Designing/Modelling/Prototyping

About:

What is the use of an amazing and creative idea if you can't make anything out of it? Some people think that every great idea needs a product behind it. Designing/ Prototyping is the key when developing your product.

Few product developers may not realize the importance of design and prototyping when developing a product. We create prototypes for visual development at the early stage of product designing. Prototyping is utilized to test and validate human factors, ergonomics, mechanical features, and aesthetics in the design process. It is the process of building a model or a draft version of an idea. It is a method of product designing that is used in various applications in mechanical engineering and software development. With prototyping, the potential issues of a product can be detected in the process and massive loss could be avoided.

Prototyping is modeling a set of data or simulating a real-world scenario for research purposes. It is a programming and numeric computing approach used by millions of engineers and scientists to analyze data, develop algorithms, and create models. Be it any domain, converting ideas and concepts into models is the first step using various platforms and tools.

Pre-Requisites:

Logical Thinking

MATLAB Basics

Engineering Drawing

Basic Circuit Elements

Basic CAD commands

Topics Involved:

- CAD / Autodesk

- MATLAB/ Simulink/ Octave

Manufacturing Processes

- Machine Design

. Electronic design: Using Breadboards and reading datasheets

. Build circuits on Perfboards using through-hole components

. Build circuits on Copper-Clad boards using SMD components

. Packaging your electronics design: Using project boxes, Designing custom enclosure and 3D printing it, Building wooden enclosures, Unconventional build methods

Syllabus

Overview:

The syllabus contains various exercises that will help you learn to design and prototype through hands-on activities. Use the resources that we provide to learn about the various techniques used in the designing/prototyping process. We will focus on a)mechanical prototyping b) electronics prototyping

The tools and equipment required for hands-on activities are available in the MARVEL lab.
We will conduct short workshops on specific days to train you in the handling of equipment, safety, etc. All enrolled members are expected to attend. The date will be informed ahead of time.
If enrolled members have any questions, they can ask their domain coordinators.

Level 1:

Overview:

Level 1 introduces you to the basics of electronics and mechanical prototyping and design. You will engage yourself in short hands-on projects that will help you get started off in the design/prototyping journey.
Topics introduced

1. Breadboard prototyping techniques
2. Using CAD tools to draw circuits
3. Engineering Drawing
4. Using CAD to make models of IRL objects

Before you start:

If you have your own personal computer/laptop, please install the following software(s). All listed softwares are either open-source or free to use.

1. KiCAD: KiCAD is an open-source tool for electronic design and automation. It facilitates the design of electronic schematics, PCB design, etc. This document has relevant information on the download of KiCAD: https://docs.kicad.org/5.1/en/getting_started_in_kicad/getting_started_in_kicad.html
2. Fusion 360: Integrated CAD, CAM, CAE, and PCB software. https://www.autodesk.com/products/fusion-360/overview

If you want a hobbyist license, check out the below link:
https://www.autodesk.in/products/fusion-360/personal

Breadboards:

A breadboard is a solderless device for temporary prototypes with electronics and test circuit designs. Most electronic components in electronic circuits can be interconnected by inserting their leads or terminals into the holes and then making connections through wires where appropriate. The breadboard has strips of metal underneath the board and connects the holes on the top of the board. The metal strips are laid out as shown below. Note that the top and bottom rows of holes are connected horizontally and split in the middle while the remaining holes are connected vertically.

Follow this introductory guide to learn how to use breadboards:

https://www.youtube.com/watch?v=6WReFkfrUIk&ab_channel=ScienceBuddies

Build the following projects using a breadboard. The components required are available in the MARVEL lab.

Project number	Project	Link	Notes
1	LED on a breadboard	https://startingelectronics.org/beginners/start-electronics-now/tut1-breadboard-circuits/ Once you finish performing the experiment in the link, try lighting up larger LED sequences(3,4,5 LEDs, etc.) Remember, the resistor values will change. Check the 'notes' section for more	The link description uses AA batteries to power the LED. However, you'll be using a breadboard power supply, which provides a different voltage. Hence the resistor value will change. Find out how to calculate resistor values here: https://www.youtube.com/watch?v=QJlzTaTU7LY&ab_channel=TheOrganicChemistryTutor

		info.	
2	Transistor as a switch	https://circuits-diy.com/how-to-use-a-transistor-bc547-as-a-switch/	Check out the datasheet of the BC547 transistor used in this experiment. Just google 'BC547 transistor'. Find out if other transistors can be used for the same purpose.
3	Flash an LED using a transistor	http://elonics.in/breadboard-projects/simple-flashing-blinking-led-circuit-using-transistors	Try playing around with different resistor-capacitor combinations to get different flashing frequencies.
4	Darkness detector using LDR	http://elonics.in/breadboard-projects/light-sensor-and-darkness-detector-circuit-using-ldr-transistor	Try building the circuit entirely using the circuit diagram. Don't use the video guide if you don't need it!
5	LED flashing using 555 timer	https://www.elprocus.com/blinking-led-using-555-timer-ic/	Use the circuit diagram only! Download the 555 datasheet. Learn about the astable multivibrator configuration and calculate R-C combinations for different frequencies.
6	BCD to 7 segment display using IC 7447	https://www.eeeguide.com/bcd-to-7-segment-decoder-using-ic-7447/	Try implementing this circuit using the datasheet only! The datasheet contains sufficient information. If you think you can't perform using the datasheet, refer to the link given. Just google '7447 datasheet' to get the datasheet. If you need help interpreting the datasheet, call your co-ordinator

Mechanical Design:

Project number	Project	Link	Notes
1	Basic drawings on paper		This is an introduction project to get everyone familiarized with shapes and putting them down on paper
2	Convert said Drawings on CAD		Use CAD software to design the same problems as the previous task to get a hang of the software
3	Machine Parts to 3D Model		Use readily available industrial diagrams to recreate the 3d model of the drawings
4	Converting a Common Household object into a 3D Model		Using your newly developed skills design a 3d model of common household objects like locks, phones, etc. by making your own measurements and produce your CAD models
5	Designing basic Mechanisms in CAD		Make mechanisms and linkages of basic mechanical linkages
6	Designing enclosure/snap-fit case for an Arduino Uno		Design a snap-fit enclosure for an Arduino Uno

CAD tools for electronic design:

To get you up and started, refer to this guide from the kiCAD website on how to start your first project on kiCAD:
https://docs.kicad.org/5.1/en/getting_started_in_kicad/getting_started_in_kicad.html#support
The relevant section is ‘Drawing electronic schematics’.

If you want a different guide, check this out:
https://learn.sparkfun.com/tutorials/beginners-guide-to-kicad/all

If you want a video guide, check this out:
https://www.youtube.com/watch?v=jTMjb-1SVHo&ab_channel=DallinDurfee

Your exercise is as follows:
Create schematics in kiCAD for any FOUR of the circuits you built on the breadboard. You should keep in mind the correct part numbers, proper labeling of the circuit, neat organization, etc.

Level 2:

Overview:

Congratulations on making it to level 2! You will now move on to permanent prototyping techniques. You will learn how to build your circuits on a perf board and also build enclosures for your projects.
You will also learn how to design a PCB on KiCAD.

Before you start:

Your co-ordinators will conduct a short workshop on how to solder, how to use the various equipment used for soldering, safety, etc.

For Slicing your 3D models, Install Ultima Cura.
https://ultimaker.com/software/ultimaker-cura

Perfboard prototyping:

Project number	Project name	Link	Notes
1	Simple soldering practice		Soldering activities during the hands-on workshop.
2	Astable multivibrator using 555 timer	Making Of Flashing/Blinking LED Circuit Diagram using 555 Timer IC	Flash an LED on the PCB using this circuit
3	Simple audio amplifier	Build a Great Sounding Audio Amplifier (with Bass Boost) from the LM386	Build the 'great sounding audio amplifier' You have to use the circuit diagram. Use a screw terminal for the speaker output.
4	Water level controller using NE555	https://www.circuitstoday.com/water-level-controller	Build a functional water level controller. Use the circuit diagram only.

KiCAD PCB design:

Use the following video tutorial to learn more about kiCAD PCB design:
https://www.youtube.com/watch?v=-_nZZLuwYd0&ab_channel=ElektorTV

Use the official kiCAD website for more detailed documentation:-
https://docs.kicad.org/5.1/en/pcbnew/pcbnew.html

Your exercise is as follows:
Create PCB designs for any FOUR of the projects that you performed using the breadboard.
If you need help, ask your coordinator.

3D printing:

Project number	Project name	Link	Notes
1	Calibrating 3D printer		Calibrate the print bed, clean the nozzle and prepare it based on the material to be used
2	Slicing and Support structures		Slice previously made models and add necessary support materials to make them ready for printing
3	Printing your model		Once everything is ready and approved, put it for printing
4	Designing and printing a custom enclosure for your custom PCB		Design and print an enclosure for your PCB that you custom built.

Level 3:

You now have the skills required to prototype a project of your choice.
Choose a project of your voice to work on. Keep in mind the tools/equipment available at the MARVEL lab while choosing your project.
Your project must include all aspects of the engineering design/prototyping process you have learnt in level 1 and level 2.

Assessment:

Level 1:

After completing each project, upload a photograph/video of the functioning circuit or model and show it to your domain co-ordinator.

When you finish level 1, you are required to provide a detailed report consisting of:

1. Project specifications
2. Challenges faced
3. Documentation (circuits,photographs etc.)
4. Material used
5. What you have learnt

A date will be fixed on which you give a brief seminar on your report. After successfully completing both the report and seminar, you'll be allowed to move on to level 2.

Level 2:

After completing each project, upload a photograph/video of the functioning circuit or model and show it to your coordinator.

When you finish level 2, you are required to provide a detailed report consisting of:-

1. Project specifications
2. Challenges faced
3. Documentation(circuits,photographs etc.)
4. Materials used
5. What you have learnt

A date will be fixed on which you give a brief seminar on your report. After successfully completing both the report and seminar, you'll be allowed to move to level 3.

Level 3:

Level 3 assessment will be on a case-by-case basis. Contact your coordinator for more details.

References:

kiCAD website:
https://www.kicad.org/

Datasheets:

555:
https://www.ti.com/lit/ds/symlink/lm555.pdf

IC 7447:

https://www.ti.com/lit/ds/symlink/sn5447a.pdf?ts=1633177112671&ref_url=https%253A%252F%252Fwww.google.com%252F

BC 547:-
https://www.sparkfun.com/datasheets/Components/BC546.pdf

Useful Links:

Ben Eater:
https://www.youtube.com/c/BenEater

Jeremy Fielding:
https://www.youtube.com/c/JeremyFieldingSr/videos

EEV Blog:
https://www.youtube.com/c/EevblogDave

Makers Muse:
https://www.youtube.com/c/MakersMuse

James Bruton:
https://www.youtube.com/c/jamesbruton

CNC kitchen:
https://www.youtube.com/c/CNCKitchen

Integza:
https://www.youtube.com/channel/UC2avWDLN1EI3r1RZ_dlSxCw

Great Scott:
https://www.youtube.com/c/greatscottlab

Simone Giertz:
https://www.youtube.com/c/simonegiertz

Spark Plug:
https://www.youtube.com/channel/UCSUDSCwC7AUB0wOJXVsKRXg

Fusion360 Tutorials:

https://www.youtube.com/playlist?list=PLrOFa8sDv6jfKx9poMArMUV2MGbZoXrCT
https://www.youtube.com/playlist?list=PLrZ2zKOtC_-DR2ZkMaK3YthYLErPxCnT-

Courses:

- https://www.coursera.org/learn/3d-cad-fundamental
- https://www.coursera.org/projects/product-development-using-autocad
- https://www.coursera.org/learn/mechanical-engineering-design-manufacturing
- https://www.coursera.org/learn/introduction-digital-manufacturing-fusion-360
- https://www.coursera.org/learn/3d-printing-software
- https://www.coursera.org/learn/fusion-360-integrated-cad-cam-cae
- https://www.coursera.org/learn/matlab
- https://www.coursera.org/learn/engineering-mechanics-statics
- https://www.edx.org/course/matlab-and-octave-for-beginners
- https://www.edx.org/course/introduction-to-engineering-and-design