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
3D Printing & Scanning for Reverse Engineering and Inspection
SUBJECT AREA CODE-COURSE NUMBER
MET - 2150
COURSE CREDIT HOURS
3.00

I. DESCRIPTION OF COURSE:

A. CATALOG DESCRIPTION: Engineering parts inspection and reverse engineering processes employing 3D printing, scanning, and Coordinate Measuring (CMM technologies.) Emphasis on performing Laser Arm Scanning to generate images for conversion into 2D/3D drawings; using applicable software to produce 3D models or converting scanned images into 2D/3D models; using CMM for parts inspection and generating points cloud for 3D modeling; interfacing generated models with reverse engineering methods.

B. LECTURE HOURS: 2.00

C. LAB HOURS: 3.00

D. OTHER REQUIRED HOURS: 00

E. PREREQUISITE(S):
MET-2601 3D Solid Modelingor concurrent enrollment

II. GENERAL EDUCATION OUTCOMES:

Upon satisfactory completion of MET 2150 - 3D Printing & Scanning for Reverse Engineering and Inspection , 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. Apply the fundamentals of CMM to analyze and inspect mechanical components
2. Apply the fundamentals Laser Arm Scanning to mechanical components for the purpose of reverse engineering and to produce engineering parts.

B. 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. Apply the fundamentals of CMM to analyze and inspect mechanical components

III. OUTCOMES/OBJECTIVES:

Upon satisfactory completion of MET 2150 - 3D Printing & Scanning for Reverse Engineering and Inspection , the student should be able to perform the following outcomes and supporting objectives:

A. Outcome: Apply the fundamentals of CMM to analyze and inspect mechanical components

Supporting Objectives:

1. Differentiate between Contact and Non-contact scanning methods with Laser Arm Technology.
2. Perform probe/scan parts and create a new CAD part.

B. Outcome: Apply the fundamentals Laser Arm Scanning to mechanical components for the purpose of reverse engineering and to produce engineering parts.

Supporting Objectives:

1. Demonstrate an understanding of Reverse Engineering.
2. Explain the principle, application and advantages of Laser Arm Scanning technology.

3. Identify the software used in reverse engineering as interfaced with Laser Arm technology.

C. Outcome: Explain the evolution of 3D printing for additive manufacturing.

Supporting Objectives:

1. Narrate the development of 3D printing.
2. Identify commercially available 3D printing machines.
3. List the advantages of 3D printing as an Additive Manufacturing process.

D. Outcome: Prepare CAD models for 3D Printing.

Supporting Objectives:

1. Explain CAD model to STL format conversion process.
2. Package STL files for 3D printing.
3. Identify 3D modeling software.
4. Explain 3D modeling processes.
5. Transfer STL files to given 3D printer.

E. Outcome: Set up a 3D Printer for Additive Manufacturing.

Supporting Objectives:

1. Recognize variations from one Additive Manufacturing machine to another in constructions and operations.
2. Load models and support materials.
3. Implement relevant Rapid set-up using standard methods.

F. Outcome: Apply the fundamentals of 3D printing, to produce and analyze printed mechanical components.

Supporting Objectives:

1. Implement Rapid set-up using standard methods.
2. Operate various types of 3D printers.

3. Run additive manufacturing software.
4. Operate various types of 3D printers for additive manufacturing.
5. Unload and post process built additive manufacturing parts.
6. Inspect additive manufacturing parts for build quality.

IV. COURSE CONTENT:

A. CONCEPTS
   1. CMM
      a. Probe calibration
      b. Part Set-Up
      c. Location Measurements
      d. Feature Measurements
      e. Report Generation
      f. Positioning tool
      g. Operating elements
      h. Errors
      i. Causes
      j. Corrective measures
   2. Printing
      a. Part Set-Up
      b. Positioning concepts
      c. Operating elements
      d. Removal of supports
      e. Errors
      f. Causes
      g. Corrective measures
      h. Maintenance of equipment
      i. Packaging of 3D files

B. SKILLS
   1. CMM
      a. Identify the relationships in geometric figures
         i. Identify Coordinate Systems such as:
            ii. Machine Coordinate System – MCS
            iii. Interim Coordinate System – ICS
            iv. Part Coordinate System – PCS
            v. Fixture Coordinate System – FCS
            vi. The PCS Setup Guide
         i. Recall System Commands:
         ii. a.ICS->PCS
         iii. b. Orient
         iv. c. Align
         v. d. Offset Align
         vi. e. Pivot Align
         vii. f. Rotate
         viii. g. Translate
         ix. h. PCS Program examples
      i. Describe System Management:
      ii. Recalling the MCS or a defined PCS
      iii. Fixture Coordinate Manager
      b. Demonstrate the use of Tolerance theory and applications
      c. Demonstrate an understanding of Constructions, in points, lines, angles, distances, circles, and Planes.
      d. Apply Support Tools and Features effectively to enable reverse engineering operations

e. Demonstrate an understanding of working with Motion Controls
f. Diagnose machine failures, identify service, and preventive maintenance requirements

2. Printing
   a. Identify the relationships in geometric figures
   b. Set up of part such as : Orient & Align
   c. Utilize System Management
   d. Understand and utilize appropriate cure times
   e. Understand and utilize temperatures appropriately in relation to the finished product
   f. Use support tools and features effectively.
   g. Work with various 3D printers.
   h. Diagnose machine failures, identify service, and preventive maintenance requirements.

C. ISSUES
   1. CMM
      a. Equipment sufficiency
      b. Safety in Operation of CMM and Laser Arm Scanner
      c. Interface with software program to convert to STL files.
   2. Printing
      a. Equipment sufficiency
      b. Safety in operation of 3D printers
      c. Interface with software program to convert to STL files

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

A. Lab reports, scan for inspection, scan for reverse engineering

B. Quizzes

C. Midterm examination

D. Final examination

VI. RESOURCES MAY INCLUDE ANY OF THE FOLLOWING:

A. John A. Bosch. *Coordinate Measuring Machines and Systems*. NY, NY , 1995.
B. . "COORD3 Metrology." *Coordinate Meassuring Machine History - Fifty Years of CMM History leading up to a Measuring Revolution* 08-23-2013.

VII. ADDITIONAL RESOURCES:

"WIZprobe Kit". nextec-wiz.com. Retrieved 2010-06-26.
Laser Scanners". HexagonMetrology.us. Retrieved 2013-04-23.
Chromatic White Light (CWS)". HexagonMetrology.us. Retrieved 2013/23/04.
Hansen H.N., Carneiro K., Haitjema H., De Chiffre L., (2006). *Dimensional Micro and Nano Metrology*. CIRP Annals, 55-2, 721-743
Weckenmann A., Peggs G., Hoffmann J., (2006). *Probing systems for dimensional micro- and nano-metrology*. Meas. Sci. Technol. 17, 504–509,
M.B. Bauza, R.J Hocken, S.T Smith, S.C Woody, (2005). *The development of a virtual probe tip with application to high aspect ratio microscale features.* Rev. Sci Instrum, 76 (9) 095112