MEAM MASTER'S DEGREE CURRICULUM PLAN WORKSHEET

Use the Course Planning Sheets to fill out this Curriculum Plan Worksheet. No courses, except MEAM 6990, may appear more than once on this page (no double-counting). For descriptions of all MEAM courses, please refer to the Course Catalog. For a list of the upcoming semester's course offerings, please refer to Courses@Penn (search "MEAM" to get MEAM's offerings). Students requesting permission to take courses outside of any of these lists can petition approval from the Master's Program Chair by filling out an Academic Program Request.

STUDENT NAME:

PENNID: **DATE:**

CONCENTRATION:

- ☐ Design and Manufacturing
- ☐ Mechatronic and Robotic Systems
- ☐ Heat Transfer, Fluid Mechanics, and Energy
- ☐ Micro/Nano Systems
- ☐ Mechanics of Materials
- ☐ Undeclared/Undecided

Engineering Mathematics Requirement

	Course Code	Course Name	Semester & Year
Course 1			
Course 2			

MEAM Concentration Required Course

	Course Code	Course Name	Semester & Year
Course 3			

MEAM Concentration Core Courses

	Course Code	Course Name	Semester & Year
Course 4			
Course 5			

MEAM Electives (may be additional MEAM Concentration Core Courses)

	Course Code	Course Name	Semester & Year
Course 6			
Course 7			

General (Free) Electives (may be additional MEAM Courses)

	Course Code	Course Name	Semester & Year
Course 8			
Course 9			
Course 10			

Seminar Requirement

	Course Code	Course Name	Semester & Year
Seminar 1			
Seminar 2			

Notes (Accelerated Master's students should note which courses they are double-counting here):

COURSE PLANNING WORKSHEETS

Use the Course Planning Sheets to help you select your courses. Below is a list of courses that will count towards your Engineering Math Requirement. The other worksheets are organized by Concentration. Note the semester in which the courses are usually offered, though all course offerings are subject to change.

For descriptions of all MEAM courses, please refer to the Course Catalog. For descriptions of the upcoming semester's course offerings, please refer to Courses@Penn (search "MEAM" to get MEAM's offerings).

Students requesting permission to count courses not on the lists provided can petition the Master's Program Chair for approval by filling out an Academic Program Request.

ENGINEERING MATHEMATICS REQUIREMENT

All MSE students are required to take at least two mathematics courses from the following list. Students may count courses outside of this list with approval from their faculty advisor and the Master's Program Chair by filling out an Academic Program Request.

In general, **students may take any graduate-level ENM or MATH course offered at the University to fulfill MEAM's Engineering Math Requirement**. The ENM courses are listed below to help you plan. There are also additional non-ENM courses that have been pre-approved to count towards the Engineering Math requirement.

Course	Title	Fall	Spring
ENM 5020	Numerical Methods and Modeling		X
ENM 5030	Introduction to Probability and Statistics	X	
ENM 5100	Foundations of Engineering Mathematics I	X	
ENM 5110	Foundations of Engineering Mathematics II		X
ENM 5120	Nonlinear Dynamics and Chaos		X
ENM 5200	Principles and Techniques of Applied Math I		X
ENM 5210	Principles and Techniques of Applied Math II	X	
ENM 5220	Numerical Methods for Partial Differential Equations		X
ENM 5310	Data Driven Modeling	X	
ENM 5400	Topics in Computational Science & Engineering		X
CIS 5200	Machine Learning	X	X
MEAM 5270	Finite Element Analysis		X
MSE 5150	Mathematics for Materials Science	X	

SEMINAR REQUIREMENT

All MEAM MSE students completing the MEAM MSE degree within 2 years (or within 3 years for students doing a Dual Degree) and MEAM Accelerated Master's students must take two semesters of the MEAM Seminar, MEAM 6990. International students may take EAS 8960 in place of MEAM 6990 once. See MEAM Seminar Requirement section in the MEAM MSE Student Handbook for more information.

DESIGN AND MANUFACTURING CONCENTRATION

Global business trends have created a demand for companies to rapidly develop new products at lower costs. In response to these demands companies have been exploring new methods to decrease costs, increase productivity, and create innovative products. In keeping with the needs of local industry the graduate courses below prepare students for careers in Product Design and Manufacturing. Students in the program will study topics such as mechatronics, CAD, computer graphics, industrial design, product design, materials engineering, manufacturing processes, assembly, tolerances, design analysis, plant/process modeling and design, robotics, electrical systems, mechanical systems, controls, intellectual property, and management skills. Graduates of the program will be prepared to be leaders in the global manufacturing environment. Much of our work involves collaborations with, among others, the Departments of Computer and Information Science, Electrical and Systems Engineering as well as the School of Design and the Wharton School of Business Administration.

MEAM Concentration Core Required Course

Course	Title	Fall	Spring	Rare
MEAM 5140	**Design for Manufacturability**		X	

MEAM Concentration Core Courses (2 Courses)

Select 2 courses from the following list.

Course	Title	Fall	Spring	Rare
MEAM 5040	Tribology		X	
MEAM 5060	Fail Analysis of Engineering Materials	X		
MEAM 5080	Materials and Manufacturing for Mechanical Design	X		
MEAM 5100	Design of Mechatronic Systems	X		
MEAM 5160	Advanced Mechatronic Reactive Spaces			X
MEAM 5270	Finite Element Analysis		X	
MEAM 5370	Nanomechanics and Nanotribology and Interfaces		X	
MEAM 5430	Performance, Stability and Control of UAVs		X	
MEAM 5500	Design of Microelectromechanical Systems			X

MEAM Electives (2 Courses)

Select 2 graduate-level MEAM courses. These can be additional Concentration Core courses, or from MEAM's overall offerings. For descriptions of all MEAM courses, please refer to the Course Catalog.

DESIGN AND MANUFACTURING CONCENTRATION (CONTINUED)

Suggested General (Free) Electives (3 courses)

Students may take any 3 graduate level courses that contribute to their degree program. In addition to more MEAM courses, students in the Design and Manufacturing concentration are pre-approved to count any of the following courses as General (Free) Electives. Students should consult their faculty advisor for approval of courses outside of this list.

Course	Title	Fall	Spring	Rare
ARCH 7260	Furniture Design		X	
CIS 5600	Interactive Computer Graphics	X	X	
EAS 5070	Intellectual Property and Business Law for Engineers	X	X	
EAS 5120	Engineering Negotiation	X	X	
EAS 5450	Engineering Entrepreneurship I	X	X	
EAS 5460	Engineering Entrepreneurship II	X	X	
EAS 5950	Foundations of Leadership		X	
ESE 5360	Nanofabrication and Nanocharacterization		X	
IPD 5010	Integrated Computer-Aided Design, Manufacturing and Analysis		X	
IPD 5040	Rehab Engineering & Design	X		
IPD 5090	Needfinding	X	X	
IPD 5110	How to Make Things	X		
IPD 5150	Product Design	X	X	
IPD 5250	Ergonomics/Human Factors Based Product Design	X		
IPD 5270	Industrial Design I		X	

HEAT TRANSFER, FLUID MECHANICS, AND ENERGY CONCENTRATION

Aerospace engineering, materials fabrication and manufacturing, cooling of microelectronic equipment, energy conversion and power generation, and thermal control and treatment of living organisms are critically important in today's economy. Our program in heat transfer, fluid mechanics, and energy is designed to provide the basic tools for dealing with these and other problems of current and future technological interest. The program maintains close collaboration with the departments of Chemical Engineering, Bioengineering, Electrical and Systems Engineering, and Materials Science.

MEAM Concentration Core Required Course

Course	Title	Fall	Spring	Rare
MEAM 5360	**Viscous Fluid Flow and Modern Applications**		X	
MEAM 5700	**Transport Processes I**	X		

MEAM Concentration Core Courses (2 Courses)

Select 2 courses from the following list.

Course	Title	Fall	Spring	Rare
MEAM 5020	Energy Engineering in Power Plants and Transportation Systems	X		
MEAM 5030	Direct Energy Conversion: From Macro to Nano	X		
MEAM 5040	Tribology		X	
MEAM 5270	Finite Element Analysis		X	
MEAM 5300	Continuum Mechanics		X	
MEAM 5360	Viscous Fluid Flow and Modern Applications		X	
MEAM 5380	Turbulence		X	
MEAM 5450	Aerodynamics	X		
MEAM 5460	Hovering Vehicle Design and Analysis Techniques		X	
MEAM 5490	Order-of-Magnitude Estimation	X		
MEAM 5610	Thermodynamics: Foundations, Energy, Materials		X	
MEAM 5620	Water Treatment Engineering		X	
MEAM 5700	Transport Processes I	X		
MEAM 5710	Advanced Transport			X
MEAM 5750	Micro and Nano Fluidics		X	
MEAM 5800	Electrochemistry for Energy, Nanofabrication, and Sensing		X	
MEAM 6420	Advanced Fluid Mechanics (rarely offered)			X
MEAM 6460	Computational Mechanics	X		
MEAM 6620	Advanced Molecular Thermodynamics	X		
MEAM 6900	Advanced Topics in Thermal Fluid Science or Energy			X
MSE 5250	Nanoscale Science and Engineering	X		

MEAM Electives (2 Courses)

Select 2 graduate-level MEAM courses. These can be additional Concentration Core courses, or from MEAM's overall offerings. For descriptions of all MEAM courses, please refer to the Course Catalog.

HEAT TRANSFER, FLUID MECHANICS, AND ENERGY CONCENTRATION (CONTINUED)

Suggested General (Free) Electives (3 courses)

Students may take any 3 graduate level courses that contribute to their degree program. In addition to more MEAM courses, students in the Heat Transfer, Fluid Mechanics, and Energy concentration are pre-approved to count any of the following courses as General (Free) Electives. Students should consult their faculty advisor for approval of courses outside of this list.

Course	Title	Fall	Spring	Rare
CBE 5050	Carbon Capture		X	
CBE 5450	Elec. Energy Conv. & Storage	X		
CBE 5460	Fundamentals of Industrial Catalytic Processes		X	
CBE 6180	Advanced Molecular Thermodynamics			
CBE 6400	Transport Processes I	X		
EAS 5010	Energy and Its Impacts	X		
EAS 5020	Renewable Energy and Its Impacts: Technology, Ecology, Economics, Sustainability		X	
EAS 5070	Intellectual Property and Business Law for Engineers	X	X	
EAS 5120	Engineering Negotiation	X	X	
EAS 5450	Engineering Entrepreneurship I	X	X	
EAS 5460	Engineering Entrepreneurship II	X	X	
EAS 5950	Foundations of Leadership		X	
ENGR 5030	Engineering in Oil, Gas and Coal, from Production to End Use		X	
MSE 5250	Nanoscale Science and Engineering	X		
MSE 5450	Materials for Energy and Environmental Sustainability	X		
MSE 5550	Elasticity and Micromechanics of Materials	X		

MECHANICS OF MATERIALS CONCENTRATION

The development of new technologies often depends critically on the availability of materials systems capable of withstanding extreme thermomechanical loading conditions. Current examples are provided by the development of advanced engines in the aerospace industry and the design of microchips that are resistant to thermal cycling in the microelectronics industry. In addition, new technologies, such as biomedical technologies, often require the development and understanding of completely new classes of materials systems. The Penn MEAM MSE in Mechanics of Materials is designed to provide the fundamental tools needed to tackle these and other problems of current and future technological interest. These include basic courses in continuum mechanics, elasticity, and plasticity, as well as more advanced ones in fracture, composite materials, biomechanics, and atomistic modeling of materials. The program maintains close collaborations with the Material Science Department and with the bio-medical community.

MEAM Concentration Core Required Course

Course	Title	Fall	Spring	Rare
MEAM 5190	**Elasticity and Micromechanics of Materials**	X		

MEAM Concentration Core Courses (2 Courses)

Select 2 courses from the following list.

Course	Title	Fall	Spring	Rare
MEAM 5040	Tribology		X	
MEAM 5050	Mechanical Properties of Macro/Nanoscale Materials		X	
MEAM 5060	Fail Analysis of Engineering Materials	X		
MEAM 5070	Fundamentals of Materials	X		
MEAM 5080	Materials and Manufacturing for Mechanical Design	X		
MEAM 5270	Finite Element Analysis		X	
MEAM 5300	Continuum Mechanics		X	
MEAM 5370	Nanomechanics and Nanotribology and Interfaces		X	
MEAM 5500	Design of Microelectromechanical Systems			X
MEAM 5530	Atomic Modeling in Materials Science	X		
MEAM 5550	Nanoscale Systems Biology	X		
MEAM 6320	Plasticity			X
MEAM 6330	Mech. of Adhesion & Fracture			X
MEAM 6340	Rods & Shells			X
MEAM 6350	Composite Materials			X
MEAM 6630	Mechanics of Macromolecules			X
MEAM 6910	Special Topics in Mechanics of Materials			X

MEAM Electives (2 Courses)

Select 2 graduate-level MEAM courses. These can be additional Concentration Core courses, or from MEAM's overall offerings. For descriptions of all MEAM courses, please refer to the Course Catalog.

MECHANICS OF MATERIALS CONCENTRATION (CONTINUED)

Suggested General (Free) Electives (3 Courses)

Students may take any 3 graduate level courses that contribute to their degree program. In addition to more MEAM courses, students in the Mechanics of Materials concentration are pre-approved to count any of the following courses as General (Free) Electives. Students should consult their faculty advisor for approval of courses outside of this list.

Course	Title	Fall	Spring	Rare
EAS 5070	Intellectual Property and Business Law for Engineers	X	X	
EAS 5120	Engineering Negotiation	X	X	
EAS 5450	Engineering Entrepreneurship I	X	X	
EAS 5460	Engineering Entrepreneurship II	X	X	
EAS 5950	Foundations of Leadership		X	

MECHATRONIC AND ROBOTIC SYSTEMS CONCENTRATION

Ongoing effort in mechanical systems focuses on modeling and controlling dynamical systems, especially as applied to mechatronic and robotic systems. The graduate courses provide students with a firm theoretical foundation and the interdisciplinary experimental skills that are necessary for dealing with modern-day complex systems. Much of our work involves collaborations with Computer and Information Science and Electrical and Systems Engineering, as well as the Wharton School of Business Administration.

MEAM Concentration Core Required Course

Course	Title	Fall	Spring	Rare
MEAM 5100	**Design of Mechatronic Systems**	X		

MEAM Concentration Core Courses (2 Courses)

Select 2 courses from the following list.

Course	Title	Fall	Spring	Rare
MEAM 5130	Feedback Control Design and Analysis		X	
MEAM 5160	Advanced Mechatronic Reactive Spaces			X
MEAM 5170	Control and Optimization with Applications in Robotics	X		
MEAM 5200	Introduction to Robotics	X	X	
MEAM 5230	Control Systems for Robotics			X
MEAM 5290	Introduction to Micro- and Nano-electromechanical Technologies		X	
MEAM 5350	Advanced Dynamics	X		
MEAM 5430	Performance, Stability and Control of UAVs		X	
MEAM 5460	Hovering Vehicle Design and Analysis Techniques		X	
MEAM 5500	Design of Microelectromechanical Systems			X
MEAM 6130	Nonlinear Control Theory			X
MEAM 6200	Advanced Robotics		X	
MEAM 6240	Distributed Robotics		X*	
MEAM 6920	Topics in Mechanical Systems			X

*MEAM 6240 is offered every other year.

MEAM Electives (2 Courses)

Select 2 graduate-level MEAM courses. These can be additional Concentration Core courses, or from MEAM's overall offerings. For descriptions of all MEAM courses, please refer to the Course Catalog.

MECHATRONIC AND ROBOTIC SYSTEMS CONCENTRATION (CONTINUED)

Suggested General (Free) Electives (3 Courses)

Students may take any 3 graduate level courses that contribute to their degree program. In addition to more MEAM courses, students in the Mechatronic and Robotic Systems concentration are pre-approved to count any of the following courses as General (Free) Electives. Students should consult their faculty advisor for approval of courses outside of this list.

Course	Title	Fall	Spring	Rare
CIS 5200	Machine Learning	X	X	
CIS 5210	Fundamentals of AI	X	X	
CIS 5400	Principles of Embedded Computation	X		
CIS 5800	Machine Perception	X	X	
CIS 5810	Computer Vision and Computational Photography	X	X	
CIT 5900	Programming Languages and Techniques	X	X	
EAS 5070	Intellectual Property and Business Law for Engineers	X	X	
EAS 5120	Engineering Negotiation	X	X	
EAS 5450	Engineering Entrepreneurship I	X	X	
EAS 5460	Engineering Entrepreneurship II	X	X	
EAS 5950	Foundations of Leadership		X	
ESE 5000	Linear Systems Theory	X		
ESE 5060	Introduction to Optimization Theory	X		
ESE 5190	Smart Devices	X		
ESE 5310	Digital Signal Processing		X	
ESE 5400	Engineering Economics	X		
ESE 5430	Human Systems Engineering	X	X	
ESE 6500	Learning in Robotics		X	
IPD 5010	Integrated Computer-Aided Design, Manufacturing and Analysis		X	

MICRO/NANO SYSTEMS CONCENTRATION

Micro/Nano systems is a broad field encompassing the design, development, and fabrication of devices and systems that derive unique functionality due to the small size of key components within them. Examples of such systems include microelectromechanical systems (MEMS), nanoelectronic devices, and microfluidics. Mechanical Engineering plays a central role in all of these systems, such as the mechanical design of MEMS-based sensors and the understanding of heat transfer in nanoelectronics. The graduate courses in this area of concentration provide students with a solid theoretical foundation, knowledge of micro/nano-fabrication techniques, and skills to design micro/nano systems.

MEAM Concentration Required Course

Course	Title	Fall	Spring	Rare
MEAM 5290	**Introduction to Micro- and Nano-electromechanical Technologies**		X	
MEAM 5370	**Nanomechanics and Nanotribology and Interfaces**		X	

MEAM Concentration Core Courses (2 Courses)

Select 2 courses from the following list.

Course	Title	Fall	Spring	Rare
MEAM 5050	Mechanical Properties of Macro/Nanoscale Materials		X	
MEAM 5070	Fundamentals of Materials	X		
MEAM 5190	Elasticity and Micromechanics of Materials	X		
MEAM 5270	Finite Element Analysis		X	
MEAM 5290	Introduction to Micro- and Nano-electromechanical Technologies		X	
MEAM 5370	Nanomechanics and Nanotribology and Interfaces		X	
MEAM 5500	Design of Microelectromechanical Systems			X
MEAM 5530	Atomic Modeling in Materials Science	X		
MEAM 5550	Nanoscale Systems Biology	X		
MEAM 5750	Micro and Nano Fluidics		X	
MEAM 5800	Electrochemistry for Energy, Nanofabrication, and Sensing		X	

MEAM Electives (2 Courses)

Select 2 graduate-level MEAM courses. These can be additional Concentration Core courses, or from MEAM's overall offerings. For descriptions of all MEAM courses, please refer to the Course Catalog.

MICRO/NANO SYSTEMS CONCENTRATION (CONTINUED)

Suggested General (Free) Electives (3 Courses)

Students may take any 3 graduate level courses that contribute to their degree program. In addition to more MEAM courses, students in the Micro/Nano Systems concentration are pre-approved to count any of the following courses as General (Free) Electives. Students should consult their faculty advisor for approval of courses outside of this list.

Course	Title	Fall	Spring	Rare
EAS 5070	Intellectual Property and Business Law for Engineers	X	X	
EAS 5120	Engineering Negotiation	X	X	
EAS 5450	Engineering Entrepreneurship I	X	X	
EAS 5460	Engineering Entrepreneurship II	X	X	
EAS 5950	Foundations of Leadership		X	
ESE 5210	The Physics of Solid State Energy Devices		X	
ESE 5360	Nanofabrication and Nanocharacterization		X	
MSE 5200	Structure of Materials		X	
MSE 5250	Nanoscale Science and Engineering	X		
MSE 5650	Fabrication and Characterization of Nanostructured Devices		X	