3D Printing Curriculum Guide

Stratasys® | Education

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Overview

About Stratasys Education

The Community

You've joined a worldwide community of educators working to cultivate and expand the use of 3D printing in education. Because technology evolves, this curriculum was built to adapt and refresh through community input.

Ask us how substantial contributions to this community can make you eligible for free FDM® or PolyJet™ 3D Printer cartridges. If you have ideas and supporting content to improve or expand this curriculum, email edu.curriculum@stratasys.com.

Our Mission

Stratasys Education is committed to promoting 3D printing in education and bridging the gap between academia and industry. In collaboration with educators like you, we're leading curriculum development for universities and vocational schools as well as for research and informal study.

Career Readiness

“The number of job ads requiring workers with 3D printing skills increased 1,834% in 4 years and 103% when comparing August 2014 to August 2013.”

Source: Wanted Analytics

Reshaping Industries

The Third Industrial Revolution is all about personal fabrication and it’s happening now. Powered by Information Age advancements, it is poised to unlock the potential in every person to create, innovate and fabricate.

While computer-aided additive manufacturing processes have been around for more than 30 years, the technology, now widely known as 3D printing, is reaching a tipping point. It is advancing rapidly, making its way to consumers, and reshaping manufacturing in the 21st century.

3D printing opens up inspiring possibilities and opportunities, like the ability to produce a fully functional “machine” in one print. It is the only manufacturing process that can interlock parts within parts to produce functioning closed systems that require no assembly.

Furthermore, because 3D printers produce objects directly from computer models, users can immediately hold, evaluate, test and use their ideas – and share them digitally with the world. The Internet revolutionized the creation, modification and dissemination of digital media. Now, 3D printing makes that possible for physical objects.

3D printing is reshaping the fields of art, design, architecture, science, technology and engineering by revolutionizing how things are made. Recognizing education as the foundation for career readiness, a means to drive future innovation, we’re providing this curriculum completely free. Use it modularly to supplement an existing class, or teach an entirely new course in 3D printing.

Something That Moves Something

Course Series

Something That Moves Something is a series of 3D printing courses created by Ohad Meyuhas. In this series of courses, students will learn about the evolution of digital fabrication with a full overview of the manufacturing industry and related technologies.

Each hands-on, project-based learning (PBL) course will let students design and fabricate 3D objects using computer-aided design (CAD) software and 3D printers. They will experience the design process and become familiar with the advantages and limitations of each 3D printing technology in terms of precision, resolution, and material capabilities.

Students will analyze real industry cases, and apply 3D printing technology appropriately while gaining hands-on experience with two leading 3D printing technologies employed in manufacturing today: FDM and PolyJet.

Introduction to 3D Printing: From Design to Fabrication

By the end of this introductory course, students will have designed and 3D printed a closed system that shifts forces from one point to another using the technical knowledge gained during the semester.

Material Memory and Multi-Material Printing (Coming soon)

This course builds on the introductory course and teaches the use of multiple materials in one print.

Robotics and 3D Printing (Coming soon)

In this advanced course students incorporate electronics and robotics into 3D printed machines, taking advantage of the technology's unique ability to interlock parts within parts in a single process.

Introduction to 3D Printing

Learning Objectives

Part of *Something That Moves Something*, this semester-long course will enrich students' knowledge in design and applied engineering as they model, fabricate, test, discuss and iterate upon mechanical 3D objects they design throughout the course.

Upon completion of this course, students will be able to:

- Demonstrate knowledge of key historical factors that have shaped manufacturing over the centuries
- Explain current and emerging 3D printing applications in a variety of industries
- Describe the advantages and limitations of each 3D printing technology
- Evaluate real-life scenarios and recommend the appropriate use of 3D printing technology
- Identify opportunities to apply 3D printing technology for time and cost savings
- Discuss the economic implications of 3D printing including its impact on startup businesses and supply chains
- Design and print objects containing moving parts without assembly

Recommended Course Structure

Semester-Long Course

This course is structured as a 14-week course with weekly class meetings. We recommend that each meeting take four to six hours. Alternatively, the weekly meetings can be split into two weekly lecture hours and two to six weekly lab hours.

The course is built in a modular fashion so you can focus on topics that cater to your students' interests and fit within your annual curriculum plan. We recommend adhering to the first four weeks of the course structure and adding units and assignments as fitting.

TIMEFRAME	14 weeks (full semester)
WEEKLY HOURS	4-6 weekly hours, consisting of: 2 lecture hours 4 lab hours
WEEKLY MEETINGS	Each weekly meeting can be taught in one continuous 4-6 hour session, or can be split into two separate weekly meetings: one for the lecture (theory) and one for the lab work (hands on).
MODULAR UNITS	The course consists of 14 units, one per week. However, to support varied student interests, six additional units are also available. Mix and match the additional units as desired. We recommend educators adhere to the first four weeks of the course structure.

Requirements

Classroom

- Educator PC with access to:
- PowerPoint® presentation graphics program
- QuickTime application program
  Internet connection
  Student PCs
  Internet connection
- Projector

Computer Lab

The classroom and computer lab don't necessarily need to be separate spaces. But, in addition to the classroom requirements listed above, lab sessions require the educator and students to have access to the **CAD software** selected for this course.

Fabrication Lab

We recommend one 3D printer for every 10-15 students. Stratasys® 3D Printers are recommended because some projects require Stratasys-specific printing materials or precision (like FDM thermoplastics with water-soluble support material or PolyJet photopolymers with rubber-like properties).

Also, because Stratasys 3D Printers are those most frequently used in Fortune 500 companies, students will gain more relevant experience and highly sought-after skills.

Educator

To provide instruction for this course, the educator should have deep knowledge of CAD principles and techniques, and some experience designing for 3D printing. Because every institution and educator has unique software access, preferences and techniques, CAD instruction for this course will rely primarily on educator-provided resources and expertise.

Educators should also have experience operating the 3D printer being used for this class, and coordinate with the fabrication lab manager to arrange access and instruction.

Students

Students should have prior experience using CAD software, however content and activities can be modified to meet a variety of student interests and skill levels. To complete assignments, students will need access to educator-selected CAD software outside the classroom, either on their own PC or in a computer lab.

Unit 1: Introduction

Learning Objectives

Upon completion of this unit, students will be able to:

1. Explain how technology shifts throughout history have made 3D printing possible.
2. Understand how the designer's role has evolved over time and how it is likely to change as we move toward mass customization.
3. Use the principles of Design Thinking and document their design process.
4. Navigate the CAD software being used for this course.

Essential Questions

Use these questions to guide student understanding:

1. Was 3D printing historically inevitable? Why or why not?
2. Has technology helped or hindered creativity? How?
3. Is there any such thing as a product that cannot be improved?

Classroom

Topic	Format	Learning Aids	Preparation
COURSE OVERVIEW	Lecture		Print materials
	Students are introduced to course objectives and syllabus.		
HISTORICAL REVIEW	Lecture	Historical Review (PPTX) ⭳	Print presentation notes
	Students will understand how technology shifts throughout history have made 3D printing possible.		
FROM CAD TO CAM	Lecture	From CAD to CAM (PPTX) ⭳	Print presentation notes
	By reviewing the evolution of design and production, students gain broad understanding of the advances that led to today's manufacturing environment. They will understand how humans, machines and code work together to make things.		

Computer Lab

Topic	Format	Learning Aids	Preparation
CAD OVERVIEW	Tutorial	Educator-provided content*	Lesson plan
	Students will become familiar with the interface and basic tools available in the CAD software used for this course.		
FINAL PROJECT EXAMPLE	Lecture	Inspiring Case Study (PPTX) ⭳ Something That Moves Something (STL) ⭳	3D print STL file provided Print speaker notes
	The *Inspiring Case Study* presentation will introduce students to Design Thinking and provide an example of what they need to present for their final project. You may choose to dig deeper into Design Thinking by facilitating one of these workshops during classroom or lab time. http://dschool.stanford.edu/dgift/		
FINAL PROJECT *Proposal 1*	Hands-on	Final Project description	Print project description
	Students will apply what they learn in this class to design and 3D print *something that moves something*. Distribute the final project description that lists the project requirements. Leave some time for Q & A.		

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Unit 2: Introduction to 3D Printing

Learning Objectives

Upon completion of this unit, students will be able to:

1. Apply the unique advantages of 3D printing to their designs.
2. Compare additive manufacturing to traditional technologies and choose the best technology for a given application.
3. Distinguish between various 3D printing technologies and materials and select appropriately for a given application.

Essential Questions

Use these questions to guide student understanding:

1. How might 3D printing change the way products are designed?
2. Will 3D printing replace traditional fabrication processes?
3. Is there any such thing as a “perfect” 3D printing technology?

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW	Discussion		
	Students will present their final project proposal and sketch to a peer. They should ask: Am I applying Design Thinking? Are my inspiration and idea clear? Do you understand the direction of my project? What can be improved?		
3D PRINTING OVERVIEW	Lecture	Intro to 3D Printing (PPTX) ⭳	3D print various samples of closed-system 3D models. Use the STL files provided by Stratasys or download additional files from GrabCad or Thingiverse. Print speaker notes
	The special advantages of 3D printing are illuminated by comparison to other technologies, both ancient and modern.		
3D PRINTING TECHNOLOGY	Lecture	3D Printing Technologies (PPTX) ⭳	Print speaker notes
	Students learn how various 3D printing technologies compare in terms of applications, advantages, relative precision and material use.		

Computer Lab

Topic	Format	Learning Aids	Preparation
INTRO TO 3D MODELING	Tutorial	Educator-provided content*	Lesson plan
	Students will become familiar with the interface and basic tools present in the CAD software used for this course.		
MEET THE 3D PRINTER	Tour	Educator-provided content*	Access to the fabrication lab
	Familiarize students with available 3D printer(s) including print heads, build envelope, materials used and related support removal system(s).		
FINAL PROJECT *Proposal 1*	Hands-on	Final Project description	Print extra project descriptions
	Students will begin refining their final project proposal and will model their designs in CAD. Use lab time to aid and advise students as needed, encouraging model complexity.		

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Unit 3: What is a Mesh?

Learning Objectives

Upon completion of this unit, students will be able to:

1. Define essential geometry terms and understand how they relate to a 3D mesh.
2. Create smooth and detailed 3D structures.
3. Repair a 3D mesh and prepare files for print.
4. Take advantage of model-sharing websites to accelerate learning and improve product designs.

Essential Questions

Use these questions to guide student understanding:

1. Can a 3D printed object ever be completely smooth?
2. Why is file size important? Will it always be?
3. Why do we call a closed mesh "watertight"?
4. What can we learn by studying designs others have created?

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW	Discussion Students will present their revised proposal and CAD model to a peer. They should ask: Am I applying Design Thinking? Are my inspiration and idea clear? Do you understand the direction of my project? What can be improved?		
WHAT IS A MESH?	Lecture A review of geometry terms conveys the concept of a 3D mesh.	What is a Mesh? (PPTX) ⤓	

Computer Lab

Topic	Format	Learning Aids	Preparation
MOVING FROM 2D TO 3D	CAD instruction	Educator-provided content*	Lesson plan
	Teach common commands for moving from 2D to 3D in CAD. Concentrate on the commands and features that will make your students the most proficient at completing this week's assignment: creating or modifying 3D models of everyday objects.		
ADVANCED CAD COMMANDS	CAD instruction	Educator-provided content*	Lesson plan
	Teach advanced CAD commands that will enhance students' ability to navigate models in 3D space.		
MAKING BY SHARING	Class activity	Making by Sharing (PPTX) ⭳	Print speaker notes
	Students will divide into three groups and receive a list of model-sharing websites to review. They will present their findings to the class, following the format described in the *Making by Sharing* project description.		
WEEKLY ASSIGNMENT *Making By Sharing*	Hands-on	Making by Sharing assignment	Print project description
	Students will use what they've learned so far to design four everyday objects. More details are provided in the project description for *Making by Sharing*. Use lab time to aid and advise students as needed, and encourage model complexity.		

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Assignment: Making By Sharing

This assignment reinforces and extends the classroom learning for **Unit 3**. This assignment lets students use what they've learned from sharing sites like Thingiverse, Shapeways and GitFab to design four everyday objects that utilize the advantages of 3D printing.

Deliverable	Description
OPTION 1: *Improvements to four everyday objects (STL)*	1. Choose four models from a sharing site like Thingiverse, Shapeways or Gitfab. 2. Improve upon a file and make it your own. Some ideas include: • Redesign it with a specific user in mind • Redesign it for a slightly different purpose • Improve the look of the product 3. Document and explain the changes you made to the file and why you made those changes.
OPTION 2: *Four everyday objects from scratch (STL)*	1. Design a product from scratch and upload it to a model sharing website. 2. Write detailed instructions for printing and include them when you upload your file.

Unit 4: Ctrl+P

Learning Objectives

Upon completion of this unit, students will be able to:

1. Use the CAM software to prepare files for 3D printing.
2. Manipulate machine movement and material layering.

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW *Making By Sharing*	Discussion Students will present their four consumer products or everyday objects to a peer and exchange feedback.		

Computer Lab

Topic	Format	Learning Aids	Preparation
CAM SKILLS	Tutorial	Catalyst (PPTX), Insight (PPTX) or Objet Studio (PPTX) ⤓	Print speaker notes
	Students will learn how to use the CAM software that powers the school's 3D printer. If none of the provided presentations apply, prepare your own tutorial. Concentrate on commands and features that will make your students most proficient at preparing files for print.		
MESH REPAIR	Hands-on	What is a Mesh? (PPTX) ⤓	
	Demonstrate how to repair a 3D mesh using a) **Freeware utilities**: Autodesk MeshMixer (http://goo.gl/x5nhYc), MeshLab (http://goo.gl/fgztLl) or Netfabb Basic or Cloud Service (http://goo.gl/Q1P47a) b) **Freeware tool tutorials:** Netfabb Basic or Cloud Service (http://goo.gl/Q1P47a), Netfabb and MeshLab (http://goo.gl/WPOVec) **c) Professional tools:** Magics or Netfabb		
GET TO KNOW THE 3D PRINTER	Tour	Educator-provided content*	Access to fabrication lab
	Visit the fabrication lab and explain additional details about how your school's 3D printer works. Ask lab manager to explain processes for maintenance, support removal, and reserving access to 3D printers.		
WEEKLY ASSIGNMENT *Making By Sharing*	Hands-on	Making by Sharing assignment	
	Students will refine their models of everyday objects based on feedback from their peers. More details are provided in the project description for *Making by Sharing*. Use lab time to aid and advise students as needed, encouraging model complexity.		

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Unit 5: Gear Systems Part I

Learning Objectives

Upon completion of Units 5 & 6, students will be able to:

1. Build a gear system in CAD.
2. Convert 2D gear drawings to 3D models.
3. Design systems with 3D printing technology in mind, including minimum tolerance and material thickness.

Essential Questions

Use these questions to guide student understanding:

1. Is the ability to create a full gear system in one print extraordinary?
2. How do you interact with a 3D design differently than a 2D design?
3. Are gear systems obsolete? Will they ever be?

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW *Making By Sharing*	Discussion Students will present their refined consumer products or everyday objects to a peer and exchange feedback.		
GEAR SYSTEMS	Lecture Students are introduced to the operating principles of gear systems, and learn the advantages and limitations of 3D printing them.	Gear Systems (PPTX) ⭳	
CASE STUDY	Lecture Review one of these case studies with students to highlight the challenges and advantages of 3D printing gear systems.	Da Vinci Case Study (PPTX) ⭳ Gear System Case Study (PPTX) ⭳ Gear Ball Case Study (PPTX) ⭳ Gear System 16 (STL) ⭳ U05 FDM Da Vinci (STL) ⭳ U05 FDM Gear System 26 (STL) ⭳	Print speaker notes 3D print STL files provided

Computer Lab

Topic	Format	Learning Aids	Preparation
DESIGNING GEARS IN CAD	CAD instruction	Educator-provided content*	Lesson plan
	Introduce formulas for determining gear specifications given tooth count and diameter. Teach students how to redesign 2D gear drawings as 3D models using photographs or old blueprints.		
WEEKLY ASSIGNMENT *Gear Systems*	Hands-on	Gear Systems assignment	Print handouts
	Students will begin designing a gear system of their own. Details for two project options are provided in the project description for *Gear Systems*. Use lab time to aid and advise students as needed, encouraging model complexity.		

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Assignment: Gear Systems

These assignments reinforce and extend the classroom learning for **Units 5 & 6**.

Deliverables	Requirements
OPTION 1: *Gear System (STL)*	1. Design a system that uses more than one gear to produce motion. 2. Consider the trade-offs between speed and force and document your design decisions. 3. Consider the tolerance and layer thickness capabilities of the 3D printer you'll use, and document design decisions related to those capabilities.
OPTION 2: *Da Vinci Machine (STL)*	In this assignment, you'll get inside the shoes of a great artist, inventor and engineer. 1. Find a da Vinci machine sketch and reproduce it using CAD. 2. Consider the ways in which 3D printing differs from Renaissance-era fabrication technologies and adjust the designs accordingly. 3. Consider the tolerance and layer thickness capabilities of the 3D printer you'll use, and document design decisions related to those capabilities.
DOCUMENTATION & PRESENTATION	Both options require documentation and a final presentation. Your presentation should include a video of your final product in action and should demonstrate your use of Design Thinking. As you work, be sure to address your problems, challenges and lessons learned. Include the following: **Material use:** What design challenges have you encountered as a result of your material? If you could have chosen another material, what would you have chosen? **Technology:** What design challenges have you encountered as a result of your 3D printing technology? If you had access to other fabrication technology, what would you have chosen? Why? **Wall thickness:** Have you encountered problems with thin areas in your model? Were any supporting parts affected? How did you fix this? **Details:** Does your design contain areas with small embossed or engraved features? Are they necessary for your design to function? Have you encountered issues with details getting lost? **Holes and Gaps:** Have you encountered any tiny holes or gaps? How did you fix this? **Scaling:** Have you been able to resolve some of your issues by increasing the scale of your model? Or have you had to significantly alter your design?

Unit 6: Gear Systems Part II

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW *Gear Systems*	Discussion Students will present their gear model from last week to a peer and exchange feedback.		
KINEMATIC MODELS	Lecture, discussion or activity Recommended resources: - Cornell University Brings Pieces of History Back to Life - http://goo.gl/826TLB - Kinematic Models Digital Library (Cornell University) - http://goo.gl/JvwuVU	Educator-provided content*	Lesson plan
CASE STUDY	Review one of these case studies with students to highlight more challenges and advantages of 3D printing gear systems.	Da Vinci case study (PPTX) ⤓ Gear System case study (PPTX) ⤓ Gear Ball case study (PPTX) ⤓	Print speaker notes

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Computer Lab

Topic	Format	Learning Aids	Preparation
WEEKLY ASSIGNMENT *Gear Systems*	Hands-on Students will improve upon the gear system they began designing last week and incorporate feedback from their peers. Use lab time to aid and advise students as needed, encouraging model complexity. Students will need to complete their models as homework if they don’t finish in class.		

Unit 7: Dynamic Surfaces and Chains

Learning Objectives

Upon completion of this unit, students will be able to:

1. Nest and orient 3D models on the build tray to conserve space and materials.
2. Make more space- and cost-efficient use of 3D printing technology.

Essential Questions

Use these questions to guide student understanding:

1. Why is material conservation important?
2. Why is space conservation important?

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW *Gear Systems*	Discussion		
	Students will present their gear models from last week to a peer and exchange feedback.		
DYNAMIC SURFACES	Lecture	Dynamic Surfaces (PPTX) ⭳	Various 3D printed dynamic surfaces supplies by the instructor, printed from the STLs provided by Stratasys
	Students will learn about 3D printing dynamic surfaces: arrays of connected surfaces in which the movement of one surface moves all other surfaces in a predictable way.		
NESTING	Lecture	Nesting (PPTX) ⭳	
	Students learn what nesting is and how it impacts the 3D printing process.		
MULTIPLIER	Case study	Multiplier Case Study (PPTX) ⭳	
	This case study demonstrates the principles of dynamic surfaces and provides an example for this week's assignment.		

Computer Lab

Topic	Format	Learning Aids	Preparation
MATERIAL BEHAVIOR	Discussion	Material spec sheet(s)	Print material spec sheets
	Provide material spec sheets for the material(s) available to your students. Discuss material properties and answer student questions. Spec sheets for Stratasys materials are available at http://www.stratasys.com/materials.		
RESOLUTION, TOLERANCE AND SUPPORT MATERIAL	Short demonstration	3D printed models	3D print models
	Students will learn 3D printing considerations for dynamic surfaces, like tolerance and support material removal. Show the resolution and tolerance capabilities of your 3D printer(s) using models you have 3D printed. Highlight the gaps between parts, layer lines, and any features that aid support removal.		
DYNAMIC SURFACES AND CHAINS	CAD instruction	Dynamic Surface (STL) ⭳	
	Keeping resolution, tolerance and support material removal in focus, demonstrate your approach to designing dynamic surfaces. Concentrate on CAD commands and features that will make your students most proficient at completing this week's assignment.		
WEEKLY ASSIGNMENT *Dynamic Surfaces and Chains*	Hands-on	Chains & Dynamic Surfaces assignment	
	Students will begin 3D modeling chains or dynamic surfaces. Details for two project options are provided in the project description for Dynamic Surfaces (PDF). Aid and advise as needed, encouraging model complexity.		

Assignment: Chains & Dynamic Surfaces

This assignment reinforces and extends classroom learning for **Unit 7**. Students will get hands on experience with nesting their designs to conserve space and material inside the 3D printer.

Deliverable	Description
OPTION 1: *3D Printed Chain*	1. Design a chain that can be printed within a cube. 2. The chain must be three times longer than the edges of the bounding box. For example, a 9 cm chain must fit inside a 3 x 3 x3 cm cube. 3. The piece must be produced in one print without assembly. 4. Document your design process.
OPTION 2: *3D Printed Mechanical Object*	1. Design a movable dynamic surface. 2. Nest your model on the print tray to conserve space and consider support removal in your design. 3. The piece must be produced in one print without assembly.
DOCUMENTATION & PRESENTATION	Your presentation should demonstrate use of Design Thinking. As you work, be sure to address your problems, challenges and lessons learned. Include the following: **Material use:** What design challenges have you encountered as a result of your material? If you could have chosen another material, what would you have chosen? **Technology:** What design challenges have you encountered as a result of your 3D printing technology? If you had access to other fabrication technology, what would you have chosen? Why? **Wall thickness:** Have you encountered problems with thin areas in your model? Were any supporting parts affected? How did you fix this? **Details:** Does your design contain areas with small embossed or engraved features? Are they necessary for your design to function? Have you encountered issues with details getting lost? **Holes and Gaps:** Have you encountered any tiny holes or gaps? How did you fix this? **Scaling:** Have you been able to resolve some of your issues by increasing the scale of your model? Or have you had to significantly alter your design?

Unit 8: The Future of Fabrication

Learning Objectives

Upon completion of this unit, students will be able to:

1. Explain the parts of a case study.
2. Identify a project for further study and analysis.

Essential Questions

Use these questions to guide student understanding:

1. What makes an application of 3D printing technology innovative rather than typical?
2. Can case studies that demonstrate innovative use of 3D printing teach us more than typical case studies?

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW *Dynamic Surfaces and Chains*	Discussion Students will present their dynamic surface or chain models from last week to a peer and exchange feedback.		
REVIEW	Lecture To prepare for next week's midterm exam, review course material with students.	Dynamic Surfaces (PPTX) ⤓	Prepare a review of course material
CASE STUDY ANALYSIS	Educator's preference To prepare for the assignment that begins this week, teach students how to analyze a case study.	Educator-provided content*	Lesson plan

Computer Lab

Topic	Format	Learning Aids	Preparation
FUTURE OF FABRICTION	Lecture	Future of Fabrication (PPTX) ⭳	Print speaker notes
	This presentation examines several novel uses of 3D printing technology, including one in-depth case study. For their case study assignment that begins this week, students should attempt to find similarly innovative uses of the technology to explore in-depth.		
CASE STUDY	Written assignment and presentation	Case Study assignment	Print project description
	Students will work in pairs to select a case study for analysis. More details are provided in the project description, Case Study Presentation (PDF)		
WEEKLY ASSIGNMENT *Dynamic Surfaces and Chains*	Hands-on	Chains & Dynamic Surfaces assignment	Print project description
	Students will refine their 3D models of dynamic surfaces or chains based on feedback from their peers. More details are provided in the project description for Dynamic Surfaces (PDF). Use lab time to aid and advise students as needed, encouraging model complexity.		

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Unit 9: Midterm Exam

Classroom

Topic	Format	Learning Aids	Preparation
WRITTEN TEST	Discussion	Question Bank	Prepare and print final exam.
CASE STUDY PRESENTATION	Student presentation One or more pairs of students present their case study findings.		

Computer Lab

Topic	Format	Learning Aids	Preparation
FINAL PROJECT *Proposal 2*	Hands-on Students will re-examine their final project proposal in light of what they've learned so far in this course.		

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Unit 10: 4D Printing

Learning Objectives

Upon completion of this unit, students will be able to:

1. Explain what 4D printing means and imagine its potential impact on the design process.

Essential Questions

Use these questions to guide student understanding:

1. Is 4D printing truly a novel concept?
2. Have products been produced through other manufacturing methods that make use of time in a similar way?

Classroom

Topic	Format	Learning Aids	Preparation
4D PRINTING	Lecture	4D Printing (PPTX) ⭳	
CASE STUDY PRESENTATION	Student presentation One or more pairs of students present their case study findings.		

Computer Lab

Topic	Format	Learning Aids	Preparation
FINAL PROJECT *Model Iteration*	Hands-on Students will continue to refine their 3D models for their final project. Use lab time to aid and advise students as needed, encouraging model complexity. Urge them to use information they have learned from their case study research and from other student presentations.		

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Unit 11: Parametric Design

Learning Objectives

Upon completion of this unit, students will be able to:

1. Hypothesize and debate about how parametric design is likely to impact the role of designers.

Essential Questions

Use these questions to guide student understanding:

1. Can non-professional “designers” be truly creative when designing parametrically?
2. Will parametric design and resulting mass customization be a passing fad or a permanent way of life?

Classroom

Topic	Format	Learning Aids	Preparation
PARAMETRIC DESIGN	Lecture	Parametric Design (PPTX) ⤓	Print speaker notes
CASE STUDY PRESENTATION	Student presentation One or more pairs of students present their case study findings.		

Computer Lab

Topic	Format	Learning Aids	Preparation
FINAL PROJECT *PRESENTATIONS*	Student presentations Students will give short presentations explaining how they've revised their final project proposal based on their re-examination.		
FINAL PROJECT *Model Iteration*	Hands-on Students will continue to refine their 3D models for their final project. Use lab time to aid and advise students as needed, encouraging model complexity. Encourage them to use information they have learned from their case study research or from other student presentations.		

Unit 12: Prototype Printing

Classroom

Topic	Format	Learning Aids	Preparation
CASE STUDY PRESENTATION	Discussion One or more pairs of students present their case study findings.		

Computer Lab

Topic	Format	Learning Aids	Preparation
FINAL PROJECT *Printing*	Hands-on Students will begin 3D printing their final project prototypes and use lab time to work on final projects with instructor guidance.		

* *If you have an amazing lesson plan you'd like to share with the Stratasys Education Community, tell us.*
If we add it to our curriculum, you'll be eligible to receive free FDM or PolyJet materials for your 3D printers.

Unit 13: Prototype Printing & Testing

Classroom

Topic	Format	Learning Aids	Preparation
CASE STUDY PRESENTATION	Discussion One or more pairs of students present their case study findings.		

Computer Lab

Topic	Format	Learning Aids	Preparation
FINAL PROJECT *Printing*	Hands-on Students will continue 3D printing and testing their final project models.		

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Unit 14: Final Presentations

Classroom

Topic	Format	Learning Aids	Preparation
CASE STUDY PRESENTATION	Student presentations Remaining students present their case study findings.		
FINAL PROJECT *Presentations*	Student presentations Students present their final projects.		
FINAL EXAM	Written test	Question Bank	Prepare and print final exam

Unit A: Sound Printing

Learning Objectives

Upon completion of this unit, students will be able to:

1. Explain how various characteristics such as wall thickness and tunnel architecture affect sound.
2. Design and 3D print a sound tunnel to amplify or distort sound from a mobile phone.

Classroom

Topic	Format	Learning Aids	Preparation
HOMEWORK REVIEW	Discussion		
SOUND PRINTING	Lecture Design and 3D print a sound tunnel that will direct sound from your mobile phone to increase its volume or distort it.	Sound Printing (PPTX) ⭳	Print speaker notes

Computer Lab

	Format	Learning Aids	Preparation
TWO-WEEK ASSIGNMENT *Sound Printing*	Hands-on Students will design and 3D print an object that will amplify sound from their cellphone. Use lab time to aid and advise students as needed, encouraging model complexity. Encourage them to use information they have learned from their case study research or from other student presentations.	Sound Printing assignment	

Assignment: Sound Printing

This assignment reinforces and extends classroom learning for **Unit A: Sound Printing**. Students will design and 3D print an object that will amplify sound from their cellphone.

Deliverable	Requirements
3D PRINTED AMPLIFIER	1. Measure your phone. 2. Decide where to put the amplifier. 3. Design the space that the sound travels through.
PRESENTATION & DOCUMENTATION	Your presentation should demonstrate use of Design Thinking. As you work, be sure to address your problems, challenges and lessons learned. Include the following: **Material use:** What design challenges have you encountered as a result of your material? If you could have chosen another material, what would you have chosen? **Technology:** What design challenges have you encountered as a result of your 3D printing technology? If you had access to other fabrication technology, what would you have chosen? Why? **Wall thickness:** Have you encountered problems with thin areas in your model? Were any supporting parts affected? How did you fix this? **Details:** Does your design contain areas with small embossed or engraved features? Are they necessary for your design to function? Have you encountered issues with details getting lost? **Holes and Gaps:** Have you encountered any tiny holes or gaps? How did you fix this? **Scaling:** Have you been able to resolve some of your issues by increasing the scale of your model? Or have you had to significantly alter your design?

Unit B: Fluid Dynamics

Classroom

Topic	Format	Learning Aids	Preparation
FLUID DYNAMICS	Educator's preference	Educator-provided content *	

Computer Lab

	Format	Learning Aids	Preparation
ASSIGNMENT	Educator's preference		Develop assignment
	Students will design and 3D print an object that will demonstrate the principles of fluid dynamics and gravity taught in class. Ask students to demonstrate the use of gravity to manipulate fluid movement. Use lab time to aid and advise students as needed, encouraging model complexity.		

* *If you have an amazing lesson plan you'd like to share with the Stratasys Education Community, tell us. If we add it to our curriculum, you'll be eligible to receive free FDM or PolyJet materials for your 3D printers.*

Unit C: Post-Processing

Classroom

Topic	Format	Learning Aids	Preparation
POST PROCESSING	Lecture	Post Processing (PPTX) ⤓	Bring examples of 3D printed models that have been post-processed.
	Students will learn techniques to make the most of models 3D printed with FDM technology or another technology that accepts post-processing.		

Computer Lab

Topic	Format	Learning Aids	Preparation
POST PROCESSING	Hands-on	Post Processing (PPTX) ⤓	
	Demonstrate post-processing tools selected and supplied by the educator and/or lab manager. Stratasys recommendations for post processing are included in the *Post Processing* presentation.		
ASSIGNMENT	Hands-on	Post Processing assignment	

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Assignment: Post-Processing

Students will implement one of the post-processing techniques they learned in **Unit C** on a model they previously 3D printed during the course.

Deliverables	Requirements
3D PRINTED OBJECT WITH POST-PROCESSING APPLIED	1. Select a model you created in a previous assignment that could benefit from post processing. 2. Take a before photo. 3. Apply one of the techniques from this week's lecture or another technique you find online. 4. Take an after photo. 5. Document the finishing process used.
DOCUMENTATION	Document your problems, challenges and lessons learned throughout the post-finishing process.

Unit D: Factory of Tomorrow

Classroom

Topic	Format	Learning Aids	Preparation
THE FACTORY OF TOMORROW	Discussion	Factory of Tomorrow (PPTX) ⭳	Print speaker notes.

Imagine the world after the Third Industrial Revolution. Discuss philosophy and ideas related to these questions: What will the real social impact be? What will factories look like in the future? How will the supply chain be different from how it is today? What new services may be offered to consumers? What will the role of service bureaus be?

Think about familiar services we use today (e.g., laundromats, copy centers) and consider how new services could be modeled after these. Also try to imagine entirely new service models.

Computer Lab

Topic	Format	Learning Aids	Preparation
WRITTEN ASSIGNMENT	Written assignment	Factory of Tomorrow assignment	

Students will continue to refine their 3D models for their final project. Use lab time to aid and advise students as needed, encouraging model complexity. Encourage them to use information they have learned from their case study research or from other student presentations.

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Assignment: Factory of Tomorrow

This assignment reinforces and extends the classroom learning for **Unit D**. Students will design a product with marketability in mind.

Deliverables	Requirements
3D PRINTED OBJECT OR STL	1. Use Design Thinking to identify a problem and generate a fresh idea to solve that problem. 2. Open a shop on ShapeWays with the goal of selling your product to 10 or more people outside your region. 3. Document your design process.
PRESENTATION & DOCUMENTATION	Your presentation should demonstrate use of Design Thinking. As you work, be sure to address your problems, challenges and lessons learned. Include the following: **Material use:** What design challenges have you encountered as a result of your material? If you could have chosen another material, what would you have chosen? **Technology:** What design challenges have you encountered as a result of your 3D printing technology? If you had access to other fabrication technology, what would you have chosen? Why? **Wall thickness:** Have you encountered problems with thin areas in your model? Were any supporting parts affected? How did you fix this? **Details:** Does your design contain areas with small embossed or engraved features? Are they necessary for your design to function? Have you encountered issues with details getting lost? **Holes and Gaps:** Have you encountered any tiny holes or gaps? How did you fix this? **Scaling:** Have you been able to resolve some of your issues by increasing the scale of your model? Or have you had to significantly alter your design?
WRITTEN ASSIGNMENT	Write a persuasive essay supporting your vision for the factory of tomorrow. Explain what you believe tomorrow's factory will look like and what its social, economic and environmental implications will be. Include research and cite at least three sources.

Unit E: Field Trip

Classroom

Topic	Format	Learning Aids	Preparation
FIELD TRIP	Scheduled activity		Arrange a visit to a traditional manufacturing setting or digital fabrication lab.

Computer Lab

Topic	Format	Learning Aids	Preparation
FINAL PROJECT *Printing*	Hands-on Students will continue to refine their 3D models for their final project. Use lab time to aid and advise students as needed, encouraging model complexity. Encourage them to use information they have learned from their case study research or from other student presentations.		

Unit F: Regulation & Carbon Footprint

Classroom

Topic	Format	Learning Aids	Preparation
HAZARDOUS WASTE DISPOSAL AND MANAGEMENT	Lecture	Legal, Ethical and Environmental Issues In 3D Manufacturing (PPTX) ⤓	Print speaker notes

Computer Lab

Topic	Format	Learning Aids	Preparation
WRITTEN ASSIGNMENT	Hands-on Students will explore ideas introduced in **Unit 8** in greater depth. **Instructions:** Write a descriptive essay about a product you could design to reduce your carbon footprint. You should consider not only the product itself but the fabrication process. Explain how parametric design would help you achieve this idea.		

Learning Aids

We provide the following tools to support classroom instruction and assignments. Everything is free. We just ask that you share your experience with us.

PowerPoint Presentation List (PPTX)

Find and download

- U01-01 Historical Review
- U01-02 From CAD to CAM
- U01-03 Inspirational Case Study
- U10-01 4D Printing
- U02-01 Intro to 3D Printing
- U02-02 3D Printing Technologies
- U03-01 What is a Mesh
- U03-02 Making by Sharing
- U04-01 Objet Studio 9
- U04-02 Catalyst Software
- U04-03 Insight Software
- U05-01 Gear Systems
- U05-02 Da Vinci Case Study
- U05-03 Gear Systems
- U05-04 Gear Ball Case Study
- U06-01 Multiplier Case Study
- U06-02 Dynamic Surfaces Case Study
- U08-01 Future Of Fabrication
- UA-01 Sound Printing
- UC-01 Post Processing
- UE-01 Legal Environmental Regulation

3D Model List (STL)

Find and download.

- U01 FDM Something That Moves Something
- U01 PolyJet Something That Moves Something
- U05 FDM Gear System 16
- U05 FDM Da Vinci
- U05 FDM Gear System 26
- U05 PolyJet Gear System 16
- U05 PolyJet Da Vinci
- U05 PolyJet Gear System 26
- U07 FDM Dynamic Surface
- U07 PolyJet Dynamic Surface

Major Projects

Case Study

Deliverables	Requirements
RESEARCH & ANALYSIS	1. Identify a project that has made innovative use of 3D printing. 2. Learn as much as possible about this project by gathering information from as many sources as possible (e.g., news, websites and interviews). 3. Analyze the case, making sure to answer the following questions: o What problem was being addressed? o Why was this technology chosen? o What other approaches were considered? o Did they choose the correct technology? o Would you recommend something different?
PRESENTATIONS	1. Prepare a presentation that presents your analysis in narrative form. 2. You may model it after case study presentations you've seen in class so far. 3. Try to make the presentation as engaging as possible and use multimedia to clarify and illustrate your main points.

Final Project

Goal

Design and 3D print something that moves something – a mechanical object that meets the requirements shown on the right. Give it meaning and try to .make the most of 3D printing's advantages.

Requirements

1. Your object must shift forces from one point to another.
2. Your object must be a closed system.
3. Your object must be created in a single 3D print with no assembly.
4. You must demonstrate thoughtful use of available 3D printers and materials.

Deliverables

Item	Format	Resources Needed	Dates
PROPOSAL 1	Sketch and presentation Using your understanding of CAD modeling and 3D printing thus far, sketch or 3D model an idea for your final project. When you have a clear project idea, give it a title and prepare a brief presentation that describes: a) your inspiration b) how it will work c) how you will make it d) what you expect to learn from the experience.		
PROPOSAL 2	STL and 3D printed models Prepare a presentation that re-examines your proposal in light of what you've learned in class, in labs and using CAD independently. Again, include: a) your inspiration b) how it will work c) how you will make it d) what you expect to learn from the experience.	3D printer, CAD, CAM	
HOMEWORK REVIEW	Discussion Present your progress to a peer. Ask: Am I applying Design Thinking? Are my inspiration and idea clear? Do you understand the direction of my project? What can be improved?		
3D PRINTED MODEL	Your final model will be evaluated based on how well it works, whether it meets the design challenge, and how well it meets the goals set forth in your proposal. More weight will be given to your process and your use of Design Thinking than to your final model.		

Item	Format	Resources Needed	Dates
DOCUMENTATION	Notes, photos, videos, screen shots and sketches	CAD, CAM	
	Document the development of your project throughout the semester, revising and building upon the information you presented in your initial proposal. Consider this documentation your notebook and reference it for your final presentation as well as for future projects. Be sure to address: **Material use:** What design challenges have you encountered as a result of your material? If you could have chosen another material, what would you have chosen? **Technology:** What design challenges have you encountered as a result of your 3D printing technology? If you had access to other fabrication technology, what would you have chosen? Why? **Wall thickness:** Have you encountered problems with thin areas in your model? Were any supporting parts affected? How did you fix this? **Details:** Does your design contain areas with small embossed or engraved features? Are they necessary for your design to function? Have you encountered issues with details getting lost? **Holes and Gaps:** Have you encountered any tiny holes or gaps? How did you fix this? **Scaling:** Have you been able to resolve some of your issues by increasing the scale of your model? Or have you had to significantly alter your design?		
FINAL PRESENTATION	PowerPoint or Poster Board		
	Your presentation should demonstrate your use of Design Thinking. Reference the documentation you kept throughout the semester, and be sure to address your problems and challenges and lessons learned throughout the process, including all of the points listed under “weekly documentation.”		

Assessment Tools

Suggested Course Grading Scheme

6%	First assignment – Making by Sharing
15%	Second assignment – Gear System
15%	Third assignment – Dynamic Surfaces
15%	Midterm exam
15%	Case study project
25%	Final Project
10%	Class participation

Suggested Project Assessments

Hands-on project assessment (except final project)

For hands-on projects in this course, we believe that the journey is much more important than the result. Therefore, we recommend the following assessment for these projects.

	Idea and documentation (75%)	Final model (25%)
EXCEEDS (5)	Documentation is complete and thorough Idea aspires to complexity and fully supports the design challenge Goal is clear, relevant and ambitious Idea makes excellent use of new information covered in class Learns from and fixes mistakes in innovative ways	Works well Demonstrates improvement over previous designs Exceeds the design challenge
MEETS (3)	Documentation is complete and thorough Idea is moderately complex and fully supports the design challenge Goal is clear and relevant Idea makes excellent use of new information covered in class Learns from mistakes and improves upon the model	Works moderately well Demonstrates improvement over previous designs Meets the design challenge
DOES NOT MEET (1)	Documentation is vague or incomplete Idea is simplistic or does not support the design challenge Goals are unclear or irrelevant Idea makes no use of new information covered in class Makes the same mistakes repeatedly without an effort to fix them	Doesn't work Demonstrates no improvement over previous designs Doesn't meet the design challenge

Case Study Presentation Assessment

	Content	Delivery
EXCEEDS (5)	Case study highlights a highly innovative application of 3D printing Students identify and understand all main issues Students demonstrate insightful and thorough analysis of the issues Proposed solutions are well reasoned and appropriate Research is thorough and well-documented	Multimedia is used to clarify and illustrate the main points Presentation captures audience attention Presentation is well-organized Presentation follows the recommended length and format
MEETS (3)	Case study highlights an innovative application of 3D printing Students identify and understand most of the main issues Students demonstrate insightful analysis of most issues Proposed solutions are well-reasoned and appropriate Research is thorough and well-documented	Multimedia is used to illustrate the main points Format is appropriate for the content Presentation captures audience attention Presentation is organized
DOES NOT MEET (1)	Case study highlights mundane use of 3D printing Students fail to identify the main issues of the case study Students fail to demonstrate thoughtful analysis of the issues Solutions are not appropriate or not proposed Research is incomplete	Multimedia loosely illustrates the main points Format does not suit the content Presentation does not capture audience attention Presentation lacks organization

Final Project Assessment

	Proposals (10%)	Presentation content (50%)	Presentation delivery (10%)	Final model (30%)
EXCEEDS (5)	Content is complete and thorough Idea aspires to complexity and fully supports the design challenge Goal is clear, relevant and ambitious Second proposal makes excellent use of new knowledge and concepts	Documentation is thorough and complete Design Thinking is put to excellent use Use of peer feedback is clearly evident Technology and materials are used innovatively Learns from and fixes mistakes in innovative ways	Multimedia is used to clarify and illustrate the main points Presentation captures audience attention Presentation is well-organized Presentation follows the recommended length and format	Works well Fully meets the design challenge Fully meets the goals outlined in the second proposal
MEETS (3)	Content is complete and thorough Idea is moderately complex and fully supports the design challenge Goal is clear and relevant Second proposal makes some use of new knowledge and concepts	Documentation is complete and thorough Design Thinking is evident Use of peer feedback is evident Technology and materials are used thoughtfully Learns from mistakes and improves upon the model	Multimedia is used to illustrate the main points Format is appropriate for the content Presentation captures audience attention Presentation is organized	Works, for the most part Meets the design challenge Meets the goals outlined in the second proposal
DOES NOT MEET (1)	Content is vague or incomplete Ideas are simplistic or do not support the design challenge Goals are unclear or irrelevant Second proposal makes no use of new knowledge or concepts	Documentation is sparse or incomplete Design Thinking is not apparent Use of peer feedback is not evident Technology and materials are used haphazardly Makes the same mistakes repeatedly with no effort to fix them	Multimedia loosely illustrates the main points Format does not suit the content Presentation does not capture audience attention Presentation lacks organization	Doesn't nearly work Doesn't nearly meet the design challenge Doesn't nearly meet the goals outlined in the proposal

Exam Question Bank

Because this course was built in a modular fashion allowing you to focus on topics that cater to your students' interests and fit within your yearly curriculum plan, this exam follows the same spirit. You may modify this test and choose questions relevant to units you have taught.

Unit 1: Introduction

Essay Questions

Compare the Third Industrial Revolution to the First Industrial Revolution. What are the differences and similarities?

Evaluator notes:

- *The **First** Industrial Revolution changed the fabrication process dramatically:*
  - *Faster fabrication*
  - *Cheaper fabrication*
  - *Collaborative manufacturing*
- *The **Third** Industrial Revolution:*
  - *Uses machines to manufacture custom products*
  - *Anyone can design and fabricate products*
  - *Anyone can operate 3D printers*
  - *3D printers can be used anywhere from factories to private homes – no size limitation*
  - *This has also lead to smaller scale factories (Normal Ears is one example)*
  - *We've returned to an era of personal fabrication*

Explain how technology shifts throughout history have made 3D printing possible.

Stalagmites and stalactites are natural products, formed by an additive process. Explain the resemblance to the 3D printing manufacturing method.

Explain how the designer's role has evolved over time. How it is likely to change as we move toward mass customization?

Multiple-Choice Questions

Which of the following best describes Design Thinking?

A. A process that progresses linearly from empathy to testing
B. A process that progresses non-linearly from ideation to testing and production
C. A process that cycles sequentially through repeatable steps
D. A process for analyzing the success of a product

Which of the following is not a design consideration for 3D printing?

A. Material
B. Tolerance
C. Size of build tray
D. CAD software

The evolution of 3D printers is similar to the evolution of personal computers is what way(s)? Select all correct answers.

A. Both began as professional tools that eventually expanded to personal use
B. Both grew more accessible over time
C. Both became cheaper due to mass production
D. Both were revolutionary products

In what way(s) did 3D printing contribute to the reemergence of personal fabrication? Select all correct answers.

A. It answered the innate human need to create
B. It encouraged design sharing and collaborative learning
C. It replaced all other fabrication methods
D. It made design available and easy for more people

What Neolithic Age characteristic reappeared as a trend during the Third Industrial Revolution?

A. Mass production
B. Additive manufacturing
C. Personal fabrication
D. None of the above

Which of the following are reduced with personal fabrication?

A. Production expenses
B. Carbon footprint
C. Shipping costs
D. Manual labor

Carving, drilling, milling and chiseling are all examples of what?

A. Additive manufacturing
B. Subtractive manufacturing
C. Cutting
D. Forming

Which of the following crafts are more likely to use cutting as a fabrication method? Select all correct answers.

A. Woodcraft
B. Fur and leather craft
C. 3D modeling
D. All crafts use cutting as a fabrication methods

Glass blowing is an example of what manufacturing method?

A. Additive manufacturing
B. Subtractive manufacturing
C. Cutting
D. Forming

Which of the following is NOT an example of additive manufacturing?

A. Electron binder jetting
B. Electron beam melting
C. Fused-deposition-modeling
D. Lost-wax casting

Unit 2: Introduction to 3D Printing

Essay Questions

Explain what design freedom means and how 3D printing contributes to it.

Which technology would provide the best basis for food printing? Why?

Choose two technologies and describe how they work.

- Laser melting (LM, DLMS)
- Fused deposition modeling (FDM)
- Electron beam melting (EBM)
- Electron binder jetting (BJ)
- Stereolithography (SL, SLA)
- Material jetting (MJ, DOD)
- Photopolymer jetting (PolyJet)
- Selective laser sintering (SLS)
- Digital materials

Multiple-Choice Questions

What purpose does support material serve in 3D printing?

A. It increases the durability of the final product
B. It allows easier assembly and post-processing
C. It reduces waste
D. It supports layers as they are printed, functioning as scaffolding

Which of the following technologies is capable of printing metal?

A. Laser melting (LM)
B. Fused deposition modeling (FDM)
C. Electron beam melting (EBM)
D. Electron binder jetting (BJ)
E. Stereolithography (SL, SLA)
F. Material jetting (MJ, DOD)
G. Photopolymer jetting (PolyJet)

Which of the following technologies build parts through melting?

A. Laser melting (LM)
B. Fused deposition modeling (FDM)
C. Electron beam melting (EBM)
D. Electron binder jetting (BJ)
E. Stereolithography (SL, SLA)
F. Material jetting (MJ, DOD)
G. Photopolymer jetting (PolyJet)

Which of the following technologies build parts in engineering plastics?

A. Laser melting (LM)
B. Fused deposition modeling (FDM)
C. Electron beam melting (EBM)
D. Electron binder jetting (BJ)
E. Stereolithography (SL, SLA)
F. Material jetting (MJ, DOD)
G. Photopolymer jetting (PolyJet)

Which technology prints with Digital Materials?

A. Laser melting (LM)
B. Fused deposition modeling (FDM)
C. Electron beam melting (EBM)
D. Electron binder jetting (BJ)
E. Stereolithography (SL, SLA)
F. Material jetting (MJ, DOD)
G. Photopolymer jetting (PolyJet)

What considerations must you make when choosing a 3D printing technology?

A. Material
B. Durability
C. Melting point
D. Surface finish
E. Focus group input
F. Time
G. Detail
H. Application

Unit 3: What is a Mesh?

Essay Questions

Explain the following: “A mesh can never be smooth.”

Describe the relationship between resolution and mesh smoothness.

Describe the relationship between mesh smoothness and file size.

What can be learned by studying the designs of others?

Multiple-Choice Questions

Which term below describes a unique location in Euclidean space that has no dimensional attributes?

A. Mesh
B. Point
C. Surface
D. Line

Which of the following is a two-dimensional shape?

A. Point
B. Line
C. Surface
D. Polygon

Every mesh is a polysurface, but not every polysurface is a mesh. True or false?

A. True
B. False

What is a watertight mesh?

A. A mesh that will hold water
B. A mesh with no holes, cracks or missing features (surfaces, polygons, lines or points)
C. A mesh that was designed to float
D. All of the above

What type of mesh makes the smoothest model?

A. High polygon density
B. Smaller polygons
C. Higher resolution
D. All of the above

For faster printing, your mesh should be

A. Lower resolution
B. Smaller polygons
C. Fewer polygons
D. None of these

Unit 4: Ctrl+P

Essay Questions

Describe the advantages of designing an object using 3D software instead of 2D software.

Describe the advantages of 2D software over hand sketches.

Explain the role of CAM software in the printing process. Why is it needed?

Multiple-Choice Questions

Which of the following describes CAD advantages over freehand drawing?

A. Higher design accuracy
B. Reduced need for measuring tools
C. Better design reuse capabilities
D. No design limitations

What was the storage medium on which manufacturing commands were encoded in NC machines?

A. Standard RAM sticks
B. Mini SD memory sticks
C. Metal plates
D. Cardboard slates

Why would you need to repair your mesh?

A. A mesh with holes will not print correctly
B. A mesh with holes will damage the 3D printer
C. A mesh with holes will double the material use
D. A mesh with holes will print a faulty part

Units 5 & 6: Closed Gear Systems

Essay Questions

Describe the unique considerations involved when designing a gear system for 3D printing.

Multiple-Choice Questions

Two or more gears working in tandem are called what?

A. Torque
B. Cog
C. Rack
D. Transmission

What are the advantage(s) of using gear systems?

A. Gear teeth prevent slippage
B. Few elements can create great force
C. Decreased power creates more force
D. Gear systems are easy to design and manufacture

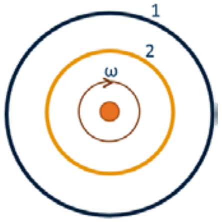
Force transmitted from a small gear diameter to a larger gear diameter is

A. Increased
B. Decreased
C. Stays the same
D. None of the above

In Spur gear systems, the tooth profile is

A. inclined to the axis of rotation.
B. vertical to the axis of rotation.
C. parallel to the axis of rotation.
D. None of these

If two discs are fixed by an axis, their radial velocity and acceleration is equal.



A. True
B. False

What important element must we consider when re-scaling a gear system design?

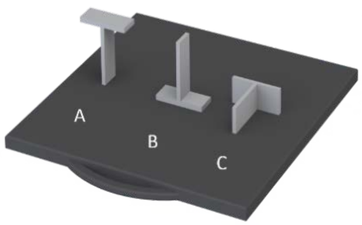
A. Space between the elements
B. Recommended minimal element thickness
C. Removal of support material is still possible
D. None of the above

Unit 7: Dynamic Surfaces and Chains

Essay Questions

Describe the making process of a dynamic surface. Include the four major phases (define, idea, prototype and production) in your description.

The image below shows three optional part orientations. Which orientation is most preferable to your opinion? Relate to printing speed, amount of support material needed and highest pack-density.



Multiple-Choice Questions

What dynamic surfaces can be found in a classic SLR camera?

A. Lens
B. Shutter
C. Aperture adjuster
D. Film

Which of the following material attributes may present a problem in dynamic surface designing?

A. Hardness
B. Elasticity
C. Opacity
D. Smoothness

What does the term “tolerance” refer to when designing dynamic surfaces?

A. Material durability
B. The space between connected parts, designed for supported materials
C. The friction and resistance between connected parts
D. The dynamic surface design complexity

Which of the following parameters must be considered before the design phase of a dynamic surface? Select all correct answers.

A. Tolerance
B. Element size
C. Friction
D. Minimum thickness
E. Support material removal
F. Positioning

A dynamic surface is an array of connected surfaces that produces a mechanical effect; the movement of one surface causes predictable movement of the others.

A. True
B. False

Which of the following are basic elements of 2D nesting? Select all correct answers.

A. Part orientation
B. Part combinations
C. Spacing between parts
D. Material selection

Which of the following are benefits of proper nesting and positioning? Select all correct answers.

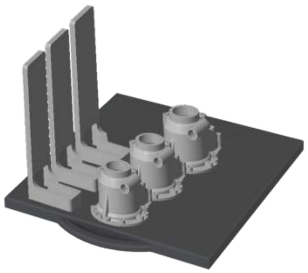
A. Reduced material waste
B. Reduced energy usage due to shorter print-head travel
C. Sharper details and smoother surface finish
D. Increased yield of parts per print job

Part orientation can affect its strength. True or false?

A. True
B. False

Examine the image below. What would you do to improve the nesting layout ad shorten print time?

A. Print tall parts and short parts separately
B. Rotate tall parts to shorten Z axis height and reduce height differences between two part types
C. Align all 6 parts to one row to reduce print-head travel time
D. Increase spacing between parts



Units 8-11: The Future of Fabrication

Essay Questions

Briefly describe the main stages along 3D printing technology evolution. How did the applications of the 3D printing technology evolve since it was first introduced to humanity?

Describe the concept of self-assembly and how it relates to 3D printing.

Multiple-Choice Questions

The lesson presented a futuristic project for printing structures on the face of the moon. What element functions as support material for the printing of these structures?

A. Lunar sand sprayed with binding material
B. Carbon fiber scaffoldings
C. Inflatable structure
D. No support material is required

What is the part of 3D printing in tissue engineering?

A. Printing a live tissue
B. Prototyping the tissue
C. Simulating the tissue function
D. Printing artificial scaffoldings to grow the tissue on

Which attribute of 3D printing may become an advantage over other fabrication methods for printing fully functional electronic devices? Select all correct answers.

A. The ability to easily interlock different parts
B. The ability to print multiple materials
C. Printing accuracy
D. Printing speed

The case study presented "Genie" - an experimental food printer. What are the advantages of "printing" dry edible ingredients over using wet mixtures and pastes?

A. Easier machine cleaning and maintenance
B. Dry ingredients shelf-life is longer than wet ingredients
C. Wet ingredients weigh more, and shipping costs increase
D. Dry ingredients packaging is simpler and cheaper

Multiple-Choice Questions

In 4D printing, what is the fourth dimension?

A. Space
B. Movement
C. Time
D. Material

What inspired the team at the MIT self-assembly lab to conceive the Autonomous Mass Assembly concept?

A. The natural growth of viruses
B. Japanese architecture
C. Islamic patterns in traditional ornaments
D. The movie "Avatar"

Which of the following are possible applications of 4D printing? Select all correct answers.

A. Smart water pipes
B. Self-assembled structures
C. Ready-made electronic devices
D. Superior sound systems

What activating energies are used in the 4D products presented in the lesson?

A. Heat
B. Water
C. Microwave
D. Sound-waves

Unit 13: Factory of Tomorrow

Essay Questions

Which of the business models that were described in the lesson, are likely to prosper to your opinion? Explain why.

Multiple-Choice Questions

What part does the customer play in democratized industries? (Local motors model)

A. The customer designs his car independently
B. The customer only buys the end product
C. The customer expresses his wishes and the professional team customizes executes
D. The customer manages and funds the project

What is the concept behind "Independent industrial hubs"? (e.g., 3D hubs)

A. Buy a 3D printer and do it yourself
B. Connect to professionals and create your own product
C. Rent your private 3D printer to others
D. Make your 3D printer profitable by offer your 3D printing services to others

What are the advantages of professional industrial hubs (e.g., Shapeways and Redeye) over independent industrial hubs (e.g., 3D hubs)? Select all correct answers.

A. Professional industrial hubs are more capable of manufacturing complex designs
B. Professional industrial hubs work as a network and use a uniform range of high-quality materials and machinery
C. Professional industrial hubs are oriented toward mass production
D. Professional industrial hubs implement quality assurance procedures

Which of the following sentences are correct regarding the Shenzhai model (Mass production of replicas)? Select all correct answers.

A. Shenzhai are collaborative manufacturing groups that include micro entrepreneurs and technical specialists
B. Shenzhai manufacturing groups only replicate well-known products
C. Shenzhai manufacturing groups replicate, re-design, improve and customize well-known products
D. Shenzhai manufacturing groups strive to provide low-cost products to the common people of the world

Unit A: Sound Printing

Essay Question

Describe the different considerations a loudspeaker designer may have, while designing a 3D printed sound device.

Multiple-Choice Questions

As a sound wave length grows, the sound tone becomes

A. Sharper
B. Higher
C. Lower
D. Louder

As a sound wave amplitude grows higher, the sound tone becomes

A. Sharper
B. Higher
C. Lower
D. Louder

Which of the following are typical sound wave behaviors? Select all correct answers.

A. Transmission
B. Stagnation
C. Reflection
D. Absorption

In loudspeaker design, what is the purpose of sealing the loudspeaker cabinet?

A. Block rear sound waves from reaching the listener’s ear
B. Naturally amplify sound waves
C. Preventing dust and other elements that effect sound quality
D. Protecting the device from physical damage

Unit B: Fluid Dynamics

To be developed by the course lecturer.

Unit C: Post Processing

Essay Question

Describe the basic FDM post processing workflow.

Multiple-Choice Questions

Which of the following are achieved by post printing processing? Select all correct answers.

A. Smoother feel
B. Higher durability
C. Antimicrobial resistance
D. Color

What is the reason most 3D printed products do not have a smooth finish after coming out of the printer's tray?

A. Printing file size and model resolution
B. The layering fabrication method
C. The material attributes
D. The interaction with support materials

Which of the following are post processes that can be applied on 3D printed objects?

A. Sand paper polishing
B. Lacquering
C. Metal coating
D. Thermal treatment

What does Distress and Patina post processing aim to achieve?

A. Product smoothness
B. Product sturdiness
C. Glossy finishing
D. Antique/vintage look and feel

Unit E: 3D Manufacturing Regulations and Carbon Footprint

Essay Question

Describe one ethical dilemma related to bio-printing of artificial organs.

Multiple-Choice Questions

According to the UC Berkley case study, what is the most effective way to reduce 3D printer's carbon foot print?

A. Reduce amount of printed material
B. Reduce usage of energy
C. Develop toxin-free materials
D. Limit the number of 3D printers

How can we reduce printer run time? Select all correct answers.

A. Prefer single materials printing upon multiple material printing
B. Print hollow parts rather than solid
C. Orient parts for the fastest printing
D. Fill the printer bed with multiple parts

Which of the following represent a legal challenge, related to the inclining use of 3D printers?

A. Counterfeiting
B. Unregistered weapons distribution
C. Personal fabrication of spare parts
D. Design rights violations

What are the positive environmental effects of 3D printing, in comparison to traditional fabrication methods? Select all correct answers.

A. Production is done closer to the consumer, reducing shipping carbon foot-print
B. 3D printing uses less support material, thus produces less waste
C. 3D printing reduces the need for packaging
D. 3D printing of spare parts increases a products sustainability and enables more moderate consumption patterns

Credits

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