Programme Structure

B.Sc. Honours/ (Honours with research) in Physics

Programme Code: SBR0203

Batch: 2023-27

Department of Physics

Sharda School of Basic Sciences & Research

Programme Structure

B.Sc. Honours/ (Honours with research) in Physics

B.Sc. Honours/ (Honours with research) in Physics with Minor in Computational Physics

B.Sc. Honours/ (Honours with research) in Physics with Minor in Renewable Energy

Programme Structure
Department of Physics
B.Sc. Honours/Honours with Research in Physics

		Subject 1	Subject 2	Subject 3		Subject 4	Vocational	Compulsory Co-curricular	Industrial Training/ Survey/ Research Project	[Minimum Credit} For the year	{Cummulative Minimum Credits} Required for Award of Certificate/ Diploma/ Degree
		Major	Major	Major		OE	SEC	AEC	VAC		
		CC	CC	DSE		Minor/ Elective	Minor	Minor	Major		
		Credits 4/5	Credits 4	Credits 3/4/5	Project	Credits 3/4	Credits 3	Credits 2	2/3/9 Credits		
Year	Sem.	own Faculty	Own Faculty	Any Faculty		Other Department / Faculty	Vocational/ Skill Development Course	Co-Curricular Course (Qualifying)	Inter/ Intra Faculty related to main Subject		
1	I	Mechanics and properties of matter (4) + **LAB**: Mechanical Properties of Matter (1)		Mathematical Physics-I (4)		Ecology and Ecosystem (3)	Vocational course in Electronics (3)	Communicative English – I (2)	Environment management (3)	40	{40} Certificate in Physics
	II	Optics (4) + **LAB**: Optics and Thermal Physics (1)	**Thermal Physics (4)**			Mathematical Expectations and Probability Distribution (3)	Fundamentals of Physical and geometrical optics for eye and vision (3)	Communicative English-II (2)	Yoga for Holistic health (3)		
2	III	Electricity and Magnetism (4) + Lab (Demonstrative Aspects of Electricity and Magnetism (1)	Solid State Physics (4)	Mathematical Physics –II (4) (Minor)	RBL –I (0)	Descriptive Statistics(3)	Nano-materials Technology and Hands on Training (3)	Logical Skills and Building Soft skills (2)		40	{80} Diploma in Physics
	IV	Electromagnetic Theory (4) + **LAB:** Modern Physics Lab (1)	Quantum Mechanics (4)	Analog Electronic Devices (3) + Basic Electronics Instrumentation Lab (2) (Minor)	RBL -2 (0)	Air Pollution and Technologies (3)		Campus to Corporate (2)			

Summer Internship (If the student is exiting the programme after Ist year/IInd year)						Vocational course in Computation on physics using Sci Lab (4)			4		
3	V	Classical Mechanics and Relativity (5)+ Oscillations and Waves (3) + Lab (Oscillations and waves lab) (2)	Numerical Analysis + Lab (NA) (3+1)	Instrumentation (3)	RBL-3 (1)				Industry Connect (2)	40	**(120)** B.Sc. In Physics
	VI	Atomic and Molecular Physics (5) + Nuclear Physics(5)	(Statistical Mechanics) (4)		RBL-4 (1)	Multivariate data Analysis (3)			Community Connect (2)		
4	VII	Advanced Quantum Mechanics (4)	Advanced Solid State Physics(4)	Research methodology (4) + Nanomaterials (4)		Solid Waste Management (4)			Project (3)	40	**(160)** Bachelor (Honours with Research) in Physics
	VIII			Characterisation Techniques (4)		Environmental Impact and Risk Assessment (4)			Project (9)		
	VII	Advanced Quantum Mechanics (4)	Advanced Solid State Physics(4)	Research methodology (4) (CC) + Nanomaterials (4)(CC)		Solid Waste Management (4)				40	160 Bachelor (Honours) in Physics
	VIII	Advanced Classical Mechanics+ Advanced Electronic Devices	Advanced Mathematical Physics (4)	Characterisation Techniques (4) (CC)		Environmental Impact and Risk Assessment (4)					

Programme Structure
Sharda School of Basic Sciences & Research
Certificate in Physics

Batch: 2023-2027
SEMESTER: I

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite/Core/Elective	Type of Course
			L	T	P			
		THEORY COURSES						
1.	PHS101	Mechanics & properties of matter	4	0	0	4	Pre-Requisite	CC
2.	PHS102	Mathematical Physics-I	4	0	0	4	Pre-Requisite	DSE
3.	BEN102	Ecology and Ecosystem	3	0	0	3	Elective	OE
4.	ARP101	Communicative English I	1	0	2	2	Co-requisite	AEC
		PRACTICAL						
5.	VOP101	Vocational course in Electronics	0	0	5	3	Pre-Requisite	SEC
6.	VAC103	Environment management	3	0	0	3	Pre-Requisite	VAC
7.	PHS151	Physics Lab-I Mechanical Properties of matter	0	0	2	1	Pre-Requisite	CC
TOTAL CREDITS						**20**		

Programme Structure
Sharda School of Basic Sciences & Research
Certificate in Physics

Batch: 2023-2027
SEMESTER: II

S.No.	SU Subject	Paper Id	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite /Core /Elective	Type of Course
				L	T	P			
1.	PHS103		Optics	4	0	0	4	Core	CC
2.	PHS104		Thermal Physics	4	0	0	4	Core	CC
3.	CMS132		Mathematical Expectation and Probability Distribution	3	0	0	3	Minor/Elective	OE
4.	ARP102		Communicative English -2	1	0	2	2	Co-requisite	AEC
5.	VAC110		Yoga for Holistic health	0	1	4	3	Co Requisite	VAC
6.	VOP102		Fundamentals of Physical and Geometrical optics for eye and vision	0	0	5	3	Co-requisite	SEC
7.	PHS152		Physics lab-2 (Optics & Thermal Physics Lab)	0	0	2	1	Co-requisite	CC
20									

CREDIT: 40

Programme Structure
Sharda School of Basic Sciences & Research
Diploma in Physics

Batch: 2023-2027
SEMESTER: III

S.No.	SU Subject Code	Paper Id	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite /	Type of Course
				L	T	P			
		THEORY SUBJECTS							
1.	PHS201	Electricity and Magnetism		4	0	0	4	Core	CC
2.	PHS202	Solid State Physics		4	0	0	4	Core	CC
3.	PHS203	Mathematical Physics-II		4	0	0	4	Minor	DSE
4.	CMS102	Descriptive Statistics		3	0	0	3	Minor	OE
5.	ARP207	Logical Skills and Building Soft Skills		0	1	2	2	Co Requisite	AEC
		Practical							
6.	VOP201	Nano-materials Technology and Hands on Training (SEC)		0	0	5	3	Co-requisite	SEC
7.	PHS251	Physics Lab-3 Demonstrative Aspects of Electricity and magnetism		0	0	2	1	Co-requisite	CC
8.	RBL001	Research Based Learning-1 (RBL1)		0	0	4	0	Co Requisite	Project
TOTAL CREDITS							**21**		

Programme Structure
Sharda School of Basic Sciences & Research
Diploma in Physics

Batch: 2023-2027
SEMESTER: IV

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS204	Electromagnetic Theory	4	0	0	4	**Pre-Requisite**	CC
2.	PHS205	Quantum Mechanics	4	0	0	4	**Pre-Requisite**	CC
3.	PHS206	Analog Electronic Devices	3	0	0	3	**Pre-Requisite**	Minor
4.	BEN205	Air Pollution and Technologies	3	0	0	3	Minor	OE
5.	ARP306	Campus to Corporate	0	1	2	2	**Co Requisite**	AEC
		Practical						
6.	PHS252	Physics lab 4 Modern Physics lab	0	0	2	1	**Co Requisite**	CC
7.	PHS253	Physics lab 5 Basic Electronics Instumentation Lab	0	0	4	2	**Co Requisite**	DSE
8.	RBL002	Research Based Learning 2	0	0	4	0	**Co Requisite**	Project
TOTAL CREDITS						**19**		

CREDIT: 80

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. in Physics

Batch: 2023-2027
SEMESTER: V

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS301	Classical Mechanics and Relativity	5	0	0	5	Pre-Requisite	CC
2.	PHS302	Oscillations and waves	3	0	0	3	Pre-Requisite	CC
3.	PHS303	Numerical Analysis	3	0	0	3	Pre-Requisite	CC
4.	PHS304	Instrumentation	3	0	0	3	Co-requisite	DSE
		Practical						
5.	PHS351	Physics lab-6 (Oscillations and waves)	0	0	4	2	Co-requisite	CC
6.	PHS352	Physics lab -7 (NA)	0	0	2	1	Co-requisite	CC
7.	INC001	Industry Connect	0	0	2	2	Co-Requisite	Survey/Audit
8.	RBL003	Research Based Learning-3 (RBL3) Project	0	0	4	1	Co-requisite	Training/Survey/Project
TOTAL CREDITS						**20**		

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. in Physics

Batch: 2023-27
SEMESTER: VI

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS305	Atomic & molecular physics	5	0	0	5	Pre-Requisite	CC
2.	PHS306	Nuclear Physics	5	0	0	5	Pre-Requisite	CC
3.	PHS307	Statistical Mechanics	4	0	0	4	Pre-Requisite	CC
4.	BDA323	Multivariate Data Analysis	3	0	0	3	Minor	OE
		Practical						
5.	CCU108	Community connect	0	0	4	2	Co-requisite	Project
6.	RBL004	Research Based Learning-4 (RBL-4) Project	0	0	2	1	Co-requisite	Project
TOTAL CREDITS						**20**		

CREDIT: 120

Programme Structure
School School of Basic Sciences & Research
B.Sc. (Honours with Research) in Physics

Batch: 2023-27
SEMESTER: VII

S.No	SU Subject Code	Paper Id	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite/Core/Minor	Type of Course
				L	T	P			
		THEORY SUBJECTS							
1.	PHS401		Advanced Quantum Mechanics	4	0	0	4	Pre-requisite	CC
2.	PHS402		Advanced Solid State Physics	4	0	0	4	Pre-requisite	CC
3.	PHS403		Research Methodology	4	0	0	4	Pre-requisite	CC
4.	PHS404		Nanomaterials	4	0	0	4	Pre-requisite	CC
5.	BEN404		Solid Waste Management	4	0	0	4	Minor	OE
		Practical							
6.	PHS451		Project	0	0	5	3	Co-requisite	Project
TOTAL CREDITS							**23**		

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Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours with Research) in Physics

Batch: 2023-27
SEMESTER: VIII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS405	Characterization Techniques	4	0	0	4	Pre-requisite	DSE
2.	BEN405	Environmental Impact and Risk Assessment	4	0	0	4	Minor	OE
		Practical						
3.	PHS452	Project	0	0	18	9	Co-requisite	Survey
TOTAL CREDITS						**17**		

CREDIT: 160

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours) in Physics

Batch: 2023-27
SEMESTER: VII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1	PHS401	Advanced Quantum Mechanics	4	0	0	4	**Pre-Requisite**	CC
2	PHS402	Advanced Solid State Physics	4	0	0	4	**Pre-Requisite**	CC
3	PHS403	Research Methodology	4	0	0	4	**Pre-Requisite**	CC
4	PHS404	Nanomaterials	4	0	0	4	**Pre-Requisite**	CC
5	PHR401	Solid waste management	4	0	0	4	**Minor**	OE
TOTAL CREDITS						**20**		

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Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. Honours in Physics
Batch: 2023-27
SEMESTER: VIII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1	PHS406	Advanced Classical Mechanics	4	0	0	4	**Pre-Requisite**	CC
2	PHS407	Advanced Electronic Devices	4	0	0	4	**Pre-Requisite**	CC
3	PHS408	Advanced Mathematical Physics	4	0	0	4	**Pre-Requisite**	CC
4	PHS405	Characterization Techniques	4	0	0	4	**Pre-Requisite**	CC
5	BEN405	Environmental Impact and Risk Assessment	4	0	0	4	**Minor**	OE
		Practical						
TOTAL CREDITS						**20**		

CREDIT: 160

Programme Structure
Department of Physics
B.Sc. (Honours/Honours with Research) in Physics with Minor in Computational Physics

		Subject 1	Subject 2	Subject 3		Subject 4	Vocational	Compulsory Co-curricular	Industrial Training/ Survey/ Research Project	[Minimum Credit} For the year	{Cummulative Minimum Credits} Required for Award of Certificate/ Diploma/ Degree
		Major	Major	Major		OE	SEC	AEC	VAC		
		CC	CC	DSE		Minor/ Elective	Minor	Minor	Major		
		Credits 4/5	Credits 4	Credits 3/4/5	Project	Credits 3/4	Credits 3	Credits 2	2/3/9 Credits		
Year	Sem.	own Faculty	O w n Faculty	Any Faculty		Other Department/ Faculty	Vocational/ Skill Development Course	Co-Curricular Course (Qualifying)	Inter/ Intra Faculty related to main Subject		
1	I	Mechanics and properties of matter (4) + **LAB**: Mechanical Properties of Matter (1)		**Mathematical Physics-I (4)**		Ecology and ecosystem (3)	Vocational course in Electronics (3)	Communicative English – I (2)	Environment management (3)	40	{40} Certificate in Physics
	II	Optics (4) + **LAB**: Optics and Thermal Physics (1)	**Thermal Physics (4)**			**Python for Computational Physics (3)**	Fundamentals of Physical and geometrical optics for eye and vision (3)	Communicative English-II (2)	Yoga for Holistic health (3)		
2	III	Electricity and Magnetism (4) + Lab (Demonstrative Aspects of Electricity and Magnetism (1)	Solid State Physics (4)	**Mathematical Physics – II (4) (Minor)**	RBL –I (0)	**AI and ML in Physics using Python (3)**	Nano-materials Technology and Hands on Training (3)	Logical Skills and Building Soft skills (2)		40	{80} Diploma in Physics
	IV	Electromagnetic Theory (4) + **LAB:** Modern Physics Lab (1)	Quantum Mechanics (4)	Analog Electronic Devices (3)(Minor) + Basic Electronics Lab (2)	RBL -2 (0)	**DFT Analysis (3)**		Campus to Corporate (2)			
3	V	Classical Mechanics and Relativity (5)+ Oscillations and Waves (3) + Lab (Oscillations and waves lab) (2)	Numerical Analysis + Lab (NA) (3+1)	Instrumentation (3)	RBL-3 (1)				Industry Connect (2)	40	**(120)** Bachelor In Physics With Minor In Computational Physics

4	VI	Atomic and Molecular Physics (5) + Nuclear Physics(5)	(Statistical Mechanics) (4)		RBL-4 (1)	**Finite Element Analysis (3)**			Community Connect (2)		**(160)**
	VII	Advanced Quantum Mechanics (4)	Advanced Solid State Physics(4)	Research methodology (4) (CC) + Nanomaterials (4)		**Molecular Dynamics(4)**			Project (3)	40	B.Sc.(Honours with Research) in Physics with minor in Computational Physics
	VIII			Characterisation Techniques (4) (CC)		Environmental Impact and Risk Assessment **(4)**			Project (9)		
	VII	Advanced Quantum Mechanics (4)	Advanced Solid State Physics(4)	Research methodology (4)(CC) + Nanomaterials (4)(CC)		Molecular Dynamics(4)				40	160 B.Sc. (Honours) in Physics with minor in Computational Physics
	VIII	Advanced Classical Mechanics+ Advanced Electronic Devices	Advanced Mathematical Physics (4)	Characterisation Techniques (4)(CC)		Environmental Impact and Risk Assessment (4)					

Programme Structure
Sharda School of Basic Sciences & Research
Certificate in Physics

Batch: 2023-2027
SEMESTER: I

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS101	Mechanics & properties of matter	4	0	0	4	Pre-Requisite	CC
2.	PHS102	Mathematical Physics-I	4	0	0	4	Pre-Requisite	DSE
3.	BEN102	Ecology and Ecosystem	3	0	0	3	Minor	OE
4.	ARP101	Communicative English I	1	0	2	2	Pre-Requisite	AEC
		Practical						
5.	VOP101	Vocational course in Electronics	0	0	5	3	Co Requisite	SEC
6.	VAC103	Environment management	3	0	0	3	Pre-Requisite	VAC
7.	PHS151	Physics lab-1 Mechanical Properties of matter	0	0	2	1	Co Requisite	CC
TOTAL CREDITS						**20**		

Programme Structure
Sharda School of Basic Sciences & Research
Certificate in Physics

Batch: 2023-2027
SEMESTER: II

S.No.	SU Subject	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
1.	PHS103	Optics	4	0	0	4	Pre-Requisite	CC
2.	PHS104	Thermal Physics	4	0	0	4	Pre-Requisite	CC
3.	ARP102	Communicative English -2	1	0	0	2	Pre-Requisite	AEC
4.	VAC110	Yoga for Holistic health	0	1	4	3	Co Requisite	VAC
5.	PHC101	Python for Computational Physics	0	0	5	3	Minor	OE
6.	VOP102	Fundamentals of Physical and Geometrical optics for eye and vision	0	0	5	3	Co Requisite	SEC
7.	PHS152	Physics lab-2 (Optics & Thermal Physics Lab)	0	0	2	1	Co Requisite	CC
						20		

CREDIT: 40

Programme Structure
Sharda School of Basic Sciences & Research
Diploma in Physics

Batch: 2023-2027
SEMESTER: III

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS201	Electricity and Magnetism	4	0	0	4	Pre-Requisite	CC
2.	PHS202	Solid State Physics	4	0	0	4	Pre-Requisite	CC
3.	PHS203	Mathematical Physics-II	4	0	0	4	Pre-Requisite	Minor
4.	PHC201	AI and ML in Physics using Python	3	0	0	3	Minor	OE
5.	ARP207	Logical Skills and Building Soft Skills	0	1	2	2	Co-requisite	AEC
		Practical						
6.	VOP201	Nano-materials Technology and Hands on Training (SEC)	0	0	5	3	Co-requisite	SEC
7.	PHS251	Physics Lab 3-Demonstrative Aspects of Electricity and magnetism	0	0	2	1	Co-requisite	CC
8.	RBL001	Research Based Learning-1 (RBL1)	0	0	4	0	Co-requisite	Project
TOTAL CREDITS						**21**		

Programme Structure
Sharda School of Basic Sciences & Research
Diploma in Physics

Batch: 2023-2027
SEMESTER: IV

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS204	Electromagnetic Theory	4	0	0	4	Pre-Requisite	CC
2.	PHS205	Quantum Mechanics	4	0	0	4	Pre-Requisite	CC
3.	PHS206	Analog Electronic Devices	3	0	0	3	Pre-Requisite	Minor
4.	PHC202	DFT Analysis	3	0	0	3	Minor	Minor
5.	ARP306	Campus to Corporate	0	1	2	2	Co-requisite	AEC
		Practical						
6.	PHS252	Physics lab 4-Modern Physics Lab	0	0	2	1	Co-requisite	CC
7.	PHS253	Physics lab 5 Basic Electronics Instrumentation Lab	0	0	4	2	Co-requisite	Minor
8.	RBL002	Research Based Learning 2	0	0	4	0	Co-requisite	Project
TOTAL CREDITS						**19**		

CREDIT: 80

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. in Physics with Minor in Computational Physics

Batch: 2023-2027
SEMESTER: V

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite /Core/Elective	Type of Course
			L	T	P			
1.	PHS301	Classical Mechanics and Relativity	5	0	0	5	Pre-Requisite	CC
2.	PHS302	Oscillations and waves	3	0	0	3	Pre-Requisite	CC
3.	PHS303	Numerical Analysis	3	0	0	3	Pre-Requisite	CC
4.	PHS304	Instrumentation	3	0	0	3	Pre-Requisite	DSE
5.		**PRACTICAL**						
6.	PHS351	Physics lab 6 (Oscillations and waves)	0	0	4	2	Co-requisite	CC
7.	PHS352	Physics lab 7 (NA)	0	0	2	1	Co-requisite	CC
8.	INC001	Industry Connect	0	0	2	2	Co-Requisite	Survey/Audit
9.	RBL003	Research Based Learning-3 (RBL3) Project	0	0	4	1	Co-Requisite	Training/Survey/Project
	Credits : 20							

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. in Physics with Minor in Computational Physics

Batch: 2023-27
SEMESTER: VI

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1	PHS305	Atomic & molecular physics	5	0	0	5	Pre-Requisite	CC
2	PHS306	Nuclear Physics	5	0	0	5	Pre-Requisite	CC
3	PHS307	Statistical Mechanics	4	0	0	4	Pre-Requisite	CC
4	PHS301	Finite Element Analysis	3	0	0	3	Minor	OE
6	CCU108	Community connect	0	0	4	2	Co-Requisite	Project/Survey
7.	RBL004	Research Based Learning-4 (RBL-4) Project	0	0	2	1	Co-Requisite	Project
TOTAL CREDITS						**20**		

CREDIT: 120

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours with Research) in Physics with Minor in Computational Physics

Batch: 2023-27
SEMESTER: VII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS401	Advanced Quantum Mechanics	4	0	0	4	**Pre-Requisite**	CC
2.	PHS402	Advanced Solid State Physics	4	0	0	4	**Pre-Requisite**	CC
3.	PHS403	Research Methodology	4	0	0	4	**Pre-Requisite**	DSE
4.	PHS404	Nanomaterials	4	0	0	4	**Pre-Requisite**	DSE
5.	PHC401	Molecular Dynamics	4	0	0	4	**Minor**	OE
		Practical						
6.	PHS451	Project	0	0	5	3	**Co-requisite**	Survey
TOTAL CREDITS						**23**		

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Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours with Research) in Physics with Minor in Computational Physics

Batch: 2023-27
SEMESTER: VIII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1	PHS405	Characterization Techniques	4	0	0	4	Pre-Requisite	DSE
2	BEN405	Environmental Impact and Risk Assessment	4	0	0	4	Minor	OE
		Practical						
3	PHS452	Project	0	0	18	9	Co-requisite	Project
TOTAL CREDITS						**17**		

CREDIT: 160

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours) in Physics with Minor in Computational Physics

Batch: 2023-27
SEMESTER: VII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1	PHS401	Advanced Quantum Mechanics	4	0	0	4	Quantum Mechanics	CC
2	PHS402	Advanced Solid State Physics	4	0	0	4	Solid State Physics	CC
3	PHS403	Research Methodology	4	0	0	4	-	CC
4	PHS404	Nanomaterials	4	0	0	4	-	CC
5	PHC401	Molecular Dynamics	4	0	0	4	-	OE
TOTAL CREDITS						**20**		

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Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours in Physics) with Minor in Computational Physics

Batch: 2023-27
SEMESTER: VIII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1	PHS406	Advanced Classical Mechanics	4	0	0	4	Pre-requisite	CC
2	PHS407	Advanced Electronic Devices	4	0	0	4	Pre-requisite	CC
3	PHS408	Advanced Mathematical Physics	4	0	0	4	Pre-requisite	CC
4	PHS405	Characterization Techniques	4	0	0	4	Pre-requisite	CC
5	BEN405	Environmental Impact and Risk Assessment	4	0	0	4	Minor	OE
TOTAL CREDITS						**20**		

CREDIT: 160

Programme Structure
Department of Physics
B.Sc. Honours/Honours with Research in Physics with Minor in Renewable Energy

		Subject 1	Subject 2	Subject 3		Subject 4	Vocational	Compulsory Co-curricular	Industrial Training/ Survey/ Research Project	[Minimum Credit} For the year	{Cummulative Minimum Credits} Required for Award of Certificate/ Diploma/ Degree
		Major	Major	Major		OE	SEC	AEC	VAC		
		CC	CC	DSE		Minor/ Elective	Minor	Minor	Major		
		Credits 4/5	Credits 4	Credits 3/4/5	Project	Credits 3/4	Credits 3	Credits 2	2/3/9 Credits		
Year	Sem.	own Faculty	Own Faculty	Any Faculty		Other Department/ Faculty	Vocational/ Skill Development Course	Co-Curricular Course (Qualifying)	Inter/ Intra Faculty related to main Subject		
1	I	Mechanics and properties of matter (4) + **LAB**: Mechanical Properties of Matter (1)		**Mathematical Physics-I (4)**		Ecology and Ecosystem (3)	Vocational course in Electronics (3)	Communicative English –I (2)	Environment management (3)	40	{40} Certificate in Physics
	II	Optics (4) + **LAB**: Optics and Thermal Physics (1)	**Thermal Physics (4)**			**Introduction to Renewable Energy and Management (3)**	Fundamentals of Physical and geometrical optics for eye and vision (3)	Communicative English-II (2)	Yoga for Holistic health (3)		
2	III	Electricity and Magnetism (4) + Lab (Demonstrative Aspecst of Electricity and Magnetism (1)	Solid State Physics (4)	**Mathematical Physics –II (4) (Minor)**	RBL –I (0)	**Renewable energy resources (3)**	Nano-materials Technology and Hands on Training (3)	Logical Skills and Building Soft skills (2)		40	{80} Diploma in Physics
	IV	Electromagnetic Theory (4) + **LAB:** Modern Physics Lab (1)	Quantum Mechanics (4)	Analog Electronic Devices (3) + Basic Electronics Lab (2) (Minor)	RBL -2 (0)	**Photovoltaics (3)**		Campus to Corporate (2)			
3	V	Classical Mechanics and Relativity (5)+	Numerical Analysis + Lab (NA) (3+1)	Instrumentation (3)	RBL-3 (1)				Industry Connect (2)		**(120)** B.Sc. In Physics With

4		Oscillations and Waves (3) + Lab (Oscillations and waves lab) (2)								40	Minor In Renewable Energy
	VI	Atomic and Molecular Physics (5) + Nuclear Physics(5)	(Statistical Mechanics) (4)		RBL-4 (1)	**Biomass Energy(3)**			Community Connect (2)		
	VII	Advanced Quantum Mechanics (4)	Advanced Solid State Physics(4)	Research methodology (4) + Nanomaterials (4)		**Nanogenerators(4)**			Project (3)		**(160)**
	VIII			Characterisation Techniques (4)		**Environment Impact and risk Assessment (4)**			Project (9)	40	B.Sc.(Honours) with Research) in Physics
4	VII	Advanced Quantum Mechanics (4)	Advanced Solid State Physics(4)	Research methodology (4)(CC) + Nanomaterials (4)(CC)		**Nanogenerators(** (4)					160
	VIII	VIII	Advanced Classical Mechanics+ Advanced Electronic Devic	Advanced Mathematical Physics (4) (CC)	Characterisation Techniques (4) (CC)	**Environment Impact and risk Assessment(4)**				40	B.Sc (Honours) in Physics

Programme Structure
Sharda School of Basic Sciences & Research
Certificate in Physics

Batch: 2023-2027
SEMESTER: I

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS101	Mechanics & properties of matter	4	0	0	4	Pre-Requisite	CC
2.	PHS102	Mathematical Physics-I	4	0	0	4	Pre-Requisite	DSE
3.	BEN102	Ecology and ecosystem	3	0	0	3	Minor	OE
4.	ARP101	Communicative English I	1	0	2	2	Pre-Requisite	AEC
		Practical						
5.	VOP101	Vocational course in Electronics	0	0	5	3	Co-Requisite	SEC
6.	VAC103	Environment management	3	0	0	3	Pre-Requisite	VAC
7.	PHS151	Physics lab-1 Mechanical properties of matter	0	0	2	1	Co-Requisite	CC
TOTAL CREDITS						**20**		

Programme Structure
Sharda School of Basic Sciences & Research
Certificate in Physics

Batch: 2023-2027
SEMESTER: II

S.No.	SU Subject	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
1.	PHS103	Optics	4	0	0	4	**Pre-Requisite**	CC
2.	PHS104	Thermal Physics	4	0	0	4	**Pre-Requisite**	CC
3.	PHR101	Introduction to Renewable energy and management	3	0	0	3	**Minor**	OE
4	ARP102	Communicative English -2	1	0	2	2	**Co-requisite**	AEC
5.	VAC110	Yoga for Holistic health	0	1	4	3	Co Requisite	VAC
6.	VOP102	Fundamentals of Physical and geometrical optics for eye and vision	0	0	5	3	**Co-requisite**	SEC
7.	PHS152	Physics lab-2 (Optics & Thermal Physics Lab)	0	0	2	1	**Co-requisite**	CC
						20		

CREDIT: 40

Programme Structure
Sharda School of Basic Sciences & Research
Diploma in Physics

Batch: 2023-2027
SEMESTER: III

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS201	Electricity and Magnetism	4	0	0	4	Pre-Requisite	CC
2.	PHS202	Solid State Physics	4	0	0	4	Pre-Requisite	CC
3.	PHS203	Mathematical Physics-II	4	0	0	4	Pre-Requisite	DSE
4.	PHR201	Renewable Energy Resources	3	0	0	3	Minor	OE
5.	ARP207	Logical Skills and Building Soft Skills	0	1	2	2	Pre-Requisite	AEC
		Practical						
6.	VOP201	Nano-materials Technology and Hands on Training (SEC)	0	0	5	3	Co-requisite	Vocational SEC
7.	PHS251	Physics Lab-3 Demonstrative Aspects of Electricity and magnetism	0	0	2	1	Co-requisite	CC
8.	RBL001	Research Based Learning-1 (RBL1)	0	0	4	0	Co-requisite	Project
TOTAL CREDITS						**21**		

Programme Structure
Sharda School of Basic Sciences & Research
Diploma in Physics

Batch: 2023-2027
SEMESTER: IV

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS204	Electromagnetic Theory	4	0	0	4	Pre-Requisite	CC
2.	PHS205	Quantum Mechanics	4	0	0	4	Pre-Requisite	CC
3.	PHS206	Analog Electronic Devices	3	0	0	3	Pre-Requisite	DSE
4.	PHR202	Photovoltaics	3	0	0	3	Minor	OE
5.	ARP306	Campus to Corporate	0	1	2	2	Co-requisite	AEC
		Practical						
6.	PHS252	Physics lab 4- Modern Physics Lab	0	0	2	1	Co-requisite	CC
7.	PHS253	Physics lab 5- Basic Electronics Instrumentation Lab	0	0	4	2	Co-requisite	DSE
8.	RBL002	Research Based Learning 2	0	0	4	0	Co-requisite	Project
TOTAL CREDITS						**19**		

CREDIT: 80

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. in Physics with Minor in Renewable Energy

Batch: 2023-2027
SEMESTER: V

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS301	Classical Mechanics and Relativity	5	0	0	5	Pre-Requisite	CC
2.	PHS302	Oscillations and waves	3	0	0	3	Pre-Requisite	CC
3.	PHS303	Numerical Analysis	3	0	0	3	Pre-Requisite	CC
4.	PHS304	Instrumentation	3	0	0	3	Pre-Requisite	DSE
		Practical						
5.	PHS351	Physics lab -5 (Oscillations and waves)	0	0	4	2	Co-Requisite	CC
6.	PHS352	Physics lab -6 (NA)	0	0	2	1	Co-Requisite	CC
7.	INC001	Industry Connect	0	0	2	2	Co-Requisite	Survey/Audit
8.	RBL003	Research Based Learning-3 (RBL3) Project	0	0	4	1	Co-Requisite	Training/Survey/Project
TOTAL CREDITS						**20**		

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. in Physics with Minor in Renewable Energy

Batch: 2023-27
SEMESTER: VI

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1.	PHS305	Atomic & molecular physics	5	0	0	5	Pre-Requisite	CC
2.	PHS306	Nuclear Physics	5	0	0	5	Pre-Requisite	CC
3.	PHS307	Statistical Mechanics	4	0	0	4	Pre-Requisite	CC
4.	PHR301	Biomass Energy	3	0	0	3	Minor	OE
5.	CCU108	Community connect	0	0	4	2	Co-Requisite	Survey
6.	RBL004	Research Based Learning-4 (RBL-4) Project	0	0	2	1	Co-Requisite	Project
TOTAL CREDITS						**20**		

CREDIT: 120

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours with Research) in Physics with Minor in Renewable Energy

Batch: 2023-27
SEMESTER: VII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1.	PHS401	Advanced Quantum Mechanics	4	0	0	4	Pre-Requisite	CC
2.	PHS402	Advanced Solid State Physics	4	0	0	4	Pre-Requisite	CC
3.	PHS403	Research Methodology	4	0	0	4	Pre-Requisite	DSE
4.	PHS404	Nanomaterials	4	0	0	4	Pre-Requisite	DSE
5.	PHR405	Nanogenerators	4	0	0	4	Minor	OE
		Practical						
6.	PHS451	Project	0	0	5	3	Co-requisite	Project
TOTAL CREDITS						**23**		

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Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours with Research) in Physics with Minor in Renewable Energy

Batch: 2023-27
SEMESTER: VIII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course
			L	T	P			
		THEORY SUBJECTS						
1	PSC405	Characterization Techniques	4	0	0	4	Pre-requisite	DSE
2	BEN405	Environment Impact and risk Assessment	4	0	0	4	Minor	OE
		Practical						
3	PHS452	Project	0	0	18	9	Co-Requisite	Project
TOTAL CREDITS						**17**		

CREDIT: 160

Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. (Honours) in Physics with Minor in Renewable Energy

Batch: 2023-27
SEMESTER: VII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1	PHS401	Advanced Quantum Mechanics	4	0	0	4	Quantum Mechanics	CC
2	PHS402	Advanced Solid State Physics	4	0	0	4	Solid State Physics	CC
3	PHS403	Research Methodology	4	0	0	4	-	CC
4	PHS404	Nanomaterials	4	0	0	4	-	CC
5	PHR401	Nanogenerators	4	0	0	4	-	Minor
TOTAL CREDITS						**20**		

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Programme Structure
Sharda School of Basic Sciences & Research
B.Sc. Honours in Physics with Minor in Renewable Energy

Batch: 2023-27
SEMESTER: VIII

S.No.	SU Subject Code	Subjects	L - T - P			Credits	Pre-Requisite/Co Requisite	Type of Course:
			L	T	P			
		THEORY SUBJECTS						
1	PHS406	Advanced Classical Mechanics	4	0	0	4	Basic Classical Mechanics	CC
2	PHS407	Advanced Electronic Devices	4	0	0	4	Basic Electronics	CC
3	PHS408	Advanced Mathematical Physics	4	0	0	4	Basic Mathematical Physics	CC
4	PHS405	Characterization Techniques	4	0	0	4	-	DSE
5	BEN405	Environment Impact and risk Assessment	4	0	0	4	-	OE
		Practical						
TOTAL CREDITS						**20**		

CREDIT: 160

COURSE MODULES

FIRST YEAR

DETAILED SYLLABUS FOR

CERTIFICATE

IN

PHYSICS

SEMESTER I

PHS101 Mechanics and properties of matter

School: SSBSR		**Batch: 2023-27**	
Program: Certificate In Physics		**Current Academic Year: 2023-24**	
Branch: Physics		**Semester: I**	
1	Course Code	PHS101	
2	Course Title	Mechanics and properties of matter	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	1. To make the students familiar with use of vector algebra to study mechanics. 2. To understand and appreciate the rotational and harmonic motion. 3. To know the elasticity of matter and bending of beams in different situation. 4. To understand the concept surface tension and viscosity.	
6	Course Outcomes	After the completion of this course, the student will be able to **CO1:** understand the concept of motion, work, energy, momentum and frame of references **CO2:** appreciate real life applications of rotational mechanics and simple harmonic motion. **CO3:** use of moment of force and properties of matter to describe the elasticity and beam bending. **CO4:** understand the cause of capillarity, and surface tension and explain the of real life observations based on it **CO5:** understand the cause of viscosity and explain the real-life observations based on it. **CO6:** appreciate mechanics with vector algebra and can apply it on real life problems	
7	Course Description	This course is designed to make students proficient in mechanics, especially rotational mechanics with vector treatment. They also learn about certain properties of matter like elasticity, surface tension and viscosity.	
8	Outline syllabus		CO Mapping
	Unit 1	**Motion, Work, Energy and Momentum**	
	A	Review of Vector Algebra, Concept of work, power and energy; Law of conservation of energy; Conservative forces	CO1
	B	Conservation law of momentum; Centre of mass; Collision of bodies	CO1
	C	Centre of mass frame of reference, Laboratory frame of reference	CO1
	Unit 2	**Simple Harmonic Motion**	
	A	Equation of Simple Harmonic Motion; Energy of a Harmonic Oscillator. Compound Pendulum	CO2
	B	Rigid body-Translational and rotational Motion, angular momentum, torque; Moment of Inertia-Radius of gyration	CO2
	C	Parallel and perpendicular theorems of Moment of Inertia, moment of inertia of disk, sphere, and rectangular lamina	CO2
	Unit 3	**Elasticity & Bending of beams**	
	A	Hooke's Law, Stress - Strain Diagram - Elastic moduli - Relation between elastic constants	CO3

	B	Poisson's Ratio – Determination of Poisson's ratio; Work done per unit volume in a strain			CO3
	C	Bending of beam; Bending moment, Cantilever			CO3
	Unit 4	**Surface Tension**			
	A	Surface Tension: Definition and dimensions of surface tension; Excess of pressure over curved surfaces			CO4
	B	Application to spherical and cylindrical drops and bubbles			CO4, CO6
	C	Variation of Surface tension with temperature, Jaegar's method			CO4, CO6
	Unit 5	**Viscosity**			
	A	Streamline Flow; Bernoulli's Theorem; Co-efficient of viscosity and its dimensions			CO5, CO6
	B	Rate of flow of liquid in a capillary tube - Poiseuilles' formula			CO5, CO6
	C	Variation of viscosity of a liquid with temperature			CO5, CO6
	Mode of examination	Class test (10) ,Assignments (10) and presentation (10)			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Mechanics, D.S.Mathur, S.Chand & Co. (Text Book) 2. Properties of matter, D.S.Mathur, S.Chand & Co.			
	Other References	3. Berkeley Physics Course, Volume I, Mechanics,C. Kittel, W. D. Knight, M. A. Rudderman, A. C. Helmhotz and B. J. Moye; McGraw-Hill 4. Mechanics , H.S.Hans and S.P.Puri, Tata McGraw-Hill (2003) 5. Physics (5th Edn.) - Principles with applications, Douglas C. Giancoli, Prentice Hall. 6. Physics (5th Edn.), John D. Cutnell & Kenneth W. Johnson, John Willey & Sons, Inc.			

Course Articulation Matrix for Mechanics and properties of matter

COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	1	1	1	2	3	1	2	3	1	1
CO2	3	3	1	1	1	1	1	1	2	2	1	1	3	1	1
CO3	3	3	1	1	1	1	2	2	1	2	1	1	3	1	1
CO4	3	3	1	1	1	1	1	1	2	1	1	2	2	1	1
CO5	3	3	1	1	1	1	1	1	1	1	1	1	2	1	1
CO6	3	3	1	1	1	1	1	1	1	1	1	1	2	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS 102 Mathematical Physics-1

School: School of Basic Sciences and Research		**Batch: 2023-27**	
Program: Certificate In Physics		**Current Academic Year: 2023-2024**	
Branch: Physics		**Semester: I**	
1	Course Code	**PHS102**	
2	Course Title	**Mathematical Physics-1**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
5	Course Status	DSE	
8	Course Objective	**1.** The student should be able to understand basic theory of matrices. **2.** The student should be able to understand basic of operations of matrices. **3.** The student should be able to understand basic theory of Linear and inverse of matrices. **4.** The student should be able to understand basic theory of Cayley-Hamilton theorem, eigen vectors, eigen values and solution of equations.	
9	Course Outcomes	After successful completion of this course the students will/will be able to: **CO1:** Students will be having the knowledge of definition of different types matrices, Basic properties, addition & multiplication. **CO2:** Students will able to understand the concepts operations of matrices. **CO3:** Inverse of matrices, System of linear equations. **CO4:** Students will able to understand the Matrices and Linear equations. **CO5:** Students will be having the knowledge of Cayley-Hamilton theorem and knowledge of Evaluation of Eigen values & Eigen vectors. **CO6:** Apply various iterative method to find out eigen vectors, eigen values and solution of equations.	
10	Course Description	This course is designed to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.	
11	Outline syllabus		**CO Mapping**
	Unit 1	**Basic of Matrices**	
	A B C	Matrices; Special matrices; Review of basic properties of matrices- addition and multiplication of matrices; Null matrices	CO1
	Unit 2	**Operations of Matrices**	
	A B C	Diagonal, Scalar and Unit matrices; Orthogonal; Upper-triangular and Lower-triangular matrices; Conjugate of a matrix; Hermitian and Skew Hermitian Matrices;	CO2
	Unit 3	**Types of Matrices**	
	A B C	Unitary matrices; Singular and non-singular matrices. Inverse of a matrix- Adjoint of a matrix, Inverse of a matrix by adjoint method,	CO3
	Unit 4	**Matrices and Linear Equation**	
	A B C	Inverse of matrix by elementary transformation; Trace of a matrix; System of linear equations.	CO4, CO6

	Unit 5	**Characteristics equation**			
	A B C	Characteristics equation; Eigen values and Eigen vectors; Caley-Hamilton theorem; Inverse using Caley-Hamilton theorem; Eigen-value problems.			CO5, CO6
	Mode of examination	Class Test (10), Assignment (10) and presentation (10)			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	Advanced Engineering Mathematics- M.K. Jain and S.R.K. Iyenger (Narosa Publications)			
	Other References	1. Engineering Mathematics Vol. 1 & 2 – Sastry (Prentice Hall of India) 2. Mathematical Methods- Potter and Goldberg (Prentice Hall of India) 3. Advanced Engineering Mathematics- Kreyszig (Wiley) 4. Complex Variable- Schaum Series (Tata McGraw Hill)			

Course Articulation Matrix for Mathematical Physics -1

COs	PO1	PO2	PO3	PO4	P05	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	3	2	1	2	2	3	2	2	2	2	1
CO2	3	3	1	1	3	3	1	2	2	3	2	2	3	2	1
CO3	3	3	1	1	3	2	1	2	2	3	2	2	3	1	1
CO4	3	3	1	1	3	2	1	2	2	3	2	2	2	1	1
CO5	3	3	1	1	3	2	1	2	2	3	2	2	2	2	1
CO6	3	3	1	1	3	2	1	2	2	3	3	2	3	2	1

1-Slight (Low) **2-Moderate (Medium)** **3-Substantial (High)**

Schools:SSET | SSOL | SSMFE | SSBS-BBA | SSBSR | SSOE | SSAP		Batch : 2023-2027 Academic Year: 2023-24 Semester: I
1	Course Code	**ARP101**
2	Course Title	Communicative English-1
3	Credits	2
4	Contact Hours (L-T-P)	1-0-2
5	Course Objective	To minimize the linguistic barriers that emerges in varied socio-linguistic environments through the use of English. Help students to understand different accents and standardise their existing English. Guide the students to hone the basic communication skills - listening, speaking, reading and writing while also uplifting their perception of themselves, giving them self-confidence and building positive attitude.
6	Course Outcomes	After completion of this course, students will be able to: CO1 Develop a better understanding of advanced grammar rules and write grammatically correct sentences CO2 Acquire wide vocabulary and punctuation rules and learn strategies for error-free communication. CO3 Interpret texts, pictures and improve both reading and writing skills which would help them in their academic as well as professional career CO4 Comprehend language and improve speaking skills in academic and social contexts CO5 Develop, share and maximise new ideas with the concept of brainstorming and the documentation of key critical thoughts articulated towards preparing for a career based on their potentials and availability of opportunities. CO6 Function effectively in multi-disciplinary teams through the knowledge of team work, Inter-personal relationships, conflict management and leadership quality
7	Course Description	The course is designed to equip students, who are at a very basic level of language comprehension, to communicate and work with ease in varied workplace environment. The course begins with basic grammar structure and pronunciation patterns, leading up to apprehension of oneself through written and verbal expression as a first step towards greater employability.
8	Outline syllabus – ARP 101	

	Unit A	**Sentence Structure**	**CO Mapping**
	Topic 1	Subject Verb Agreement	CO1
	Topic 2	Parts of speech	
	Topic 3	Writing well-formed sentences	
	Unit B	**Vocabulary Building & Punctuation**	
	Topic 1	Homonyms/ homophones, Synonyms/Antonyms	CO1, CO2
	Topic 2	Punctuation/ Spellings (Prefixes-suffixes/Unjumbled Words)	CO1, CO2
	Topic 3	Conjunctions/Compound Sentences	CO1, CO2
	Unit C	**Writing Skills**	
	Topic 1	Picture Description – Student Group Activity	CO3
	Topic 2	Positive Thinking - Dead Poets Society-Full-length feature film - Paragraph Writing inculcating the positive attitude of a learner through the movie | SWOT Analysis – Know yourself	CO3, CO2, CO3

	Topic 3	Story Completion Exercise –Building positive attitude - The Man from Earth (Watching a Full length Feature Film)	CO2, CO3
	Topic 4	Digital Literacy | Effective Use of Social Media	CO3
	Unit D	**Speaking Skill**	
	Topic 1	Self-introduction/Greeting/Meeting people – Self branding	CO4
	Topic 2	Describing people and situations - To Sir With Love (Watching a Full length Feature Film)	CO4
	Topic 3	Dialogues/conversations (Situation based Role Plays)	CO4
	Unit E	**Professional Skills | Career Skills**	
	Topic 1	Exploring Career Opportunities	CO4, CO5
	Topic 2	Brainstorming Techniques & Models	CO4, CO5
	Topic 3	Social and Cultural Etiquettes	CO4, CO5
	Topic 4	Internal Communication	CO4, CO5
	Unit F	**Leadership and Management Skills**	
	Topic 1	Managerial Skills	CO6
	Topic 2	Entrepreneurial Skills	CO6
9	Evaluations	*Class Assignments/Free Speech Exercises / JAM Group Presentations/Problem Solving Scenarios/GD/Simulations (60% CA and 40% ETE*	*N/A*
10	Texts & References | Library Links	• Blum, M. Rosen. *How to Build Better Vocabulary*. London: Bloomsbury Publication • Comfort, Jeremy (et.al). *Speaking Effectively*. Cambridge University Press	

COURSE ARTICULATION MATRIX FOR COMMUNICATIVE ENGLISH -I

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO2	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO3	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO4	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO5	3	3	2	3	2	2	1	2	1	2	3	3	1	1	1
CO6	3	3	2	3	2	2	1	2	1	2	3	3	1	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

OE- BEN102 Ecology and Ecosystems

School: SBSR		**Batch: 2023-2027**	
Program: B.Sc.		**Current Academic Year: 2023-2024**	
Branch: Physics		**SEMESTER: I**	
1	Course Code	**BEN102**	
2	Course Title	**Ecology and Ecosystems**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
4	Course Status	OE	
5	Max. Marks	15+10 +75= 100	
6	Min. Marks		
7	Course Objective	This paper will introduce to the students the basic understanding of ecosystemand its structural and functional aspects.	
8	Course Outcomes	CO1: Demonstrate sound understanding on scientific inquiry in the field of modernecology. CO2: Describe the characteristics of population and modals of population growth. CO3: Explain the link between community composition and ecosystem functions.CO4: Describe the characteristics of the major biomes and ecosystems of the Earth.CO5: Describe and relate biogeochemical cycles with elements of the atmosphere, the biosphere, the hydrosphere, the pedosphere and the lithosphere. CO6: Describe the basic principles of ecology, including population ecology,community ecology, and ecosystem function.	
9	Course Description	It will explore the interconnectedness among all the biotic and abiotic components of environment and the dynamic nature of the ecological processes in maintainingequilibrium in nature.	
10	Outline syllabus		CO Mapping
	Unit 1	**Introduction to Ecology**	
	A	Basic concepts and definitions: ecology, landscape, habitat,ecozones, biosphere, ecosystems, ecosystem stability	CO1/ CO6
	B	Autecology; synecology; major terrestrial biomes. Ecologicalamplitude; phenotypic plasticity	CO1/ CO6
	C	Ecoclines; acclimation; ecological niche; types of niches: fundamental niche; niche breadth; niche partitioning; niche differentiation	CO1/ CO6
	Unit 2	**Population Ecology**	
	A	Concept of population and meta-population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality	CO2/ CO6
	B	Life tables, survivorship curves, age structure; population growth: exponential, logistic, density-dependent; limits to population growth	CO2/ CO6

	C	Deterministic and stochastic models of population dynamics;competitive and stress-tolerance strategies			CO2/ CO6
	Unit 3	**Community Ecology**			
	A	Discrete versus continuum community view; community structureand organization: biomass, stability, keystone species			CO3/ CO6
	B	Speciesinteractions:mutualism,symbiotic relationships ,commensalism, amensalism, predation, competition, parasitism			CO3/ CO6
	C	Ecological succession: primary and secondary successions, models and types of successions, climax community concepts, examples of succession			CO3/ CO6
	Unit 4	**Ecosystem Ecology**			
	A	Types of ecosystems: forest, grassland, lentic, lotic, desert, ecosystem structure and function; abiotic and biotic components ofecosystem; ecosystem. function; primary production and models ofenergy flow			CO4/ CO6
	B	Secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological pyramids: pyramids ofnumber			CO4/ CO6
	C	Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities			CO4/ CO6
	Unit 5	**Biogeochemical Cycles and Nutrient Cycling**			
	A	Carbon cycle; Nitrogen cycle; Phosphorus cycle; Sulphur cycle; Hydrological cycle; Nutrient Cycle Models			CO5/ CO6
	B	Ecosystem input of nutrients; biotic accumulation; ecosystem losses;nutrient supply and uptake			CO5/ CO6
	C	Decomposition and nutrient release; nutrient use efficiency; nutrientbudget; nutrient conservation strategies			CO5/ CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar.05 marks for Class Interaction			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK. 2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. The Ecology ofPlants. Sinauer associates incorporated. 3. Loreau, M. & Inchausti, P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK. 4. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrastingeffects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist 203: 697-703.			

Course Articulation Matrix For Environmental management

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	3	1	1	3	3	2	2	2	2	1	1
CO2	3	3	2	1	3	1	1	3	3	2	2	2	3	1	1
CO3	3	3	2	1	3	1	1	3	3	2	2	2	3	1	1
CO4	3	3	2	1	3	1	1	3	3	2	2	2	2	1	1
CO5	3	3	2	1	3	1	1	3	3	2	2	2	2	1	1
CO6	3	3	2	1	3	1	1	3	3	2	2	2	3	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

VOP101 Vocational Course in Electronics

School: Sharda School of Basic Sciences and Research		**Batch: 2023-2027**	
Program: Certificate In Physics		**Current Academic Year: 2023-2024**	
Branch: All		**Semester: I**	
1	Course Code	**VOP101**	
2	Course Title	**Vocational course in Electronics**	
3	Credits	3	
4	Contact Hours (L-T-P)	0-0-5	
5	Course Status	Vocational	
6	Max. Marks	25+25+50 = 100	
7	Min. Marks		
8	Course Objective	1. Acquainting Students with the technical skills of Electronics. 2. To know about some Electrical Power Supply Devices. 3. To study about the basic Communication techniques. 4. To study about the Solar Power.	
9	Course Outcomes	**CO1:** Identification of Different Electronic components and their practical applications. **CO2:** Interpretation of the concepts of diodes and transistors in Electronic circuits **CO3:** Inference the concepts and Applications of protection devices in SMPS and UPS. **CO4:** The knowledge about various electronics communication techniques, equipment's and fiber optics and various transducers. **CO5:** Apply the fundamental of Renewable Energy System in installation of solar module. **CO6:** Application of various electronics components in Electrical Power Supply Devices, Fibre optic communication and Solar Power.	
10	Course Description	This course is designed to provide students training on practical knowledge of Electronics, Electrical Power Supply Devices, Communication techniques and Basics of Solar cell.	
11	Outline syllabus		**CO Mapping**
	Unit 1		
	A	Basics of AC and Electrical Cables, Passive Components	CO1
	B		
	C	Soldering & De-soldering and switches Practical knowledge of Electronics	
	Unit 2		
	A	p-n junction diode, Zener diode and LED	CO2
	B		
	C	Transistors Introduction to Digital Electronics, Some Projects of Electronics	
	Unit 3		
	A	Protection devices	CO3
	B		
	C	Switched mode power supply (SMPS) Uninterrupted Power Supply (UPS)	
	Unit 4		
	A	Transducers	CO4, CO6
	B		
	C		

		Communication electronics Fibre optic communication	
	Unit 5		
	A B C	Solar Power Basics of Solar cell Components of Solar unit	CO5, CO6
	Mode of examination	15 marks for Record File (depending upon the no. of experiments performed out of the total assigned experiments) 05 marks for Viva Voce 05 marks for Class Interaction	
	Weightage Distribution	CA: 25% / CE: 25% / ESE: 50%	
	Text book/s*	Principles of Electronics by V. K. Mehta	
	Other References	Electronics engineering by B.L theraja. Electronics devices and circuit theory by R. L. Boylestad	

Course Articulation Matrix for Vocational Course in Electronics

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2	2	1	2	3	2	2	3	-	-
CO2	3	2	3	2	3	2	2	1	2	3	2	2	3	-	-
CO3	3	2	3	2	3	2	2	1	2	3	2	2	3	-	-
CO4	3	2	3	2	3	2	2	1	2	3	2	2	3	-	-
CO5	3	2	3	2	3	2	3	1	2	3	2	2	3	-	-
CO6	3	2	3	2	3	2	3	1	2	3	2	2	3	-	-

1-Slight (Low) **2-Moderate (Medium)** **3-Substantial (High)**

School: SET | SOL | SMFE | SBS-BBA | SBSR | SOE | SAP		**Batch: 2023-2027**
Program: All		**Current Academic Year: 2023-24**
Branch: All		**Semester: I**
1	**Course Code**	**VAC103**
2	Course Title	Environmental Management
3	Credits	03
4	Contact Hours (L-T-P)	3-0-0
	Course Status	Compulsory
5	Course Objective	1. Enable students to learn the concepts, principles and importance of environmental science 2. Provide students an insight of various causes of natural resource depletion and its conservation 3. Provide detailed knowledge of causes, effects and control of different types of environmental pollution and its effect on climate change, global warming and ozone layer depletion. 4. Provide knowledge of different methods of water conservation 5. Provide and enrich the students about sustainable practices and environmental management
6	Course Outcomes	CO1.Develop a better understanding of the principles and scope of environmental science CO2. Acquire to learn various pollution causes, effects and control and solid waste management. CO3. Interpret the effect of global warming and ozone layer depletion CO4. Comprehend about various types of natural resources and its conservation CO5. Develop a better understanding about sustainable practices and environmental management CO6. Function effectively on overall understanding of various environmental components, its protection and management.
7	Course Description	Environmental Science emphasises on various factors as 1. Importance and scope of environmental science 2. Natural resource conservation 3. Pollution causes, effects and control methods 4. Sustainable and Environmental environment
8	Outline syllabus	CO Mapping

	Unit 1	**Natural resource management**			
	A	Introduction to Natural Resources			CO1
	B	Management of Land and Forest Resources			CO1
	C	Water and Energy resource Management			CO1
	Unit 2	**Environmental Pollution Management**			
	A	Air pollution Control and Water Pollution treatment Methods			CO2
	B	Soil and Noise Pollution Management			CO2
	C	Solid waste management			CO2
	Unit 3	**Climate Change Mitigation**			
	A	Concept of Global Warming and greenhouse effect			CO3/CO6
	B	Ozone layer Depletion and its consequences			CO3/CO6
	C	Climate change, its effect on ecosystem and its mitigation. Kyoto protocol and IPCC concerns on changing climate.			CO3/CO6
	Unit 4	**Biodiversity Management**			
	A	Hot spots, Endangered and endemic species of India			CO4/CO6
	B	Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions			CO4/CO6
	C	Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.			CO4/CO6
	Unit 5	**Sustainable practices and environmental management**			
	A	Sustainable development and sustainable consumption			CO5/CO6
	B	Environmental Issues and Management in India			CO5/CO6
	C	Environmental Management System (EMS)			CO5/CO6
	Mode of examination	Theory based survey			
	Weightage Distribution	CA	MSE	ESE	
		15	10	75	
	Text book/s*	Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha, Pub: Orient Blackswan Pvt Ltd			

	Other References	Environmental Science by G. Tyler Miller, JR. and Scott E. Spoolman; Broks/Cole.	

Course Articulation Matrix for VACElectronics

COs	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	1	1	1	1	2	1	3	1	2	1	1	1
CO2	1	1	1	1	2	1	3	1	2	1	1	1
CO3	1	1	1	1	2	1	3	1	2	1	1	1
CO4	1	1	1	1	2	1	3	1	2	1	1	1
CO5	1	1	1	1	2	1	3	1	2	1	1	1
CO6	1	1	1	1	2	1	3	1	2	1	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

Physics Lab 1 Mechanical Properties of Matter

School: SSBSR		**Batch : 2023-2027**	
Program: Certificate In Physics		**Current Academic Year: 2023-2024**	
Branch: Physics		**SEMESTER: I**	
1	Course Code	**PHS151**	
2	Course Title	**Physics Lab 1** : **Mechanical Properties of Matter**	
3	Credits	1	
4	Contact Hours (L-T-P)	0-0-2	
5	Course Status	Course	
6	Course Objective	This course provides an opportunity to develop knowledge and understanding of the basic working of experiments used to determine various mechanical properties of matter.	
7	Course Outcomes	CO1: Apply the concept of Rotational Motion and Calculate the Moment of Inertia of flywheel and of irregular bodies. CO2: Apply the concept of Elasticity and compare the Modules of Rigidity by statistical and dynamical method. CO3: Apply the concept of Elasticity to determine Young Modules of metallic material and Poisson´s ratio of rubber. CO4: To determine Surface tension of water using the concept of capillarity. CO5: Understanding the stream line flow and to determine the viscosity of water using Poiseuille´s method CO6: Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the mechanical properties.	
8	Course Description	This course provides students a full exposure to the basic principles and essential concepts of performing experiments and calculating mechanical parameters.	
9	Outline syllabus		CO Mapping
	Unit 1		
	A	Moment of inertia of a flywheel	CO1
	B and C	Moment of inertia of an irregular body by inertia table	CO1
	Unit 2		
	A	Modulus of rigidity by statistical method (Barton′s apparatus)	CO2
	B and C	Modulus of rigidity by dynamical method (sphere / disc / Maxwell′s needle)	CO2, CO6
		Young′s modulus and Poisson′s ratio by Searle′s method	
	Unit 3		
	A	Young′s modulus by bending of beam	CO3

	B and C	Poisson's ratio of rubber by rubber tubing			CO3
	Unit 4				
	A	Surface tension of water by capillary rise method			CO4, CO6
	B and C	Surface tension of water by Jaeger′s method			CO4, CO6
	Unit 5				
	A B and C	Coefficient of viscosity of water by Poiseuille′s method			CO5, CO6
	Mode of examination	15 marks for Record File (depending upon the no. of experiments performed out of the total assigned experiments) 05 marks for Viva Voce 05 marks for Class Interaction			
	Weightage Distribution	CA	CE	ESE	
		15%	10%	75%	
	Text book/s*	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 3. R.K. Agrawal, G. Jain, R. Sharma, "Practical Physics", Krishna Prakashan Media (Pvt.) Ltd., Meerut, 2019 4. S.L. Gupta, V. Kumar, "Practical Physics", Pragati Prakashan, Meerut, 2014, Virtual Labs at Amrita Vishwa Vidyapeetham https://vlab.amrita.edu/?sub=1&brch=74 1. Torque and angular acceleration of a fly wheel 2. Torsional oscillations in different liquids 3. Moment of inertia of flywheel 4. Newton's second law of motion 5. Ballistic pendulum 6. Collision balls 7. Projectile motion 8. Elastic and inelastic collision			

Course Articulation Matrix for Physics Lab 1 Mechanical Properties of Matter

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	2	2	3	3	2	2	2	3	1	1
CO2	2	2	2	1	3	2	2	3	3	2	2	2	3	1	1
CO3	1	2	3	1	3	2	2	3	3	2	2	2	3	1	1
CO4	2	2	3	2	3	2	2	3	3	2	2	2	3	1	1
CO5	2	3	3	2	3	2	2	3	3	2	2	2	3	1	1
CO6	2	2	3	2	3	2	2	3	3	2	2	2	3	1	1

SEMESTER II

PHS103-Optics

School: SSBSR		**Batch: 2023-27**	
Program: Certificate in Physics		**Current Academic Year: 2023-24**	
Branch: Physics		**Semester: II**	
1	Course Code	**PHS103**	
2	Course Title	Optics	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	This course provides the knowledge of fundamental concepts of optics and understanding of wave and optics phenomena, with emphasis on everyday effect.	
6	Course Outcomes	After the completion of this course, the student will be able to **CO1:** Apply the laws and concepts of geometrical optics to find cardinal points and solve a variety of numerical problems. **CO2:** Understand the concepts and phenomena of wave optics and analyze the intensity variation of light due to interference. **CO3:** Understand the concepts of diffraction and analyze the intensity variation of light due to single slit, double slits and N-slits diffraction. **CO4:** Understand mean of resolution and working of telescope and microscope. **CO5:** Understand optical phenomena in terms of electromagnetic wave properties including polarization of light and its applications. **CO6:** Apply conceptual understanding and mathematical methods to solve the problems.	
7	Course Description	This course provides students with an understanding of optical phenomena based on the wave description of light. The geometrical optics and principles of polarization, interference and diffraction and optical devices that use these properties of light will be described.	
8	Outline syllabus		CO Mapping
	Unit 1	**Geometrical Optics**	
	A	Cardinal Points of an Optical System (six points), Newton's formula	CO1
	B	Nodal slide, Coaxial Lens System(equivalent focal length and cardinal points)	CO1
	C	Huygens Eyepiece, Ramsden Eyepiece and their cardinal points	CO1
	Unit 2	**Interference**	
	A	Introduction, Coherent sources, Concept of spatial and temporal coherence, Interference of light	CO2
	B	Division of wave front: Young's Double slit experiment and Fresnel's bi-prism	CO2
	C	Division of amplitude: Interference in thin films, wedge shaped films, Newton's rings.	CO2
	Unit 3	**Diffraction**	
	A	Introduction, Fresnel and Fraunhoffer diffraction,	CO3
	B	Fraunhoffer diffraction due to single slit, double slit	CO3
	C	n slits diffraction, Plane diffraction grating	CO3
	Unit 4	**Resolving power**	
	A	Resolving power, Rayleigh criteria	CO4

	B	Resolving power of diffraction grating			CO3,CO4, CO6
	C	Resolving power of microscope, telescope			CO4,CO6
	Unit 5	**Polarization**			
	A	Phenomenon of polarization, Production of polarized light by reflection, refraction, Brewster's law, Malus law,			CO5
	B	Nicol prism, Polarization by double refraction Retardation plates (Quarter and half wave plates), production and analysis of circularly and elliptically polarized light			CO5, CO6
	C	Optical activity and Fresnel's theory of optical rotation, specific rotation, polarimeter			CO5, CO6
	Mode of examination	Class test (10) ,Assignments (10) and presentation (10)			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Optics by Brijlal and Subrahmanyam 2. Optics by Vasudeva			
	Other References	1.Optics by A. K.Ghatak 2. Principles of Optics, B.K. Mathur, New Global Printing Press, Kanpur 3. Fundamentals of Optics - F.A. Jenkins and H.E. White ((McGraw Hill) 4. Principles of Optics, M. Born and E. Wolf, Sixth Edition, Pergamon Press, Oxford			

Course articulation Matrix

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	2	2	1	2	2	2	1	1	3	1
CO2	2	2	2	1	3	2	2	1	2	2	2	1	1	3	1
CO3	1	2	3	1	3	2	2	1	2	2	2	1	1	3	1
CO4	2	2	3	2	3	2	2	1	2	2	2	1	1	3	1
CO5	2	3	3	2	3	2	2	1	2	2	2	1	1	3	1
CO6	2	2	3	2	3	2	2	1	2	2	2	1	1	3	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS104- Thermal Physics

School:SSBSR		**Batch: 2023-27**	
Program: Certificate in Physics		**Current Academic Year: 2023-24**	
Branch: Physics		**Semester: II**	
1	**Course Code**	**PHS104**	
2	**Course Title**	**Thermal Physics**	
3	**Credits**	**4**	
4	**Contact Hours (L-T-P)**	**4-0-0**	
	Course Status	**Compulsory**	
5	**Course Objective**	1. To make students aware of concept of heat, temperature and heat flow. 2. To teach students the thermodynamics of various engines 3. To impart the knowledge of entropy and second law of thermodynamics. 4. To differentiate the ideal gas from real gas behavior. 5. To learn to derive and use thermodynamic equations.	
6	**Course Outcomes**	After the completion of this course, the student will be able to **CO1**: understand the importance of Zeroth law and concept of temperature. **CO2:** appreciate second law of thermodynamics and understand the thermodynamics of engines. **CO3:** know the concept of entropy and second law of thermodynamics. **CO4:** differentiate real gases from ideal gases and will know special properties of real gases. **CO5:** understand Maxwell's thermodynamic equations and will be able to apply them on some real life problems. **CO5:** appreciate the laws of thermodynamics and will understand how the things behave thermodynamically. **CO6:** apply thermodynamic principle on various practical and research problems.	
7	**Course Description**	This course is designed to teach students the basic laws of thermodynamics, thermodynamic potentials and behaviour of ideal and real gases	
8	Outline Syllabus		CO Mapping
	Unit 1	**Zeroth and first law of thermodynamics**	
	A	Thermodynamic Equilibrium; Zeroth Law of Thermodynamics and Concept of Temperature	CO1
	B	Work and Heat Energy; First Law of Thermodynamics; Applications of First Law	CO1
	C	General Relation between Cp and Cv; Work Done during Isothermal and Adiabatic Processes.	CO1
	Unit 2	**Second law of thermodynamics**	
	A	Limitations of first law of thermodynamics, Reversible and Irreversible Processes	CO2
	B	Heat Engines; Carnot Cycle; Carnot Engine and its Efficiency; Refrigerator and its Efficiency; Otto engine	CO2
	C	Kelvin-Planck and Clausius Statements and their Equivalence; Carnot Theorem; Second Law of Thermodynamics; Thermodynamic Scale of Temperature	CO2
	Unit 3	**Entropy**	
	A	Entropy of a State; Clausius Theorem; Clausius Inequality; Second Law of Thermodynamics in terms of Entropy	CO3

	B	Entropy of a Perfect Gas; Entropy Changes in Reversible and Irreversible Processes; Principle of Increase of Entropy			CO3
	C	Third Law of Thermodynamics; Temperature-Entropy Diagrams			CO3
	Unit 4	**Real gases**			
	A	Behavior of Real Gases; Deviations from the Ideal Gas Equation; The Virial Equation; Andrew's Experiments on CO_2 Gas			CO4, CO6
	B	Critical Constants; Continuity of Liquid and Gaseous State; Vapour and Gas; Boyle Temperature; Van der Waal's Equation of State for Real Gases; Values of Critical Constants; P-V Diagrams			CO4, CO6
	C	Joule-Thomson Porous Plug Experiment; Joule-Thomson Effect for Real and Van der Waal Gases; Temperature of Inversion; Phase transformation			CO4, CO6
	Unit 5	**Thermodynamic Equations**			
	A	Extensive and Intensive Thermodynamic Variables; Thermodynamic Potentials U; H; F and G; Their Definitions			CO5, CO6
	B	Properties and Applications; Derivations of Maxwell's Relations; Applications of Maxwell's Relations: (1) Clausius Clapeyron equation; (2) Values of Cp-Cv; (3) Tds Equations			CO5, CO6
	C	(4) Joule-Kelvin Coefficient for Ideal and Van der Waal Gases; (5) Energy Equations (6) Cooling due to Adiabatic demagnetization; Approach to Absolute Zero			CO5, CO6
	Mode of Examination	Theory			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text books	1. Heat and thermodynamics by Brijlal and Subrahmanyan, S.Chand & co.			
	Other References	1.A Treatise on Heat ; Including Kinetic Theory of Gases; Thermodynamics and Recent Advances in Statistical Thermodynamics By Meghnad Saha; B; N; Srivastava (Indian Press; 1958) 2.Heat and Thermodynamics; An Intermediate Textbook By Mark Waldo Zemansky; Richard Dittman (McGraw-Hill; 1981) (Text Book) 3.Thermal Physics by Garg; Bansal and Ghosh (Tata McGra-Hill; 1993)			

Course Articulation Matrix

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	2	1	2	2	2	1	2	1	1
CO2	3	3	2	1	2	1	2	1	2	2	2	1	2	1	1
CO3	3	3	2	1	2	1	2	1	2	2	2	1	2	1	1
CO4	3	3	2	1	2	1	2	1	2	2	2	1	2	1	1
CO5	3	3	2	1	2	1	2	1	2	2	2	1	2	1	1
CO6	3	3	2	1	2	1	2	1	2	2	2	1	2	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

Schools: SET | SOL | SMFE | SBS-BBA | SBSR | SOE | SAP		Batch : 2023-2027 Current Academic Year: 2023-2024 Semester: II	
1	Course Code	**ARP102**	
2	Course Title	Communicative English -2	
3	Credits	2	
4	Contact Hours (L-T-P)	1-0-2	
5	Course Objective	To Develop LSRW skills through audio-visual language acquirement, creative writing, advanced speech et al and MTI Reduction with the aid of certain tools like texts, movies, long and short essays.	
6	Course Outcomes	After completion of this course, students will be able to: CO1 Acquire Vision, Goals and Strategies through Audio-visual Language Texts CO2 Synthesize complex concepts and present them in creative writing CO3 Develop MTI Reduction/Neutral Accent through Classroom Sessions & Practice CO4 Determine their role in achieving team success through defining strategies for effective communication with different people CO5 Realize their potentials as human beings and conduct themselves properly in the ways of world. CO6 Acquire satisfactory competency in use of Quantitative aptitude and Logical Reasoning	
7	Course Description	The course takes the learnings from the previous semester to an advanced level of language learning and self-comprehension through the introduction of audio-visual aids as language enablers. It also leads learners to an advanced level of writing, reading, listening and speaking abilities, while also reducing the usage of L1 to minimal in order to increase the employability chances.	
8	Outline syllabus – ARP 102		
	Unit A	**Acquiring Vision, Goals and Strategies through Audio-visual Language Texts**	**CO Mapping**
	Topic 1	Pursuit of Happiness / Goal Setting & Value Proposition in life	CO1
	Topic 2	12 Angry Men / Ethics & Principles	
	Topic 3	The King's Speech / Mission statement in life | strategies & Action Plans in Life	
	Unit B	**Creative Writing**	
	Topic 1	Story Reconstruction - Positive Thinking	CO2
	Topic 2	Theme based Story Writing - Positive attitude	
	Topic 3	Learning Diary Learning Log – Self-introspection	
	Unit C	**Writing Skills 1**	
	Topic 1	Precis	CO2
	Topic 2	Paraphrasing	
	Topic 3	Essays (Simple essays)	

	Unit D	**MTI Reduction/Neutral Accent through Classroom Sessions & Practice**	
	Topic 1	Vowel, Consonant, sound correction, speech sounds, Monothongs, Dipthongs and Tripthongs	CO3
	Topic 2	Vowel Sound drills , Consonant Sound drills, Affricates and Fricative Sounds	
	Topic 3	Speech Sounds | Speech Music| Tone | Volume| Diction |Syntax |Intonation | Syllable Stress |	
	Unit E	**Gauging MTI Reduction Effectiveness through Free Speech**	
	Topic 1	Jam sessions	CO3
	Topic 2	Extempore	
	Topic 3	Situation-based Role Play	
	Unit F	**Leadership and Management Skills**	
	Topic 1	Innovative Leadership and Design Thinking	CO4
	Topic 2	Ethics and Integrity	CO4
	Unit F	**Universal Human Values**	
	Topic 1	Love & Compassion, Non-Violence & Truth	CO5
	Topic 2	Righteousness, Peace	CO5
	Topic 3	Service, Renunciation (Sacrifice)	CO5
	Unit G	**Introduction to Quantitative aptitude & Logical Reasoning**	
	Topic 1	Analytical Reasoning & Puzzle Solving	CO6
	Topic 2	Number Systems and its Application in Solving Problems	CO6
9	Evaluations	*Class Assignments/Free Speech Exercises / JAM Group Presentations/Problem Solving Scenarios/GD/Simulations (60% CA and 40% ETE*	*N/A*
10	Texts & References | Library Links	• Wren, P.C.&Martin H. *High English Grammar and Composition*, S.Chand& Company Ltd, New Delhi. • Blum, M. Rosen. *How to Build Better Vocabulary*. London: Bloomsbury Publication • Comfort, Jeremy(et.al). *Speaking Effectively*. Cambridge University Press. The Luncheon by W.Somerset Maugham - http://mistera.co.nf/files/sm_luncheon.pdf	

Course Articulation Matrix of Communicative English-2

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	2	1	2	1	2	3	3	2	2	1
CO2	3	3	2	3	1	2	1	2	1	2	3	3	2	2	1
CO3	3	3	2	3	1	2	1	2	1	2	3	3	2	2	1
CO4	3	3	2	3	1	2	1	2	1	2	3	3	2	2	1
CO5	3	3	2	3	2	2	1	2	1	2	3	3	2	2	1
CO6	3	3	2	3	2	2	1	2	1	2	3	3	2	2	1

CMS132 -Mathematical Expectations & Probability Distributions

School: SSBSR		**Batch: 2023-27**	
Program: B.Sc.		**Academic Year: 2023-24**	
Branch: Physics		**Semester: II**	
1	Course Code	**CMS132**	
2	Course Title	**Mathematical Expectations & Probability Distributions**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
	Course Status	OE	
5	Course Objective	Uncertainty is ubiquitous and probability theory provides a rational description of uncertainty. There is a growing realization that randomness is an essential component in the modeling and analysis of a variety of systems. Probability has become an important conceptual framework of computer science, engineering, and physical and biological sciences. Several problems in computer engineering and other disciplines arise, which require probabilistic modeling. The complete specification of the model enquires statistical tools for the analysis of data and inference	
6	Course Outcomes	CO1: Describe the basic concepts of probability and randomness with their applications. (K2, K5). CO2: Describe the properties of discrete and continuous random variables. (K2). CO3: Calculate the measures of central tendency and dispersion of data and describe the method used for analysis, including a discussion of advantages, disadvantages, and necessary assumptions. (K2, K3) CO4: Calculate and interpret the probability distributions and their applications in real life; and limit theorems. (K2,K3). CO5: Monte Carlo simulation of simple probability models, entropy, and mutual information. (K2, K5) CO6: Develop the skills to interpret the results of statistical analysis. (K2, K5).	
7	Course Description	This is an introductory course in probability. Axioms of probability, conditional probability and independence, Bayes theorem, and probability distributions.	
8	**Outline syllabus**		**CO Mapping**
	Unit 1	**Mathematical Expectation**	
	A	Axioms of probability, conditional probability and independence, Bayes theorem,	CO1
	B	Random variables: discrete and continuous random variables, probability mass function (p.m.f), probability density function (p.d.f) and cumulative distribution function (c.d.f), Illustrations and properties of random variables.	CO1
	C	Mathematical Expectation: Expectation of single and bivariate random variables, properties of expectation, conditional expectation, and its properties. Moments and cumulants. Moment generating function, probability generating function.	CO1
	Unit 2	**Discrete Random Variable**	
	A	Random variables, distribution function, discrete random variable, expectation, variance	CO2
	B	Discrete distributions: Bernoulli and Binomial random variable, Poisson random variable, demerits	CO2
	C	Negative binomial random variable, Geometric random variable, and their properties, merits, and demerits	CO2
	Unit 3	**Continuous Random Variable**	
	A	Continuous random variable: the expectation of random variable, variance	CO3

	B	Continuous distributions: Uniform, Normal, Exponential, Gamma, and Cauchy, computing probabilities by conditioning, moment generating function, their properties, merits, and demerits.	CO3
	C	Markov inequality and Chebyshev's inequality.	CO3
	Unit 4	**Jointly Distributed Random Variables**	CO4
	A	Jointly distributed random variables, Independent random variable, the sum of independent random variable	CO4, CO5
	B	Central Limit Theorem, conditional distribution with example.	CO4, CO5
	C	Joint probability distribution, covariance, correlation coefficient.	
	Unit 5	**Generation of Random Numbers**	
	A	Generation of random numbers and elements of Monte Carlo simulation.	CO5, CO6
	B	Elements of information theory: entropy as a measure of randomness.	CO5, CO6
	C	Exploratory data analysis, types of data, frequency tables, descriptive measures, variability measures	CO6
	Mode of examination	Theory	
	Weightage Distribution	CA: 25%; MTE: 25%; ETE:50%	
	Text book/s*	1. Gupta, S.C. and Kapoor, V.K., "Fundamentals of Mathematical Statistics".	
	Other References	2. Daniel, Wayne W., "Biostatistics": Basic Concept and Methodology for Health Science. 3. Grewal, B.S, "Higher Engineering Mathematics". 4. Rohatgi, V.K. Introduction to Probability.	

Course Articulation Matrix

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	1	1	3	2	2	2	1	2	1	1
CO2	2	2	2	1	3	1	1	3	2	2	2	1	2	1	1
CO3	2	2	2	1	3	1	1	3	2	2	2	1	2	1	1
CO4	2	2	2	1	3	1	1	3	2	2	2	1	2	1	1
CO5	2	2	2	1	3	1	1	3	2	2	2	1	2	1	1
CO6	3	3	2	1	3	1	1	3	3	2	2	2	2	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

School: SSHSS		Semester – 2	ACADEMIC SESSION:	FOR VAC – 1 Practical
1	Course code	VAC110		
2	Course Title	Yoga for Holistic health		
3	Credits	3		
4	Learning Hours	0-1-4		
5	Course Objective	To make the students familiar with the different practices of yoga, chantingand meditation techniques and learn the correct teaching skills.		
6	Course Outcomes	1. To make the students understand the concept of health and wellness through Yoga 2. To define the concept and principles of Yoga. 3. To interpret and understand the breathing practice. 4. To describe the knowledge about Yoga, its foundations and applications to the aspirants. 5. To make students aware of Yogic impact on the positive health and personality development. 6. The students will learn primary level of Yoga practices, which will groom their personality.		
7	Outline syllabus:			CO mapping
7.1		Unit A	Importance of Health, Wellness through Yoga	
7.11		Unit A Topic 1	Meaning, Definition, Aim of Yoga; Concept of health according to WHO and Ayurveda	CO1, CO2, CO4, CO5, CO6
7.12		Unit A Topic 2	Misconception about Yoga, Difference between asana and physical exercise	CO1, CO2, CO4, CO5, CO6
7.13		Unit A Topic 3	Need, Importance of Yoga in health and wellness	CO1, CO2, CO4, CO5, CO6
7.2		Unit B	Schools of Yoga, Modern and Ancient schools of Yoga existing in India, Yogic diet, Yogic attitudes, Sadhak tatva & Badhak tatva	
7.21		Unit B Topic 1	Schools/ Streams of Yoga – Ashtanga Yoga, Bhakti Yoga, Karma Yoga, Jnana Yoga	CO3, CO4, CO5, CO6
7.22		Unit B Topic 2	Modern and ancient schools of Yoga existing in India – Natha Sampradaya, Kaivalyadhama, Bihar School of Yoga, Munger, Pragya Yoga (Shantikunj), Iyengar Yoga, Patanjali Yoga Peeth, Ashtanga Vinyasa Yoga	CO3, CO4, CO5, CO6

7.23		Unit B Topic 3	Yoga Ahaara (Yogic diet), Yogic Attitudes – Maitri Karuna, Mudita, Upeksha, Sadhak Tatva Badhak Tatva (facilitating/helping factors and obstacles in Yoga sadhana)	CO3, CO4, CO5, CO6
7.3		**Unit C**	**Beginner level practices – Sukshma Vyayama and Surya Namaskara**	
7.31		Unit C Topic 1	Sukshma Vyayama and their benefits for health Part-1 (Bihar School of Yoga) Part-1	CO4, CO5, CO6
7.32		Unit C Topic 2	Sukshma Vyayama & their benefits for health (Swami Dhirendra Brahmachari) Part-1	CO4, CO5, CO6
7.33		Unit C Topic 3	Surya Namaskara (Sun Salutation) with mantra chanting (12 steps) & their benefits for health	CO4, CO5, CO6
7.4		**Unit D**	**Asana - all categories**	
7.41		Unit D Topic 1	Standing & Sitting - Tadasana, Vrikshasana, Katichakrasana, Padmasana, Vajrasana, Ushtrasana, Paschimottanasana, Vakrasana	CO4, CO5, CO6
7.42		Unit D Topic 2	Supine and Prone: Uttanapadasana, Pawanamuktasana, Shalabhasana, Bhujangasana	CO4, CO5, CO6
7.43		Unit D Topic 3	Balancing and Inverted: Trivikramasana, Sarvangasana, Viparitakarani mudra	CO4, CO5, CO6
7.5		Unit E	**Pre-practices of Pranayama, Pranayama and Dhyana**	
7.51		Unit E Topic 1	Kapalabhati, Mukha dhauti, Vibhagiya pranayama (Sectional breathing)	CO1, CO4, CO5, CO6
7.52		Unit E Topic 2	Anuloma – Viloma, Bhastrika, Shitali	CO1, CO4, CO5, CO6
7.53		Unit E Topic 3	Om Dhyana, Aanapaanasati Dhyana (breath meditation)	CO1, CO4, CO5, CO6
8	**Course Evaluation**			

8.1	Course work:	
8.11	Attendance	
8.12	Homework	Three best out of five assignments: 10 marks
8.13	Quizzes	Three best out of five tests: 10 marks
8.14	Projects	None
8.15	Presentations	One best out of two: 10 marks
8.2	CA: 60 % Practical	
8.3	End-term examination: 40% Viva	
9	**References**	
9.1	Text book	1. Sri Ananda: The Complete book of Yoga, Orient Course Backs, Delhi,2003. 2. Basavaraddi, I.V. & other: SHATKARMA: A Comprehensive description about Cleansing Process, MDNIY New Delhi, 2009 3. Joshi, K.S.: Yogic Pranayama, Oriental Paperback, New Delhi, 2009 4. Dr. Nagendra H R: Pranayama, The Art & Science, Swami VivekanandaYoga Prakashan, Bangalore, 2005. 5. Swami Niranjanananda Saraswati: Asana Pranayama Mudra Bandha, Yoga Publication Trust, Munger Bihar. 6. Joshi, K.S.: Yogic Pranayama, Oriental Paperback, New Delhi, 2009 7. Swami Kuvalyananda: Pranayama, Kaivalyadhama, Lonavla, 2010 8. Swami Rama: Science of Breath, A Practical Guide, The Himalayan International Institute, Pennselvenia, 1998. 9. Swami Niranjanananda Saraswati: Prana, Pranayama & Pranavidya, Yoga Publications Trust, Munger, Bihar, 2005

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12
CO1	1	1	1	1	2	1	3	1	2	1	1	1
CO2	1	1	1	1	2	1	3	1	2	1	1	1
CO3	1	1	1	1	2	1	3	1	2	1	1	1
CO4	1	1	1	1	2	1	3	1	2	1	1	1
CO5	1	1	1	1	2	1	3	1	2	1	1	1
CO6	1	1	1	1	2	1	3	1	2	1	1	1

VOP102 Fundamentals of Physical and geometrical optics for eye and vision

School:SSBSR		**Batch : 2023-2027**	
Program: Certificate In Physics		**Current Academic Year: 2023-2024**	
Branch: Physics		**Semester: II**	
1	Course Code	**VOP102**	
2	Course Title	**Fundamentals of Physical and geometrical optics for eye and vision**	
3	Credits	3	
4	Contact Hours (L-T-P)	0-0-5	
5	Course Status	Vocational	
6	Course Objective	This course provides an opportunity to develop knowledge and understanding fundamental concepts of geometrical optics and optics of eye.	
7	Course Outcomes	**CO1:** Explain the concepts of reflection, refraction and geometry of lens. **CO2:** Formulate the refractive power of lenses and analyze the focal power and surface power of a lens. **CO3:** Concepts building and applications of Cylindrical lenses and Toric lenses. **CO4:** Demonstration of geometry of eye for estimation of errors. **CO5:** Apply the concept of Ophthalmic lenses to compensate the refractive error of the eye. **CO6:** Apply conceptual understanding and mathematical methods of lens system for Ophthalmology.	
8	Course Description	This course provides students with an understanding of Opticianry skills and knowledge of physical, geometrical and visual optics as they relate to the eye and vision. ***Introduction to Indian ancient Physics and contribution of Indian Physicists, in context with the holistic development of modern science and technology, should be included under Continuous Internal Evaluation (CIE).***	
9	Outline syllabus		CO Mapping
	Unit 1	**Introduction**	
	A	Concepts of reflection and refraction	CO1
	B	Applications of reflection and refraction	CO1
	C	Description of lenses and their applications.	CO1
	Unit 2	**Refractive power and lenses**	
	A	Curved refracting surfaces	CO2
	B	Optical axis and thin lens power	CO2

	C	Back vertex power and front vertex power.	CO2
	Unit 3	**Sphero-cylindrical lenses**	
	A	Cylindrical lenses	CO3
	B	Toric lenses	CO3
	C	Spherical equivalent	CO3
	Unit 4	**The eye and refractive errors**	
	A	Optics of eye	CO4
	B	Refractive errors	CO4, CO6
	C	Refractive errors	CO4, CO6
	Unit 5	**Accommodation and correcting lenses**	
	A	Far point accommodation	CO5
	B	Near point accommodation	CO5
	C	correcting lenses	CO5, CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar. 05 marks for Class Interaction	
	Weightage Distribution	CA: 25% / CE: 25% / ESE: 50%	
	Text book/s*	1. Optics by Brijlal and Subrahmanyam 2. Introduction of Ophthalmic Optics by Darryl Meister 3. Ophthalmic Prescription work: 2nd Edition, A.G. Bennett Simon J. L. Blumlein	
	Suggestive Digital Platforms / Web Links	1. MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	
	Suggested Equivalent Online Courses	1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX, https://www.edx.org/course/subject/physics 5. MIT Open Course Ware - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/	

Course Articulation Matrix for Fundamentals of Physical and geometrical optics for eye and vision

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	3	3	2	1	1	2	1	2	2	2	1	1	3	1
CO2	3	3	3	2	2	1	2	1	2	2	2	1	1	3	1
CO3	3	3	3	2	2	1	2	1	2	2	2	1	1	3	1
CO4	3	3	3	2	2	1	2	1	2	2	2	1	1	3	1
CO5	3	3	3	2	2	1	2	1	2	2	2	1	1	3	1
CO6	2	3	3	2	2	1	2	1	2	2	2	1	1	3	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS 152 Physics lab II- Optics and Thermal Physics

School: SSBSR		**Batch: 2023-27**	
Program: Certificate in Physics		**Current Academic Year: 2023-24**	
Branch:Physics		**Semester: II**	
1	Course Code	PHS152	
2	Course Title	**Physics Lab 2 (Optics and Thermal Physics)**	
3	Credits	1	
4	Contact Hours (L-T-P)	0-0-2	
	Course Status	Compulsory	
5	Course Objective	1. To provide students an understanding of prism, Fresnel's biprism, and spectrometer. 2. To provide students an understanding of thermal conductivity. 3. To study the thermocouples and also to have knowledge of Stefan's law. 4. Students will learn about plane transmission grating and Newton's ring method.	
6	Course Outcomes	After the completion of this course, CO1: Students will learn about the fundamentals of optics i.e. dispersion, diffraction, interference etc. CO2: Students will understand about bad conductor, good conductor and how to determine their thermal conductivity. CO3: Students will learn about thermocouples and their working. CO4: Students will learn about black body radiation through Stefan's law. They will also learn to determine the wavelength of light through plane diffraction grating and Newton's Ring method. . CO5: Students will gain knowledge of lenses and learn to determine the focal length of lenses. CO6: Students will be able to correlate theory and practical together through the experiments and get the clear understanding of the concepts behind them.	
7	Course Description	This course will help students to have basic understanding of basics of Optics, Thermal conductivity and blackbody Radiation. It also helps them to understand the working of spectrometer, Newton's ring, plane diffraction grating and Nodal slides.	
8	Outline syllabus		CO Mapping
	Unit 1		
	A B C	1. To determine the dispersive power of a material of the prism and its angle using spectrometer. Also calculate speed of light in the given prism. 2. To determine wavelength of monochromatic light source (λ) by Fresnel's biprism	CO1
	Unit 2		
	A B C	**3.** To determine thermal conductivity of a bad conductor in form of a disc using Lee's method. 4. Calculate the thermal conductivity of copper by Searle's method	CO2
	Unit 3		
	A B C	5. To calibrate a thermocouple to determine the temperature of a given object. 6. To verify Stefan's law using radiation method.	CO3 CO4
	Unit 4		
	A B C	7. To determine the wavelength of prominent lines of mercury by plane diffraction grating. 8. To determine the wavelength of monochromatic light by Newton's Ring method.	CO1 CO4 CO6
	Unit 5		

	A B C	9. To determine the focal length of the combination of two lenses separated by a distance with the help of a nodal slide and to verify the formula.			CO5 CO6
	Mode of examination	Practical/Viva			
	Weightage Distribution	CA	CE	ETE	
		25%	25%	50%	
	Text book/s*	1. B.Sc. Practical Physics- Harnam Singh, S. Chand Publishing 2. B.Sc. Practical Physics- C L Arora, S. Chand Publishing			
	Other References	1. Basic electronics and linear circuits – N N Bhargava, D C Kulshreshtha, S C Gupta, Tata McGraw-Hill publishing company Ltd.			

Course Articulation Matrix for Physics Lab 2- Optics and Thermal Physics

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	3	2	3	2	2	1	2	3	2	2	1	2	2	-
CO2	3	3	2	3	2	2	1	2	3	2	2	1	2	2	-
CO3	3	3	2	3	2	2	1	2	3	2	2	1	2	2	-
CO4	3	3	2	3	2	2	1	2	3	2	2	1	2	2	-
CO5	3	3	2	3	2	2	1	2	3	2	2	1	2	2	-
CO6	3	3	2	3	2	2	1	2	3	2	2	1	2	2	-

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

SECOND YEAR

DETAILED SYLLABUS FOR

DIPLOMA

IN

PHYSICS

SEMESTER III

PHS-201 Electricity and Magnetism

School: SSBSR		**Batch: 2023-27**	
Program: Diploma in Physics		**Current Academic Year: 2024-25**	
Branch:Physics		**Semester: III**	
1	**Course Code**	**PHS201**	
2	**Course Title**	**Electricity and Magnetism**	
3	**Credits**	**4**	
4	**Contact Hours (L-T-P)**	**4-0-0**	
	Course Status	**Compulsory**	
5	**Course Objective**	This course aims to establish a foundation in electromagnetism and to make the students learn fundamental concepts of electricity, magnetism and circuit theory to use them in real life problems.	
6	**Course Outcomes**	**On successful completion of this course students will /will be able to:** **CO1:** Understand Coulomb's Law of force, Electric field, Gauss Law and will solve problems based on it, Electric potential and electrostatic energy. **CO2:** Distinguish different types of capacitors and derive energy stored in a capacitor, force of attraction between capacitor plate. **CO3:** Learn magnetic effect of current, definition of **B**, magnetic flux density, Bio-Savart's Law, Ampere's Law, Gauss' Law in magnetism; Derive expression for magnetic force between two parallel conductors, Evaluate magnetic field along the axis of circular coil and solenoid. **CO4:** Explain electromagnetic induction, Faraday's law of induction, Lenz's law, self and mutual inductance; Evaluate energy stored in magnetic field, inductances in series and parallel combination. **CO5:** Acquire knowledge AC circuits, Kirchoff's laws for AC circuits, complex reactance and impedance, RC, RL, LC and LCR circuits (series and parallel). **CO6:** Evaluate electric and magnetic fields, potential, force and work using various laws; use Faradays laws in solving induction problems and learn the properties of basic circuit elements.	
7	**Course Description**	This course describes the various laws related to electricity and magnetism laying foundation for advance courses such as electromagnetic theory. The course also provides an understanding of electromagnetic induction to further describe the properties of electrical circuits.	
8	Outline Syllabus		CO Mapping
	Unit 1	**Electrostatics**	
	A	**Coulomb's Law:** Coulomb's Law of force, electrostatic field and intensity, electric flux.	CO1
	B	**Gauss Law:** Gauss law and calculation of electric field using Gauss Law	CO1
	C	**Potential**: Electric potential, equipotential surfaces, electrostatic energy and potential energy due to charge distribution	CO1
	Unit 2	**Capacitor**	
	A	**Types of capacitors:** Different types of capacitors: parallel plate capacitor, spherical, cylindrical and guard ring capacitor.	CO2

	B	**Energy stored:** energy stored in a capacitor, force of attraction between capacitor plate	CO2
	C	**Capacitors with dielectrics:** capacitance of partially and completely filled dielectric	CO2
	Unit 3	**Magnetic effect of current**	
	A	**Magnetic effect of current:** Magnetic effect of current, definition of **B,** magnetic force on a current carrying conductor, torque on a current loop in a uniform magnetic field.	CO3
	B	**Bio Savart's Law:** magnetic flux density, Bio-Savart's Law, Magnetic force between two parallel conductors, Ampere's Law.	CO3
	C	**Gauss Law in magnetism:** Gauss' Law in magnetism, Magnetic field along the axis of circular coil and solenoid.	CO3
	Unit 4	**Electromagnetic Induction**	
	A	**Electromagnetic induction:** Faraday's Law of induction, Lenz's Law, induced emf and electric field	CO4, CO6
	B	**Energy:** Energy stored in magnetic field.	CO4, CO6
	C	**Inductance:** Self Inductance, Mutual inductance, inductances in series and parallel.	CO4, CO6
	Unit 5	**Electrical Circuits**	
	A	**AC Circuits:** AC circuits, Kirchhoff's laws for AC circuits.	CO5, CO6
	B	**Reactance:** Complex reactance and Impedance.	CO5, CO6
	C	**Series and Parallel circuits:** RC, RL, LC and LCR circuits (series and parallel) excluding oscillations	CO5, CO6
	Mode of Examination	Theory	
	Weightage Distribution	CA / MSE / ESE	
		15% / 10% / 75%	
	Text books	1. David J Griffiths, "Introduction to electrodynamics" Pearson New International Edition 2. Halliday, Resnick and Walker, "Fundamentals of Physics Electricity and Magnetism" John Wiley	
	Other References	1. S Mahajan and Chaudhary, "Electricity, Magnetism and electromagnetic theory" TMH 2. D N Vasudeva, "Fundamentals of Electricity and Magnetism" S Chand and Company 3. K K Tewari, "Electricity and Magnetism" S. Chand 4. Matthew N O Sadiku, "Principles of Electromagnetics" 5. John David Jackson, "Classical Electrodynamics" John Wiley and Sons, Inc. 6. Joseph Edminister, "Schaum's Outline of Electromagnetics"	

Course Articulation Matrix for Electricity and Magnetism

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	1	3	1	2	1	3	3	2	2	2
CO2	3	3	3	3	1	1	3	1	2	1	3	3	2	2	2
CO3	3	3	3	3	1	1	1	1	2	1	3	3	2	2	2
CO4	3	3	3	3	1	1	2	1	1	2	3	3	2	2	2
CO5	3	3	3	3	2	2	1	1	1	2	3	3	2	2	2
CO6	3	3	3	3	2	2	1	1	1	2	3	3	2	2	2

PHS202 Solid State Physics

School: SSBSR		**Batch: 2023-27**	
Program: Diploma In Physics		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: III**	
1	Course Code	PHS202	
2	Course Title	Solid State Physics	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	This course provides an opportunity to develop knowledge and understanding of the key principles and applications of physics of solids including theoretical description of crystal and electronic structure, lattice dynamics and optical properties of different materials (metals, semiconductors, dielectrics, magnetic materials and superconductors)	
6	Course Outcomes	After the completion of this course, the student will be able to **CO1:** Demonstrate knowledge for crystal structures of solids, different physical mechanisms involved in crystal binding and lattice dynamics. **CO2:** Understand the theory of X-ray diffraction, use the lattice structure of crystalline materials both in real space and in reciprocal space (k-space) and be able to transform between these two spaces. **CO3:** Knowledge of fundamental principles of conductor, semiconductors, and insulators on the basics of band theory and be able to estimate the charge carrier mobility and density. **CO4:** Explain atomistic mechanism of thermal properties of solids. **CO5:** Explain the physical principles for different types of electric and magnetic phenomena in solid materials (like e.g. dielectricity, superconductivity, paramagnetism, diamagnetism, ferromagnetism etc). **CO6:** Apply physics principles and mathematical methods in solid state physics to explain crystal structure and various physical, electrical, thermal and magnetic properties of materials.	
7	Course Description	This course provides the basic understanding of crystal structure, symmetry, electrical, thermal, dielectric and magnetic properties of materials and their technological applications.	
8	Outline syllabus		CO Mapping
	Unit 1	**Crystal Structure and Bonding**	
	A	Bonding in solids- ionic, covalent, metallic, Van der Waals and hydrogen bonding.	CO1
	B	Crystalline and amorphous solids, Crystal Lattice, Unit Cell, Miller Indices and Miller Planes, Bravais lattice	CO1
	C	Simple crystal structure (SC, BCC, FCC), Atomic packing fractions for Simple cubic(SC), BCC and FCC	CO1
	Unit 2	**Reciprocal lattice**	
	A	X-rays Diffraction, Bragg law, Laue method, Rotating–crystal method	CO2

	B	Scattering from lattice, Diffraction conditions			CO2
	C	Reciprocal lattice, Ewald construction.			CO2
	Unit 3	**Electrical properties of solids**			
	A	Electrical conductivity, classification of solids; conductors, semiconductors and insulators			CO3
	B	intrinsic and extrinsic semiconductors, electrons and holes			CO3
	C	Hall Effect			CO3
	Unit 4	**Thermal properties of Solids**			
	A	Lattice vibration and phonons, vibrational modes of a 1-D lattice			CO4, CO6
	B	Lattice heat capacity, Classical theory of specific heat			CO4, CO6
	C	Thermal Conductivity, Thermoelectricity: Seebeck Effect and Peltier Effect.			CO4, CO6
	Unit 5	**Dielectric and magnetic properties**			
	A	Dielectrics, dielectric polarization, polar and nonpolar dielectrics, relation between electric field and polarization.			CO5, CO6
	B	Classification of magnetic materials: diamagnetism, paramagnetism, ferromagnetism, Magnetic Susceptibility, Curie law, Hysteresis Curve			CO5, CO6
	C	Superconductivity, Type-I and type-II superconductors. Meissner effect.			CO5, CO6
	Mode of examination	Class test (10) ,Assignments (10) and presentation (10)			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Solid State Physics: S.O. Pillai 2. Introduction to material science: Raghvan			
	Other References	3. Introduction to solid state physics: C. Kittel 4. Solid State Physics: A. J. Dekker			

Course Articulation Matrix for Solid State Physics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	1	1	1	1	2	3	3	1	2	1
CO2	3	3	1	1	1	1	1	1	1	2	3	3	1	2	1
CO3	3	3	1	1	1	1	1	1	1	2	3	3	1	2	1
CO4	3	3	1	1	1	1	1	1	1	2	3	3	1	2	1
CO5	3	3	2	1	2	2	1	1	1	2	3	3	1	2	1
CO6	3	3	2	1	2	2	1	1	1	2	3	3	1	2	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS203- Mathematical Physics-II

School: Sharda School of Basic Sciences and Research		**2023-2027**	
Program: Diploma in Physics		**Current Academic Year: 2024-2025**	
Branch: Physics		**Semester: III**	
1	Course Code	**PHS203**	
2	Course Title	**MATHEMATICAL PHYSICS-II**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
5	Course Status	DSE	
8	Course Objective	1. The student should be able to understand basic theory of vector analysis. 2.The student should be able to understand basic theory of vector space and linear transformations 3. The student should be able to understand basic theory of Convolution theorem and Laplace transformation. 4. Understanding of common numerical method to obtain approximate solution. 5. Method to find out eigen vectors, eigen values and solution of equations.	
9	Course Outcomes	After successful completion of this course the students will/will be able to: **CO1:** Student will be used to describe Vector spaces & Subspaces. Linearly dependent and independent vectors; Basis and Dimensions of a vector space; Linear transformations. **CO2:** Students will able to understand the concepts of Gradient, Divergence, and Curl; in Cartesian, Polar and spherical polar coordinates; Vector integral – Line, Surface and Volume integrals; Gauss's theorem, Stokes's theorem, and Green's theorem. **CO3:** Students will be able to carry out evaluation of Integral transforms, Development & Inversion theorem. Fourier transform of derivatives. **CO4:** Students will able to understand the Convolution theorem, Elementary Laplace transforms, Laplace transforms of derivatives, Convolution or faulting theorem, Inverse Laplace transformation **CO5:** Demonstrated understanding of common numerical method to obtain approximate solution. **CO6:** Apply various iterative method to find out eigen vectors, eigen values and solution of equations.	
10	Course Description	This course is designed to introduce students to methods of mathematical physics and to develop required mathematical skills to solve problems in quantum mechanics, electrodynamics and other fields of theoretical physics.	
11	Outline syllabus		**CO Mapping**
	Unit 1	**Vector and Dimensions**	
	A B C	Vector space and subspaces; Linearly dependent and independent vectors; Basis and dimensions of a vector space; Linear transformations.	CO1
	Unit 2	**Coordinates and Vector integral**	
	A B C	Gradient, divergence, and curl; ∇^2 in Cartesian, Polar and spherical polar coordinates; Vector integral – line, surface and volume integrals; Gauss's theorem, Stokes's theorem, and Green's theorem.	CO2
	Unit 3	**Integral and Fourier Transform**	
	A B C	Integral transforms; Development of the Fourier integral; Fourier transforms- Inversion theorem; Fourier transform of derivatives; Convolution theorem; Elementary Laplace transforms; Laplace transforms of derivatives; Convolution or faulting theorem; Inverse Laplace transformation	CO3,

	Unit 4	**Solution of Algebraic and Transcendental Equations**			
	A B C	Foundation of numerical analysis- Types of errors, Truncation and round-off errors, Floating point computation, Overflow and underflow, Single and double precision arithmetic, Iterative methods, Solution of transcendental equations- Fixed-point iteration method, Bisection method, Newton- Raphson method, Comparison and error estimation.			CO4, CO6
	Unit 5	**Matrices and Linear System of Equations**			
	A B C	Solution of linear equations- Jacobi method, Gauss elimination method, Gauss-Seidel iterative method; Computation of eigenvalues of and eigenvectors- power and inverse power methods, QR method.			CO5, CO6
	Mode of examination	Class Test (10), Assignment (10) and presentation (10)			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	Advanced Engineering Mathematics- M.K. Jain and S.R.K. Iyenger (Narosa Publications)			
	Other References	5. Engineering Mathematics Vol. 1 & 2 – Sastry (Prentice Hall of India) 6. Mathematical Methods- Potter and Goldberg (Prentice Hall of India) 7. Advanced Engineering Mathematics- Kreyszig (Wiley) 8. Complex Variable- Schaum Series (Tata McGraw Hill)			

Course Articulation matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	1	1	1	2	3	3	3	1	1
CO2	3	3	2	1	1	1	1	1	1	2	3	3	3	1	1
CO3	3	3	2	1	1	1	1	1	1	2	3	3	3	1	1
CO4	3	3	2	1	1	1	1	1	1	2	3	3	3	1	1
CO5	3	3	2	1	2	2	1	1	1	2	3	3	3	1	1
CO6	3	3	2	1	2	2	1	1	1	2	3	3	3	1	1

School: SET		**Batch :** 2023-2027	
Program:Diploma in Physics		**Academic Year:** 2024-2025	
Branch: Physics		**Semester:** III	
1	Course Code	**ARP207**	Course Name : **Logical Skills Building and Soft Skills**
2	Course Title	**Logical Skills Building and Soft Skills**	
3	Credits	2	
4	Contact Hours (L-T-P)	1-0-2	
	Course Status	Active	
5	Course Objective	To enhance holistic development of students and improve their employability skills. To provide a 360 degree exposure to learning elements of Business English readiness program, behavioural traits, achieve softer communication levels and a positive self-branding along with augmenting numerical and altitudinal abilities. To step up skill and upgrade students' across varied industry needs to enhance employability skills. By the end of this semester, a student will have entered the threshold of his/her 1st phase of employability enhancement and skill building activity exercise.	
6	Course Outcomes	After completion of this course, students will be able to: CO1: Ascertain a competency level through Building Essential Language and Life Skills CO2: Build positive emotional competence in self and learn GOAL Setting and SMART Goals techniques CO3: Apply positive thinking, goal setting and success-focused attitudes, time Management, which would help them in their academic as well as professional career CO4: Acquire satisfactory competency in use of aptitude, logical and analytical reasoning CO5: Develop strategic thinking and diverse mathematical concepts through building number puzzles CO6: Demonstrate an ability to apply various quantitative aptitude tools for making business decisions	
7	Course Description	This Level 1 blended training approach equips the students for Industry employment readiness and combines elements of soft skills and numerical abilities to achieve this purpose.	
8	Outline syllabus – ARP 207		

	Unit 1	**BELLS (Building Essential Language and Life Skills)**	**CO Mapping**
	A	*Know Yourself*: Core Competence. A very unique and interactive approach through an engaging questionnaire to ascertain a student's current skill level to design, architect and expose a student to the right syllabus as also to identify the correct TNI/TNA levels of the student.	CO1
	B	Techniques of Self Awareness | Self Esteem & Effectiveness| Building Positive Attitude | Building Emotional Competence	CO1, CO2
	C	Positive Thinking & Attitude Building | Goal Setting and SMART Goals – Milestone Mapping | Enhancing L S R W G and P (Listening Speaking Reading Writing Grammar and Pronunciation) |	CO1, CO2,CO3
	Unit 2	**Introduction to APTITUDE TRAINING- Reasoning- Logical/ Analytical**	

	A	Syllogism | Letter Series | Coding, Decoding , Ranking & Their Comparison Level-1	CO4
	B	Number Puzzles	CO5
	C	Selection Based On Given Conditions	CO5
	Unit 3	**Quantitative Aptitude**	
	A	Number Systems Level 1 | Vedic Maths Level-1	CO6
	B	Percentage ,Ratio & Proportion | Mensuration - Area & Volume |Algebra	CO6
	Unit 4	**Verbal Abilities – 1**	
	A	Reading Comprehension	CO1
	B	Spotting the Errors	CO2
	Unit 5	**Time & Priority Management**	
	A	Steven Covey Time Management Matrix	CO3
	B	Creating Self Time Management Tracker	CO3
	Weightage Distribution	*Class Assignment/Free Speech Exercises / JAM – 60% | Group Presentations/Mock Interviews/GD/ Reasoning, Quant & Aptitude – 40%*	
	Text book/s*	*Wiley's Quantitative Aptitude-P Anand* | ***Quantum CAT – Arihant Publications*** | ***Quicker Maths- M. Tyra*** | *Power of Positive Action (English, Paperback, Napoleon Hill) | Streets of Attitude (English, Paperback, Cary Fagan, Elizabeth Wilson) The 6 Pillars of self-esteem and awareness – Nathaniel Brandon | Goal Setting (English, Paperback, Wilson Dobson*	

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO2	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO3	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO4	3	3	2	3	1	2	1	2	1	2	3	3	1	1	1
CO5	3	3	2	3	2	2	1	2	1	2	3	3	1	1	1
CO6	3	3	2	3	2	2	1	2	1	2	3	3	1	1	1

OE-CMS102 Descriptive Statistics

School: SSBSR		**Batch: 2023-27**	
Program: B.Sc.		**Academic Year: 2024-25**	
Branch: Physics		**Semester: III**	
1	Course Code	**CMS102**	
2	Course Title	**Descriptive Statistics**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
	Course Status	OE	
5	Course Objective	1. To introduce basic statistical concepts, logic and analytical tools, analyze and communicatequantitative data verbally, graphically, symbolically, and numerically. 2. To make students familiar with the concept of Probability and Statistics and display data utilizingvarious tables, charts, and graphs.	
6	Course Outcomes	CO1: Describe the process and particular steps in designing studies, collecting and analyzing data, interpreting and presenting results; and developing skills in presenting quantitative data using appropriatediagrams, tabulations, and summaries. (K2, K5). CO2: Describe the properties of discrete and continuous distribution functions. (K2). CO3: Calculate the measures of central tendency and dispersion of data and describe the method used for analysis, including a discussion of advantages, disadvantages, and necessary assumptions. (K2, K3) CO4: Calculate and interpret the correlation between two variables, Calculate the simple linear regression equation for a set of data and know the basic assumptions behind regression analysis. (K2,K3). CO5: Understand the line of best fit as a tool for summarizing a linear relationship and predicting future observed values, and develop the ability to use formal mathematical argument in the context of probability. (K2, K5) CO6: Develop the skills to interpret the results of statistical analysis. (K2, K5).	
7	Course Description	This is an introductory course in statistics. Students are introduced to the fundamental concepts involved in using sample data to make inferences about populations. Included are the study of measures of central tendency and dispersion, finite probability, statistical inferences from large and small samples, linear regression, and correlation.	
8	**Outline syllabus**		**CO Mapping**
	Unit 1	**Presentation of data**	
	A	Classification, tabulation, diagrammatic & graphical representation of groupeddata.	CO1
	B	Frequency distributions, cumulative frequency distributions	CO1
	C	Histogram, Ogives, frequency polygon, Tree and leaf diagram.	CO1
	Unit 2	**Descriptive statistics**	CO2
	A	Measures of central tendency – arithmetic mean, median, quartiles, mode, harmonicmean, geometric mean.	CO2
	B	Their properties, merits, and demerits	CO2
	C	Measures of dispersion, range, quartile deviation, mean deviation, standard deviation,and coefficient of variation.	
	Unit 3	**Moments**	CO3
	A	Moments, Skewness, Measures of skewness: Karl Pearson's coefficient of skewness.	CO3
	B	Quartile, coefficient of skewness, Measure of skewness based on moments.	CO3
	C	Kurtosis, Measures of Kurtosis.	

	Unit 4	**Bi-variate data analysis**	CO4
	A	Bivariate data, principles of least squares, fitting of polynomial curves, and fitting ofcurves reducible to polynomial form.	CO4
	B	Correlation: Spearman's rank correlation, Partial and Multiple Correlation (only two independent variables case).	CO4
	C	Regression lines.	
	Unit 5	**Probability**	CO5
	A	Probability: Introduction, random experiment, outcomes, sample space, events, various definitions of probability, laws of total and compound probability.	CO5
	B	Boole's inequality. Conditional probability, independence of events.	CO5
	C	Bayes theorem and its applications in real-life problems.	CO6
	Mode of examination	Theory	
	Weightage Distribution	CA: 25%; MTE: 25%; ETE:50%	
	Text book/s*	1. Gupta, S.C. and Kapoor, V.K., "Fundamentals of Mathematical Statistics".	
	Other References	1. Daniel, Wayne W., "Biostatistics": Basic concept and Methodology forHealth Science. 2. Grewal, B.S, "Higher Engineering Mathematics". 3. Rohatgi, V.K. Introduction to Probability.	

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	2	1	2	2	3	2	2	2	1	1	3	1	1
CO2	3	3	3	2	1	1	3	2	2	2	1	2	3	1	1
CO3	3	3	3	2	2	2	2	2	3	1	1	1	3	1	1
CO4	2	2	2	1	1	1	3	3	2	2	2	1	3	1	1
CO5	3	2	1	1	1	1	3	2	2	3	1	1	3	1	1
CO6	3	3	2	1	1	2	3	2	2	2	1	1	3	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

VOP201- Nano-materials Technology and Hands on Training

School: School of Basic Sciences and Research		**Batch: 2023-2027**	
Program: Diploma in Physics		**Current Academic Year: 2024-2025**	
Branch: All		**Semester: III**	
1	Course Code	**VOP201**	
2	Course Title	**Nano-materials Technology and Hands on Training**	
3	Credits	3	
4	Contact Hours (L-T-P)	0-0-5	
5	Course Status	Vocational	
6	Max. Marks	25+25+50 = 100	
7	Min. Marks		
8	Course Objective	**1.** To know about basic requirement of materials for applications in Solar cell and Photocatalytic activity. **2.** To know about synthesis of nanomaterials for their applications in Solar cell and Photocatalytic activity. **3.** To know how to characterize the prepared materials using different characterization techniques. **4.** To know how to study the various parameters of solar cell and photocatalytic activity to identify the best materials for the same.	
9	Course Outcomes	After successful completion of this course the students will/will be able to: CO1: To introduce the concepts of nanomaterials and get acquainted with the facilities available in Laboratory. CO2: Apply the concept of bottom up approach and top down approach to synthesize various nanostructured materials. CO3: Preparation of materials for electrode, electrolyte and polymer electrolyte. CO4: Investigation of structural and optical properties of nanostructured materials. CO5: Fabrication of solar cell and measurement of its various parameters. CO6: Examine various physical parameters of solar cell, photocatalytic activity and finding the best suitable material for solar cell and water purification from chemical dyes.	
10	Course Description	This course is designed to provide students training on practical knowledge of synthesis the nanoparticles, characterization and measuring the physical and chemical properties required to get the best possible solar cell device and photocatalytic activity.	
11	Outline syllabus		**CO Mapping**
	Unit 1		
	A B C	Introduction to nanostructured materials, Type of nanostructured materials, Lab facility demonstration	CO1
	Unit 2		
	A B C	Synthesis of different nanostructured materials by Sol-gel Synthesis of different nanostructured materials by Co-Precipitate method Synthesis of different nanostructured materials by solid state method	CO2
	Unit 3		
	A B C	Preparation of electrolyte materialPreparation of electrode material, Preparation of polymer electrolyte films using solution cast technique	CO3
	Unit 4		
	A		CO4,CO6

	B C	Characterization of all synthesized materials using various techniques such as XRD, UV spectrometer, Optical microscopy etc	
	Unit 5		
	A B C	Preparation of Solar cells Measurement of various physical parameters of Solar cell. Measurement of photocatalytic activity of synthesized nanoparticles.	CO5, CO6
	Mode of examination	15 marks for Record File (depending upon the no. of experiments performed out of the total assigned experiments) 05 marks for Viva Voce 05 marks for Class Interaction	
	Weightage Distribution	CA: 25% / CE: 25% / ESE: 50%	
	Text book/s*	1. Nanostructures and Nanomaterials: Synthesis, Properties and Applications (World Scientific Series in Nanoscience and Nanotechnology). 2. Electrical Properties of Polymers by Tony Blythe and David Bloor, Cambridge University Press, Second Edition, 2005.	
	Other References	References 1. Gong, J., Sumathy, K., Qiao, Q., & Zhou, Z. (2017). Review on dye-sensitized solar cells (DSSCs): Advanced techniques and research trends. Renewable and Sustainable Energy Reviews, 68, 234–246. doi:10.1016/j.rser.2016.09.097. 2. Xu, C., Ravi Anusuyadevi, P., Aymonier, C., Luque, R., & Marre, S. (2019). Nanostructured materials for photocatalysis. Chemical Society Reviews, 48(14), 3868–3902. doi:10.1039/c9cs00102f. 3. Electrochemical Supercapacitors by B. E. Conway, Kluwer Academic/Plenum Publisher, New York, Boston, London, 1999	

Course Articulation Matrix for VOP201 Nano-materials Technology and Hands on Training

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	3	1	3	1	2	2	3	3	1	2	1
CO2	3	3	3	1	3	1	3	1	2	2	3	3	1	2	1
CO3	3	3	3	1	3	1	1	1	2	2	3	3	1	2	1
CO4	3	3	3	1	3	1	3	1	2	2	3	3	1	2	1
CO5	3	3	3	1	3	2	3	1	2	2	3	3	1	2	1
CO6	3	3	3	1	3	2	3	1	2	2	3	3	1	2	1

1-Slight (Low) **2-Moderate (Medium)** **3-Substantial (High)**

PHS251 Physics Lab 3: Demonstrative Aspects of Electricity & Magnetism

School: SSBSR		**Batch : 2023-2027**	
Program: Diploma In Physics		**Current Academic Year: 2024-2025**	
Branch: Physics		**SEMESTER: III**	
1	Course Code	**PHS251**	
2	Course Title	**Physics Lab 3: Demonstrative Aspects of Electricity & Magnetism**	
3	Credits	1	
4	Contact Hours (L-T-P)	0-0-2	
4	Course Status	CC	
5	Max. Marks	25+25+50 = 100	
6	Min. Marks		
7	Course Objective	Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine band gap, laser properties, study of interference and diffraction phenomena, Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modeling.	
8	Course Outcomes	CO1: Use the concept of electricity and magnetism to find out variation of magnetic field of a current carrying coil and specific resistance by CFB. CO2: Examine the various electrical parameters using Ballistic Galvenometer. CO3: Apply the concept of Diffraction phenomena to determine the diameter of a wire, slit width and wavelength of given Laser source. CO4: Apply the concept of Interference of Light to determine the wavelength of light. CO5: Apply the concept of optics to determine the optical properties. CO6: Apply the mathematical concepts/equations to obtain quantitative results and ability to conduct, analyze and interpret experiments.	
9	Course Description	This course provides students a full exposure to the basic principles and essential concepts of performing experiments and calculating mechanical parameters.	
10	Outline syllabus		CO Mapping
		Part A: Electromagnetic Theory	
	Unit 1		
	A	To determine the specific resistance by Carey Foster's Bridge	CO1
	B and C	To determine the variation of magnetic field along the axis of a current carrying coil and estimate the radius of the coil.	CO2
			CO2
	Unit 2		
	A	Ballistic Galvanometer: (a) Ballistic constant, (b) current Sensitivity and (c) voltage sensitivity	CO2
	B and C	Ballistic Galvanometer: (a) High Resistance by leakage method. Ballistic Galvanometer: Low resistance by Kelvin's Double Bridge Method.	CO1
	Unit 3		
	A	To determine the diameter of thin wire by diffraction using laser.	CO4, CO6
	B and C	To determine the wavelength of laser light by diffraction at a single slit. To determine slit width of single and double slit by using Laser.	CO4,CO6
	Unit 4		

	A	To determine the wavelength of monochromatic light by Fresnel's Biprism.			CO4,CO6
	B and C	To determine the wavelength of monochromatic light by Newton's Ring method			CO4,CO6
	Unit 5				
	A	To determine the focal length of the combination of two lenses separated by a distance with the help of a nodal slide and to verify the formula.			CO5,CO6
	B and C	To determine the dispersive power of prism using Spectrometer			CO5,CO6
	Mode of examination	15 marks for Record File (depending upon the no. of experiments performed out of the total assigned experiments) 05 marks for Viva Voce 05 marks for Class Interaction			
	Weightage Distribution	CA	CE	ESE	
		25%	25%	50%	
	Text book/s*/Virtual modes and links	1. B.Sc. Practical Physics- Harnam Singh, S. Chand Publishing. 2. B.Sc. Practical Physics- C L Arora, S. Chand Publishing. 3. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e 1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=194 2. Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/be/# 3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities			

Course Articulation for Demonstrative Aspects of Electricity & Magnetism

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	2	3	1	1	1	2	1	2	2	2	2	2	2	1
CO2	1	2	3	1	2	1	2	1	2	2	2	2	2	2	1
CO3	1	2	3	1	2	1	2	1	2	2	2	2	2	2	1
CO4	2	2	3	2	2	1	2	1	2	2	2	2	2	2	1
CO5	2	2	3	2	2	1	2	1	2	2	2	2	2	2	1
CO6	2	2	2	1	2	1	2	1	2	2	2	2	2	2	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

RBL001: Research Based Learning-1

School: SBSR		**Batch:2023-2027**	
Program: B. Sc		**Current Academic Year: 2024-25**	
Branch:Physics		**Semester III**	
1	Course Code	RBL001	
2	Course Title	Research Based Learning 1	
3	Credits	Audit Based	
4	Contact Hours (L-T-P)	(0-0-4)	
	Course Status	Compulsory	
5	Course Objective	• Develop an interest towards research	
6	Course Outcomes	CO 1: Recognize research-based investigation carried out on problems in physics and interdisciplinary science CO 2: Comprehend and compare a research article with a review article or a survey-based article CO 3: Demonstrate capacity to follow research articles CO 4: Identify concepts of physics referred in research articles CO 5: Extract important results of research findings CO 6: Report research findings in written and verbal forms	
7	Course Description	Reading in a field of special interest under the supervision of a faculty member. Intended for students interested in studying topics not offered in regularly available courses. Format and grading are determined by the supervising faculty member and the audit members then approved by the Head of Department.	
8	Outline		CO Achievement
	Part 1	**Introduction to various research problems**	**CO1**
	Part 2	**Identify a research question**	**CO2, CO3**
	Part 3	**Literature survey**	**CO4**
	Part 4	**Report writing**	**CO5**
	Part 5	**Presentation**	**CO6**
	Mode of examination	1. Rubric assessment 2. Monthly Presentation to be audited by supervisor 3. Mid Term Presentation and End Term Presentation	
	Text book/s*	10 Recent International Journal Articles of repute.	
	Other References	-	

Course Articulation Matrix for RBL001:

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	3	3	3	1	1	2	1	2	2	2	2	2	2	2
CO2	2	3	3	3	2	1	2	1	2	2	2	2	2	2	2
CO3	2	3	3	3	2	1	2	1	2	2	2	2	2	2	2
CO4	2	3	3	3	2	1	2	1	2	2	2	2	2	2	2
CO5	2	3	3	3	2	1	2	1	2	2	2	2	2	2	2
CO6	2	3	3	3	2	1	2	1	2	2	2	2	2	2	2

SEMESTER IV

PHS204 Electromagnetic Theory

School: SSBSR		**Batch: 2023-27**	
Program: DIPLOMA IN PHYSICS		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: IV**	
1	Course Code	**PHS204**	
2	Course Title	**Electromagnetic theory**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	This course provides the knowledge of fundamental theory and concepts of Electromagnetic waves, transmission lines and propagation, reflection, and transmission of plane waves in different media and interface.	
6	Course Outcomes	CO1: Able to interpret vector calculus operators and their application in electromagnetic. CO2: Understanding the concepts of displacements current and Analyze the Maxwell's equations in differential and integral form. CO3: Use Maxwell's equations to describe the propagation of electromagnetic waves in different media, nature of EM waves and can apply complex Poynting theorem to calculate average power. CO4: Understanding and solving the reflection and transmission of EM waves at normal and oblique incidence in linear media and conducting media. CO5: Understand the basic concepts of transmission lines, waveguides and calculate the characteristic impedance, attenuation constant and phase constant of different transmission lines. CO6: Apply conceptual understanding and mathematical methods to solve the problems.	
7	Course Description		
8	Outline syllabus		CO Mapping
	Unit 1		
	A	Gradient of a scalar and its physical significance, Line, Surface and Volume integrals of a vector and their physical significance	CO1
	B	Flux of a vector field, Divergence and curl of a vector and their physical significance, Gauss's divergence theorem	CO1
	C	Stoke's theorem, Laplace's and Poisson equations. The Uniqueness Theorem.	CO1
	Unit 2		
	A	Ampere's law and concept of Displacement current	CO2
	B	Equation of continuity	CO2
	C	Maxwell's equations in differential form and integral form	CO2 ,CO1
	Unit 3		
	A	EM wave equation and their solutions; Propagation of plane EM waves in free space	CO2,CO3
	B	Propagation of plane EM waves in dielectrics and conductors	CO2,CO3
	C	Poynting theorem and energy conservation , Transverse nature of EM waves	CO2, CO3
	Unit 4		
	A	Polarization of EM wave	CO4
	B	transmission at normal and oblique incidence in linear media and total internal reflection and Brewster angle	CO3 ,CO4

	C	transmission at normal and oblique incidence in conducting media			CO3 ,CO4,CO6
	Unit 5				
	A	Propagation of e.m. wave through transmission line			CO5
	B	reflection coefficient, standing wave, characteristic impedance,			CO5, CO6
	C	propagation constant, Introduction to waveguides			CO5, CO6
	Mode of examination	Class test (10) ,Assignments (10) and presentation (10)			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	Introduction to electromagnetics by Richard, Millford and Christi, Narosa Pub.			
	Other References	1. Introduction to Electrodynamics J. D. Griffith, PHI. 2. Electromagnetic waves- R. K. Shevgaonkar, TMH. 3. Schaum's outline on Electromagnetics-J. A. Edminister, TMH. 4. Electromagnetic Waves and Radiating System-Edward C. Jordan, K.G. Balmain, PHI. 5. Electromagnetics- J.D. Kraus, TMH. 6. Elements of Electromagnetics- N.N. Rao, Pearson			

Course Articulation Matrix for Electromagnetic Theory

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	2	1	2	1	2	3	1	3	1
CO2	1	3	3	3	3	1	1	2	2	2	1	3	1	3	1
CO3	3	3	3	2	1	2	1	1	2	2	3	3	1	3	1
CO4	2	2	2	3	3	2	1	1	1	1	3	3	1	3	1
CO5	2	2	2	2	3	2	1	1	1	1	3	3	1	3	1
CO6	2	2	2	2	2	3	1	1	1	1	3	3	1	3	1

1-Slight (Low)

2-Moderate (Medium)

3-Substantial (High)

PHS205 Quantum Mechanics

School: SSBSR		**Batch: 2023-27**	
Program: Diploma In Physics		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: IV**	
1	Course Code	PHS205	
2	Course Title	Quantum Mechanics	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	1. To study the basic principles of quantum mechanics. 2. Explain the operator formulation of quantum mechanics. 3. Students learn the concept of wave function. 4. To study role of uncertainty in quantum physics. 5. Student will learn Schrodinger equation and their applications.	
6	Course Outcomes	After the completion of this course students will be able to: CO1: Pinpoint the historical aspects of development of quantum mechanics. CO2: Understand the idea of wave particle duality. CO3: understand the uncertainty relations and its applications. CO4: explain the postulates of quantum mechanics. CO5: solve the Schrödinger equation and describe the properties of a particle in simple potential wells. CO6: appreciate quantum mechanics with wave function approach and can apply it on real life problems.	
7	Course description	This course develops concepts in quantum mechanics such that the behaviour of the physical universe can be understood from a fundamental point of view. It provides a basis for further study of quantum mechanics.	
8	Outline Syllabus		CO Mapping
	Unit 1	**Introduction to modern physics**	
	A	Need for Quantum Physics-Historical Overview: Inadequacy of classical physics	CO1
	B	origin of quantum theory, Blackbody radiation and Plank's hypothesis	CO1
	C	Photo electric effect, Compton Scattering, Pair production.	CO1
	Unit 2	**Wave Aspect of Particles**	
	A	Matter waves: de-Broglie Hypothesis. Experimental evidence: Davission and Germer experiment, G.P. Thomson experiment	CO2
	B	Electron diffraction and wave-particle duality of matter and light, Quantization of Energy,	CO2
	C	Quantum mechanics on the basis of Bohr's theory; Sommerfield theory, Short comings of old quantum theory.	CO2
	Unit 3	**Uncertainty principle**	
	A	Wave packets, Phase velocity and Group velocity, Superposition Principle	CO3
	B	The Heisenberg Uncertainty Principle - Statement, interpretation and examples:	CO3
	C	Non existence of electron in a nucleus, radius of Bohr's first orbit, binding energy.	CO3
	Unit 4	**Basic features of Quantum Mechanics**	

	A	Basic postulates of Quantum Mechanics.	CO4
	B	Wave functions, Probability Density, Observable and operators. Expectation values	CO4
	C	Pauli's exclusion principle, Symmetric and anti-symmetric wave functions.	CO4
	Unit 5	**Schrodinger Equation and Applications**	
	A	Equation of motion of matter waves: Time In-dependant Schrodinger equation, Time dependant Schrodinger equation	CO5
	B	Potential well (infinite and finite), potential step,	CO5, CO6
	C	Potential barrier, tunnelling and One dimensional Harmonic Oscillator.	CO5, CO6
	Mode of Examination	Theory	
	Weightage Distribution	CA: 15% / MSE: 10% / ESE: 75%	
	Text books	**1.** Concepts of modern physics by A. Beiser **2.** Quantum Mechanics by A. Ghatak and S. Lokanathan, Macmillan India Ltd. **3.**	
	Other References	**1.** Modern Quantum Mechanics by J.J. Sakurai and San Fu Tuan (Addison Wesley) **2.** Quantum Mechanics by L.I. Schiff (Mc Graw Hill) **3.** A Text book of Quantum Mechanics, P. M. Mathews and K.Venkatesan, Tata McGraw Hill **4.** Quantum Physics by R. Eisberg and R. Resnick (Wiley and Sons) **5.** Quantum Mechanics: Concept and Applications by Nouredine Zettili **6.** Introduction to quantum mechanics by D. I. Griffiths (Pearson Education) (IInd Edition)	

Course Articulation Matrix for Quantum Mechanics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	2	1	2	1	2	3	1	1	3
CO2	1	3	2	2	3	1	1	2	2	2	1	3	1	1	3
CO3	2	2	3	2	1	2	1	1	2	2	2	3	1	1	3
CO4	2	2	2	3	3	2	1	1	1	1	3	2	1	1	3
CO5	2	2	2	2	3	2	1	1	1	1	2	3	1	1	3
CO6	2	2	2	2	2	3	1	1	1	1	3	2	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS206 Analog Electronic Devices

School: SSBSR		**Batch: 2023-27**	
Program: Diploma In Physics		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: IV**	
1	Course Code	PHS206	
2	Course Title	Analog Electronic Devices	
3	Credits	5	
4	Contact Hours (L-T-P)	3-0-4	
	Course Status	DSE	
5	Course Objective	6. 1. To provide students an understanding of fundamentals of electrical circuits and theorems. 7. To develop understanding of the working principle of Bipolar junction transistor as a switch. 8. To demonstrate JFET and MOSFET and variety of special diodes used in electronic industry. 9. To provide knowledge of basics of operational amplifier and its applications.	
6	Course Outcomes	After the completion of this course, **CO1:** Students will show that they have learned basics of electrical circuits with the help of variety of theorems. **CO2:** Students will gain knowledge of Biploar junction transistor and its various parameters **CO3:** Students will differentiate between JFET and MOSFET **CO4:** Students will learn the concept of different types of special diodes and their applications in research problems **CO5:** Students will have a clear understanding of fundamentals of operational amplifiers used in electronic industries. **CO6:** Students will get the deep insight of analog electronic devices useful in day to today life.	
7	Course Description	This course will help students to know about the fundamentals of various analog devices.	
8	Outline syllabus		CO Mapping
	Unit 1	**Electrical Circuits**	
	A	Constant current source and constant voltage source, Conversion of voltage source into current source	CO1
	B	Thevenin's theorem, Norton's theorem, Superposition theorem	CO1
	C	Maximum power transfer theorem	CO1
	Unit 2	**Bipolar Junction Transistor**	
	A	Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias, Single stage amplifier	CO2
	B	Practical circuit of transistor amplifier, DC and AC load lines analysis, Q point, h-parameter equivalent circuit	CO2
	C	Analysis of a single-stage CE amplifier using Hybrid Model, BJT as a switch	CO2, CO6
	Unit 3	**JFET and MOSFET**	
	A	Construction of JFET, Idea of channel formation, Minimum channel width, Field dependent mobility, pinch-off, I-V curves,	CO3
	B	Basic construction of MOSFET and its working, I-V characteristics and its similarity with JFET, Enhancement and depletion modes	CO3
	C	Comparison of n channel and p channel MOSFET. Applications of JFET and MOSFET	CO3
	Unit 4	**Special Diodes**	

	A	Metal Semiconductor junction (Schottky diode), Light emitting Diode, Photodiode			CO4, CO6
	B	Semiconductor Laser diode, Solar cell, Tunnel Diode			CO4, CO6
	C	Silicon-Controlled Rectifier			CO4, CO6
	Unit 5	**Operational Amplifier**			
	A	Introduction to Op-amp, Properties of ideal amplifier			CO5, CO6
	B	Inverting and non-inverting amplifier, CMRR			CO5
	C	Applications of operational amplifier as Adder, Subtractor, Differentiator, Integrator			CO5, CO6
	Mode of examination	Theory			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Integrated Electronics- Millman - Halkias, Tata Mc Graw Hill. 2. Electronic Devices and Circuit Theory- Robert Boylestad and Louis Nashelsky, Prentice Hall.			
	Other References	1. Solid State Electronic Devices- B. Streetman, Pearson Education. 2. Semiconductor Device Fundamentals- Robert F. Pierret Addison Wesley Longman. 3. Semiconductor Physics and Devices by Donald A Neaman, Tata McGraw Hill			

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	2	1	2	1	2	3	3	1	1
CO2	1	3	2	2	3	1	1	2	2	2	1	3	3	1	1
CO3	2	2	3	2	1	2	1	1	2	2	2	3	3	1	1
CO4	2	2	2	3	3	2	1	1	1	1	2	3	3	1	1
CO5	2	2	2	2	3	2	1	1	1	1	3	2	3	1	1
CO6	2	2	2	2	2	3	1	1	1	1	2	3	3	1	1

1-Slight (Low)
2-Moderate (Medium)
3-Substantial (High)

OE-BEN205 Air Pollution and Technology

School: SBSR		**Batch: 2023-2027**	
Program: B.Sc.		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: IV**	
1	Course Code	**BEN205**	
2	Course Title	**Air Pollution and Technology**	
3	Credits	3	
4	Contact Hours(L-T-P)	3-0-0	
	Course Status	Compulsory	
5	Course Objective	1. On the completion of the course one should be able to understand: 2. Concepts of air pollution. 3. How to estimate the quantity of air pollutant. 4. Be able to develop control technologies.	
6	Course Outcomes	After the successful completion of this course students will be able to:CO1: To Define the air pollution CO2: Explain the air pollution CO3: Identify the causes of air pollution. CO4: Analysis he types of air pollution. CO5: Determine the impact of air pollution. CO6: Develop the air quality sampling modeling	
7	Course Description	The main aim of the course is to provide students with a scientific and technical background in air pollution monitoring, pollution control technologies andenvironmental management. This OCW course is especially focused on industrial processes and plants. Students will also be introduced to the European legislative framework on air quality and to international conventions.	
8	Outline syllabus		CO Mapping
	Unit 1	**Introduction**	
	A	History of Air pollution and episodes, Sources of air pollution and types, Introduction to meteorology and transport of air pollution	CO1/CO6
	B	Global winds, wind rose terrestrial windprofile	
	C	Effects of terrain and topography on winds, lapse rate,maximum mixing depths, plume rise	
	Unit 2	**Transport of Pollution in Atmosphere**	
	A	Plume behavior under different atmospheric conditions,Mathematical models of dispersion of air pollutants	CO2/CO6
	B	Plume behavior in valley and terrains	
	C	Plume behavior under different meteorologicalconditions	
	Unit 3	**Effects of Air Pollution**	

	A	Effects of Air Pollution on human beings, plants and animals and Properties. Global Effects-Greenhouse effect			CO3/CO6
	B	Ozone depletion, heat island, dust storms, Automobile pollution sources and control,			
	C	Photochemical smog, Future engines and fuels			
	Unit 4	**Air Pollution Control**			
	A	Air Pollution control- at source-equipment for control of air pollution-For particulate matter-Settling Chambers- Fabric Filters-Scrubbers-Cyclones Electrostatic precipitators			CO4/CO6
	B	For Gaseous pollutants-control by absorption-adsorption scrubbers- secondary combustion after burners			
	C	Working principles advantages and disadvantages, designcriteria and examples.			
	Unit 5	**Air Quality Sampling and Monitoring**			
	A	Stack sampling, instrumentation and methods of analysisof SO2, CO			CO5/CO6
	B	Legislation for control of air pollution			
	C	Automobile pollution			
	Mode of examination	Theory			
	Weightage Distribution	CA	MSE	ESE	
		15	10	75	
	Textbook/s*	Martin Crawford, Air Pollution Control Theory, TMHPubl.			
	Other References	1. H.C Parkins, Air Pollution Mc Graw Hill Publication 2. H.S. Peavy, D.R. Row & G. Tchobanoglous, Environmental Engineering, Mc Graw Hill International Edition			

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	2	3	2	2	2	1	1	1	1	1
CO2	3	3	3	2	1	1	3	2	2	1	1	1	1	1	1
CO3	3	3	3	1	2	2	3	2	3	1	1	1	1	1	1
CO4	3	3	2	2	1	1	3	2	2	1	2	1	1	1	1
CO5	3	2	3	3	1	2	3	2	2	1	1	1	1	1	1
CO6	3	2	3	3	1	2	3	2	2	2	1	1	3	1	1

School: SBSR		**Batch :** 2023-2024	
Program:		**Current Academic Year:** 2023-2024	
Branch: All		**Semester:IV**	
1	Course Code	**ARP 306**	Course Name : **Campus to Corporate**
2	Course Title	**Campus to Corporate**	
3	Credits	2	
4	Contact Hours (L-T-P)	0-1-2	
	Course Status	Active	
5	Course Objective	To enhance holistic development of students and improve their employability skills. Provide a 360 degree exposure to learning elements of Business English readiness program, behavioural traits, achieve softer communication levels and a positive self-branding along with augmenting numerical and altitudinal abilities. To up skill and upgrade students' across varied industry needs to enhance employability skills. By the end of this semester, a will have entered the threshold of his/her 4th phase of employability enhancement and skill building activity exercise.	
6	Course Outcomes	After completion of this course, students will be able to: CO1: Develop a creative resumes, cover letters, interpret job descriptions and interpret KRA and KPI statements and art of conflict management. CO2: Build negotiation skills to get maximum benefits from deals in practical life scenarios. CO3: Develop skills of personal branding to create a brand image and self-branding CO4: Acquire higher level competency in use of logical and analytical reasoning such as direction sense, strong and weak arguments CO5: Develop higher level strategic thinking and diverse mathematical concepts through building analogies, odd one out CO6: Demonstrate higher level quantitative aptitude such as average, ratio & proportions, mixtures & allegation for making business decisions.	

7	Course Description	This penultimate stage introduces the student to the basics of Human Resources. Allows the student to understand and interpret KRA | KPI and understand Job descriptions. A student also understands how to manage conflicts, brand himself/herself, understand relations and empathise others with level-4 of quant, aptitude and logical reasoning
8	Outline syllabus – ARP 306	

	Unit 1	**Ace the Interview**	**CO MAPPING**
	A	HR Sensitization (Role Clarity | KRA | KPI | Understanding JD) | Conflict Management	CO1
	B	Negotiation Skills | Personal Branding	CO3, CO4
	C	Uploading & Curating Resumes in Job Portals, getting Your Resumes Noticed | Writing Cover Letters | Relationship Management	CO1, CO3
	Unit 2	**What is Personality? | Who Am I ? Creating a positive impression**	
	A	Group Discussion, Email writing	CO4
	B	Personal Interviews and Mock PI's followed by personalised feedback	CO4
	C	Story Telling and Analogies	CO5
	Unit 3	**Accent neutralization and Power Dressing**	
	A	JAM for confidence Building	CO6
	B	MTI reduction - Phonetics (V and A)	CO6
	C		CO6
	Unit 4	**Written Communication**	
	A	• Writing a Letter of Recommendation for Higher Studies	CO1
	B	Email Etiquettes	CO2
	Unit 5	**Problem Solving and Case Studies**	
	A	Real time Case Study Solving Exercises	CO4
	B	Intra student Mock Situation Handling Exercises	CO4
	Evaluation Weightage	*(CA)Class Assignment/Free Speech Exercises / JAM – 60% | (ETE) Group Presentations/Mock Interviews(MIP's)/GD/ Reasoning, Quant & Aptitude– 40%*	

	Text book/s*	*| Power of Positive Action (English, Paperback, Napoleon Hill) | Streets of Attitude (English, Paperback, Cary Fagan, Elizabeth Wilson) The 6 Pillars of self-esteem and awareness – Nathaniel Brandon | Goal Setting (English, Paperback, Wilson Dobson*	

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	3	2	2	3	2	2	2	1	1	2	2	2
CO2	2	2	3	3	1	1	3	2	2	1	1	1	2	2	2
CO3	2	2	3	3	2	2	3	2	3	1	1	1	2	2	2
CO4	2	2	2	3	1	1	3	2	2	1	2	1	2	2	2
CO5	2	2	3	3	1	2	3	2	2	1	1	1	2	2	2
CO6	2	2	3	3	1	2	3	2	2	2	1	1	2	2	2

PHS252- Modern Physics Lab

School: Sharda School of Basic Sciences and Research		**Batch: 2023-27**	
Program: B.Sc. (Hons)		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: IV**	
1	Course Code	PHS252	
2	Course Title	Modern Physics Lab	
3	Credits	1	
4	Contact Hours (L-T-P)	0-0-2	
	Course Status	Compulsory	
5	Course Objective	**1.** To provide students an understanding of discrete nature of radiation by Planck's constant and Frank-Hertz experiment. **2.** To provide students an understanding of silicon solar cell. **3.** To study Lissajous figures by using CRO and transverse and longitudinal mode of vibrations by tuning fork. **4.** To study speed of ultrasonic waves in kerosene oil.	
6	Course Outcomes	After the completion of this course, **CO 1:** Students will show that they have learned fundamentals of mercury vapor filled tubes and discrete energy levels. **CO 2:** Students will understand basics of solar cell and their characteristics. **CO 3:** Students will have a clear understanding cathode ray tube and measure e/m ratio. **CO 4:** Students will learn the concept of superposition of waves "Lissajous figures by using C.R.O". **CO 5:** Students will gain knowledge of longitudinal and transverse mode of vibrations by tuning fork. **CO 6:** Students will be able to correlate theory and practical together and get the clear understanding of waves and oscillations.	
7	Course Description	This course will help students to have basic understanding of quantum mechanics and wave and oscillations. These experiments enable students to see various oscillators in action, investigate factors that affect their periodic time and represent the motion graphically. They are suitable for students at introductory and intermediate levels of study.	
8	Outline syllabus		CO Mapping
	Unit 1		
	A B C	3. To determine the Planck's constant by measuring radiation in a fixed spectral range. 4. To measure the excitation potential of mercury using the Franck-Hertz method.	CO1
	Unit 2		
	A B C	3. To determine the value of the ratio of charge to mass (e/m) of an electron by Thomson's method using a cathode-ray tube. 4. To study Solar cell characteristics.	CO2 CO3
	Unit 3		
	A B C	5. Study of damping a bar pendulum and determination of coefficient of damping, relaxation time, and quality factor of a damped simple harmonic motion.	CO4 CO5 CO6

		6. To determine the frequency of an electrically maintained tuning fork using Melde's Apparatus. (i). Transverse mode of vibration (ii). Longitudinal mode of vibration			
	Unit 4				
	A B C	7. Calculate the speed of ultrasonic waves in kerosene oil. 8. To determine unknown frequency or to compare the frequencies of two unknown signals with the method of Lissajous figures by using C.R.O.			CO4 CO6
	Unit 5				
	A B C	9. To measure the phase difference between current and voltage in R-C and L-R circuits with the method of Lissajous figures by using a CRO. 10. To determine the velocity of sound using resonance tube.			CO5 CO6
	Mode of examination	Practical/Viva			
	Weightage Distribution	CA	CE	ESE	
		25%	25%	50%	
	Text book/s*	4. B.Sc. Practical Physics- Harnam Singh, S. Chand Publishing 5. B.Sc. Practical Physics- C L Arora, S. Chand Publishing			
	Other References	1. Vibrations and Waves by A. P. French. (CBS Pub. & Dist., 1987) 2. Fundamentals of Waves & Oscillations by K. Uno Ingard (Cambridge University Press, 1988)			

Course Articulation Matrix

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	3	2	3	1	1	1	2	3	2	2	1	1	2	1
CO2	3	3	3	2	1	1	1	2	3	2	2	1	1	2	1
CO3	3	3	2	2	1	1	1	2	3	2	2	1	1	2	1
CO4	3	3	3	2	1	1	1	2	3	2	2	1	1	2	1
CO5	3	3	2	2	1	1	1	2	3	2	2	1	1	2	1
CO6	3	3	3	2	1	1	1	2	3	2	2	1	1	2	1

PHS253 Basic Electronics Instrumentation Lab

School: SSBSR		**Batch: 2023-2027**	
Program: DIPLOMA IN PHYSICS		**Current Academic Year: 2024-2025**	
Branch: Physics		**Semester: IV**	
1	Course Code	**PHS253**	
2	Course Title	**Basic Electronics Instrumentation**	
3	Credits	2	
4	Contact Hours (L-T-P)	0-0-4	
4	Course Status	CC	
5	Max. Marks	25+25+50 = 100	
6	Min. Marks		
7	Course Objective	This course provides an opportunity to study and determine the electronic properties using different electronic components /instruments and to give an insight in simulation techniques and provide a basis for modelling.	
8	Course Outcomes	After the completion of this course, the student will be able to CO1. Apply the concept of a transistor as an amplifier and perform different types of amplifier configurations like CE, CB and CC amplifiers CO2. Apply the concept of a transistor in the circuit as Clippers and Clampers & Emitter Follower CO3. Measurement of frequency response of single stage RC coupled amplifier and single stage Transformer coupled amplifier CO4. Comprehend the effect of negative feedback on frequency response of RC coupled amplifier and will be able to carry out complete study of Schmitt Trigger CO5. Examine the working of Hartley oscillator and Wein Bridge oscillator in the form of sinusoidal output waveform. CO6. Comprehend the working of Amplifiers, Oscillators and different electronic circuits for Industrial Applications.	
9	Course Description	This course has the most striking impact on the industry wherever the components / Instruments are used to study and determine the electronic properties. Measurement precision and perfection is achieved through Lab Experiments. Online Virtual Lab Experiments give an insight in simulation techniques and provide a basis for modelling.	
10	Outline syllabus: This course involves the study of different components /instruments for determining the electronic properties through which measurement precision and perfection can be achieved.		CO Mapping
	Unit 1	**Transistor Bias Stability and Comparative Study of CE, CB and CC amplifier**	
	A	To study the different biasing modes of a transistor and understand bias stability.	CO1
	B	To study and understand the function of a BJT transistor as a switch and load lines for a BJT transistor.	CO1
	C	To use a transistor as an amplifier and study different types of amplifier configurations like CE, CB and CC amplifiers.	CO1
	Unit 2	**Clippers & Clampers and Study of Emitter Follower**	
	A	To understand Clipping Circuits by constructing a positive clamper circuit.	CO2
	B	To understand Clipping Circuits by constructing a negative Clamper circuit.	CO2
	C	To understand Clipping Circuits by constructing a positive biased Clamper circuit.	CO2

	Unit 3	**Frequency response of single stage RC coupled amplifier and single stage Transformer coupled amplifier**			
	A	To study and understand the basics of RC coupled amplifier and Transformer coupled amplifier.			CO3
	B	To study the Frequency response of single stage RC coupled amplifier.			CO3
	C	To study the Frequency response of single stage Transformer coupled amplifier.			CO3
	Unit 4	**Effect of negative feedback on frequency response of RC coupled amplifier and Study of Schmitt Trigger**			
	A	To study and understand the basics of introducing negative feedback on amplifier and its advantages.			CO4, CO6
	B	To study the effect of negative feedback on frequency response of RC coupled amplifier.			CO4, CO6
	C	Oscillator Circuits: Use of positive feedback for oscillator operation. Barkhausen criterion for selfsustained oscillations. Feedback factor and frequency of oscillation for RC Phase Shift oscillator and Wein Bridge oscillator. Qualitative discussion of Reactive Network feedback oscillators (Tuned oscillator circuits): Hartley & Colpitt oscillators.			CO4, CO6
	Unit 5	**Study of Hartley oscillator and Wein Bridge oscillator**			
	A	To study and understand the basics of Hartley oscillator and Wein Bridge oscillator.			CO5, CO6
	B	To design and set up a Hartley oscillator using BJT and to observe the sinusoidal output waveform.			CO5, CO6
	C	To design and set up a Wein Bridge oscillator using BJT and to observe the sinusoidal output waveform.			CO5, CO6
	Mode of examination	Practical			
	Weightage Distribution	CA	CE	ESE	
		25%	25%	50%	
	Text book/s*	• J. Millman, C.C. Halkias, Satyabrata Jit, "Electronic Devices and Circuits", McGraw Hill, 2015, 4e • B.G. Streetman, S.K. Banerjee, "Solid State Electronic Devices", Pearson Education India, 2015, 7e			
	Suggestive Digital Platforms / Web Links	• Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/psac/# • Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/be/# • Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/index.php?sub=1&brch=201 • Virtual Labs at Amrita Vishwa Vidyapeetham, http://vlab.amrita.edu/index.php?sub=59&brch=269			

Course Articulation Matrix for Physics Lab 7: Basic Electronics Instrumentation Lab

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	2	2	1	1	1	1	2	3	2	2	1	3	2	1
CO2	2	2	2	1	1	1	1	2	3	2	2	1	3	2	1
CO3	2	2	3	1	1	1	1	2	3	2	2	1	3	2	1
CO4	2	2	2	1	1	1	1	2	3	2	2	1	3	2	1
CO5	2	2	3	1	1	1	1	2	3	2	2	1	3	2	1
CO6	2	2	3	1	1	1	1	2	3	2	2	1	3	2	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

RBL002 RBL-2: Research Based Learning-2

School: SSBSR		**Batch:2023-2027**	
Program: B. Sc		**Current Academic Year: 2024-25**	
Branch:Physics		**Semester IV**	
1	Course Code	RBL002	
2	Course Title	Research Based Learning 2	
3	Credits	Audit Based	
4	Contact Hours (L-T-P)	(0-0-2)	
	Course Status	Compulsory	
5	Course Objective	• Develop knowledge of a specific area of specialization. • Develop research skills especially in project writing and oral presentation.	
6	Course Outcomes	CO1: Articulate research-based investigation done on a topic CO2: Demonstrate capacity to identify theoretical/ experimental method followed in the research articles CO3: Demonstrate an understanding of the ethical issues associated with practitioner research CO4: Compare research data and extract the outstanding results CO5: Report research findings in written and verbal forms CO6: Use research findings to advance education theory and practice	
7	Course Description	Reading in a field of special interest under the supervision of a faculty member. Intended for students interested in studying topics not offered in regularly available courses. Format and grading are determined by the supervising faculty member and the audit members then approved by the Head of Department.	
8	Outline		CO Achievement
	Part 1	**Introduction to various research problems**	**CO1**
	Part 2	**Identify a research question**	**CO2, CO3**
	Part 3	**Literature survey**	**CO4**
	Part 4	**Report writing**	**CO5**
	Part 5	**Presentation**	**CO6**
	Mode of examination	4. Rubric assessment 5. Monthly Presentation to be audited by supervisor 6. Mid Term Presentation and End Term Presentation	
	Text book/s*	10 Recent International Journal Articles of repute.	
	Other References	-	

Course Articulation Matrix for RBL-2: Research Based Learning 2

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	3	3	3	1	1	1	2	3	2	2	1	2	2	2
CO2	2	3	3	3	1	1	1	2	3	2	2	1	2	2	2
CO3	2	3	3	3	1	1	1	2	3	2	2	1	2	2	2
CO4	2	3	3	3	1	1	1	2	3	2	2	1	2	2	2
CO5	2	3	3	3	1	1	1	2	3	2	2	1	2	2	2
CO6	2	3	3	3	1	1	1	2	3	2	2	1	2	2	2

Course Exit Summer Internship

(After Ist year / 2nd year Course Exit)

School: SBSR		**Batch: 2022-2026**	
Program: Certificate/Diploma In Physics		**Current Academic Year: 2023-2024**	
Branch: Physics		**Semester: Course Exit Summer Internship**	
1	Course Code	**VOP202**	
2	Course Title	**Vocational course in Computation Physics using Sci Lab**	
3	Credits	4	
4	Contact Hours (L-T-P)	0-0-8	
4	Course Status	Vocational	
5	Max. Marks	25+25+50 = 100	
6	Min. Marks		
7	Course Objective	• To Understand Scilab basics • To learn inbuild functions of scilab and will learn to define new function and Students will have good understanding of Linear algebra • Students will able to evaluate, analyze and plot results, To verify various physics laws • The course contents will enable the students to learn basic SCILAB programming for to develop skills of writing programs to solve problems • After training over this course, learners may teach this programming as a helper • In different companies (HCL, Wipro, etc..), learners may use this programming to analyse risk analysis and to compare prices in consideration of other factors	
8	Course Outcomes	CO1. To install an open access programming platform sci lab software and able to identify different windows of Sci Lab CO2. To define variables, arrays, conditional statements and apply inbuilt and user defined functions. CO3. To write programs on mathematical operations to analyze matrices and differential equation using Sci Lab. CO4. Apply different problem-solving skills of Sci Lab for plotting of different functions. CO5. Apply different problem-solving skills of Sci Lab to analyze physics problems. CO6. This course will develop the skills of the students to write different programs for real life problems which is the requirement of current era.	
9	Course Description	This course is about to understand scilab basics, to learn inbuild functions of scilab and will learn to define new function, to verify various physics laws and to solve mathematical problems.	
10	Outline syllabus: This course is about to understand scilab basics, to learn inbuild functions of scilab and will learn to define new function, to verify various physics laws and to solve quantum mechanics problems.		CO Mapping
	Unit 1	**Introduction to Scilab and its installation**	
	A	Command window, Figure window, Editor window	CO1
	B	Variables and arrays, Initializing variables in Scilab	CO1
	C	Introduction to Scilab file processing, file opening and closing	CO1
	Unit 2	**Inbuilt functions and User Defined Functions**	
	A	Built in Scilab functions: their uses and applications	CO2
	B	Solution of real-life problems using inbuild functions and user Defined Functions, displaying output data	CO2
	C	break and continue statements, use of functions in analysis, probability and statistics	CO2
	Unit 3	**Mathematical problems and Vector analysis**	
	A	Addition, subtraction, multiplication, increment, decrement	CO3
	B	supplements on metrices and vectors, operations in metrices	CO3
	C	solving first order and second order differential equations	CO3
	Unit 4	**Plotting and Problem-solving skills using loops in Sci lab**	
	A	Introduction to plotting, 2D and 3D plotting, plotting of bivariate statistical data,	CO4, CO6
	B	relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements	CO4, CO6

	C	nested loops, logical arrays and vectorization, comparison operators			CO4, CO6
	Unit 5	**Practical related to solve Physics problems**			
	A	Ohm's law, Hook's law, Calculation of spring constant			CO5, CO6
	B	How to draw a straight line with and without regression method using some experimental data, Equation of motions,			CO5, CO6
	C	Simple harmonic oscillations, developing the skills of writing a program			CO5, CO6
	Mode of examination	Practical			
	Weightage Distribution	CA	CE	ESE	
		25%	25%	50%	
	Text book/s*	Scilab text book companion for Modern Physics by K. S. Krane, Edition 2, John Wiley & Sons, 1996			
	Suggestive Digital Platforms / Web Links	• Scilab Software • Computational Physics, D.Walker, 1st Edn., 2015, Scientific International Pvt. Ltd. • Scilab by Dr. Ranjit Kumar • Introduction to Scilab, Consortium Scilab, Domaine de Voluceau -B.P. 105-78153 Le Chesnay Cedex France			
	Suggested Equivalent Online Courses	NA			

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	1	1	2	2	2	1	1	-	2	1
CO2	3	2	2	2	1	1	1	2	2	2	1	1	-	2	1
CO3	3	2	3	2	1	1	1	2	2	2	1	1	-	2	1
CO4	3	2	3	2	1	1	1	2	2	2	1	1	-	2	1
CO5	3	2	3	2	1	1	1	2	2	2	1	1	-	2	1
CO6	3	2	3	2	1	1	1	2	2	2	1	1	-	2	1

THIRD YEAR

DETAILED SYLLABUS FOR

B.SC. IN PHYSICS

SEMESTER V

PHS301 Classical Mechanics and Relativity

School: SSBSR		**Batch: 2023-27**	
Program: B. Sc. In Physics		**Current Academic Year: 2025-26**	
Branch: Physics		**Semester: V**	
1	Course Code	PHS301	
2	Course Title	Classical Mechanics and Relativity	
3	Credits	5	
4	Contact Hours (L-T-P)	5-0-0	
	Course Status	Compulsory	
5	Course Objective	1. To know about the concepts of Mechanics of single particle, system of particles, Constraints, Generalised Coordinates. 2. To explain the concepts concept of virtual work, de-Alembert's principle, Lagrange's equation, Basis of variation, Applications of calculus of variation, Generalized momenta. 3. To get introduced about the concept of Hamiltonian and Hamilton's equations of motion, Inertial frames, Galilean Transformation. 4. To analyze the concept of Michelson Morley experiment, postulates of special theory, Lorentz transformations, Velocity addition, etc.	
6	Course Outcomes	**CO1:** Learn the basic concepts of Mechanics of single particle, system of particles in vector form, centre of mass, Conservation of linear momentum, energy and angular momentum, Constraints. **CO2:** Understand the concepts Generalised Coordinates, virtual work, de-Alembert's principle, Lagrange's equation, Applications of the Lagrange's equations. **CO3:** Able to explain the Basis of variation, derivation of Lagrange's equation, Applications of calculus of variation. **CO4:** Figure out the Generalized momenta, Hamiltonian and Hamilton's equations of motion. **CO5:** State the concepts of Inertial frames, Galilean Transformation, Michelson Morley experiment, postulates of special theory, Lorentz transformations. **CO6:** Analyze the concepts of Constrained motion, Lagrangian Formalism, Calculus of Variation, The Hamilton's Equation of Motion, Special Theory of Relativity	
7	Course Description	This course is about describing the concepts of Constrained motion, Lagrangian Formalism, Calculus of Variation, The Hamilton's Equation of Motion, Special Theory of Relativity	
8	Outline syllabus		CO Mapping
	Unit 1	**Elementary Principles and Constrained motion**	
	A	Mechanics of single particle, system of particles in vector form, centre of mass	CO1
	B	Conservation of linear momentum, energy and angular momentum	CO1
	C	Constraints, Classification of constraints.	CO1
	Unit 2	**Lagrangian Formalism**	
	A	Generalised Coordinates, virtual work, de-Alembert's principle	CO2
	B	Lagrange's equation	CO2
	C	Applications of the Lagrange's equations (simple harmonic oscillator, simple pendulum, compound pendulum, double pendulum, Atwood's machine)	CO2
	Unit 3	**Calculus of Variation**	
	A	Basis of variation, derivation of Lagrange's equation	CO3
	B	Applications of calculus of variation	CO3

	C	shortest path between two points, bead sliding on a curved path, surface due to revolution around an axis			CO3
	Unit 4	**The Hamilton's Equation of Motion**			
	A	Generalized momenta, Hamiltonian and Hamilton's equations of motion			CO4, CO6
	B	Application (Simple Harmonic Oscillator, simple pendulum, compound pendulum)			CO4, CO6
	C	Phase space			CO4, CO6
	Unit 5	**Special Theory of Relativity**			
	A	Galilean Transformation, Michelson Morley experiment			CO5, CO6
	B	postulates of special theory, Lorentz transformations			CO5, CO6
	C	Velocity addition, Length contraction, Time dilation, relativity of mass, mass energy relationship			CO5, CO6
	Mode of examination	Theory/Jury/Practical/Viva			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Classical Mechanics by H.Goldstein, Narosa Publishing Home, New Delhi. 2. Classical Mechanics by N.C.Rana and P.S.Joag, Tata Mc-Graw Hill Publishing Company Limited, New Delhi.			
	Other References	3. Introduction to Classical Mechanics by R.G.Takawale and P.S.Puranik, Tata Mc-Graw Hill Publishing Company Limited, New Delhi. 4. Classical Mechanics by J.C.Upadhyaya, Himalaya Publishing House.			

Course Articulation Matrix for Classical Mechanics and Relativity

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	1	2	2	1	1	1	2	3
CO2	3	3	2	2	2	2	1	1	2	2	1	1	1	2	3
CO3	3	3	2	2	2	1	1	1	2	2	1	1	1	2	3
CO4	3	3	2	2	2	1	1	1	2	2	1	1	1	2	3
CO5	3	3	3	2	2	2	1	1	2	2	1	1	1	2	3
CO6	3	3	3	2	2	2	1	2	3	2	2	1	1	2	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS302 Oscillations and Waves

School: SSBSR		**Batch: 2023-27**	
Program: B.Sc. in Physics		**Current Academic Year: 2025-26**	
Branch: Physics		**Semester: V**	
1	Course Code	PHS302	
2	Course Title	Oscillations and Waves	
3	Credits	5	
4	Contact Hours (L-T-P)	3-0-3	
	Course Status	Compulsory	
5	Course Objective	1. To develop an idea of superposition of waves and nature of oscillation 2. To know the brief detail of damping of oscillation and energy related to the system. 3. To know about the forced damping of waves and resonance of waves and to know about the wave motion and also about the coupled oscillation. 4. Deduce the classical, differential equations of waves and to learn about the modulation, propagation and dispersion of waves. 5. To understand the basics of acoustics of building and conditions of a good quality hall.	
6	Course Outcomes	CO1: Learn the basics of waves and oscillation. CO2: Learn the superposition principle of waves and beat phenomenon and Lissajous Figures. CO3: learn about the damping of waves and about its energy. CO4: learn about forced oscillations and coupled oscillation CO5: learn about the idea of classical wave equation, propagation of waves in different media. CO6: learn about acoustics and able to apply course knowledge on mechanical and electrical systems.	
7	Course Description	This course is designed for B.Sc. third year students. This course deals the basics of different types of oscillations and waves. It also describes the basic knowledge of the subject to electrical and mechanical systems.	
8	Outline syllabus		CO Mapping
	Unit 1	**Superposition of Harmonic Oscillations**	
	A	The superposition principle and linearity, Superposition of Two Collinear Harmonic Oscillations	CO1
	B	Superposition of Two Collinear Harmonic Oscillations: Oscillations having equal and different frequencies: Beats, Application of Beats,	CO1
	C	Superposition of two perpendicular harmonic oscillations: Oscillations having equal frequencies and different frequencies, Lissajous Figures.	CO1
	Unit 2	**Free Damped Oscillations (One degree of freedom)**	
	A	Damping forces, Oscillation of systems with one degree of freedom,	CO1, CO2
	B	Energy of a weakly damped oscillator, Logarithmic Decrement, Relaxation time, Quality factor,	CO1, CO2
	C	Damped Oscillations of Mechanical impedances.	CO1, CO2
	Unit 3	**Forced Oscillations and Coupled Oscillations**	
	A	Forced Oscillations, Forced Oscillations of one dimensional harmonic oscillator: Steady State – Amplitude	CO3,
	B	Coupled Oscillations, Two coupled pendulums, Normal Coordinates and Normal Modes	CO1, CO3,
	C	Transverse vibration of a string, Classical wave equation	CO1, CO3, CO6
	Unit 4	**Wave Motion**	

	A	Differential equation of Wave motion, Wave velocities in continuous systems: Newton's Formula for velocity of sound			CO1, CO4,
	B	Modulations, Wave Groups and Pulses, Particle and Wave Velocities			CO1, CO4
	C	Normal and Anomalous dispersion			CO1, CO4
	Unit 5	**Acoustics**			
	A	Acoustics of building, Condition for a good hall			CO4, CO5
	B	Reverberation time, Sabine's Reverberation formula			CO5, CO6
	C	Absorption Coefficient measurement.			CO5, CO6
	Mode of examination	Theory/Jury/Practical/Viva			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	The Physics of Waves and Oscillations by N.K. Bajaj (Tata McGraw-Hill, 1988			
	Other References	1. Vibrations and Waves by A. P. French. (CBS Pub. & Dist., 1987) 2. Fundamentals of Waves & Oscillations by K. Uno Ingard (Cambridge University Press, 1988) 3. An Introduction to Mechanics by Daniel Kleppner, Robert J. Kolenkow (McGraw-Hill, 1973) 4. Waves: Berkeley Physics Course (SIE) by Franks Crawford.			

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	2	3	1	2	2	1	1	1	2	2	1	1	1	1	3
CO2	2	3	1	2	2	2	1	1	2	2	1	1	1	1	3
CO3	2	3	1	2	2	1	1	1	2	2	1	1	1	1	3
CO4	2	3	1	2	2	1	1	1	2	2	1	1	1	1	3
CO5	2	3	1	2	2	2	1	1	2	2	1	1	1	1	3
CO6	2	3	1	2	2	2	1	2	3	2	2	1	1	1	3

PHS304 Instrumentation

School: Sharda School of Basic Sciences and Research		**Batch: 2023-27**	
Program: B.Sc. in Physics		**Current Academic Year: 2024-2025**	
Branch: Physics		**Semester: V**	
1	Course Code	**PHS304**	
2	Course Title	Instrumentation	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
	Course Status	DSE	
5	Course Objective	1. To provide students an understanding of fundamentals of various measurement techniques and errors along with the working principle of digital and analog instruments. 2. To demonstrate CRO, variety of transducers and sensors used in physics, material sciences, chemistry, nanotechnology and electronics. 3. To provide knowledge of various mechanical pumps in line with physics principles and theories.	
6	Course Outcomes	After the completion of this course, CO1: Students will show that they have learned basic measurements techniques and errors CO2: Students will differentiate among digital and analog instruments used in daily life CO3: Students will gain knowledge of CRO to analyze input output signals CO4: Students will have a clear understanding of fundamentals of various transducers and sensors used in professional and scientific community. CO5: Students will learn the concept of different types of mechanical pumps and their uses in research problems. CO6: Students have complete knowledge of various instruments used in laboratories and day to day life.	
7	Course Description	This course provides basic knowledge of various instruments used in scientific laboratories and the measurement errors encountered during experiments.	
8	Outline syllabus		CO Mapping
	Unit 1	**Measurement and Errors Analysis**	
	A	Instruments accuracy, precision, sensitivity and resolution range, Errors in measurements	CO1
	B	Statistical analysis – T test and chi^2 test	CO1
	C	Units and Standards of Measurements, Fundamental and Derived Units, Hierarchy of Standards.	CO1
	Unit 2	**Analog and Digital Instrumentation**	
	A	Galvanometer (moving coil, and moving magnet), Voltmeter and ammeter - Principle and working, Impedance and sensitivity, measurement of high/ low voltage, AC and DC options.	CO2
	B	Digital Instruments: Principle and working of digital meters. Comparison of analog& digital instruments.	CO2
	C	Multimeter: Principles of measurement, Specifications of a multimeter and its significance	CO2
	Unit 3	**Cathode Ray Oscilloscope**	
	A	Block diagram of basic CRO, Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only), Front panel controls	CO3

	B	Use of CRO for the measurement of voltage (dc and ac frequency, time period, Special features of dual trace),			CO3
	C	Introduction to digital oscilloscope, probes, Digital storage Oscilloscope: Block diagram and principle of working.			CO3
	Unit 4	**Transducers & Sensors**			
	A	Static and dynamic characteristics of measurement Systems.			CO4
	B	Transducers and their characteristics, Temperature transducers. Thermocouples.			CO4, CO6
	C	Sensors – definition and classification, LDR, Photo diode.			CO4, CO6
	Unit 5	**Fundamental of Vacuum System**			
	A	Characteristics of vacuum: Mean free path. Applications of vacuum.			CO5
	B	Measurement of Vacuum: Pressure gauges – Pirani and Penning Gauge.			CO5, CO6
	C	Mechanical pumps, Rotary Vane Pumps, Diffusion & Molecular pump, pumping speed.			CO5, CO6
	Mode of examination	Theory			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Industrial Instrumentation and Control; S. K. Singh; The McGraw-Hill. 2. Electronic Instrumentation: Second Edition, H. S. Kalsi; The McGraw-Hill 3. Electrical Measurements and Measuring Instruments (EMMI), A. K. Sawhney. 4. Modern Electronic Instrumentation and Measurement Techniques, Albert D. Helfrik and William D. Cooper.			
	Other References	1. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill 2. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd. 3. Statistical Methods, S. P. Gupta			

Course Articulation Matrix for Instrumentation

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	P10	P11	P12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	1	1	2	2	1	2	1	2	3
CO2	3	3	2	2	2	2	1	1	2	2	1	2	1	2	3
CO3	3	3	2	2	2	1	1	1	2	2	1	2	1	2	3
CO4	3	3	2	2	2	1	1	1	2	2	1	2	1	2	3
CO5	3	3	3	2	2	2	1	1	2	2	1	2	1	2	3
CO6	3	3	3	2	2	2	1	2	3	2	2	2	1	2	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS303 NUMERICAL ANALYSIS

School: SSBSR		**Batch: 2023-2027**			
Program: Diploma in Physics		**Current Academic Year: 2025-2026**			
Branch: Physics		**Semester: V**			
1	Course Code	**PHS303**			
2	Course Title	**Numerical Analysis**			
3	Credits	4			
4	Contact Hours (L-T-P)	3-0-2			
5	Course Status	MAJOR			
6	Max. Marks	15+10+75 = 100			
7	Min. Marks				
8	Course Objective	This course provides an opportunity to develop knowledge and understanding of the numerical analysis methods and functions and physical principles involved.			
9	Course Outcomes	CO1: Demonstrated understanding of common numerical analysis of method to obtain approximate solution. CO2: Apply the calculus of finite difference to find the solution of equations. CO3: Derive various numerical methods for interpolation of data. CO4: Derive various numerical methods for Differentiation and Integration. CO5: Apply various numerical methods for Solution of Ordinary Differential Equation CO6: Analyse different mathematical operations and task as interpolation, differentiation, Integration and solution of Ordinary Differential Equation			
10	Course Description	This course provides students a full exposure to various important mathematical functions and physical principles involved in understanding the subject of numerical analysis.			
11	Outline syllabus				CO Mapping
	Unit 1	**Introduction**			
	A	Introduction to Numerical analysis, types of errors			CO1
	B	Locating Roots of Equations, solution of transcendental equations: Bisection method			CO1
	C	solution of transcendental equations: Newton- Raphson method			CO1
	Unit 2	**Calculus of finite difference**			
	A	Finite differences			CO2
	B	forward, backward			CO2
	C	Central difference tables.			CO2
	Unit 3	**Interpolation**			
	A	Newton forward interpolation formula for equi- spaced points.			CO1, CO3
	B	Newton backward interpolation formula for equi- spaced points.			CO1,
	C	Lagrange's interpolation formula for unequal spaced data.			CO1, CO3
	Unit 4	**Numerical Differentiation and Integration**			
	A	Numerical differentiation by using Newton formulae for equal intervals			CO1, CO4,
	B	numerical integration by Trapezoidal rule			CO1, CO4
	C	numerical integration by Simpson's $1/3^{rd}$ & $3/8^{th}$ rule.			CO1, CO4
	Unit 5	**Solution of Ordinary Differential Equation**			
	A	Solution of differential equation by Euler's method, modified Euler's method			CO5, CO6
	B	Solution of differential equation by Picard's method			CO5, CO6
	C	Solution of differential equation by Runge- Kutta method of second order with error estimation			CO5, CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar. 05 marks for Class Interaction			
	Weightage Distribution	CA	CE	ESE	
		15%	10%	75%	
	Text book/s*	1. Introductory Methods of Numerical Analysis by S. S. Sastry			

		2. Mathematical Physics by H K Das	
	Reference Books:	1. Numerical analysis: Richare L. Burden and J. Doujlas Faires 2. Applied numerical analysis: Gerald (Pearson) 3. Numerical analysis: G. Sankar Rao	
	Suggested Equivalent Online Courses	1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera, https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy	

Course Articulation Matrix for Numerical Analysis

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	3	1	1	2	2	1	2	1	1	3
CO2	3	3	2	2	2	3	1	1	2	2	1	2	1	1	3
CO3	3	2	2	2	2	3	1	1	3	3	3	3	1	1	3
CO4	3	2	2	1	2	3	1	1	2	3	3	2	1	1	3
CO5	3	3	2	3	2	3	1	1	2	2	2	2	1	1	3
CO6	3	3	2	3	2	3	1	1	3	3	3	2	1	1	3

Oscillation and Waves LAB

School: SSBSR		**Batch : 2023-2027**	
Program: B.Sc. In Physics		**Current Academic Year: 2025-2026**	
Branch: Physics		**SEMESTER: V**	
1	Course Code	**PHS351**	
2	Course Title	**Oscillation and Waves Lab**	
3	Credits	2	
4	Contact Hours (L-T-P)	0-0-4	
4	Course Status	CC	
5	Course Objective		
6	Course Outcomes	CO1: Apply the concept of Condensed matter Physics to determine various properties of liquid CO2: Apply the concept of solid-state physics to determine the acoustic and optical properties of materials CO3: Apply the concept of oscillation and waves to determine the velocity of sound in air. CO4: Apply the concept of optics to study the various phenomenon of reflection CO5: Apply the concept of optics to study the various phenomenon of refraction CO6: Experimental technique to study the various properties of different phases of matter.	
7	Course Description	This course provides students a full exposure to the basic principles and essential concepts of performing experiments and calculating mechanical parameters.	
8	Outline syllabus		CO Mapping
	Unit 1		
	A	Find the velocity of Ultrasonic waves in Liquid.	CO1
	B	Find the bulk modulus of the given liquid	
	C	To find the compressibility of the Liquid	
	Unit 2		
	A	To measure the acoustical properties of material	CO2
	B	Measurement of Absorption and reflection co-efficient of material.	
	C	Measurement of Transmission loss	
	Unit 3		
	A	To find the velocity of Sound in air with the help of head phone To find the velocity of sound in air using Lissajous figure	CO3
	B		
	C		
	Unit 4		
	A	To verify the Law of reflection	CO4
	B		
	C		
	Unit 5		
	A	To verify the Law of refraction and to find the refractive index of water.	CO5,CO6
	B		
	C		

	Mode of examination	15 marks for Record File (depending upon the no. of experiments performed out of the total assigned experiments) 05 marks for Viva Voce 05 marks for Class Interaction			
	Weightage Distribution	CA	CE	ESE	
		25%	25%	50%	
	Text book/s*/Virtual modes and links	1. B.Sc. Practical Physics- Harnam Singh, S. Chand Publishing. 2. B.Sc. Practical Physics- C L Arora, S. Chand Publishing. 3. B.L. Worsnop, H.T. Flint, "Advanced Practical Physics for Students", Methuen & Co., Ltd., London, 1962, 9e 1. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=194 2. Virtual Labs an initiative of MHRD Govt. of India, http://vlabs.iitkgp.ac.in/be/# 3. Digital Platforms /Web Links of other virtual labs may be suggested / added to this lists by individual Universities			

Course Articulation Matrix for Physics Lab 6:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	1	2	3	1	2	3	2	2	2	1	1	3
CO2	2	2	3	1	2	3	1	2	3	2	2	2	1	1	3
CO3	2	2	3	1	2	3	1	2	3	3	2	2	1	1	3
CO4	2	2	3	2	2	3	1	2	3	3	2	2	1	1	3
CO5	2	3	3	2	2	3	1	2	3	2	2	2	1	1	3
CO6	2	2	3	2	2	3	1	2	3	3	3	2	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS352 Numerical Analysis Lab

School: SSBSR		**Batch: 2023-2027**	
Program: B.Sc.		**Current Academic Year: 2025-2026**	
Branch: B.Sc. In Physics		**Semester: V**	
1	Course Code	**PHS352**	
2	Course Title	**Numerical Analysis Lab**	
3	Credits	1	
4	Contact Hours (L-T-P)	0-0-2	
	Course Status	CC	
5	Course Objective	To make the students familiar with the instruments which are used to study and determine the optical properties.	
6	Course Outcomes	After the completion of this course, CO1. Students will know how to apply Bisection method, Newton Raphson method to solve various problems. CO2. Students will know how to apply Jacobi Method, Gauss Elimination Method to solve various problems. CO3. Students will know how to apply Forward interpolation, backward interpolation Method to solve various problems. CO4. Students will know how to apply trapezoidal rule to solve various problems. CO5. Students will know how to apply Runge Kutta method, Euler's Method to solve various problems.. CO6.Analyse different mathematical operations and task as interpolation, differentiation, Integration and solution of Ordinary Differential Equation	
7	Course Description	Experimental physics has the most striking impact on the industry wherever the instruments are used to study and determine the optical properties. Measurement precision and perfection will be achieved through the Lab Experiments of this course.	
8	Outline syllabus		CO Mapping
	Unit 1	**Determination of Roots**	
	A	Bisection Method	CO1
	B	Newton Raphson Method	CO1
	C	Secant Method	CO1
	Unit 2	**Matrices and Linear Systems of Equations**	
	A	Jacobi Method	CO2
	B	Gauss Elimination Method	CO2
	C	Gauss Seidal	CO2
	Unit 3	**Interpolation**	
	A	Forward interpolation,	CO3
	B	Backward interpolation.	CO3, CO4
	C	Lagrange's interpolation	CO3
	Unit 4	**Numerical Differentiation and Integration**	
	A	Trapezoidal rule	CO4
	B	Simpson1/3andSimpson3/8rules	CO4
	C	Gaussian Quadrature	CO3 ,CO4
	Unit 5	**Solution of Ordinary Differential Equation**	
	A	Euler's Method	CO5,CO6
	B	Runge Kutta Method	CO5,CO6
	C		CO5,CO6

	Mode of examination	Practical	
	Weightage Distribution	CA (25%)+CE (25%) and ESE (50%)	
	Text book/s*	• S. Panigrahi, B. Mallick, "Engineering Practical Physics", Cengage Learning India Pvt. Ltd., 2015, 1e • R.K. Agrawal, G. Jain, R. Sharma, "Practical Physics", Krishna Prakashan Media (Pvt.) Ltd., Meerut, 2019	

Course Articulation Matrix For Numerical Analysis Lab

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	3	1	2	2	2	2	2	1	1	3
CO2	3	3	2	2	2	3	1	2	2	2	2	2	1	1	3
CO3	3	2	2	2	2	3	1	2	3	3	3	2	1	1	3
CO4	3	2	2	2	2	3	1	2	2	3	3	2	1	1	3
CO5	3	3	2	3	2	3	1	2	2	2	2	2	1	1	3
CO6	3	3	2	3	2	3	1	2	3	3	3	2	1	1	3

	School: SSBSR	**Batch: 2023-2027**	
	Program: B.Sc.	**Current Academic Year:2025-2026**	
	Branch: Physics	**SEMESTER: V**	
	Course Code	**INC001**	
	Course Title	Industry Connect	
	Credits	2	
	Contact Hours(L-T-P)	0-0-4	
	Course Status	Compulsory	
	Course Objective	This course will expose students to apply theories learned in the classroom and providescurrent technological developments relevant to the subject area of training. Students will be able to identify the career preferences and professional goals.	
	Course Outcomes	Students will be able to: CO1: Get familiarize with industry principles and practices.CO2: Identify and analyze an appropriate problem. CO3: Develop teamwork and apply prior acquired knowledge in problem solving.CO4: Demonstrate effective verbal and written communication skills. CO5: Practice scientists' responsibilities, self-understanding, self-discipline and ethicalstandards. CO6: Identify the career preferences and professional goals.	
	Course Description	The Internship aims to offer students the opportunity to apply their prior acquired knowledge in problem solving. Students will acquire skills important for time management, discipline, self-learning, and effective communication and so on.	
	Outline syllabus		**CO Mapping**
	Unit 1		
	A, B, C	Define objectives and conditions for the internship, ensuring students that itis related to the study path carried out at the University	CO1, CO6
	Unit 2		
	A, B, C	Problem Definition and identification, Team/Group formation and ProjectAssignment. Finalizing the problem statement, resource requirement, if any.	CO2, CO6
	Unit 3		
	A, B, C	The internship work plan is drawn up by developing team work and applies Prior acquired knowledge in problem solving.	
	Unit 4		
	A, B, C	Demonstrate and execute Project with the team. Submission of evaluationform and final report completed by the intern.	
	Unit 5		

	A, B, C	Final evaluation form completed by the supervisor at the Host Organization and final presentation before departmental committee.		
	Mode of examination	Jury+Practical+Viva		
	Weightage Distribution	CA	CE	ESE
		25	25	50

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	2	3	1	2	2	2	2	2	1	1	1
CO2	2	2	3	2	2	3	1	2	2	2	2	2	1	1	1
CO3	2	2	3	2	2	3	1	2	3	3	3	2	1	1	1
CO4	2	2	3	2	2	3	1	2	2	3	3	2	1	1	1
CO5	2	2	3	3	2	3	1	2	2	2	2	2	1	1	1
CO6	2	2	3	3	2	3	1	2	3	3	3	2	1	1	1

RBL003 Research Based Learning 3

School: SBSR		**Batch:2023-2027**			
Program: B.Sc. In Physics		**Current Academic Year: 2025-26**			
Branch:Physics		**Semester V**			
1	Course Code	RBL003			
2	Course Title	Research Based Learning 3			
3	Credits	1			
4	Contact Hours (L-T-P)	(0-0-2)			
	Course Status	Compulsory			
5	Course Objective	• Develop knowledge of a specific area of specialization. • Develop research skills especially in project writing and oral presentation.			
6	Course Outcomes	CO1: Apply the understanding of various research articles to identify research gap on a given topic CO2: Extract line of approach to overcome the research gap CO:3 Conclude appropriate method/s suitable for a given problem CO:4 Identify characterization techniques/ theoretical analysis for obtaining result CO:5 Explain graphs, diagrams, flow chart etc. CO:6 Report research findings in written and verbal forms			
7	Course Description	Reading in a field of special interest under the supervision of a faculty member. Intended for students interested in studying topics not offered in regularly available courses. Format and grading are determined by the supervising faculty member and the audit members then approved by the Head of Department.			
8	Outline				CO Achievement
	Part 1	**Introduction to various research problems**			**CO1**
	Part 2	**Identify a research question**			**CO2, CO3**
	Part 3	**Literature survey**			**CO4**
	Part 4	**Report writing**			**CO5**
	Part 5	**Presentation**			**CO6**
	Mode of examination	7. Rubric assessment 8. Monthly Presentation to be audited by supervisor 9. Mid Term Presentation and End Term Presentation			
	Weightage	CA	CE (Viva + PPT)	ETE	
		25	25	50	
	Text book/s*	10 Recent International Journal Articles of repute.			
	Other References	-			

Course Articulation Matrix for RBL-3; Research Based Learning-3

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2
CO2	2	3	3	3	3	3	1	2	3	3	3	2	2	2	2
CO3	2	3	3	3	3	3	1	2	3	3	3	2	2	2	2
CO4	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2
CO5	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2
CO6	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2

SEMESTER VI

Atomic and Molecular Physics

School: SSBSR		**Batch: 2023-27**	
Program: BSc (Physics)		**Current Academic Year: 2025-26**	
Branch:		**Semester: VI**	
1	Course Code	PHS305	
2	Course Title	Atomic and Molecular Physics	
3	Credits	5	
4	Contact Hours (L-T-P)	5-0-0	
	Course Status	Compulsory	
5	Course Objective	1. To know concept of atomic particle and structure of an atom. 2. To understand the orbital and spin motion of an electron in an atom. 3. To know the concept of pauli principle and coupling. 4. To understand the concept of molecular spectra and scattering mechanism concept of pauli principle and coupling.	
6	Course Outcomes	After the completion of this course, the student will be able to **CO1:** To understand the electron discovery and different atomic models **CO2:** To know the hydrogen atom spectra and the relativistic corrections for the energy levels of the hydrogen atom. **CO3:** To explain the observed dependence of atomic spectral lines on externally applied electric and magnetic fields. **CO4:** To understand the importance of spin orbit interactions. **CO5:** State and justify the selection rules for various optical spectroscopies in terms of the symmetries of molecular vibrations, Raman Spectra and Raman Scattering. **CO6:** To understand the concepts and potential applications of atomic and molecular physics and successfully apply the theoretical techniques presented in the course to practical problems.	
7	Course Description	Atom and molecule are the fundamental unit for all matters in universe. Matter, whatever the states, is made of atoms. The properties of all matters are governed by the electronic structure of atom and molecule. They have individual properties like electronic, magnetic and optical properties, which are quite different from the collective properties of matter made of atoms and molecules. This course will enlighten the knowledge of atoms and molecules and build up the pre-requisite knowledge for all science and engineering field. The course contains description of atomic models, atomic spectra, energy levels of hydrogen atom and other heavier atoms, effect of magnetic and electric field on the energy spectra, spin orbit interactions, molecular spectra, Raman spectra and Raman Scattering.	
8	Outline syllabus		CO Mapping
	Unit 1	**Atomic model**	
	A	Elementary particles of atom; Atom radius; electron's discovery	CO1,
	B	Thomson model, Rutherford model, Bohr's model, Somerfield model	CO1
	C	Bohr's postulates, Bohr's theory of hydrogen atom, Somerfield correction.	CO1
	Unit 2	**Atom in electric and magnetic field**	
	A	Electron Angular Momentum, Space Quantization, Electron Spin and Spin Angular Momentum.	CO2
	B	Larmor's Theorem, Spin Magnetic Moment, Stern-Gerlach Experiment	CO2
	C	Total Angular Momentum of an electron, Gyromagnetic Ratio and Bohr Magneton. Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).	CO3
	Unit 3	**Many electrons atoms**	
	A	Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions	CO3

	B	Fine structure, Spin orbit coupling, Spectral Notations for Atomic States, Total Angular Momentum			CO3
	C	Vector Model, L-S and J-J couplings, Hund's Rule, selection rules, Spectra of Hydrogen and Alkali Atoms (Na etc.).			CO4
	Unit 4	**Molecular Spectra**			
	A	Born-Oppenhiemer approximation, potential energy curve			CO4
	B	Introduction to rotational and vibrational spectra of a molecule			CO4, CO6
	C	Introduction to electronic spectra of a molecule, energy levels and Selection rule.			CO5, CO6
	Unit 5	**Scattering**			
	A	Rayleigh scattering			CO5, CO6
	B	Raman scattering, Raman Effect			CO5, CO6
	C	Characteristics of Raman Lines, Stoke's and Anti-Stoke's Lines.			CO5, CO6
	Mode of examination	Theory/Jury/Practical/Viva			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. Introduction to Atomic Spectra: H.E. White. 2. Atomic and Molecular Spectra, Raj Kumar, Kedar Nath and Ram Nath. Delhi.			
	Other References	3. Physics of Atoms and Molecules: Bransdenand Joachain. 4. Introduction to Atomic Spectra: HG Kuhn. 5. Fundamentals of Molecular Spectroscopy, IVth Edition, Colin N. Banwell and Elaine M. McCash,Tata McGraw Hill Publishing Company Limited, New Delhi. (Text Book)			

Course Articulation Matrix Atomic and Molecular Physics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	1	1	2	1	1	2	3	2	2	1	1	3
CO2	2	3	1	1	1	2	1	1	2	3	2	2	1	1	3
CO3	2	3	1	1	1	2	1	1	2	3	2	2	1	1	3
CO4	1	3	2	1	1	2	1	1	2	3	2	2	1	1	3
CO5	1	3	2	1	1	2	1	1	2	3	2	2	1	1	3
CO6	1	1	2	1	1	2	1	1	2	3	3	2	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS306 Nuclear Physics

School: SSBSR		**Batch: 2020-23**	
Program: B.Sc. In Physics		**Current Academic Year: 2021-22**	
Branch: Physics		**Semester: VI**	
1	**Course Code**	**PHS306**	
2	**Course Title**	**Nuclear Physics**	
3	**Credits**	**5**	
4	**Contact Hours (L-T-P)**	**5-0-0**	
	Course Status	**Compulsory**	
5	**Course Objective**	This course aims: 1. To explore nuclear matter 2. To introduce students to the concepts governing nuclear models 3. To explain nuclear decay and radioactivity 4. To learn about various detectors	
6	**Course Outcomes**	**Upon successful completion of this course students will /will be able to:** **CO1:** Explain the properties of nucleus and illustrate how to measure radius of the nucleus; Describe various models of the nucleus **CO2:** Evaluate half-life, mean lifetime, activity of the decaying nucleus **CO3:** Explain the theory behind alpha beta and gamma decay **CO4:** Compare different types of nuclear reactions and learn about nuclear fission and fusion and their reactors **CO5:** Explain the concept of nuclear detection and differentiate various counters **CO6:** Acquire relevant knowledge about nuclear physics to apply it to the real-life problems.	
7	**Course Description**	This course illustrates in depth the composition and properties of nucleus, nuclear forces, different models depicting the nucleus, laws governing radioactivity, nuclear decay, types of nuclear reactions and introduces to the concept nuclear detection.	
8	Outline Syllabus		CO Mapping
	Unit 1	**Nuclear Structure**	
	A	**Structure:** Nuclear Composition- basic concepts of neutrons, protons, electrons, atomic number, isotopes, atomic mass unit; Experimental procedure to measure nuclear size- Rutherford scattering formula	CO1
	B	**Properties:** Properties of the Nucleus- charge, mass, size of the nucleus, angular momentum, spin, parity and magnetic moment, nuclear forces; Stable Nuclei- odd-even effect, pairing of nucleons, N-Z diagram; Binding Energy of the Nucleus- binding energy per nucleon;	CO1
	C	**Models**: Nuclear Models- (i) The Liquid-Drop Model- volume effect, surface effect, Coulomb repulsion effect, symmetry effect, semi-empirical binding-energy formula (Weizackers's-Bethe mass formula) (ii) The Shell Model- evidences, theory, energy level diagram, spin-orbit interaction, magic numbers	CO1
	Unit 2	**Radioactivity**	
	A	**Discovery:** Discovery of radioactivity; Types of radioactive decay	CO2
	B	**Laws:** Radioactivity- the laws of radioactive decay, half-life, mean lifetime, Activity; Natural Radioactivity and Radioactive Dating (^{14}C, ^{40}K)	CO2
	C	**Series:** Radioactive Series	CO2

	Unit 3	**Nuclear Decay**			
	A	**Alpha decay:** The Decay Processes- (i) Alpha Decay- disintegration energy (Q-value calculation), alpha-particle energy, Gamow's theory/tunnel theory of alpha decay, Geiger-Nuttal Law and alpha particle spectra			CO3
	B	**Beta Decay:** Beta Decay- negative and positive beta decay, electron capture, Q-value calculation, beta ray spectra, neutrino hypothesis, non-conservation of parity in beta decay			CO3
	C	**Gamma Decay:** Gamma Decay- gamma rays, internal conversion, recoil of nucleus.			CO3
	Unit 4	**Nuclear Reactions**			
	A	**Laws:** Introduction; Conservation Laws in Nuclear Reactions- disintegration energy or Q-value, exothermic and endothermic reactions, threshold energy;			CO4, CO6
	B	**Fission:** Nuclear Fission; Fission in Liquid Drop Model; Chain Reactions; Nuclear Reactors;			CO4, CO6
	C	**Fusion:** Nuclear Fusion; Fusion Reactors and their uses			CO4, CO6
	Unit 5	**Nuclear Radiations and Detectors**			
	A	**Detection-Counters:** Introduction, Concepts to radiation detection, GM Counter and Bubble Chamber, Scintillation Counter;			CO5, CO6
	B	**Radiation Hazard:** Radiation Hazards, Radiation protection and covering.			CO5, CO6
	C	**Benefits:** Beneficial uses of Radiation- tracing, materials analysis, radiation therapy, food preservation, etc.;			CO5, CO6
	Mode of Examination	Theory			
	Weightage Distribution	CA	MTE	ETE	
		15%	10%	75%	
	Text books	1. Concepts of Modern Physics-Arthur Beiser (Tata McGraw Hill Education) 2. Nuclear Physics-Alex E S Green (Tata McGraw Hill Education) 3. Introductory Nuclear Physics-David Halliday (Asia Publishing House)			
	Other References	1. Concepts of Nuclear Physics- B L Cohen (Tata McGraw Hill Education) 2. Nuclear Physics-J B Rajam (S Chand Publishing Co.) 3. Nuclear Physics- S N Ghoshal (S Chand Publishing Co.) 4. Nuclear Physics-D C Tayal (Himalayan Publishing House) 5. Concept of Nuclear Physics- S P Kuila 6. Nuclear and Particle Physics-S L Kakani & Shubhra Kakani			

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	1	1	1	1	1	2	3	2	2	1	1	3
CO2	3	3	2	1	2	1	1	1	2	3	2	2	1	1	3
CO3	3	3	2	1	2	1	1	1	2	3	2	2	1	1	3
CO4	3	3	1	1	1	1	1	1	2	3	2	2	1	1	3
CO5	3	3	1	1	1	1	1	1	2	3	2	2	1	1	3
CO6	3	3	2	1	2	1	1	1	2	3	3	2	1	1	3

1-Slight (Low)

2-Moderate (Medium)

3-Substantial (High)

PHS307 Statistical Mechanics

School:SSBSR		**Batch: 2023-27**	
Program: B.Sc. In Physics		**Current Academic Year: 2025-26**	
Branch: Physics		**Semester: VI**	
1	**Course Code**	**PHS307**	
2	**Course Title**	**Statistical Mechanics**	
3	**Credits**	**4**	
4	**Contact Hours (L-T-P)**	**4-0-0**	
	Course Status	**Compulsory**	
5	**Course Objective**	This course aims: 1. To establish an understanding of the basics of Statistical mechanics. 2. Students are made aware of the concept of phase space, ensembles and the types of ensembles. 3. To make students aware of partition function, Maxwell velocity distribution and Gibb's paradox. 4. To provide detailed understanding of black body radiation and its properties.	
6	**Course Outcomes**	**Upon successful completion of this course, the student will be able to:** **CO1:** Acquire knowledge of phase space, entropy, classical and quantum statistics. **CO2:** Understand the concept of ensembles and their types and probability functions. **CO3:** Develop an understanding of Entropy of mixing and Gibb's paradox, Sackur Tetrode equation, Maxwell Boltzmann Statistics and partition function. **CO4:** Learn fundamentals of thermal radiation, black body radiation and its properties, Rayleigh jeans law, Planck's law of Radiation. **CO5:** Learn the concept of quantum statistics, Boson gas, fermions, B-E statistics and Fermi dirac statistics **CO6:** Understand, analyze and apply the concept of statistical mechanics to various problems which help to explain the behavior of large system.	
7	**Course Description**	This course introduces the various concepts, methods and terminologies of statistical mechanics that are further used to develop the statistics for Bose-Einstein, Fermi-Dirac etc. Also to understand the concept of Radiation. Statistical Mechanics can be used to explain the thermodynamic behavior of large system.	
8	Outline syllabus		CO Mapping
	Unit 1	**Introduction to Classical Statistics**	
	A	Scope and aim of Statistical mechanics, Transition from thermodynamics to statistical mechanics, Classical and quantum statistics.	CO1
	B	Statistical approach to thermodynamic quantities: (Pressure, temperature, internal energy, Entropy)	CO1
	C	Entropy as a variable of state, Thermodynamic probability, Microscopic and Macroscopic states, Phase Space	CO1
	Unit 2	**Concepts of ensembles**	
	A	Contact between statistical and thermodynamic quantities, Boltzmann relation for entropy	CO2

	B	Calculation of thermodynamic properties, Elementary concept of Ensemble: micro-canonical, canonical and grand-canonical ensembles			CO2
	C	Ω_0 as a function of energy, Calculation of Ω_{MB}.			CO2
	Unit 3	**Classical Statistics**			
	A	Statistical approach to the laws of classical thermodynamics, Entropy of mixing and Gibb's paradox,			CO3
	B	Sackur Tetrode equation, Maxwell Boltzmann Statistics, Partition function,			CO3
	C	Maxwell velocity distribution and mean values			CO3
	Unit 4	**Theory of Radiation**			
	A	Properties of Thermal Radiation; Blackbody Radiation; Kirchhoff's Law; Stefan-Boltzmann Law.			CO4, CO6
	B	Wien's Displacement law, Radiation Pressure, Rayleigh-Jean's Law, Ultraviolet Catastrophe,			CO4, CO6
	C	Planck's Quantum Postulates, Planck's Law of Blackbody Radiation, Experimental Verification.			CO4, CO6
	Unit 5	**Quantum Statistics**			
	A	Quantum restrictions on translational, rotational and vibration forms of the energy, Calculation of Ω_{MB} and Ω_{BE},			CO5, CO6
	B	Distribution functions: Bose-Einstein (BE) Distribution Function, Fermi Dirac (FD) Distribution function			CO5, CO6
	C	Photon gas, Boson Gas, Applications of BE and FD distributions.			CO5, CO6
	Mode of examination	Theory/Viva			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	1. 1.Fundamentals of classical and statistical thermodynamics, Bimalendu N. Roy, Wiley 2. 2.Heat thermodynamics and Statistical Physics, S. S. Singhal, J. P. Agrawal, Satya Prakash			
	Other References	1. Thermodynamics and Statistical Mechanics, Greiner, Springer 2. Statistical and Thermal Physics: an introduction by S. Lokanathan and R.S. Gambhir. 3. Thermal Physics, S. C. Garg, R. M. Bansal, C. K. Ghosh, Tata McGraw-Hill 4. Heat and Thermodynamics, Zemanskay and Dittman, McGraw Hill 5. Statistical Mechanics, R.K. Patharia, Pergamin press, Oxford			

Course Articulation Matrix Statistical Mechanics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1	1	1	1	1	2	3	2	2	1	1	3
CO2	3	1	1	1	1	1	1	1	2	3	2	2	1	1	3
CO3	2	1	1	1	1	1	1	1	3	3	3	2	1	1	3
CO4	3	2	2	3	1	2	1	1	2	3	3	2	1	1	3

CO5	3	2	1	3	1	2	1	1	3	3	2	2	1	1	3
CO6	3	2	1	2	1	2	1	1	2	3	3	2	1	1	3

School: SSBSR	**Batch: 2023-27**		
Program: B.Sc.	**Academic Year: 2025-26**		
Branch: Physics	**Semester: VI**		
1	Course Code	**BDA323**	
2	Course Title	**Multivariate Data Analysis**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
	Course Status	OE	
5	Course Objective	Familiarise students with the multivariate normal distribution, estimation of the mean vector and the covariance matrix, the distributions and uses of sample correlation coefficients, classification of observations, the distribution of the sample covariance matrix, and the sample generalized variance.	
6	Course Outcomes	CO1: Demonstrate knowledge and understanding of the multivariate normal distribution. (K2, K3) CO2: Demonstrate knowledge and understanding of the concept of estimation of the mean vector and the covariance matrix. (K2, K3) CO3: Demonstrate advanced understanding of the concepts of dimension reduction technique. (K2, K3) CO4: Describe the concepts of how to use and apply dependence techniques in multivariate data analysis. (K2, K3) CO5: Describe the concepts of analysis of variance and covariance in multivariate data analysis. (K3, K4, K5) CO6: Apply the statistical tool and software in multivariate data analysis. (K2, K6)	
7	Course Description	This module aims to provide an understanding of the multivariate normal distribution, estimation of the mean vector and the covariance matrix, the distributions and uses of sample correlation coefficients, classification of observations, the distribution of the sample covariance matrix, and the sample generalized variance.	
8			
	Unit 1		
	A	A brief review of Univariate and Bivariate distribution with their properties.	CO1
	B	Basic Multivariate Distribution: mean, variance, Covariance, correlation, and the linear combination of variables.	CO1
	C	The multivariate normal distribution, Mean Vectors, and Covariance Matrices.	CO1
	Unit 2		
	A	Multivariate normal distribution; maximum likelihood estimation, Wishart's distribution	CO2

	B	Hotelling's T2 and hypothesis testing for multivariate normal data. Inference from a single sample, Inference from two dependent samples Inference from two independent samples.	CO2
	C	Simple, Multiple, Partial, and Canonical correlations with their properties.	CO2
	Unit 3		
	A	Principal Components Analysis and derivation of principal components; PCA structural model; PCA on normal populations; bi-plots.	CO3
	B	Factor Analysis, Factor extraction Factor rotation, Factor scores Validation of factor analysis, Higher order factor analysis Q-type factor analysis	CO3, CO4
	C	Cluster Analysis, Types of clustering, Correlation, and distance, Partitioning methods, hierarchical clustering, K-means clustering, and their interpretation.	CO4
	Unit 4		
	A	Simple, Multiple, and Multivariate regression with their properties.	CO5
	B	Binary and multidimensional Logistic regression.	CO5
	C	Linear discriminant function analysis. Estimating linear discriminant functions and their properties.	CO5
	Unit 5		
	A	Analysis of variance and covariance.	CO6
	B	Multivariate analysis of variance and Covariance.	CO6
	C	Concepts of correspondence analysis, chi-square distance and inertia, multiple correspondence analysis.	CO6
	Mode of examination	Theory	
	Weightage Distribution	CA: 25%; MTE: 25%; ETE:50%	
	Text book/s*	1. Johnson, R.A. and Wichern, D.W.: (2015). Applied Multivariate Statistical Analysis, Sixth Edition, Pearson Education India. 2. Hardle, W.K. and Hlavka, Z. (2015): Multivariate Statistics, Springer.	
	Other References	1. Anderson, T.W. (2003): An Introduction to Multivariate Statistical Analysis, Third Edition, Wiley. 2. Härdle, W.K. and Simar, L. (2015): Applied Multivariate Statistical Analysis, Springer.	

Course Articulation Matrix for Multidata Variate

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	2	3	1	2	1	2	1	2	1	3	1	1
CO2	2	1	2	2	3	2	3	1	2	1	2	1	3	1	1
CO3	2	1	2	2	3	2	3	1	2	1	2	1	3	1	1
CO4	2	1	2	2	3	2	3	1	3	1	2	1	3	1	1
CO5	3	1	2	2	3	2	3	1	3	1	2	1	3	1	1
CO6	3	1	3	2	3	2	3	1	3	1	2	1	3	1	1

1-Slight (Low) **2-Moderate (Medium)** **3-Substantial (High)**

RBL004 Research Based Learning 4

School: SBSR		**Batch:2023-2027**			
Program: B. Sc		**Current Academic Year: 2025-26**			
Branch:Physics		**Semester VI**			
1	Course Code	RBL004			
2	Course Title	Research Based Learning 4			
3	Credits	1			
4	Contact Hours (L-T-P)	(0-0-2)			
	Course Status	Compulsory			
5	Course Objective	• Develop knowledge of a specific area of specialization. • Develop research skills especially in project writing and oral presentation.			
6	Course Outcomes	CO1: Reframe a research topic under study CO:2 Describe the research gap CO:3 Defend the best method to solve the problem CO4: Categorize and correlate the observations CO:5 Analyse observations and tabulate major research findings CO:6 Report research findings in written and verbal forms			
7	Course Description	Reading in a field of special interest under the supervision of a faculty member. Intended for students interested in studying topics not offered in regularly available courses. Format and grading are determined by the supervising faculty member and the audit members then approved by the Head of Department.			
8	Outline				CO Achievement
	Part 1	**Introduction to various research problems**			**CO1**
	Part 2	**Identify a research question**			**CO2, CO3**
	Part 3	**Literature survey**			**CO4**
	Part 4	**Report writing**			**CO5**
	Part 5	**Presentation**			**CO6**
	Mode of examination	10. Rubric assessment 11. Monthly Presentation to be audited by supervisor 12. Mid Term Presentation and End Term Presentation			
	Weightage	CA	CE (Viva + PPT)	ETE	
		25	25	50	
	Text book/s*	10 Recent International Journal Articles of repute.			
	Other References	-			

Course Articulation Matrix for RBL-4: Research Based Learning -4

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2
CO2	2	3	3	3	3	3	1	2	3	3	3	2	2	2	2
CO3	2	3	3	3	3	3	1	2	3	3	3	2	2	2	2
CO4	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2
CO5	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2
CO6	2	3	3	3	3	3	1	2	3	3	3	3	2	2	2

FOURTH YEAR

DETAILED SYLLABUS FOR

B.SC. (HONOURS/HONOURS WITH RESEARCH) IN PHYSICS

VII SEMESTER

School: SSBSR		**Batch:2023-2027**	
Program: B.Sc. (Honours/Honours with Research) in Physics		**Current Academic Year**	
Branch: Physics		**Semester: VII**	
1	Course Code	PHS401	
2	Course Title	Advance Quantum Mechanics	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	CC	
5	Course Objective	1. The course should give the in-depth knowledge about the foundations of quantum mechanics and skills in problem solving in quantum mechanics. 2. Various approximation methods for not exactly solvable systems. 3. To know the concept of angular momentum and scattering. 4. The course treats non-relativistic quantum mechanics, in detail and gives an introduction to relativistic quantum mechanics.	
6	Course Outcomes	After the completion of this course students will be able to: CO 1: Explain orbital and spin momentum operator formalism. CO 2: Demonstrate the time independent perturbation theory. CO 3: Explain the variational and WKB methods. CO 4: Apply the scattering theory to various problems. CO 5: Explain the relativistic quantum mechanics. CO 6: Comprehend quantum mechanical applications at the research level	
7	Course description	"Advanced Quantum Mechanics" is a core continuation course in quantum mechanics including angular momentum, approximate methods, scattering theory and relativistic quantum mechanics that aim at the applications of quantum mechanics. The course should give you deeper knowledge about the foundations of quantum mechanics and skills in problem solving in quantum mechanics.	
8	Outline Syllabus		CO Mapping
	Unit 1	**Angular Momentum**	
	A	Generalized angular momentum, Infinitesimal rotation, Generator of rotation, Commutation rules, Matrix representation of angular momentum operators	CO1
	B	Spin, Pauli spin matrices, Rotation of spin states	CO1
	C	Coupling of two angular momentum operators, Clebsch Gordon coefficients, Applications	CO1
	Unit 2	**Approximate methods: Time Independent Perturbation Theory**	
	A	Approximation methods: Time-independent perturbation theory for non-degenerate states,	CO2

	B	Approximation methods: Time-independent perturbation theory for degenerate states,	CO2
	C	Time independent perturbation theory Applications: anharmonic oscillator, Helium atom, Stark effect in hydrogen atom.	CO2
	Unit 3	**Approximation Methods: Time dependent perturbation, variational and WKB methods**	
	A	Time-dependent perturbation theory; Harmonic perturbation; Fermi's golden rule. Sudden approximation.	CO3
	B	Variational method and its applications (1-D harmonic oscillator, ground state energy of Hydrogen atom),	CO3, CO6
	C	WKB approximation and application to 1-D harmonic oscillator, WKB method; Connection formula,	CO3
	Unit 4	**Scattering Theory**	
	A	Scattering theory- Scattering of a particle by a fixed centre of force, scattering amplitude differential and total cross sections,	CO4
	B	Method of partial waves, Phase shifts, Optical theorem, Scattering by a hard sphere and potential well	CO4, CO6
	C	Integral equation for potential scattering, Green's function, Born approximation, Yukawa and Coulomb potential.	CO4, CO6
	Unit 5	**Relativistic quantum mechanics**	
	A	Introduction to Relativistic quantum mechanics	CO5
	B	Klein-Gordon and Dirac equations,	CO5
	C	Semi-classical theory of radiation.	CO5, CO6
	Mode of Examination	Theory	
	Weightage Distribution	CA: 15% / MSE: 10% / ESE: 75%	
	Text books	1. Quantum Mechanics by L.I. Schiff 2. Introduction to quantum mechanics, 3rd edition, David J. Griffiths, Cambridge University Press 3. Quantum mechanics – concepts and applications by N. Zettili.	
	Other References	1. Modern quantum mechanics by J.J. Sakurai and San Fu Tuan 2. Introductory Quantum Mechanics, R. L. Liboff, Addison-Wesley. 3. Principles of Quantum Mechanics, R. Shankar.	

Course Articulation matrix PHS401 Advanced Quantum mechanics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	1	1	1	1	1	2	3	3	1	1	3
CO2	3	3	2	1	1	1	1	1	1	2	3	3	1	1	3
CO3	3	3	2	1	1	1	1	1	1	2	3	3	1	1	3
CO4	3	3	2	1	1	1	1	1	1	2	3	3	1	1	3
CO5	3	3	2	1	1	1	1	1	1	2	3	3	1	1	3
CO6	3	3	2	1	1	1	1	1	1	2	3	3	1	1	3

1-Slight (Low) **2-Moderate (Medium)** **3-Substantial (High)**

PHS402 Advanced Solid State Physics

School: SSBSR		**Batch: 2023-2027**	
Program: B.Sc. (Honours/Honours with Research) in Physics		**Current Academic Year: 2026-2027**	
Branch: Physics		**Semester: VII**	
1	Course Code	PHS402	
2	Course Title	Advanced Solid State Physics	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	This course provides an opportunity to develop knowledge and understanding of the key principles and applications of physics of solids.	
6	Course Outcomes	CO1: Knowledge of real space, reciprocal space (k-space), Electrons in a Periodic Potential and Free electron theory. CO2: Knowledge and understanding the theory of defects and diffusion in Solids. CO3: Knowledge and understanding the theory of lattice vibrations (phonons) and use that to determine thermal properties of solids. CO4: Knowledge and understanding of dielectric and Ferro-electric Properties of Materials. CO5: Knowledge and understanding of magnetic and superconducting properties of solids. CO6: Apply the knowledge gained to solve problems in solid state physics using relevant mathematical calculations.	
7	Course Description	This course provides students a full exposure to the basic principles and essential concepts of Solid State Physics including theoretical description of crystal structure, lattice dynamics, thermal, electrical and magnetic properties of solids.	
8	Outline syllabus		CO Mapping
	Unit 1	**Electronic Energy Bands**	
	A	Wigner Seitz cell, Brillouin Zone, Bragg planes	CO1
	B	Band structure, Bloch Theorem, Electrons in a Periodic Potential	CO1,CO6
	C	Kronig-Penney Model, Classical and quantum Free electron theory	CO1,CO6
	Unit 2	**Defects and Diffusion in Solids**	
	A	Point defects, line defects and dislocations	CO2
	B	Fick's law, diffusion constant	CO2
	C	self-diffusion, color centres and excitons.	CO2
	Unit 3	**Lattice Vibration and Thermal Properties of Solids**	
	A	Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains	CO3,CO6

	B	Acoustical and Optical Phonons. Qualitative description of the Lattice heat capacity	CO3,CO6
	C	Classical theory of specific heat, Einstein's and Debye's theory of specific heat of solids.	CO3
	Unit 4	**Dielectric and Ferro-electric Properties of Materials**	
	A	Local Field and Clausius-Mossotti Equation, Polarization mechanism: Ionic Polarization, Orientational Polarization, Interfacial Polarization, Total Polarization	CO4
	B	Piezoelectricity, Ferroelectricity, Pyroelectricity effect, Ferroelectric effect,	CO4
	C	Curie-Weiss Law, Ferroelectric domains, Structural phase transition.	CO4, CO6
	Unit 5	**Magnetism and Superconductivity**	
	A	Ferromagnetic Domains – Anisotropy energy, origin of domains, transition region between domains, Bloch wall, Coercive force, Temperature dependence of spontaneous magnetisation,	CO5, CO6
	B	Saturation Magnetization, Antiferromagnetism, Ferrimagnetism, Anisotropic and Giant Magnetoresistance, London equation;	CO5
	C	Elementary BCS theory, coherence Length, Quantization of magnetic flux, Josephson effect.	CO5
	Mode of examination	Class test (10), Assignments (5) and presentation (10)	
	Weightage Distribution	CA: 15% / MTE: 10% / ETE: 75%	
	Text book/s*	1. Introduction to solid state physics: C. Kittel	
	Other References	2. Solid State Physics: S.O. Pillai 3. Solid State Physics: A. J. Dekker 4. Physics of Materials: Richar Jerome Weiss 5. Introduction to solids: L.V. Azaroff	

CO-PO Articulation Matrix

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	1	2	2	3	1	1	1	1	3
CO2	3	3	3	2	3	2	1	2	1	3	1	1	1	1	3
CO3	3	3	3	2	3	2	1	2	1	3	3	2	1	1	3
CO4	3	3	3	2	3	2	1	2	2	3	3	2	1	1	3
CO5	3	3	3	2	3	2	1	2	1	3	3	3	1	1	3
CO6	3	3	3	2	3	2	1	2	2	3	3	3	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS403 Research Methodology

School: SSBSR		**Batch: 2023-27**	
Program: B.Sc. (Honours /Honours with research) in Physics		**Current Academic Year: 2026-27**	
Branch: Physics		**Semester: VII**	
1	**Course Code**	PHS403	
2	**Course Title**	**Research Methodology**	
3	**Credits**	4	
4	**Contact Hours (L-T-P)**	4+0+0	
	Course Status	Compulsory	
5	**Course Objectives**	This course will help learners To understand the modern concept of research methodology To learn the importance of research methodology in higher education curriculum To acquire the knowledge of the innovative research methodology in digital age. To learn the role of research methodology in research. To understand the issues and policies in research methodology.	
6	**Course Outcomes**	After the completion of this course, the student will be able to: **CO 1**: explain historical and Modern perspective of research methodology **CO 2:** justify the importance of research methodology in higher education. **CO 3:** explain the innovation in research methodology. **CO 4:** formulate the process for research based on research methodology **CO 5:** demonstrate the web tools for assessment and development of research quality CO6: Apply the concepts in the field of measurements and sampling and probability errors.	
7	**Course Description**	This course covers historical aspects of research methodology, role of research methodology in curriculum, innovative research methodology, evaluation in choice based credit system web tools for assessment and policies in research.	
8	**Course Outlines**		CO Mapping
	Unit 1		
	A	Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method - Understanding the language of Research - Concept, Construct, Definition, Variable. Research Process, Modern Perspective of Research Methodology	CO1
	B	Problem Identification & Formulation - Research Question - Investigation Question - Measurement Issues - Hypothesis - Qualities of a good Hypothesis Null Hypothesis & Alternative Hypothesis. Hypothesis Testing - Logic & Importance.	
	Unit 2		

	A	Research Design: Concept and Importance in Research - Features of a good research design - Exploratory Research Design - concept, types and uses, Descriptive Research Designs - concept, types and uses. Experimental Design: Concept of Independent & Dependent variables.	CO2
	Unit 3		
	A	Qualitative and Quantitative Research: Qualitative research - Quantitative research - Concept of measurement, causality, generalization, replication. Merging the two app	CO3
	Unit 4		
	A	Measurement: Concept of measurement- what is measured? Problems in measurement in research- Validity and Reliability. Levels of measurement Nominal, Ordinal, Interval, Ratio.	CO4,CO6
	Unit 5		
	A	Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample- Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample Practical considerations in sampling and sample size.	CO5,CO6
	B	Brief Idea of Data Analysis, Data Interpretaion, Literature Search Methods and Usage of Web based tools for improving the quality of research	
	Mode of Examination	Theory	
	Weightage Distribution	CA / MSE / ESE 15% / 10% / 50%	
	Text books*	Research Methodology- C. R. Kothari	
	Other References	Research Methodology (Methods, Approaches and Techniques) By B.Mishra, A K Stapathy and S Mishjra	

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	1	1	1	1	1	3	1	2	2
CO2	1	3	3	3	3	1	2	2	2	1	2	2	1	2	2
CO3	3	3	3	2	1	1	2	1	2	2	2	3	1	2	2
CO4	2	2	2	3	3	3	1	1	1	1	3	2	1	2	2
CO5	2	2	2	2	3	3	1	1	1	1	2	3	1	2	2
CO6	1	1	2	2	3	3	1	2	2	1	3	2	1	2	2

PHS404 Nanomaterials

School: SSBSR		**Batch: 2022-26**	
Program: B.Sc. (Honours/Honours with Research) in Physics		**Current Academic Year: 2024-2025**	
Branch: Physics		**Semester: VII**	
1	Course Code	**PHS404**	
2	Course Title	**Nanomaterials**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	CC	
5	Course Objective	To provide students an understanding of fundamentals of nanomaterials. To provide knowledge of various characterization techniques of nanomaterials.	
6	Course Outcomes	After the completion of this course, CO1: Students will show that they have learned basics of nanotechnology CO2: Students will differentiate among various methods of the Synthesis of nanomaterials CO3: Students will gain knowledge of various characterization techniques of nanomaterials CO4: Students will have a clear understanding of fundamentals of Carbon based nanomaterials CO5: Students will learn the applications of nanomaterials. CO6: Students will have the knowledge of the basics of nanotechnology and nanomaterials, their characterization techniques and various applications	
7	Course Description	This course provides basic knowledge of nanomaterials and nanotechnology	
8	Outline syllabus		CO Mapping
	Unit 1	**Introduction to Nanotechnology**	
	A	Background of Nanoscience and Nanotechnology	CO1
	B	Various types of Nanomaterials	CO1
	C	Applications of Nanomaterials	CO1
	Unit 2	**Synthesis of nanomaterials**	
	A	Nanomaterials and quantum dots	CO2
	B	Common synthesis method: Sol-gel method	CO2
	C	Hydrothermal and solvothermal method, Template method	CO2
	Unit 3	**Characterization of nanomaterials**	
	A	Scanning Electron Microscopy (SEM), Transmission Electron Microscopy(TEM)	CO3
	B	Atomic force microscopy (AFM), UV-visiblespectroscopy	CO3
	C	FT-IR absorption spectroscopy,X-ray diffraction.	CO3
	Unit 4	**Carbon based nanomaterials**	
	A	Fullerenes- preparation, characterization and application	CO4
	B	Graphene - preparation, characterization and application	CO4, CO6
	C	Carbon nanotube-preparation, characterization and application.	CO4, CO6
	Unit 5	**Application of nanomaterials**	
	A	Application of nanomaterials in Batteries and Fuel Cells	CO5, CO6
	B	Application of nanomaterials in Solar cell	CO5, CO6
	C	Application of nanomaterials in Sensors	CO5, CO6

	Mode of examination	Theory			
	Weightage Distribution	CA	MSE	MTE+ETE	
		15%	10%	75%	
	Text books	1. Carbon Nanotubes: Synthesis, Characterization and Applications by Kamal K Kar, Research Publishing, Singapore, 2011 2. Principles of Nanoscience and Nanotechnology –M. A. Shah, Tokeer Ahmad (Narosa Publishing House, New Delhi, 2011)			
	Other References	3. Chemistry of nanomaterials: Synthesis, properties and applications by CNR Rao (Taylor & Francis 2008) 4. Introduction to Nanotechnology - Charles P. Poole Jr. and Franks. J. Qwens (Wiley Interscience, 2003)			

Course Articulaiton Matrix for Nanomaterials

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	3	2	1	1	3	2	2	2	1	2	1	1	3
CO2	2	3	3	2	1	1	3	2	2	2	1	2	1	1	3
CO3	2	3	3	2	1	1	3	2	2	2	1	2	1	1	3
CO4	2	3	3	2	1	1	3	2	2	2	1	1	1	1	3
CO5	2	3	3	2	1	1	3	2	2	2	1	1	1	1	3
CO6	2	3	3	2	1	1	3	2	2	2	1	2	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

BEN404 Solid Waste Management

School: SSBSR		**Batch: 2023-2027**	
Program: B.Sc.		**Current Academic Year: 2026-2027**	
Branch: Physics		**SEMESTER: VII**	
1	Course Code	**BEN404**	
2	Course Title	**Solid Waste Management**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
4	Course Status	Compulsory	
5	Max. Marks	15+10+75 = 100	
6	Min. Marks		
7	Course Objective	To deal with solid waste generation, management and to minimize its effects on environment.	
8	Course Outcomes	CO1: Explain the concept of solid waste management and its impacts on environment. CO2: understanding on various technological applications for processing ofwaste and their disposals in various ways. CO3: explain the hierarchical structure in solid waste management andrequirement for an integrated solution. CO4: Conclude the recent trends in reuse of solid waste CO5: Describe the components of solid waste management and the lawgoverning it. CO6: understand the implications of the production, resource management and environmental impact of solid waste management.	a s
9	Course Description	This paper throws light on the current scenario of solid waste generation and problem its handling and management. It deals with the different governmental policies that expla proper transportation, handling and disposal of solid waste to minimize its effect c environment.	l

10	Outline syllabus		CO	
	Unit 1	**Solid Waste**		
	A	Sources and generation of solid waste; their classification andchemical composition; characterization of municipal solid waste	CO1	

	B	hazardous waste and biomedical waste, Impact of solid waste on environment, human and plant health; water quality and aquatic life	CO1	
	C	mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution	CO1	
	Unit 2	**Solid waste Management**		
	A	Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste)	CO2	
	B	Recycling, Composting, thermal treatment (pyrolysis and incineration) of waste material, Energy recovery options from organic wastes	CO2	
	C	landfill (traditional and sanitary landfill design), drawbacks in waste management techniques	CO2	
	Unit 3	**Integrated waste management**		
	A	Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management	CO3	
	B	Cradle-to-grave approach; lifecycle inventory of solid waste; role of life cycle assessment (LCA) in waste management	CO3	
	C	Advantage and limitation of LCA; case study on LCA of a product	CO3	
	Unit 4	**Resource Recovery**		
	A	4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment	CO4	
	B	Reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment. Concept of waste-to-energy (WTE)	CO4/ CO6	
	C	energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis	CO4/ CO6	
	Unit 5	**Policies for solid waste management**		
	A	Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989	CO5/ CO6	
	B	Bio-Medical Waste (Management and Handling) Rules 1998, Fly ash Management Rules, (1999)	CO5/ CO6	
	C	Plastic Waste (Management and Handling) Rules, 2011; E-Waste (Management) Rules, 2016	CO5/ CO6	

	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar.05 marks for Class Interaction				
	Weightage Distribution	CA	MTE	ETE		
		15	10	75		
	Text book/s*	1. Solid Waste Management Manual CPCB, New Delhi 2. Ecotechnology for Pollution Control and Environmental Management by Trivedy R.K. and Arvind Kumar Basic Environmental Technology Nathanson, J.A				

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	3	2	2	2	3	2	2	2	1	1	1	1	3
CO2	2	2	3	2	2	2	3	2	2	2	1	1	1	1	3
CO3	2	2	3	2	2	2	3	2	2	2	1	1	1	1	3
CO4	2	2	3	2	1	2	3	2	2	2	1	2	1	1	3
CO5	2	2	3	2	2	2	3	2	2	2	1	1	1	1	3
CO6	2	2	3	2	1	2	3	2	2	2	1	1	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

VIII SEMESTER

PHS405 Characterization Techniques

School: School of Basic Sciences and Research		**Batch: 2023-27**	
Program: B.Sc. (H) Physics		**Current Academic Year: 2026-2027**	
Branch: Physics		**Semester: VIII**	
1	Course Code	**PHS405**	
2	Course Title	**Characterization Techniques**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
5	Course Status	Core	
8	Course Objective	**1.** The student should be able to understand the basic principles of the characterization techniques of the materials. **2.** The student should be able to understand analytical techniques used to identify, isolate or quantify chemicals or materials, or to characterize their physical properties. **3.** The student should be able to learn the principles of optical and electron microscopy. **4.** The students should be able to learn X-ray diffraction and various spectroscopic techniques	
9	Course Outcomes	After successful completion of this course the students will/will be able to: **CO1.** Apply appropriate characterization techniques for microstructure examination at different magnification level and use them to understand the microstructure of various materials. **CO2.** Choose and appropriate electron microscopy techniques to investigate microstructure of materials at high resolution. **CO3.** Determine crystal structure of specimen and estimate its crystallite size and stress. **CO4.** Students will learn to use appropriate spectroscopic technique to measure vibrational / electronic transitions to estimate parameters like energy band gap, elemental concentration, etc. **CO5.** Apply thermal analysis techniques to determine thermal stability of and thermodynamic transitions of the specimen. **CO6.** Characterization and analytical techniques are used to identify, isolate or quantify chemicals or materials, or to characterize their physical and structural properties.	
10	Course Description	This course is designed to introduce various Characterization and analytical techniques for investigating the structural, and electrical properties of the materials.	
11	Outline syllabus		**CO Mapping**
	Unit 1	**Optical Microscopy**	
	A B C	Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarised light, Hot stage, Interference techniques), Stereomicroscopy, Photomicroscopy, Colour metallography, Specimen preparation, Applications.	CO1, CO6
	Unit 2	**Electron Microscopy**	
	A B C	Interaction of electrons with solids, Scanning electron microscopy (SEM) Transmission electron microscopy (TEM) and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.	CO2 CO6
	Unit 3	**Diffraction Methods**	

	A B C	Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction (XRD) techniques, Electron diffraction.			CO3, CO6
	Unit 4	**Surface Analysis**			
	A B C	Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.			CO4, CO6
	Unit 5	**Spectroscopy**			
	A B C	Atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy			CO5, CO6
	Mode of examination	Class Test (10), Assignment (10) and presentation (10)			
	Weightage Distribution	CA	MTE	ETE	
		30%	20%	50%	
	Text book/s*	**1.** Li, Lin, Ashok Kumar Materials Characterization Techniques Sam Zhang; CRC Press, (2008).			
	Other References	**1.** Cullity, B.D., and Stock, R.S., "Elements of X-Ray Diffraction", Prentice-Hall, (2001). **2.** Murphy, Douglas B, Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Liss, Inc. USA, (2001). 3. Tyagi, A.K., Roy, Mainak, Kulshreshtha, S.K., and Banerjee, S., Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series), Volumes 49-51, (2009). **4**. Wendlandt, W.W., Thermal Analysis, John Wiley & Sons, (1986). **5.** Wachtman, J.B., Kalman, Z.H., Characterization of Materials, ButterworthHeinemann, (1993).			

Course Articulation matrix PHS405 Characterization Techniques

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	1	1	1	1	2	1	3	1	2	2
CO2	1	3	3	3	3	1	2	2	2	2	1	3	1	2	2
CO3	3	3	3	2	3	2	2	1	2	1	3	3	1	2	2
CO4	2	2	2	3	3	3	1	1	1	1	3	3	1	2	2
CO5	2	2	2	2	3	3	1	1	1	1	3	3	1	2	2
CO6	2	2	2	2	3	3	1	2	2	1	3	3	1	2	2

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS406 Advanced Classical Mechanics

School: SSBSR		**Batch: 2023-2027**	
Program: B.Sc.		**Current Academic Year: 2023-24**	
Branch: Physics		**Semester: VIII**	
1	Course Code	PHS406	
2	Course Title	Advanced Classical Mechanics	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	1. 1.The primary objective is to teach the students Classical Mechanics at a level more advanced. This is a course which forms the basis of Physics. 2. To make the students familiar with the concepts Basic Principles and Constraints and also with the Lagrangian and Hamiltonian formalism. 3. To understand the concept of Variational Calculus and Canonical Transformations, Concept of Rigid Body Dynamics and Kepler's Concepts.	
6	Course Outcomes	**CO1:** Learn the concepts of some basic principles of classical mechanics and Constraints. **CO2:** Understand the concepts Lagrangian and Hamiltonian formalism in detail. **CO3:** Able to explain the Hamilton's equations and Canonical Transformations. **CO4:** Figure out in detail the concept of rigid body dynamics. **CO5:** State the concepts of two body problem, centre of mass, Central Force problem and small oscillations in detail. **CO6:** Analyze the various advanced concepts of classical mechanics such as Constrained motion, Lagrangian formalism, Hamilton's concepts, variational Calculus, Canonical Transformations, Kepler's concepts etc.	
7	Course Description	The students learn to deal with the concepts of classical mechanics at an advanced level. This course is describing the concepts of Constrained motion, Lagrangian and Hamiltonian formalism, variational calculus and canonical transformation etc.	
8	Outline syllabus		CO Mapping
	Unit 1	**Basic Principles and Constraints**	
	A	Newton's laws, D' Alembert's principle, Detailed concept of constraints with examples	CO1
	B	Generalized coordinates, Generalized momentum	CO1
	C	Principle of least action, Cyclic coordinates, Lagrangian for a free particle	CO1
	Unit 2	**Lagrangian and Hamiltonian formalism**	
	A	Lagrange's Equation, Deduction of Lagrange's equations from D' Alembert's Principle	CO2
	B	Applications of the Lagrange's equations for double pendulum, and Atwood's machine	CO2
	C	Phase space, Hamilton's principle, Derivation of Hamilton's canonical equations of motion	CO2
	Unit 3	**Variational Calculus and Canonical Transformations**	
	A	The calculus of variations, Derivation of Euler-Lagrange equation	CO3

	B	Poisson's bracket, Action and angle variables, Jacobi identity			CO3
	C	Canonical Transformations, Generating functions, Hamilton-Jacobi equation.			CO3
	Unit 4	**Concept of Rigid Body Dynamics**			
	A	Rotational motion, moments of inertia, torque, Euler's theorem, Euler angles, Symmetric top			CO4, CO6
	B	Rotating frame, Coriolis force, Foucault's pendulum			CO4, CO6
	C	Eularian coordinates and equations of motion for a rigid body			CO4, CO6
	Unit 5	**Kepler's Concepts and Small Oscillations**			
	A	Two Body Problem, Reduction to one-body problem, Centre of mass, Central Force problem			CO5, CO6
	B	Kepler's laws, Kepler's problem, Virial theorem, differential equation of orbit			CO5, CO6
	C	Concept of Small Oscillations. Normal modes and coordinates.			CO5, CO6
	Mode of examination	Theory/Jury/Practical/Viva			
	Weightage Distribution	CA	MTE	ETE	
		15%	10%	75%	
	Text book/s*	1. Classical Mechanics, H. Goldstein (Pearson Education) 2. Classical Mechanics, N. C. Rana and P. S. Jaog (McGraw-Hill)			
	Other References	1. Theoretical Mechanics: Murray Spiegel 2. Classical Mechanics Systems of Particles and Hamiltonian Dynamics: Walter Greiner			

Course Articulation Matrix for Advanced Classical Mechanics

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	2	1	2	1	1	2	1	2	1	1	3
CO2	3	3	2	2	2	1	2	1	1	2	1	2	1	1	3
CO3	3	3	2	2	2	1	2	1	1	2	1	2	1	1	3
CO4	3	3	2	2	2	1	2	1	1	2	1	2	1	1	3
CO5	3	3	1	2	2	1	2	1	2	2	2	2	1	1	3
CO6	3	3	2	2	2	1	2	1	1	2	1	2	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS407 Advanced Electronic Devices

School: SSBSR Research		**Batch: 2023-2027**	
Program: B.Sc. (Honours) in Physics		**Current Academic Year: 2026-2027**	
Branch: Physics		**Semester: VIII**	
1	Course Code	**PHS407**	
2	Course Title	**Advanced Electronic Devices**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
5	Course Status	Core	
8	Course Objective	1. The student should be able to understand basic of operating characteristics of the pn junction diode, Zener diode and LEDS and their operation in analog circuits , rectifiers, clippers and clampers. 2. The student should be able to analyze the different operating parameters and configurations of Bipolar Junction Transistors. 3. The student should be able to analyze and design amplifiers. 4. The student should be able to design unipolar transistors, the Junction Field Effect Transistor (JFET) and MOSFET and design of IC circuit amplifiers.	
9	Course Outcomes	After successful completion of this course the students will/will be able to: **CO1:** Learn the basic of diodes and devices **CO2:** Students will be having the knowledge of bipolar junction transistors (BJT's). **CO3:** Students will be having the knowledge of amplifiers. **CO4:** Basic of Transistor with proper biasing voltages. **CO5:** Students will easily design the IC circuit amplifiers. **CO6:** Describe the operating characteristics of the different pn junction diode.	
10	Course Description	This course is designed to introduce students the basic of advanced electronic devices.	
11	Outline syllabus		**CO Mapping**
	Unit 1	**Diode Characteristics**	
	A B C	Load-Line Analysis. pn junction diode, Zener diode and LEDS and their operation in analog circuits, rectifiers, clippers and clampers. The diode circuit models will be used in the analysis and design of diode circuits.	CO1, CO6
	Unit 2	**Bipolar Junction Transistors**	
	A B C	Types of the bipolar junction transistors (BJT's) as a semiconductor device. transistor circuits with proper biasing voltages. V− I characteristic curves. Operation of the npn-pnp Bipolar Junction Transistor. Design and analysis of different linear dc BJT circuits.	CO2 CO6
	Unit 3	**Amplifier Analysis**	
	A B C	BJT circuits with stable operating points. BJT amplifiers in the three configurations – the Common Emitter, the Common Collector, and the Common Base. Transistor parameters such as Z_{in}, Z_{out}, A_v. High-Frequency Response of RC-Coupled Amplifiers. Low-Frequency Response of RC-Coupled Amplifiers. Input and output impedance.	CO3, CO6

	Unit 4	**Field Effect Transistors**	
	A B C	Metal−Oxide−Semiconductor Field Effect Transistor (MOSFET) junction. Operation of the MOSFET in the depletion region, and enhancement modes. Biasing of the JFET and MOSFET. Transistor circuits with proper biasing voltages. Common-Source Amplifier. Depletion-Mode MOSFETs.	CO4, CO6
	Unit 5	**Operational Amplifiers**	
	A B C	Ideal Operational Amplifier. Inverting Amplifier. Noninverting Amplifier. Design of Simple Amplifiers. Op-Amp Imperfections in the Linear Range of Operation. Large-Signal Operation. Integrators and Differentiators.	CO5, CO6
	Mode of examination	Class Test (10), Assignment (10) and presentation (10)	
	Weightage Distribution	CA: 15% / MSE: 10% / ESE: 75%	
	Text book/s*	1. Solid state electronic devices- Streetman and Banerjee, Pearson education.	
	Other References	2. Electronic devices and circuit theory- Robert Boylestad and Louis Nashelsky, Prentice Hall. 3. Op-amp and linear integrated circuit by: R.A Gayakwad. 4. Op-amp and circuits by: Coughlin and Driscoll.	

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	2	1	1	2	3	2	1	3	3	1	1
CO2	3	3	3	1	2	1	1	2	3	2	1	3	3	1	1
CO3	3	3	3	1	2	1	1	2	3	2	1	3	3	1	1
CO4	3	3	3	1	2	1	1	2	3	2	1	3	3	1	1
CO5	3	3	3	1	2	1	1	2	3	2	1	3	3	1	1
CO6	3	3	3	1	2	1	1	2	3	2	1	3	3	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHS408 Advanced Mathematical Physics

School: SBSR		**Batch: 2023-2027**	
Program: B.Sc. (H) Physics		**Current Academic Year:**	
Branch: Physics		**SEMESTER: I**	
1	Course Code	**PHS408**	
2	Course Title	**Advanced Mathematical Physics**	
3	Credits	4	
4	Contact Hours (L-T-P)	4-0-0	
5	Course Status	CC	
6	Max. Marks	100	
7	Min. Marks		
8	Course Objective	1. The objective of this course is to familiarize the students with various techniques of solving ordinary and partial differential equations. 2. To understand the concepts of Laplace and Fourier transformations, basic statistical and numerical methods and their applications.	
9	Course Outcomes	CO1: Explain the methods of solving differential equations of various types. CO2: Explains the methods of solving Heat, Wave and Laplace's Equations CO3: Know that any periodic function can be expressed as a Fourier series and fundamental mathematical properties of the Fourier and Laplace transform. CO4: Know the condition(s) for a complex variable function to be analytic and/or harmonic, able to determine the points of singularities of a function and understand the concept of sequences and series with respect to the complex numbers. CO5: Describe various probability distributions and their applications. CO6: Describe and use the concepts of Tensor Analysis.	
10	Course Description	This course is an introduction to the fundamentals of Ordinary and partial differential equations, Special functions, complex variables, statistics and numerical analysis. The main objective of the course is to develop the basic understanding of differential equations,complex numbers and analysis ,probability and tensor analysis.	
11	Outline syllabus		CO Mapping
	Unit 1	**Linear and Ordinary Differential Equations**	
	A	Ordinary differential equations of first and second order	CO1
	B	Linear Differential Equations	CO1
	C	Partial differential equations (Laplace, wave and heat equations in two and three dimensions)	CO1
	Unit 2	**Series solution of Differential Equations**	
	A	Series solution of differential equation, , Ordinary and singular points, Green's function.	CO2
	B	Hermite and Bessel Functions	CO2

	C	Laguerre and Legendre functions			CO2
	Unit 3	**Complex Analysis**			
	A	Elements of complex analysis, analytic functions.			CO3
	B	Taylor & Laurent series.			CO3
	C	Poles, residues and evaluation of integrals.			CO3, CO6
	Unit 4	**Probability and Statistics**			
	A	Elementary probability theory, random variables.			CO4
	B	Binomial, Poisson and normal distributions			CO4, CO6
	C	Central limit theorem.			CO4, CO6
	Unit 5	**Tensor analysis**			
	A	The index notation, Bases, co- and contravariant vectors.			CO5
	B	Tensors, definitions and properties			CO5, , CO6
	C	The metric tensor and the new inner product, Tensor calculus, Covariant derivatives, Tensors in special relativity			CO5, CO6
	Mode of examination	0 marks for Test / Quiz / Assignment / Seminar. 05 marks for Class Interaction			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s* Reference book/s*	1. Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons Inc. 2. Jain, M.K., and Iyengar, S.R.K., "Advanced Engineering Mathematics", Narosa Publications **PART B** 1. S.L. Ross, " Differential Equations" , John Willey & Sons Inc. 2. S. C. Gupta and V. K. Kapoor: Fundamentals of Mathematical Statistics: Sultan Chand and Sons.			

Course Articulation Matrix for Advanced Mathematical Physics

COs	PO1	**PO2**	**PO3**	**PO4**	**P05**	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSO1**	**PSO2**	**PSO3**
CO1	3	**3**	**1**	**1**	**3**	2	1	2	2	3	2	2	3	1	1
CO2	3	**3**	**1**	**1**	**3**	3	1	2	2	3	2	2	3	1	1
CO3	3	**3**	**1**	**1**	**3**	2	1	2	2	3	2	2	3	1	1
CO4	3	**3**	**1**	**1**	**3**	2	1	2	2	3	2	2	3	1	1
CO5	3	**3**	**1**	**1**	**3**	2	1	2	2	3	2	2	3	1	1
CO6	3	**3**	**1**	**1**	**3**	2	1	2	2	3	3	2	3	1	1

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

BEN-405 Environment Impact and Risk Assessment

Environmental Impact and Risk Assessment		
School: SSBSR		**Batch: 2023-2027**
Program: B.Sc.		**Current Academic Year: 2026-2027**
Branch: Environmental Sciences		**SEMESTER: VIII**
1	Course Code	**BEN405**
2	Course Title	**Environmental Impact and Risk Assessment**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
4	Course Status	Compulsory
5	Max. Marks	15+10+75 = 100
6	Min. Marks	
7	Course Objective	This course recognizes the growing need of industry to anticipate and incorporateenvironmental concerns and risks while developing large-scale projects.
8	Course Outcomes	CO1: Explain the philosophies and historical development of EIA in Indi and elsewhere. CO2: understanding of the EIA process and the methodologies to prepar an EIS CO3: Identifies development actions with the fundamenta understanding of EIA and sustainable development. CO4: Understand the impacts of various industries CO5: Identify the characteristics and risk assessment CO6: Knowledge of tools and techniques to assess various environment impacts and outlines various management options needed to mitigate these risks
9	Course Description	The course emphasizes on the contemporary tools and techniques to assessvarious environmental impacts and outlines various management options neede to mitigate these risks.
10	Outline syllabus	CO Mapping

	Unit 1	**Introduction**	
	A	Environmental impact assessment (EIA): definitions, introductionand concepts; rationale and historical development of EIA	CO1/ CO6

	B	Environmental Assessment (SEA) – Principles and process; EIAnotification (MOEF) 1994, 2006	CO1/ CO6
	C	Scope and methodologies of EIA; role of project proponents, Termsof Reference	CO1/ CO6
	Unit 2	**EIS Formation**	
	A	Impact Identification methods, impact prediction, models of prediction. Impact evaluation – Cost benefit analysis	CO2/ CO6
	B	Acquisition of base line data, its importance, Mitigation of impacts – approaches	CO2/ CO6
	C	Environmental Impact Statement (EIS), EnvironmentalManagement Plan (EMP)	CO2/ CO6
	Unit 3	**EIA monitoring and auditing**	
	A	Public participation in EIA, presentation and review process, methods and role of monitoring in EIA, Environmental auditing	CO3/ CO6
	B	Rapid EIA; Strategic Environmental Assessment; Social Impact Assessment	CO3/ CO6
	C	Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies	CO3/ CO6
	Unit 4	**EIA and sustainable development**	
	A	Environmental planning; introduction to ISO and ISO 14000;sustainable development	CO4/ CO6
	B	Status of EIA in India; current issues in EIA; case study of hydropower projects, thermal projects	CO4/ CO6
	C	Environmental Impacts of mining industry, nuclear and thermalpower plant, textile industry, paper and pulp industry	CO4/ CO6
	Unit 5	**Risk assessment**	
	A	Risk assessment: introduction and scope; project planning; exposureassessment; toxicity assessment	CO5/ CO6
	B	Hazard identification and assessment; risk characterization; risk communication; environmental monitoring	CO5/ CO6
	C	Community involvement; legal and regulatory framework; humanand ecological risk assessment.	CO5/ CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar.05 marks for Class Interaction	

	Weightage	CA	MTE	ETE	

	Distribution	15%	10%	75%	
	Text book/s*	1. Methods of Environmental Impact Assessment – Morris & Therivel 2. Environmental Impact Assessment – L.W. Canter 3. Chemical Principles of Environmental Pollution – Alloway &Ayers 4. Industrial Environment – Assessment and Strategy – S.K. Aggarwal			

Course Articulation matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	3	2	2	2	3	2	2	2	3	2	1	1	2
CO2	2	2	3	2	2	2	3	2	2	2	3	2	1	1	2
CO3	2	2	3	2	2	2	3	2	2	2	3	2	1	1	2
CO4	2	2	3	2	2	2	3	2	2	2	3	2	1	1	2
CO5	2	2	3	2	2	2	3	2	2	2	3	2	1	1	2
CO6	2	2	3	2	2	2	3	2	2	2	3	2	1	1	2

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

Minor courses

In

Renewable Energy

PHR101 (Introduction to Renewable energy and management)

School: SSBSR		**Batch : 2023-2027**	
Program: Certificate in Physics		**Current Academic Year: 2023-2024**	
Branch: Physics		**SEMESTER: II**	
1	Course Code	**PHR101**	
2	Course Title	**Introduction to Renewable energy and management**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
5	Course Status	Minor Elective	
6	Max. Marks	15+10+75 = 100	
7	Min. Marks		
8	Course Objective	1. To familiarize the concept of energy and its classification. 2. To know the importance of renewable energy. 3. To provide the awareness about climate change. 4. To familiarize with various renewable energy resources and its management.	
9	Course Outcomes	After the completion of this course, the student will be able to CO1: comprehend the different types of energy. CO2: examine the importance of fossil fuels and renewable energy resources. CO3: apply the concept of greenhouse effect for climate change. CO4: inculcate the knowledge of renewable energy resources to obtain clean energy and its environmental impact. CO5: familiarize with energy management and sustainable development. CO6: obtain asses the importance of various renewable energy resources and their impacts.	
10	Course Description	This course deals with different types of energy and their impact on the climate change. In this course, the students will learn about the energy management and sustainable energy development.	
11	Outline syllabus		CO Mapping
	Unit 1	**Energy and its classification**	
	A	Introduction to energy: Definition and units of energy and power.	CO1, CO2
	B and C	Forms of energy and conservation of energy. Fossil fuels, renewable and non-renewable energy & their types. Conventional and non-conventional energy.	CO1, CO2
	Unit 2	**Fossil fuels and Alternate Sources of Energy**	
	A	Fossil Fuels - Types, Uses, Advantages & Disadvantages, need of renewable energy.	CO1, CO3
	B and C	An overview of renewable energy resources: solar energy, wind energy, hydroelectric energy, wave energy, ocean thermal energy, tidal energy, geothermal energy and biomass energy.	CO1, CO3
	Unit 3	**Climate Change**	
	A	Greenhouse gases (GHG) types and sources. The greenhouse effect.	CO1, CO3

	B and C	The link between energy and climate change. Climate change – causes and consequences. global warming.			CO3, CO6
	Unit 4	**Renewable energy resources**			
	A	Various renewable energy resources- Introduction, availability, classification, relative merits and demerits.			CO4, CO6
	B and C	Social, economic and environmental impacts of renewable energy resources.			CO4, CO6
	Unit 5	**Energy Management**			
	A	Principles of Energy Management, energy needs of growing economy, energy conservation and its importance.			CO5, CO6
	B and C	Concept of sustainability; Renewable energy for sustainable development.			CO5 ,CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Presentation. 05 marks for Class Interaction			
	Weightage Distribution	CA	MSE	MTE+ETE	
		15%	10%	75%	
	Text book/s	1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi 2. Solar energy - M P Agarwal - S Chand and Co. Ltd. 3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd. 4. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, 5. Oxford University Press, in association with The Open University. 6. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009 7. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA). 8. http://en.wikipedia.org/wiki/Renewable_energy			

Course Articulation Matrix
(Introduction to Renewable energy and management)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	2	1	1	1	1	1	1	1	3
CO2	3	3	2	1	2	1	2	1	1	1	1	1	1	1	3
CO3	3	3	2	1	2	1	2	1	1	1	1	1	1	1	3
CO4	3	3	2	1	2	1	2	1	1	1	1	1	1	1	3
CO5	3	3	2	1	2	1	2	1	1	1	1	1	1	1	3
CO6	3	3	2	1	2	1	2	1	1	1	1	1	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHR201- Renewable Energy Resources

School: SSBSR		**Batch: 2023-2027**	
Program: DIPLOMA IN PHYSICS		**Current Academic Year: 2023-2024**	
Branch: Physics		**SEMESTER: III**	
1	Course Code	**PHR201**	
2	Course Title	**Renewable Energy Resources**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
5	Course Status	Minor	
6	Max. Marks	15+10+75=100	
7	Min. Marks		
8	Course Objective	This course provides an opportunity to develop knowledge and understanding of the key principles and applications of biomass energy and resources	
9	Course Outcomes	CO1: Understand and develop knowledge about the different kinds of renewable energy resources. CO2: Analyse the energy consumption (both in rural and urban areas) and energy demand and current Indian energy scene. CO3: Understand the Impact on environmental degradation due to production and utilization of energy. CO4: Understand and Analyse the solar cells CO5: Understand and develop knowledge about the Geothermal, wind, ocean and bioenergy resources. CO6: Students will have deep knowledge about the various renewable resources including solar energy, geothermal energy, wind and ocean energy and adverse effect of energy consumption on environment.	
10	Course Description	This course provides deep knowledge about the different forms of energy, various renewable resources including solar energy, geothermal energy, wind and ocean energy, solar cells (1st, 2nd, and 3rd generation), and adverse effect of energy consumption on environment.	
11	Outline syllabus		CO Mapping
	Unit 1	**Renewable energy and its Resources**	
	A	Definition, units, and power of energy, Forms of energy, Second law of thermodynamics and conversion of energy, Origin and time scale of fossil fuels.	CO1

	B	Conventional and nonconventional energy sources, Renewable-non-renewable energy resources, Green energy, clean energy (definition and example only),			CO1
	C	Energy resources, coal, oil, natural gas, nuclear and hydroelectric power, Concepts of ecological footprint, green footprint, and carbon footprint.			CO1
	Unit 2	**Energy demand, Energy Consumption, and Indian Energy Scene:**			
	A	Role of energy in economic development, Energy consumption in various sectors, Exponential increase in energy consumption and its impact on global economy, Energy demand and Energy trilemma index.			CO2
	B	Indian Energy Scene: Energy resources available in India, Urban and rural energy consumption, Nuclear energy (scope and future) variation of energy consumption as a function of energy,			CO2
	C	Need of new renewable resources, National Green Tribunal (NGT) act and activities.			CO2
	Unit 3	**Environmental effects on energy consumption**			
	A	Environmental degradation due to production and utilization of energy, Impact of environmental degradation activities on biological damage.			CO3
	B	Environmental effects of thermal power stations and nuclear power generation, Air and water pollution, Effect on Ozone layer, Global warming.			CO3
	C	Hydroelectric power, Geothermal power, Energy harvesting (Ocean, wind, solar and bioenergy).			CO3, CO6
	Unit 4	**Solar Energy and Solar Cells**			
	A	Need of Solar energy, Solar Energy, Solar constant, Solar radiation spectrum			CO4
	B	Classification of solar cells: 1st generation (single vs polycrystalline), 2nd generation, 3rd generation.			CO4, CO6
	C	Key elements of silicon solar cells, PV solar cell, Module, Panel and array, solar thermal system types. Applications of solar thermal systems.			CO4, CO6
	Unit 5	**Geothermal, Wind, Ocean and Bioenergy**			
	A	Geothermal Energy: Introduction, Geothermal power, Geothermal resources, Advantage and disadvantage of geothermal energy over other form of energy.			CO5
	B	Wind energy: Introduction, Principle of wind energy conversion, Advantage and Disadvantage of wind mills, Application of wind energy.			CO5, , CO6
	C	Ocean Energy: Introduction, Principle of ocean thermal energy conversion, Tidal power generation, tidal energy technologies, Wave energy conversion, Advantages and Disadvantages. Bio Energy: Introduction, Sources of biomass, Advantage and disadvantage of bio energy over other form of energy.			CO5, CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar. 05 marks for Class Interaction			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	
	Text book/s*	**PART A** 1. Renewable Energy: Power for a Sustainable Future, Godfrey Boyle.			

	Reference book/s*	2. Solar Photovoltaics: Fundamentals, Technologies and Applications, Chetan Singh Solanki **PART B** 1. Physics of Energy Sources, G. C. King 2. Physics and Technology of Sustainable Energy; E L Wolf 3. Advanced renewable Energy Systems, S C Bhatia 3. D.P.Kothari, K.C Singal and Rakesh Ranjan "Renewable Energy Sources And Emerging Technologies", 2011, PHI Learning Private Ltd, New Delhi.	
	Suggestive Digital Platforms / Web Links	1. https://www.edx.org/learn/renewable-energy 2. https://www.coursera.org/courses?query=renewable%20energy 3. National Programme on Technology Enhanced Learning (NPTEL), https://onlinecourses.nptel.ac.in/noc21_ch11/preview	
	Suggested Equivalent Online Courses	1. The Renewable Energy Institute, renewable energy course, 2. National Programme on Technology Enhanced Learning (NPTEL), https://onlinecourses.nptel.ac.in/noc21_ch11/preview 3. https://onlinecourses.nptel.ac.in/noc22_ph44/preview (swayam course)	

Course Articulation Matrix

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	3	3	1	1	1	1	3	1	2	2	1	1	1	1	3
CO 2	3	3	3	1	1	1	2	1	2	2	1	1	1	1	3
CO 3	3	3	3	1	2	1	3	1	2	2	1	1	1	1	3
CO 4	3	3	3	1	2	1	3	1	2	2	1	2	1	1	3
CO 5	3	2	3	1	2	1	3	1	2	2	1	2	1	1	3
CO 6	2	2	2	1	1	2	2	1	2	2	2	2	1	1	3

PHR202- Photovoltaics

School:Sharda School of Basic Sciences and Research		**Batch 2023-2027**	
Program: Diploma In Physics		**Current Academic Year: 2024-25**	
Branch: Physics		**Semester: IV**	
1	Course Code	**PHR202**	
2	Course Title	**Photovoltaics**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
5	Course Status	Minor	
8	Course Objective	1. The student should be able to understand basic of semiconductors and their application. 2. The student should be able to understand basic of Solar energy and solar cell. 3. The student should be able to understand basic theory of Batteries and Devices. 4. The student should be able to understand basic theory of Switches and its function.	
9	Course Outcomes	After successful completion of this course the students will/will be able to: **CO1:** Learn the basic of Semiconductors **CO2:** Students will be having the knowledge Solar Energy and Solar Cell. **CO3:** Students will be having the knowledge of Solar Energy Devices. **CO4:** Develop devices using materials. **CO5:** Basic and switches and their function **CO6:** Different type of semiconducting materials and their Photovoltaic device fabrication	
10	Course Description	This course is designed to introduce students to basic of semiconductors and their use in photovoltaics application.	
11	Outline syllabus		**CO Mapping**
	Unit 1	**Basic of Semiconductor**	
	A B C	Fundamentals on Junctions: p-n junction, Type of junctions, homo, hetero and schottky junctions, depletion layer, junction in equilibrium, application of bias, energy band diagram, abrupt and graded junctions, electric field and potential distribution at the interface, calculation of built-in voltage, Expression depletion layer capacitance.	CO1, CO6
	Unit 2	**Solar Energy and Solar Cell**	
	A B C	Sun - Earth geometric relationship, Layers of the sun, Earth-Sun angles and their relationships, Solar energy reaching the earthís surface, Solar cell, Module, Panel and array construction, Theory of solar cell - Energy band diagrams, Junction current, Solar cell equivalent circuit, IV Characteristics, Efficiency of Solar cell, Maximizing the solar PV output and load matching, Maximum power point tracker.	CO2 CO6

	Unit 3	**Solar Energy device**	
	A B C	Planning - Calculating daily load demand, Amp-hour Vs. Watt-hour calculations, Choosing modules, batteries, control systems, inverter, Site surveying and Shadow analysis - Shadow types, shading analysis, Shading and PV array configuration, Mounting system and building integration - Roof basics, Slopping roofs, Flat roofs, FaÁade basics, Photovoltaic Facades, Glass roofs, Solar protection devices, Mounting systems for free standing installations.	CO3, CO6
	Unit 4	**Batteries and Devices**	
	A B C	Batteries, Rated storage capacity, Charging-discharging cycles, Choosing the best battery, Charge controllers and inverters - Why use charge controllers?, Low voltage disconnect, Overcharge protection, Charge controllers and system connections, Charge controller system connections, choosing charge controllers, Inverters, Choosing inverters, Voltage converters, Wiring cables, Switches, sockets and fuses, Wire size and voltage drop calculations, Earthing and lightning protection	CO4, CO6
	Unit 5	**Switches and Function**	
	A B C	PV array combiner/junction boxes, string diodes and fuses, Grid connected inverters, Cabling, wiring and connection system, DC Main switch, AC switch disconnector, Inverter and PV array configurations, Inverter installation site, Sizing the inverter, Selecting and Sizing cables, Monitoring operating data and presentation.	CO5, CO6
	Mode of examination	Class Test (10), Assignment (10) and presentation (10)	
	Weightage Distribution	CA: 15% / MSE: 10% / ESE: 75%	
	Text book/s*	1. Non-Conventional Energy Resources by B.H. Khan, Tata McGraw Hill Pub., 2009. (Ch:6)	
	Other References	1. Non-Conventional Energy Resources by Shobh Nath Singh, Pearson India., 2016. (Ch:2, 4) 2. Stand-Alone Solar Electric Systems by Frank Jackson, Mark hankins, Earthscan Publishing (2010) 3. Grid-connected Solar Electric Systems, Geoff Stapleton and Susan Neill, Mark hankins, Earthscan Publishing (2010) 4. Planning and Installing Photovoltaic Systems - A guide for installers, architects and engineers Second Edition, Earthscan publishing (2008)	

Course Articulation Matrix

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	1	1	2	1	3	2	1	2	1	1	3
CO2	3	3	3	1	1	1	2	1	3	2	1	2	1	1	3
CO3	3	3	3	1	1	1	2	1	3	2	1	2	1	1	3
CO4	3	3	3	1	1	1	2	1	3	2	1	2	1	1	3
CO5	3	3	3	1	1	1	2	1	3	2	1	2	1	1	3
CO6	3	3	3	1	1	1	2	1	3	2	1	2	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHR301 Biomass Energy

School: SSBSR		**Batch: 2023-2027**	
Program: B.Sc. In Physics With Minor In Renewable Energy		**Current Academic Year: 2025-2026**	
Branch: Physics		**SEMESTER: VI**	
1	Course Code	**PHR301**	
2	Course Title	**Biomass Energy**	
3	Credits	3	
4	Contact Hours (L-T-P)	3-0-0	
5	Course Status	Minor	
6	Max. Marks	15+10+75 = 100	
7	Min. Marks		
8	Course Objective	This course provides an opportunity to develop knowledge and understanding of the key principles and applications of biomass energy and resources	
9	Course Outcomes	CO1: Understand and develop knowledge about the concept of biomass energy and its various resources. CO2: Analyse and compare the biomass conversion process. CO3: Understand the characteristics of products obtained from the biomass conversion CO4: Understand the basics of biomass gasification and gasifier design CO5: Assess the potential of electrical power production from biomass CO6: Students will have deep knowledge about the biomass resources, biomass produts conversion techniques and bioenergy technologies.	
10	Course Description	This course provides students a full exposure to the basic principles of biomass energy, various resources of biomass energy, biomass conversion techniques, characterization of the products and bioenergy technologies etc.	
11	Outline syllabus		CO Mapping
	Unit 1	**Biomass and its Resources**	
	A	Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection,	CO1
	B	Waste biomass (municipal, industrial, agricultural and forestry) availability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, sorghum sugar beet,	CO1

		hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow),			
	C	Oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels,			CO1
	Unit 2	**Biomass Conversion**			
	A	Biomass conversion processes – Biological – Thermal – Chemical – Hybrid conversions.			CO2
	B	Application of biomass conversion products – Biomass properties for conversion process – Physical properties: Particle size, distribution, heat capacity and thermal conductivity.			CO2
	C	Thermal properties : Proximate, Ultimate and heating value analysis – Biomass pretreatment processes – Biodiesel and bioethanol : Sources and extraction methods. challenges in conversion.			CO2
	Unit 3	**Characteristics of products**			
	A	Torrefaction – products obtained – properties of torrified biomass – Physical and chemical – composition changes			CO3
	B	Torrefaction as pretreatment process – Pyrolysis – types – effects of process parameters – Product characterization techniques – oxidation stability –			CO3
	C	Bio-oil upgradation – applications – Liquefaction – direct and indirect methods – advanced liquefaction techniques.			CO3, CO6
	Unit 4	**Biomass gasification**			
	A	Biomass growth, Chemistry fundamentals: stoichiometry, mass balances in chemical reactions, enthalpy of reaction, Anaerobic digestion, Bioethanol, Biodiesel, Combustion, Gasification, Pyrolysis.			CO4
	B	Biomass gasification – chemistry – types of gasifiers – gasifier design : TDR, throughput, A/F ratio and equivalence ratio calculations – advanced gasification – fluidized bed gasifier – component design – cold fluidization tests –			CO4, CO6
	C	Electrical power production – Biomass combustion – types of combustors – Co-combustion and Co-firing – applications – Eutectic point of biomass ash.			CO4, CO6
	Unit 5	**Organic Commodity Chemicals from Biomass and Integrated Biorefinery**			
	A	Basic concept, types of biorefineries, biorefinery feedstocks and properties, economics			CO5
	B	Organic Commodity Chemicals from Biomass: Biomass as feedstock for synthetic organic chemicals, lactic acid, polylactic acid, succinic acid, propionic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanedioil, PHA			CO5, , CO6
	C	Concept, corn/soybean/sugarcane biorefinery, lignocellulosic biorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation, life-cycle assessment			CO5, CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar. 05 marks for Class Interaction			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	

	Text book/s* Reference book/s*	**PART A** 1Sergio C. Capareda "Introduction to Biomass Energy Conversions", 2019, CRC Press, Taylor and Francis Group. 2. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), Biomass to Biofuels : Strategies for Global Industries, Wiley, 2010. **PART B** 1. Erik Dahlquist, "Biomass as Energy Source: Resources, systems and applications", Sustainable Energy Developments series, 2012, CRC Press, Taylor and Francis Group. 2. Anju Dahiya, "Bioenergy : Biomass to Biofuels", 2014, Academic press, Elsevier Publication. 3. D.P.Kothari, K.C Singal and Rakesh Ranjan "Renewable Energy Sources And Emerging Technologies", 2011, PHI Learning Private Ltd, New Delhi. 4. S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers, Wiley, 2013. 5. Shang-Tian Yang (Ed.), Bioprocessing for Value Added Products from Renewable Resources, Elsevier, 2007.	
	Suggestive Digital Platforms / Web Links	1.University of ABERDEEN, Renewable Energy Engineering. https://on.abdn.ac.uk/degrees/renewable-energy-engineering/ 2. Ministry of new and renewable energy/bioenergy.	
	Suggested Equivalent Online Courses	1. The Renewable Energy Institute, renewable energy course, 2. National Programme on Technology Enhanced Learning (NPTEL), https://onlinecourses.nptel.ac.in/noc22_ch28/preview	

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	**PSO 1**	**PSO 2**	**PSO 3**
CO 1	3	3	1	1	1	1	3	1	2	2	2	1	1	1	3
CO 2	3	3	3	1	1	1	1	2	2	2	1	1	1	1	3
CO 3	3	3	3	1	2	1	3	1	2	1	1	1	1	1	3
CO 4	3	3	3	1	2	1	3	1	2	1	1	1	1	1	3
CO 5	3	2	3	1	2	1	3	1	2	1	1	1	1	1	3
CO 6	2	2	2	1	1	2	2	1	1	2	2	2	1	1	3

School: Sharda School of Basic Sciences and Research		**Batch:2023-2027**
Program: B. Sc		**Current Academic Year**
Branch: Physics		**Semester: VII**
1	Course Code	PHR401
2	Course Title	**Nanogenerators**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1.With a focus on the synthesis, characterization, and applications of nanomaterials in Energy harvesting, this course will introduce students to the topic of nanotechnology and nanogenerators. 2.The fundamental ideas, such as the nanoscale effect, the relationship between process, structure, and property, the characterization of the properties of nano- and micro-structures, multifunctional materials, and the fabrication of nanodevices and their applications for energy harvesting, water infiltrations, and environmental sensing, will be covered.
6	Course Outcomes	After the completion of this course, the student will be able to **CO1:** describe the terminology and basic concepts of thermoelectricity and piezoelectricity. **CO2:** identify suitable methods for various nanodevice synthesis and processing method. **CO3:** understand different characterization techniques of PENG and TENG. **CO4:** explain the fundamental mechanism of unique properties of piezoelectric materials and thermoelectric materials. **CO5:** describe the application of nanogenerators for energy harvesting and sensing. **CO6:** appreciate the potential applications of Nanomaterials in different fields.
7	Course description	With a focus on the synthesis, characterization, and applications of nanomaterials in Energy harvesting, this course will introduce students to the topic of nanotechnology and nanogenerators. Adapting mechanical properties, durability, energy harvesting, and other multi-functionality are only a few of the specialized

		uses. The fundamental ideas, such as the nanoscale effect, the relationship between process, structure, and property, the characterization of the properties of nano- and micro-structures, multifunctional materials, and the fabrication of nanodevices and their applications for energy harvesting, water infiltrations, and environmental sensing, will be covered. Students taking the course will have access to a lab where they can practice their nano- and micro-structure characterization techniques.	
8	Outline Syllabus		CO Mapping
	Unit 1	**Introduction & Piezoelectric Nanogenerators**	
	A	Introduction to nanogenerators, Types of Nanogenerators,	CO1
	B	Triboelectric Nanogenerators (TENG), Piezoelectric Nanogenerators (PENG)	CO1
	C	Pyroelectric Nanogenerators, Thermoelectric Nanogenerators & Electromagnetic generators.	CO1
	Unit 2	**Nanomaterials Synthesis and Fabrication of PENG and TENG**	
	A	Nanomaterials synthesis, Ball milling, Sol-Gel	CO2
	B	Hydrothermal, Sono-chemical method	CO2
	C	Fabrication of TENG and PENG by electrospinning and solution-cast method	CO2
	Unit 3	**Characterization of PENG and TENG**	
	A	X-ray Diffraction (XRD)	CO3
	B	Scanning Electron Microscopy (SEM)	CO3
	C	Electrical characterizations of TENG and PENG	CO3
	Unit 4	**Materials Properties for Energy Harvesting (TENG and PENG)**	
	A	Band Theory, Violation of Octet Rule, Hardness of Materials, Grain Boundary & Creep Fracture, Flexoelectricity	CO4
	B	Static Electricity, Pros & Cons of Static Electricity, EMG VS TENG (or PENG)	CO4
	C	Working Mechanism – Contact, Working Mechanism – Rotation, Efficiency of TENG and PENG	CO4
	Unit 5	**Energy Harvesting (TENG and PENG) and Applications**	
	A	Surface Charge Density, Impedance, other applications with TENG and PENG	CO5

	B	Bio application of TENG and PENG	CO5
	C	Antibacterial, Acoustic Sensor (pressure sensor) using TENG and PENG.	CO5, CO6
	Mode of Examination	Theory	
	Weightage Distribution	CA: 15% / MSE: 10% / ESE: 75%	
	Text books	1. Triboelectric Nanogenerators, Zhong Lin Wang, Long Lin, Jun Chen, Simiao Niu, Yunlong Zi, Springer 2016, https://doi.org/10.1007/978-3-319-40039-6 2. Jae Kim, Sang, Arunkumar Chandrasekhar, and Nagamalleswara Rao Alluri, eds. 2020. Nanogenerators. IntechOpen. doi:10.5772/intechopen.78915.	
	Other References	1. Review Article: Dongwhi Choi, et. al. "Recent Advances in Triboelectric Nanogenerators: From Technological Progress to Commercial Applications", ACS Nano, 2023, https://doi.org/10.1021/acsnano.2c12458 2. Review Article: Briscoe, Joe, and Steve Dunn. "Piezoelectric nanogenerators–a review of nanostructured piezoelectric energy harvesters." Nano Energy 14 (2015): 15-29.	

Course Articulation Matrix:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	3	1	2	1	1	2	3	3	1	1	3
CO2	3	3	2	1	3	1	2	1	1	2	3	3	1	1	3
CO3	3	3	2	1	3	1	2	1	1	2	3	3	1	1	3
CO4	3	3	2	1	3	1	2	1	1	2	3	3	1	1	3
CO5	3	3	2	1	3	1	2	1	1	2	3	3	1	1	3
CO6	3	3	2	1	3	1	2	1	1	2	3	3	1	1	3

1-Slight (Low) **2-Moderate (Medium)** **Substantial (High)**

Minor Courses in Computational Physics

PYTHON FOR COMPUTATIONAL PHYSICS

School		SSBSR	**Batch: 2023-27**	
Program		Certificate in Physics	**Current Academic Year**	**2023-24**
Branch		Physics	**Semester**	**II**
Specialization			**Computational Physics**	
1	Course Code		PHC101	
2	Course Title		Python for Computational Physics	
3	Credits		3	
4	Contact Hours (L-T-P)		0-0-5	
	Course Status		Compulsory	
5	Course Objective		To make students understand, learn and use python programming.	
6	Course Outcomes		After the completion of this course, the student will be able to **CO1:** configure and install python **CO2:** choose suitable data types and control statements **CO3:** Apply standard modules for physics applications **CO4:** Learn scientific plotting using Python **CO5:** Understand the object-oriented program design and development. **CO6:** Write code/simulate solutions for physics problems using python	
7	Course Description		Introduction to programming basics, binary computation, problem-solving methods and algorithm development. Includes procedural and data abstractions, program design, debugging, testing, and documentation. Covers data types, control structures, functions, parameter passing, library functions, arrays, inheritance and object oriented design	
8	Outline syllabus			CO Mapping
	Unit 1		**Introduction**	
	A		Python as a scripting language. Installing Anaconda Python distribution. Using the Conda and PIP package Managers.	CO1
	B		Launching and working with Jupyter Notebook interface for Python Programming.	CO1
	C		Working with Google Colab online interface for Jupyter Notebooks. Creating Python Scripts using IDLE or SPYDER IDEs.	CO1
	Unit 2		**Data types and control structures**	
	A		Operators (unary, arithmetic, logical, relational), Python data types: Integers, Floats, lists, tuples, arrays, dictionaries Variables, expressions, and statements	CO2
	B		Assignment statements, Characters, Strings and string operations Conditional statements (If-else-elseif statements)	CO2
	C		Flow control Loops: For and While loops Defining functions	CO2
	Unit 3		**Standard Modules for Physics Applications**	
	A		Numerical Python (NumPy)	CO3
	B		Scientific Python (SciPy)	CO3
	C		Tabular Data Processing (Pandas)	CO3
	Unit 4		**Scientific Plotting Using Python**	
	A		Using MatPlotLib for basic plotting	CO4, CO6
	B		Using Seaborn for plotting of tabular data	CO4, CO6
	C		Using Plotly for interactive plots	CO4, CO6
	Unit 5		**Advanced Topics**	
	A		Difference between Procedural Programming and Object Oriented Programming, Inheritance and Polymorphism , Object Oriented Design of Python	CO5, CO6

	B	Signal processing with Python (SciPy, Librosa modules). Fourier transforms, generating and plotting spectrograms.			CO5, CO6
	C	Image processing with Python (OpenCV module). Opening, modifying and saving images.			CO5, CO6
	Mode of examination	Class test (10) ,Assignments (10) and presentation (10)			
	Weightage Distribution	CA	CE	ESE	
		25%	25%	50%	
	Text book/s*	1. Python for Everybody: Exploring Data Using Python Book by Charles Severance 2. Learning Scientific programming with Python by Christian Hill			
	References	1.Effective Computation in Physics by Anthony Scopatz, Kathryn D. Huff 2.Essential Python for Physicists, by Giovanni Moruzzi			

Course Articulation Matrix

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

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

PHC201 AI and ML in Physics using Python

School: SSBSR		**Batch:2023-27**
Program:Diploma in Physics		**Current Academic Year: 2025-2026**
Branch: Physics		**SEMESTER: III**
1	Course Code	**PHC201**
2	Course Title	**AI and Machine learning in Physics using Python**
3	Credits	3
4	Contact Hours (L-T-P)	3-0-0
5	Course Status	Compulsory
6	Max. Marks	15+10+75=100
7	Min. Marks	
8	Course Objective	This course provides an opportunity to develop knowledge and understanding of the key principles and applications of AI and Machine learning
9	Course Outcomes	CO1: Understand basics of Python for AI-ML CO2: Understanding some basic ML algorithms for classification, regression and clustering, and basics of neural network Architecture CO3:Learning to program and train basic ML algorithms for regression, classification and unsupervised clustering CO4: Learning basics of Neural Network Architecture, neural network training process, determining performance metrics and adjusting hyperparameters CO5: Learning to program, train and optimize AI-ML Applications in Physics CO6: Analyze, understand and Apply the concept of AI and ML on practical problems.
10	Course Description	This course provides students an exposure to the basic principles and essential concepts of AI and Machine learning. Students learn to program, train and optimize Machine Learning and Deep Learning models in Python language. Students also learn applications of AI-ML in some areas of physics.

		Introduction to Indian ancient Physics and contribution of Indian Physicists, in context with the holistic development of modern science and technology, should be included under Continuous Internal Evaluation (CIE).	
11	Outline syllabus		CO Mapping
	Unit 1	**Introduction to Python for AI and ML**	
	A	Python Introduction and its features, Installing python and basic packages, Using its predefined functions. Python identifiers, Data types, Arithmetic, Assignment, Comparison, Logical operators.	CO1
	B	Lists, tuples, dictionaries, arrays, functions, for and while loops	CO1
	C	Useful Python modules: NumPy, Pandas, MatplotLib, SciPy	CO1
	Unit 2	**Introduction to Machine Learning and Deep Learning**	
	A	Machine Learning Introduction, Supervised, Unsupervised and Semisupervised learning. Scaling or normalization of data, Splitting data into training and validations sets.	CO2
	B	Basic algorithms of Machine Learning for regression, classification and clustering (Linear, polynomial, Support Vector Machine regression, Logistic regression, Algorithms for classification: Support Vector Machine, Decision Trees, Random Forest classifier, Unsupervised clustering using K-means and Gaussian Mixture Model.	CO2
	C	Perceptrons as artificial neurons, Artificial Neural Networks, Feed-Forward and Backpropagation algorithm for training neural networks. Training performance evaluation using accuracy, loss, F1 score, precision, recall, ROC and AUC curves,	CO2
	Unit 3	**Machine learning Application using Scikit-Learn**	
	A	Scikit-Learn API. Linear, logistic and Support Vector Machine based regression using Scikit-Learn	CO3

	B	Support Vector Machine classifier, Decision Tree classifier and Random Forest classifier using Scikit-Learn			CO3
	C	Unsupervised classification (Clustering) using Scikit-Learn. K-Means (K nearest neighbors), Gaussian Mixture Model using Scikit-Learn.			CO3, CO6
	Unit 4	**Deep Learning Applications**			
	A	Installing TensorFlow and Keras Python packages for neural networks. Activation functions (logistic, ReLU, softmax), Optimizers. Hyperparameters and trainable parameters of neural networks, Loss and Cost Functions.			
	B	Designing fully connected Networks. Training the network, measuring its performance on actual data and optimizing the network by adjusting hyperparameters, batch size and epochs.			CO4
	C	Basics of Convolutional Neural Networks (CNN). Designing CNNs using Keras. Designing and training a CNN for NIST handwritten digit image classification.			CO4, CO6
	Unit 5	**AI-ML in Physics**			
	A	Data types in Physics applications: numerical, categorical, tabular form, image form, time series data. Loading and pre-processing different data types in Python.			CO5, CO6
	B	Applications of AI-ML on tabular or time-series data in nanoscience and physics of materials.			CO5
	C	Applications of AI-ML on image data in medical imaging, space & astrophysics, microscopy and remote sensing.			CO5, CO6
	Mode of examination	20 marks for Test / Quiz / Assignment / Seminar. 05 marks for Class Interaction			
	Weightage Distribution	CA	MSE	ESE	
		15%	10%	75%	

	Text book/s*	1. Python Data Science Handbook by Jacob T. Vanderplas 2. Ian Goodfellow, YoshuaBengio and Aaron Courville, Deep Learning. MIT Press 2016 3. Artificial Intelligence: A Modern Approach, Third Edition, Stuart Russell and Peter Norvig, Pearson Education. 4. Hastie, Tibshirani, Friedman The elements of Statistical Learning Springer Verlag 5. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition	
	Suggestive Digital Platforms / Web Links	1.MIT Open Learning - Massachusetts Institute of Technology, https://openlearning.mit.edu/ 2. National Programme on Technology Enhanced Learning (NPTEL), https://www.youtube.com/user/nptelhrd 3. Uttar Pradesh Higher Education Digital Library, http://heecontent.upsdc.gov.in/SearchContent.aspx 4. Swayam Prabha - DTH Channel, https://www.swayamprabha.gov.in/index.php/program/current_he/8	
	Suggested Equivalent Online Courses	1. Swayam - Government of India, https://swayam.gov.in/explorer?category=Physics 2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html 3. Coursera,https://www.coursera.org/browse/physical-science-and-engineering/physics-and-astronomy 4. edX,https://www.edx.org/course/subject/physics 5. MIT OpenCourseWare - Massachusetts Institute of Technology, https://ocw.mit.edu/courses/physics/	

Course Articulation Matrix for AI and Machine learning in Physics using Python

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	2	3	1	2	1	3	3	3	3	1	1	3
CO2	2	3	2	2	3	2	3	1	3	3	3	3	1	1	3
CO3	2	3	2	2	3	2	3	1	3	3	3	3	1	1	3
CO4	2	3	2	2	3	2	3	1	3	3	3	3	1	1	3
CO5	3	3	2	2	3	2	3	1	3	3	3	3	1	1	3
CO6	3	3	3	2	3	2	3	1	3	3	3	3	1	1	3

1-Slight (Low) **2-Moderate (Medium)** **3-Substantial (High)**

PHC202-DFT Analysis

School: School of Basic Sciences and Research		**Batch:2023-2027**
Program: DIPLOMA IN PHYSICS		**Current Academic Year: 2024-25**
Branch: Physics		**Semester: IV**
1	Course Code	PHC202
2	Course Title	DFT Analysis
3	Credits	3
4	Contact Hours (L-T-P)	3-0-0
	Course Status	Compulsory
5	Course Objective	➢ **The main aims of the course are two fold:** ➢ **1. Learning basic methods, tools and techniques of DFT in computational physics.** ➢ **2. Developing practical computational problem solving skills using DFT in Computational Physics.**
6	Course Outcomes	After the completion of this course, **CO1:** The students should be able to account for the fundamental background of Density Functional Theory (DFT) and how the concepts of electron correlation are approximated within DFT. In addition they should be able to compare and compare these approximations to other correlated methods. **CO2:** The students should be able to explain the Hohenberg-Kohn theorems and their application. **CO3:** The students should be able to account for the Kohn-Sham equations and density functionals, such as Slater's X-alpha and the Local Density Approximation (LDA), adiabatic connection, exchange correlation hole, applications of these concepts. **CO4:** The students should be able to comprehend the theory and applications of the Generalized Gradient Approximation (GGA), Perdrew-Burke-Ernzerhof (PBE) Functional and (LDA) in the perspective of DFT. **CO5:** The students should be able to understand the theory and applications of the Becke 3-parameter, Lee–Yang–Parr (B3LYP) Functional and its difference with the PBE Functional in the perspective of DFT, Further the students shoud be able to comprehend the concepts of The theory of the Exchange interaction, self-interaction, functional derivative, Janak's theorem, transition state theory, The theory of the Finite temperature (Mermin) functional, and the

		potential (V) representation (V-representation) of a system of particles (electrons). **CO6:** The students should be able to determine in non-relativistic quantum mechanics situation whether a 1- or 2-particle mixed state is a reduced density matrix of a pure N-particle wave function (N-representation), Applications of DFT in solving problems related to Optical, Electronic, Thermal, Magnetic etc. properties of materials.	
7	Course Description	This course provides the basic foundation for understanding the application of DFT in solving problems related to Computational Physics	
8	Outline Syllabus		CO Mapping
	Unit 1	**Introduction to DFT basics**	
	A	Introduction, Historical Background of DFT and Time Dependent DFT (ID-DFT),	**CO1**
	B	Overview of Successes and Failures of DFT,	**CO1**
	C	Electron correlation.	**CO1**
	Unit 2	**Kohn-Sham equations, Hohenberg-Kohn's Theorem, LDA, Exchange Interaction**	
	A	The theory of the Kohn-Sham equations, Hohenberg-Kohn's Theorem,	**CO2**
	B	Local Density Approximation (LDA), adiabatic connection, exchange correlation hole,	**CO2**
	C	Applications of these concepts.	**CO2**
	Unit 3	**Generalized Gradient Approximation (GGA), Comparison with LDA performance, Applications of GGA**	
	A	The theory of the Generalized Gradient Approximation (GGA) in the perspective of DFT.	**CO3**
	B	Comparison of the performance of GGA with LDA.	**CO3**
	C	Application of GGA.	**CO3**
	Unit 4	**Advanced Applications of GGA, PBE Functional, Comparison with LDA performance**	
	A	Advanced applications of GGA	**CO4, CO6**
	B	The theory and applications of Perdrew-Burke-Ernzerhof (PBE) Functional	**CO4, CO6**
	C	Comparison with LDA in the perspective of DFT.	**CO4, CO6**
	Unit 5	**B3LYP Functional, Comparison with PBE Functional Performance, Exchange and Interaction, Finite Temperature Functional, V-Representation**	
	A	The theory and applications of the Becke 3-parameter, Lee–Yang–Parr (B3LYP) Functional and its difference with the PBE Functional in the perspective of DFT.	**CO5, CO6**

	B	The theory of the Exchange interaction, self-interaction, functional derivative, Janak's theorem, transition state theory.			**CO5, CO6**
	C	The theory of the Finite temperature (Mermin) functional, the exchange correlation potential (V) evaluation method of N interacting/non-interacting electrons (V-representation).			**CO5, CO6**
	Mode of Examination	Theory			
	Weightage Distribution	CA	MSE	ESE	
		!5%	10%	75%	
	Text books	DENSITY FUNCTIONAL THEORY, David S Sholl, Janice S Steckel, Wiley 2015			
	Other References	1. Density Functional Theory An Advanced Course, Eberhard Engel · Reiner M. Dreizler, Springer, 2011. https://wiki.physics.udel.edu/wiki_qttg/images/5/53/BOOK%3Ddft_an_advanced_course.pdf (Free e-book) 2. Density Functional Theory: An Approach to the Quantum Many-Body Problem, Reiner M. Dreizler , and Eberhard K. U. Gross, Springer, 1990 3. http://www.physics.rutgers.edu/~haule/509/DFT.pdf 4. 4.A Primer in Density Functional Theory, Carlos Fiolhais, Fernando Nogueira, Miguel A. L. Marques (editors), Springer-Link, 2003			

Course Articulation Matrix for PHC202

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	1	1	1	1	2	1	3	1	1	3
CO2	1	3	3	3	3	1	2	2	2	2	1	3	1	1	3
CO3	3	3	3	2	2	2	2	1	2	1	3	3	1	1	3
CO4	2	2	2	3	3	3	1	1	1	1	3	3	1	1	3
CO5	2	2	2	2	3	3	1	1	1	1	3	3	1	1	3
CO6	2	2	2	2	3	3	1	1	1	1	3	3	1	1	3

PHC-301 Finite Element Analysis

School: SSBSR		**Batch:2023-2027**
Program: B.Sc. in Physics with Minor in Computational Physics		**Current Academic Year: 2024-2025**
Branch:		**Semester: VI**
1	Course Code	PHC301
2	Course Title	Finite Element Analysis

3	Credits	3
4	Contact Hours (L-T-P)	3-0-0
	Course Status	Compulsory
5	Course Objective	➢ This course is an introduction to the finite element method (FEM) as applicable to a range of problems in physics and engineering sciences. ➢ To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools. ➢ The development itself focuses on the classical forms of partial differential equations (PDEs): elliptic, parabolic and hyperbolic.
6	Course Outcomes	After the completion of this course, the student will be able to: CO1.The students should be able to account for the fundamental background finite elements method and its principal. They will learn the review of matrices, definition, types, addition or subtraction, multiplication, inverse of a matrix, calculus of matrix of partial differential equations (PDEs). In addition, they should be able to Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses. CO2.The students should be able to explain mechanics of materials and machine design to provide preliminary results used for testing the reasonableness of finite element results. CO3. Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis. CO4. Interpret the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors. CO5. The students should be able to understand the finite element method (FEM), Differential equation solving, mathematical, modeling. In addition, they will learn structural

		analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential.	
7	Course Description	This course provides the basic foundation for understanding the application of DFT in solving problems related to Computational Physics	
8	Outline Syllabus		CO Mapping
	Unit 1: Introduction to Fine Element Methods		
			CO1
A	Introduction, exact solution vs approximate solution, principle of FEM, general procedure for finite element analysis, pre-processing, solution, post processing,		**CO1**
B	various approximate methods, weighted residual method, variational or Rayleigh Ritz method, principle of minimum potential energy.		**CO1**
C	Review of matrices, definition, types, addition or subtraction, multiplication, inverse of a matrix, calculus of matrix.		**CO1**
	Unit 2: Stiffness Methods and Applications		**CO1**
A	Direct stiffness methods, linear spring as finite element.		**CO2**
B	Direct formulation of uni-axial bar, truss and beam elements, local and global coordinates, nodes and elements, stiffness matrix.		**CO2**
C	Formulation of global stiffness matrix, application of boundary conditions and forces, essential and natural boundary conditions, elimination method, penalty methods, calculation of element stresses and strains.		**CO2**
	Unit 3	**Various FEM formulations for Problem Solving in 1-D**	**CO3**
	A	Finite element formulation of 1-d problems, method of weighted residuals, strong and weak form.	**CO3,**
	B	The Galerkin finite element method, application of Galerkin's method to uni-axial bar and truss elements.	**CO3**
	C	Galerkin method for one dimensional heat conduction problems like heat transfer through wall, heat transfer through fin etc., one dimensional conduction with convection.	**CO3**
	Unit 4	**Interpolation and Shape Functions for 1-D and 2-D Problem Solving**	
	A	Interpolation or shape functions, compatibility, completeness and convergence requirements.	**CO4, CO6**
	B	Shape functions for one and two-dimensional elements, finding shape function using Lagrange polynomials.	**CO4, CO6**
	C	Application of FEM in scalar field problems, heat transfer in two dimensions, time dependent heat transfer.	**CO4, CO6**
	Unit 5	**Various Stress and Strain Concepts, Treatment of Various Forces, Practical Applications of other FEM techniques**	

	A	Concepts of plane stress and plain strain, displacement relation, stress-strain relations, equilibrium and compatibility equations, vector field problems,	**CO5, CO6**
	B	Derivation of constant strain triangular element stiffness matrix and equations, treatment of body and surface forces, stress and strain computation.	**CO5, CO6**
	C	Practical considerations in finite element application, programming aspects, commercially available FEM packages, desirable features of a FEM packages, problem solving on a general purpose FEM software package like ANSYS, ABAQUS, NISA etc.	**CO5, CO6**
	Mode of Examination	Theory	
	Weightage Distribution	CA: 15% / MTE: 10% / ETE: 75%	
	Text Books	1. Fundamentals of Finite Element Analysis by David V Hutton, McGraw-Hill Learning 2. A First Course in Finite Element Method 5e by Daryl L Logan, Cengage Learning	
	REFERENCE BOOKS	**1.** Finite Element Analysis by G L Narasaiah, BS Publications **2.** An Introduction to Finite Element Method, 3e by J N Reddy, McGraw-Hill **3.** Finite Element Method with Application in Engineering by Desai, Eldho and Shah, Pearson Education. **4.** Introduction to Finite Element Analysis and Design by Kim & Shankar, John Wiley & Sons. **5.** Introduction to Finite Elements in Engineering by Chandrupatla&Belagundu, Pearson Education.	

Course Articulation matrix

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	2	2	1	1	1	1	1	3	1	1	3
CO2	1	3	3	3	3	1	1	2	2	2	1	3	1	1	3
CO3	3	3	3	2	2	2	2	1	2	2	3	3	1	1	3
CO4	2	2	2	3	3	3	1	1	1	1	3	3	1	1	3
CO5	2	2	2	2	3	3	1	1	1	1	3	3	1	1	3
CO6	2	2	2	2	3	3	1	1	1	1	3	3	1	1	3

1-Slight (Low) 2-Moderate (Medium) 3-Substantial (High)

School	SSBSR	**Batch**		**2023-2027**	
Program	BSc	**Current Academic Year**			
Branch	Physics	**Semester**		**VII**	
Specialization		**Computational Physics**			
1	Course Code				
2	**Course Title**	**Molecular Dynamics**			
3	Credits	4			
4	Contact Hours (L-T-P)	4-0-0			
	Course Status	Compulsory			
5	Course Objective	To develop skills in implementing basic molecular dynamics codes, running simulations, and analyzing their output; to measure equilibrium and transport properties using both molecular dynamics and Monte Carlo sampling and understand underlying approximations and associated advantages and limits;			
6	Course Outcomes	After the completion of this course, the student will be able to **CO1:** Understand molecular modelling **CO2:** visualize molecular trajectories using VMD **CO3:** able to install LAMMPS and learn its commands **CO4:** develop knowledge on molecular dynamics **CO5:** simulate molecular systems **CO6:** gain skill in simulating molecular dynamics			
7	Course Description				
8	Outline syllabus				CO Mapping
	Unit 1	**Introduction**			
	A	Molecular modeling			CO1
	B	Computer simulations			CO1
	C	Intermolecular forces			CO1
	Unit 2	**Using Visual Molecular Dynamics (Software)**			
	A	Introduction to VMD and Installation of VMD			CO2
	B	Filetype, Running VMD			CO2
	C	Viewing multiple molecules and trajectories; Scripting in VMD			CO2
	Unit 3	**Installing and Running LAMMPS (Software package)**			
	A	Introduction to LAMMPS, Install LAMMPS			CO3, CO6
	B	Build LAMMPS, Run LAMMPS			CO3, CO6
	C	Commands in LAMMPS			CO3, CO6
	Unit 4	**Molecular dynamics**			
	A	Newton's equations of motion for many-body systems; Numerical integration, accuracy, and stability			CO4, CO6
	B	Classical potentials and force fields			CO4, CO6
	C	Periodic boundary conditions and neighbor lists; Implementation of thermostats and barostats			CO4, CO6
	Unit 5	**Simulation on LAMMPS**			
	A	Simple molecular simulation of a Lennard-Jones binary gas			CO5, CO6
	B	Simulation of longitudinal deformation of small graphene sheet			CO5, CO6
	C	Simulation of breaking of the bonds of a carbon nanotube under extreme deformation			CO5, CO6
	Mode of examination	Class test (10) ,Assignments (10) and presentation (10)			
	Weightage Distribution	CA	MTE	ETE	
		25%	25%	50%	

	Text book/s*	3. Michael P Allen and Dominic J Tildesley.Computer simulation of liquids. Oxford university press, (2017) 4. VMD: https://sassie-web.chem.utk.edu/training/aps_2016/files/lab_I.pdf 5. Tutorial on LAMMPS: https://www.lammps.org/#gsc.tab=0 https://docs.lammps.org/Manual.html https://www.lammps.org/tutorials.html https://lammpstutorials.github.io/index.html https://lammpstutorials.github.io/sphinx/build/html/howto.html	
	References	7. An Introduction to Molecular Dynamics (Physics Research and Technology) BY Mark S Kemp	

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	2	2	1	1	1	1	1	3	1	1	3
CO2	3	3	3	3	3	1	1	1	2	2	1	3	1	1	3
CO3	3	3	3	2	2	2	2	1	2	2	3	3	1	1	3
CO4	2	2	2	3	3	3	1	1	1	1	3	3	1	1	3
CO5	2	2	2	2	3	3	1	1	1	1	3	3	1	1	3
CO6	2	2	2	2	3	3	1	1	1	1	3	3	1	1	3