MOBILE ROBOT CONTROL ARCHITECTURES.

(3 cr; prereq 3151; no Grad School credit; A-F only)

Basic concepts and tools for the analysis, design, and control of robotic mechanisms. Topics include basic robot architecture and applications to dynamical systems, mobile mechanisms, kinematics, inverse kinematics, trajectory and motion planning, mobile robots, collision avoidance, and control architectures.

EE 5477/4477. ANTENNAS AND TRANSMISSION LINES.

(3 cr; prereq 3445; A-F only)

Concepts and theory of antennas and transmission lines; emphasis on design and applications. Topics: nonlinear source and loads, cross talk, interconnecting circuits, line characteristics, radiation, measurements. EM propagation, scattering and antenna design techniques. Numerical analysis of wire, aperture, reflector antennas, diffraction theory.

EE 5479. ANTENNAS AND TRANSMISSION LINES LABORATORY.

(1 cr; prereq 5477 or concurrent registration in 5477; A-F only)

This laboratory course provides hands-on experience with designing, constructing, and measuring the performance of radiofrequency (RF) antennas and transmission lines. Concepts include velocity factor, propagation factors, characteristic impedance, tuning stubs and matching sections, resonance, parasitic elements, gain, directivity, return loss, and RF safety. This course supports the theory presented in EE5477 (Antennas and Transmission Lines), and is optional for those enrolled in, or having completed, 5477.

EE 5501. ENERGY CONVERSION SYSTEMS.

(3 cr; prereq Chem 1153/1154; A-F only)

Theory, design and operation of conventional and alternative electrical energy conversion systems. Carbon dioxide cycle, Earth/Sun radiation balance, and environmental impacts. Power delivery systems and integration of conversion systems with the grid. Development of generation portfolios. Impact of energy policies and current energy issues. Case studies.

EE 5522/4522. POWER ELECTRONICS.

(3 cr; prereq 3235; A-F only)

Power semiconductor devices; traditional power converters; ac-dc converters: half-wave and full-wave rectifiers; dc-dc converters: traditional and transformer derived choppers; dc-ac converters: single-phase and three-phase inverters; ac-ac converters; pulse-width modulation; applications

EE 5533/4533 GRID – RESILIENCY, EFFICIENCY AND TECHNOLOGY.

(3 cr; 2006 or permission of instructor; A-F only)

Concepts and architecture of grid, smart grid and microgrid; resiliency under physical and cyber attacks; grid efficiency via sensors, networks and control; technology including standards and protocols for cybersecurity and protection of the grid; case studies and testbeds.

EE 5621/4621. MICROELECTRONICS TECHNOLOGY.

(3 cr; prereq 3235; A-F only)

Various fabrication processes in micro-/nano-scale semiconductor electronic and optoelectronic devices: lithography, oxidation, diffusion, thin film deposition, etching and integration of various technologies; device simulation using COMSOL software; new materials and fabrication technologies.

EE 5741. DIGITAL SIGNAL PROCESSING.

(3.0 cr; prereq 2111, § 4741 ; A-F only)

The fundamentals of two-dimensional signal processing techniques, discrete image analysis, and image quality measures.

EE 5742. PATTERN RECOGNITION AND MACHINE LEARNING.

(4 cr; prereq 2111; A-F only)

Various methods of pattern recognition, non-parametric techniques, linear discriminant functions, support vector machines, statistical classification, minmax procedures, maximum likelihood decisions, case studies.

EE 5745. MEDICAL IMAGING.

(3 cr; prereq 2111; A-F only)

Introduction to the methods and devices for medical imaging, including x-ray imaging, x-ray computed tomography (CT), nuclear medicine (single photon planar imaging, single photon emission computed tomography (SPECT), and positron emission tomography (PET), magnetic resonance imaging (MRI), and ultrasound imaging. The physics and design of systems, typical applications, medical image processing, and tomographic reconstruction.

EE 5765/4765. MODERN COMMUNICATION.

(4 cr; prereq 2111, 3235; A-F only)

Design and analysis of modern communication systems; evaluation of analog and digital modulation techniques. (3 hrs lect, 3 hrs lab)

EE 5801. INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS.

(3.0 cr; prereq CS 1521, Math 3280, Stat 3611 or #,§ 4801 ; A-F only)

General techniques and theory of neural networks, their applications and limitations. The course particularly addresses the design issues and learning algorithms for diverse areas of applications.

EE 5995. SPECIAL TOPICS: (Various titles to be assigned).

(1.0-3.0 cr; 3.0 max cr; prereq #; A-F only)

Current problems and research. Discussions, selected reading, and/or invited speakers.

### **Open to Graduate Students Only**

EE 8001. GRADUATE PROFESSIONAL COMMUNICATION SEMINAR.

(1 cr)

EE 8151. OPTIMAL CONTROL SYSTEMS.

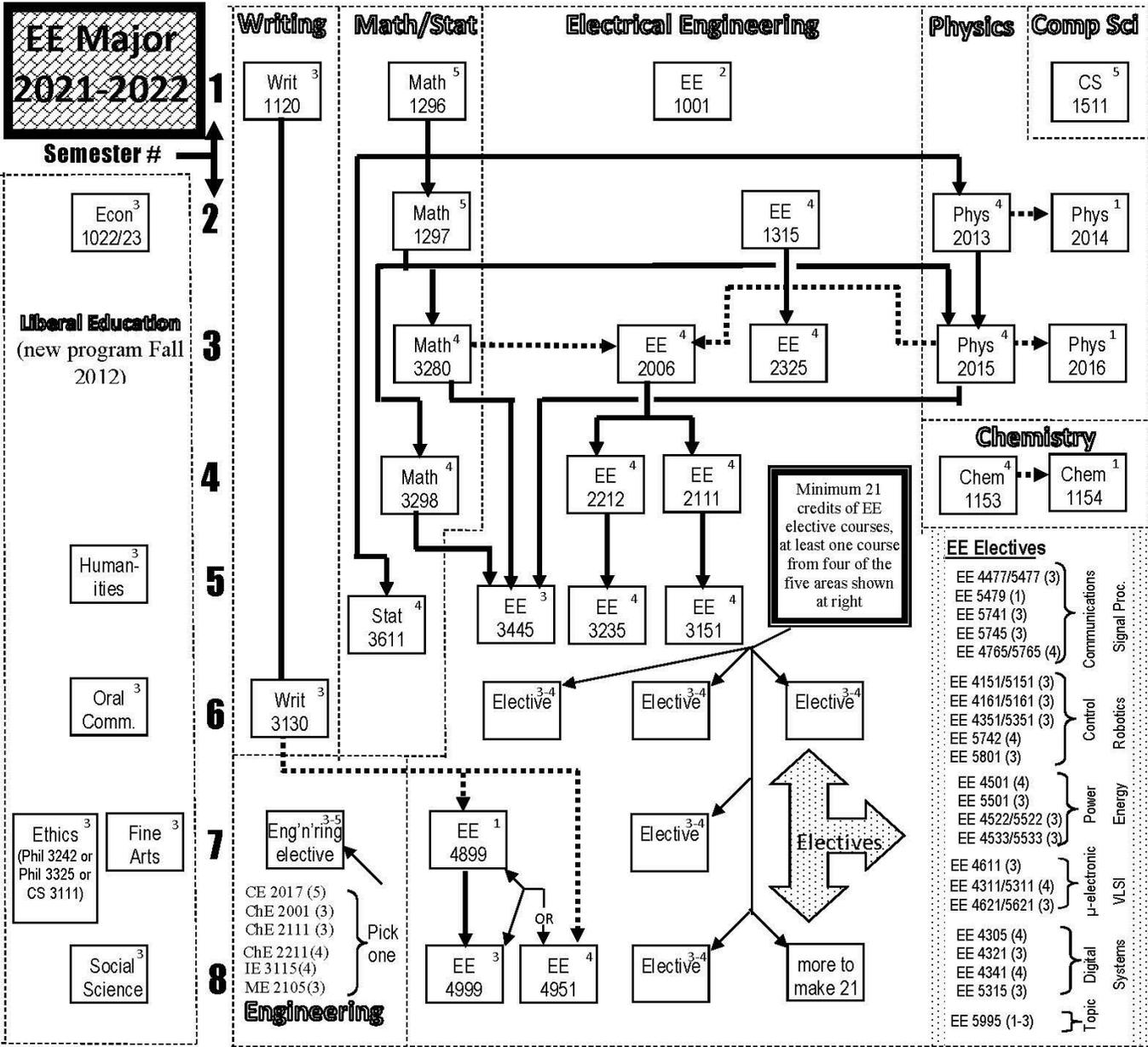
(3 cr; prereq EE 3151, A-F)

EE 8741. DIGITAL IMAGE PROCESSING.

(4 cr; prereq EE 4741, A-F)

EE 8765. DIGITAL COMMUNICATIONS.

(3 cr; prereq 4765, A-F)



Lib. Ed. requirements must include courses covering the following Key Topic issues...

- Global Perspectives (3 cr)
- Cultural Diversity in US (3 cr)
- Environmental Sustainability (3 cr)

Bold arrows indicate prerequisite structure  
Dotted arrows indicate concurrent

**Min 127 cr**

**EE Minor (41-42 cr)**  
Math 1296, 1297, 3280  
Phys 2013, 2015,  
EE 1315, 2006, 2111, 2212  
and one of the following:  
EE 3151, 3235, 3445, 4501, 4611

**CpE Minor (36 cr)**  
Math 1296, 1297  
CS 1511, 1521, 2511  
EE 1315, 2325, 4305  
(CS subs CS 2521 for 2325)

**Energy Minor (40 cr)**  
Math 1296, 1297, 3280; Phys  
2013, 2014, 2015, 2016; EE  
2006, ChE 2111, 2121.6 cr.  
from the following... CE  
5515, ChE 4603, 4612, ME  
4050, 4375 or EE 4501, 5501

**CpE minor** achieved by choosing EE 4305, and adding two extra courses, CS 1521 and 2511

**Energy minor** achieved by choosing EE 4501 and 5501, ChE 2111 and adding one extra course, ChE 2121 or ME 2212

**Math minor** achieved by adding one extra Math/Stat course numbered 3000 or above, except 3411 and 3326

**CS minor** achieved by choosing EE 4341 and 4305, and adding two extra courses, CS 1521 and 2511

**Other minors** can be achieved but require several extra courses  
**Other minors** can be achieved but require several extra courses

# Undergraduate Minor in Energy Engineering

Administered by: The Department of Electrical Engineering

## Description

The objective of this undergraduate Energy Engineering minor is to provide students with basic knowledge and skills needed to understand and address energy and environmental concerns, and to make effective decisions about the production and utilization of energy in engineering applications. It provides high quality education in energy that will prepare students for employment opportunities, graduate studies and research. This interdisciplinary minor administered by the Department of Electrical Engineering is designed for students seeking education for careers in the field of energy or as preparation for graduate work in a wide range of academic disciplines. It is intended for students with majors in engineering. Coursework provides broad-based science and engineering knowledge suited to energy management.

## Degree Requirements

A minimum of 16 credit hours of course work must be completed to meet the requirements for the minor in Energy Engineering. This includes three core courses (10 credits) and at least two elective courses (6 credits minimum).

## Core courses (10 cr.)

### EE 2006 – **Electrical Circuit Analysis**

(4.0 cr; Prereq-Phys 2011, Math 3280; A-F or Aud, fall, spring, every year)

Basic circuit analysis: resistive circuits, voltage and current sources - independent and dependent. Nodal and mesh analysis. Network theorems. Energy storage elements. RC, RL, and RLC transient and steady state analysis, phasors. SPICE analysis.

### ChE 2111– **Material and Energy Balances**

(3.0 cr; Prereq-Chem 1151 or 1161, Math 1296 or 1596 minimum grade of C; fall, spring, every year)

Elementary principles of chemical processes, emphasizing material and energy balances.

### ChE 2121– **Chemical Engineering Thermodynamics**

(3.0 cr; Prereq-2111, (prereq or coreq Math 3280); A-F or Aud, spring, every year)

Application of thermodynamic principles to chemical engineering, emphasizing pressure-volume-temperature relationships, thermodynamic laws, thermochemistry, chemical equilibrium, and phase relationships.  
OR

### ME 2211 – **Thermodynamics**

(3.0 cr; Prereq-Phys 2013; credit will not be granted if already received for ME 3211; A-F or Aud, fall, spring, every year)

Thermodynamics, thermodynamic properties of liquids and gases, 1st and 2nd laws of thermodynamics, irreversibility and entropy. Carnot systems, work producing systems, combustion engine cycles, work absorbing systems, refrigeration cycles, psychrometrics.

## Elective courses (6 cr. minimum)

### CE 5515 – **Sustainable Design and Construction**

(3.0 cr; Prereq-BSCE or BSCE or BSECE or BSIE or BSME or Grad student; A-F or Aud, fall, spring, offered periodically)

Introduction to sustainable design and construction including LEED, materials, construction/transportation/production, life-cycle/service, rating systems, codes, regulations, economical issues and social issues.

### ChE 4603 – **Biorenewable Resources**

(3.0 cr; Prereq-2111 or #; no grad credit; A-F or Aud, spring, even years)

Comprehensive investigation of the engineering systems involved in the sustainable production of fuels, chemicals, and materials from bioresources.

**ChE 4612 – Hazardous Waste Processing Engineering**

(3.0 cr; Prereq-ChE 2111; A-F or Aud, once a year)

Identification of hazardous substances and their effects. Federal and state regulations. Design of waste treatment processes. Management of hazardous wastes. Modification of processes to avoid hazardous waste formation.

**ME 4050/5050 – Fundamentals of Nuclear Engineering**

(3.0 cr; Prereq – Chem 1151, Chem 1154, Phys 2012, Math 3280)

Introduction to the fundamentals of nuclear engineering including atomic and nuclear physics, fission, fusion, isotopes, radioactivity, nuclear reactions, radiation detection, criticality, and reactor kinetics. Overview of types of reactors and some operational considerations.

**ME 4375 - Pipeline Engineering**

(3.0 cr; Prereq-ME 3111 or ChE 3111 or CE 3221; A-F or Aud, spring, offered periodically)

Overview of basic elements of pipeline transportation. Multi-disciplined introduction to concepts and methods of pipeline engineering. Topics include mechanical, electrical and geotechnical design, hydraulics, route selection, materials selection, construction, operation and maintenance.

**EE 4501– Power Systems**

(4.0 cr; Prereq-2006; no Grad School cr; A-F or Aud, spring, every year)

Fundamentals of rotating machines: DC, synchronous, and induction machines. Transformers. Power system representation. Transmission lines. Power system analysis: stability and dynamic performance. Balanced and unbalanced faults. Power system protection.

**EE 5501– Energy Conversion Systems**

(3.0 cr; Prereq – Chem 1153 and Chem 1154; A-F or Aud, fall, every year)

Theory, design and operation of conventional and alternative electrical energy conversion systems. Carbon dioxide cycle, Earth/Sun radiation balance, and environmental impacts. Power delivery systems and integration of conversion systems with the grid. Development of generation portfolios. Impact of energy policies and current energy issues. Case studies.

OR

**ME 5325 – Sustainable Energy Systems**

(3.0 cr; Prereq-3211, BSChE or BSECE or BSIE or BSME candidate, or %; A-F only, spring, even years)

A comparison of different energy systems will be made in terms of economic, environmental and political implications. Specific energy alternatives will include coal, oil, geothermal, bioenergy, solar, wind, fission, fusion, hydrogen, fuel cell.

**EE 5533/4533 GRID – Resiliency, Efficiency and Technology (3 cr; 2006 or permission of instructor; A-F only)**

Concepts and architecture of grid, smart grid and microgrid; resiliency under physical and cyber attacks; grid efficiency via sensors, networks and control; technology including standards and protocols for cybersecurity and protection of the grid; case studies and testbeds.

## MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

The University of Minnesota Duluth (UMD), Department of Electrical Engineering (EE) welcomes applications from students interested in pursuing a graduate degree at the master's level. The EE Department has active research programs in several major research areas that include control systems, communications, signal processing, VLSI and nanoscale optoelectronics and photovoltaics, biomedical engineering digital systems, and intelligent transportation systems.

The MSEE degree combines scholarship and research in a program oriented towards students and engineering practitioners in the private and public sectors who are interested in advanced coursework and applied research. The program requires 31 credits of graduate coursework and research with focus on the departmental faculty's research areas of control systems, communications, signal processing, VLSI, nanoscale optoelectronics and photovoltaics, biomedical engineering, and intelligent transportation systems.

In our department, faculty and students have a close working relationship. We strive for research that balances laboratory and theoretical studies. Although most of the candidates will have completed a bachelor's degree in electrical engineering, computer engineering, or related fields, students in other engineering fields, physics or mathematical sciences are encouraged to apply.

### Requirements

The Master of Science in Electrical Engineering (MSEE) degree requires 31 semester credits. The program offers two degree plans, plan A and plan B. Plan A is research oriented and it requires students to complete a research thesis (10 credits) and additional coursework. Plan B is coursework oriented with a project (1~3 credits) as the research component. For both thesis research and project research, a student is expected to identify a research adviser during the first two semesters in the program. All students are required to take EE8001 (1 credit) course. Plan A: Thesis Option Students must complete a minimum of 31 semester credits including 10 thesis credits and 21 coursework credits. Plan A students must register for 10 thesis (EE 8777) credits, and write and defend a thesis on original research. Students may take up to 6 credits from graduate programs in related fields outside of EE. All courses must be 4xxx or above; a maximum of 6 credits in courses at 4xxx level is allowed, a minimum of 3 credits in courses at 8xxx is required (excluding EE8001 and EE8777). Plan B: Project Option Students must complete a minimum of 31 semester credits including project credits. Plan B students must register for at least 1 project credit (EE 8222), and write and defend a project report. Students may take up to 6 credits from graduate programs in related fields outside of EE. All courses must be 4xxx or above; a maximum of 6 credits in courses at 4xxx level is allowed, a minimum of 3 credits in courses at 8xxx (excluding 8001 and EE8222)

### Goals

The goal of the MSEE program at UMD is to provide EE graduate students and practicing engineers the opportunity to expand their knowledge in the field of electrical engineering. The department is committed to offering research and knowledge development recognizing the importance of collaboration between students and faculty to solve complex engineering problems.

### Admission Requirements

Students wishing to major in Electrical Engineering at the master's level should have completed an undergraduate degree in Electrical, Computer, Electrical and Computer Engineering, or a related discipline, and must meet the general admission requirements of the Graduate School of the University of Minnesota Duluth, namely: a preferred performance level of 3.0/4.0 GPA from an accredited U.S. institution or foreign equivalent, and two letters of recommendation concerning the student's readiness for graduate education, and academic abilities.

For applicants whose native language is not English, the preferred performance level on the TOEFL is a score of at least 213 on the computer-based test. GRE score is not required by EE, but may be provided.

Industrial experience and professional licensure will be considered for admittance to the MSEE program. Previous graduate-level coursework completed after receiving baccalaureate degree may qualify for transfer credit upon recommendation and approval by the MSEE Program's Director of Graduate Studies at [umdee@d.umn.edu](mailto:umdee@d.umn.edu) or (218) 726-6147, or visit the website at [www.d.umn.edu/ee/](http://www.d.umn.edu/ee/)

## MSEE Program Director of Graduate Studies for 2019-2020

Dr. Jiann-Shiou Yang  
Electrical Engineering Department  
University of Minnesota Duluth  
274 MWAH, 1023 University Drive  
Duluth, MN 55812  
Phone: (218) 726-6290  
Email: [jyang@d.umn.edu](mailto:jyang@d.umn.edu)

### Application Deadlines

Applicants are encouraged to apply for admission well in advance of the term in which they wish to enter the Graduate School, but no more than one year in advance of the proposed entry date. The Graduate School application, completed with all required materials, must be submitted by the following deadlines:

- Fall Semester – April 15<sup>th</sup>
- Spring Semester – November 1<sup>st</sup>

### Online Application System

All applications for admission must be submitted online rather than in paper form. Please check the web page [www.d.umn.edu/grad](http://www.d.umn.edu/grad) for details.

### Request Online Resources and information from:

Graduate School  
University of Minnesota Duluth  
420 Darland Administration Building  
Duluth, MN 55812  
Phone: (218) 726-7523  
Email: [grad@d.umn.edu](mailto:grad@d.umn.edu)  
[www.d.umn.edu/grad](http://www.d.umn.edu/grad)

**PART III**  
**MISCELLANEOUS**

## **UNIVERSITY OF MINNESOTA**

### **GRADUATION PLANNER**

<https://onestop2.umn.edu/gradplanner/home.jsp>

Graduation Planner is an interactive planning tool for University of Minnesota students on all campuses. Use Graduation Planner to:

- Explore the requirements for majors and minors
- Discover what courses you need to take, and when you should take them
- Make a plan that will help you stay on track for graduation

Your adviser will be able to review and comment on the plans you create. Be sure to work with your adviser as you plan for your degree. Some majors or programs have application procedures or special requirements, and your adviser is the best source for this information.

### **ACADEMIC PROGRESS AUDIT SYSTEM (APAS) INFORMATION**

The APAS provides reports about undergraduate degree requirements and how your credits transfer to UMD. Generate an APAS report to see what courses are needed and how completed courses fulfill degree those requirements. Generate a “What-if” report for the University of Minnesota Duluth and explore other undergraduate majors and run your Transfer Course Evaluation report.

View APAS report in your MyU, Academics tab, there is a link in the planning section.

Each APAS report indicates how your academic coursework or test credits apply to the Liberal Education and degree requirements for a specific major.

The APAS is what is used to determine if you are eligible to receive your degree, so if there is any difficulties or discrepancies, please contact the EE Department or your advisor for assistance.

# **APPENDIX**

## **A. Relationship of Program Outcomes to Program Educational Objectives**

Accreditation Outcomes include{

1. An ability to apply knowledge of mathematics, science, and engineering, an ability to identify, formulate, and solve engineering problems, and an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
2. An ability to design a system, component, or process to meet desired needs, and an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
3. An ability to communicate effectively in writing and orally
4. An understanding of professional and ethical responsibility, the broad education necessary to understand the impact of engineering solutions in a global and societal context, and a knowledge of contemporary issues
5. An ability to function on multi-disciplinary teams
6. An ability to design and conduct experiments, as well as to analyze and interpret data, and an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
7. A recognition of the need for, and an ability to engage in life-long learning

The five EE Educational Objectives are described in Criterion 2 and are listed below:

1. Develop a productive career.
2. Advance knowledge in their field through technical innovation and scholarly research.
3. Integrate the imparted ethical foundation, creative purpose, and technical knowledge into responsible citizenship.
4. Contribute to the well-being of their community.
5. Pursue life-long learning.

EE Student Outcomes align very well with the EE Educational Objectives. Each of the 7 Outcomes relates to at least one Program Educational Objective:

Objective 1, Develop a productive career, is supported directly by eight Student Outcomes as indicated in the summary shown on the next page. In addition, most of the remaining Outcomes provide at least some indirect support as well. Assessment data associated with Outcomes (1), (2), and (6) provide ample resources for measuring progress in achieving Objective 1.

Objective 2, Advance knowledge in their field through technical innovation and scholarly research, aligns with five Outcomes, (1), (2), (3), (4), and (6).

Objective 3, Integrate the imparted ethical foundation, creative purpose, and technical knowledge into responsible citizenship, is reinforced by Outcomes (1) formulate and solve engineering problems, (4) professional and ethical responsibility and (4) understanding global and societal context.

Objective 4, Contribute to the well-being of their community, is supported by Outcomes (5) multidisciplinary teams, (4) global and societal context and (4) knowledge of contemporary issues.

Objective 5, Pursue life-long learning, is supported by Outcomes (4) understanding global and societal context, and (7) engaging in lifelong learning.

These relationships are summarized below:

**Table 1 Program Objectives and Outcomes**

| <b>Program Educational Objective</b>   | <b>Supporting EE Student Outcomes</b> |
|--|---------------------------------------|
| 1. Develop a productive career   | 1, 2, 6                               |
| 2. Advance knowledge in their field through technical innovation and scholarly research                              | 2, 3, 4, 6                            |
| 3. Integrate the imparted ethical foundation, creative purpose, and technical knowledge into responsible citizenship | 1, 4                                  |
| 4. Contribute to the well-being of their community   | 4, 5                                  |
| 5. Pursue life-long learning   | 4, 7                                  |

A.1 Relationship of Courses in the Curriculum to the Student Outcomes

The EE curriculum has evolved over time, reacting to the forces of change, most notably with the transition from Computer Engineering to Electrical and Computer Engineering and then to Electrical Engineering. Much of the present curriculum was established prior to the adoption of Student Outcomes as an assessment tool. The faculty have identified gaps in the coverage and revised either course content or the curriculum to fulfill this new need. As a result, revisions to curriculum and course content are driven primarily by the process through which Student Outcomes are assessed. Therefore, curriculum and Student outcomes have now come into alignment.

Every required course in the curriculum addresses at least one aspect from multiple Student Outcomes. Table 2 summarizes the relationship between course content in EE Required Courses and the Student Outcomes. Table 3 summarizes the relationship between course content in EE Elective Courses and the Student Outcomes.

**Table 2 EE Course Outcomes – Required Courses**

| <b>STUDENT OUTCOMES</b>                        | <b>1</b> | <b>2</b> | <b>3</b> | <b>4</b> | <b>5</b> | <b>6</b> | <b>7</b> |
|--|----------|----------|----------|----------|----------|----------|----------|
| <u>EE Introduction</u>                         |          |          |          |          |          |          |          |
| EE 1001 Introduction to Electrical Engineering | X        |          |          | X        | X        |          |          |
| <u>EE Digital (with labs)</u>                  |          |          |          |          |          |          |          |
| EE 1315 Digital Logic                          | X        | X        |          |          |          | X        |          |
| EE 2325 Microprocessor Systems                 | X        | X        |          |          |          | X        |          |

|  |   |   |   |   |   |   |   |
|--|---|---|---|---|---|---|---|
| <u>EE Systems (with labs)</u>                              |   |   |   |   |   |   |   |
| EE 2006 Electrical Circuit Analysis                        | X | X |   |   |   | X |   |
| EE 2111 Linear Systems and Signal Analysis                 | X | X |   |   |   | X |   |
| EE 3151 Control Systems                                    | X | X |   |   |   | X |   |
| <u>EE Electronics (with labs)</u>                          |   |   |   |   |   |   |   |
| EE 2212 Electronics I                                      | X | X | X |   |   | X |   |
| EE 3235 Electronics II                                     | X | X | X |   |   | X |   |
| <u>EE Engineering Physics</u>                              |   |   |   |   |   |   |   |
| EE 3445 Electromagnetic Fields                             | X | X |   |   |   |   |   |
| <u>EE Capstone Design (with labs)</u>                      |   |   |   |   |   |   |   |
| EE 4899 Senior Project I                                   | X | X | X | X | X | X | X |
| EE 4951 Design Workshop                                    | X | X | X | X | X | X | X |
| EE 4999 Senior Project II                                  | X | X | X | X | X | X | X |
| <u>Basic Sciences (with labs)</u>                          |   |   |   |   |   |   |   |
| Phys 2013/2014 Mechanics (Physics I)                       | X |   |   |   |   | X |   |
| Phys 2015/2016 Electricity, Magnetism, Optics (Physics II) | X |   |   |   |   | X |   |
| Chem 1153/1154 General Chemistry I                         | X |   |   |   |   | X |   |
| <u>Computer Science</u>                                    |   |   |   |   |   |   |   |
| CS 1511 Computer Science I                                 | X | X |   |   |   | X |   |
| <u>Mathematics/Statistics</u>                              |   |   |   |   |   |   |   |
| Math 1296 Calculus I                                       | X |   |   |   |   |   |   |
| Math 1297 Calculus II                                      | X |   |   |   |   |   |   |
| Math 3280 Differential Equations with Linear Algebra       | X |   |   |   |   |   |   |
| Math 3298 Calculus III                                     | X |   |   |   |   |   |   |
| Stat 3611 Introduction to Probability and Statistics       | X |   |   |   |   |   |   |
| <u>Composition</u>   |   |   |   |   |   |   |   |
| WRIT 1120 College Writing                                  |   |   | X |   |   |   |   |

|   |  |  |   |  |  |  |  |
|---|--|--|---|--|--|--|--|
| WRIT 3130 Advanced Writing- Engineering |  |  | X |  |  |  |  |
|---|--|--|---|--|--|--|--|

**Table 3 EE Student Outcomes by Elective Courses and Optional Student Activities**

| <b>STUDENT OUTCOMES</b>                                | <b>1</b> | <b>2</b> | <b>3</b> | <b>4</b> | <b>5</b> | <b>6</b> | <b>7</b> |
|--|----------|----------|----------|----------|----------|----------|----------|
| <u>Liberal Education Electives<sup>1</sup></u>         |          |          |          |          |          |          |          |
| Econ 1022 Principles of Economics: Macro               |          |          |          | X        |          |          | X        |
| Or Econ 1023 Principles of Economics: Micro            |          |          |          | X        |          |          | X        |
| Phil 3242 Values and Technology <sup>2</sup>           |          |          |          | X        |          |          | X        |
| Or Phil 3325 Environmental Ethics <sup>2</sup>         |          |          |          | X        |          |          | X        |
| Or CS 3111 Computer Ethics <sup>2</sup>                |          |          |          | X        |          |          | X        |
| Category LE - Oral Communication and Languages         |          |          |          | X        |          |          | X        |
| Category LE - Social Sciences                          |          |          |          | X        |          |          | X        |
| Category LE - Humanities                               |          |          |          | X        |          |          | X        |
| Category LE - Fine Arts                                |          |          |          | X        |          |          | X        |
| <u>Engineering Breadth Elective<sup>3</sup></u>        |          |          |          |          |          |          |          |
| CE 2017 Engineering Mechanics                          | X        | X        |          |          |          | X        |          |
| ChE 2001 Introduction to Environmental Engineering     | X        | X        |          |          |          | X        |          |
| ChE 2111 Material and Energy Balance                   | X        | X        |          |          |          | X        |          |
| IE 3115 Operation Research                             | X        | X        |          |          |          | X        |          |
| ME 2105 Introduction to Material Science               | X        | X        |          |          |          | X        |          |
| <u>EE Technical Electives<sup>4,5</sup></u>            |          |          |          |          |          |          |          |
| EE 4305 Computer Architecture                          | X        | X        |          |          |          |          |          |
| EE 4311 Design of Very Large Scale Integrated Circuits | X        | X        |          |          |          |          |          |
| EE 4321 Computer Networks                              | X        |          |          |          |          | X        |          |
| EE 4341 Digital Systems                                | X        | X        |          |          |          |          |          |
| EE 4501 Power Systems                                  | X        | X        |          |          |          |          |          |
| EE 4611 Solid State Semiconductors                     | X        | X        |          |          |          |          |          |
| EE 4781 Telecommunications                             | X        | X        |          |          |          |          |          |
| EE 5211 Advanced Analog IC Circuit Design              | X        | X        |          |          |          |          |          |
| EE 5315 Multiprocessor-Based System                    |          |          |          |          |          |          |          |

|   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|
| Design  | X | X |   |   |   |   |   |
| EE 5351 Robotics and Mobile Robot Control Architectures           | X | X |   |   |   |   |   |
| EE 5477 Antennas and Transmission Lines                           | X | X |   |   |   | X |   |
| EE 5479 Antennas and Transmission Lines Laboratory                | X | X |   | X | X | X |   |
| EE 5501 Energy Conversion Systems                                 |   |   |   | X | X |   |   |
| EE 5522 Power Electronics   | X | X |   |   |   |   |   |
| EE 5611 Microelectronics Technology                               | X | X |   |   |   |   |   |
| EE 5742 Pattern Recognition and Machine Learning                  | X | X |   |   |   |   |   |
| EE 5745 Medical Imaging   | X | X |   |   |   |   |   |
| EE 5765 Modern Communications                                     | X | X |   |   |   |   |   |
| EE 5995 Special Topics<br>... for Applied Math Minor <sup>7</sup> | X | X |   |   |   |   |   |
| EE 5151 Digital Control System Design                             | X | X |   |   |   |   |   |
| EE 5741 Digital Signal Processing                                 | X | X |   |   |   |   |   |
| EE 5801 Introduction to Artificial Neural Networks                | X | X |   |   |   |   |   |
| Professional Society IEEE   |   |   |   | X |   |   | X |
| EE 4896 Co-Op in EE (Internships)                                 | X | X | X | X | X | X | X |
| UROP and Undergraduate Research                                   | X | X | X | X | X | X | X |

1. Liberal education electives chosen to meet UMD campus requirements.
2. Effective Fall 2014, EE students can take one of the following three courses to fulfill this requirement: Phil 3242 Values and Technology, Phil 3325 Environmental Ethics, CS 3111 Computer Ethics
3. Engineering breadth elective (3 credits): choose one of the specified five courses.
4. EE technical electives (21 credits): Electives may not include EE 4899, 4951, or 4999.
5. 5XXX courses are open to both undergraduate and graduate students.
6. Course outcomes vary with the topics offered.
7. Effective Spring 2008, the “Applied Mathematics” Minor no longer exists. EE students need to take one additional 3xxx level\* (or above) mathematics course to earn a “Mathematics” Minor.

\* Math 3411 and Math 3326 do not count for a “Mathematics” Minor

