**Name of Institute: Indus Institute of Technology and Engineering**

**Name of Faculty: Prof. Hinal Shah**

**Course code: EL0623**

**Course name: Advanced Control Theory**

Pre-requisites: Laplace transform, Linear Algebra, Differential Equations, Control System basics, Matrix Algebra

Credit points: 04

Offered Semester: 6th

**Course Coordinator (weeks 01-15)**

Full Name: Hinal Shah

Department with siting location: 3rd floor Staff room, Bhanwar Building

Telephone: 9727554848

Email: hinalshah.el@indusuni.ac.in

Consultation times: Tuesday: 3:25-4:15

**Course Lecturer (weeks 01-15)**

Full name: Hinal Shah

Department with siting location: 3rd floor Staff room, Bhanwar Building

Telephone: 9727554848

Email: hinalshah.el@indusuni.ac.in

Consultation times: Tuesday: 3:25-4:15

Students will be contacted throughout the Session via Mail with important information relating to this Course.

## Course Objectives

By participating in and understanding all facets of this Course a student will:

1) To Learn various methodology of modelling in state space,
2) State transition matrix and solution in state equation, controllability and observability will be studied.
3) Stability analysis issues of linear and nonlinear system in state space will be discussed.
4) To know the concepts of controller design and observer design.

## Course Outcomes (CO)

CO1: Apply state space representation and state transformation techniques. [BT- 3]

CO2: Understand state transition matrix, its properties and solution of state equations. [BT-2]

CO3: Understand and apply controllability and observability concepts in control systems. [BT-3]

CO4: Understand the different types of nonlinear systems and stability conditions for them. [BT-2]

CO5: Apply Liapunov Stability Analysis conditions for control systems. [BT-3]

CO6: Design and Analyze pole placement technique and state observer designs. [BT-6]

## Course Outline

**UNIT-I** **[11]**

State Space Analysis of Control Systems: State Variables; State-Space Representation of Electrical, Mechanical and Electromechanical Systems; State Space Representation of nth Order Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between State Equations and Transfer Functions; Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan Canonical Form; Controllability Canonical Form; Observability Canonical Form; Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition;

**UNIT-II** **[11]**

State Diagram; Solution of the Time Invariant State Equation; State Transition Matrix and its Properties; Transfer Matrix; Transfer Matrix of Closed Loop Systems.

Controllability and Observability: Concept of Controllability and Observability; Kalman's Theorems on Controllability and Observability, Alternative Tests (Gilbert's Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability and Transfer Function.

**UNIT-III** **[12]**

Introduction to nonlinear systems, Types of common nonlinearities, Stability of nonlinear systems, describing functions analysis, limit cycles.

Liapunov Stability Analysis: Stability of Equilibrium State in the Sense of Liapunov, Graphical

representation of Stability Asymptotic Stability and Instability, Sign-Definiteness of Scalar Function.

**UNIT-IV** **[11]**

Pole placement Design & State Observers:

Stability improvement state feedback control, Pole Placement Design, State Regulator Design, Observer Design, State Feedback with Integral Control, Design of Full order state Observer, Design of reduced order state observer

## Method of delivery

Face to face lectures

## Study time

3 Hours Lecture and 2Hours Laboratory per week

## CO-PO Mapping (PO: Program Outcomes)

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO1 0 | PO1 1 | PO1 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 3 | - | - | - | - | - | - | - |
| **CO2** | 2 | 3 | 2 | - | 2 | - | - | - | - | - | - | - |
| **CO3** | 2 | 2 | 2 | 1 | 3 | - | - | - | 2 | - | - | - |
| **CO4** | 2 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - |
| **CO5** | 2 | 2 | 3 | 2 | 3 | - | - | - | 2 | - | - | - |
| **CO6** | 2 | 3 | 3 | 2 | 3 | - | - | - | 2 | - | - | - |
| **EL0623** | **2** | **2.5** | **2.3** | **1.8** | **2.8** | **-** | **-** | **-** | **2** | **-** | **-** | **-** |

1-Lightly Mapped 2- Moderately Mapped 3- Highly Mapped

## Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

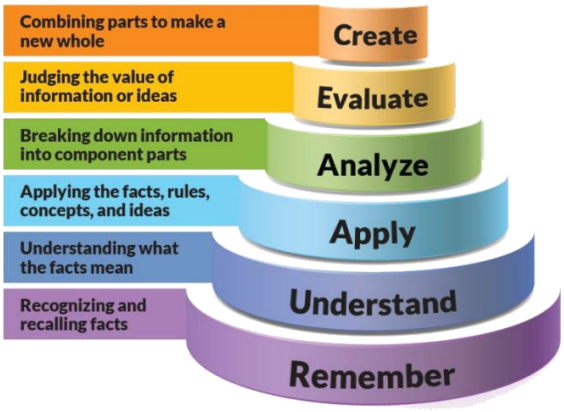



**Figure 1: Blooms Taxonomy**

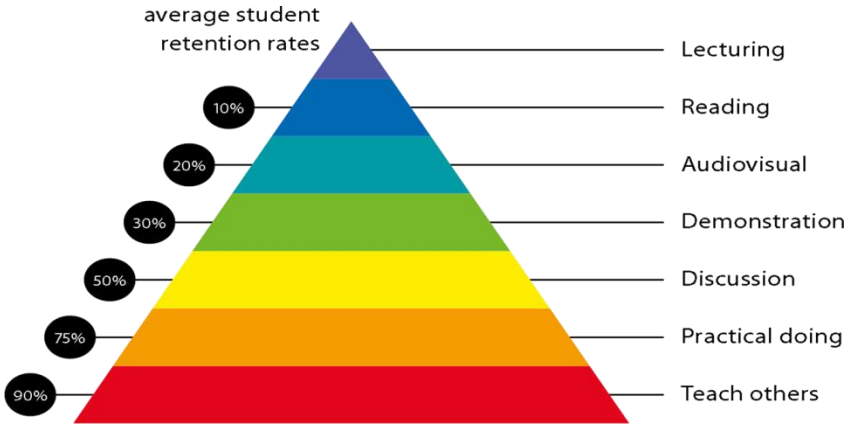



**Figure 2: Knowledge retention**

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of Electrical Graduate Capabilities |
|---|---|
| **Informed**<br><br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas. | **1 Professional knowledge, grounding & awareness** |

| | |
|---|---|
| **Independent learners**<br><br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others. | **2 Information literacy, gathering & processing** |
| **Problem solvers**<br><br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, and innovative and aim for high standards. | **4 Problem solving skills** |
| **Effective communicators**<br><br>Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication. | **5 Written communication**<br>**6 Oral communication**<br>**7 Teamwork** |
| **Responsible**<br><br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities. | **10 Sustainability, societal & environmental impact** |

## Practical work:

| | |
|---|---|
| 1. | Introduction to Matlab for Control System Toolbox. |
| 2. | Introduction to Matlab for various matrix operations. |

| | |
|---|---|
| 3. | Simulate Matlab for various state space model. |
| 4. | Simulate program to convert transfer function to canonical form. |
| 5. | Simulate MATLAB program for controllability. |
| 6. | Simulate MATLAB program for Observability. |
| 7. | Simulate Matlab program for the pole placement technique. |
| 8. | Simulate Matlab Program of Observer Design. |
| 9. | Simulate MATLAB program for Lyapunov's methods |
| 10. | Application of control system verify using MATLAB |

## Lecture/Lab times

(Give lecture times in the format below)

| |
|---|
| Lecture:<br>Laboratory: |

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

## Details of referencing system to be used in written work

## Text books

1. M. Gopal, "Digital control and state variable methods", 2nd Ed, TMH Publication.

2. Katsuhiko Ogata, “Modern Control Engineering”, 4th Ed, Prentice Hall of India.
3. Benjamin C. Kuo, “Automatic Control Systems”, PHI Learning Private Limited,

## Reference books

4. Norman S Nise, “Control system engineering”, 4th Ed., Wiley-India Edition.
5. A. Tewari, Modern Control Design: with MATLAB and SIMULINK, Wiley, 2002.
6. I. J. Nagrath and M. Gopal, Control Systems Engineering, New Age International Publishers, Fifth Edition, 2007.
7. D. R. Choudhuary, “Modern Control Engineering, PHI, 2005.
8. Stefani et. al., Design of Feedback Control Systems, Oxford, Fourth edition, 2002.

https://nptel.ac.in/courses/101108047/32.
https://nptel.ac.in/courses/101108047/module9/Lecture%2022.pdf

## Web Resource

1) www.edx.org
2) www.nptel.ac.in
3) www.coursera.org

## ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

| |
|---|
| Class test (MSE) (40 marks) |
| Assignment (10 marks) |
| Innovative/Project/Presentation (10 marks) |
| Final exam (*closed book*) (40 marks) |

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

### Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

### Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of 5% of the maximum mark per calendar day

### Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

### Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

### University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if

it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***

***Do not share your work with other students (except where required for a group activity or assessment).***

## Course schedule (subject to change)

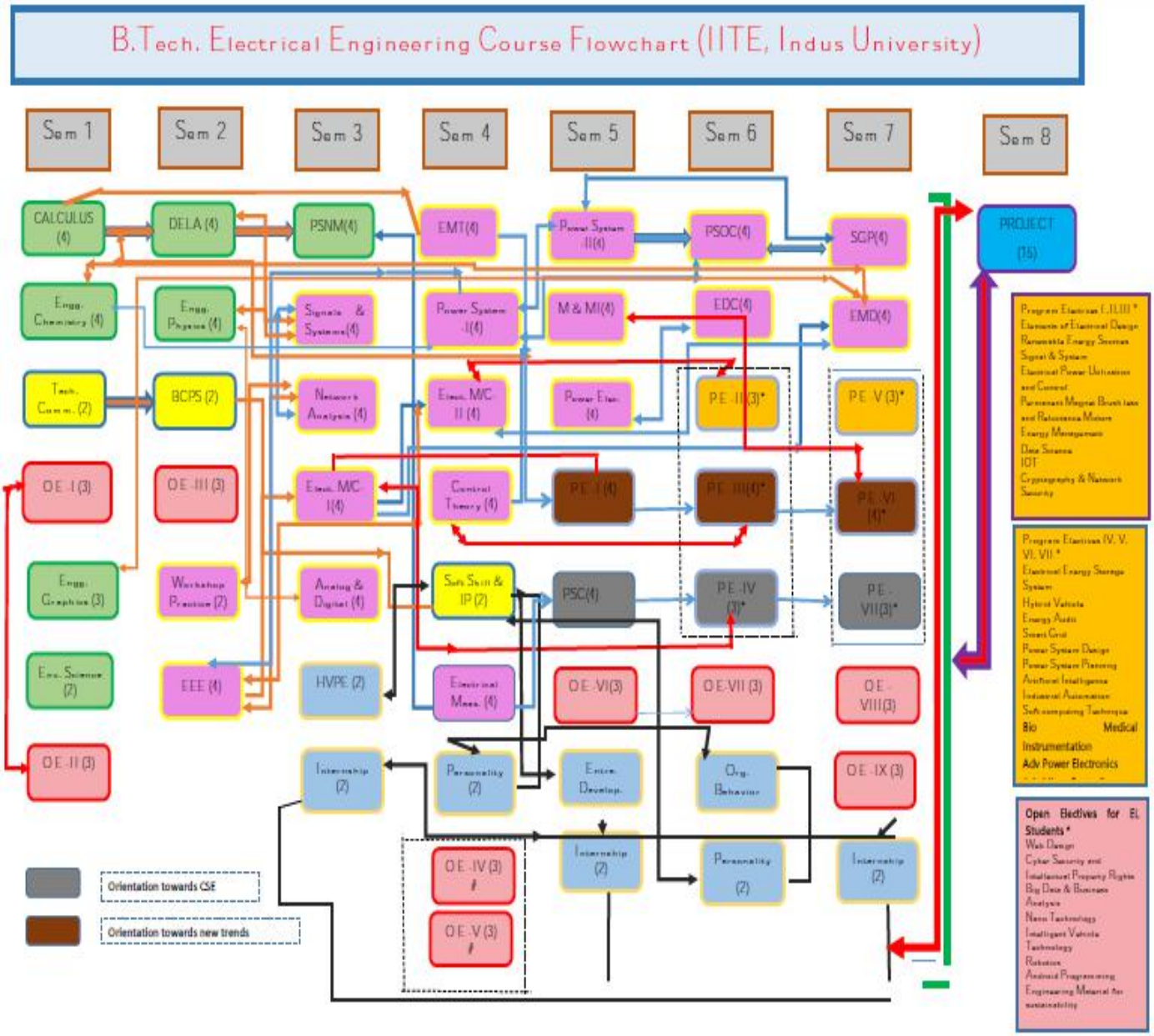
**(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)**

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | State Space Analysis of Control Systems: State Variables; State-Space Representation of Electrical, Mechanical and Electromechanical Systems | 1 | *BB, PPT* |
| | Weeks 2 | Space Representation of nth Order Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between State Equations and Transfer Functions; | 1 | *BB, PPT* |
| | Week 3 | Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan | 1 | *BB, PPT* |

| | | | | |
|---|---|---|---|---|
| | | Canonical Form; | | |
| | Week 4 | Controllability Canonical Form; Observability Canonical Form; Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition; State Diagram; Solution of the Time Invariant State Equation; | 1,2 | *BB, PPT* |
| | Week 5 | State Diagram; Solution of the Time Invariant State Equation; State Transition Matrix and its Properties; | 1,2 | *BB, PPT* |
| | Week 6 | Example of canonical form, transition matrix | 1,2 | *BB, PPT* |
| | Week 7 | Transfer Matrix; Transfer Matrix of Closed Loop Systems.<br>Controllability and Observability: Concept of Controllability and Observability; | 2 | *BB, PPT* |
| | Week 8 | Kalman's Theorems on Controllability and Observability, Alternative Tests (Gilbert's Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability | 3 | *BB, PPT* |

| | | | | |
|---|---|---|---|---|
| | | and Transfer Function. | | |
| | Week 9 | Example of Controllability and observability | 3 | *BB, PPT* |
| | Week 10 | Introduction to nonlinear systems, Types of common nonlinearities, Stability of nonlinear systems, describing functions analysis, limit cycles. | 4,5 | *BB, PPT* |
| | Week 11 | Liapunov Stability Analysis: Stability of Equilibrium State in the Sense of Liapunov | 4,5 | *BB, PPT* |
| | Week 12 | Graphical representation of Stability Asymptotic Stability and Instability, Sign-Definiteness of Scalar Function. | 5 | *BB, PPT* |
| | Week 13 | Pole placement Design & State Observers:<br>Stability improvement state feedback control, Pole Placement Design, State Feedback with Integral Control, Design of Full order state Observer, Design of reduced order state observer | 5,6 | *BB, PPT* |
| | Week 14 | State Design, Observer Design | 6 | *BB, PPT* |
| | Week 15 | State Feedback with Integral Control, Design of Full order | 6 | *BB, PPT* |

| | | | | |
|---|---|---|---|---|
| | | state Observer, Design of reduced order state observer | | |



## SYLLABUS

| Subject: Advanced Control Theory | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Program: B.Tech. Electrical Engineering** | | | | **Subject Code:EL0623** | | | **Semester:VI** | |
| | | | | | | | | |
| **Teaching Scheme** | | | | **Examination Evaluation Scheme** | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **University Theory Examination** | **University Practical Examination** | **Continuous Internal Evaluation (CIE)- Theory** | **Continuous Internal Evaluation (CIE)- Practical** | **Total** |
| 3 | 0 | 2 | 4 | 40 | 40 | 60 | 60 | 200 |

**Prerequisites:**

i) Laplace transform
ii) Linear Algebra
iii) Differential Equations
iv) Control System basics
v) Matrix Algebra

**Course Objectives:**

(i) To Learn various methodology of modelling in state space,
(ii) State transition matrix and solution in state equation, controllability and observability will be studied.
(iii) Stability analysis issues of linear and nonlinear system in state space will be discussed.
(iv) To know the concepts of controller design and observer design.

**Course Outcome:**

Students will be able to:

i) Understand the basic concepts of state space representation and state transformation techniques.

ii) Able to learn state transition matrix, its properties and solution of state equations.

iii) Understand and apply controllability and observability concepts in control systems.

iv) Understand the different types of nonlinear systems and stability conditions for them.

v) Learn and apply Liapunov Stability Analysis conditions for control systems.

vi) Design and Analyze pole placement technique and state observer designs.

## SYLLABUS

**UNIT-I** **[11]**

**State Space Analysis of Control Systems:** State Variables; State-Space Representation of Electrical, Mechanical and Electromechanical Systems; State Space Representation of nth Order Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between State Equations and Transfer Functions; Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan Canonical Form; Controllability Canonical Form; Observability Canonical Form; Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition;

**UNIT-II** **[11]**

State Diagram; Solution of the Time Invariant State Equation; State Transition Matrix and its Properties; Transfer Matrix; Transfer Matrix of Closed Loop Systems.

**Controllability and Observability**: Concept of Controllability and Observability; Kalman's Theorems on Controllability and Observability, Alternative Tests (Gilbert's Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability and Transfer Function.

**UNIT-III** **[12]**

Introduction to nonlinear systems, Types of common nonlinearities, Stability of nonlinear systems, describing functions analysis, limit cycles.

Liapunov Stability Analysis: Stability of Equilibrium State in the Sense of Liapunov, Graphical

representation of Stability Asymptotic Stability and Instability, Sign-Definiteness of Scalar Function.

**UNIT-IV** **[11]**

Pole placement Design & State Observers:

Stability improvement state feedback control, Pole Placement Design, State Regulator Design, Observer Design, State Feedback with Integral Control, Design of Full order state Observer, Design of reduced order state observer

**Text Books**


i) M. Gopal, "Digital control and state variable methods", 2nd Ed, TMH Publication.

ii) Katsuhiko Ogata, "Modern Control Engineering", 4th Ed, Prentice Hall of India.

iii) Benjamin C. Kuo, "Automatic Control Systems", PHI Learning Private Limited, 2010.


**Reference Books**


i) Norman S Nise, "Control system engineering", 4th Ed., Wiley-India Edition.

ii) A. Tewari, Modern Control Design: with MATLAB and SIMULINK, Wiley, 2002.

iii) I. J. Nagrath and M. Gopal, Control Systems Engineering, New Age International Publishers, Fifth Edition, 2007.

iv) D. R. Choudhuary, "Modern Control Engineering, PHI, 2005.

v) Stefani et. al., Design of Feedback Control Systems, Oxford, Fourth edition, 2002.


**Web resources**

i) https://nptel.ac.in/courses/101108047/32.

ii) https://nptel.ac.in/courses/101108047/module9/Lecture%2022.pdf

**MOOCs**

i) https://www.edx.org/

ii) https://www.nptel.ac.in/

iii) https://www.coursera.org/

**Name of Institute: Indus Institute of Technology and Engineering**

**Name of Faculty: Prof. Hinal Shah**

**Course code: EL0622**

**Course name:Digital Signal Processing**

Pre-requisites: Laplace transform, Linear Algebra, Differential Equations, Signal and System

Credit points: 04

Offered Semester: 6th

**Course Coordinator (weeks 01-15)**

Full Name: Hinal Shah

Department with siting location: 3rd floor Staff room, Bhanwar Building

Telephone: 9727554848

Email: hinalshah.el@indusuni.ac.in

Consultation times: Tuesday: 3:25-4:15

**Course Lecturer (weeks 01-15)**

Full name: Hinal Shah

Department with siting location: 3rd floor Staff room, Bhanwar Building

Telephone: 9727554848

Email: hinalshah.el@indusuni.ac.in

Consultation times: Tuesday: 3:25-4:15

Students will be contacted throughout the Session via Mail with important information relating to this Course.

## Course Objectives

By participating in and understanding all facets of this Course a student will:

5) To Learn discrete time signals in frequency domain.
6) Digital and analog signals and systems will be studied.
7) To know conceptualize the need of adaptive filters in communication applications.
8) To know the concepts of Digital filter and Digital signal processor.

## Course Outcomes (CO)

CO1:Analyse digital and analog signals and systems. [BT- 5]

CO2: Analyze discrete time signals in frequency domain [BT-6]

CO3: Design digital filters. [BT-3]

CO4: Understand the key Architectural features of Digital Signal Processor. [BT-2]

CO5: Apply digital signal processing algorithms to various areas. [BT-3]

CO6: Apply Discrete and Fast fourier transform method to various application. [BT-3]

## Course Outline

**UNIT-I** **[10]**

**Introduction to DSP**: Overview: Signals, systems and signal processing, classification of signals, elements of digital signal processing system, concept of frequency in continuous and discrete time signals, Periodic Sampling, Frequency domain representation of sampling, Reconstructions of band limited signals from its samples

**Discrete-Time Signals and Systems** (Frequency Domain analysis): Z-transform & Inverse z-transform, Linear convolution and its properties, Linear Constant Coefficient Difference equations, Frequency domain representation of Discrete-Time Signals & Systems, Representation of sequences by discrete time Fourier Transform, (DTFT), Properties of discrete time Fourier Transform, and correlation of signals, Fourier Transform Theorems.

**UNIT-II** **[10]**

**Analysis of Linear Time Invariant System**: Analysis of LTI systems in time domain and stability considerations. 8 15 Frequency response of LTI system, System functions for systems with linear constant-coefficient Difference equations, Freq. response of rational system functions relationship between magnitude & phase, All pass systems, inverse systems, Minimum/Maximum phase systems, systems with linear phase.

**UNIT-III** **[15]**

**Structures for Discrete Time Systems:** Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, Basic Structures of IIR Systems, lattice and lattice-ladder structures, Transposed forms, Direct and cascade form Structures for FIR Systems, Linear Phase FIR structure, Effects of Co-efficient quantization.: Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, Basic Structures of IIR Systems, lattice and lattice-ladder structures, Transposed forms, Direct and cascade form Structures for FIR Systems, Linear Phase FIR structure, Effects of Co-efficient quantization.

**Filter Design Techniques**: Design of Discrete-Time IIR filters from Continuous-Time filters Approximation by derivatives, Impulse invariance and Bilinear Transformation methods; Design of FIR filters by windowing techniques..

**UNIT-IV** **[10]**

**Discrete-Fourier Transform & Fast Fourier Transform**: Representation of Periodic sequences: The discrete Fourier Series and its Properties Fourier Transform of Periodic Signals, Sampling the Fourier Transform, The Discrete-Fourier Transform, Properties of DFT, Linear Convolution using DFT. FFT-Efficient Computation of DFT, Goertzel Algorithm, radix2 Decimation-in-Time and Decimationin-Frequency FFT Algorithms.

## Method of delivery

Face to face lectures

## Study time

3 Hours Lecture and 2Hours Laboratory per week

## CO-PO Mapping (PO: Program Outcomes)

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 3 | - | - | - | - | - | - | - |
| **CO2** | 2 | 3 | 2 | - | 2 | - | - | - | - | - | - | - |
| **CO3** | 2 | 2 | 2 | 1 | 3 | - | - | - | 2 | - | - | - |
| **CO4** | 2 | 3 | 2 | 2 | 3 | - | - | - | - | - | - | - |
| **CO5** | 2 | 2 | 3 | 2 | 3 | - | - | - | 2 | - | - | - |
| **CO6** | 2 | 3 | 3 | 2 | 3 | - | - | - | 2 | - | - | - |
| **EL0623** | **2** | **2.5** | **2.3** | **1.8** | **2.8** | **-** | **-** | **-** | **2** | **-** | **-** | **-** |

1-Lightly Mapped 2- Moderately Mapped 3- Highly Mapped

## Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)


**Figure 1: Blooms Taxonomy**

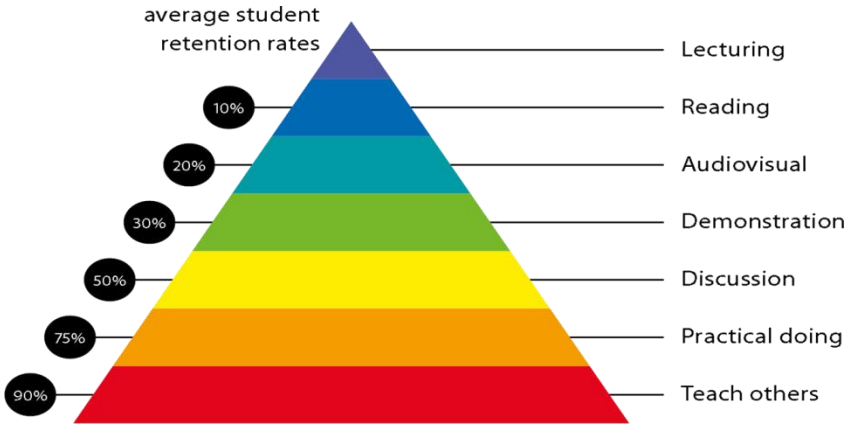



Figure 2: Knowledge retention

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of Electrical Graduate Capabilities |
|---|---|
| **Informed**<br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas. | **1 Professional knowledge, grounding & awareness** |
| **Independent learners**<br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others. | **2 Information literacy, gathering & processing** |
| **Problem solvers**<br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, and innovative and aim for high standards. | **4 Problem solving skills** |
| **Effective communicators** | **5 Written communication** |

| | |
|---|---|
| Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication. | **6 Oral communication**<br>**7 Teamwork** |
| **Responsible**<br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities. | **10 Sustainability, societal & environmental impact** |

## Practical work:

| | |
|---|---|
| 11. | Introduction to Matlab for Signal Processing Toolbox. |
| 12. | To Find Dft / Idft Of Given Dt Signal |
| 13. | Simulate Matlab Code For Linear Convolution Of Two Sequences |
| 14. | Simulate program to compute auto correlation between two sequences. |
| 15. | Simulate MATLAB program to find frequency response of a given system in differential equation form. |
| 16. | Simulate MATLAB program to find the FFT of a given sequence |
| 17. | Determination of Power Spectrum of a given signal. |
| 18. | To implement LP FIR filter for a given sequence. |
| 19. | To implement HP FIR filter for a given sequence. |
| 20. | To implement IIR filter. |

## Lecture/Lab times

(Give lecture times in the format below)

Lecture:

Laboratory:

## Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

## Details of referencing system to be used in written work

## Text books


1. "Digital Signal Processing: Principles, Algorithm & Application", 4th edition, Proakis, Manolakis, Pearson
2. "Discrete Time Signal Processing":Oppeheim, Schafer, Buck Pearson education publication, 2nd Edition, 2003.
3. Digital Signal Processing fundamentals and Applications,Li Tan , Jean Jiang, Academic Press,2nd edition,2013


## Reference books


1. Digital Signal Processing – A computer based Approach, S.K.Mitra, Tata McGraw Hill,3rd edition,2006
2. Fundamentals of digital Signal Processing –Lonnie c.Ludeman, Wiley
3. Digital Signal processing-A Practical Approach,second edition, Emmanuel I. feacher, and BarrieW..Jervis, Pearson Education
4. Digital Signal Processing, S.Salivahanan, A.Vallavaraj, C.Gnapriya TMH
5. Digital Signal Processors, Architecture, programming and applications by B. Venkatramani, M Bhaskar, Mc-Graw Hill


## ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

E

| |
|---|
| Class test (MSE) (40 marks) |
| Assignment (10 marks) |
| Innovative/Project/Presentation (10 marks) |
| Final exam (*closed book*) (40 marks) |

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

### Practical Work Report/Laboratory Report:

A report on the practical work is due the subsequent week after completion of the class by each group.

### Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of 5% of the maximum mark per calendar day

### Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

### Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

### University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***

***Do not share your work with other students (except where required for a group activity or assessment).***

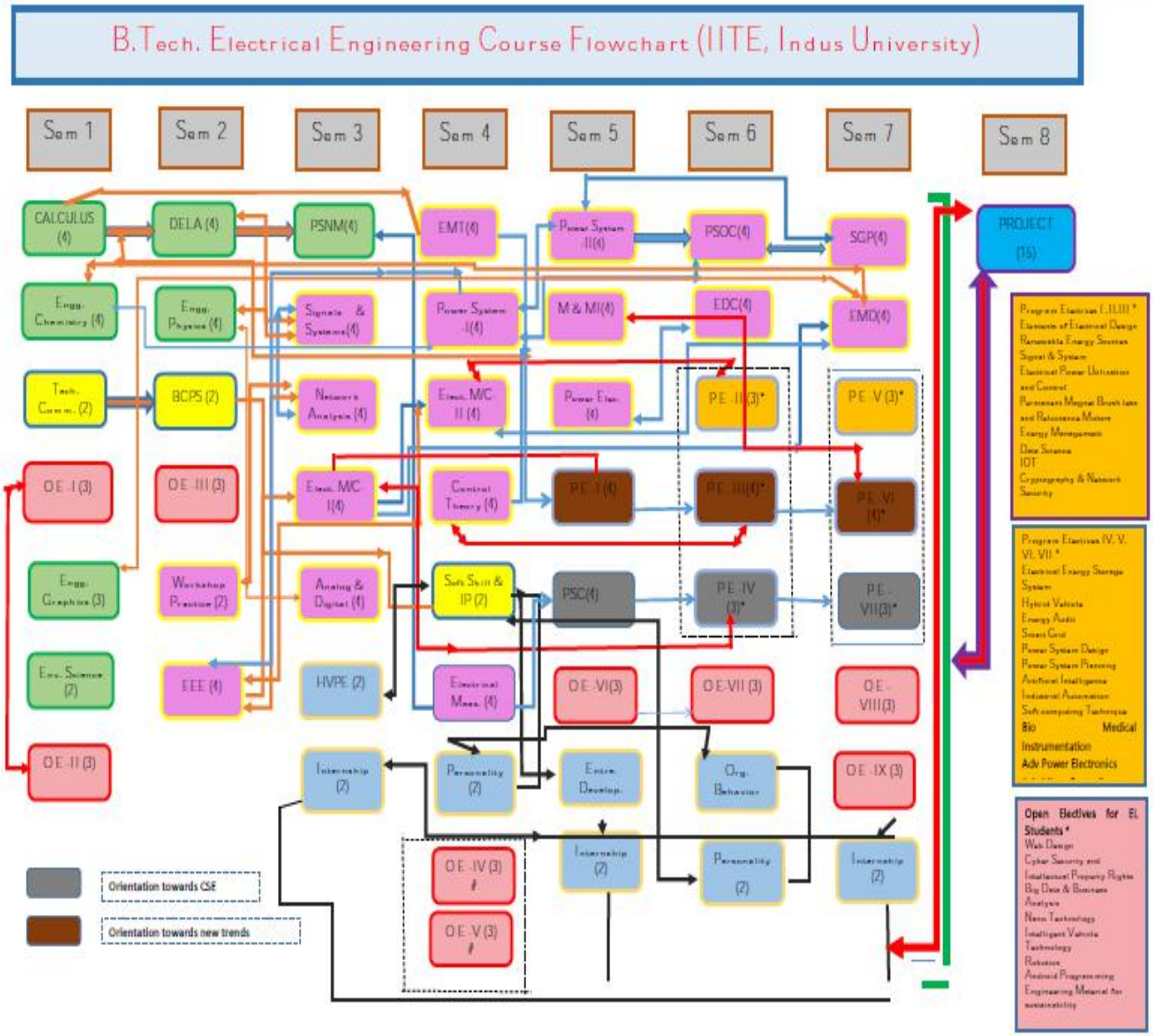
## Course schedule (subject to change)

**(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)**

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | **Introduction to DSP**: Overview: Signals, systems and signal processing, Classification of signals, elements of digital signal processing system.concept of frequency in continuous and discrete time signals. | 1 | *BB, PPT* |
| | Weeks 2 | Periodic Sampling, Frequency domain representation of sampling, Reconstructions of band limited signals from its samples **Discrete-Time Signals and Systems** (Frequency Domain analysis): Z-transform & Inverse z-transform, | 1,2 | *BB, PPT* |
| | Week 3 | Linear convolution and its properties, Linear Constant Coefficient Difference equations, Frequency domain representation of Discrete-Time Signals & Systems, Representation of sequences by discrete time Fourier Transform, (DTFT), | 1,2 | *BB, PPT* |
| | Week 4 | Properties of discrete time Fourier Transform, and correlation of signals, | 1,2, | *BB, PPT* |

| | | | | |
|---|---|---|---|---|
| | | Fourier Transform Theorems.**Analysis of Linear Time Invariant System**: Analysis of LTI systems in time domain and stability considerations | | |
| | Week 5 | Frequency response of LTI system, System functions for systems with linear constant-coefficient Difference equations, | 2 | *BB, PPT* |
| | Week 6 | Freq. response of rational system functions relationship between magnitude & phase, All pass systems, inverse systems, | 2 | *BB, PPT* |
| | Week 7 | Minimum/Maximum phase systems, systems with linear phase.**Structures for Discrete Time Systems:** Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, Basic Structures of IIR Systems, lattice and lattice-ladder structures. | 2,3,4 | *BB, PPT* |
| | Week 8 | Transposed forms, Direct and cascade form Structures for FIR Systems, Linear Phase FIR structure, | 3,4 | *BB, PPT* |
| | Week 9 | Effects of Co-efficient quantization.: Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, | 3,4 | *BB, PPT* |

| | | | | |
|---|---|---|---|---|
| | Week 10 | Basic Structures of IIR Systems, lattice and lattice-ladder structures, Transposed forms, Direct and cascade form Structures for FIR Systems, | 3,4,5 | *BB, PPT* |
| | Week 11 | Linear Phase FIR structure, Effects of Co-efficient quantization.<br>**Filter Design Techniques**: Design of Discrete-Time IIR filters from Continuous-Time filters. | 3,4,5 | *BB, PPT* |
| | Week 12 | Approximation by derivatives, Impulse invariance and Bilinear Transformation methods; Design of FIR filters by windowing techniques. | 3,5,6 | *BB, PPT* |
| | Week 13 | **Discrete-Fourier Transform & Fast Fourier Transform**: Representation of Periodic sequences: The discrete Fourier Series and its Properties Fourier Transform of Periodic Signals, Sampling the Fourier Transform, The Discrete-Fourier Transform, Properties of DFT, | 5,6 | *BB, PPT* |
| | Week 14 | Linear Convolution using DFT. FFT-Efficient Computation of DFT. | 6 | *BB, PPT* |
| | Week 15 | Goertzel Algorithm, radix2 Decimation-in-Time and Decimationin-Frequency FFT Algorithms. | 6 | *BB, PPT* |


B.Tech. Electrical Engineering Course Flowchart (IITE, Indus University)
Sem 1
Sem 2
Sem 3
Sem 4
Sem 5
Sem 6
Sem 7
Sem 8
CALCULUS (4)
DELA (4)
PSNM(4)
EMT(4)
Power System -II(4)
PSOC(4)
SGP(4)
PROJECT (15)
Engg. Chemistry (4)
Engg. Physics (4)
Signals & Systems(4)
Power System -I(4)
M & MI(4)
EDC(4)
EMD(4)
Tech. Comm. (2)
BCPS (2)
Network Analysis (4)
Elect. MIC-II (4)
Power Elec. (4)
PE -II (3)*
PE -V (3)*
OE -I (3)
OE -III (3)
Elect. MIC-I(4)
Control Theory (4)
PE -I (4)
PE -III(4)*
PE -VI (4)*
Engg. Graphics (3)
Workshop Practice (2)
Analog & Digital (4)
Soft Skill & IP (2)
PSC(4)
PE -IV (3)*
PE -VII(3)*
Env. Science (2)
EEE (4)
HVPE (2)
Electrical Mass. (4)
OE -VI(3)
OE -VII (3)
OE -VIII(3)
OE -II (3)
Internship (2)
Personality (2)
Entre. Develop.
Org. Behavior
OE -IX (3)
OE -IV (3)
OE -V (3)
Internship (2)
Personality (2)
Internship (2)
Orientation towards CSE
Orientation towards new trends
Program Electives I, II, III *
Elements of Electrical Design
Renewable Energy Sources
Signal & System
Electrical Power Utilization and Control
Permanent Magnet Brush less and Reluctance Motors
Energy Management
Data Science
IOT
Cryptography & Network Security
Program Electives IV, V, VI, VII *
Electrical Energy Storage System
Hybrid Vehicle
Energy Audit
Smart Grid
Power System Design
Power System Planning
Artificial Intelligence
Industrial Automation
Soft computing Techniques
Bio Medical Instrumentation
Adv Power Electronics
Open Electives for EL Students *
Web Design
Cyber Security and Intellectual Property Rights
Big Data & Business Analysis
Nano Technology
Intelligent Vehicle Technology
Robotics
Android Programming
Engineering Material for sustainability

## SYLLABUS

| Subject: Digital Signal Processing | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Program: B.Tech. Electrical Engineering** | | | | **Subject Code:EL0622** | | | **Semester: VI** | |
| | | | | | | | | |
| **Teaching Scheme** | | | | **Examination Evaluation Scheme** | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **University Theory Examination** | **University Practical Examination** | **Continuous Internal Evaluation (CIE)- Theory** | **Continuous Internal Evaluation (CIE)- Practical** | **Total** |
| 3 | 0 | 2 | 4 | 40 | 40 | 60 | 60 | 200 |

**Course Outcome**

By the end of this course, the student will be able to:

1. Formulate engineering problems in terms of DSP tasks 2
2. Analyse digital and analog signals and systems
3. Analyze discrete time signals in frequency domain
4. Design digital filters
5. Change sampling rate of the signal
6. Conceptualize the need of adaptive filters in communication applications.
7. Understand the key Architectural features of Digital Signal Processor
8. Apply digital signal processing algorithms to various areas

## SYLLABUS

**UNIT-I** **[10]**

**Introduction to DSP**: Overview: Signals, systems and signal processing, classification of signals, elements of digital signal processing system, concept of frequency in continuous and discrete time signals, Periodic Sampling, Frequency domain representation of sampling, Reconstructions of band limited signals from its samples

**Discrete-Time Signals and Systems** (Frequency Domain analysis): Z-transform & Inverse z-transform, Linear convolution and its properties, Linear Constant Coefficient Difference equations, Frequency domain representation of Discrete-Time Signals & Systems, Representation of sequences by discrete time Fourier Transform, (DTFT), Properties of discrete time Fourier Transform, and correlation of signals, Fourier Transform Theorems.

**UNIT-II** **[10]**

**Analysis of Linear Time Invariant System**: Analysis of LTI systems in time domain and stability considerations. 8 15 Frequency response of LTI system, System functions for systems with linear constant-coefficient Difference equations, Freq. response of rational system functions relationship

between magnitude & phase, All pass systems, inverse systems, Minimum/Maximum phase systems, systems with linear phase.

**UNIT-III** **[15]**

**Structures for Discrete Time Systems:** Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, Basic Structures of IIR Systems, lattice and lattice-ladder structures, Transposed forms, Direct and cascade form Structures for FIR Systems, Linear Phase FIR structure, Effects of Co-efficient quantization.: Block Diagram and signal flow diagram representations of Linear Constant-Coefficient Difference equations, Basic Structures of IIR Systems, lattice and lattice-ladder structures, Transposed forms, Direct and cascade form Structures for FIR Systems, Linear Phase FIR structure, Effects of Co-efficient quantization.

**Filter Design Techniques**: Design of Discrete-Time IIR filters from Continuous-Time filters Approximation by derivatives, Impulse invariance and Bilinear Transformation methods; Design of FIR filters by windowing techniques..

**UNIT-IV** **[10]**

**Discrete-Fourier Transform & Fast Fourier Transform**: Representation of Periodic sequences: The discrete Fourier Series and its Properties Fourier Transform of Periodic Signals, Sampling the Fourier Transform, The Discrete-Fourier Transform, Properties of DFT, Linear Convolution using DFT. FFT-Efficient Computation of DFT, Goertzel Algorithm, radix2 Decimation-in-Time and Decimationin-Frequency FFT Algorithms.

**Text Books:**

1. “Digital Signal Processing: Principles, Algorithm & Application”, 4th edition, Proakis, Manolakis, Pearson

2. “Discrete Time Signal Processing”:Oppeheim, Schafer, Buck Pearson education publication, 2nd Edition, 2003.

3. Digital Signal Processing fundamentals and Applications,Li Tan , Jean Jiang, Academic Press,2nd edition,2013

**Reference Books:**

1. Digital Signal Processing – A computer based Approach, S.K.Mitra, Tata McGraw Hill,3rd edition,2006

2. Fundamentals of digital Signal Processing –Lonnie c.Ludeman, Wiley

3. Digital Signal processing-A Practical Approach,second edition, Emmanuel I. feacher, and BarrieW..Jervis, Pearson Education

4. Digital Signal Processing, S.Salivahanan, A.Vallavaraj, C.Gnapriya TMH 5. Digital Signal

Processors, Architecture, programming and applications by B. Venkatramani, M Bhaskar, Mc-Graw Hill

**Name of Institute: ITE**

**Name of Faculty:**

**Course code:** EL0620

**Course name:** Energy Management and Audit

Pre-requisites: Power system, EEE

Credit points: 4

Offered Semester: VI

**Course Coordinator**

**Course Lecturer**

Students will be contacted throughout the Session via Mail with important information relating to this Course.

## Course Objectives

By participating in and understanding all facets of this Course a student will able to:

1) To understand the set up of an energy management program for industries.
2) To be able to prepare an energy audit report for various industrial and commercial units
3) To be able to evaluate time value of equipment, utility and money.

4) To be able to calculate the energy bills based on utility rate structures

5) To be able to analyze and recommend the possible energy conservation opportunities in various electrical equipments.

6) To be able to use and demonstrate various metering equipments for energy management program.

## Course Outcomes (CO)

After completion of this course, student will have,

**CO-1** Set up an energy management program for various industrial entities.

**CO-2** Prepare an energy audit report for various industrial and commercial units.

**CO-3** Evaluate time value of equipment, utility and money.

**CO-4** Calculate the energy bills based on utility rate structures.

**CO-5** Analyze and recommend the possible energy conservation opportunities in various electrical equipments.

**CO-6** Use and demonstrate various metering equipments for energy management program.

## Course Outline

Proposed course mainly deal with energy management process, energy bill calculation and energy conservation opportunities.

## Method of delivery

Face to face lectures

## Study time

3 lectures + 2 hours Tutorial per week

## CO-PO Mapping (PO: Program Outcomes)

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 3 | 2 | 3 | - | - | 2 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 2 | - | 2 | - | - | 2 | 2 | 1 | 2 | 2 |
| **CO3** | 3 | 3 | 2 | 3 | - | - | - | - | 2 | 2 | 2 | 3 |
| **CO4** | 3 | 3 | 2 | - | 2 | - | - | 3 | 3 | 3 | 3 | 2 |
| **CO5** | 1 | 3 | 3 | 3 | 3 | - | - | - | 3 | 3 | 3 | 3 |
| **CO6** | 2 | 1 | 2 | 3 | 3 | - | - | - | 2 | 3 | 2 | 1 |

## Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

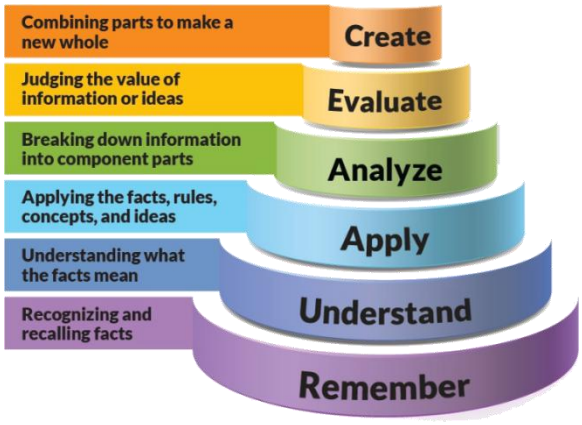



Figure 1: Blooms Taxonomy

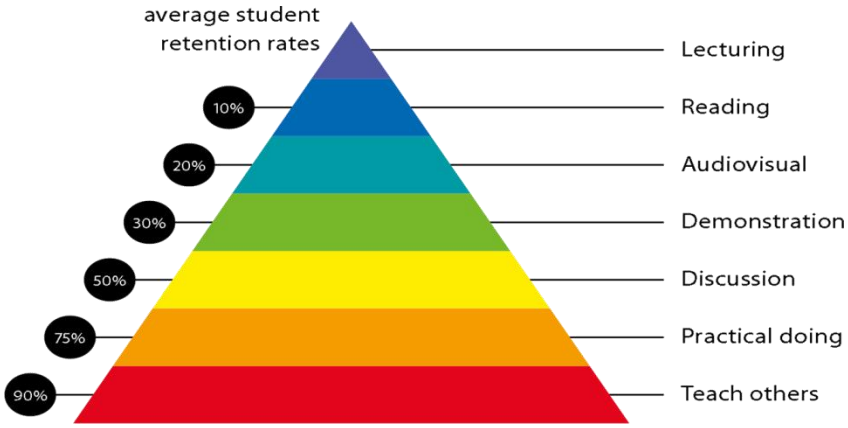



Figure 2: Knowledge retention

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of _____Graduate Capabilities |
|---|---|
| **Informed**<br><br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas. | **1 Professional knowledge, grounding & awareness** |
| **Independent learners**<br><br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others. | **2 Information literacy, gathering & processing** |
| **Problem solvers**<br><br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative | **4 Problem solving skills** |

| | |
|---|---|
| and aim for high standards. | |
| **Effective communicators**<br><br>Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication. | **5 Written communication** |
| | **6 Oral communication** |
| | **7 Teamwork** |
| **Responsible**<br><br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities. | **10 Sustainability, societal & environmental impact** |

## Practical work:

NA

## Lecture/tutorial times

(Give lecture times in the format below)

| |
|---|
| |

## Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

## Details of referencing system to be used in written work

## Text books

1. Eastop T.D, Croft D.R, “Energy Efficiency for Engineers and Technologists”, Logman Scientific &Technical, 1990.

## Additional Materials

1. Reay D. A. “Industrial Energy Conservation”, first edition, Pergamon Press, 1977.
2. IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities, IEEE, 1996.

## ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

| |
|---|
| |

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

## Practical Work Report/Laboratory Report:

NA.

## Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -1% of the maximum mark per calendar day

## Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

## Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

## University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***

***Do not share your work with other students (except where required for a group activity or assessment)***

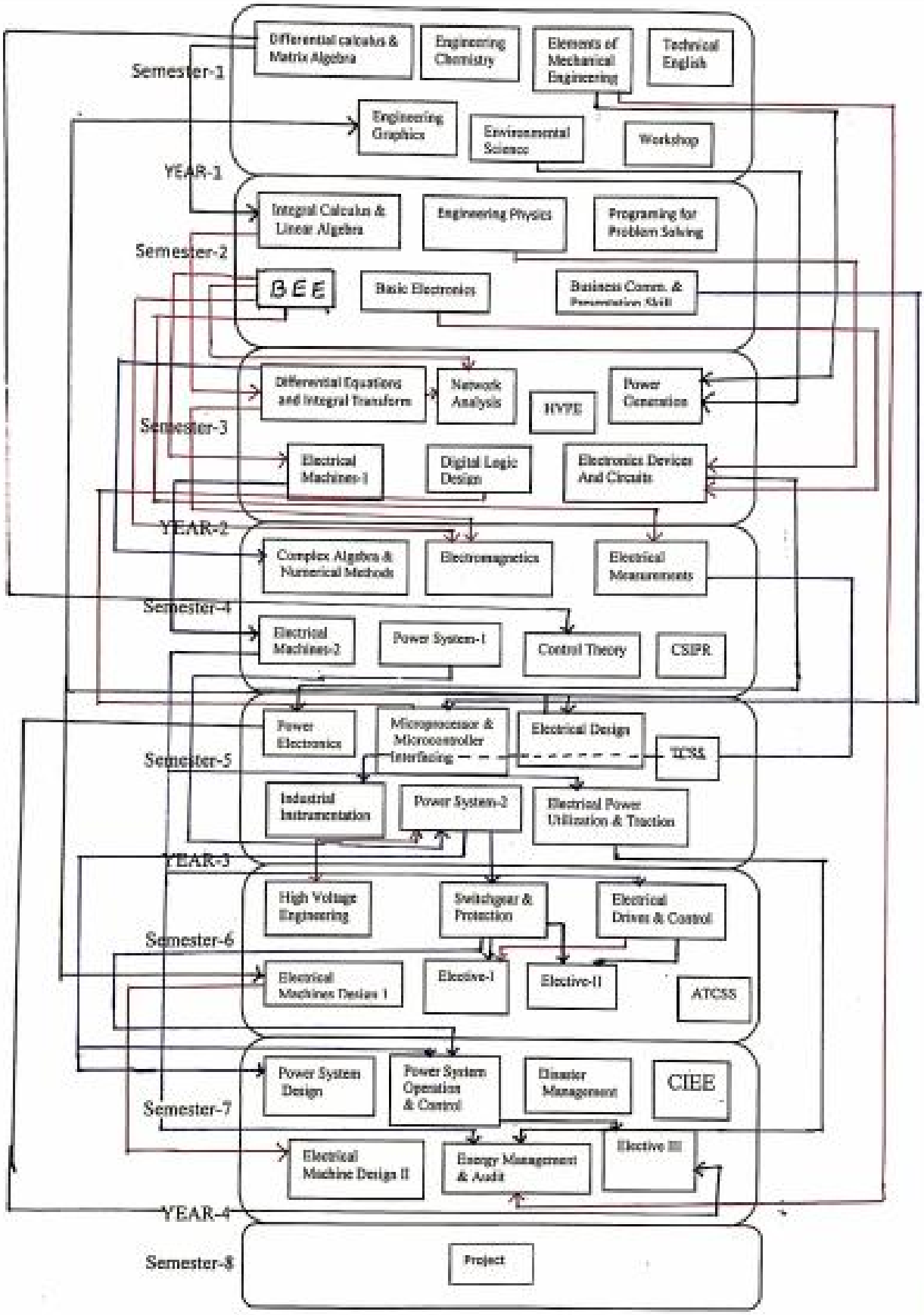
.

## Course schedule (subject to change)

**(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)**

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | Need for energy management<br>Energy basics<br>Designing energy management program | 1,2 | BB |
| | Weeks 2 | Designing energy management program<br>Starting energy management program<br>Starting energy management program | 1,2,5 | BB |
| | Week 3 | Energy accounting<br>Energy monitoring, targeting and reporting<br>Energy audit process | 1,2,5 | BB |
| | Week 4 | Exercise based on above topics<br>Important concepts in an economic analysis<br>Economic models | 2,3,5 | BB |
| | Week 5 | Time value of money<br>Utility rate structures<br>Cost of electricity | 2,3,5 | BB |
| | | | | |
| | Week 6 | Loss evaluation<br>Load management<br>Demand control techniques | 2,3,5 | BB |

| | | | | |
|---|---|---|---|---|
| | Week 7 | Utility monitoring and control system<br>HVAC and energy management | 3,4 | BB |
| | Week 8 | Economic justification<br>Systems and equipment<br>Analysis of energy consumption | 3,4 | BB |
| | Week 9 | Electric motors, Analysis of motor load and power used<br>Improvement of efficiency of motor to reduce consumption | 3,4 | BB |
| | Week 10 | Calculations of energy, exercise<br>Transformers and reactors<br>Calculations of energy, exercise | 3,4,5 | BB |
| | Week 11 | capacitors and synchronous machines<br>Calculations of energy, exercise<br>Relationships between parameters | 3,4,5 | BB |
| | Week 12 | Units of measure<br>typical cost factors<br>utility meters | 3,4,5 | BB |
| | Week 13 | timing of meter disc for kilowatt measurement<br>demand meters<br>paralleling of current transformers | 6 | BB |
| | Week 14 | instrument transformer burdens<br>Multitasking solid-state meters<br>metering location vs. requirements | 5,6 | BB |
| | Week 15 | Metering techniques<br>practical examples<br>practical examples | 5,6 | BB |




EL

Elective-I: Advanced Control Theory, Industrial Automation, Soft Computing
Elective-II: Electrical Power Quality, EHV AC & DC, Special Machines, MOOC
Elective-III: FACTS, Advanced Power Electronics, Power System Planning, MOOC

**Name of Institute: Institute of Technology & Engineering**

**Name of Faculty:**

**Course code: EL0618**

**Course name: Electrical Power Utilization and Control**

**Pre-requisites:**

i) Basic Knowledge of Electrical Machines and basics of electrical Drives.

ii) Basic Knowledge of electrical power transmission and distribution

Credit points: 04

Offered Semester: **V**

**Course coordinator (weeks 01 - 15)**

Full name:

Department with siting location:

Telephone:

Email:

Consultation times: 9:00 a.m. to 5:00 p.m.

**Course lecturer (weeks 01 - 15)**

Full name:

Department with siting location:

Telephone:

Email:

Consultation times: 9:00 a.m. to 5:00 p.m.

Students will be contacted throughout the session via mail with important information relating to this course.

## Course Objectives

By participating in and understanding all facets of this course a student will:

(i) To make a student understand basic concepts of electric drives, their applications, different types of loads.

(ii) To provide the concept of electric traction, track electrification.

(iii) To know the train mechanics, OHE, traction motors and their control.

(iv) To study illumination concepts, different lamps, electric heating methods, and HEVs.

## Course Outcomes (CO)

After studying this subject, Student will able to,

1) Understand the operating characteristics of electric drive and Load Equalization techniques.
2) Understand the principles of different Electric Traction System, track electrification methods and various speed time curves.
3) Understand the Power Supply arrangements for Traction System and OHE.
4) Understand different traction motors and their control.
5) Gain knowledge of different electric heating methods and illumination concepts.
6) Understand electric and hybrid vehicles, their performance and structure.

## Course Outline

In this course electrical drives and different industrial loads will be studied which are used for power utilization. Further different Electric Traction System prevailing in the country will be studied. Also this course will cover various electric heating equipments and illumination methods used for industrial and domestic purpose.

## Method of delivery

Face to face lectures, Assignments, Quiz

## Study time

3-hour lecture and 2-hour tutorial per week

## CO-PO Mapping (PO: Program Outcomes)

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | 1 | 1 | - | 2 |
| **CO2** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | 1 | 1 | - | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 |
| **CO5** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | 1 | 1 | - | 2 |
| **CO6** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |

## Blooms Taxonomyand Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

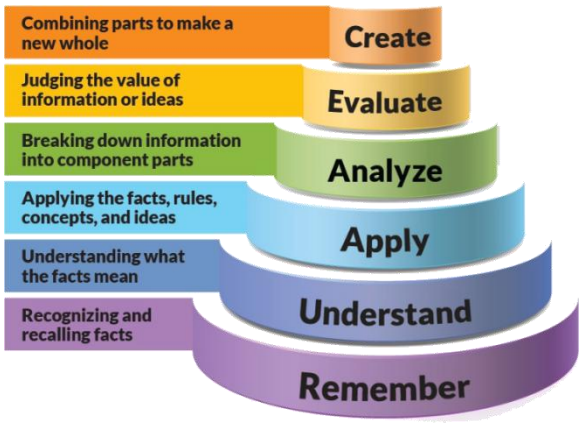



Figure 1: Blooms Taxonomy

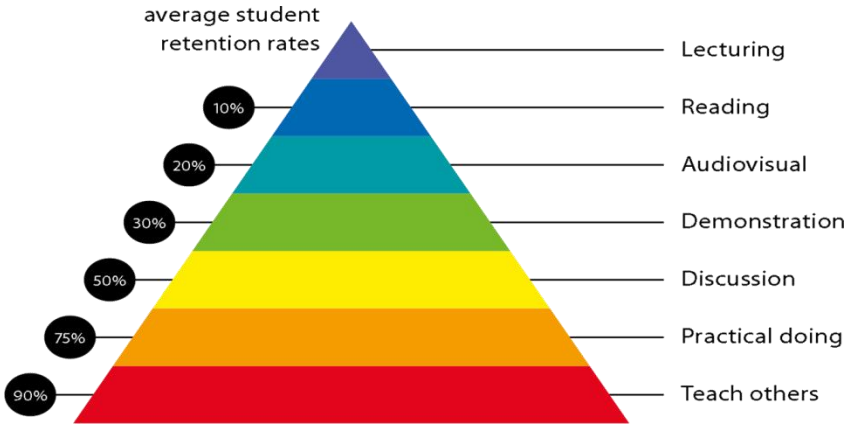



Figure 2: Knowledge retention

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of _____Graduate Capabilities |
|---|---|
| **Informed**<br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas. | **1 Professional knowledge, grounding & awareness** |
| **Independent learners**<br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others. | **2 Information literacy, gathering & processing** |
| **Problem solvers**<br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards. | **4 Problem solving skills** |

| | |
|---|---|
| **Effective communicators**<br><br>Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication. | **5 Written communication** |
| | **6 Oral communication** |
| | **7 Teamwork** |
| **Responsible**<br><br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities. | **10 Sustainability, societal & environmental impact** |

## Practical work:

NA

## Lecture/tutorial times

(Give lecture times in the format below)

| |
|---|
| |

## Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for semester examinations.

## Details of referencing system to be used in written work

## Text books

1) Utilization of Electrical Energy, E. Open Shaw Taylor, Orient Longman Publication.
2) Utilization of electrical power & electric traction, J. B. Gupta, S. K. Kataria Publications

## Additional Materials

1) A course in Electrical Power: Soni, Gupta and Bhatnagar, Dhanpat Rai & Sons
2) Modern electric traction, H. Partab, Dhanpat Rai Publications.
3) Utilisation of Electric Power & Electric Traction, G. C. Garg, Khanna Publishers

**Web Resource**

i) https://nptel.ac.in/courses/108102046/3
ii) http://www.rknec.edu/FirstYearContents/2017-18/Electrical%20heating.pdf
iii) http://www.darshan.ac.in/Upload/DIET/Documents/EE/UEET_2160907_CH_7_27012018_042415AM.pdf
iv) https://rdso.indianrailways.gov.in/works/uploads/File/STC-TrD-01.pdf

**MOOCS:**

i) https://www.edx.org/
ii) https://www.nptel.ac.in/
iii) https://www.coursera.org/

## ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in internalcomponent or less than 40% in the end semester will be considered for supplementary assessment in the respective components (i.e internal component or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (internal component or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

### Practical Work Report/Laboratory Report:

N.A.

### Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -% of the maximum mark per calendar day

### Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

### Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

### University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***

***Do not share your work with other students (except where required for a group activity or assessment)***

.

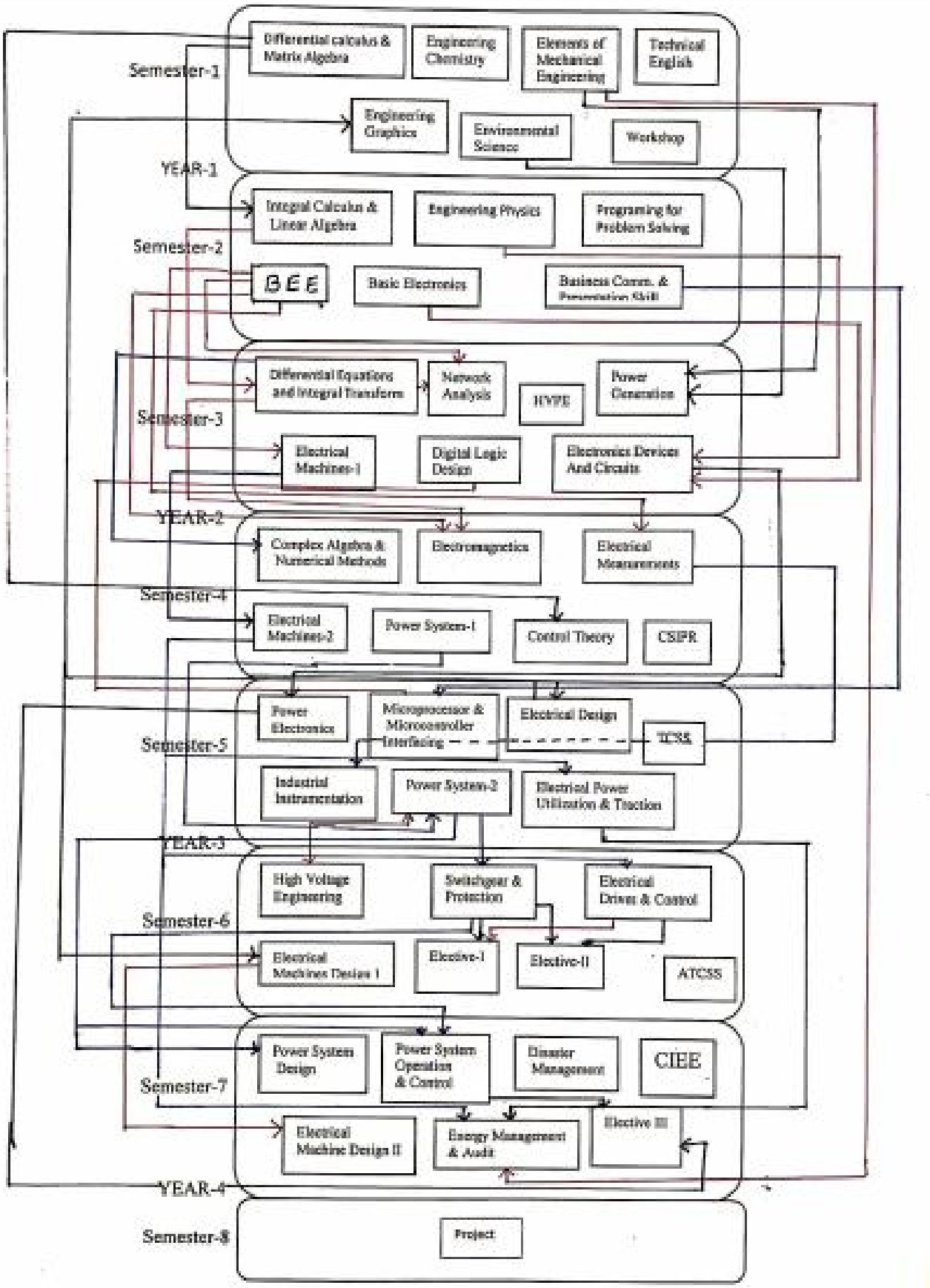
## Course schedule(subject to change)

**(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)**

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | **Introduction**<br>Type of electric drives, choice of motor, starting and running characteristics | 1 | BB |
| | Weeks 2 | speed control, temperature rise, particular applications of electric drives | 1 | BB |
| | Week 3 | types of industrial loads, continuous, intermittent and variable loads, load equalization. | *1* | BB, PPT |
| | Week 4 | **Electric Traction**<br>Traction System, Choice of traction system for India, Battery Drive | 2 | BB, PPT |
| | Week 5 | hybrid drive, flywheel drive, tramways, trolley bus. | 2 | BB, PPT |
| | | | | |
| | Week 6 | **Track Electrification:**<br>DC system, AC system, composite system, comparison between AC & DC system, traction mechanics, | 2 | BB |
| | Week 7 | types of services, speed time curve, average speed, schedule speed, tractive effort, power of traction motor, specific energy consumption. | 2 | BB, PPT |
| | Week 8 | **Mechanics of train Movement** | 3 | BB, PPT |

| | | | | |
|---|---|---|---|---|
| | | Coefficient of Adhesion, Power supply arrangements, | | |
| | Week 9 | remote control centre, function of DC substation, Block diagram of AC Electric locomotive, OHE, polygonal OHE, OHE supporting structure, current collection system. | *3* | BB, PPT |
| | Week 10 | **Traction Motors**<br>Suitability of motor, traction motor control, drum controller, bridge transition controller, series-parallel starting, | 4 | BB,PPT |
| | Week 11 | metadyne control, multiple unit control, wheel arrangement, braking, types of braking, mechanical braking, electrical braking, regenerative braking. | 4 | BB, PPT |
| | Week 12 | **Illumination**<br>Introduction, Definitions, sources of light, Inverse square law of illumination, requirements of good lighting, lamp fittings, | 5 | BB,PPT |
| | Week 13 | lighting systems, CFL, LED, outdoor lighting system, photometers. | 5 | BB |
| | Week 14 | **Electric Heating**<br>Introduction, heating methods, resistance heating, radiant heating, electric arc furnaces, induction furnaces, dielectric heating. | 5 | BB,PPT |
| | Week 15 | **Introduction to Electric and hybrid vehicles:**<br>Configuration and performance of electric vehicles, traction motor | 6 | BB,PPT |

| | | | | |
|---|---|---|---|---|
| | | characteristics, tractive effort, transmission requirement, vehicle performance and energy consumption. | | |




Elective-I: Advanced Control Theory, Industrial Automation, Soft Computing
Elective-II: Electrical Power Quality, EHV AC & DC, Special Machines, MOOC
Elective-III: FACTS, Advanced Power Electronics, Power System Planning, MOOC

# EPUT QUIZ

**NOTE:- Following MCQs carry one mark each:- [TOTAL - 10 MARKS]**

1) A drive suitable for mines where explosive gas exist, is

(A) Diesel engine

(B) Steam engine

(C) Battery locomotive

(D) Any of the above.

2) The main drawback of the electric drive is that

A. It is cumbersome drive
B. It is costlier in initial and maintenance cost
C. Electrical power supply failure makes the drive standstill
D. All of the above.

3) What type electric drive is used in cranes?

A. Multimotor
B. Group
C. Individual.
D. Both A and C

4) Which of the following is called the inertial torque? (J is moment of inertia in kg-$m^2$, B is the coeffiecient of viscous friction in Nm/(rad/s) and Wm is the rotor speed in rad/sec)

A. J dWm/dt
B. J $d^2$Wm/$dt^2$
C. B*Wm
D. B*Wm^2

5) Which of the following Load Speed-Torque characteristics represents a hyperbola?

A. Fan type of load
B. Traction load
C. Low speed hoist load
D. Constant power load

6) Which of the following load offers a constant load torque?

A. Traction Load
B. Low speed hoist
C. Fan type of load
D. High speed hoist

7) In which braking, back emf exceeds the supply voltage?

A. Plugging
B. Regenerative
C. Dynamic
D. None of these

8) Speed control by variation in field flux results in

A. Variable power drive
B. Constant power drive
C. Constant torque drive
D. None of these

9) The heating time constant of an electrical machine gives an induction of its

A. Overload capacity
B. Rating
C. Cooling
D. Short time rating

10) The load torque decreases with the increase in speed in the case of

A. Hoist winches, machine tool feed mechanism
B. Lathes, boring machines, milling machines
C. Blowers, fans, centrifugal pumps
D. Both (a) and (b)

**EPUC CLASS TEST** **[TOTAL 20 MARKS]**

1) Explain the temperature rise phenomena (heating condition) in electric drives by deriving equation for θ and showing heating time curve and time constant τ. **[5 marks]**

2) The full load temperature rise of a totally enclosed motor is 20°C after one hour, and 34°C after two hours. Find i) final steady temperature rise on full load, ii) heating time constant, iii) one hour rating of the motor for the same final temperature rise. Take no load losses = copper losses at rated continuous load. **[5 marks]**

3) A motor fitted with a flywheel has to supply the load torque of 200 kg-m for 10 sec followed by a no load period. During the no load period, the motor regains its speed. If it is desired to limit the motor torque to 100 kg-m, what should be the moment of inertia of the flywheel? The no load speed of the motor is 500 rpm and has a slip of 10% at a torque of 100 kg-m. Assume the motor inertia as 10 kg-$m^2$. **[4 marks]**

4) A flywheel is normally fitted to_____**[1 mark]**
   A. Dc series motor driving a constant torque load
   B. Separately excited dc motor driving pulsed torque load
   C. Cumulatively compound motor driving pulsed torque load
   D. Differentially compound motor driving pulsed torque load.

5) In DC motor, _____part can sustain the maximum temperature rise. **[1 mark]**
   A. Field winding B. Commutator C. Slip rings D. Armature winding

6) Draw the speed torque characteristics for dc shunt motor, dc series motor, AC series motor and 3-ph squirrel cage induction motor. **[4 marks]**

**OR**

Mention all the factors affecting the choice of the motor for electric drive. **[4 marks]**

_____ALL THE BEST_____

## EPUC Tutorial

**1)** The temperature rise of motor after operating for 30 minutes on full load is 20°C, After another 30 minutes on the same load the temperature rise becomes 30°C. Assuming that the temperature increases according to exponential law. Determine final temperature rise and heating time constant.

**2)** A 4 pole, 50 Hz Induction motor has a flywheel on its shaft. Total inertia at the motor shaft is 1000 kg-$m^2$. Load torque is 100kg-m for 10 seconds followed by a no load period along enough for the flywheel to regain its full speed. Motor has a slip of 6% at a torque of 50 kg-m. Calculate the speed at the end of deceleration period. Assume motor speed torque characteristic to be straight line in the region of interest and neglect windage and friction.

3) A train with a locomotive having four motors has a total mass of 250 tonnes. Stating from rest the train attains the speed of 40 kmph in 20 sec on a 1% gradient. The gear ratio is 3, The gear efficiency is 95%, the wheel diameter 95cm, the train resistance (average) is 40N per tones and rotational inertia is 10%. Find the torque developed by each of the motors and the minimum weight of the locomotive, given the adhesive coefficient is 0.25.

4) A train has a schedule speed of 30 kmph on a level track. The distance between two stations being 1 km., station stopping time is 20 seconds. Assuming braking retardation of 3 kmphps and maximu m speed 25 percentages greater than average speed, calculate acceleration to run the service. Assume trapezoidal speed time curve.

5) A motor equipped with flywheel has a supply of a load torque of 600Nm for 10 seconds followed by a no load period long enough for the flywheel to regain its full speed. It is required to limit the motor torque to 450 Nm. What should be the moment of inertia of the flywheel? The no load speed of the motor is 600 rpm and it has a slip of 8% at torque 400Nm. Assume the motor speed torque characteristic to be a straight line in the range of operation. Motor has an inertia of 10Kg-$m^2$.

Enrollment No: _____

**INDUS UNIVERSITY**

**ITE//IMS/ISHLS**

**Constituent Institutes of Indus University**

| **Semester:** | **5th** | **Branch:** | **Electrical** |
|---|---|---|---|
| **End Semester Examination (Nov/Dec 2019)** | | | |
| **Subject Code:** | **EL0506** | **Subject Name:** | **Electrical Power Utilization & Traction** |
| **Date:** | | **Time:** | |
| **Day:** | | **Total Marks:** | **40** |

Instructions:

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

| | | |
|---|---|---|
| **Q.1** | Enumerate the factors affecting the choice of motor for electric drive. | **04** |
| **Q.2** | Derive the equation for temperature rise phenomena (heatingcondition) with heatingtime curve with a neat diagram. | **06** |
| | **OR** | |
| | Derive the equation for maximum speed for trapezoidal speed time curve and analyze it. | **06** |
| **Q.3** | Compare between battery drive and hybrid drive. | **04** |
| **Q.4** | A 200 tonne train is started with a uniform acceleration and reaches a speed of 40km/hr in 24 seconds on a level track. Find the specific energy consumption assuming trapezoidal speed time curve if the rotational inertia is 10% and retardation rate is at 3kmphps and the distance between two stations is 2 km. Take the train resistance as 5kg/tonne and efficiency of motor as 80%. | **06** |
| | **OR** | |
| | Illustrate with neat figure, the power supply arrangements for traction system. | **06** |

| | | |
|---|---|---|
| **Q.5** | Illustrate any two types of polygonal OHE system. | **04** |
| **Q.6** | Elucidate the function of various parts of AC Electric Locomotive with its neat block diagram. | **06** |
| | **OR** | |
| | Discuss the different configurations used for hybrid electric vehicle | **06** |
| | | |
| **Q.7** | With suitable diagram, explain the construction and working of CFL. | **04** |
| **Q.8** | Analyze the direct resistance heating method with a neat figure. | **06** |
| | **OR** | |
| | A 4 pole 50 Hz Induction motor has a flywheel on its shaft. Total inertia at motor shaft is 1000 $kgm^2$. Load torque is 100 kg-m for 10 seconds followed by a no load period long enough for the flywheel to regain its full speed. Motor has a slip of 6% at a torque of 50 kg-m. Calculate the speed at the end of deceleration period. Assume motor speed torque characteristic to be a straight line in the region of interest and neglect friction and windage. | **06** |

**Name of Institute: IITE**

**Name of Faculty: Prof. Vineeta Chauhan**

**Course code:** EL0616

**Course name:** Power System Operation and Control

Pre-requisites: Power system I, Power System II, Switch gear and Protection Credit points: 4

Offered Semester: 7th

**Course Coordinator**

Full Name: Prof. Vineeta Chauhan

Department with siting location: Electrical, 3rd floor staff room Telephone: 9638251076

Email: hod.el@indusuni.ac.in Consultation times: 3.45 to 4.20pm

## Course Lecturer

Full Name: Prof. Vineeta Chauhan

Department with siting location: Electrical, 3rd floor staff room Telephone: 9638251076

Email: hod.el@indusuni.ac.in Consultation times: 3.45 to 4.20 pm

Students will be contacted throughout the Session via Mail with important information relating to this Course.

## Course Objectives

By participating in and understanding all facets of this Course a student will:

1) Learn Load flow analysis for interconnected system.
2) Learn the Economic Operation of power system.
3) Learn Unit commitment.
4) Learn Load Voltage and frequency control.
5) Learn Steady state stability and transient stability analysis for interconnected system.
6) Learn power system security and optimal power flow.

## Course Outcomes (CO)

1. Able to apply load flow analysis for interconnected system.
2. Able to apply economic load dispatch and Unit commitment.
3. Learn the concept of load frequency control for isolated system and parallel operated units.
4. Students will be able to understand the steady state and transient stability conditions.
5. Students will be able to understand voltage control methods.
6. Able to understand contingency analysis and power system security.

## Course Outline

Proposed course mainly deal with load flow analysis, economic load dispatch, unit commitment, load frequency control, power system stability and system security analysis.

## Method of delivery

Face to face lectures/ online lectures

## Study time

3 lectures + 2 Practical/week

## CO-PO Mapping (PO: Program Outcomes)

Mapping CO's with PO's

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 2 | 1 | | | 2 | 1 | | |
| **CO2** | 3 | 2 | 2 | 2 | 2 | 1 | | | 2 | 1 | | |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 1 | | | 2 | 1 | | |
| **CO4** | 3 | 2 | 2 | 2 | 2 | 1 | | | 2 | 1 | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO5** | 3 | 2 | 2 | 2 | 1 | 1 | | | 2 | 2 | | |
| **CO6** | 3 | 2 | 1 | 1 | 1 | 1 | | | 2 | 2 | | |

## Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

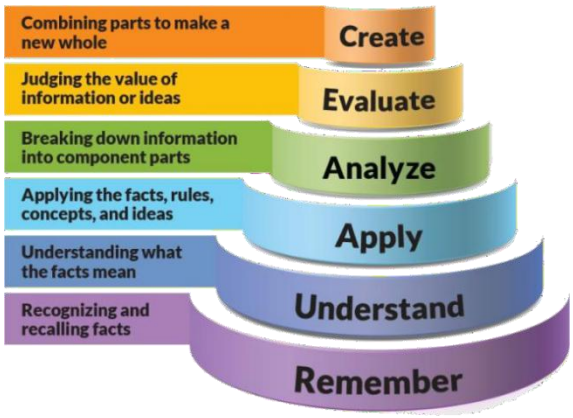



**Figure 1: Blooms Taxonomy**

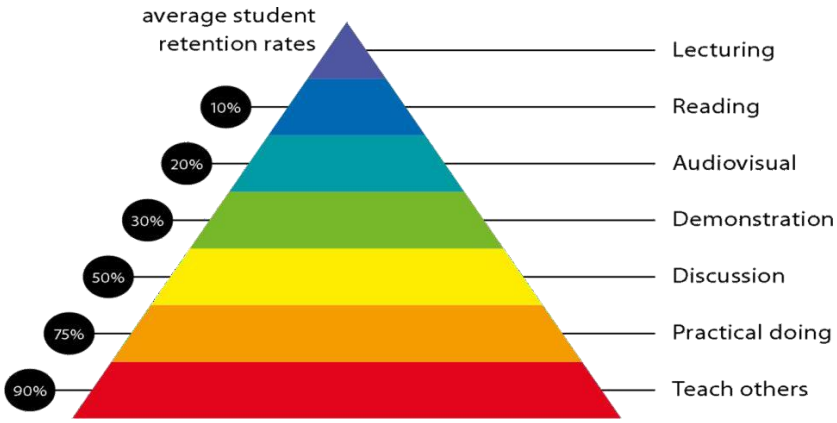



**Figure 2: Knowledge retention**

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of _____Graduate Capabilities |
|---|---|

| | |
|---|---|
| **Informed**<br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed<br>and how it relates to other areas. | **1 Professional knowledge, grounding & awareness** |
| **Independent learners**<br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry<br>and reflection. Find and evaluate | **2 Information literacy, gathering & processing** |

| | |
|---|---|
| information, using a variety of sources and technologies.<br>Acknowledge the work and ideas of others. | |
| **Problem solvers**<br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high<br>standards. | **4 Problem solving skills** |
| **Effective communicators** Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings.<br>Recognize how culture can shape<br>communication. | **5 Written communication**<br>**6 Oral communication**<br>**7 Teamwork** |
| **Responsible**<br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and<br>professional communities. | **10 Sustainability, societal & environmental impact** |

## Practical work:

1. To Perform load flow analysis using GS method
2. To Perform load flow analysis using NR method.
3. To perform LFA for IEEE 6 Bus system.
4. To perform AC load flow analysis.
5. To perform Economic load dispatch using B-coefficient method.
6. To perform Unit commitment using dynamic programming method.
7. To perform short circuit analysis.
8. To perform LG fault analysis.

9. To perform load frequency control using flat frequency control.
10. To perform load frequency control using Tie line frequency control.
11. To perform contingency analysis for line outage.
12. To perform contingency analysis for Generator outage.

## Lecture/tutorial/Lab times

(Give lecture times in the format below)

Monday 10:00- 11:00

Tuesday 11:10-12:10

Wednesday 11:10-1:20 (PSOC LAB)

Thursday 10:00-11:00

## Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

## Details of referencing system to be used in written work Text books

1. Power generation, operation and Control,Wood and Wollenbarg, John Willey.
2. Power system operation and Control Shivnagaraju, TMH

## Additional Materials

1. Power Station Engineering, I. J. Nagrath& D. P. Kothari, TMH.
2. A Course in Electricla Power, Sony, Gupta, Bhat., Chakra, DhanpatRai.
3. Electrical Power System, C. L. Wadhva, New Age.
4. Elements of Electrical power Station Design, M. V. Deshpande, Willy.

## ASSESSMENT GUIDELINES

Theory

CIE 60 marks (40 marks mid semester examination + 20 marks internal evaluation) Components of internal evaluation

05 marks as attendance bonus for all students having attendance > 80% 05 marks for presentation

~~10 marks for~~ assignment or case studies

Laboratory

File Work (10 marks)

Lab Participation (20 marks) Project / Presentation (20 marks) Viva – Voice

Your final course mark will be calculated from the following:

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

## Practical Work Report/Laboratory Report:

-

## Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -1% of the maximum mark per calendar day

## Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

## Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

## University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***

***Do not share your work with other students (except where required for a group activity or assessment)***

.

## Course schedule (subject to change)

**(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)**

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | Load flow analysis, Bus incidence matrix, Y Bus formulation, Numerical | 1 | PPT |
| | Weeks 2 | GS method, Numerical, NR Method, Jacobian Matrix, Numerical, FDLF Method | 1 | PPT |
| | Week 3 | Introduction to economic load dispatch, System constraints and system variable, Economic load dispatch without consideration of line losses, Problems | 2 | PPT |
| | Week 4 | Economic load dispatch with consideration of line losses, Penalty factor derivation, related numerical, Transmission loss formula, Loss coefficient derivation. | 2 | PPT |
| | Week 5 | Dynamic programming method, Unit commitment, Priority list method, Numericals | 3 | PPT |
| | | | | |
| | Week 6 | Governor characteristic for isolated system, Governor characteristic for parallel units, Turbine speed governing system. | 3 | BB, PPT, |
| | Week 7 | Load frequency control of isolated system, single area | 3 | BB, PPT |

| | | | | |
|---|---|---|---|---|
| | | control of frequency, Problems | | |
| | Week 8 | Tie line frequency control, ALFC loop, AVR loop, problems | 4 | BB, PPT,<br>MATLAB tool |
| | Week 9 | Importance of voltage control, methods, shunt reactor, shunt and series capacitors, | 4 | BB, PPT |
| | Week 10 | Synchronous phase modifiers, Tap changing transformers, booster transformers, Induction regulators. | 5 | BB, PPT |

| | | | | |
|---|---|---|---|---|
| | Week 11 | Power system stability, Steady state stability, Swing equation,<br>numerical | 5 | BB, PPT |
| | Week 12 | Condition of steady state stability, power angle curve, numerical | 5 | BB,PPT,<br>MATLAB tool |
| | Week 13 | Transient stability, equal area criteria for different cases. Numerical | 6 | BB, PPT |
| | Week 14 | Power system security, Introduction, factors affecting power system security,<br>Contingency analysis. | 6 | BB,PPT,<br>MATLAB Tool |
| | Week 15 | Flow chart for contingency analysis, Line outage and generator outage, System state classification, Sensitivity Factors,<br>problems. | 6 | BB, PPT |

## SYLLABUS

| Subject: Power System Operation & Control | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Program: B.Tech. Electrical Engineering | | | | Subject Code: EL0616 | | | | Semester: VI |
| | | | | | | | | |
| Teaching Scheme | | | | Examination Evaluation Scheme | | | | |
| Lecture | Tutorial | Practical | Credits | University Theory Examination | University Practical Examination | Continuous Internal Evaluation (CIE)- Theory | Continuous Internal Evaluation (CIE)- Practical | Total |
| 3 | 0 | 2 | 4 | 40 | 40 | 60 | 60 | 200 |

**Perquisites:**

iii) Power System I

iv) Power System II

v) Switchgear and Protection

**Course Objective:**

(v) To understand concept of Load flow Analysis.

(vi) To learn the concept Economic Load dispatch

(vii) To learn the concept of Unit Commitment.

(viii) To understand steady state and transient stability

(ix) To understand the concept of load frequency control.

(x) To understand the concept of power system security

**Course Outcome:**

7) Able to analyze load flow study.

8) Able to apply economic load diapatch.

9) Able to apply unit commitment.

10) Able to understand steady state stability condition.

11) Able to understand transient stability condition.

12) Able to apply Load frequency control.

**UNIT-I** **[09]**

**Load Flow Studies**

Network model formulation, Bus Incidence matrix, formation of Y bus, Y Bus Algorithm, power flow problem, different types of buses, approximate power flow, Gauss Seidel method, Algorithm, Flow chart, Newton-Raphson method, NR algorithm, Jacobian Matrix, FDLF.

**UNIT-II** **[10]**

**Economic Load Dispatch**

Economic dispatch of thermal units and methods of solution, Transmission losses, B matrix loss formula, Composite generation production cost function-solution by gradient search techniques, Nonlinear function optimization

**Unit Commitment**

Constraints in Unit commitment, Spinning reserve, Thermal and hydro constraints, Unit commitment solution methods-Priority list methods, Dynamic programming solution.

**UNIT-III** **[09]**

**Automatic Generation Control**

Governor characteristic for single area and parallel operated unit, Turbine speed governing system, Single area load frequency control, speed governing system and characteristics, Tie line load frequency control, cascade tripping and restoration process.

**Reactive Power and Voltage Control**

Reactive power and its relation to voltage control, location of voltage control equipment, methods of voltage control, excitation control, voltage regulators, tap changing transformers, booster transformers, reactive power injection and voltage control by synchronous condenser.

**UNIT-IV** **[12]**

**Power System Stability**

Introduction, dynamics of a synchronous machine, power angle equation-swing equation, power angle curve, simple systems, steady state stability, condition of steady state stability, transient stability, equal area criteria- Sudden change in Mechanical input, effect of clearing time on stability, sudden loss of one of parallel lines, sudden short circuit on one of parallel lines, numerical solution of swing equation, some factors affecting transient stability.

**Power System Security**

Factors affecting power system security, Contingency analysis: Detection of network problems, Correcting the generation approach: Sensitivity factors.

**Text Book**

1. A. J. Wood and B.F. Wollenberg, “Power Generation Operation and Control”, John Wiley & Sons, ICN., 2nd Edition.

**Reference Book**

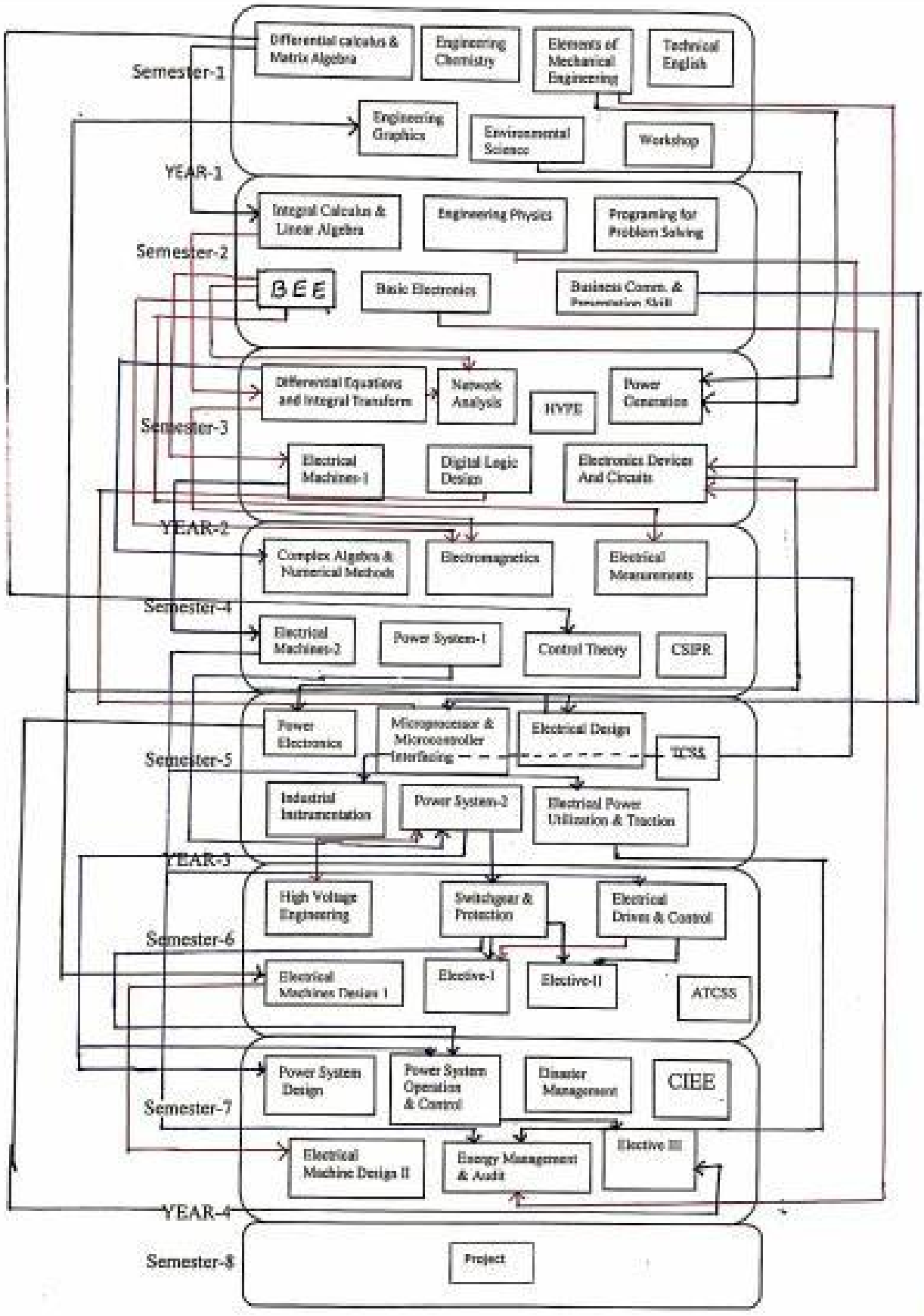
2. A. K.Mahalanabis, “Computer Aided Power system analysis and control”, Tata McGraw Hill 1991
3. O. I. Elgerd, “Electric Energy Systems Theory”, McGraw Hill, 2nd Edition, 1982,Dec
4. Stevenson J V, William D, “Elements of Power System Analysis”, McGraw Hill, 1988.
5. I. J. Nagrath & D.P. Kothari, “Modern Power System Analysis”, Tata McGraw Hill,1989

**Web Resource**

nptel.ac.in/downloads/108101040/

**MOOCS:**

i) https://www.edx.org/
ii) https://www.nptel.ac.in/
iii) https://www.coursera.org/




Elective-I: Advanced Control Theory, Industrial Automation, Soft Computing
Elective-II: Electrical Power Quality, EHV AC & DC, Special Machines, MOOC
Elective-III: FACTS, Advanced Power Electronics, Power System Planning, MOOC

**Name of Institute: Institute of Technology & Engineering**

**Name of Faculty:**

**Course code: EL0624**

**Course name: Testing & Commissioning of Electrical Equipment**

Pre-requisites:

1) Electrical Power System I
2) Electrical Machine -1
3) Electrical Machine -2

Credit points: 04

Offered Semester: VII

**Course coordinator (weeks 01 - 15)**

Full name: Ruchit R Soni

Department with siting location: 3rd floor, Bhawar Building

Telephone:

Email: ruchitsoni.ee@indusuni.ac.in

Consultation times: 9:00 a.m. to 5:00 p.m.

**Course lecturer (weeks 01 - 15)**

Full name: Ruchit R Soni

Department with siting location: 3rd floor, Bhawar Building

Telephone:

Email: ruchitsoni.ee@indusuni.ac.in

Consultation times: 9:00 a.m. to 5:00 p.m.

Students will be contacted throughout the session via mail with important information relating to this course.

## Course Objectives

By participating in and understanding all facets of this course a student will:

1) To understand different types of testing of transformers
2) To learn about different configuration of connections of transformers.
3) To provide knowledge of installation of transformers.
4) To understand the types of testing of Induction Motors
5) To understand the Maintenance and service of substation equipments.
6) Analysis of different types of cables and conductors of transmission line.
7) To understand the Sizing and requirement of substation.

## Course Outcomes (CO)

CO 1: Learn the Transformer &Induction Motor Testing.

CO 2: Learn Sub Station Equipments & Commissioning of Transmission Line& Cable.

CO 3: Students can understand the knowledge Service & Maintenance of Transformers.

CO 4: Student will be able to Calculate the cable sizing , Operation & Maintenance of Transmission Line

CO 5: Learn the Commissioning of Substation and Its Equipments

CO 6: Learn the Commissioning & Testing of large scale motors

Course Outline

In this course different techniques to solve a complex electrical circuit is discussed. In this course application of Laplace transform and Differential equations in electrical engineering is also given.

## Method of delivery

Face to face lectures, Assignments, Quiz

## Study time

3-hour lecture and 2-hour tutorial per week

## CO-PO Mapping (PO: Program Outcomes)

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 | PO 8 | PO 9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | 1 | 1 | - | 2 |
| **CO2** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | 1 | 1 | - | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 |
| **CO5** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | - | 1 | 1 | - | 2 |
| **CO6** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |

## Blooms Taxonomy and Knowledge retention (For reference)

(Blooms taxonomy has been given for reference)

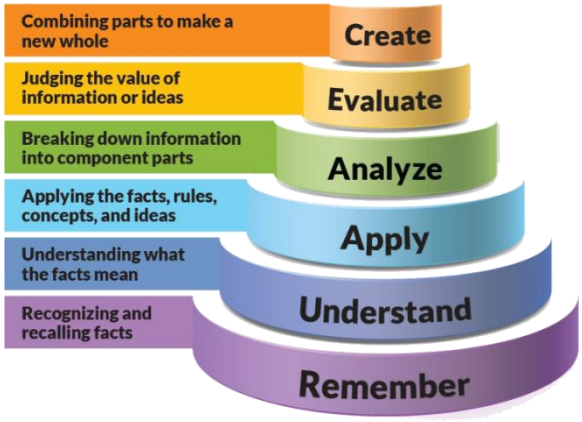



**Figure 1: Blooms Taxonomy**

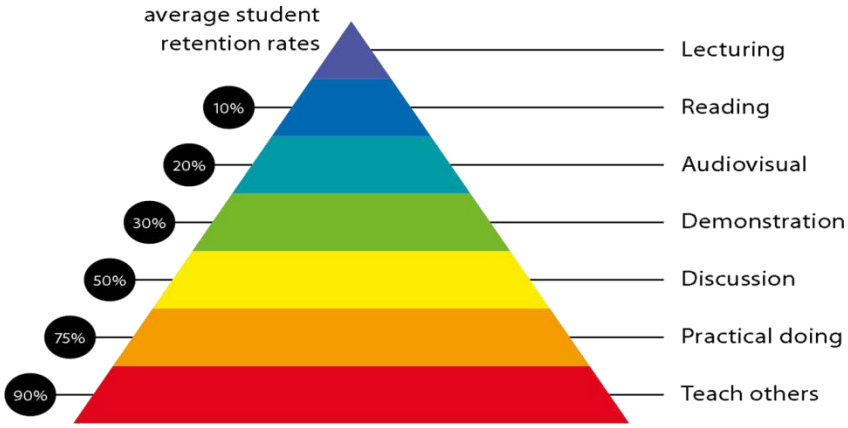



Figure 2: Knowledge retention

## Graduate Qualities and Capabilities covered

(Qualities graduates harness crediting this Course)

| General Graduate Qualities | Specific Department of _____Graduate Capabilities |
|---|---|
| **Informed**<br>Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas. | **1 Professional knowledge, grounding & awareness** |
| **Independent learners**<br>Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others. | **2 Information literacy, gathering & processing** |
| **Problem solvers**<br>Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards. | **4 Problem solving skills** |
| **Effective communicators**<br>Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. | **5 Written communication**<br>**6 Oral communication**<br>**7 Teamwork** |

| | |
|---|---|
| Recognize how culture can shape communication. | |
| **Responsible**<br><br>Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities. | **10 Sustainability, societal & environmental impact** |

## Tutorial work:

## Lecture/tutorial times

(Give lecture times in the format below)

| |
|---|
| |

## Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for semester examinations.

## Details of referencing system to be used in written work

## Text books

3) Testing, Commissioning & maintenance of electrical equipment By S. S. Rao, khanna publications

## Additional Materials

1. The commissioning of Electrical Plant by RCH Richardson (Chapman & Hall)

**Web Resource:**

1. https://www.electrical4u.com/high-voltage-testing/
2. https://www.electrical4u.com/open-and-short-circuit-test-on-transformer/
   www.electricalindia.in/blog/post/id/7247/various-routine-test-of-power-transformer
3. http://nachengg.net/transformer-oil-purification-process/
4. '/www.scribd.com/doc/31525693/Test-Procedure-for-AC-Generators

**MOOCS:**

1. https://www.edx.org/
2. https://www.nptel.ac.in/
3. https://www.coursera.org/

## ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

## SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in internal component or less than 40% in the end semester will be considered for supplementary assessment in the respective components (i.e

internal component or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (internal component or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

### Practical Work Report/Laboratory Report:

N.A.

### Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of -% of the maximum mark per calendar day

### Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

### Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

### University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

**Plagiarism** - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

***Do not copy the work of other students.***

***Do not share your work with other students (except where required for a group activity or assessment)***

.

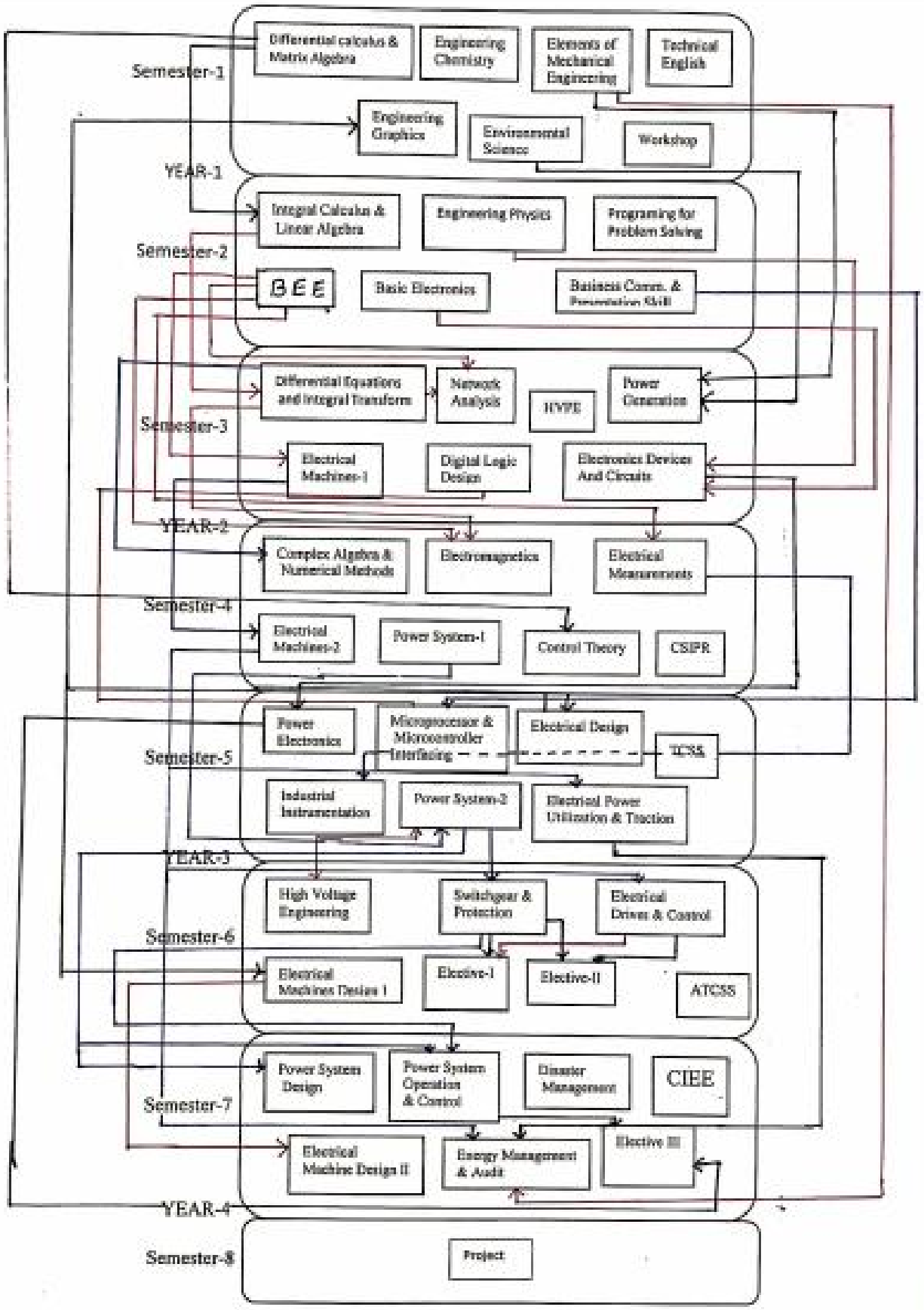
## Course schedule (subject to change)

**(Mention quiz, assignment submission, breaks etc as well in the table under the Teaching Learning Activity Column)**

| | Week # | Topic & contents | CO Addressed | Teaching Learning Activity (TLA) |
|---|---|---|---|---|
| | Weeks 1 | Testing procedure for HV testing, Phase shifting / phase group, Radio interference, Ratio Test, Load loss , Separate source voltage testing | 1 | BB |
| | Weeks 2 | Induced voltage testing, Impulse & Surge testing, Noise level & vibration testing, Short circuit withstand test, Tan Delta test, Core insulation voltage test, Measurement of impedance, Testing of auxiliaries & safety device, Oil testing, Classification of testing methods, | 1 | BB |
| | Week 3 | Testing of bushing, DC & AC Resistance measurement, Temp. rise test, Short circuit test, Dielectric test, Partial discharge, Insulation resistance testing. Polarity testing, Short time current rating, Impulse & surge testing ,Determination of error & accuracy class, Power frequency voltage withstand test, | *1* | BB |
| | Week 4 | Drying out procedure for transformer, Commissioning steps for transformer Purification & Filtration Procedure for Transformer oil, Troubleshooting & Maintenance of transformer, conditioning monitoring | 2 | BB |
| | Week 5 | Induction Motor: Testing (3-phase & 1-phase), Hammer test, Testing against variation of voltage/current/frequency, Load test, NL & BR test, DC & AC Resistance measurement, Insulation measurement | 2 | BB |
| | | | | |

| | | | | |
|---|---|---|---|---|
| | Week 6 | Starting test, Temp. rise test, Slip measurement, HV test, Testing on auxiliaries, Vibration Test, Noise level test, Drying out methods / Polarization Index / Hot Temperature measurement. | *3* | BB |
| | Week 7 | Degree of protection (IP Grade), Commissioning steps for Induction motor, Heat Run Test. Commissioning of Induction Generator | 3,4 | BB |
| | Week 8 | Troubleshooting & maintenance of induction motor, condition monitoring, Sub Station Equipments:<br>Bus bar-Temp. Rise test, Rated short time current test, HV test, Power frequency voltage withstand test, Impulse / surge testing. | 4 | BB |
| | Week 9 | Vibration & earthquake Test , Earthing resistance measurement, Substation grid Earthing, Soil resistivity measurement, Substation grid Earthing, Soil resistivity measurement | *4* | BB |
| | Week 10 | Short circuit test, Charging current making & breaking test, Inductive current making & breaking test. Circuit breaker-Testing of HV/LV circuit breaker-No load Mechanical Operation, Mechanical endurance test, Temp. rise test. | 5 | BB |
| | Week 11 | Impulse & surge testing , short time current test, Short circuit making & breaking test, Line Charging current making & breaking test. | 5 | BB |
| | Week 12 | Cable charging & capacitor bank making & breaking test, Out of phase switching, Short line fault test, Electrical & Mechanical endurance test for LT switch gear like MCB / MCCB / ELCB etc. C.T. & P.T. Testing, Relay testing, Coupling capacitors, Station Batteries for D.C. Supply, Fire Shifting Equipments. | 5,6 | BB |
| | Week 13 | Testing & Commissioning of Lightning Arrestor, Substation Commissioning by Thermography, Troubleshooting & maintenance of | 5,6 | BB |

| | | | | |
|---|---|---|---|---|
| | | circuit breakers. | | |
| | Week 14 | Commissioning Of Transmission Line& Cable: De-rating of cable capacity, HV test, AC & DC Resistance check, Insulation resistance, Impedance measurement, | 6 | BB |
| | Week 15 | Location finding technique for fault in underground cables (Murray loop test &Warley loop test) , Testing of open circuit faults in cables, Line charging, loading & Dropping. | 6 | BB |




Elective-I: Advanced Control Theory, Industrial Automation, Soft Computing
Elective-II: Electrical Power Quality, EHV AC & DC, Special Machines, MOOC
Elective-III: FACTS, Advanced Power Electronics, Power System Planning, MOOC

S

| Subject: Testing & Commissioning of Electrical Equipment | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Program: B.Tech. Electrical Engineering | | | | Subject Code:EL0624 | | | Semester: VI | |
| | | | | | | | | |
| Teaching Scheme | | | | Examination Evaluation Scheme | | | | |
| Lecture | Tutorial | Practical | Credits | University Theory Examination | University Practical Examination | Continuous Internal Evaluation (CIE)- Theory | Continuous Internal Evaluation (CIE)- Practical | Total |
| 3 | 0 | 0 | 3 | 60 | | | 40 | 100 |

**Perquisites:**

vi) Electrical Power System I

vii) Electrical Machine -1

viii) Electrical Machine -2

**Course Objectives:**

(xi) To understand different types of testing of transformers

(xii) To provide knowledge of installation of transformers.

(xiii) To understand the types of testing of Induction Motors

(xiv) To understand the Maintenance and service of substation equipments.

(xv) Analysis of different types of cables and conductors of transmission line.

(xvi) To understand the Sizing and requirement of substation.

**Course Outcome:**

After the end of the course the students will be able to

13) Service & Maintenance of Transformers

14) Commissioning of Substation and Its Equipments

15) Calculate the cable sizing , Operation & Maintenance of Transmission Line

16) Commissioning & Testing of large scale motors.

17) Service & Maintenance of Different types of Power Apparatus.

18) Commissioning and installation of Earthing System.

**SYLLABUS**

**UNIT-I** **[09]**

**Transformer**

Testing procedure for HV testing ,Phase shifting/ phase group , Radio interference, Ratio Test , Load loss ,Separate source voltage testing ,Induced voltage testing , Impulse & Surge testing , Noise level & vibration testing , Short circuit withstand test ,Tan Delta test , Core insulation voltage test, Measurement of impedance ,Testing of auxiliaries & safety device , Oil testing , Classification of testing methods , Testing of bushing. DC & AC Resistance measurement, Temp. Rise test, Short circuit test, Dielectric test, Partial discharge, Insulation resistance testing. Polarity testing, Short time current rating, Impulse & surge testing, Determination of error & accuracy class, Power frequency voltage withstand test, over voltage inter-turn test. Determination of polarization index for transformer. Drying out procedure for transformer. Commissioning steps for transformer, Purification & Filtration Procedure for Transformer oil. Troubleshooting & Maintenance of transformer.

**UNIT-II** **[12]**

**Induction Motor Testing (3-phase & 1-phase)**

Hammer test, Testing against variation of voltage/current/frequency, Load test, NL & BR test, DC & AC, Resistance measurement, Insulation measurement, Starting test, Temp. Rise test, Slip measurement, HV test, Testing on auxiliaries, Vibration Test, Noise level test. Drying out methods / Polarization Index / Hot Temperature measurement Degree of protection (IP Grade) Commissioning steps for Induction motor, Heat Run Test. Commissioning of Induction Generator. Troubleshooting & maintenance of induction motor.

**DC Machines**

Testing Voltage drop test or bar to bar test, Load test, Open circuit & magnetizing test, Insulation resistance, Starting performance, Dielectric test. Swinburne ' s test, Hopkinson's test, Field test, Separation of losses in DC shunt machine. Temp. rise test & Heat run test Drying out process Commissioning steps for DC machines Troubleshooting & maintenance.

**UNIT-III** **[12]**

**Substation Equipments**

Bus bar Temp. Rise test, Rated short time current test, HV test, Power frequency voltage withstand test, Impulse / surge testing, Vibration. Earthing Earthing resistance measurement, Substation grid Earthing, Soil resistivity measurement. Isolator Testing Temp. Resistance test, Short circuit test, Charging current making & breaking test, Inductive current making & breaking test.

**Circuit breaker: Testing of HV/LV circuit breaker**

No load Mechanical Operation, Mechanical endurance test, Temp. Rise test, Impulse & surge testing, short time current test. Short circuit making & breaking test, Line Charging current making &

breaking test, Cable charging & capacitor bank making & breaking test, Out of phase switching, Short line fault test, and Electrical & Mechanical endurance test for LT switch gear like MCB / MCCB /ELCB etc. C.T. & P.T. Testing, Relay testing, Coupling capacitors, Station Batteries for D.C. Supply, Fire Shifting Equipments. Testing & Commissioning of Lightning Arrestor, Substation Commissioning by Thermograph. Troubleshooting & maintenance of circuit breakers.

**UNIT-IV** **[12]**

**Synchronous machine: Testing**

OC & SC test, Characteristics, Loss measurement, Temp. rise test , Over speed test , HV testing , Insulation resistance wave form interference , DC & AC Resistance of armature & field winding measurement , Dielectric testing on armature & field winding , Mechanical balance , Magnetic balance , Current balance , Phase sequence.

**Commissioning of transmission line & Cable**

Derating of cable capacity, HV test, AC & DC Resistance check, Insulation resistance, Impedance measurement, Location finding technique for fault in underground cables (Murray loop test & Warley loop test), Testing of open circuit faults in cables. Line charging, loading & Dropping.

**Text Books**

1. Testing, Commissioning & maintenance of electrical equipment By S. S. Rao, khanna publications

**Reference Book**

1. The commissioning of Electrical Plant by RCH Richardson (Chapman & Hall)

**Web Resource**

**MOOCS:**

iv) https://www.edx.org/

v) https://www.nptel.ac.in/

vi) https://www.coursera.org/