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

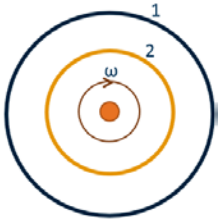
Force transmitted from a small gear diameter to a larger gear diameter is

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?

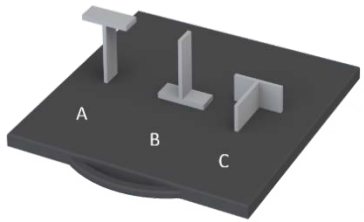
A. Space between the elements
B. Recommended minimal element thickness
C. Removal of support material is still possible
D. None of the above

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.

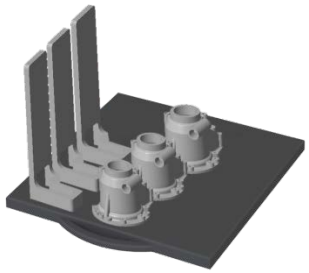
A. Reduced material waste
B. Reduced energy usage due to shorter print-head travel
C. Sharper details and smoother surface finish
D. Increased yield of parts per print job

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



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