TO: The Faculty of the College of Engineering

FROM: The Faculty of the School of Mechanical Engineering

RE: ME 41200 Additive Manufacturing: Fundamentals, Equipment, and Applications – Permanent Course Number

The Faculty of the School of Mechanical Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ME 41200 Additive Manufacturing: Fundamentals, Equipment, and Applications
Credits: 3 credits
Offered: Spring and Fall
Prerequisite: junior standing

Course Description: Introduction to additive manufacturing through lecture and project-based learning. The focus is additive process fundamentals, materials, characterization, and testing. Students will develop and understanding of processes and equipment for additive manufacturing; design for additive manufacturing; Implementation of Additive Manufacturing for Product Applications.

Learning Outcomes:
1. Fundamentals of materials, properties, and testing for additive manufacturing.
2. Develop understanding of processes and equipment for additive manufacturing.
3. Understanding design(s) for additive manufacturing with material(s) and process(es) for application specific functionality.
4. Complete a project based on product innovation or novel research

History: This course has previously been offered as a ME 49601 course titled "Additive Manufacturing: Fundamentals, Equipment, and Applications" four times since Fall 2022. The student enrolment in the course was as follows:
- Fall 2022 with 48 students
- Fall 2023 with 50 students
- Fall 2024 with 50 students
- Spring 2025 with 44 students

The course syllabus is attached.

Jitesh Panchal
Associate Head for Undergraduate Programs
Professor of Mechanical Engineering

ME 41200
Additive Manufacturing: Fundamentals, Equipment, and Applications

Course Outcomes [Related ME Program Outcomes in brackets]

1. Fundamentals of **materials, properties, and testing** for additive manufacturing. [1,2]
2. Develop understanding of **processes and equipment** for additive manufacturing. [2,3,5]
3. Understanding **design(s)** for additive manufacturing with material(s) and process(es) for application specific functionality. [2,6]
4. Complete a project based on **product innovation** or novel research [1, 2]

Foundations for materials, additive process fundamentals, and testing (4 wks)

1. Technical principles and workflows of additive manufacturing for metals, ceramics, polymers, and bio-materials
2. Properties and testing methods of additive manufactured parts
3. Tradeoffs for additive manufactured parts over subtractive manufacturing
4. Feedstock form factors
5. AM metallurgy from thermal gradients and solidification rates
6. Defect formation

Develop understanding of processes and equipment for additive manufacturing (5 weeks)

1. Fundamentals of additive process mechanisms for various materials
2. Introduction to additive manufacturing equipment and suppliers
3. Parametric modeling (.step); standard tessellation language (.stl)' computer aided manufacturing (g-code)
4. Combination of additive processes with other manufacturing processes
5. Decision making for process(es) selection

Design for Additive Manufacturing (3 weeks)

1. Design for AM
2. Computational methods and tools
3. Assess the value of an additively manufactured part based on production cost, performance, and use case
4. Multifunctionality for surfaces and bulk for engineering applications
5. Biologicalization: bio-inspired, bio-mimetic and bio-integrated designs

Design Project (3 weeks) OR Research Project (3 weeks)

Design Project (3 weeks)

- Applications for additive manufacturing (traditional: aerospace, automotive; non-traditional: social innovation; democratization, space, food)
- Identify how, when, and where AM can create value across the entire product lifecycle
- Open-source product development and intellectual property
- Future trends and digitization of additive manufacturing

OR

Research Project (3 weeks)

- Conduct an open-ended research project on additive manufacturing
- Complete a literature review
- Develop an additive manufacturing research objective and experiment plan
- Characterization of printed coupons (e.g., DMA, DSC, TGA, tensile test, hardness, corrosion, residual stress, porosity)

COURSE NUMBER: ME 41200 **COURSE TITLE:** Fundamentals of Additive Manufacturing (3 credits)

REQUIRED COURSE OR ELECTIVE COURSE: Elective

TERMS OFFERED: Fall & Spring semesters

TEXTBOOK/REQUIRED MATERIAL:

Gibson, Ian; Rosen, David W.; Stucker, Brent; Khorasani, Mahyar (2021) "Additive Manufacturing Technologies," 3rd, Springer, New York. pp. 1-675. https://doi.org/10.1007/978-3-030-56127-7.

Additional reading material provided by the instructor.

PRE-REQUISITIES: Fundamental knowledge of design, materials, heat transfer, fluids, and CAD

ATTRIBUTES: Upper Division (junior and senior status)

COORDINATING FACULTY: Michael Sealy / Ajay Malshe / Salil Bapat

COURSE DESCRIPTION: Course provides an introduction to additive manufacturing through lecture and project-based learning. The focus is additive process fundamentals, materials, characterization, and testing. Students will develop and understanding of processes and equipment for additive manufacturing; design for additive manufacturing;

Implementation of Additive Manufacturing for Product Applications

COURSE OUTCOMES [Related ME Program Outcomes in brackets]:

1. Fundamentals of materials, properties and testing for additive manufacturing. [1,2]
2. Develop understanding of processes and equipment for additive manufacturing. [2,3,5]
3. Understanding design(s) for additive manufacturing with material(s) and process(es) for application specific functionality. [2,6]
4. Apply combination of understanding of designs, materials and additive manufacturing process(es) for a product innovation. [1,2]
5. Adopt an interdisciplinary approach to additive manufacturing across science, engineering, economics, and social innovations. [2,4]

ASSESSMENTS TOOLS:

1. Homework
2. Participation in guest lectures
3. Project reports / presentations
4. Exams

NATURE OF DESIGN CONTENT: Design-for-additive manufacturing approach given complex multivariate interactions; design of experiments; computational design methods; bio-inspired designs for surface and bulk for multifunctionality; design for sustainability additive manufacturing; implementation of additive manufacturing for product design innovations and analysis

RELATED ME PROGRAM OUTCOMES:

1. **Engineering Fundamentals** - An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. **Engineering Design** - An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. **Communication Skills** - An ability to communicate effectively with a range of audiences.
4. **Ethical/Prof. Responsibilities** - An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. **Teamwork Skills** - An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. **Experimental Skills** - An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. **Knowledge Acquisition** - An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

PROFESSIONAL COMPONENT:

1. Engineering Topics: Materials and manufacturing science – 75%
   Engineering design and innovations – 25%

COMPUTER USAGE: The design and manufacturing projects require students to apply computer programs.

COURSE STRUCTURE/SCHEDULE:

Lecture - 2 days per week at 75 minutes per lecture

PREPARED BY: Ajay P. Malshe / Revised by Michael P. Sealy **REVISION DATE:** Jan. 24, 2025