STRANDS AND STANDARDS

3D PRINT TECHNOLOGY

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Course Description

This course is an introduction to 3D printing – its fundamental principles, technologies, and applications. Students will gain hands-on experience with various 3D printing methods and learn to design, prepare, and execute 3D prints. Through a combination of lectures, demonstrations, and practical exercises, students will also explore real-world applications and implications of 3D printing.

Intended Grade Level	9-12
Units of Credit	0.5
Core Code	35.02.00.00.025
Concurrent Enrollment Core Code	35.02.00.13.025
Prerequisite	None
Skill Certification Test Number	821
Skill Certification Cut Score	**PILOT**
Test Weight	0.5
License Area of Concentration	CTE and/or Secondary Education 6-12
Required Endorsement(s)	
Endorsement 1 or	Programming & Software Development
Endorsement 2 or	Information Technology Systems
Endorsement 3 or	CAD Mechanical Design
Endorsement 4 or	Engineering
Endorsement 5 or	Technology
Endorsement 6	Multimedia

STRAND 1

Printer Technology

Students will understand different types of 3D printing technology and components of those technologies.

NOTE: Standards 1 – 2 could be hands on and Standards 3 – 5 could be lecture based.

Standard 1

Fused Deposition Modeling (FDM) Printers

- Understand how FDM printers work.
- Explore the variety of filament materials used with FMD printers, such as PLA, ABS, PETG, etc.

Standard 2

Stereolithography (SLA, DLP) Printers

- Understand how SLA and DLP printers work.
- Explain the difference between SLA and DLP processes.
- Explore the variety of liquid polymer materials such as standard ABS, castable, flexible, and high temp.

Standard 3

Selective Laser Sintering (SLS, SLM) Printers

- Understand how SLS printers work.
- Explain the difference between SLS and SLM printers.
- Explore the variety of powdered materials used with SLS printers, such as Powder

Standard 4

Multi Jet Fusion (MJF) Printers

- Understand how MJF printers work.
- Explore the variety of powdered materials used with MJF printers, such as Alloy metals, wood, and polymers.

Standard 5

Directed Energy Deposition (DED) Printers

- Understand how DED printers work.
- Explore the variety of powdered alloy metal materials used with DED pri

STRAND 2

Printer Hardware/Software

Students will understand how to use the hardware and software involved with 3D Printing.

Standard 1

Printer Hardware Functions

Explore the most common hardware components of 3D printers, such as:

- Stepper Motors
- Extruders
- Hotend
  - heat sink – A metal device for absorbing and dissipating heat
  - heat break – The piece connecting the heatsink to the heat block
  - heat block – Conducts heat from the thermistor to the nozzle
  - nozzle
- Light sources
- Limit switch
- Lead screw
- Etc.

Understand how the 3D printer software uses G-Code to drive the hardware.

Standard 2

Slicer Programs

- Use different Slicer Programs to prepare 3D Models for printing. These are Cura, PrusaSlicer, LycheeSlicer, and ChiTuBox.
- Explore the variety of slicer settings and how they affect the printing process, such as Layer Height, Wall Count, Infill (density, type/pattern), Exposure Time, Print Orientation, Support Structures (normal, tree/organic), etc.
- Understand and use the steps of the slicing process.
  1. Import 3D File into slicing software
  2. Adjust slicing settings and orient 3D Model
  3. Generate the toolpath by slicing the 3D model into layers.
  4. Preview the sliced layers to ensure accuracy and identify any potential issues.
  5. Export the sliced model in the appropriate file format (e.g., G-code) compatible with the 3D printer.
  6. Transfer the sliced file to the 3D printer for printing.

Standard 3

File Types

- Use 3D Modeling Software to export 3D Models to appropriate printable formats, such as
- .stl, .obj, .3mf, .svg, etc.
- Unzip files from Compressed/Zipped folders when downloading files off the internet.
- Use Slicer Programs to export 3D Printer files for printing, such as .gcode.

STRAND 3

Printer Maintenance

Students will understand and be able to maintain a 3D printer, including assembly and troubleshooting

Standard 1

Filament (FDM) Maintenance

- Assemble and maintain basic consumable parts such as Nozzle, Print Bed, Hot End, Bowden Tube, Stepper Motors, and Extruder

Standard 2

Resin (SLA/DLP) Maintenance

- Understand the process of assembling and maintaining basic parts such as FEP Film, Reservoir, & Cleaning Station.
- Understand and implement proper safety equipment such as Nitrile Gloves, Safety Goggles, Isopropyl Alcohol, & Ventilation.

Standard 3

Identify & troubleshoot common print problems, such as:

- Bed Leveling (Nozzle too far, nozzle too close)
- Flow rate
- Bed & nozzle temperature

STRAND 4

3D Design for Printing
Students will understand how to efficiently design 3D models for printing

Standard 1

3D Modeling Software

- Use 3D Modeling Software to create 3D models for printing such as Sketchup, Blender, Inventor, Onshape, Tinkercad, etc.
- Use 3D Modeling Software to modify/kitbash existing models downloaded from the internet.
- Use 3D Modeling Software to clean up existing models to make them suitable for 3D Printing.

Standard 2

Designing For Printing Limitations

- Students will understand how to design models that are optimized for 3D printing, using concepts such as Overhangs, Bridging, Orientation, Thickness, Tolerance, Supports, etc.
- Students will be able to accurately measure an object in metric and/or imperial units using calipers, rulers, etc.

Standard 3

CAD Modeling

- Students will create a variety of hard surface models such as fixtures, assembly parts, etc.

Standard 4

Organic Modeling

- Students will create a variety of organic models such as characters, animals, etc.

Standard 5

Design Process

- Students will understand the steps in a design process from having a need to finishing a final product that fulfills that need.
  - Identify & define the design problem
  - Brainstorm and plan
  - Build a prototype
  - Test the prototype
  - Refine & Optimize
- Students will understand and demonstrate sketching designs from different perspectives.
- Students will find and solve local problems using designs and 3D printed products of their own design

STRAND 5

3D Printing Real World Applications

Students will explore what industries and groups are using 3D Printing currently and what areas it is growing in.

Standard 1

Understand the difference between primary and secondary manufacturing processes:

- Primary – creation of stock (ie: filament, resin, polymer powder, etc.)
- Secondary – converting stock to finished goods

Students should have knowledge of several industries that use additive manufacturing:

- Aerospace
- Manufacturing
- Medical
- Automotive

Standard 2

Students should have knowledge of several hobbyists' uses of 3D printing:

- Tabletop Gaming
- Art
- Home Improvement
- DIY
- Cosplay

Performance Skills:

- Students will be able to apply design principles and techniques with 3D modeling software and tools to create digital models of objects that can be printed with a 3D printer.
- Students will be able to operate and maintain a 3D printer, including setting up the printer, loading the filament, adjusting the settings, troubleshooting common issues, and cleaning the printer.

Workplace Skills:

The following workplace skills should be discussed and modeled throughout the strands and standards of the course:

- Communication
- Teamwork
- Critical and Creative Thinking
- Problem Solving
- Dependability

Skill Certification Test Points by Strand

Test Name	Test #	Number of Test Points by Strand										Total Points	Total Questions
		1	2	3	4	5	6	7	8	9	10		
3D Print Technology	821	5	17	10	10	2	0					44	31

Vocabulary Terms

ABS	Stands for Acrylonitrile Butadiene Styrene, which is a thermoplastic used for 3D printing. ABS is a common form of plastic found in most household items that were injection molded.
Additive Manufacturing	The process of creating an object from a digital file by stacking 2D layers to form a 3D object. Also called 3D printing.
Belt	Toothed gear belt that is used to transfer movement.
Bed Leveling	The act or process of adjusting the build plate/print bed, so that the first layer will be level
Bridging	Bridging occurs in a 3D print when filament is extended across an open area without supports. The distance a print can bridge is determined by the hardware capabilities of the printer and the slicer settings.
Brim	A platform adhesion option whose function is to reduce shrinkage of bottom print layers or better adhere a low surface area object by providing a larger base platform.
Build Plate	The surface where the printer deposits the materials used for printing. Also known as the Print Bed. see also Print Bed
Bowden Extruder	An extruder assembly used pushing filament that uses a tube to feed the filament from the motor to heated areas. This type of extruder assembly reduces heat transfer to filament pressure point, thereby reducing plastic buildup and clogs.
Calibration	The act or process of adjusting a device or instrument to perform correctly or more efficiently.
Control Screen	LCD screen that displays information and provides an interface to select settings and manipulate the printer
Cooldown	The process of cooling down the hot end. Cooldown occurs automatically after a print is finished, or can be done manually after changing filament to to prevent filament baking and clogs. Can be controlled using the Control Screen or turning off the 3D printer.
Endstop	Mechanical switches that indicate where the “home” or “zero” position is on each print axis. Also called Limit Switch
Extrude	The act of dispensing build material onto the build platform through a small nozzle commonly referred to as a “hot end.”
Extruder	The assembly that handles feeding and extruding filament during a print. The extruder has two parts: the stepper motor and feeding system that pushes the material into the printer, and a hot end that heats and extrudes the material through a nozzle onto the build surface.
Filament	Typically a thermoplastic formed into a continuous wire and wound onto a spool so it is compatible with a 3D printer’s extrusion system. see also ABS, PLA, TPU
Fill	The area within a 3D-printed object that connects the top, bottom, and side layers. Also called Infill or Fill Density
Flow	The action of filament moving in a steady continuous stream. see also Extrusion Multiplier
Fused Deposition Modeling (FDM)	FDM is another name for material extrusion. It is a trade name created by Stratasys, the company that invented and first commercialized the material extrusion process.

G-code	Coding language that the 3D printer understands. It is used to transmit instructions to a 3D printer's control system to tell the printer how to print the 3D model. see also Cura, Slicer
Hot End	The heated portion of the extruder assembly that includes the nozzle and heating block.
Layer	Extruded plastic of a closed loop, represented as a two-dimensional drawing on the X-Y plane. When replicated over again in the Z direction, it produces a 3D object or multi-layered X-Y drawing. see also Layer Height
Layer Height	Utmost determinant of quality for 3D printing, it defines the distance between lines of extruded plastic in the Z-direction. Material extrusion 3D printers typically print layers between 0.1mm and 0.3mm high. A lower layer height translates to a smoother, higher quality print. A higher layer height translates into a faster, low quality print.
Mesh	A collection of polygons attached by edges and vertices that makes up a net-like surface area in CAD.
Nozzle	A brass or steel funnel-shaped die through which melted plastic is extruded. Also called an Extruder Nozzle or Hot End
OBJ	OBJ stands for Object File, an alternative to the STL file format. OBJ (.obj) files store object exterior pattern and color.
PLA	Polylactic Acid (PLA) is a biodegradable thermoplastic polymer derived from the starch in plants (normally corn) that is used for 3D printing.
Preheat	Heating prior to using the device or tool. In 3D printing, the nozzle needs to be preheated before printing or for loading and unloading filament.
Print Speed	The rate at which a 3D printer is capable of moving while extruding plastic. A print speed of 50mm/s will be successful on most FDM printers. A print speed of 20–30mm/s will produce higher quality prints.
Print Quality	Refers to the quality of the print and is determined by many factors including mechanical capabilities of the printer, slicer used, layer height, print speed, support, and print orientation.
Printing Temperature	The temperature of the hot end at which the filament is melted and extruded.
Raft	- A platform adhesion option in which several layers of printed material are deposited on the build surface to smooth out any irregularities in the build surface and help prevent warping in the model being printed on top of the raft. A raft also helps with bed adhesion of delicate models.
Resolution	The smallest movement a printer's extruder can make within a single X-Y layer. Often indicates the produced quality of a printed model.
SD Card	A non-volatile memory card for use in portable devices to transfer information, such as .gcode to 3D printers.
Shell	The sidewalls of a 3D printed model, created by the exterior edges of every layer. Also called a Perimeter
Shell Thickness	The total width of an outside wall of a 3D-printed part. Shell thickness should be a multiple of nozzle size. Two shells is typically best. An increased number of shells will lead to a stronger model. see also Shell

Skirt	A platform adhesion option that extrudes an offset outline of the model on the first layer of the print. The skirt helps to remove unwanted colors and build pressure for material extrusion. It also checks the accuracy of bed leveling.
Slice	The action of changing a model file (STL, OBJ, etc.) into a a G-code file. The coordinate type can vary depending upon setting selection. The most common type uses cartesian coordinates on an XYZ plane. see also Slicer
Slicer	A type of program, such as Cura or Repetier Host, that allows manipulation of a 3D model and converts the file type into a coordinate system (usually .gcode) the printer follows to create a model. see also Cura, Repetier Host
Stepper Motor	In 3D printing, the stepper motor that produces precise movement of the extruder, X-, Y-, or Z-axis.
STL	The STL file format (STL stands for stereolithography) is the recommended file format for 3D models for 3D printing. The filetype contains the best mesh for solid 3D-printed objects.
Support	Additional removable structures that are printed to support overhangs or other parts of a model that do not make contact with the build plate during printing
X-Axis	The principal or horizontal axis of a system of coordinates.
Y-Axis	The secondary or vertical axis of a system of coordinates.
Z-Axis	The axis in three-dimensional Cartesian coordinates which is usually oriented vertically.