

## DEPARTMENT OF PRODUCTION TECHNOLOGY

### MADRAS INSTITUTE OF TECHNOLOGY CAMPUS

ANNA UNIVERSITY :: CHENNAI – 600 044.

#### COURSE PLAN

##### COURSE DETAILS:

|                     |   |         |                           |
|---------------------|---|---------|---------------------------|
| Degree              | M.E.  |         |                           |
| Programme Name      | Mechatronics  |         |                           |
| Course Code & Title | MR3030 & Design of Experiments  |         |                           |
| Credits             | 3   | Session | January 2024 – April 2024 |
| Course Type         | Theory/ Theory with Lab/ Lab  | Section |                           |
| Name of the Faculty | <b>Dr.S.Sathish</b><br>Assistant Professor,<br>Department of Production Technology<br>MIT, Anna University, Chennai – 600044. |         |                           |

##### COURSE CONTENT:

**Syllabus:** (Approved Syllabus as per Regulation 2023)

##### COURSE OBJECTIVES:

The objective of this course is

1. To familiarize the concepts of Single Factor Experiment and Post hoc tests
2. To illustrate understanding of Factorial experiments
3. To enable students with the extensions of Factorial experiments and Response Surface Methods
4. To provide students with an understanding of Taguchi method for parameter optimization
5. To provide students with understanding of Shainin DOE

#### UNIT I SINGLE FACTOR EXPERIMENTS 9

Introduction to Hypothesis testing – Experimentation – Need, Conventional test strategies, terminology, basic principles of design – steps in experimentation – Completely Randomized Design- effect of coding the observations- model adequacy checking - estimation of model parameters, residuals analysis- treatment comparison methods – Duncan’s multiple range test, Newman-Keuel’s test, Fisher’s LSD test, Tukey’s test- Testing using contrasts-Randomized Block Design – Latin Square Design- Graeco Latin Square Design – Applications

#### UNIT II FACTORIAL DESIGNS 9

Main and Interaction effects - Two and three factor full factorial designs - Fixed effects and random effects model – Rule for sum of squares and Expected Mean Squares - 2K Design with two and three factors– Yate’s Algorithm – Fitting regression model– Randomized lock Factorial Design- Introduction to MANOVA&ANCOVA.

#### UNIT III SPECIAL FACTORIAL DESIGNS & RESPONSE SURFACE METHODS 9

Blocking and Confounding in 2K Designs- blocking in replicated design – 2K Factorial Design in two blocks– Complete and partial confounding – Confounding 2K Design in four blocks – Two level Fractional Factorial Designs - Construction of one-half and one-quarter fraction of 2K Design - Introduction to Response Surface Methods- Designs for fitting First –order Model -Central Composite Design – Box- Behnken Designs

#### UNIT IV TAGUCHI DESIGN OF EXPERIMENTS 9

Taguchi’s Quality Loss Function- Philosophy- Design of Experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments - Response Graph Method- ANOVA Attribute data analysis- Robust design- noise factors, Signal to Noise ratios, Inner/outer OA design- case studies.



## UNIT V SHAININ DESIGN OF EXPERIMENTS 9

Basics of Shainin DOE - Comparison between Taguchi DOE Vs Shainin DOE methods - Problem Solving Algorithm - Problem Identification Tools- Shainin Design of Experiments Tools - Case studies

**TOTAL = 45 PERIODS**

### COURSE OUTCOMES:

At the end of the course, the students are expected to

1. Understand the fundamental principles of Classical Design of Experiments.
2. Apply single factor experiment for process parameter understanding and optimization.
3. Apply Factorial Design principles for understanding of process parameters and its optimization.
4. Gain knowledge on Taguchi's approach to experimental design for attaining robustness.
5. Apply Response Surface Method and Shainin DOE to evaluate quality.

### TEXTBOOKS:

1. Krishnaiah K, and Shahabudeen P, "Applied Design of Experiments and Taguchi Methods", PHI, 1st Edition, 2011.

### REFERENCES:

1. Douglas C. Montgomery, "Design and Analysis of Experiments", John Wiley & sons, 2012.
2. Krishnaiah K, Applied Statistical Quality Control and Improvement, 1st Edition, 2014
3. Box, G. E., Hunter, W.G., Hunter, J.S., Hunter, W.G., "Statistics for Experimenters: Design, Innovation, and Discovery", 2nd Edition, Wiley, 2005.
4. Phillip J. Ross, "Taguchi Techniques for Quality Engineering", Tata McGraw-Hill, India, 2005

### COURSE ARTICULATION MATRIX

| Course Outcome | Programme Outcomes |   |     |   |   |   |
|----------------|--------------------|---|-----|---|---|---|
|                | 1                  | 2 | 3   | 4 | 5 | 6 |
| CO1            | 2                  | - | 1   | 1 | 1 | - |
| CO2            | 2                  | 1 | 2   | 1 | 1 | - |
| CO3            | 2                  | 1 | 2   | 1 | 1 | - |
| CO4            | 2                  | 1 | 2   | 1 | 1 | - |
| CO5            | 2                  | 1 | 2   | 1 | 1 | - |
| Average        | 2                  | 1 | 1.8 | 1 | 1 | - |

### COURSE ALIGNED PROGRAMME OUTCOMES (PO) & PROGRAMME SPECIFIC OUTCOMES (PSO)

| PO | Programme Outcome  |
|----|--|
| 1  | An ability to independently carry out research/investigation and development work to solve practical problems.   |
| 2  | An ability to write and present a substantial technical report/document.   |
| 3  | Students should be able to demonstrate a degree of mastery in the area of mechatronics.  |
| 4  | Graduates will have a solid understanding of key concepts, methodologies, core components, and contemporary tools and techniques essential for unified mechatronics systems with intelligence.         |
| 5  | Students will develop, analyze and optimize the solution for diverse engineering challenges using a mechatronics-based approach.   |
| 6  | Graduates will be capable of constructing real-time or virtual mechatronic systems with considerations for industrial standards, environmental impact, ethical principles, and socio-economic factors. |



# COURSE TENTATIVE SCHEDULE / PLAN

| Week  | Date       | Hrs | Unit | Topics   | Mode of Delivery | Text / Ref. |
|---|------------|-----|------|--|------------------|-------------|
| <b>UNIT I - STRESS - STRAIN, AXIAL LOADING</b>    |            |     |      |  |                  |             |
| 4   | 24.01.2024 | 3   | 1    | Introduction to Hypothesis testing – Experimentation – Need, Conventional test strategies, terminology, basic principles of design | PPT              | T1 & T2     |
|   | 25.01.2024 | 1   | 1    | Steps in experimentation – Completely Randomized Design  | PPT              | T1 & T2     |
|   | 25.01.2024 | 2   | 1    | Effect of coding the observations- model adequacy checking   | PPT              | T1 & T2     |
| 5   | 31.01.2024 | 3   | 1    | Estimation of model parameters, residuals analysis   | PPT              | T1 & T2     |
|   | 01.02.2024 | 1   | 1    | Treatment comparison methods – Duncan's multiple range test  | PPT              | T1 & T2     |
|   | 01.02.2024 | 2   | 1    | Newman-Keuel's test, Fisher's LSD test, Tukey's test   | PPT              | T1 & T2     |
| 6   | 07.02.2024 | 3   | 1    | Testing using contrasts-Randomized Block Design  | PPT              | T1 & T2     |
|   | 08.02.2024 | 1   | 1    | Latin Square Design  | Flipped class    | T1 & T2     |
|   | 08.02.2024 | 2   | 1    | Graeco Latin Square Design – Applications  | PPT              | T1 & T2     |
| <b>UNIT II - STRESSES IN BEAMS</b>                |            |     |      |  |                  |             |
| 7   | 14.01.2024 | 3   | 2    | Main and Interaction effects   | PPT              | T2          |
|   | 15.01.2024 | 1   | 2    | Two and three factor full factorial designs  | PPT              | T2          |
|   | 15.02.2024 | 2   | 2    | Fixed effects and random effects model   | PPT              | T2          |
| 8   | 21.02.2024 | 3   | 2    | Rule for sum of squares and Expected Mean Squares  | PPT              | T2          |
|   | 22.02.2024 | 1   | 2    | 2K Design with two and three factors–  | PPT              | T2          |
|   | 22.02.2024 | 2   | 2    | Yate's Algorithm   | PPT              | T2          |
| 9   | 28.02.2024 | 3   | 2    | Fitting regression model   | PPT              | T2          |
|   | 29.02.2024 | 1   | 2    | Randomized block Factorial Design  | PPT              | T2          |
|   | 29.02.2024 | 2   | 2    | Introduction to MANOVA&ANCOVA.   | PPT              | T2          |
| <b>UNIT III - DEFLECTION OF BEAMS AND COLUMNS</b> |            |     |      |  |                  |             |
| 10  | 06.03.2024 | 3   | 3    | Blocking and Confounding in 2K Designs- blocking in replicated design  | PPT              | T2          |
|   | 07.03.2024 | 1   | 3    | 2K Factorial Design in two blocks  | PPT              | T2          |
|   | 07.03.2024 | 2   | 3    | Complete and partial confounding   | PPT              | T2          |
| 11  | 13.03.2024 | 3   | 3    | Confounding 2K Design in four blocks   | PPT              | T2          |
|   | 14.03.2024 | 1   | 3    | Two level Fractional Factorial Designs   | PPT              | T2          |



|                                      |            |   |   |  |            |                   |
|--------------------------------------|------------|---|---|--|------------|-------------------|
|                                      | 14.03.2024 | 2 | 3 | Construction of one-half and one-quarter fraction of 2K Design                   | PPT        | T2                |
| 12                                   | 20.03.2024 | 3 | 3 | Introduction to Response Surface Methods- Designs for fitting First –order Model | PPT & Quiz | T2                |
|                                      | 21.03.2024 | 1 | 3 | Central Composite Design   | PPT & Quiz | T2                |
|                                      | 21.03.2024 | 4 | 3 | Box- Behnken Design  | PPT & Quiz | T2                |
| <b>UNIT IV - TORSION AND SPRINGS</b> |            |   |   |  |            |                   |
| 13                                   | 27.03.2024 | 3 | 4 | Taguchi's Quality Loss Function- Philosophy                                      | PPT        | T2                |
|                                      | 28.03.2024 | 1 | 4 | Design of Experiments using Orthogonal Arrays                                    | PPT        | T2                |
|                                      | 28.03.2024 | 2 | 4 | Data analysis from Orthogonal experiments  | PPT        | T2                |
| 14                                   | 03.04.2024 | 3 | 4 | Response Graph Method  | PPT        | T2                |
|                                      | 04.04.2024 | 1 | 4 | ANOVA Attribute data analysis  | PPT        | T2                |
|                                      | 04.04.2024 | 2 | 4 | Robust design- noise factors, Signal to Noise ratios                             | PPT        | T2                |
| 15                                   | 10.04.2024 | 3 | 4 | Inner/outer OA design  | PPT        | R3                |
|                                      | 11.04.2024 | 1 | 4 | Case studies   | PPT        | R3                |
| <b>UNIT V - BIAxIAL STRESS</b>       |            |   |   |  |            |                   |
|                                      | 11.04.2024 | 2 | 5 | Basics of Shainin DOE - Comparison between Taguchi DOE Vs Shainin DOE methods    | PPT        | R2                |
| 16                                   | 17.04.2024 | 3 | 5 | Problem Solving Algorithm  | PPT        | R2                |
|                                      | 18.04.2024 | 1 | 5 | Problem Solving Algorithm  | PPT        | R2                |
|                                      | 18.04.2024 | 2 | 5 | Problem Identification Tools   | PPT        | R2                |
| 17                                   | 24.04.2024 | 3 | 5 | Problem Identification Tools   | PPT        | R2                |
|                                      | 25.04.2024 | 1 | 5 | Shainin Design of Experiments Tools  | PPT        | R2                |
|                                      | 25.04.2024 | 2 | 5 | Shainin Design of Experiments Tools  | PPT        | R2                |
| 18                                   | 02.05.2024 | 1 | 5 | Shainin Design of Experiments Tools  | PPT        | Cross word puzzle |
|                                      | 02.05.2024 | 2 | 5 | Case studies   | PPT        | R2                |

#### COURSE DELIVERY/INSTRUCTIONAL METHODOLOGIES:

|                    |                     |                  |
|--------------------|---------------------|------------------|
| ✓ Chalk & Talk/PPT | ✓ Stud. Assignments | ✓ Web Resources  |
| ✓ LCD/Smart boards | ✓ Stud. Seminars    | □ Add-On Courses |



**COURSE ASSESSMENT METHODOLOGIES-DIRECT**

|   |   |   |  |
|---|---|---|--|
| <input checked="" type="checkbox"/> University (End Semester) Examination |   | <input checked="" type="checkbox"/> Internal Assessment Tests |  |
| <input checked="" type="checkbox"/> Assignments                           | <input type="checkbox"/> Laboratory Practices | <input type="checkbox"/> Mini/Major Projects                  | <input checked="" type="checkbox"/> Stud. Seminars |
| <input type="checkbox"/> Viva Voce  | <input type="checkbox"/> Certifications       | <input type="checkbox"/> Add-On Courses                       | <input type="checkbox"/> Others                    |

**COURSE ASSESSMENT METHODS**

| S.N.   | Mode of Assessment          | Date | Duration | % Weight |
|--|-----------------------------|------|----------|----------|
| 1  | Internal Assessment Tests 1 |      | 1½ hr    | 20 %     |
| 2  | Internal Assessment Tests 2 |      | 1½ hr    | 20 %     |
| 3.   | University Examination      |      | 3 hr     | 60 %     |
| Additional marks may be given for Assignments / Group / Team Seminar Presentation) |                             |      |          |          |

**COURSE ASSESSMENT METHODOLOGIES-INDIRECT**

|  |  |
|--|--|
| <input checked="" type="checkbox"/> Assessment of CO (By Feedback, Once)   | <input checked="" type="checkbox"/> Student Feedback On Faculty (Once) |
| <input type="checkbox"/> Assessment of Mini/Major projects by Ext. Experts | <input type="checkbox"/> Others  |

**COURSE (EXTRA) ESSENTIAL READINGS:**

1. NPTEL LINK
2. Refer Books

**COURSE EXIT SURVEY** (will be collected at end of the course)

The purpose of this survey is to find out from students about their learning experiences and their thoughts about the course.

| COURSE OUTCOMES | STUDENTS RATING<br>Low (1) /Medium(2)/ High(3) |
|-----------------|--|
| CO1:            |  |
| CO2:            |  |
| CO3:            |  |
| CO4:            |  |
| CO5:            |  |

| PROGRAMME OUTCOMES | STUDENTS RATING<br>Low (1) /Medium(2)/ High(3) |
|--------------------|--|
| PO1                |  |
| PO2                |  |
| PO3                |  |
| PO4                |  |
| PO5                |  |
| PO6                |  |

|         |  |
|---------|--|
| PO7     |  |
| PO8     |  |
| PO9     |  |
| PO10    |  |
| PO11    |  |
| PO12    |  |
| Average |  |

| PROGRAMME SPECIFIC OUTCOMES | STUDENTS RATING<br>Low (1) /Medium(2)/ High(3) |
|-----------------------------|--|
| PSO1                        |  |
| PSO2                        |  |
| PSO3                        |  |

#### COURSE POLICY (Compensation Assessment)

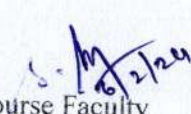
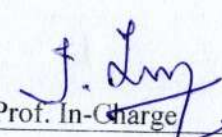
1. Attending all the assessment is mandatory for every student
2. Course policy will be followed as per the academic course regulation

#### COURSE ACADEMIC DISHONESTY AND PLAGIARISM

1. All rules and regulation prescribed by the ACOE, University Departments, are applicable in the Internal Assessment Tests and University (End Semester) Examinations. ([https://acoe.annauniv.edu/download\\_forms/student\\_forms/Guidelines.pdf](https://acoe.annauniv.edu/download_forms/student_forms/Guidelines.pdf))
2. In general, possessing a mobile phone, carrying bits of paper with materials, talking to other students, copying from other students during Internal Assessment Tests and University (End Semester) Examinations will be treated as Malpractice and punishable as per the rules and regulations. The misuse of Assignment / Project / Seminar works from others is considered as academic dishonesty and will be treated with the rules and regulations of the University.

#### COURSE ADDITIONAL INFORMATION

Queries / clarifications / discussion (if required) may be e-mailed to / contact the course instructors during their Office Hours.

|   |  |              |
|---|--|--------------|
| For Approval  |  |              |
| <br>Course Faculty | <br>Prof. In-Charge | <br>HOD (PT) |