SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI

AFFILIATED TO MADURAI KAMARAJ UNIVERSITY, MADURAI

RE-ACCREDITED WITH 'A' GRADE (THIRD CYCLE) BY NAAC WITH CGPA 3.11)

Programme Scheme, Scheme of Examination and Syllabi

(From 2024-2025 Batch onwards)

Department of Physics

PG Diploma Course

Approved in the Academic Council – XV held on 29/08/2024

Curriculum Design and Development Cell

Annexure A

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI

(AFFILIATED TO MADURAI KAMARAJ UNIVERSITY, MADURAI
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Programme Scheme, Scheme of Examination and Syllabi

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Curriculum Design and Development Cell

HOD	Dean of Pure Science	Dean of Academic Affairs	Principal

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS

PG DIPLOMA COURSE ON ENERGY STORAGE AND CONVERSION TECHNOLOGY (BATTERY, SUPERCAPACITOR AND FUEL CELL)
MEMBERS OF BOARD OF STUDIES

S.No.	Board Members	Name and Designation
1.	Chairman of the Board	Dr. C.R. Kumaran Head & Assistant Professor of Physics Department of Physics Sri Kaliswari College (Autonomous) Sivakasi.
2.	University Nominee	Dr. G. Gnanakumar Assistant Professor Department of Physical Chemistry School of Chemistry Madurai Kamaraj University Madurai - 625 021.
3.	Academic Expert 1.	Dr. R. Kothandaraman Professor Department of Chemistry IIT Madras Chennai.
4.	Academic Expert 2. (ONLINE)	Dr. Yogesh Kr. Sharma Prof. of Physics Department of Physics IIT Roorkee Roorkee.
5.	Academic Expert 3. (ONLINE)	Dr. Ramesh T Subramaniam Professor Department of Physics University of Malaysia Malaysia.
6.	Academic Expert 4.	Dr. R. Kalai Selvan Associate Professor Department of Physics Bharathiyar University Coimbatore - 641 046.
7.	Academic Expert 5.	Dr. B. Nalini Assistant Professor Department of Physics Avinashilingam Deemed University for Women Coimbatore - 641 043.
8.	Industrialist	Dr. M. Raja Research Associate High Energy Battery (India) Ltd., Mathur - 622 515 Pudhukottai District.
9.	Special Invitees	1. Dr. S. Selvasekarapandian Emeritus Professor Bharathiyar University Coimbatore.

		2. Dr. C. Sanjeeviraja Hon. Professor Alagappa Chettiyar Govt. College of Engg. & Tech., Karaikudi. 3. Mr. S. Karuppiah Senior Professor in Physics (Retd.) Sivakasi.
Members		
10.	Dr. M. Alagar	Associate Professor of Physics
11.	Dr. L.T. Parvathi	Head & Assistant Professor of Chemistry
12.	Dr. T. Jeyakumaran	Assistant Professor of Physics
13.	Dr. M. Murugalakshmi	Assistant Professor of Chemistry
14.	Mrs. M. Sankareswari	Assistant Professor of Chemistry
15.	Mrs. R. Vijayalekshmi	Assistant Professor of Chemistry
16.	Mr. M. Nazeer	Assistant Professor of Chemistry
17.	Dr. J. Sherin	Assistant Professor of Chemistry
18.	Dr. R. Deepa	Assistant Professor of Chemistry
19.	Dr. M.Vijaya Chandra Sekar	Assistant Professor of Chemistry

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI

(Affiliated to Madurai Kamaraj University, Re-accredited with A Grade (CGPA 3.11) by NAAC)

DEPARTMENT OF PHYSICS

Programme - PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

GUIDELINES FOR OUTCOME-BASED EDUCATION WITH CHOICE BASED CREDIT SYSTEM

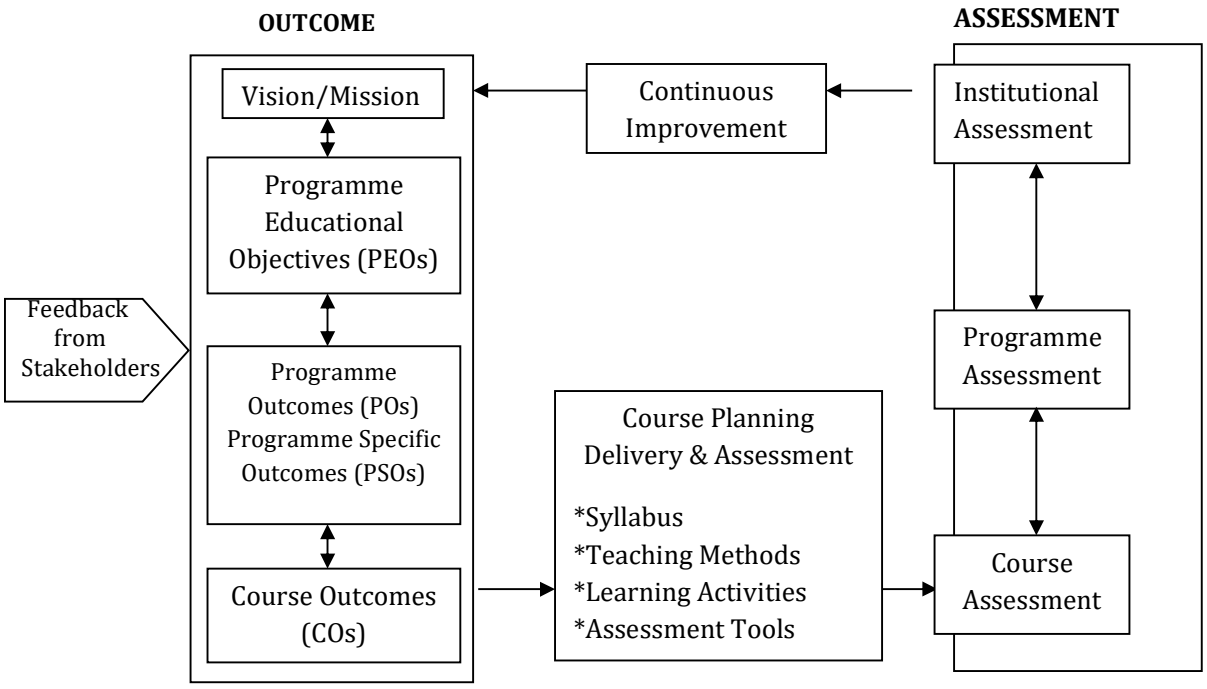
(From 2024-2025 Batch onwards)

INTRODUCTION

Sri Kaliswari College in its pursuit of imparting quality education has marked a remarkable growth in terms of academic excellence, infrastructure, student strength, ICT facilities, library and placement records since its establishment in 2000-2001.This institution constitutes an academic community that is committed to encourage the student community to experience and share knowledge, identify their potential, enhance the employability skills and enable them to pursue their goals. After the conferment of autonomous status in the year 2012, the college has so far gone for revision of the syllabi three times and is continually updating the syllabi to meet the needs and demands of the student community.

The institution in its success journey of imparting quality education has been Re-Accredited with A grade with CGPA (3.11) in its third cycle of accreditation by NAAC. As an added feather to its cap, the institution has taken a giant leap to embrace the Outcome-Based Education system to enable the student community to develop their knowledge, skill and attitude simultaneously through a focussed learning and help the graduates to compete with their global counterparts and prepare them for life.

I. OUTCOME-BASED EDUCATION (OBE) FRAMEWORK



II. VISION OF THE INSTITUTION

- To impart quality higher education to produce highly talented youth capable of developing the nation

III. MISSION OF THE INSTITUTION

- Ensuring quality in all aspects of the activities
- Developing the latent skills of the rural youth
- Providing value - based education to instill courage and confidence
- Nurturing the entrepreneurial skills of the rural youth
- Creating competency to meet global challenges
- Imbibing social awareness and social responsibilities

IV. VISION OF THE DEPARTMENT

- To provide an ambient environment for teaching and research in physics with focus on achieving academic and professional excellence.

V. MISSION OF THE DEPARTMENT

- To impart knowledge in theoretical as well as experimental physics
- To provide a conducive environment for the students to develop scientific insights and practical skills and apply them to real world problems
- To bridge the gap between curriculum based learning and career readiness

VI. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The Graduates will

PEO1: achieve advance in-depth knowledge of energy storage and conversion technologies and can pursue research programme/join in national and international level institution/battery industry.

PEO2: able to apply theoretical knowledge and practical experience in tackling complex challenges in battery storage and conversion technologies, fostering innovation in energy systems and contributing to advancements in sustainable energy solutions.

PEO3: equip with skills in research, critical thinking and analytical area.

PEO4: strengthen professional attitude with ethical values to enhance entrepreneurial skills.

PEO5: develop creativity, inventiveness, leadership and lifelong learning to become a successful professional.

VII. PROGRAMME OUTCOMES (POs)

PO1: Disciplinary knowledge

Acquire comprehensive and scientific knowledge in the field of energy storage and conversion technology.

PO2: Critical thinking, Problem solving and Analytical reasoning

Engage in critical investigation through principle approaches or methods and draw realistic conclusions of problems by employing highly developed analytical and quantitative skills.

PO3: Scientific reasoning and Research related skills

Ability to analyze, draw conclusions from qualitative/quantitative data and critically evaluate ideas and also acquire necessary research skills to carry out an experiment or investigation.

PO4: Communication skills and Digital literacy

Communicate effectively on scientific achievements, basic concepts and recent developments with society at large and make use of appropriate software to prepare project report.

PO5: Ethics, Values and Multicultural competence

Embrace ethical principles in all their activities, commit to professional and research ethics and practice tolerance and respect differences.

PO6: Team Work, Leadership and Employability skills

Recognize the opportunities and contribute positively in collaborative scientific research and acquire the pre-requisite skills required for placements and higher education.

PO7: Self-directed and Life-long learning

Recognize the need for engaging in independent and life-long learning in the emerging areas of the field of specialization.

VIII. PROGRAMME SPECIFIC OUTCOMES (PSOs) – PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

On successful completion of PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell), the students will

PSO1: acquire comprehensive knowledge and understanding of both theoretical and experimental knowledge in materials, modern tools, techniques, equipment and technology necessary for the design, analysis, and testing of battery storage systems, supercapacitors, and fuel cells.

PSO2: develop skills and knowledge necessary to meet the demands of the energy storage and conversion technology industry, including the ability to troubleshoot, optimize, and scale up energy storage systems for commercial deployment.

PSO3: design, investigate experimentally and optimize batteries, supercapacitors and fuel cells for various applications.

PSO4: communicate effectively the concepts through technical writing as well as through oral presentation and acquire the ability to work in simulation software and related computational work.

PSO5: embrace moral and research ethics, including fair benefit sharing, plagiarism, scientific misconduct and so on and develop the ability to spot data fabrication and fake news by applying rational scepticism and analytical reasoning.

PSO6: act as a team player by contributing in laboratory, field based situation and industry by acquiring technical, communicative, problem solving, intellectual and leadership skills.

PSO7: engage in independent and lifelong learning through use of advanced ICT techniques for personal academic growth as well as for increasing employability opportunity.

IX. PO-PSO Mapping Matrix – PG Diploma Course on Energy Storage and Conversion Technology ((Battery, Supercapacitor and Fuel Cell)

PO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
PO1	✓						
PO2		✓					
PO3			✓				
PO4				✓			
PO5					✓		
PO6						✓	
PO7							✓

X. PO-PEO Mapping Matrix – PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

PO / PEO	PEO1	PEO2	PEO3	PEO4	PEO5
PO1	✓				
PO2	✓	✓	✓		✓
PO3		✓	✓		
PO4			✓		
PO5				✓	✓
PO6				✓	
PO7					✓

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
(Affiliated to Madurai Kamaraj University, Re-accredited with A Grade (CGPA 3.11) by NAAC)
DEPARTMENT OF PHYSICS
Programme: PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

REGULATIONS

Duration of the Programme **:** One year (equivalent to two semesters)

Eligibility

Candidate should have passed any UG Degree in Science or Engineering

Medium of Instruction : English

Age Limit

Maximum age limit : No Age Limit

Transitory Permission

Students joined from 2024 - 2025 may be permitted to write their examinations in this pattern up to April 2029.

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
Programme: PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

SCHEME OF EXAMINATION

For PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell), the internal and external marks are distributed as follows:

For all Theory Courses: Internal Marks: 25; External Marks: 75

For all Practical Courses,
Project and Internship: Internal Marks: 25; External Marks: 75

Internal Mark Distribution for Theory Courses

Assessment Type	Marks	Scheme of Assessment
Internal Test	10 marks	Two Internal Tests and 1 Model Exam will be conducted and average of the best two will be considered
Assignment	5 marks	One Assignment will be given
Quiz	5 marks	One Quiz Test will be conducted
Viva	5 marks	One Viva-voce (Oral) will be conducted

Internal Mark Distribution for Practical Courses

Assessment Type	Marks	Scheme of Assessment
Lab work	10 marks	One Internal Test will be conducted
Observation	10 marks	Assessment will be done during every practical class
Viva –Voce	5 marks	One Viva-voce (Oral) will be conducted

External Mark Distribution for Practical Courses

Assessment Type	Marks	Scheme of Assessment
Lab work	65 marks	End result of the Practical
Viva –Voce	10 marks	Oral Mode Test

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
Programme: PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

QUESTION PAPER PATTERN THEORY COURSES

Internal Test – 30 Marks – 1 hr Duration

S.No	Type of Questions	Marks
1.	Objective type Questions: Multiple Choice – 5 questions	5x2 =10
2.	Long Answer–2 questions – either or type	2x10=20

Summative Examinations – 75 Marks -3 hrs Duration

S.No	Type of Questions	Marks
1.	Objective type Questions: Multiple Choice – 15 questions	15x2=30
2.	Long Answer - 5 questions – either or type	5x 9=45

(Avoid the Questions with Derive, Describe etc.,)

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
Programme: PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

Attainment of Course outcomes

Attainment of Course outcomes is computed using Direct and Indirect assessment methods. Direct Method of Assessment is based on performance of the students in the Continuous Internal Assessment Tests, Summative Examinations and supporting activities such as Seminar, Assignment, Case study, Group Discussion, Quiz, etc., and Indirect Method of Assessment is based on periodical feedback from the students at the end of each course.

Weightage of Direct and Indirect Assessment in computation of attainment of each course is 70% for Direct Assessment and 30% for Indirect Assessment.

Direct Assessment of Course outcome attainment

i) Rubrics:

Internal Assessment contributes 60% and Summative Examinations Assessment contributes 40% to the Direct Assessment of a course outcome for Theory Courses. For the Practical Courses, Internal Assessment contributes 70% and Summative Examinations Assessment contributes 30% to the Direct Assessment of a course outcome.

ii) Setting of Target:

50% of the maximum mark is set as target of Internal Assessment tools and the average mark of the class is set as target of Summative Examinations Assessment.

Formula for calculating percentage attainment of each course outcome

Based on the result of Summative Examinations and Internal Assessment tools, the number of students scoring more than the target is found out.

For each Internal Assessment Tools,

$$\text{Percentage attainment of each course outcome} = \frac{\text{No. of. Students who scored more than the target in the concerned course outcome}}{\text{Total Number of Students}} \times 100$$

$$\text{Percentage attainment of each Course outcome for Internal Assessment tools} = \text{Average of percentage attainment of all Internal Assessment tools}$$

For Summative Examinations,

Percentage attainment of each Course outcome =

$$\frac{\text{No. of. Students who scored more than the target in the concerned co}}{\text{Total Number of Students}} \times 100$$

Formula for calculating Attainment Percentage of Course outcome of a course

Percentage Attainment of Course outcome for Internal Assessment tools	=	Average of percentage attainment of all COs
Percentage Attainment of Course outcome for Summative Examinations	=	Average of percentage attainment of all COs

Final Direct Assessment of Course outcome Attainment

For Theory Courses

Percentage Attainment of Course outcome through Direct Assessment	=	(0.6 x percentage attainment of CO for internal assessment tool) + (0.4 x percentage attainment of CO for summative examinations)

For Practical Courses

Percentage Attainment of Course outcome through Direct Assessment	=	0.7 x percentage attainment of CO for Internal Assessment tools + 0.3 x percentage attainment of CO for Summative Examinations

Indirect Assessment of CO Attainment

The course outcome feedback is conducted at the end of every semester by distributing structured feedback questionnaire to the students. The analysis of this feedback questionnaire is done on the following score. The feedback forms will be sorted with various scores and feedbacks with a score more than 5.5 are considered as satisfactory level for calculations for indirect attainment.

A : 10-8.5 **B :** 8.4-7.0 **C :** 6.9-5.5 **D :** 5.4-4.0 **E :** 3.9-0

Percentage attainment for each CO = $\frac{\text{Satisfaction Number}}{\text{Response Received}} \times 100$

Percentage Attainment of CO of a course = Average of percentage attainment of all COs

Final Assessment of CO attainment

Average course attainment = 0.7 x Direct assessment of CO attainment + 0.3 x Indirect assessment of CO attainment

Expected Level of Attainment for each of the Course Outcomes

Percentage of CO Attainment	Level of Attainment
= 70% and above	Excellent
= 60% - <70 %	Very good
= 50% -< 60 %	Good
= 40% - < 50 %	Satisfactory
Below 40%	Not Satisfactory

Assessment of PO attainment

At the end of the each programme, the Direct PO Assessment is done from the CO Attainment of all courses. The Direct PO Attainment for a particular course is determined from the attainment values obtained for each course outcome related to that PO and the CO-PO mapping values.

$$\text{Weighted contribution of the course in attainment of each PO} = \frac{\text{Weighted Percentage of contribution of the course in attainmentof each PO x average course attainment}}{100}$$

$$\text{Percentage attainment for each PO} = \frac{\text{Total weightage of all courses contributed to each PO}}{\text{Total weightage of all courses contributed to all POs}} \times 100 \text{ x weighted contribution of the course in the attainment of each PO}$$

Percentage Attainment of PO = Average of Percentage attainment of all POs

Expected Level of Attainment for each of the Programme Outcomes

Percentage of PO Attainment	Level of Attainment
= 70% and above	Excellent
= 60% - <70 %	Very good
= 50% -< 60 %	Good
= 40% - < 50 %	Satisfactory
Below 40%	Not Satisfactory

Attainment of Programme Educational Objectives (PEO)

PEOs are assessed after 3 to 4 years of graduation. Attainment is measured based on the Feedback from Stakeholders

1. Alumni
2. Parents
3. Employer

The analysis of this feedback questionnaire is done on the following score. The feedback forms will be sorted with various scores and feedbacks with a score more than 5.5 are considered as satisfactory level for calculations for Indirect Attainment.

A : 10-8.5 **B :** 8.4-7.0 **C :** 6.9-5.5 **D :** 5.4-4.0 **E :** 3.9-0

$$\text{Percentage attainment of PEOs} = \frac{\text{Satisfaction number}}{\text{Response Received}} \times 100$$

Expected Level of Attainment for each of the Programme Educational Objectives

Percentage of PEO Attainment	**Level of Attainment**
= 70% and above	Excellent
= 60% - <70 %	Very good
= 50% -< 60 %	Good
= 40% - < 50 %	Satisfactory
Below 40%	Not Satisfactory

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DEPARTMENT OF PHYSICS

Programme: PG Diploma Course on Energy Storage and Conversion Technology (Battery, Supercapacitor and Fuel Cell)

CURRICULUM STRUCTURE

OUTCOME-BASED EDUCATION WITH CHOICE BASED CREDIT SYSTEM

(From 2024-2025 Batch onwards)

Courses	**Semester I Hours (Credit)**	**Semester II Hours (Credit)**	**Total Credits**
Core Courses	6 (5) 6 (5) 6 (5) 6 (5) 6P (4)		24
Internship / Project with Viva Voce		(16)	16
Total	30 (24)	(16)	40

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CURRICULUM PATTERN

OUTCOME-BASED EDUCATION WITH CHOICE BASED CREDIT SYSTEM

(From 2024-2025 Batch onwards)

PROGRAMME CODE – PDPH

Semester	Course Code	Course Name	Hours	Credits	Internal Marks	External Marks
I	24PDPHC11	**Core Course –I :** Solid State Ionics	6	5	25	75
	24PDPHC12	**Core Course –II :** Material Characterisation Techniques	6	5	25	75
	24PDPHC13	**Core Course –III :** Battery and Supercapacitor Technology	6	5	25	75
	24PDPHC14	**Core Course –IV :** Fuel Cell Technology	6	5	25	75
	24PDPHC1P	**Core Course –V :** Practical: Energy Storage and Conversion Devices	6	4	25	75
		Total	**30**	**24**		
II	24PDPHJ21/ 24PDPHJ22	**Core Course – VI :** Internship / Project with Viva Voce	-	16	25	75
		Total	**-**	**16**		

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(From 2024-2025 Batch onwards)

PROGRAMME ARTICULATION MATRIX (PAM)

Semester	Course Code	Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7
I	24PDPHC11	**Core Course –I :** Solid State Ionics	15	13	8	5	2	5	4
	24PDPHC12	**Core Course –II :** Material Characterisation Techniques	13	12	12	7	6	6	6
	24PDPHC13	**Core Course –III :** Battery and Supercapacitor Technology	15	12	10	7	7	6	6
	24PDPHC14	**Core Course –IV :** Fuel Cell Technology	13	11	10	8	8	7	7
	24PDPHC1P	**Core Course –V :** Practical: Energy Storage and Conversion Devices	10	13	13	8	8	10	8
II	24PDPHJ21/ 24PDPHJ22	**Core Course – VI :** Internship / Project with Viva Voce	12	11	11	10	4	5	7
Total Weightage of all Courses Contributing to PO			**78**	**72**	**64**	**45**	**35**	**39**	**38**

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DEPARTMENT OF PHYSICS

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(From 2024-2025 Batch onwards)

PROGRAMME ARTICULATION MATRIX – WEIGHTAGE PERCENTAGE

Semester	Course Code	Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7
I	24PDPHC11	**Core Course –I :** Solid State Ionics	19.23	18.06	12.5	11.11	5.71	12.82	10.53
	24PDPHC12	**Core Course –II :** Material Characterisation Techniques	16.67	16.67	18.75	15.56	17.14	15.38	15.79
	24PDPHC13	**Core Course –III :** Battery and Supercapacitor Technology	19.23	16.67	15.63	15.56	20	15.38	15.79
	24PDPHC14	**Core Course –IV :** Fuel Cell Technology	16.67	15.28	15.63	17.78	22.86	17.95	18.42
	24PDPHC1P	**Core Course –V :** Practical: Energy Storage and Conversion Devices	12.82	18.06	20.31	17.78	22.86	25.64	21.05
II	24PDPHJ21/ 24PDPHJ22	**Core Course – VI :** Internship / Project with Viva Voce	15.38	15.28	17.19	22.22	11.43	12.82	18.42
Total Weightage of all Courses Contributing to PO			**100**	**100**	**100**	**100**	**100**	**100**	**100**

Semester - I

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - I
CORE COURSE - I: SOLID STATE IONICS (24PDPHC11)
(From 2024-2025 Batch onwards)

HOURS/WEEK	**: 6**	**INT. MARKS**	**: 25**
CREDITS	**: 5**	**EXT. MARKS**	**: 75**
DURATION	**: 90 hrs**	**MAX. MARKS**	**: 100**

Course Objectives

- To describe different types of crystal structures in terms of the crystal lattice & basis of constituted atoms.
- To compare the crystal binding and their atomic radii.
- To classify the super ionic conductors and differentiate them from normal conductors.
- To elaborate the characterization of ionic conductors with theory.
- To elucidate the applications of super ionic solids in present energy devices.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K1]: infer the kinds of crystal structures & their reciprocal lattices

CO2[K2]: examine the basic formation of bonding in crystals

CO3[K3]: relate the various types of ionic conductors and differentiate from normal conductors

CO4[K4]: analyze the characterization procedures of ionic conductors

CO5[K5]: elaborate the concept of super ionic applications in battery.

CO-PO Mapping table (Course Articulation Matrix)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K1]	3	2	1	1	-	-	-
CO2 [K2]	3	3	1	1	-	1	-
CO3 [K3]	3	3	2	1	-	1	1
CO4 [K4]	3	3	2	1	1	1	1
CO5 [K5]	3	2	2	1	1	2	2
Weightage of the course	15	13	8	5	2	5	4
Weighted percentage of Course contribution to POs	**19.23**	**18.06**	**12.5**	**11.11**	**5.71**	**12.82**	**10.53**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

UNIT I - CRYSTAL STRUCTURE & RECIPROCAL LATTICE (18 Hrs)

Periodic Arrays of Atoms – Fundamental Types of Lattices – Index System for Crystal Planes – Simple Crystal Structures – NaCl, CsCl, HCP, Diamond & ZnS – Non-Ideal Crystal Structures.

Diffraction of Waves by Crystals – Scattered Wave Amplitude – Fourier Analysis – Reciprocal Lattice Vectors – Diffraction Conditions – Laue Equations – Brillouin Zones – Reciprocal Lattice to SC, BCC & FCC Lattice – Structure Factor of the BCC and FCC Lattice – Atomic Form Factor – Quasicrystals.

UNIT II - CRYSTAL BINDING AND DEFECTS (18 Hrs)

Crystals of Inert Gasses – Ionic Crystals – Covalent Crystals – Metals – Hydrogen Bonds – Atomic Radii.

Point Defects – Lattice Vacancies – Diffusion – Color Centers - Surface Crystallography.

UNIT III - CLASSIFICATION OF SUPERIONIC CONDUCTORS (18 Hrs)

Conductivity - Ionic Conductivity - Fast Ionic Conductors - Difference between Superionic Conductors and Normal Ionic Conductors - Classification of Superionic Conductors in Detail. Classification Based on Mobile Ions with Examples - Simple Theory of Ionic and Super Ionic Conductors with Proper Explanation (Theoretical Models).

UNIT IV - THEORETICAL BACKGROUND OF TRANSPORT PROPERTIES (18 Hrs)

Theory of X-ray Diffraction (XRD) - Study of Ion Transport - Macroscopic Techniques - Transference Number Measurement Technique - Complex Impedance Spectroscopy - Basic Concepts - Electrical Conductivity (Band Theory) at Different Temperature and Its Theory - Electrical Conductivity (Band Theory) at Different Frequency and Its Theory.

UNIT V – SOLID STATE IONIC MATERIALS AND SYNTHESIS METHODS (18 Hrs)

Phase Diagrams and Phase Stability of Ionic Materials – Thermodynamics – Brief Explanation of Phase Diagrams and Phase Stability - Classification of Solid State Ionic Materials; Family of Lithium, Sodium, Noble Metal, Oxygen, Halogen, Proton and Magnesium.

Bulk Solid State Ionic Materials; High-Temperature Solid State Synthesis - Temperature-Controlled Precipitation as a Strategy for SSI Materials Synthesis - Sol–Gel Combustion or Solvothermal Synthesis - Mechanochemical Reaction Synthesis - Hydrothermal Synthesis - Microwave Synthesis or Microwave-Assisted Synthesis.

TEXTBOOKS

1. Charles Kittel. *Introduction to Solid State Physics*. John Wiley & Sons, Inc., Eighth Seven Edition, 2012.
2. Sunandana C.S. *Introduction to Solid State Ionics- Phenomenology And Applications.* Florida, USA: CRC Press, First Edition, 2016.

REFERENCES

Books

1. Chandra S. *Superionic Solids - Principle and Applications.* Amsterdam: North Holland. 1981.
2. Chowdari B.V.R, Kawamura J, Mizusaki J and Amezawa K. *Solid State Ionics: Ionics for Sustainable World.* Singapore: World Scientific Publishing Company, 2012.
3. Tsutomu Minami, Masahiro Tatsumisago, Wakihara M, Iwakura C, Kohjiya S and Tanaka I. *Solid State Ionics for Batteries.* New York: Springer, 2005.

Web Sources

1. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Physical_Methods_in_Chemistry_and_Nano_Science_(Barron)/07%3A_Molecular_and_Solid_State_Structure/7.01%3A_Crystal_Structure#:~:text=A%20crystal%20structure%20is%20defined,external%20appearance%20of%20the%20crystal.
2. https://www.britannica.com/science/crystal/Molecular-binding
3. https://scijournals.onlinelibrary.wiley.com/doi/full/10.1002/ese3.1163
4. https://www.youtube.com/watch?v=QYL3mkFF4V4
5. https://www.youtube.com/watch?v=RdRMKZE2Ig4
6. https://www.youtube.com/watch?v=LPfbCWpzj1o

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - I
CORE COURSE - II: MATERIAL CHARACTERISATION TECHNIQUES (24PDPHC12)
(From 2024-2025 Batch onwards)

HOURS/WEEK	**: 6**	**INT. MARKS**	**: 25**
CREDITS	**: 5**	**EXT. MARKS**	**: 75**
DURATION	**: 90 hrs**	**MAX. MARKS**	**: 100**

Course Objectives

- To introduce Rietveld refinement to analyze X-ray diffraction patterns and determines crystallinity / amorphous nature.
- To analyze the material properties and calculate vibrational force constants using FTIR and Raman spectroscopy.
- To analyze the complex dielectric constant and its frequency and temperature dependence to evaluate dielectric properties.
- To interpret Nyquist plots and develop equivalent circuits using impedance spectroscopy for material characterization.
- To perform cyclic voltammetry and linear sweep voltammetry to assess electrochemical properties and charge-discharge performances.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K1]: recall the fundamental principles of characterization techniques used in course

CO2[K2]: explain the methods for analyzing and interpreting data

CO3[K3]: apply different techniques in real-world material characterization and problem-solving

CO4[K4]: analyze the data obtained from various techniques to determine material properties and assess performance in different conditions

CO5[K5]: evaluate various multiple analytical techniques used in material and performance characterization.

CO-PO Mapping table (Course Articulation Matrix)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K1]	3	1	1	1	-	-	-
CO2 [K2]	3	2	2	1	-	-	-
CO3 [K3]	3	3	3	1	2	2	2
CO4 [K4]	2	3	3	2	2	2	2
CO5 [K5]	2	3	3	2	2	2	2
Weightage of the course	13	12	12	7	6	6	6
Weighted percentage of Course contribution to POs	**16.67**	**16.67**	**18.75**	**15.56**	**17.14**	**15.38**	**15.79**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

UNIT I – STRUCTURAL AND MORPHOLOGICAL STUDIES (18 Hrs)

X-Ray Diffraction - Crystallite size - Debye Scherer Formula - Rietveld Refinement Technique - Deconvolution of XRD Pattern-Calculation of Crystallinity / Amorphous Nature Percentage - Hodge Criteria.

Theory and Instrumentation of Following Instruments/Techniques; Scanning Electron Microscope – Transmission Electron Microscope – Atomic Force Microscope – Scanning Tunnelling Microscope – X-ray Photoelectron Spectroscopy - Brunauer-Emmett-Teller (BET).

UNIT II – OPTICAL AND VIBRATIONAL (18 Hrs)

UV-Vis-IR Spectroscopy - Photoluminescence - Vibrational Spectra: FTIR & Raman - Calculation of Force Constant for Different Vibrational Frequencies - Bond Length Discussion.

UNIT III – DIELECTRIC STUDIES (18 Hrs)

Dielectric Modulus Studies: Theory-Complex Dielectric Constant-Polarization-Frequency and Temperature Dependence of Dielectric Constant and Dielectric Loss.

UNIT IV – IMPEDANCE ANALYSIS (18 Hrs)

Impedance Spectroscopy: Basic Concepts - Basic Theory of Complex Impedance Spectroscopy - Nyquist Plot - Equivalent Circuit - Interfaces - Electrode - Electrolyte Interfaces - Grain Boundaries - Grain Interfaces - Transport Properties of Superionic/Solids.

UNIT V – ELECTROCHEMICAL AND THERMAL TECHNIQUES (18 Hrs)

Cyclic Voltammetry - Linear Sweep Voltammetry – Open Circuit Voltage - Charge Discharge Performance - Amperometry - Chromatometry – Differential Pulse Voltametry (DPV) - 4 Single Electrode Potential Measurement - Electrochemical Active Surface Area Measurement.

Differential Thermal Analysis (DTA) - Differential Scanning Calorimetry (DSC) - Thermo Gravimetric Analysis (TGA) - Specific Heat - Gibbs Free Energy.

TEXTBOOKS

1. B.D. Cullity and S.R. Stock. *Elements of X-Ray Diffraction.* Pearson new International Edition, Third Edition, 2014.
2. Shah M A and Shah K A. *Nanotechnology -The Science of Small.* New Delhi: Wiley India Pvt. Ltd., First Edition, 2013.
3. Colin N.Banewell and Elaine M.Mccash. *Fundamentals of Molecular Spectroscopy.* New Delhi: McGraw Hill Education (India) Pvt. Ltd., Fifth Edition, Reprint 2014.

4. Charles Kittel. *Introduction to Solid State Physics*. John Wiley & Sons, Inc., Eighth Seven Edition, 2012.
5. Mark E. Orazem and Bernard Tribollet. *Electrochemical Impedance Spectroscopy*. John Wiley & Sons, 2017.
6. John O'M. Bockis and Amulya K. N. Reddy. *Modern Electrochemistry.* New York: Kluwer Academic Publishers, Second Edition, 1998.

REFERENCES

Books

1. Peter zaralig and Vitaley peeharsky. *Fundamentals of Powder Diffraction and Structural characterization of Materials.* Florida, USA: Springer, 2005.
2. Robert Alan Young. *The Rietveld Method*. Oxford Science Publications, 1995.
3. Sathyanarayana D.N. *Vibrational Spectroscopy-Theory and Applications*. Chennai:New Age Inter National Publishers, FirstEdition, 2006.
4. Ergenig Barsoukov and Ross Macdonald J. *Impedance Spectroscopy, Theory, Experimental and Applications,* Hoboken, New Jersey: A John Wiley and Sons, Inc., Publication, Second Edition, 2005.
5. Larry R. Faulkner and Allen J. Bard, *Electrochemical Methods: Fundamentals and Applications*, Second Edition, 2000.

Web Sources

1. https://www.youtube.com/watch?v=hLL9rPPXL20
2. https://www.youtube.com/watch?v=mZ-U7Qpkz8Y&list=PL0pJUwkI0YCbhsS5k0E7QR_oullkblLlh
3. https://www.youtube.com/watch?v=kexDd0kFAK8&t=18s
4. https://www.youtube.com/watch?v=cz67DnyS9-w
5. https://www.youtube.com/watch?v=OFh_Id8Ja4Y
6. https://www.youtube.com/watch?v=m8L-B4A75Ec

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - I
CORE COURSE - III: BATTERY AND SUPERCAPACITOR TECHNOLOGY (24PDPHC13)
(From 2024-2025 Batch onwards)

HOURS/WEEK	**: 6**	**INT. MARKS**	**: 25**
CREDITS	**: 5**	**EXT. MARKS**	**: 75**
DURATION	**: 90 hrs**	**MAX. MARKS**	**: 100**

Course Objectives

- To familiarise the basic concepts, electrochemical principles and reactions of batteries.
- To discuss characteristics, chemistry, components, standard construction and performance of different types of primary and rechargeable batteries.
- To elaborate emerging applications of the advanced batteries for electric vehicles.
- To familiarise the basic concepts, design, operations and applications of electrochemical supercapacitor.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K1]: state the basic concepts, electrochemical principles and reactions of batteries

CO2[K2]: explain characteristics and performance of primary and rechargeable batteries

CO3[K3]: identify advanced batteries for electric vehicles

CO4[K4]: distinguish the characteristics of different types of batteries and supercapacitors

CO5[K5]: elaborate the design, fabrication, operation and applications of batteries and electrochemical supercapacitors.

CO-PO Mapping table (Course Articulation Matrix)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K1]	3	1	1	1	1	-	-
CO2 [K2]	3	2	1	1	1	-	-
CO3 [K3]	3	3	2	1	1	2	2
CO4 [K4]	3	3	3	2	2	2	2
CO5 [K5]	3	3	3	2	2	2	2
Weightage of the course	15	12	10	7	7	6	6
Weighted percentage of Course contribution to POs	**19.23**	**16.67**	**15.63**	**15.56**	**20**	**15.38**	**15.79**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

UNIT I - BASIC CONCEPTS, ELECTROCHEMICAL PRINCIPLES AND REACTIONS (18 Hrs)

Components of Cells and Batteries - Classification of Cells and Batteries - Operation of a Cell - Theoretical Cell Voltage Capacity and Energy - Specific Energy and Energy Density of Practical Batteries - Upper Limits of Specific Energy and Energy Density - Coulomb Efficiency (CE) - Voltage Efficiency (VE) - Energy Efficiency (EE) – C-rate of Battery.

Thermodynamic Background - Electrode Process - Electrical Double Layer Capacity and Ionic Absorption - Mass Transport to the Electrode Surface.

UNIT II - PRIMARY BATTERIES (18 Hrs)

General Characteristics – Chemistry – Components - Standard Construction - Performance Characteristics - Discharge Capacity Performance - Shelf Life - Temperature Effect - Energy Power Density of Following Batteries; Zinc-Carbon Batteries - Magnesium and Aluminium Battery - Alkaline Manganese Dioxide Batteries - Silver Oxide Batteries - Zinc/Air Batteries - Lithium Batteries.

UNIT III - RECHARGEABLE BATTERIES (18 Hrs)

General Characteristics – Chemistry – Components - Standard Construction - Performance Characteristics Discharge Capacity Performance - Shelf Life - Temperature Effect - Energy Power Density – Charging Characteristics of Following Batteries; Lead Acid Batteries- Portable Sealed Nickel-Cadmium Batteries – Nickel-Zinc Batteries - Nickel-Iron - Silver-Zinc - Silver-Cadmium - Lithium Ion - Sodium Ion - Magnesium Ion Batteries - Redox flow Battery Operation, Types and Working Principle.

UNIT IV - ADVANCED BATTERIES FOR ELECTRIC VEHICLES EMERGING APPLICATIONS (18 Hrs)

General Characteristics - Description of the Electrochemical Systems – Construction – Performance Characteristics and Applications of Following Batteries; Zinc/Air - Magnesium/Air - Lithium/Air - Sodium-Beta Batteries - Lithium/Iron Sulphide Batteries – Li-Sulphur Battery - Sodium Ion Salt Battery – Designing of EV Vehicles - Battery Package - Different Battery Standards - Commercial Batteries – Scale- up Activity and Current Scenario of Batteries.

UNIT V – SUPERCAPACITOR (18 Hrs)

Basic Concepts of Capacitor – Types and Structures of Capacitor – Fundamentals of Electrochemical Double Layer Supercapacitor – Electrochemical Psuedocapacitor – Components and Materials for Electrochemical Supercapacitor – Electrochemical Supercapacitor Design, Fabrication and Operation – Characterization and Diagnosis Techniques for Electrochemical Supercapacitors – Applications of Electrochemical Supercapacitor.

TEXTBOOKS

1. Davind Linden and Thomas B. Reddy. *Handbook of Batteries.* New Delhi: Mc Graw-Hill Publisher, Third Edition, 2001.
2. Aiping Yu, Victor Chabot and Jiujun ZhangYu. *Electrochemical Supercapacitors for Energy Storage and Delivery – Fundamentals and Applications.* Boca Raton: CRC Press Taylor & Francis Group, 2013.
3. Prachi Patel. *Rechargeable Battery Science: A Survey of Advancements in Materials and Technology.* ACS Publications, 2019.
4. Shichun Yang, Xinhua Liu, Shen Li and Cheng Zhang. *Advanced Battery Management System for Electric Vehicles.* Springer Publications, 2022.

REFERENCES

Books

1. Lukasz Bednarsk. *Lithium- The Global Race to Battery Dominance and The New Energy Revolution*. London: C. Hurst & Co. Publishers Ltd., 2021.
2. Tripathi P.K. *Handbook on Production, Recycling of lithium-ion and lead acid batteries.* New Delhi: NIIR Project Consultancy Services, First Edition, 2023.
3. Kai Peter Birke. *Modern battery Engineering: A Comprehensive Introduction*. World Scientific Publishing, 2019.
4. Slobodam Petnovic. *Battery Technology Crash Course- A Concise Introduction*. Springer, First Edition, 2020.
5. Isdo Buchmann. *Batteries: in a portable world (Hand book on Rechargeable batteries for Non-engineer).* Cadex Electronics Inc., Fourth Edition, 2017.
6. Conway B.E. *Electrochemical Supercapacitors, Scientific Fundamentals and Technological Applications.* New York: Kluwer Academic Plenum Publisher, 1999.
7. Sandeep A. Arote. *Electrochemical Energy Storage Devices and Super Capacitors: An Overview.* Bristol, England: Institute of Physics Publishing, IOP e-Books, 2021.

Web Sources

1. https://depts.washington.edu/matseed/batteries/MSE/components.html
2. https://www.youtube.com/watch?v=NYg9dNDNSaA
3. https://www.youtube.com/watch?v=3E1SXG7VkQk&list=PLyqSpQzTE6M9spod-UH7Q69wQ3uRm5thr&index=2
4. https://www.youtube.com/watch?v=iFVVv23ZzGE
5. https://www.iea.org/reports/global-ev-outlook-2024/trends-in-electric-vehicle-batteries
6. https://www.youtube.com/watch?v=iihYXx79QiE

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - I
CORE COURSE - IV: FUEL CELL TECHNOLOGY (24PDPHC14)
(From 2024-2025 Batch onwards)

HOURS/WEEK	**: 6**	**INT. MARKS**	**: 25**
CREDITS	**: 5**	**EXT. MARKS**	**: 75**
DURATION	**: 90 hrs**	**MAX. MARKS**	**: 100**

Course Objectives

- To study the various types of fuel cells and its components.
- To understand the thermodynamic properties of fuel cells.
- To gain knowledge kinetics of fuel cell reactions.
- To identify the in-situ and ex-situ characteristics of fuel cells.
- To know the various hydrogen generation methods.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K1]: identify the basic concepts in fuel cells and hydrogen storage and generation methods

CO2[K2]: explain the thermodynamic property, reaction kinetics and characterization of fuel cells

CO3[K3]: apply the thermodynamic and kinetic property of fuel cells and hydrogen generation methods

CO4[K4]: analyze the safety issues, efficiency and components of fuel cells

CO5[K5]: examine the various components of fuel cell, thermodynamic property, reaction kinetics and characterization of fuel cells.

CO-PO Mapping table (Course Articulation Matrix)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K1]	3	2	3	2	1	1	1
CO2 [K2]	3	2	2	1	1	1	1
CO3 [K3]	3	2	2	1	1	1	2
CO4 [K4]	2	3	1	2	2	2	1
CO5 [K5]	2	2	2	2	3	2	2
Weightage of the course	13	11	10	8	8	7	7
Weighted percentage of Course contribution to POs	**16.67**	**15.28**	**15.63**	**17.78**	**22.86**	**17.95**	**18.42**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

UNIT I - BASIC CONCEPTS AND COMPONENTS OF FUEL CELL (18 Hrs)

Overview of Fuel Cells - Types of Fuel Cell – Proton Exchange Membrane Fuel Cell - Methanol Fuel Cell - Alkaline Fuel Cell - Solid Oxide - Basic Electrochemistry for the Fuel Cells.

Components of Fuel Cell - Membrane Electrode Assembly (MEA) - Effect of Impurities such As, CO, S and Others in fuels - Liquid Hydrogen and Compressed Hydrogen-Metal Hydrides.

UNIT II - FUEL CELL THERMODYNAMICS (18 Hrs)

Fuel Cell Thermodynamics - Heat Potential of a Fuel: Enthalpy of Reaction, Work Potential of a Fuel: Gibbs Free Energy - Reversible and Irreversible Losses - Predicting Reversible Voltage of a Fuel Cell Under Non-Standard-State Conditions - Fuel Cell Efficiency - Nernst Equation - Effect of Temperature, Pressure, Concentration on Nernst Potential - Concept of Electrochemical Potential - Thermal and Mass Balances in Fuel Cells - Thermodynamics of Reversible Fuel Cells.

UNIT III – FUEL CELL REACTION KINETICS (18 Hrs)

Fuel Cell Reaction Kinetics: Electrode Kinetics – Overvoltages - Buttler Volmer Equation Tafel Equation - Charge Transfer Reaction - Exchange Currents - Electrocatalyses – Design - Activation Kinetics - Fuel Cell Charge and Mass Transport - Flow Field -Transport In Electrode and Electrolyte.

Concentration Polarization - Diffusion Transport in Electrodes - Limiting Current Density - Concentration Polarization Derivation - Transport through Flow Channels (Bipolar Plate). Ohmic Polarization - Ionic Conductivity - Electronic Conductivity - Modelling of Fuel Cell - Current Voltage Predictions.

UNIT IV - FUEL CELL CHARACTERIZATION AND BALANCE OF PLANT (18 Hrs)

Fuel Cell Characterization: Need of Characterization – Possible Ways of Characterization - In-Situ Characterization Techniques - I-V Characteristics - Electrochemical Impedance Spectroscopy - Cyclic Voltammetry - Current Interruption Technique - Ex-Situ-Characterization Especially Electrolyte and Bipolar Plate.

Balance of Plant - Commercialization Issues - Power Electronics and System Integration - Hydrogen Production and Storage - Endurance Analysis - Safety Issues - Cost Issues. Safety Issues and Cost Expectation and Life Cycle Analysis of Fuel Cells.

UNIT V - HYDROGEN GENERATION METHODS AND ITS EFFICIENCY (18 Hrs)

Hydrogen Generation Methods: Steam Methane Reforming - Electrolysis (Alkaline, PEM, And Solid Oxide Electrolysis) - Coal/Biomass Gasification - Solar and Wind-based Hydrogen Production - Emerging Hydrogen Generation Technologies. Hydrogen Storage -Metal Hydrides - Sievert Apparatus.

Performance and Efficiency: Efficiency Considerations in Hydrogen Generation - Performance Assessment of Hydrogen Production. Applications – Current Scenario – Scale-up Activity.

TEXTBOOKS

1. Ryan O'Hayre, Suk won Cha, Whitney Colella and Prinz F.B. *Fuel Cell Fundamentals*. New York: Wiley, 2006.
2. Bard A.J. and Faulkner L.R. *Electrochemical Methods, Fundamentals and Applications.* , New York: Wiley, Second Edition, 2004.
3. Detlef Stolten and Bernd Emonts. *Fuel Cell Science and Engineering: Materials, Processes, Systems and Technology.* Wiley-VCH, 2012.

REFERENCES

Books

1. Basu S. *Recent trends in Fuel Cell Science and Technology*. New York: Springer, First Edition, 2007.
2. Xianguo Li. *Principles of Fuel Cells*, New York: CRC Press, Taylor and Francis, 2006.
3. Amgad Elgowainy. *Electric, Hybrid, and Fuel Cell Vehicles (Encyclopedia of Sustainability Science and Technology Series).* Springer, 2021.
4. Nicu Bizon. *Optimization of the Fuel Cell Renewable Hybrid Power Systems (Green Energy and Technology).* Springer, 2020.

Web Sources

1. https://www.energy.gov/eere/fuelcells/fuel-cell-basics
2. https://americanhistory.si.edu/fuelcells/basics.htm
3. https://www.youtube.com/watch?v=eytxnS1OnXs&list=PLVh9DMcM5uny7jOh9r-yRTdxCk_yeCJg2
4. https://www.youtube.com/watch?v=62363H_I_Qk
5. https://www.youtube.com/watch?v=L2VSOccUrSk
6. https://www.youtube.com/watch?v=kbDtm_3zNlA

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - I
CORE COURSE - V: PRACTICAL: ENERGY STORAGE AND CONVERSION DEVICES
(24PDPHC1P)
(From 2024-2025 Batch onwards)

HOURS/WEEK	**: 6**	**INT. MARKS**	**: 25**
CREDITS	**: 4**	**EXT. MARKS**	**: 75**
DURATION	**: 90 hrs**	**MAX. MARKS**	**: 100**

Course Objectives

- To comprehense the experiment concepts to understand the concepts behind the measurement of physical parameters used in energy devices.
- To evaluate physical parameters of materials used in energy devices.
- To quantify and analyze experimental results.
- To know the procedure for construction of energy devices.
- To study performances of energy devices.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K2]: setup the experiment and collect data to determine the physical parameters

CO2[K3]: calculate the basic parameters involved in the experiments from the data

CO3[K4]: analyze / interpret the collected experimental data

CO4[K5]: evaluate the physical parameters using appropriate formula/make conclusions

CO5[K6]: fabricate/construct devices/experiments to evaluate physical parameters

CO-PO Mapping table (Course Articulation Matrix)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K2]	2	2	2	1	1	2	1
CO2 [K3]	2	2	2	2	1	2	1
CO3 [K4]	2	3	3	2	2	2	2
CO4 [K5]	2	3	3	2	2	2	2
CO5 [K6]	2	3	3	1	2	2	2
Weightage of the course	10	13	13	8	8	10	8
Weighted percentage of Course contribution to POs	**12.82**	**18.06**	**20.31**	**17.78**	**22.86**	**25.64**	**21.05**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

List of Experiments (Any eight)

1. Measurement of Transference Number by Wagner's Method.
2. Measurement of Transference Number by Evans Method.
3. Nyquist Plot – Determination of Conductivity.
4. Conductance Spectrum & Determination of Conductivity & Dielectric Constant.
5. Calculation of Transport Parameter – Mobility, Diffusion Constant and Charge Carrier Concentration.
6. Cyclic Voltammetry Study of Any Commercially Available Coin Cell.
7. Investigation of Charge Discharge Characteristics of Any Cell and Evaluation of Its Parameters.
8. Construction of Single Proton Conducting Fuel Cell.
9. Investigation of Fuel Cells Performance with Flow Rate Variation with Constant Temperature.
10. Investigation of Fuel Cells Performance with Temp Variation with Constant Flow Rate.
11. Construction of Super Capacitor & Its Evaluation.
12. Determination of Crystallite Size, Lattice Parameters from the Power XRD Data.
13. Analyze the Recorded FTIR Data.

TEXTBOOKS

1. B.D. Cullity and S.R. Stock. *Elements of X-Ray Diffraction.* Pearson new International Edition, Third Edition, 2014.
2. Bard A.J. and Faulkner L.R. *Electrochemical Methods, Fundamentals and Applications.* , New York: Wiley, Second Edition, 2004.
3. Mark E. Orazem and Bernard Tribollet. *Electrochemical Impedance Spectroscopy*. John Wiley & Sons, 2017.

REFERENCES

Books

1. John O'M. Bockis and Amulya K. N. Reddy. *Modern Electrochemistry.* New York: Kluwer Academic Publishers, Second Edition, 1998.
2. Ramanathan Srinivasan and Fathima Fasmin. *An Introduction to Electrochemical Impedance Spectroscopy*. CRC Press, Taylor & Francis Group, First Edition, 2021.
3. Elton N. Kaufmann. *Characterization of Materials.* New Jersey: A John Wiley and Sons Publication, 2003.
4. Colin N.Banewell and Elaine M.Mccash. *Fundamentals of Molecular Spectroscopy.* New Delhi: McGraw Hill Education (India) Pvt. Ltd., Fifth Edition, Reprint 2014.

Web Sources

1. https://www.youtube.com/watch?app=desktop&v=EHvi85r0bIA&pp=ygUQI3VsdHJhY2FwYWNpdG9ycw%3D%3D
2. https://www.youtube.com/watch?v=Rt83bYHjimQ
3. https://www.youtube.com/watch?v=m8L-B4A75Ec

Semester - II

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)

SEMESTER - II

During Second Semester Students can select any one of the following Courses.

1. Internship

2. Project with Viva Voce

SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - II
CORE COURSE - VI: INTERNSHIP (24PDPHJ21)
(From 2024-2025 Batch onwards)

		INT. MARKS	**: 25**
CREDITS	**: 16**	**EXT. MARKS**	**: 75**
DURATION	**: 90 Days**	**MAX. MARKS**	**: 100**

Course Objectives

- To learn and develop new skills relevant to the field of study or career interests.
- To understand different departments, roles, and functions within the organization to broaden knowledge and explore potential career paths.
- To apply the knowledge gained in academic studies to real-world scenarios.
- To bridge the gap between classroom learning and professional life.
- To gain exposure to different tasks, projects, and challenges relevant to the chosen field.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K2]: identify different career paths within the industry and gain insights into potential future roles

CO2[K3]: apply theoretical concepts and academic knowledge to real-world situations and challenges encountered during the internship

CO3[K4]: analyse problems, generate innovative solutions, and make informed decisions

CO4[K5]: evaluate how to manage time effectively and prioritize tasks to meet deadlines and deliver quality work

CO5[K6]: create a portfolio of the work, projects and achievements during the internship

CO-PO Mapping table (Course Articulation Matrix)

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K2]	3	2	1	2	-	1	1
CO2 [K3]	3	2	2	2	1	1	2
CO3 [K4]	2	2	2	2	1	1	1
CO4 [K5]	2	2	3	2	1	1	1
CO5 [K6]	2	3	3	2	1	1	2
Weightage of the course	12	11	11	10	4	5	7
Weighted percentage of Course contribution to POs	**15.38**	**15.28**	**17.19**	**22.22**	**11.43**	**12.82**	**18.42**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

Rules and Regulations

1. Each Student should undergo 90 days of institutional/industry based training during the second semester.

2. Internships could be undertaken in different relevant high standard organizations, industries and educational institutions which should be approved by the department.

3. Students should keep a detailed record of activities performed and hours spent in training and report the same to the Faculty Coordinator/Mentor/Guide regularly about the progress of internship on weekly basis.

4. At the end of the internship, the student must submit a full-fledged detailed internship report (not exceeding 40 pages) along with attendance certificate

5. The Internship carries 100 marks out of which 25 marks for Internal and 75 Marks for External.

6. The viva voce board shall consist of the Head of the Department and the Internal Examiner (Senior Faculty member).

7. The training programme shall be evaluated as per the following pattern

The following rubrics will be taken into account for the evaluation of the Training Programme:

Internal Assessment (25 Marks)		**External Examination (75 Marks)**	
Training Report & Review	: 20 Marks	Training Report	: 25 Marks
Daily Log Report/Attendance	: 5 Marks	Viva Voce	: 50 Marks

EACH INTERNSHIP REPORT WILL FOLLOW THE FORMAT DESCRIBED:

- Title Page
- College Certificate Page
- Internship Certificate provided by the internship institution
- Declaration Page
- Acknowledgement
- Company Profile
- Organizational structure of the concern
- Weekly work plan
- List of figures, List of Tables
- Index
- Chapters

List of Chapters

1. Introduction
2. Nature of work
3. Role in the organization
4. Questionnaires and Observations about work
5. Operating Environment
6. Detailed Description of Technology used
7. Implementation
8. Conclusion
9. Appendix

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SRI KALISWARI COLLEGE (AUTONOMOUS), SIVAKASI
DEPARTMENT OF PHYSICS
PG Diploma Course on Energy Storage and Conversion Technology
(Battery, Supercapacitor and Fuel Cell)
SEMESTER - II
CORE COURSE - VI: PROJECT WITH VIVA VOCE (24PDPHJ22)
(From 2024-2025 Batch onwards)

		INT. MARKS	**: 25**
CREDITS	**: 16**	**EXT. MARKS**	**: 75**
DURATION	**: 90 Days**	**MAX. MARKS**	**: 100**

Course Objectives

- To familiarize the learners with the objectives and stages in formulating a research project.
- To relate conceptual knowledge and the fundamentals of the research.
- To apply fundamental and disciplinary concepts and methods in ways appropriate to their principal areas of study.
- To develop the art of writing the project report coherently, originally and analytically.

Course Outcomes (CO)

On successful completion of the course, the learners will be able to

CO1[K2]: demonstrate the physical, chemical and mathematical treatments of project work

CO2[K3]: present the procedure adopted in the project work

CO3[K4]: analyze the project work qualitatively and quantitatively

CO4[K5]: justify the benefits of the project work to the society

CO5[K6]: develop new plans for advanced applications of the project work

CO-PO Mapping table (Course Articulation Matrix)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1 [K2]	3	2	1	2	-	1	1
CO2 [K3]	3	2	2	2	1	1	2
CO3 [K4]	2	2	2	2	1	1	1
CO4 [K5]	2	2	3	2	1	1	1
CO5 [K6]	2	3	3	2	1	1	2
Weightage of the course	12	11	11	10	4	5	7
Weighted percentage of Course contribution to POs	**15.38**	**15.28**	**17.19**	**22.22**	**11.43**	**12.82**	**18.42**

Based on the level of contribution ('3'-High, '2'-Medium, '1'-Low ,'-' No Correlation)

Guidelines for Project Submission

1. Students will work individually on a semester-long project. The student will work under a faculty member as the research guide at our college / university / industry. Our college Faculty member will be internal mentor, if faculty of other university / industry is chosen as research guide.
2. Depending on the interest of the students, project titles will be chosen.
3. Students must meet the internal mentor periodically.
4. The project report should be of minimum 50 pages (excluding bibliography & appendices)
5. The project carries 100 marks of which 25 marks for Internal Assessment and 75 Marks for External Examination.
6. Each student must either present paper or participate in National/International Conferences/Seminars related to his Project work.
7. There will be two project review sessions.
8. A draft of the final project report should be submitted to the Project Guide for review at least two weeks prior to the end of the semester.
9. Three copies of the final project report in hard copy should be submitted along with the soft copy.
10. The Head of the department and the Project Guide will evaluate the final Project Report.
11. The viva-voce board shall consist of the External Examiner, the Head of the Department and the Internal Examiner/Mentor.

The following rubrics will be taken into account for the evaluation of Project work and viva-voce:

Internal Assessment (25 Marks)		**External Examination (75 Marks)**	
Project Report & Review	: 20 Marks	Project Report	: 25 Marks
Demo/Performance	: 5 Marks	Viva Voce	: 50 Marks

Text Format in the report: Times New Roman 12 with 1.5 line Margins 1.5" left and 1" all other