Syllabus of IV Semester Physics

Program Outcomes:	
13.	Disciplinary knowledge
14.	Communication Skills
15.	Critical thinking, Reflective thinking, Analytical reasoning, Scientific reasoning
16.	Problem-solving
17.	Research-related skills
18.	Cooperation/ Teamwork/ Leadership readiness/Qualities
19.	Information/ Digital literacy/Modern Tool Usage
20.	Environment and Sustainability
21.	Multicultural competence
22.	Multi-Disciplinary
23.	Moral and ethical awareness/Reasoning
24.	Lifelong learning / Self-Directed Learning

Course Content Semester – IV

Thermal Physics and Electronics

Course Title: Thermal Physics and Electronics	Course Credits:4
Total Contact Hours: 52	Duration of ESA: 3 hours
Formative Assessment Marks: 40	Summative Assessment Marks: 60
Model Syllabus Authors: Physics Expert Committee	

Prerequisites

viii.	Study of Pre-University

Course Learning Outcomes

At the end of the course students will be able to:

vii.	Apply the laws of thermodynamics and analyzethe thermal system.
viii.	Apply the laws of kinetic theory and radiation laws to the ideal and practical thermodynamics systems through derived thermodynamic relations.
ix.	Use the concepts of semiconductors to describe different Semiconductor devices such as diode transistors, BJT, FET etc and explain their functioning.
x.	Explain the functioning of OP-AMPS and use them as the building blocks of logic gates.
xi.	Give the use of logic gates using different theorems of Boolean Algebra followed by logic circuits.

Course Articulation Matrix

Mapping of Course Outcomes (CO) Program Outcomes

CourseOutcomes/ProgramOutcomes		1	2	3	4	5	6	7	8	9	10	11	12
i	Apply the laws of thermodynamics and analyze the thermal system.	X	X	X	X	X	X					X	X
ii	Apply the laws of kinetic theory and radiation laws to the ideal and practical thermodynamics systems through derived thermodynamic relations.	X	X	X	X	X	X					X	X
iii	Use the concepts of semiconductors to describe different Semiconductor devices like diode transistors, BJT, FET etc and explain their functioning.	X	X	X	X	X	X					X	X
iv	Explain the functioning of OP-AMPS and them as the building blocks of logic gates.	X	X	X	X	X	X					X	X
v	Give the use of logic gates using different theorems of Boolean Algebra followed by logic circuits.	X	X	X	X	X	X					X	X

Thermal Physics and Electronics

Unit – 1

The Portion to be Covered

Laws of Thermodynamics:
Review of the concepts of Heat and Temperature. **(1 Hours)**
First Law of Thermodynamics: Differential form, Internal Energy. Equation of state for an adiabatic process, Work Done during Isothermal and Adiabatic Processes. **(2 Hours)**
Second Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Reversible and Irreversible processes with examples. Concept of Entropy, Change of Entropy in reversible and irreversible process, Refrigeration & coefficient of performance, T-S diagram, Second Law of Thermodynamics in terms of Entropy. Problems **(5 Hours)**
Third Law of Thermodynamics: Statement, Significance and Unattainability of Absolute Zero.
Heat Engines: Carnot engine, Otto and Diesel engines, Derivation for efficiency of Otto and Diesel engines. Applications of Carnot engine in locomotion, Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. Problems**(5 Hours)**

Topic Learning Outcomes
At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Explain the first law of thermodynamics.	L1	1	1-6,11-12
ii.	Give the differential form of the first law of thermodynamics and define what is the internal energy.	L2	1	1-6,11-12
iii.	Obtain an expression for work done in isothermal and adiabatic processes.	L2	1	1-6,11-12
iv.	Give two systems of units of temperature measurement and give their equivalence.	L2	1	1-6,11-12
v.	Describe and Discuss heat engine based on Carnot cycle.	L2	1	1-6,11-12
vi.	Explain how the efficiency of refrigeration is measured?	L2	1	1-6,11-12
vii.	Detail out the application of the Carnot engine to a locomotion system.	L1	1	1-6,11-12
viii.	Define entropy and write an expression for entropy using the second law of thermodynamics.	L2	1	1-6,11-12
ix.	State the third law of thermodynamics and give its significance using the third law of thermodynamics describing why absolute zero temperature is not unattainable.	L2	1	1-6,11-12
x.	High Order Problems.	L3	1	1-6,11-12

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self-Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities

Activity No. 1	I feel cold because coldness enters my body. Discuss the statement in day-to-day life. Approximately give examples of a) open system b) closed system and c) isolated system Discuss when the temperature of the body is locked until what time you hold the thermometer in contact with a body. Discuss it in contact with laws of thermodynamics.

	Discuss why when a person works or does exercise, he sweats. Reason it with the laws of thermodynamics.
Activity No. 2	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Take four different sizes of same metal, preferable of same shape and give one piece to each group. Heat it uniformly on a hot plate. Keep a beaker of water with a thermometer immersed in it. Drop one hot metal into the water and record the temperature with time. Repeat the experiment for the other heated metal pieces of different sizes. 1. Plot a graph for the volume of the metal piece used v/s respective temperature change observed. 2. Determine the heat capacity and specific heat of the metal used. All groups shall also do the following activity:
Activity No. 3	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Take ice cubes of different size and immerse in water and measure the temperature change with time and repeat the experiment. Graph the observations.

Thermal Physics and Electronics
Unit – 2
The Portion to be Covered
Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Properties and Applications. **(2 Hours)** **Maxwell's Thermodynamic Relations**: Derivations and applications of Maxwell's Thermodynamic Relations (1) First order Phase Transitions with examples, Clausius - Clapeyron

Equation (2) Values of Cp-Cv (3)Joule-Thomson Effect and Joule-Thomson coefficient and derive an equation for Vander Walls gas. Attainment of low temperature by liquefaction of gases and adiabatic demagnetization. Problems **(4 Hours)**

Kinetic Theory of Gases: Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas: Mean, RMS and Most Probable Speeds. Degrees of Freedom, Law of Equipartition of Energy. Specific heats of Gases. Problems **(4 Hours)**

Radiation: Blackbody radiation, spectral distribution, the concept of energy density and pressure of radiation, Wien's law, Wien's displacement law,Stefan-Boltzmann law, Rayleigh-Jeans law, and Planck's law of radiation. Problems**(3 Hours)**

Topic Learning Outcomes

At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	State Maxwell relations.	L1	2	1-6, 11-12
ii.	Give examples where Maxwells relations are used.	L1	2	1-6, 11-12
iii.	Explain the phase transition. Which is called as first order phase transition? Give Examples	L2	2	1-6, 11-12
iv.	State Clausius - Clapeyron Equation.	L1	2	1-6, 11-12
v.	Obtain an equation for difference in C_P - C_V.	L2	2	1-6, 11-12
vi.	State Joule-Thomson effect and Joule-Thomson coefficient.	L1	2	1-6, 11-12
vii.	Obtain an expression, giving the relation between pressure, volume and temperature for a real gas (Vander Waals gas).	L2	2	1-6, 11-12
viii.	Explain adiabatic demagnetization and how it is used to obtain low temperature by the liquidation of gases?	L2	2	1-6, 11-12
ix.	State Maxwell-Boltzmann Law of Distribution of Velocities in Ideal gases.	L1	2	1-6, 11-12
x.	Explain the mean RMS and most probable speeds in ideal gases.	L1	2	1-6, 11-12
xi.	Explain degrees of freedom associated with particles in an ideal gas?	L2	2	1-6, 11-12
xii.	Define the specific heat of a gas.	L1	2	1-6, 11-12
xiii.	Explain black body radiation and its spectral distribution.	L1	2	1-6, 11-12
xiv.	Explain the different laws used to describe different parts of the curves of a spectral distribution of black body radiation.	L2	2	1-6, 11-12
xv.	Define ultraviolet radiation catastrophe? Discuss its importance in the explanation of black body radiation.	L2	2	1-6, 11-12

xvi.	Define Planck's law of radiation and discuss how it could describe the whole black body radiation curve.	**L2**	**2**	**1-6, 11-12**
xvii	High Order Problems.	**L3**	**2**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self-Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities

Activity No. 4	1. Measuring the Solar Constant Materials: Simple flat sided Jar and Thermometer. Activity: Bottle containing water is exposed to solar radiation. The rise in temperature and time taken are noted. Calculate the heat absorbed by water and relate it to the output of the Sun. 2. Thermo emf Materials: Suitable two dissimilar metal wires, voltage measuring device. Activity: In this experiment student will assemble the thermocouple and study the three effects namely, See beck, Peltier, and Thompson. 3. Inverse square law of radiation Materials: A cardboard with a grid, cardboard with a hole, supporting clips, a ruler, candle. 4. Activity: Students set the device. They count the lighted squares on the cardboard with the grid by varying the distance. And make necessary measurements and calculations to arrive at the inverse square law of radiation. Ref: Activity Based Physics Thinking Problems in Thermodynamics: Kinetic Theory http://www.physics.umd.edu/perg/abp/think/thermo/kt.htm
Activity No. 5	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement.

	3. In the third slide, they will list three observations from that study. **Activity:** Take two dissimilar metal wires. Spot weld them forming two junctions. Dip one junction in ice and heat the other junction with a burner. Plot a graph of time of heating v/s Thermo EFM generated in the voltmeter.
Activity No. 6	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Make 4 groups and give different-sized balloons to each group.Fit different-sized nozzles into the mouth of the large balloons. Measure the temperature or the EMF generated using a thermocouple placed at the mouth of the nozzle as the pressurised gas is released. Plot a graph of time v/s temperature. Vary the volume of the balloon and repeat the experiment. Plot the graph of volume v/s temperature difference created.

Thermal Physics and Electronics

Unit – 3

The Portion to be Covered

Semiconductor devices: Semiconductor and its types, doping, Intrinsic and Extrinsic semiconductors, semiconductor diode (p-n junction) and its V-I Characteristics (Forword & Reverse).

Rectifier: Rectifications, Half-wave rectifier, Full-wave rectifier-i) Full wave centre tap ii) Full wave Bridge(Qualitative). Comparison between them.

Filters: Capacitor filter, Inductor filter, LC filter, π - section filter(study of waveforms-qualitative),Comparison between them.

Zener diode:V-I Characteristics, Explanation of Zener Breakdown mechanism(Avalanche& Zener).Voltage regulator -Zener diode used as voltage regulator using unregulated DC voltage bridge rectifier.Problems**(6 hours)**

Junction Transistors: Basics of Bipolar Junction (BJT), types of transistors, construction and operation transistors, Transistor configuration , Common Base, Common Emitter and Common Collector Characteristics, h-parameters ofatransistor andtheirdetermination usingCEconfiguration,Transistor as an Amplifier (CE) with frequency response .

Feedback:-Feedback and types of feedback.

Oscillators:-Oscillators and its types, Essentials of a feedback LC oscillator. Hartley and Phase

shift oscillators, Comparison between amplifier and oscillator.
Field Effect Transistor (FET): FET-Types, characteristics and parameters, Relation between FET parameters. FET as a common source amplifier (Qualitative).Problems**(7hours)**

Topic Learning Outcomes
At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	DefineSemiconductors and Band Gap. Explain on what basis they are classified as intrinsic and extrinsic.	L2	3	1-6, 11-12
ii.	Define PN junction.Explain its functioning in forward and reverse bias.	L1	3	1-6, 11-12
iii.	Explain the approximation used in a real diode with respect to an ideal PN Junction?	L2	3	1-6, 11-12
iv.	With a schematic diagram, explain half wave and full wave rectifiers.	L1	3	1-6, 11-12
v.	Define a Zener diode and explain how it is different from an ordinary diode usingV-I curves?	L2	3	1-6, 11-12
vi.	With the schematic diagram, explain the working of voltage regulators of different types using a Zener diode.	L1	3	1-6, 11-12
vii.	Give the basic concepts used in the instruction of bipolar junction transistor and its operation.	L1	3	1-6, 11-12
viii.	Compare the V-I curve of common base common emitter and common collector BJT curves while explaining their working principles.	L2	3	1-6, 11-12
ix.	Define FET? Give its characteristics.	L1	3	1-6, 11-12
x.	Explain how a transistor can be used as an amplifier and an oscillator using a circuit diagram.	L2	3	1-6, 11-12
xi.	High Order Problems.	L3	3	1-6, 11-12

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self-Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities	
Activity No. 7	a. Activity: Wire a DC power supply on a bread board or groove board to give a regulated output voltage of + 5 V; +15 V; Dual power output : ± 5 V; Dual power output : ± 15 V b. Use: 3-pin regulators c. Learn to identify the terminals of different types (packages) of BJTs. d. In the case of power transistors, learn how to fix a heat sink for the transistor. e. Understand the concept of virtual ground of an OP-AMP. f. Learn the different types of op-amps used for different applications. What is a buffer? Prepare a report on the application of buffers in instrumentation electronics. Seeing ½ wave of a full wave verification on a bread board.
Activity No. 8	(i)Learn to identify the terminals of different types (packages) of BJTs. (ii)In the case of power transistors, learn how to fix a heat sink for the transistor. (iii) Learn the difference between BJT and FET in its operational characteristics.
Activity No. 9	**Build your own Regulated DC power supply (5V)** Components required: 1.Step down transformer- 1 No. (5 V tapping, 100 – 500 mA current rating), BY 127 semiconductor diodes – 4 Nos, Inductor -1, Capacitor - 1, 3 pin 5V regulator-1 Wire a DC power supply on a bread board or groove board to give a regulated output voltage of + 5 V. Search for circuit diagram in books/net.
Activity No. 10	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Form 3 groups and tell them to make a DC supply of low current of different voltages like 5V, 10V, and 15V on a breadboard
Activity No. 11	**Note for the teachers for the activity:** Make 3-4 groups among students and assign each group the activity of drawing one of the graphs given below. Provide a few days to complete the activity. One the specific day, each group has to make a ppt presentation of the following three slides. One the day of the presentation select a member from each group randomly to make the presentation. Based on the work and

	presentation, teacher shall assign marks to each group, wherein all members of the group will get equal marks. 1. The first slide will explain the process of doing the experiment. 2. In the second slide. Students will show the graph of measurement. 3. In the third slide, they will list three observations from that study. **Activity:** Take any 3 diode and assign one to each group. Measure its resistance when dipped in ice and heating the ice till it boils. Using this data, plot calibration curve of temperature v/s resistance and also the cooling curve of temperature V/s time for the diode by each group.

Thermal Physics and Electronics

Unit – 4

The Portion to be Covered

Electronics: Integrated Circuits (Analog and Digital)and their types , Operational Amplifier: Block diagram of Op-Amplifier, symboland polarity convention, Characteristics of Op-Amp, Pin diagram of IC-741, Concept of virtual ground and summing point, Feedback concepts, Advantages of feedback, types of feedback, Expression for Gain; Op-Amp as a feedback amplifier– Non–Inverting and Inverting amplifier, Modification of input and output impedances with feedback; Differential amplifier with feedback;
Op-Amplifier Applications- Voltage Follower, Adder and Subtractor. Problems**(6 hours)**
Digital: Switching and Logic Levels, Digital Waveform. Number Systems: Decimal Number System, Binary Number System, Converting Decimal to Binary, Hexadecimal Number System: Converting Binary to Hexadecimal, Hexadecimal to Binary. Problems**(4 hours)**

Boolean Algebra Theorems: Digital Circuits: Logic gates, NOT Gate, AND Gate, OR Gate, NAND Gate,IC-7400 Pin diagram, NOR Gate, Algebraic Simplification, Implementation of NAND and NOR functions. Boolean algebra, Truth tables, De- Morgan's theorems.Problems**(3 hours)**

Topic Learning Outcomes
At the end of the topic, students should be able to:

SL No	TLO's	BL	CO	PO
i.	Define op-amps and give the characteristics of an ideal op-amp.	L1	4	1-6, 11-12
ii.	Explains an inverting and non-inverting configuration of typical op-amps, with a schematic diagram.	L2	4	1-6, 11-12
iii.	Explain how op-amps can be used as a voltage follower, with a schematic diagram and with relevant expressions.	L2	4	1-6, 11-12
iv.	Explain how op-amps can be used as a voltage follower, adder and subtractor, with a schematic diagram and with relevant expressions.	L2	4	1-6, 11-12
v.	Give different digital wave forms and explain how one can	L1	5	1-6, 11-12

	visualize the switching and logic levels.			
vi.	Write any four-digit numbers other than zero in the decimal number system and convert that into binary and hexadecimal.	**L2**	**5**	**1-6, 11-12**
vii.	Write any number in a Binary System of 8 digits other than zero and convert it into decimal and hexadecimal.	**L2**	**5**	**1-6, 11-12**
viii.	Write any number in the hexadecimal system of 4 digits other than zero and converted it into a binary and decimal number.	**L2**	**5**	**1-6, 11-12**
ix.	Give simplified diagram for a given Boolean circuit diagram of logic gates, and verify using the De-Morgans theorem.	**L2**	**5**	**1-6, 11-12**
x.	Why are X-NOR gates called Universal Gates?	**L2**	**5**	**1-6, 11-12**
xi.	High Order Problems.	**L3**	**4, 5**	**1-6, 11-12**

Teaching and Learning Methodology

Lecture/ PPT/ Videos/ Animations/ Role Plays/ Think-Pair-Share/ Predict-Observe-Explain/ Demonstration/ Concept mapping/ Case Studies examples/ Tutorial/ Activity/ Flipped Classroom/ Jigsaw/ Field based Learning/ Project Based Learning/ Mini Projects/ Hobby Projects/ Forum Theatre/ Dance/ Problem Based Learning/ Game Based Learning/ Group Discussion/ Collaborative Learning/ Experiential Learning / Self-Directed Learning etc.

Assessment Techniques

One minute paper/ Predict-Observe-Explain/ Think-Pair-Share/ Class Test/ Quiz/ Crosswords/ Group Assessment/ Assignment/ Peer-to-Peer Evaluation/Seminar etc

Suggested Activities

Activity No. 12	Learn how to implement logic functions (AND, OR, NOT) using just diodes and resistors. With a circuit diagram show how different types of gates can be built by X-NOR gates.
Activity No. 13	**Operational Amplifiers** (i)Understand the concept of virtual ground of an OP-AMP. (ii)Learn the different types of op-amps used for different applications. (iii)What is a buffer? Prepare a report on buffers and its application in instrumentationelectronics.
Activity No. 14	**Activity**A man has to take a wolf, a goat, and some cabbage across a river. His rowboat has enough room for the man plus either the wolf or the goat or the cabbage. If he takes the cabbage with him, the wolf will eat the goat. If he takes the wolf, the goat will eat the cabbage. Only when the man is present are the goat and the cabbage safe from their enemies. All the same, the man carries

	wolf, goat, and cabbage across the river. How? Write the truth table for the above story and implement using gates. **Activity**A locker has been rented in the bank. Express the process of opening the locker in terms of digital operation. **Activity** A bulb in a staircase has two switches, one switch being at the ground floor and the other one at the first floor. The bulb can be turned ON and also can be turned OFF by and one of the switches irrespective of the state of the other switch. The logic of switching of the bulb resembles.

Textbooks	
Sl No	**Title of the Book**
1.	Electronic Devices and Circuits, David A. Bell, 2004, PHI, New Delhi
2.	Integrated Electronics, Jacob Millman and CC Halkias
3.	Digital Fundamentals, Floyd, 2001, PHI, New Delhi

References Books	
Sl No	**Title of the Book**
1.	Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2.	Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
3.	A Treatise on Heat, MeghnadSaha, and B.N.Srivastava, 1958, Indian Press
4.	Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5.	Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6.	An Introduction to Thermal Physics, Daniel V Schroeder, 2020, Oxford University Press

Formative Assessment	
Assessment	**Marks**
Internal Assessment	20
REU based Group Activity (Conduction, Report, Presentation)	20
Total	40

List of Experiments to be performed in the Laboratory **Note:** Minimum Eight experiments to be carried out	
1.	Mechanical Equivalent of Heat, J by Electrical method.
2.	Coefficient of thermal conductivity of Copper by Searle's apparatus.
3.	Coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
4.	Determination of Stefan's constant/ Verification of Stefan's law.

5.	Variation of thermo-emf across two junctions of a thermocouple with temperature.
6.	Verification of Clausius –Clapeyron equation and determination of specific enthalpy.
7.	V-I Characteristics of Silicon & Germanium PN Junction diodes (FB & RB)
8	Full -Wave bridge Rectifier Without Filter(internalresistance andvoltage regulation).
9	Full- Wave Rectifier bridge with π section Filter(internalresistance andvoltage regulation).
10.	Zenerdiode asvoltage regulatorusingbridge rectifierpowersupply.
11.	H- Parameter of transistor.
12.	Frequency response of CE Amplifier
13.	FET-staticcharacteristics and parameters.
14.	Frequency response of FET Amplifier.
15.	Non-inverting and Inverting using op-amp circuits.
16.	Adder and Subtractor using op-amp circuits.
17.	Realization of basic gates using NAND gate.
18.	Verification Boolean Algebra using NAND gate using IC-7400.
19.	Verification of De -Morgan's laws using IC-7400.

Reference Book for Laboratory Experiments	
Sl No	**Title of the Book**
1	Basic Electronics Lab (P242) Manual 2015-16, National Institute of Science Education andResearch,Bhubaneswar, 2015.
2	**Suggested Readings:** 1. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e. 2. S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e.

OPEN ELECTIVE PAPER

Year	2	**Course Code: 21BSC4O4PHY4**	**Credits**	03
Sem.	4	**Course Title: ELECTRICAL INSTRUMENTS**	**Hours**	40
Formative Assessment Marks: 40		Summative Assessment Marks: 60	Duration of ESA:.02 hrs.	
Unit No.		**Course Content**		
Unit I		**Voltage and current sources**, Kirchoff's current and voltage laws, loop and nodal analysis of simple circuits with dc excitation. Ammeters,voltmeters: (DC/AC) **Representation of sinusoidal waveforms**, peak and rms values, power factor. Analysis of single-phase series and parallel R-L-C ac circuits. Three-phase balanced circuits, voltage and current relations in star and delta connections. Wattmeters: Induction type, single phase and three phase wattmeter, Energy meters: AC.		

	Induction type single phase and three phase energy meter . **(10 Hours)**
Unit II	**Instrument Transformers**: Potential and current transformers, ratio and phase angle errors, phasor diagram, methods of minimizing errors; testing and applications. **Galvanometers:** General principle and performance equations of D'Arsonval Galvanometers, Vibration Galva nometer and Ballistic Galvanometer. **Potentiometers:** DCPotentiometer, Crompton potentio meter, construction, standardization, application. AC Potentio meter, Drysdalepolarpotentio meter; standardization, application. **(10 Hours)**
Unit III	**DC/AC Bridges**: General equations for bridge balance, measurement of self inductance by Maxwell's bridge (with variable inductance & variable capacitance), Hay's bridge, Owen's bridge, measurement of capacitance by Schearing bridge, errors, Wagner's earthing device, Kelvin's double bridge. **Transducer:** Strain Gauges, Thermistors, Thermocouples, Linear Variable Differential Transformer (LVDT), Capacitive Transducers, Peizo-Electric transducers, Optical Transducer, Hall Effect Transducer . **(10 Hours)**
Unit IV	**CRO:** Block diagram, Sweep generation, vertical amplifiers, use of CRO in measurement of frequency,phase, Amplitude and rise time of a pulse. Digital Multi-meter: Block diagram, principle of operation. **Basics of lead acid batteries**, Lithium Ion Battery , Battery storage capacity, Coulomb efficiency, Numerical of high and low charging rates, Battery sizing. **(10 Hours)**
Activity No. 1	Identify variety of electrical switches and note down their applications/utility.
Activity No. 2	Identify the hazards involved in handling electrical circuits and instruments, make a list of safety precautions as well as first aid for electrical shocks.
Activity No. 3	Make a study of importance of grounding in electrical circuits.
Activity No. 4	Prepare a detailed account of various methods of earthing and their utility/applications
Activity No. 5	Prepare a document on evolution of incandescent bulbs to the present day LED lights
Activity No.6	Make a comparative study of Fuses, MCB, ELCB and Relays highlighting their use and applications
	Tex Books
	AK.Sawhney, ACourseinElec.&Electronics Measurements&Instrumentation **,Dhanpatrai& Co. 1978**
	A.D. Helfrick& W.D. Cooper, Modern Electronic Instrumentation and Measurement Techniques **PHI,2016**
	Reference Books
	D C Kulshreshtha, Basic Electrical Engineering, McGraw Hill Publications,**2019**
	David G Alciatore and Michel B Histand, Introduction to Mechatronics and Measurement Systems, 3rd, Tata McGraw Hill Education Private Limited, New Delhi., 2005
	1. Vincent Del Toro, Electrical Engineering Fundamentals Prentice Hall India**2009**

List of Experiments to be performed in the Laboratory

Sl No	Experiments	
1	Introduction to Lab Equipment	
2	Voltmeter Design	
3	Ammeter Design	
4	Ohmmeter Design	
5	Multimeter Design	
6	Measurement of Resistance using Wheatstone Bridge	
7	Measurement of Capacitance using Schering Bridge	
8	Measurement of Inductance using Maxwell Bridge	
9	Measurement of Light Intensity	
10	Measurement of Temperature	
	Reference Book for Laboratory Experiments	
	AK.SawhneyACourseinElec.&Electronics Measurements&Instrumentation:	
	Helfrick& Cooper, Modern Electronic Instrumentation and Measurement Techniques:	