Master of Science in Electrical Engineering Graduate Program:

A student may pursue a Master of Science in Electrical Engineering (M.Sc. EE) via one of the following three options: (i) M.Sc. with thesis, (ii) an accelerated M.Sc. (for SDSMT undergrad only), or (iii) a M.Sc. non-thesis (a course work only) degree. The student must focus within one of the following discipline focus areas, as well as complete the specified requirements for the chosen degree option given below.

- Applied Electromagnetics
- Controls and Autonomous Robotics Systems (CARS)
- Power Systems and Power Electronics
- Communications and Networking

The courses for each area of focus are listed in Section G. Section A describes the detailed requirements for each of the M.Sc. EE degree options offered by the Electrical and Computer Engineering Department. Sections B-F describe additional department requirements, policies and capabilities.

A. Degree Options:

(I) M.Sc. EE with Thesis:

The thesis M.Sc. EE degree consists of a program of graduate course work and thesis research. Candidature for the M.Sc. EE degree with thesis is contingent on an aptitude to do research and/or development. A limited number of students are accepted into the M.Sc. EE thesis option, on the recommendation of a major professor. Teaching and research assistantships are normally reserved for thesis students. Upon commencement of this program, transfer from a M.Sc. EE thesis degree program to a non-thesis degree would require additional approvals from the student's existing major professor and department head, and usually is not granted.

The requirements for the M.Sc. EE thesis degree are as follows:

1. A program of at least 30 credit hours of course work and research approved by the student's major advisor and committee.
2. No more then 15 credit hours (included in the 30 credits required for graduation) can be taken at the 500 level (i.e. additional classes should be taken at the 600 level or above).
3. At least 6 credit hours, but no more then 9 credit hours, of thesis research may be included in the 30 credits required for graduation.
4. A satisfactory thesis based upon individual research and development.
5. Meeting or exceeding prescribed ECE and graduate program academic standards.
6. Successfully defending one's thesis.

An example **M.Sc. EE with thesis** program of study would be:

4	courses within focus area, from the set specified in section G.
2	courses outside one's focus area but within the discipline of Electrical and Computer Engineering– also specified in section G.
2	courses outside of the discipline of Electrical and Computer Engineering.
6-9	credits of thesis research, EE 798

(II) M.Sc. EE Accelerated option (SDSMT undergrads only):

The accelerated M.Sc. EE degree consists of a program of graduate course work and a significant engineering project resulting in a project report and/or a peer-reviewed conference or journal paper. This degree is meant as an honors type of degree available to SDSMT students in good standing at the beginning of their junior year, i.e., a student with a GPA 3.0 or above within ECE related course work. Students desiring to be a part of the program need to apply to the M.Sc. EE graduate program at the beginning of their junior year and be accepted into the M.Sc. EE Accelerated option graduate program. The student must also be accepted into a focus track before taking any classes counted towards their master degree, i.e. obtain a major professor that will mentor their project research within a focus track. These degree students are normally not supported by the department via teaching or research assistantships. However, as an undergraduate student they may qualify for any available undergraduate scholarships. **It is encouraged that the student align their senior project with their graduate research project.** The degree is designed to allow the student to complete both their B.Sc. EE or B.Sc. CENG, and their M.Sc. EE within a five-year time frame. The student's engineering project is meant to be completed during the summer between the senior and graduate year and/or the summer just after their graduate year, if needed. Students in this program are assumed to be able to complete their B.Sc. and M.Sc. degree requirement in 5 years.

The requirements for the M.Sc. EE accelerated degree are as follows:

1. A program consisting of at least 32 credit hours of course work is required for this degree approved by the student's major advisor and the M.Sc. EE Graduate Coordinator (or designee). A student must apply and be admitted into a track at the beginning of their junior year before taking any of their "double counted" courses (specified below) towards the M.Sc. degree. Furthermore, the student must complete one of the following focus area tracks to be eligible for this degree. Courses taken within a focus area track (specified below) are considered "double counted" and apply towards both BS and MS degree program requirements. By completing a track, the 10 credits taken within the track as an undergraduate will then be applied towards both the undergraduate degree as well as their graduate degree. The tracks are listed below:

Applied Electromagnetics Track Required Courses:

EE 581/581L	4(3-1)	Microwave Engineering
EE 583/583L	4(3-1)	Antennas for Wireless Communications
EE 465	2	Senior Design II topic selected should have some Applied EM component (not necessarily focused 100% on Applied EM). Counts towards EE 788 and EE 798 5 credit limit within degree.

Controls and Autonomous Robotics Systems Track Required Courses:

EE 553/553L	4(3-1)	Control Systems
EE 655 (was 551)	3	Linear Systems Theory
CENG 514	3	Introduction to Computer Vision

Power Systems and Power Electronics Track Required Courses:

EE 531	3(1*)	Power Systems
EE 547	3	Advanced Power Systems
EE 532/532L	4(3-1)	Power Electronics

Communications and Networking Track Required Courses:

CENG 544/544L	3(1*)	Computer Networks
EE 521/521L	4(3-1)	Communication Systems
EE 626	3	Wireless Communications

(* Lab credit not double counted)

2. In addition to completing one of the focus area tracks above, the candidate's program of study must include the following four "common" courses:

EE 655 (was 551)	3**	Linear Systems Theory
EE 626	3	Wireless Communications
EE 680 (was 580)	3**	Engineering Electromagnetics
EE 531*	3	Power Systems

*** Lab section not taken.**
**** Planned curriculum change requests.**

3. At least 4 credit hours of project research must be part of the candidate's program of study, i.e. EE 788 - Master's Research Problems/Projects. (No more than 5 credit hours of project research may be applied to the degree requirements. This limit includes any EE 465 credits that are double counted.) These credits are generally taken during the summer between the senior year and graduate year as well as the summer following the graduate year.

4. **A student must prepare, submit, and have accepted a completed project report and/or have an accepted peer-reviewed conference article based upon the individual's research and development contributions under the direction and collaboration of their major professor, with their major professor's approval.**

5. No more then 16 credit hours (included in the 32 credits required for graduation) can be taken at the 500 level (i.e., additional classes should be take at the 600 level or above).
6. No more then 9 credits may be taken from outside the ECE department and count towards the 32 credits to graduate.

7. The student must meet or exceed the prescribed academic standards by the department and the graduate school.

An example **M.Sc. EE accelerated** program of study would be:

3	courses within a focus area track (double counted)
2	additional courses within a focus area (from the set specified in section G)
4	courses from the "common" courses prescribed above (one of these might be double counted within the focus track).
1	course outside of the discipline of Electrical and Computer Engineering 4-5

credits of EE 788 - Master's Research Problems/Projects
(includes any double counted EE 465 credits taken as part of a track above)

(III) M.Sc. EE with Non-Thesis option:

The non-thesis M.Sc. EE degree consists of a program of graduate course work. A project and/or research are not required and are normally discouraged for the M.Sc. EE non-thesis option. These degree students are normally not supported by the department via teaching or research assistantships.

The requirements for the M.Sc. EE non-thesis degree are as follows:

1. A program of at least 32 credit hours of course work approved by the M.Sc. EE's graduate coordinator (or designee), which <u>must include</u> the following four "common" courses, is required:

EE 655 (was 551)	3**	Linear Systems Theory
EE 626	3	Wireless Communications
EE 680 (was 580)	3**	Engineering Electromagnetics
EE 531*	3	Power Systems

*** Lab section not taken.**
**** Planned curriculum change requests.**

2. In addition to the required common courses, the candidate's program of study must focus within the field of electrical engineering by including a depth of at least four courses within a focus area listed in section G (as in the accelerated program).
3. No more then 16 credit hours (included in the 32 credits required for graduation) can be taken at the 500 level (i.e., additional classes should be take at the 600 level or above).
4. No more than 12 credits may be taken from outside the ECE department and count towards the 32 credits to graduate.
5. No more than 3 credits of EE 788, Master's Research Problems/Projects, may be counted towards the 32 credits to graduate.
6. Meeting or exceeding prescribed academic standards by the department and the graduate school.

An example **M.Sc. EE non-thesis** program of study would be:

4	common courses specified above in requirement 1
3	courses within a focus area track in addition to the common courses as given above, specified in section G
2	courses outside one's focus area (as specified in section G) but within the discipline, of Electrical and Computer Engineering
2	courses outside of the discipline of Electrical and Computer Engineering

B. Language Requirements:

1. Students whose native language is not English are generally required to take the Test of

English as a Foreign Language Test (TOEFL).

2. Graduate students with a TOEFL score below 560 are required to attend a remedial course in English.
3. Meeting or exceeding prescribed academic standards in English composition and oral presentations.

C. Graduate Credit Taken as an Undergraduate

Undergraduate students taking 600 level graduate courses and petitioning these courses for graduate credit should realize that application of these credits to the program of study is subject to the approval of the student's graduate committee. A student's graduate program will come under the control of the graduate committee at the time the student is accepted into the graduate program.

D. Graduate Committee and Program of Study

The ECE Graduate Committee is the graduate committee for all M.Sc. EE non-thesis degree students, with the ECE Graduate Coordinator or designee serving as the advisor. M.Sc. EE thesis and accelerated students must form a graduate committee with a major professor who has agreed to supervise the research/project of the student. In both cases, the student must arrange to have a faculty member external to the Department of Electrical and Computer Engineering serve on their committee.

Each student must submit a program of study to the candidate's graduate committee by the end of the first semester of study within their program. Approval of the program of study is necessary in order to register for the second and subsequent semesters.

The student's graduate committee has the right to disallow any course proposed in the student's program of study that they feel is not appropriate for a graduate degree in electrical engineering.

E. ECE Faculty Research Areas and Resources

The M.Sc. EE degree offers emphases in the areas of applied electromagnetics, antennas, and microwave, power systems and power electronics, robotics and autonomous systems, communications and networking. In addition to the more discipline-specific equipment listed below, the ECE department has well-equipped laboratories of networked PCs, general purpose test and measurement equipment such as high-speed oscilloscopes, arbitrary function generators, logic analyzers, and printed circuit board prototyping machines and software.

Research activities in the Applied Electromagnetics area include:

- *Electromagnetic materials* (development of accurate and novel materials characterization methods; artificial materials analysis, design, fabrication, and measurement; materials with tailorable properties).
- *Antennas* (electrically small antennas; miniaturization of ultrawideband antennas; reconfigurable / autonomous robotic antennas and antenna arrays; novel antenna reconfiguration methods and phase-change materials; "green" antennas on paper for

security applications; resistively loaded antennas; wideband, coplanar and flexible antennas; metamaterial-inspired antennas).

- *Artificial electromagnetic surfaces* (high impedance and textured surfaces).
- *Microwaves* (Design of passive microwave components and baluns; applications of metamaterial-inspired designs for microwave components and antennas from MHz to THz).
- *Direct-write manufacturing of electromagnetic devices* (antennas and microwave frequency devices; MEMS).

Resources in support of this program include an anechoic chamber, many vector network analyzers, a number of electromagnetic materials characterization systems, impedance analyzers, fast rise time pulse generators and detectors, Agilent Advanced Design System, Microwave Studio, and IE3D. In addition, the Steven P. Miller Endowed Chair in electrical engineering was established in 2001 to support telecommunications in the ECE department.

Research activities in the area of controls, and autonomous robotics systems (CARS) include: unmanned systems, autonomous systems, robotics, machine control, fuzzy logic control, nonlinear and adaptive control, visual servo-ing, system identification, fault analysis, modeling of power systems, power systems stability, generator dynamics, and wind power. In addition, a number of robotics and controls projects are performed in association with the School of Mines Center of Excellence in Advanced Manufacturing and Production (CAMP) and Advanced Material Processing Center (AMP). Resources in support of this program include logic analyzers, a variety of microcontroller and microprocessor development systems, FPGA and CPLD prototyping boards, VHDL and Verilog compilers, Analog Devices DSP development tools, Mentor Graphics Computer Aided Design Toolset, Matlab/Simulink embedded coding tool sets, Kiel complier tool chains, and printed circuit board manufacturing equipment.

Research activities in the area of power systems and power electronics include: the design, analysis and modeling of power system, control and protection of power transmission and distribution grids, electric machines and motor drives, design and control of power electronics converters based on semiconductor switching devices (Si, SiC, and GaN), integration of renewable energy resources (wind, solar, fuel-cell, etc.), and applied power electronics devices in power systems. Resources in support of this program include high-voltage dc power supply, DSpace board with toolbox embedded in Matlab for hardware-in-loop experiment, electric machines, DSP control boards, power modules, various relays, and many other related equipments, tools, and software for lab research.

Research activities in the area of communications and networking include problems in the physical layer, MAC, and networking layers, coding and modulation, flow and congestion control; mathematical and simulation techniques for the analysis of networks and communications systems; protocol design, performance evaluation and experimental implementation for wireless networking including cognitive radio networks, vehicular networks, wireless autonomous networks; optical and other technologies.

F. Additional ECE Graduate Policies:

1. Non-US Admissions:

WES (or similar) translation of foreign transcripts is required for regular admissions within the M.Sc. EE applications.

2. Regular Admissions:

   Engineering graduates from an accredited US or Canada ABET-accredited school are required to have a minimum GPA of 3.0 on a 4.0 scale (i.e., a B average is required). Likewise, international students are required to have a minimum equivalent GPA of 3.0 on a 4.0 scale. Moreover, students from a non-ABET-accredited US Canada school or from an international school are additionally required to have a minimum score of 50% on the Quantitative Reasoning section of the GRE test.

   In addition, to the minimums listed above, all students must submit a statement of purpose discussing why they wish to obtain a masters degree in electrical engineering at SDSMT. They must also submit three letters of reference in support of their pursuit of a graduate degree at SDSMT.

3. Probationary Admission:

   A student not meeting the minimum requirements for regular admissions can be admitted under a probationary status with a minimum GPA of 2.75 on a scale of 4.0 given the additional requirements that a department faculty member agrees to serve as the students advisor. The student is then converted to a non-probationary student after passing, with a B average, at least 9 credits of approved M.Sc. EE program of study courses while attending SDSMT.

4. Probationary Status:

   A student may continue their studies within the M.Sc. EE program at SDSMT while on probation for up to 2 semesters, if the student has not cleared up the issues that placed them in probation at the end of the second semester on probation the student will be required to end their graduate work in the M.Sc. EE program at SDSMT at that time.

5. GPA Graduation Policy:

   In order to be eligible to graduate from the M.Sc. EE graduate program a student must obtain at least a 3.0 GPA on SDSMT's 4.0 GPA scale within the classes listed on their approved program of study, i.e. the student must have a program of study GPA of B or better for graduation.

G. M.Sc. EE classes organized by areas of focus:

Students should select their program of study classes from the list below with consultation and approval by their major advisor and/or committee or by the M.Sc. EE graduate program coordinator (or his designee) (depending on the degree option being sought). Classes not from this list maybe approved on a case-by-case basis by a student's advisor and/or committee or by the M.Sc. EE graduate program coordinator (or his designee) (depending on the degree option being sought).

Course Code	Credits (Lect-Lab)	Course Title
Applied Electromagnetics focus area courses:		
EE 581/581L	4(3-1)	Microwave Engineering
EE 583/583L	4(3-1)	Antennas for Wireless Communications
EE 680 (was 580)*	3	Engineering Electromagnetics
EE 792	3	Topics: Advanced Antenna Engineering
EE 792	3	Topics: Computational Electromagnetics
EE 792	3	Topics: Advanced Microwave Engineering
EE 792	3	Topics: Finite Difference Time Domain
EE 792	3	Topics: Guided Waves and Material Measurements
Controls and Autonomous Robotics Systems (CARS) focus area courses:		
EE 553/553L	4(3-1)	Control Systems
EE 556/556L	4(3-1)	Digital Control Systems
CENG 514	3	Introduction to Computer Vision
EE 655 (was 551)*	3	Linear Systems Theory
EE 757 (was 557)*	3	Intelligent Control Systems
EE 623	3	Random Signals and Noise
EE 641	3	Digital Systems Design
EE 643	3	Advanced Digital Systems
EE 751 (was 651)*	3	Advanced Digital Control Systems
EE 753 (was 653)*	3	Optimal Control
EE 754 (was 654)*	3	Nonlinear Control
EE 792	3	Topics: Adaptive Control
EE 792	3	Topics: System Identification
EE 792	3	Topics: State Space Digital Control
EE 755 (was 792)*	3	Topics: Linear Control Systems
CARS out of department -- out of discipline courses:		
CSC 515	3	Introduction to Robotics
CSC 516	3	Autonomous Systems
CSC 449	3	Pattern Recognition
CSC 752	3	Computer Vision
CSC 761	3	Advanced Artificial Intelligence
CSC 762	3	Neural Networks
MATH 421	3	Complex Analysis
MATH 423	3	Advanced Calculus I
MATH 424	3	Advanced Calculus II
MATH 431	3	Dynamical Systems
MATH 432	3	Partial Differential Equations
MATH 451	3	Math Modeling
MATH 471	3	Numerical Analysis I
ME 455/455L	3(2-1)	Vehicle Dynamics
ME 673	3	Applied Engineering Analysis I
ME 683	3	Advanced Mechanical System Control
ME 781	3	Robotics

*** planned curriculum change requests.**

Power Systems and Power Electronics focus area courses:

EE 531/531L	4(3-1)	Power Systems
EE 547	3	Advanced Power Systems
EE 532/532L	4(3-1)	Power Electronics
EE 535	3	Power Transmission and Distribution
EE 548	3	Power Generation
EE 539	3	Grid-Connected Power Electronics Devices
EE 437	3	Electronic Motor Drives
EE 449	3	Power Conversion
EE 633	3	Power Systems Analysis I
EE 634	3	Power System Analysis II

Communications and Networking (CN) focus area courses:

CENG 544/544L	4(3-1)	Computer Networks
CENG 521/521L	4(3-1)	Communication Systems
EE 623	3	Random Signals and Noise
EE 626	3	Wireless Communications
EE 583/583L	4(3-1)	Antennas for Wireless Communication
EE 551	3	Linear Systems Theory
EE 621	3	Information and Coding Theory
EE 622	3	Statistical Communication Systems

CN out of department -- out of discipline courses:

CSC 548	3	Machine Learning
MATH 421	3	Complex Analysis
MATH 423	3	Advanced Calculus I
MATH 424	3	Advanced Calculus II
MATH 431	3	Dynamical Systems
MATH 432	3	Partial Differential Equations
MATH 451	3	Math Modeling
MATH 471	3	Numerical Analysis I
MATH 441	3	Engineering Statistics I