OAN Number: | **Board of Trustees Date: 06/19/14**
OAN Date: | **Effective Date: 08/25/14**

CUYAHOGA COMMUNITY COLLEGE
OFFICIAL COURSE OUTLINE
Mapped

SUBJECT AREA TITLE
Mechanical Engineering Technology/Manufacturing Industrial Engineering Technology
COURSE TITLE
Additive Manufacturing Project Based/Team Oriented Capstone
SUBJECT AREA CODE-COURSE NUMBER
MET - 2190
COURSE CREDIT HOURS
3.00

I. DESCRIPTION OF COURSE:

A. CATALOG DESCRIPTION: Examines the key elements of product development from the concept through design to production. Application technologies learned in the Additive Manufacturing curricula to complete group projects involving product development and production.

B. LECTURE HOURS: 2.00

C. LAB HOURS: 3.00

D. OTHER REQUIRED HOURS: 00

E. PREREQUISITE(S):
Departmental approval: Must be taken in the last semester of the program.

II. GENERAL EDUCATION OUTCOMES:

Upon satisfactory completion of MET 2190 - Additive Manufacturing Project Based/Team Oriented Capstone, the student should be able to perform the following outcomes and supporting objectives:

A. Outcome: Critical Thinking: Analyze and synthesize ideas to make evidence-based decisions and find rational solutions to problems.

Supporting Outcomes:

1. Design a solution to address a given problem by following the key elements of product development from concept through design to production.

B. Outcome: Oral Communication: Produce verbal and non-verbal communication for an intended audience that is clear and concise, uses standard rules for spoken language, and effectively organizes language, images and other symbols.

Supporting Outcomes:

1. Design a solution to address a given problem by following the key elements of product development from concept through design to production.

C. Outcome: Written Communication: Produce writing for an intended audience that is clear and concise, uses standard rules for written language, and effectively organizes language, images and other symbols.

Supporting Outcomes:

1. Design a solution to address a given problem by following the key elements of product development from concept through design to production.

III. OUTCOMES/OBJECTIVES:

Upon satisfactory completion of MET 2190 - Additive Manufacturing Project Based/Team Oriented Capstone, the student should be able to perform the following outcomes and supporting objectives:

A. Outcome: Design a solution to address a given problem by following the key elements of product development from concept through design to production.

Supporting Objectives:

1. Investigate and identify relevant manufacturing problems requiring engineered solution.
2. Apply the appropriate knowledge and skills to resolve manufacturing problems.
3. Apply other relevant research to solve engineering and manufacturing problems.
4. Evaluate proposed solutions in terms of current skills and knowledge.

5. Determine the requisite knowledge and skills for the resolution of pending problems.
6. Apply the tools of project management to ensure timely project completion.
7. Design a new solution or build on past work to resolve designs or process problems.
8. Evaluate actual solution performance against expected outcome.
9. Experiment and re-design for proper operation.
10. Design a production process applying quality control, cost analysis components, and marketability considerations.
11. Write standard technical reports.

IV. COURSE CONTENT:

A. Introduction and basic principles
    1. What is Additive Manufacturing?
    2. What are AM parts used for?
    3. Generic AM Process
        a. CAD
        b. Conversion to STL
        c. Transfer to AM Machine and STL file manipulation
        d. Machine Setup
        e. Build
        f. Removal
        g. Post Processing
        h. Application

B. Development of Additive Manufacturing Technology
    a. Computers
    b. Computer Aided Design Technology
    c. Lasers
    d. Printing Technology
    e. Programmable Logic Controllers
    f. Materials
    g. Computer Numerically Controlled Machines

C. Generalized Additive Manufacturing Process Chain
    1. Eight steps in AM
    2. Variations in AM Machines
    3. Metal Systems
    4. Maintenance of equipment
    5. Material handling issues
    6. Design for AM

D. Photo Polymerization Processes
    1. Photo-polymerization materials
    2. Reaction rate
    3. Vector scan SL
    4. SL Resin curing process

    5. SL Scan pattern
    6. Vector scan micro-stereo-lithography
    7. Mask Projection Photo-polymerization

E. Powder Bed Fusion Processes
    1. SLS Process description
    2. Power fusion mechanism
    3. Powder handling
    4. Approaches to metal and ceramic part creation
    5. Variants of powder bed fusion processes

F. Extrusion-Based Systems
    1. Basic principles
        a. Material loading
        b. Liquification
        c. Extrusion
        d. Solidification
        e. Positional control
        f. Bonding
        g. Support generation
    2. Plotting and path control
    3. Fused deposition modeling from Stratasys
    4. Materials
    5. Limitations of FDM
    6. Bioextrusion

G. Printing Processes
    1. Evolution of printing as an Additive Manufacturing process
    2. Research achievements in printing deposition
    3. Technical challenges of printing
    4. Printing process modeling
    5. Materials modification methods
    6. 3 Dimensional printing
    7. Advantages of binder printing

H. Sheet Lamination Processes
    1. Gluing or adhesive bonding
    2. Thermal bonding
    3. Process based on sheet-metal clamping

I. Beam Deposition Processes
    1. Description of beam deposition process
    2. Material delivery
    3. BD system
    4. Process parameters
    5. Typical materials and microstructure

J. Direct Write Technologies
    1. Ink based DW
    2. Laser Transfer DW
    3. Thermal spray DW
    4. Beam deposition DW
    5. Liquid phase direct deposition
    6. Hybrid technology

7. Application of DW technologies

K. Design for Additive Manufacturing
   1. Motivation
   2. Design for Manufacturing and Assembly
   3. Core DFAM concepts and objectives
   4. AM unique capabilities
   5. Design tools for AM

L. Guidelines for Process Selection
   1. Selection methods for a part
   2. Challenges of selection
   3. Production planning and control

M. Software Issues for Additive Manufacturing
   1. Preparation of CAD models
   2. STL file format, Binary/ASCH
   3. STL files manipulation

N. Direct Digital Manufacturing
   1. Align technology
   2. Siemens and Phonaks
   3. DDM drivers
   4. Manufacturing vs. prototyping
   5. Cost estimation
   6. Life cycle costing

O. Medical Applications for Additive Manufacturing
   1. Use of AM to support medical applications
   2. Software support for medical applications
   3. Limitation of AM for medical applications
   4. Materials

P. Post-Processing
   1. Support materials removal
   2. Surface texture improvements
   3. Accuracy improvements
   4. Aesthetic improvements
   5. Preparation for use as patterns
   6. Property enhancements using non-thermal techniques
   7. Properties enhancements using thermal techniques

Q. The use of Multiple Materials in Additive Manufacturing
   1. Multiple materials approaches
   2. Discrete multiple materials processes
   3. Porous multiple materials processes
   4. Blended multiple materials processes

R. Business Opportunities and Future Directions
   1. New types of products and employment
   2. Digiproneurship

S. Economics of Additive Manufacturing
   1. Rational decision process
   2. Time value of money
   3. Rate of return analysis
   4. Accounting for depreciation

V. METHODS OF STUDENT EVALUATION MAY INCLUDE ANY OF THE FOLLOWING:

A. Participation

B. Assignments

C. Projects

D. Reports

E. Oral Presentation

VI. RESOURCES MAY INCLUDE ANY OF THE FOLLOWING:

A. Besterfield, Dale H. *Quality Control*. 8th Ed Upper Saddle River, NJ, 2011.
B. Chan S. Park. *Fundamentals of Engineering Economics*. 3ed Auburn University, Prentice Hall, 2012.
C. Foston, Arthur; Smith, Carolena; Au, Tony. *Fundamentals of Computer Integrated Manufacturing*. Upper Saddle River, NJ, 1991.
D. Heldman, K. *PMP: Project management professional study-guide* . (5th ed.) Hoboken, NJ: Wiley Publishing, 2009.
E. Wright, Kenneth. *21st Century Manufacturing*. Upper Saddle River, NJ, 2001.

VII. ADDITIONAL RESOURCES: