IME 100 Interdisciplinary Design and Manufacturing Introduction to Additive Manufacturing Processes

Abishek Balsamy Kamaraj
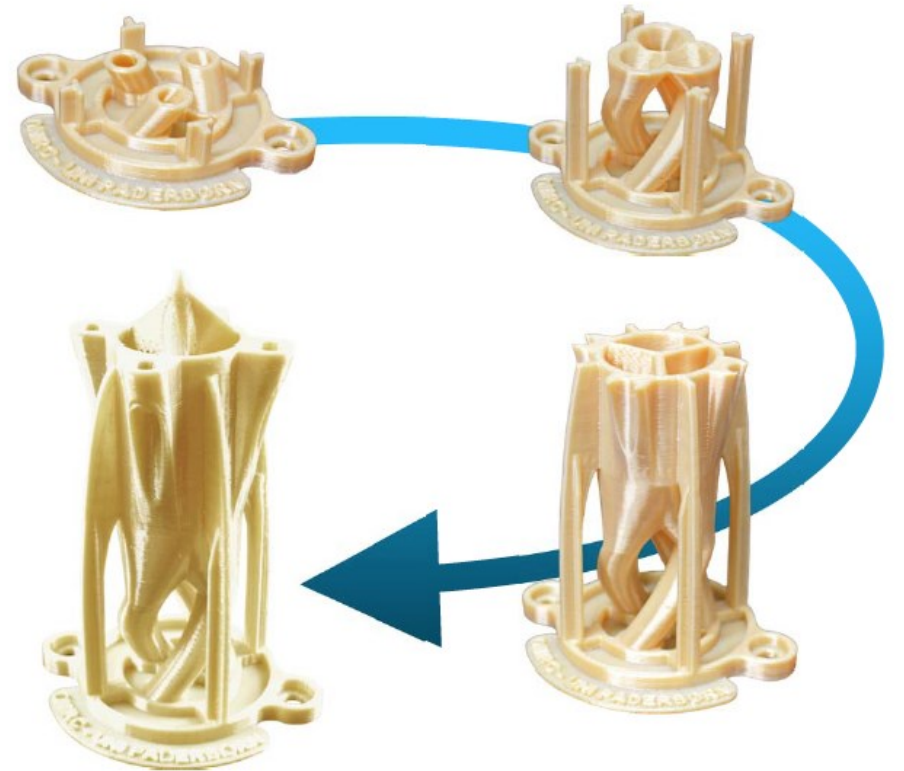
Summer 2022

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General Announcements

- Midterm Grades Posted
    - Check the **estimated final grade** column for the more updated feedback
- Coasters are due Friday!
    - Any questions?

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Additive Manufacturing

Using additive manufacturing technology, three-dimensional solid objects of virtually any shape can be made from a digital model
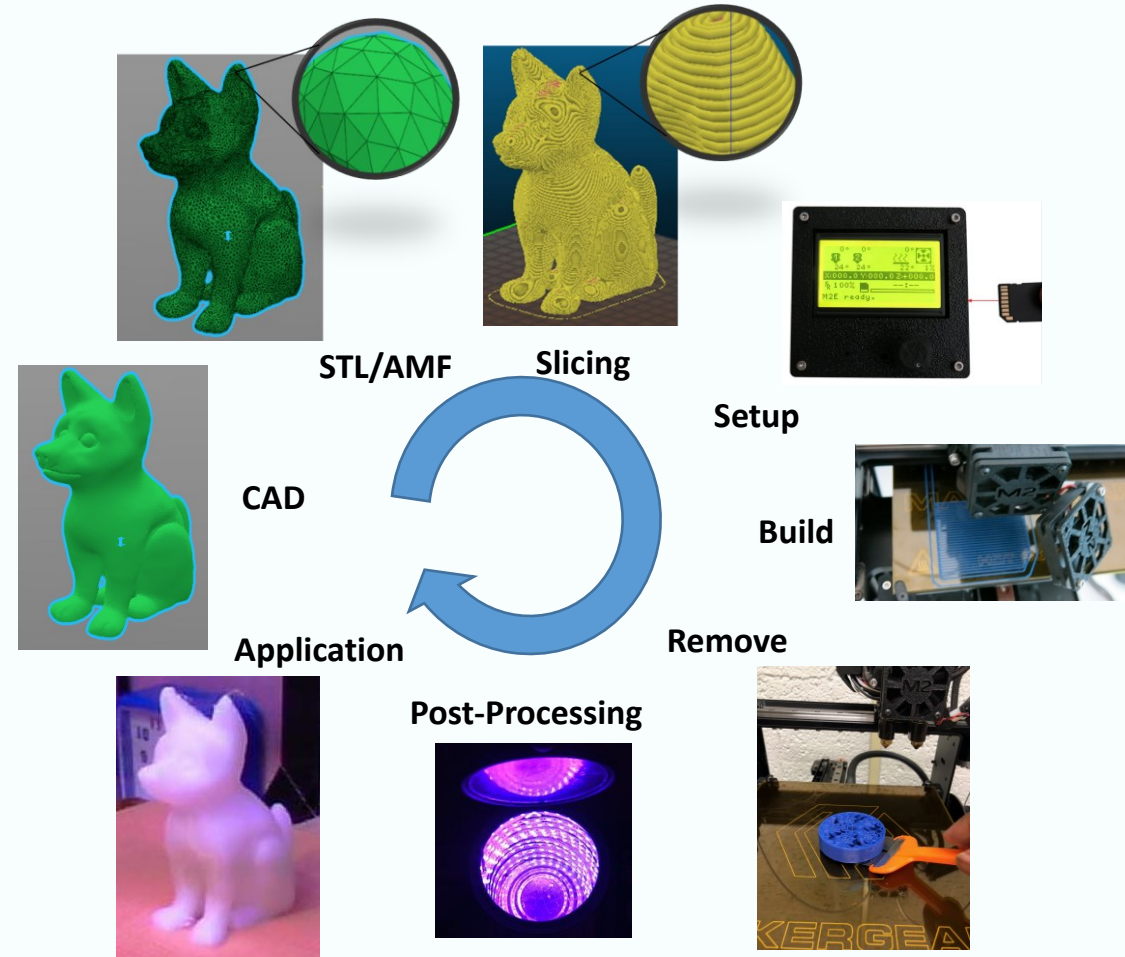
- Additive manufacturing (AM) is the process of **joining materials** to make parts from **3D model data**, usually **layer upon layer**, as opposed to subtractive manufacturing and formative manufacturing methodologies.

- AM has more than 30-year history for plastic objects.

- The capacity to make metal objects relevant to the engineered products and high-tech industries has been around since 1995

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Additive Manufacturing Production Cycle

STL/AMF

Slicing

Setup

CAD

Build

Application

Remove

Post-Processing

Additive Manufacturing Process Flow: CAD → STL/AMF → Slicing → Setup → Build (Print) → Remove → Post-Processing → Application

STL file source: www.thingiverse.com/thing:38493

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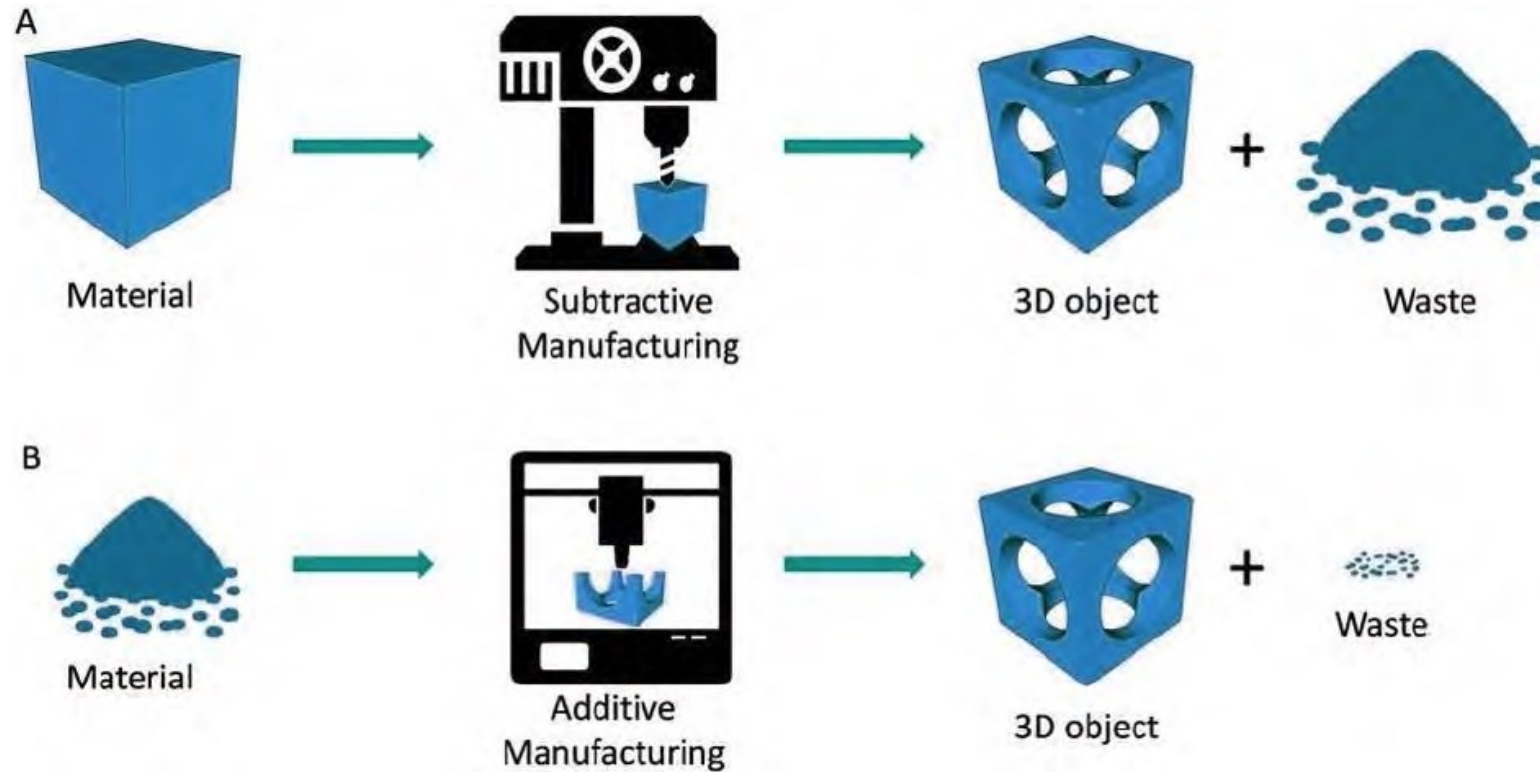
Additive Manufacturing vs. Subtractive Manufacturing

Figure – Additive vs. Subtractive Manufacturing. From *Additive Manufacturing The Good, the Bad, the Ugly* by Penn State University, CIMP-3D.

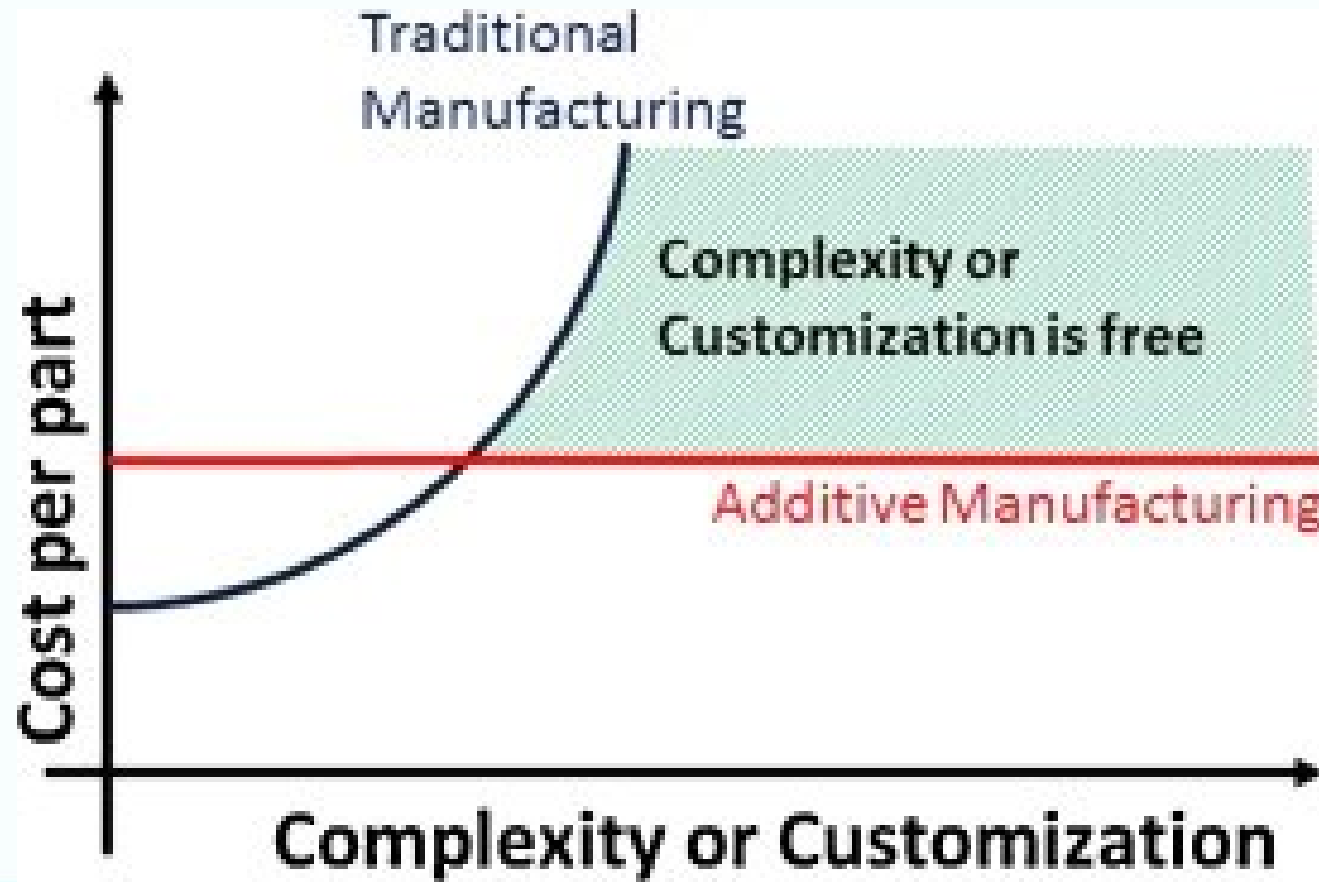Kettering University

Benefits of AM

Figure – Values and Scale. From *Making sense of 3-D printing: Creating a map of additive manufacturing products and services* by B. Conner, et all (October 2014).

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Disadvantages of AM
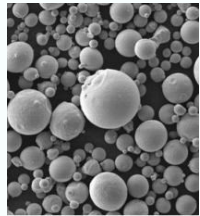

Speed

Scale

Material Capabilities

Cost

Reliability

Figure – Additive vs. Subtractive Manufacturing. From *Additive Manufacturing The Good, the Bad, the Ugly,* by Penn State University, CIMP-3D.

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Additive Manufacturing Materials

Material Forms / States
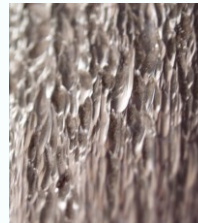
Powder

Powder courtesy of US-nano

Liquid

Sheet

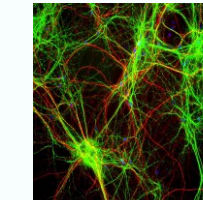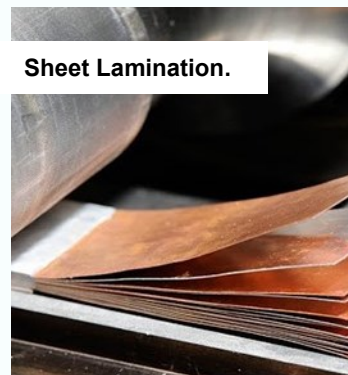Filament

Materials Commonly Used

Plastic

Glass
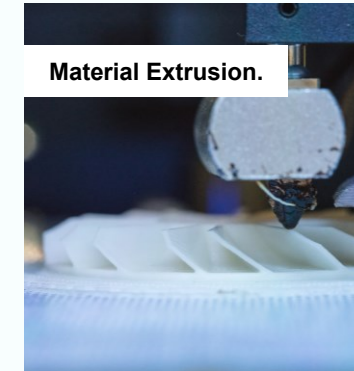
Metal

Paper

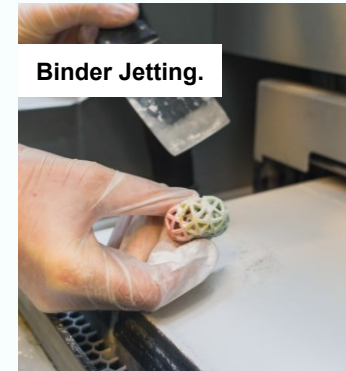Composite

Living Cells

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Additive Manufacturing Technologies

Vat Photopolymerization.

Material Jetting.

Binder Jetting.

Material Extrusion.

Sheet Lamination.

Powder Bed Fusion.

Directed Energy Deposition.
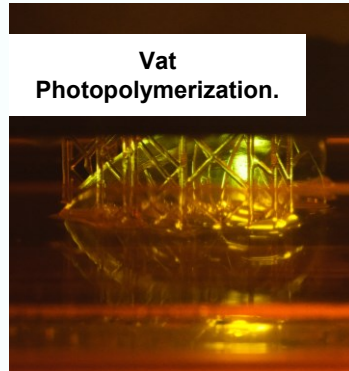
Material Extrusion Technology

- Most common, larger number of open-source development communities
- Various engineering polymers can be used
- In general, the polymer is in the form of a filament
- Usually requires a support structure for overhanging geometries

Material extrusion is defined as:

"an additive manufacturing process in which material is selectively dispensed through a nozzle or orifice."
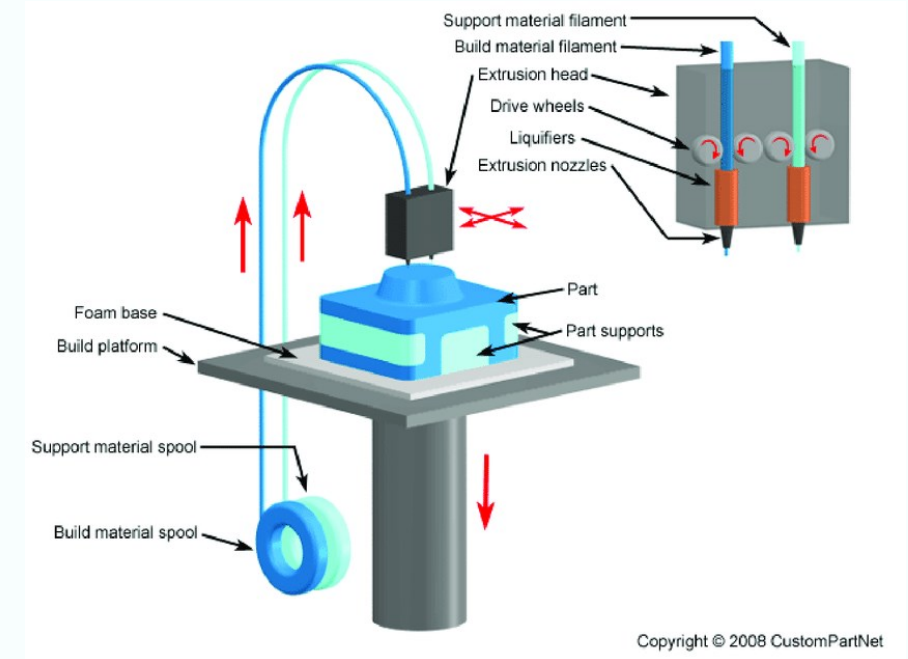
Figure: Fused Disposition Modeling, courtesy of Custom PartNet

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Demonstration of Material Extrusion Process

CLICK TO WATCH
FDM Printer

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Powder Bed Fusion Technology

- Similar to polymer powder bed fusion (laser + powder bed)
- Use metal powder vs. polymer powder
- "Melting" vs. sintering
- Melting of metal requires the use of support structures
- Final parts need significant post processing
- EBAM uses a electron-beam instead of a laser

Powder bed fusion is defined as:

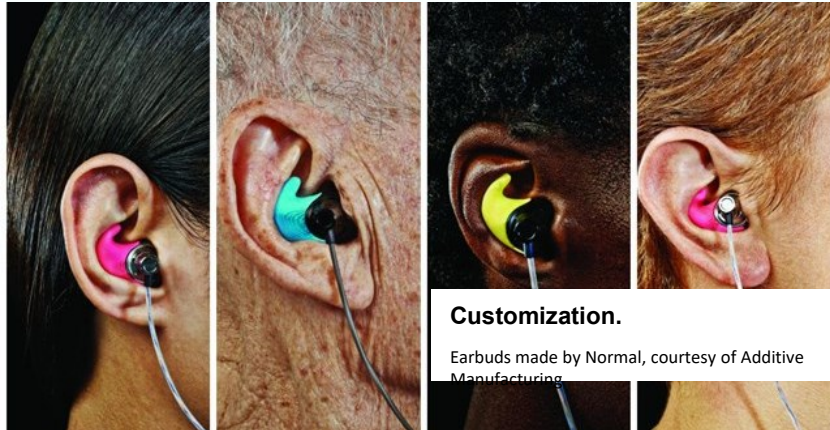> **"an additive manufacturing process in which thermal energy selectively fuses regions of a powder bed."**
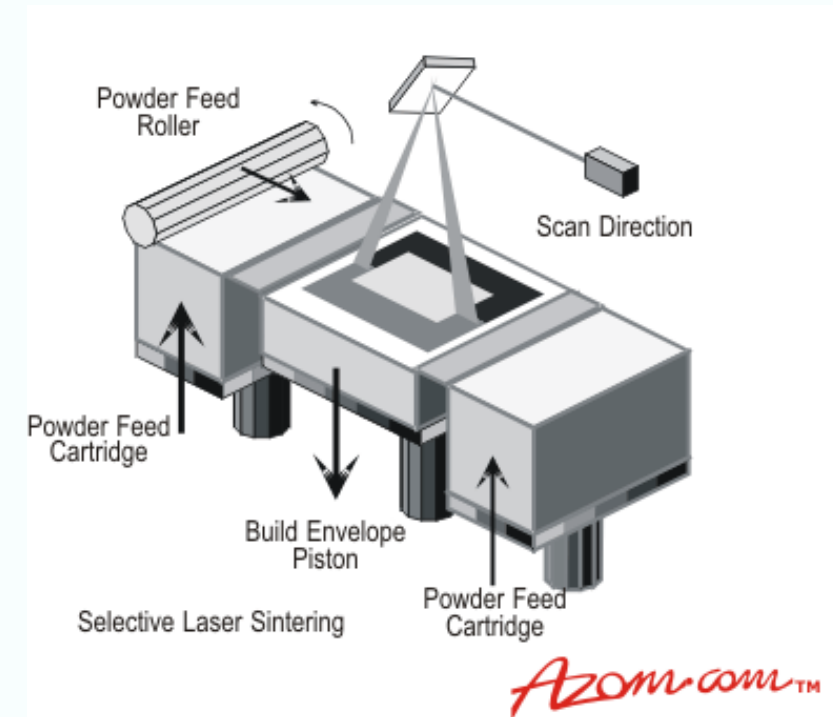
Demonstration of Powder Bed Fusion Process

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Examples of Additive Manufacturing in Industry

Customization.

Earbuds made by Normal, courtesy of Additive Manufacturing

Functional Topologies.

The Futurecraft 4D by Adidas, courtesy of 3D Natives

Part Consolidation.

Turning a 17-component into a single 3D printed piece, courtesy of NAVAIR Lakehurst, Penn State University

Light Weighting.

Seat bracket by GE, 40% lighter, courtesy of Wired

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Examples of Additive Manufacturing in Industry

Material Substitution.

Wheel carriers, courtesy of Renishaw

Structural Optimization.

3D Printed Metal Bridge, courtesy of MX3D

Performance Optimization.

Fuel Nozzle, courtesy of GE

Medical Customization.

Medical Equipment, courtesy of 3dprintingindustry

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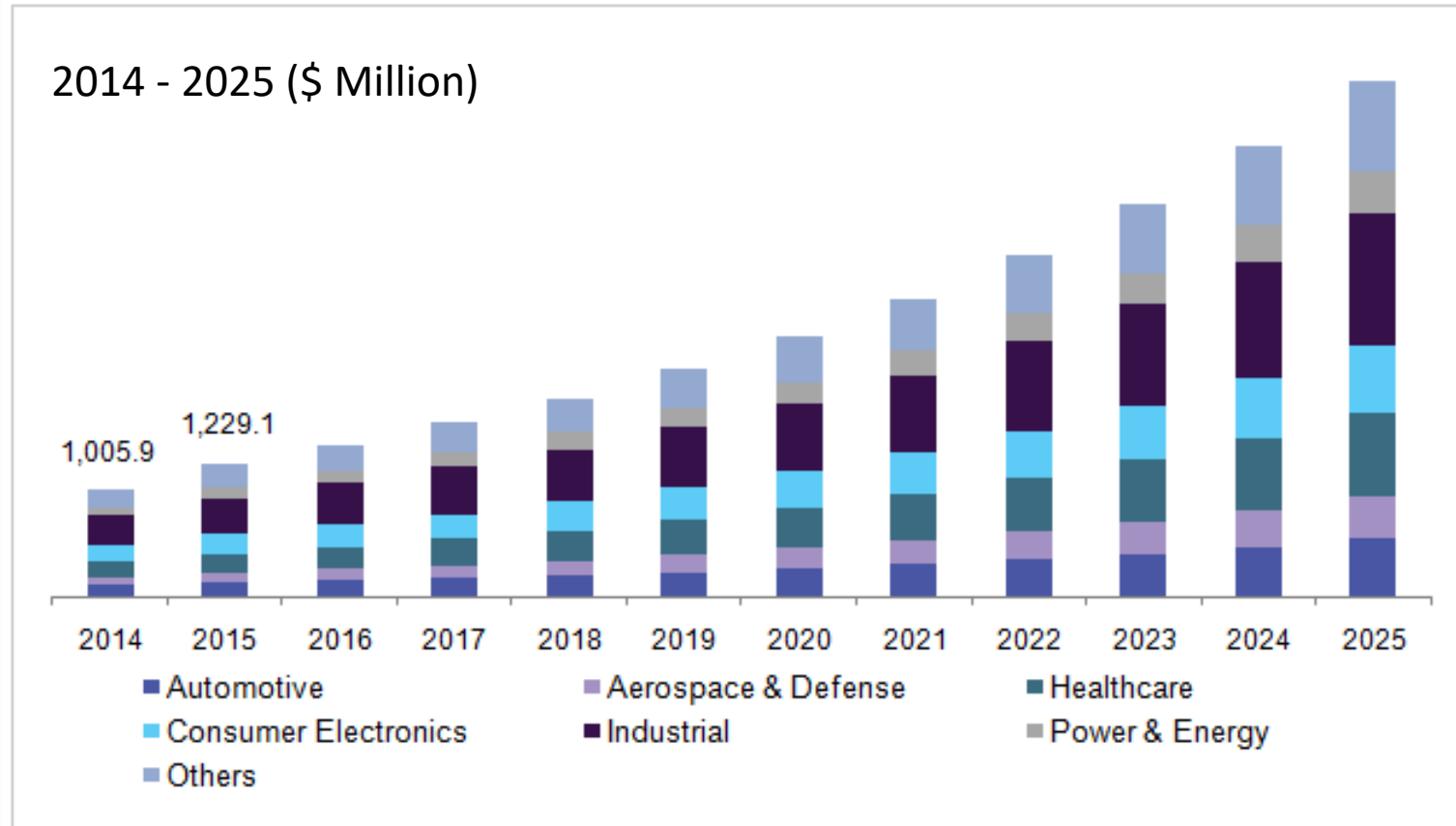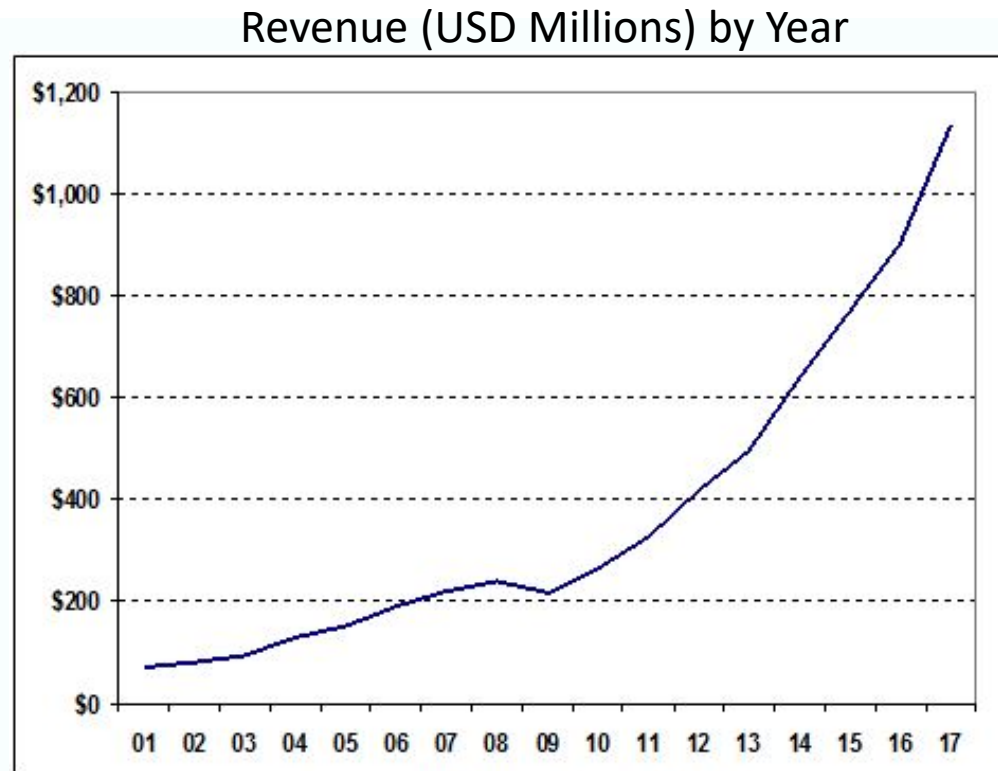
U.S. 3D Printing Market by Vertical,

Figure – U.S 3D printing market by vertical, 2014-2025 (USD Million). From *3D Printing (3DP) Market Analysis By Printer Type (Desktop, Industrial), By Technology, By Software (Design, Inspection, Printer, Scanning), By Application, By Vertical, By Region, and Segment Forecasts, 2018 – 2025.* From Grand View Research (July 2017).
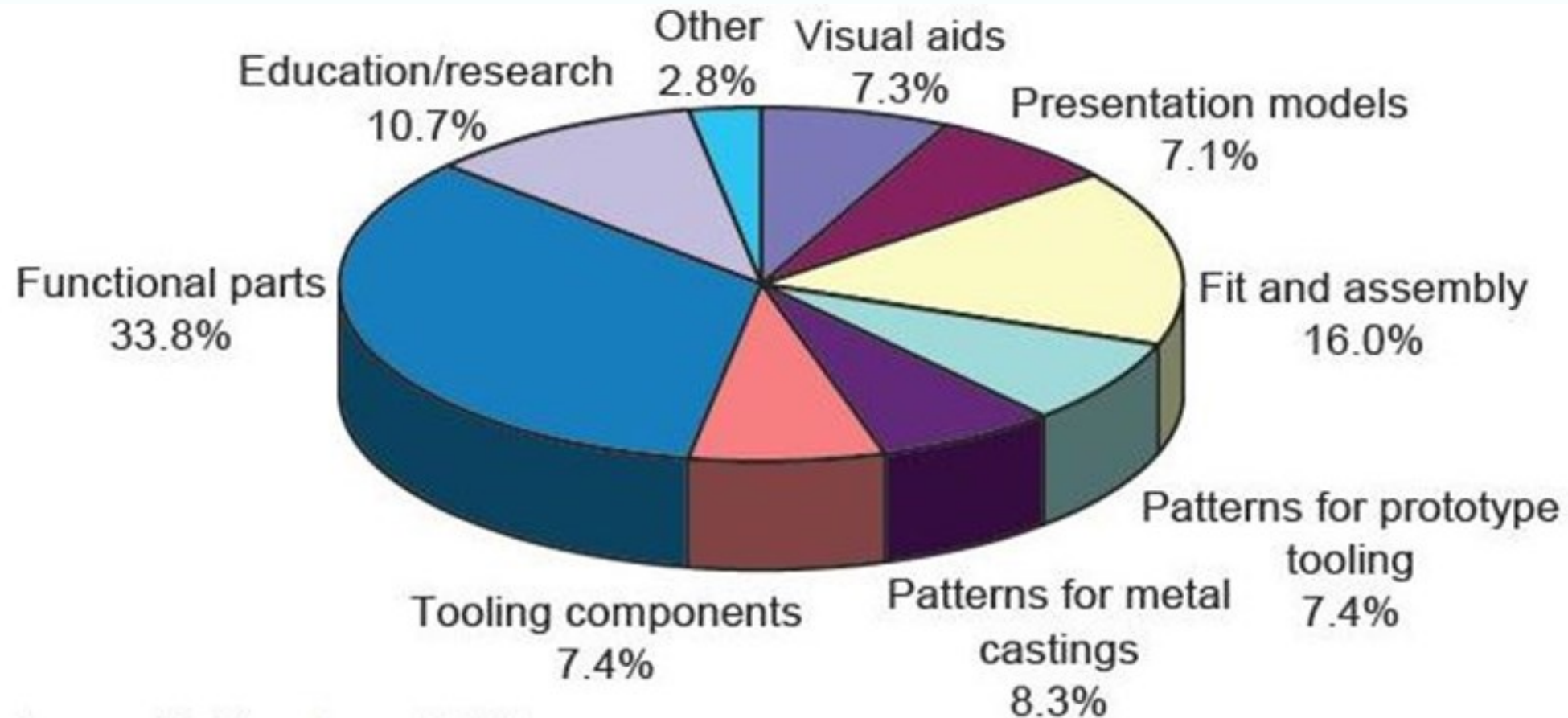
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Growth Trend in AM

Revenue (USD Millions) by Year

Source: Wohlers Report 2018

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How Organizations Are Using Industrial AM

Source: Wohlers Report 2017

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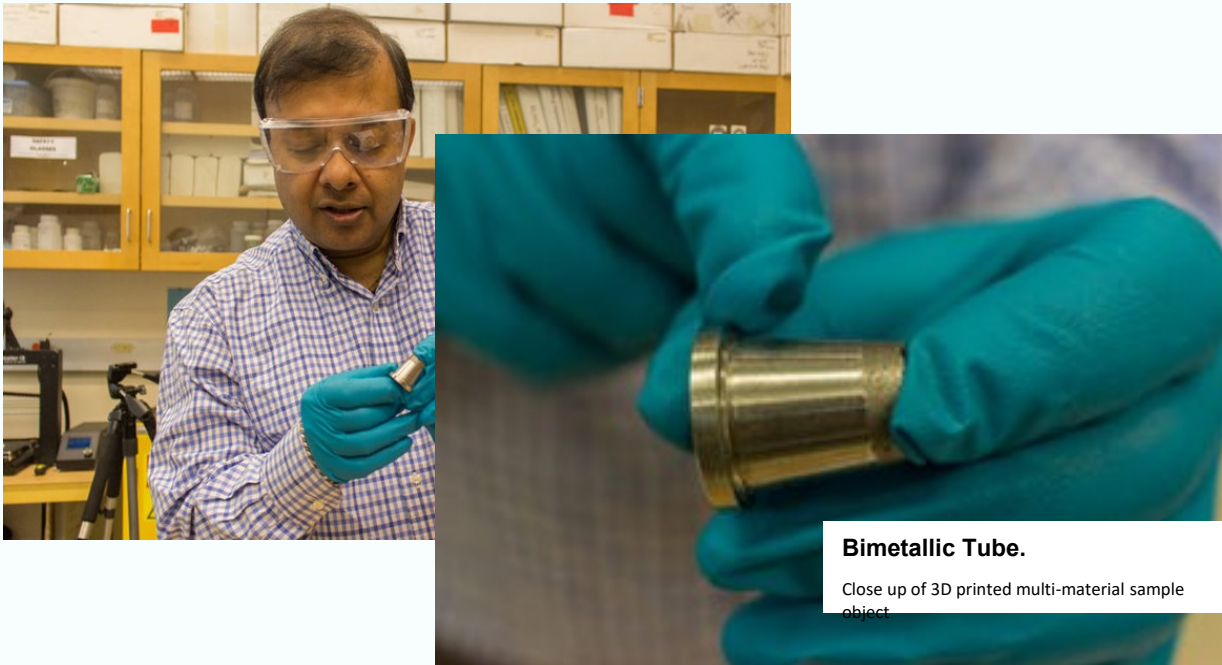# Future AM Applications

Bio-medical

Organs.

Bone and Cartilage.
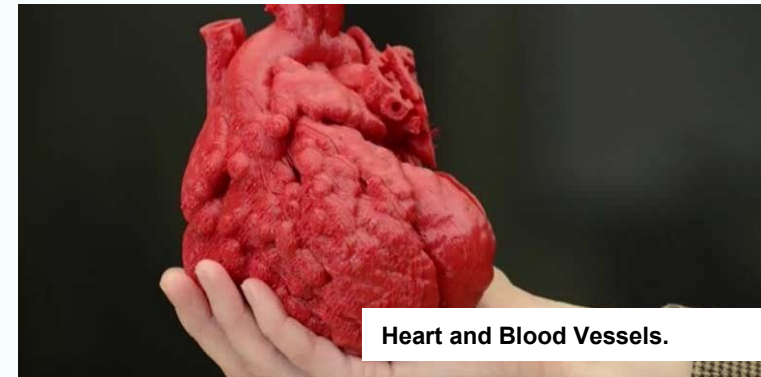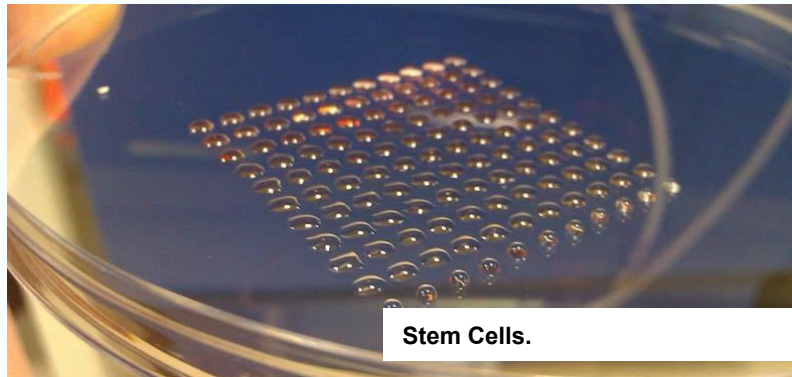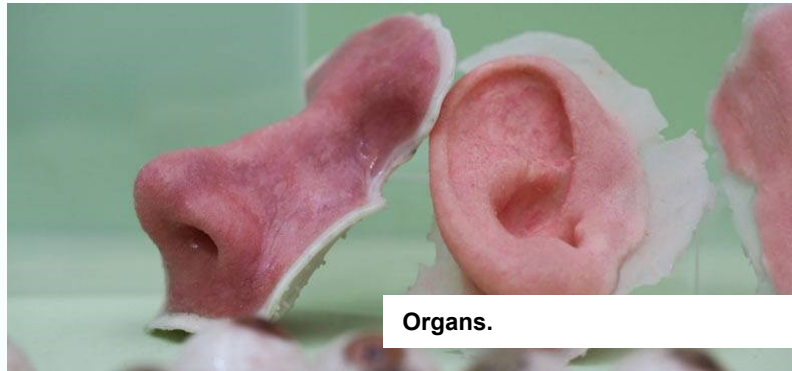
Figures – The Future of Things. Retrieved from http://thefutureofthings.com/8973-7-major-advancements-3d-printing-is-making-in-the-medical-field/.

Stem Cells.

Heart and Blood Vessels.

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Future AM Applications

Multi-materials

Bimetallic Tube.

Close up of 3D printed multi-material sample object

Multi Materials.

Eliminate the need for adhesives and allow for greater design variety and specificity

Figures – Multi materials. From *Researchers develop one-step, 3D printing for multimaterial projects,* Washington State University (May 2018). Retrieved from https://news.wsu.edu/2018/05/30/multimaterial-3d-printing/.

Future AM Applications

Biomimicry

Aircraft Spoiler.

Courtesy of Peter Sanders, Airbus

Biomimicry.

Cabin of Curiosities by Emerging Objects, courtesy of 3D pioneers challenge

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Manufacturing Projects

Musical Instrument

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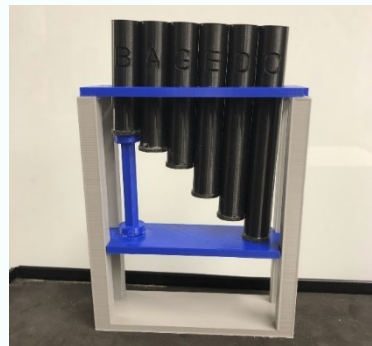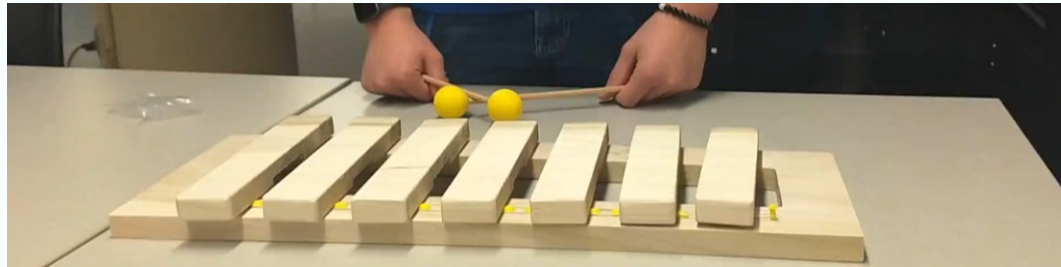
Manufacturing Projects

Toy Project

- 4 Students

- No choking hazard

- Strong enough to be handled by toddlers

- Check available stock size (Laguna) or polymer (3D Print)

- Due end of week 8

Musical Instrument

- 4 Students

- Must be "Playable"

- Purchases need to be preapproved

- Check available stock size (Laguna) or polymer (3D Print)

- Due on Monday of Finals week

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Acknowledgements

Some of this material is based of content from Cincinnati State Workforce Development Center.

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