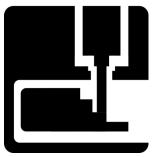
ADDITIVE MANUFACTURING



PURPOSE

To evaluate each team's preparation for employment and to recognize outstanding students for excellence and professionalism in the field of Digital and Additive Manufacturing (AM).

Additive manufacturing embraces a wide range of materials and derivative processes building parts suitable for end-use service. The virtually unlimited design freedom enabled by additive manufacturing allows the creation of shapes and the integration of feature and function that previously required subassemblies.

Employment opportunities for creative individuals are growing while industry adopts AM methods. Ready access to workstations and service providers makes the Internet a growing marketplace for public additive manufacturing.

3D printing plays a role in nearly every industry. From teaching creativity in education to designing surgical guides in difficult medical procedures to cost savings in manufacturing, 3D printing demands of its practitioners' literacy in many areas. Contestants should expect to demonstrate their ability to use 3D CAD, design for the advantages of additive manufacturing, account for limitations of major 3D printing technologies, advocate for design choices, and use creativity to solve physical problems with real constraints.

First, download and review the General Regulations at: http://updates.skillsusa.org.

ELIGIBILITY

Open to active SkillsUSA members enrolled in Computer Aided Design classes, design classes, manufacturing, etc.

CLOTHING REQUIREMENT

Class E: Contest specific — Business Casual

- Official SkillsUSA white polo shirt.
- Black dress slacks (accompanied by black dress socks or black or skin-tone seamless hose) or black dress skirt (knee-length, accompanied by black or skin-tone seamless hose).
- Black leather closed-toe dress shoes.

These regulations refer to clothing items that are pictured and described at: www.skillsusastore.org. If you have questions about clothing or other logo items, call 1-888-501-2183.

Note: Contestants must wear their official contest clothing to the contest orientation meeting.

EQUIPMENT AND MATERIALS

1. Supplied by the technical committee:
   a. 3D printers and post processing equipment
   b. Gloves for wash tank
   c. Post processing tools
   d. Blank engineering notebooks for teams to use during contest
2. Supplied by the contestant:
   a. Personal computer system (laptop or desktop) with a computer design system capable of rendering files in STL format. Make sure software licensing will work without an internet connection in the contest space outside of your school's location and outside of your school's normal calendar year. You may bring up to one computer per contestant or two computers per team. Only one computer is necessary to complete the contest. Stratasys, SME, and SkillsUSA are not responsible for computers or any property left overnight in the competition space.
   b. GrabCAD Print software downloaded to computer for contestant to use at contest. Software available for download at this link: https://grabcad.com/print. This software will be used during the contest. Contestants should download

and familiarize themselves with this software before contest.

c. New and empty USB Drive for transferring competition files (including .print, .txt, STL files). The USB Drive must be clearly labeled with team identification (number and letter). ID must be on the outside of USB drive, must not be able to fall off, and clearly visible to the naked eye.
d. Calipers
e. Needle nose pliers
f. Pencil or pen in engineering notebook
g. Sandpaper
h. All competitors must create a one-page résumé and submit a hard copy to the technical committee chair at orientation. Failure to do so will result in a 10-point penalty.

   ***Note*:** Your contest may also require a hard copy of your résumé as part of the actual contest. Check the Contest Guidelines and/or the updates page on the SkillsUSA website at updates.skillsusa.org.

Scope of the Contest

Knowledge Performance

The exam taken during the SkillsUSA National Additive Manufacturing Contest will be the Additive Manufacturing Fundamentals Certification Exam at this link: http://www.sme.org/certified-additive-manufacturing-fundamentals/.

This exam is being given at no additional cost to the students because they have earned a spot competing at the national level. The certification in Additive Manufacturing Fundamentals is the first and only certification validating an individual's knowledge of industry-standard concepts in additive manufacturing, based on revisions to the Additive Manufacturing Body of Knowledge by the Additive Manufacturing Leadership Initiative (AMLI) in 2016.

This certification was developed by Tooling U-SME and is co-sponsored by America Makes. If a passing score of 70 percent or higher is achieved, the contestant will earn the Additive Manufacturing Fundamentals Certification. This certification does not expire.

Please review our exam preparation tips at: http://www.sme.org/examtips/ to increase chances of certification. This is an open-book and open-notes exam. Sharing of books, notes and other materials during the exam is not permitted. Use of the Internet to search for answers is strictly prohibited during the exam and will result in your exam being terminated.

If you are using an eBook version of the recommended reading, it is required that you use a second device to avoid any interruptions during your online exam. A second device can be an additional laptop, iPad, tablet, kindle or smartphone. Please note that internet usage is not allowed during your exam

Please see the Additive Manufacturing Fundamentals Certification Recommended Review Books (www.sme.org/amreading) and Additive Manufacturing Fundamentals Certification Body of Knowledge PDF (www.sme.org/uploadedFiles/Certified_Additive_Manufacturing/additive-BOK.pdf) for additional information to aid in preparation.

Skill Performance

1. This contest will be a team-oriented event. Teams will be comprised of two contestants from the same school in the same division. The contest will consist of:
   a. 3D design that demonstrates thoughtful design for additive manufacturing and solves a given problem under given constraints to be printed onsite.
   b. 3D printing "mini challenge" designed to quickly test the contestants' knowledge of 3-D printing.
   c. Engineering notebook documenting design process for challenges during contest.
   d. Evaluation from judges.

2. The contest will focus on real-world challenges of an individual and build on each team's understanding of:
   a. Physical, functional, and performance characteristics or specifications that uniquely identify a component or

device and determine its interchangeability in a system
   b. Material properties (material specifications will be provided

3. Final designs will demonstrate an ability to:
   a. Design for integration into an existing process
   b. Adapt to an existing design/interface

Contest Guidelines

1. The first design challenge will focus on use of moving parts, model and support material usage, build size, print time and functionality. Software to virtually estimate print time and material usage can be accessed using GrabCAD Print.

   Moving parts that rotate freely must be part of the design. The design will show the benefits of additive manufacturing by incorporating complex geometric features. The geometry of the design must be defined within a three-dimensional (3D), computer design system capable of rendering files in STL and .print format. Stratasys will print designs from the first design challenge during the contest.

   The competition will use Stratasys FDM 3-D Printers. Stratasys FDM 3-D Printers build parts by extruding a model material along with a dissolvable support material. The support material is used to fill in negative spaces in the part that is being built. This allows for complex geometries and moving parts. At the end of the build, the support material is dissolved away.

   Notes about the use of support material: If you would like support material to fill in a space to achieve moving parts or a negative space in your design, you must leave an opening of at least 0.023".

   Process considerations:
   - Self-supporting angles are 45 degrees.
   - More support means longer build time because the machine takes time to switch from model to support on each layer.
   - Air gap for freedom of movement in parts ≥ 0.023".
   - How the file is oriented to be built will affect the amount of support material being used and the overall time of the build.
   - See http://www.stratasys.com/3d-printers/technologies/fdm-technology/faqs for additional information about the printers being used during the contest.

2. The mini challenge given during the contest will emphasize other additive manufacturing principles and benefits, such as rapid prototyping and design modification to an existing part.

3. Teams will present and turn in to the judges their engineering notebooks. Notebooks should include all areas of the scoring rubric provided on the day of the competition, such as: concept description, specifications, dimensional drawings, design tree (flow chart), considerations of design for 3-D, finishing aspects that impact design, and mistakes/lessons learned.

4. Engineering notebook and designs from the contest, in printed form as well as in 3-D design software, will be presented to the judges. Teams can use a simple PowerPoint to show screen shots of the design process to complement their engineering notebook. The PowerPoint (PowerPoint not a requirement) and engineering notebook will guide the conversation with judges. Be prepared to answer questions about designs and process.

5. Items on which contestants will be evaluated:
   - Design Challenge.
   - Mini Challenge.
   - Engineering Notebook.
   - Presentation.
   - Knowledge Exam.

Standards and Competencies

ADMFG 1.0 — Design sketch and plan machine work to U.S. National CAD Standards

1.1 Create CAD file for manufacturing using standard CAD terminology and standard practice
1.2 Initiate manufacturing documentation process
1.3 Export a CAD file to .stl format
1.4 Process engineering change orders

ADMFG 2.0 — Preform and inspect part(s) using a Total Quality Management process

2.1 Verify part(s) to provided standards
2.2 Verify part(s) to ECO standards
2.3 Document process of verification and inspection

ADMFG 3.0 — Demonstrate safety practices in a working situation to the related duty tasks of the National Institute for Metalworking Skills (NIMS) Duties and Standards

3.1 Carry out assigned responsibilities while adhering to safe practices in accordance with OSHA requirements and guidelines
3.2 Document safety activities as required

ADMFG 4.0 — Provide an accurate quotation given an automated manufacturing technology simulated scenario

4.1 Solve various solutions to the process that is involved in quoting a job in a rapid prototyping environment

Committee Identified Academic Skills

The technical committee has identified that the following academic skills are embedded in this contest.

Math Skills

- Numbers and operations.
- Algebra.
- Geometry.
- Measurement.
- Problem Solving.
- Reasoning and proof.
- Communication.
- Connections.
- Representation.
- Use fractions to solve practical problems.
- Use proportions and ratios to solve practical problems.
- Simplify numerical expressions.
- Solve single variable algebraic expressions.
- Solve multiple variable algebraic expressions.
- Measure angles.
- Use scientific notation.
- Find surface area and perimeter of two-dimensional objects.
- Construct three-dimensional models.
- Apply Pythagorean Theorem.
- Make predictions using knowledge of probability.
- Solve problems using proportions, formulas and functions.
- Find slope of a line.
- Solve practical problems involving complementary, supplementary and congruent angles.
- Solve problems involving symmetry and transformation.

Science Skills

- Use knowledge of the particle theory of matter.
- Describe characteristics of types of matter based on physical and chemical properties.
- Use knowledge of physical properties (shape, density, solubility, odor, melting point, boiling point, color).
- Use knowledge of classification of elements as metals, metalloids and nonmetals.
- Describe and identify physical changes to matter.
- Predict changes to matter (types of reactions, reactants, and products; and balanced equations).
- Use knowledge of potential and kinetic energy.
- Use knowledge of Newton's laws of motion.
- Use knowledge of work, force, mechanical advantage, efficiency and power.
- Use knowledge of simple machines, compound machines, powered vehicles, rockets and restraining devices.

Language Arts Skills

- Provide information in conversations and in group discussions.
- Demonstrate comprehension of a variety of informational texts.
- Use text structures to aid comprehension.
- Organize and synthesize information for use in written and oral presentations.
- Demonstrate knowledge of appropriate reference materials.
- Demonstrate use of such verbal communication skills as word choice, pitch, feeling, tone and voice.
- Demonstrate use of such nonverbal communication skills as eye contact, posture and gestures using interviewing techniques to gain information.
- Demonstrate informational writing.
- Edit writing for correct grammar, capitalization, punctuation, spelling, sentence structure and paragraphing.

Connections to National Standards

State-level academic curriculum specialists identified the following connections to national academic standards.

Math Standards

- Numbers and operations.
- Algebra.
- Geometry.
- Measurement.
- Data analysis and probability.
- Problem solving.
- Reasoning and proof.
- Communication.
- Connections.
- Representation.

Source: NCTM Principles and Standards for School Mathematics. NCTM Principles and Standards for School Mathematics. For more information, visit: http://www.nctm.org.

Science Standards

- Understands the structure and properties of matter.
- Understands the sources and properties of energy.
- Understands forces and motion.
- Understands the nature of scientific inquiry.

Source: McREL Compendium of National Science Standards. To view and search the compendium, visit: http://www2.mcrel.org/compendium/browse.asp.

Language Arts Standards

- Students apply a wide range of strategies to comprehend, interpret, evaluate and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics).
- Students adjust their use of spoken, written and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.
- Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language and genre to create, critique and discuss print and nonprint texts.
- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.
- Students participate as knowledgeable, reflective, creative and critical members of a variety of literacy communities.
- Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).

Source: IRA/NCTE Standards for the English Language Arts. To view the standards, visit: www.ncte.org/standards.