# Course Abstract

## Design Engineering – 2B (2160001) (6th Semester)

## Module 4: Building the Solution

Name of the Discipline & the Programme: ***Every discipline of the Engineering***

Usual time of occurrence: ***6th Semester***

Duration: ***Six (6) months***

Course category: ***Core - Advance***

Credits: ***03***

Examination Pattern: ***Only Practical/Viva exam at end of semester***

Prerequisites: ***Design Engineering – 1A, Design Engineering – 1B, Design Engineering – 2A***

### Relevance

This is an advance level course designed for those who have undergone the fundamentals of Design Thinking process and understand the importance and process completely.

### Objective: Building the Solution

The course aims to validate the learnings from the understanding Design Thinking course by translating the concepts into exercises. In this module, student will continue their work from 5th semester on Community based project and complete the Design Thinking cycle with emphasis on product development, detail design, prototyping and validation of the solutions in real environment.

### Course Contents

Students have started community based projects and successfully gone through the process of Observation, Empathy, Ideation and initial stages of Product Development in 5th semester. Now in 6th semester, they will **continue their work** from concept to product development, detail design, prototyping and validation of the solutions in real environment. All students' team need to work towards final prototype and then test it in real environment. Final working model with YouTube video link is required for this module.

In 6th semester, students will consider various design considerations as described further in this document for detail design and then first prepare their models in software if required and then use prototyping techniques to further build the concepts. The content is divided into week-wise activities to better understand the course and to give enough time to all the learning aspects, but depending upon the type and nature of projects, students and guide may re-schedule the

activities. Students in 6th semester need to follow below week-wise activities to complete the course requirement for 6th semester.

| Design Thinking Process – with Tools & Techniques | | | |
|---|---|---|---|
| **Module 4: DE-2B Building the Solutions** | | | |
| **Broad segment** | **Week** | **Description** | **Operational need** |
| | | | |
| System level Design | 1 | ○ Plan of Action in 6th semester<br>✓ Based on revalidation, feedback from last semester (5th semester) plan for future aspects | ○ Discussion with faculty guide and modification based on feedbacks |
| | | | |
| Detailed Design | 2, 3, 4 | ○ Detailed Design (including all aspects of products, material, process, resources, standards etc.) | ○ Brief lecture/exercise<br>○ Very minute details of the concept will be considered<br>○ Prototyping techniques may be used to iterate |
| | | | |
| CAD Modelling & Analysis | 5, 6, 7 | ○ CAD Modelling & Analysis (Branch specific software will be used depending on projects) | ○ Software saves on time, money, resources etc.<br>○ Branch specific softwares must be provided by the college for students to use for their projects |
| | | | |
| Building the solutions | 8, 9, 10, 11 | ○ Prototyping (sequential prototyping for iterations)<br>○ Customer Revalidation<br>○ Modification<br>○ Iterate, Iterate, Iterate….. | ○ Prototype does not mean final product or working model but it is the process/phase to reach up to final product |
| | | | |

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|---|---|---|---|
| Final Prototype | 12 | ○ Final working model should be prepared (The projects that involve higher cost and limitations on technology should be allowed other ways of prototyping other than working model) | ○ YouTube link of final working model is required for full mark |
| | | | |
| Project Fair | 13 | ○ Open project showcase/fair for showing the projects for Students, faculty members, local people and industrialists | ○ This fair should be open for all in surrounding area of college<br>○ It is compulsory to organize DE project fair |
| Feedback & Final Report | 14 | ○ Feedback & Final Report | ○ As per the feedback received from Users/Stakeholders/other student groups/guide, student teams need to modify their design and further action plan.<br>○ Report writing should be continuous activity throughout the semester |

In the 6th semester, student's team will validate their concept and detailed design part with reference to (1) Design for performance, safety and reliability, (2) Design for Ergonomics and Aesthetics, (3) Design for Manufacturing & Assembly (DFMA), (4) Design for cost & Environment, (5) Modelling and Analysis of their design (6) Prototyping (7) Engineering Economics of Design, (8) Design for Use, Reuse and Sustainability and (9) Test the prototype. And additionally students will also learn topic like (10) *Ethics in Design*.

Following aspects should be taken into account while developing product.

**1. Design for Performance, Safety and Reliability:**

- ✓ *Design for performance:* The final product/process must perform for designed (projected in Product Development Canvas - PDC) features and functions as per the requirement of the user in actual working environment (revealed through rough-prototype validation).

- ✓ *Design for Safety:* Safety is the most important aspect of human centric product/process. Reasonable factor of safety should be taken into account considering all adverse and factual factors (Ideation canvas – location/context/situation may be referred back here) as there is human interaction with product/process in manifold circumstances.
- ✓ *Design for Reliability:* Reliability is the ability of a system or component to perform its required functions under stated conditions for a specified period of time[1]. Your final product/process should be reliable as required by the user and should perform its desired functions as required for desired time period.

**2. Design for Ergonomics and Aesthetics:**

- ✓ *Ergonomics* is all about designing for human factors/comforts wherever they interact with product/process and surrounding environments. According to the **International Ergonomics Association** within the discipline of ergonomics there exist domains of specialization: (a) ***Physical Ergonomics*** – is concerned with the human anatomy, bio mechanical and physiological ability and its relevance to the product and surrounding systems; (b) ***Cognitive Ergonomics*** – is concerned with the mental ability such as perception, memory, reasoning and response power as they affect the interactions between humans and products/systems ; (c) ***Organizational Ergonomics*** – is concerned with the optimization of socio-technical systems including organizational structures, policies and processes.
- ✓ *Aesthetics* is all about designing for physical appearance (looks) of the product. In current time, customers are willing to buy the products which have stunning looks with respect to their competitive products. Design for Aesthetics includes appearance, style, colour, form/shape, visuals and so on.

**3. Design for Manufacturability & Assembly (DFMA)**

- ✓ DFMA stands for two terms; *DFM – Design for Manufacturability* which means for ease of manufacturing of parts/components of final product. *DFA – Design for Assembly* which means manufactured parts can be easily assembled to form a final product. DFMA approach helps to design and manufacture/construct the product easily and economically. Designer must design components/parts that can be easily manufactured with available resources at minimum cost of production and can be easily assembled by assembly personnel. The intentions behind implementing DFMA practice in product development is to minimize manufacturing and assembly cost, improve efficiency,

[1] Definition by IEEE.

eliminate waste of material and time. Iteration on involved raw materials may be performed to check available alternatives – as materials play a major role in production cost. Basic guidelines may be followed as below:

- Check for alternative and compatible raw materials (Refer/ revise to LNM)
- Minimize the number of parts (Refer/ revise to PDC)
- Develop a modular design
- Design parts to be multi-functional
- Design parts for multiple-use
- Design for ease of fabrication/ production/ assemble
- Minimize assembly paths
- Avoid separate fasteners (i.e. monolithic units)
- Eliminate adjustments as possible (i.e. movement in parts addressing multiple use – it's a trade-off)
- Design for minimum handling
- Avoid use of additional tools when possible
- Minimize subassemblies (i.e. joining and removing some of the parts)
- Use standard parts when possible (refer/ revise to LNM)
- Simplify operations
- Design for efficient and adequate testing (refer/ revise to LNM)
- Use repeatable & understood processes
- Analyze failures
- Rigorously assess value (i.e. cost of production against minimizing cost of human efforts being done at present – Refer to AEIOU observation framework)

**4. Design for Cost, Environment**

- ✓ *Design for cost* means designing for lowest possible life cycle cost. It involves – assumed product design cost (manufacturing), delivery cost (to the end-user) as well as cost of operation and maintenance.
- ✓ *Design for environment* strategy describes best practices of designing a product/process to minimize health and environmental ill-impacts. Four main concepts of Design for Environment includes: (a) Design for Environmental aspects during Processing and Manufacturing; (b) Design for Environmental aspects in Packaging; (c) Design for Disposal or Reuse (i.e. after end of product/ process life-cycle as involved in one's case); (d) Design for Energy Efficiency (i.e. energy consumption during the product/ process usable life)

**5. Modelling and Analysis using Software:**

- ✓ *Branch Specific software can be used for simulation/analysis purpose to further refine the design before investing more time, money and resources.*

**6. Prototyping and Proofing of Concepts:**

- ✓ *Prototypes, Models and Proof of concepts*
  - *Prototypes* [1]*:* Prototypes are the first full scale and usually a functional form of design and in this sense, it is a working models of designed parts/artefacts. They are tested in the same environments in which they are expected to perform as final products.
  - *Models* [1]*:* A model is "a miniature representation of something". They may be a paper model or computer model or physical model. Models are usually a smaller and made of different material than are of original products, and they are tested in laboratory or controlled environment to validate their expected behaviour.
  - *Proof of Concepts* [1]*:* A proof of concept, in this context, refers to a model of some part of a design that is used specifically to test whether a particular concept will actually work as proposed. Proof of concept test will validate the idea or concept in controlled environment.
- ✓ *Building series of Prototypes to further refine the project*
- ✓ *How much it will cost?*

**7. Engineering Economics of Design:**

- ✓ *Cost Estimation*
- ✓ *Labour, Material and overhead cost*
- ✓ *The time value of money*

**8. Design for Use, Reuse and Sustainability**

- ✓ *Design for USE –* How long this design will work?
  - Reliability
  - Maintainability
- ✓ *Design for Reuse*
- ✓ *Design for Sustainability*

[1] Engineering Design – A project Based Introduction by Clive L. Dym, Patrick Little, Elizabeth J. Orwin – Wiley publications

**9. Test the prototype**

- ✓ *Test your design in real operational environment and then iterate if required.*

**10. Ethics in Design**

- ✓ *Codes of Ethics*
- ✓ *Ethics: Understanding Obligations*
- ✓ *Ethics: on engineering practice and the welfare of the public*
- ✓ *Ethics: Always a part of engineering practice*

***Optional Areas:***

GTU Innovation Council will help in below areas for the students whose projects are innovative & extraordinary and who really want to develop their projects further. Visit http://www.gtuinnovationcouncil.ac.in/ for more info.

- Design Support
- Intellectual Property Right
- Business Model Canvas
- Student Start-up
- Incubation and Co-working space

**Submissions by the end of 6th semester shall be:**

A. Process Report comprising:
   a. Introduction (Describe your project in detail including domain – type, place, why and how team selected this domain and why this domain is important in relation to Design Thinking/Human-Centered process etc.)
   b. Canvases and framework from 5th semester based on different phase of Design Thinking
   c. Feedback analysis with the user and Summary on validation process and refinement in the rough prototype shall be clearly included in the report
   d. Detail design calculations/data
   e. CAD/Software modelling details
   f. Testing of final model if available
   g. Any other important aspects you feel should be included

B. Iterative versions of the prototype models with all necessary details
C. Individual Log Book (duly signed by faculty guide)

**Note: As per the guidelines and evaluation schemes given in this document, students need to prepare report for their projects. Separate report format will not be provided by University.**

## Appendix 1: The END SEMESTER Evaluation Scheme for Design Engineering – 2B (2160001) (6th Semester)

### BE - III year – all branches

To,

The Principals/ Directors of Colleges/ Institutes, the Heads of Departments and GTU/Design Engineering coordinators:

Students deserve a proper practical/ viva/ project examination of the work that they have done over the semester (or over the year for a 2-semester project).

It is the responsibility of the University and Colleges that all its examinations are conducted fairly, sincerely and with due diligence.

So please look into the following:

1. Please make proper arrangements so that all the examinations start in-time. If due to any reason, the exam should not start at the right time, please inform the examiners that they should take extra time. But in no case the viva/ practical exam be conducted in a hurry without giving sufficient time for evaluation of every student. If an exam is scheduled to be held over two days, please make the necessary arrangements.

2. The University expects the Deans (and or special teams headed by the Dean or his/ her nominee) to visit the Colleges during the practical/ viva examinations.

3. Please see that all the necessary help and information is provided. Please receive them so that they can do their job properly without wasting their time in searching for the place and in contacting the concerned examiners and students. If they should want to visit the laboratories/ workshops, please make the necessary arrangements.

4. Please inform the external examiner that he/ she must note down **the best 3 projects of the department** and convey the details of such projects by uploading the details of the project or/ and the complete project report on the University's server or send it to design@gtu.edu.in .

5. In case Internet or the server should not work, please provide the technical help to the external examiner for preparing a CD of the reports of the best three projects of every department and please make arrangements to deliver the CD to the examination department of the University.

**PROCESS OF EVALUATION:** At the ensuing 6th semester examinations, the work of the students in Design Engineering-2B is to be evaluated by VIVA and the evaluation is to be out of 80 marks.

A Viva-Voce examination will be conducted at the end of the semester by a team of two examiners, one of whom will be an internal Faculty Member, who may have taught the subject. (Internal examiner must remain the same throughout the entire of examination for batch). The other will be an external examiner to be appointed by the University. Both examiners must be trained in Design Thinking through the FDP conducted by University. (Please note that all the other practical and viva voce examinations at the end of the 6th semester will be conducted internally by the College/ Institute.)

**EVALUATION SCHEME:**

| Sr. No. | Particular | Sub-Head Weightage |
|---|---|---|
| 1. | ✓ Design calculation (it may include size & shape specifications, tolerances, material requirement, standards/safety rules/govt. policies, sketches, detail & assembly drawings, list of components with specifications etc.) These all aspects are case sensitive so one can add/remove some aspects from the list.<br>✓ For CE, IT, other process related branches, one may also use Flow chart/Block Diagrams/Algorithms/Programming etc.<br>✓ Measuring Instruments/techniques - knowledge and use<br>✓ Comparison of existing materials, methods, tools and equipment for your project<br><br>**Detail Design:** Considerations for-<br>**Design for Performance, Safety and Reliability**<br>✓ Different aspects of design for performance, safety and reliability introduced/ considered for defined problem<br>**Design for Ergonomics and Aesthetics**<br>✓ Consideration of Ergonomics and Aesthetics aspects to raise the value of products<br>**Design for Manufacturability & Assembly (DFMA)**<br>✓ Reference, different considerations and guidelines followed for DFMA during the work<br>**Design for Cost, Environment**<br>✓ Cost and Environment consideration as they play major role in Product design<br>**Design for Use, Reuse and Sustainability** | 25 |
| 2. | Simulation & Analysis (CAD/Software modelling), Mathematical model | 15 |

| | | |
|---|---|---|
| 3. | **Prototyping & Testing:**<br>✓ Versions of Prototypes with all possible modification and iterations to further refine the solutions (15 marks out of 25 - for students who have made iterative versions for prototype with refinement; if students only present final prototype without any version/s or modification/s then this 15 marks will not be counted for such students)<br>**Note:** Report should carry all details/modification for the versions of prototype with images, it is not required to have different physical models for the different versions<br>✓ Testing/user feedback results (10 marks out of 25 - if the details and testing/user feedback results are there)<br>✓ Video of Prototypes (YouTube link) | 25 |
| 4. | **Report & Log book** (Compilation of work, complete Log book, Future action plan, Question and Answer, Communication Skill) | 15 |
| | | 80 |

**Note:**

- ✓ Total Marks for the subject: 100 (Practical viva – 80 (External – 40 & Internal – 40), Internal continuous evaluation – 20)
- ✓ Minimum passing marks: 40/80
- ✓ Ratio of evaluation by internal & external examiner appointed: 50% in each sub-head
- ✓ Examiner essentially needs **to evaluate the learning process** of the student during the semester, not only the final outcome. As outcome is important for any project but during the student stage, projects are intended for practical learning and "Learning by doing" is the Mantra for Design Engineering subject *(One should celebrate the failure also and learn from it to get success).* So please evaluate the process properly with giving sufficient time for each project.
- ✓ Students need to explain all canvases prepared in hard copy to the panel of examiners (internal and external).
- ✓ Power point presentation is not mandatory.

**Note: In final year, students will use their learning of Design Thinking from these four modules of DE-1A, 1B, 2A, 2B to complete their IDP/UDP projects. There would not be separate Design Engineering subject in final year. On successfully completion of these four modules and repeating Design Thinking process again and again, students would be able to use it effectively and can solve any problem with creativity.**