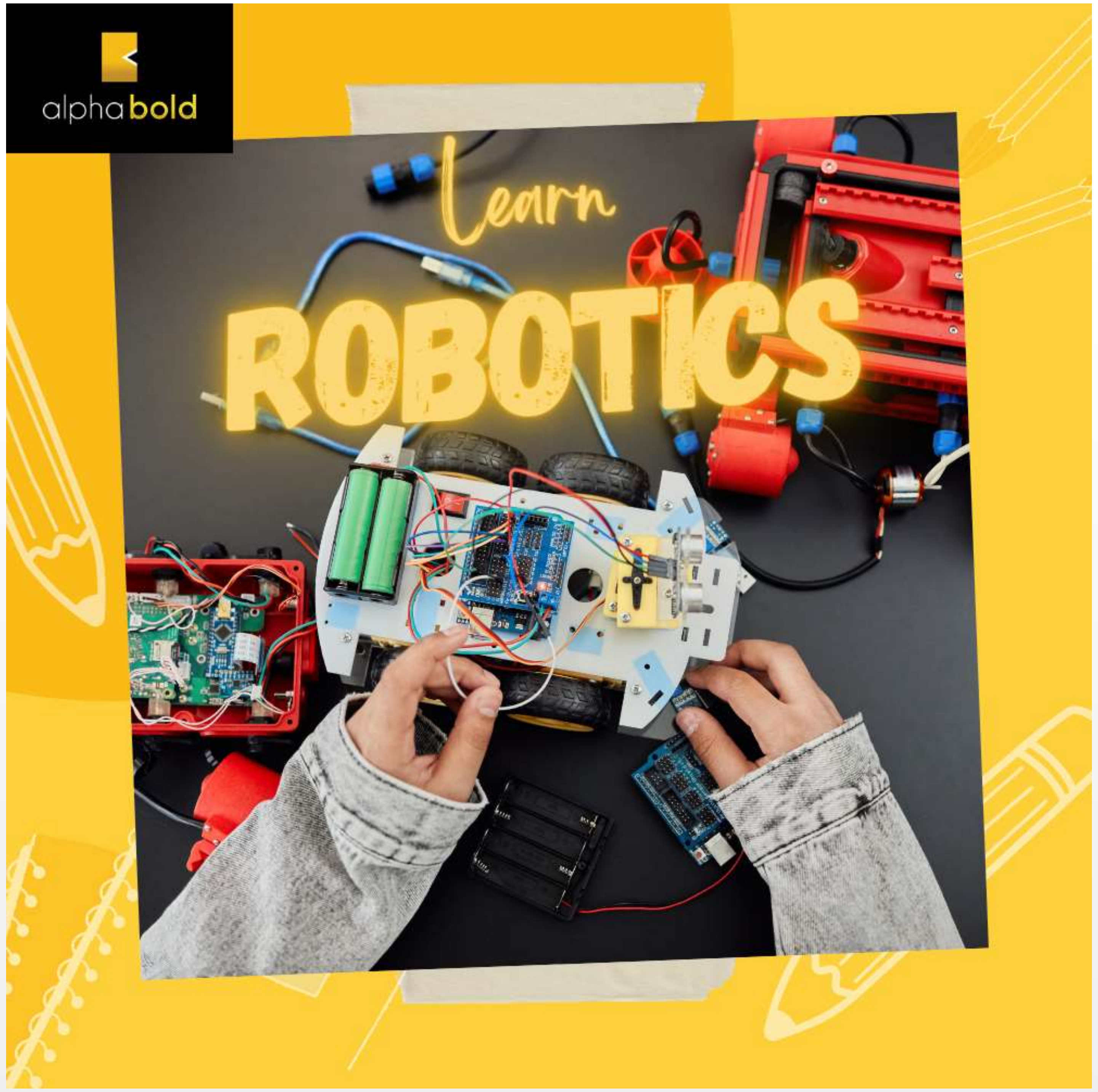
Additive Manufacturing

3D Printing



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Learning Pathway: Robotics

MT

- **MT01** Basic Electronics →
- **MT02** Arduino with C++ →
- **MT03** IoT with NodeMCU ESP32 and C++ →
- **MT04** IoT with Raspberry Pi and Python →
- **MT05** Machine Visual Perception →
- **MT06** PCB Design and Fabrication →
- **MT07** Mechanical Designing →
- **MT08** Additive Manufacturing →
- **MT09** Connected and Autonomous Vehicles →
- **MT10** Product Development and Entrepreneurship

Course Unit Details

Overview

Additive Manufacturing (AM), also known as 3D printing, is revolutionizing industries by enabling the creation of complex, personalized designs with unparalleled speed and sustainability. This course equips you with the knowledge and skills to become a leader in this transformative technology.

Throughout this course, students will delve into the foundational principles of Additive Manufacturing (AM), mastering techniques such as FDM, SLA, SLS, and DMLS. They will also acquire expertise in Reverse Engineering (RE), learning to extract design information from existing objects for optimization in AM production. Exploring industry-specific applications across manufacturing, medicine, aerospace, and beyond, students will grasp the disruptive potential of AM. Moreover, they will develop practical design skills tailored for AM processes and gain insights into future trends and challenges in the field. By the course's end, participants will confidently design complex objects using AM technologies, apply AM solutions to real-world problems, leverage RE techniques for design enhancement, and stay abreast of the latest advancements and challenges in the dynamic realm of AM.

Aims

- Provide a comprehensive understanding of core concepts and processes in Additive Manufacturing.
- Equip you with the knowledge of different AM technologies and their applications across diverse industries.
- Develop skills for preparing data for 3D printing using industry-standard formats.
- Foster design thinking for optimizing models for successful AM production.
- Explore the impact of AM on conventional manufacturing and the future of production.

Learning Outcomes

- Confidently apply your knowledge of additive manufacturing and reverse engineering to solve problems across diverse fields like healthcare, aerospace, and beyond.
- Fine-tune your AM skills by experimenting and optimizing process parameters for different materials and desired outcomes.
- Analyze and compare the strengths and weaknesses of various AM and reverse engineering technologies to make informed choices.
- AM Optimizer: Strategically select the perfect AM technology based on cost, quality, time, and resource constraints to achieve project goals.
- Master the principles of design for additive manufacturing (DfAM) and translate them into practical solutions for developing innovative new products.
- Effectively communicate your AM expertise and work seamlessly in teams to bring your projects to life.

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Syllabus

Module 1: Additive Manufacturing Technologies – Principles and Applications

1.1: Additive Manufacturing Basic Concepts and processes

- 1 Additive Manufacturing workflow
- 2 Benefits and Limitations of Additive Manufacturing
- 3 Applications of 3D printing (Aerospace, Automotive, Robotics, Tooling, Healthcare, Design, Education etc.)

1.2: 7 Categories of Additive Manufacturing (ISO/ ASTM 52900:2021)

- A. Solid-Based Additive Manufacturing Technologies
  - 1 Material Extrusion(MEX)
    - Fused Deposition Modelling (FDM)
    - Fused Filament Fabrication (FFF)
    - Freeform Fabrication (FF)
  - 2 Sheet Lamination (SHL)
    - The Ultrasonic Additive Manufacturing(UAM)
    - Laminated Object Manufacturing (LOM)

Syllabus

B. Powder-Based Additive Manufacturing Technologies

- 3. Powder Bed Fusion (PBF)
  - Multi Jet Fusion (MJF)
  - Selective Laser Sintering (SLS)
  - Direct Metal Laser Sintering (DMLS)
  - Selective Laser Sintering (SLS)
  - Electron Beam Melting (EBM)
- 4. Directed Energy Deposition (DED)
  - Laser Engineering Net Shape (LENS)
  - Electron Beam Additive Manufacturing (EBAM)

C. Liquid-Based Additive Manufacturing Technologies

- 5. Vat Photopolymerization (VP)
  - Stereolithography (SLA)
  - Digital Light Processing (DLP)
  - Continuous Digital Light Processing (CDLP)
- 6. Material Jetting (MJ)
  - Nano Particle Jetting (NPJ)
  - Drop on Demand (DOD)
- 7. Binder Jetting (BJ)

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Module 2: Data Interfacing for Additive Manufacturing

2.1 STereoLithography (STL) Models

- 1. ASCII STL
- 2. Binary STL
- 3. Color in binary STL
- 4. Facet normal
- 5. Use in 3D printing
- 6. Use in other fields
- 7. STL processing software

2.2 Slicing Techniques

- 1. STL-based Slicing
- 2. Direct Slicing
- 3. Slicing Software

2.3 Reverse Engineering for Additive Manufacturing Applications

- 1. Reverse Engineering Technologies
- 2. Reverse Engineering Workflow
- 3. From Physical to Digital: Meshes and Solids

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Module 3: Design for Additive Manufacturing

3.1 Optimization of 3D printing process parameters

- 1. Machine preparation and settings
- 2. Design rules for 3D printing
- 3. Part quality (layer height, line width etc.)
- 4. Part shell (wall thickness, top/bottom thickness, bottom pattern initial layer etc.)
- 5. Part infill (infill density, infill pattern, infill support etc.)
- 6. Material characteristics (printing temperature, flow rate, diameter etc)
- 7. Printing speed and travel
- 8. Post-processing
- 9. Technology specific parameters

3.2. Influences, complementarity and Synergy in AM and conventional technologies

- 1. CNC manufacturing
- 2. Injection molding
- 3. Laser cutting and engraving
- 4. Stamping and cold plastic deformation

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3.3. Macro environment of AM

- 1. Workforce of the future
- 2. Intellectual property issues
- 3. Standards
- 4. Quality assurance
- 5. Manufacturing and Supply chain
- 6. Product design
- 7. Digital thread and Industry 4.0
- 8. European policies

3.4. AM Business models and reshaping production

- Cloud Manufacturing
- Shape ways
- 3d Hubs
- Sculpteo
- Materialise
- 3d Print
- Voxel Maters
- Fab Lab

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Case Studies/Group Projects

- Creating High Fidelity Concept Cars With 3D Printing

Labs

Laboratory Sessions

During each laboratory session, students engage in a series of activities including identifying a need, designing and developing a CAD model of a product, simulating the working movements in the CAD environment, optimizing 3D printing parameters for product functionality, 3D printing the product components, post-processing each component, assembling the product, and demonstrating its functionality.

Laboratory 1:

- Design and 3D print a master part; manufacture a silicone mold for rapid casting of epoxy resin.

Laboratory 2:

- Design and 3D print a non-demountable assembly (ex.: a whistle with the pellet inside);

Laboratory 3:

- Design and 3D print a functional gear assembly (use cylindrical, helical, conical or rack gears);

Laboratory 4:

- Reverse engineering of a mechanical part (engine cover and) and of an amorphous part (e.g., hand, wrist)

Laboratory 5: Design and 3D print three joint types - cylindrical, spherical/ toroidal, universal joints (recommended application omni wheel)

Laboratory 6:

- Design and 3D print a Lithophane application (used pictures must be taken during the laboratory; a support must be designed for the 3D printed picture to incorporate the light source)

Laboratory 7:

- Design and 3D print a complex assembly with at least 8 moving parts (choose between: an adaptable phone/ camera mount)

Course Unit Requirements

Prerequisite Course Units

- MT06, MT07

Software

- Almost any 3D CAD Software for Designing e.g.,
  - PTC Creo Parametric
  - SolidWorks
- 3D Printing Software i.e., Slicing Software
  - UltiMaker Cura

Computing device with internet connectivity

3D Printer and its filament

Thank you for learning with alpha bold