TEACHING INSTRUCTIONAL DESIGN (BRP)

COURSE

SPECTROSCOPY A

by

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PREFACE

The Learning Design Book (BRP) for the Spectroscopy A course contains a lesson plan for one semester and is compiled as a learning reference for the Spectroscopy A course in the Undergraduate Program at the Department of Physics, Faculty of Mathematics and Natural Sciences UI.

The Spectroscopy A course is a compulsory subject for students of the Bachelor of Physics program who major in Condensed Matter Physics. The requirements needed by students to be able to take this course are already taking Basic Physics 3 and Modern Physics courses.

The Spectroscopy A lecture which is held in one semester is designed to provide students with a deeper description of the theory of several spectroscopic techniques and their applications. The first unit is an introduction to the characteristics of electromagnetic radiation and the types of interactions that occur between matter and electromagnetic radiation as well as techniques and instrumentation in spectroscopy. The microwave spectroscopy used to identify the rotational characteristics of the molecules is contained in the second unit. The third and fourth units contain techniques and instrumentation in infrared spectroscopy and Raman spectroscopy to identify the structure of matter through the characteristics of vibrations and rotational vibrations of the molecules that make up the material as well as the harmonic oscillator approach. The basic theory, techniques and instrumentation for luminescence spectroscopy are contained in the fifth unit. The sixth unit contains the basic theory, techniques and instrumentation of electron spectroscopy for atoms and molecules. The basic theory, techniques and spectroscopic instrumentation for the analysis of surface matter are studied in the seventh unit.

The implementation of Spectroscopy A lectures is carried out with a combination of face-to-face interactive methods at the beginning of lectures and a student-centered learning approach in subsequent courses. At the beginning of the lecture, the face-to-face session discusses the first unit and the student's independent task division about one of the five spectroscopic techniques learned in Spectroscopy A. Students independently learn the material and explore deeper material to be delivered in the form of presentations to other lecture participants and teachers. Students are expected to be able to convey their understanding and understanding effectively, sequentially and systematically and be able to argue in discussions with other lecture participants and lecturers.

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Prof. Dr. Rosari Saleh

I. General Information

1.	Name of Program / Study Level	:	Physics / Undergraduate
2.	Course Name	:	Spectroscopy A
3.	Course Code	:	SCPH603709
4.	Semester	:	6
5.	Credit Points	:	2 credits
6.	Teaching Method(s)	:	Interactive lecture
7.	Prerequisite course(s)	:	Modern Physics, Vibrations and Waves, Electromagnetic Field 1, Classical Mechanics
8.	Requisite for course(s)	:	-
9.	Integration Between Other Courses	:	Modern Physics, **Spectroscopy B**
10.	Lecturer(s)	:	Prof. Dr. Rosari Saleh
11.	Course Description	:	In the Spectroscopy A course, students will study the interaction of electromagnetic waves with materials, basic components of spectroscopy, rotational spectroscopy techniques and instrumentation, vibration spectrum: infrared (IR) and Raman, techniques and instrumentation of luminescence spectroscopy, techniques and electron spectroscopy for atoms and molecules, electron spectroscopy for surface analysis of materials.

II. Course Learning Outcome (CLO) and Sub-CLOs

A. CLO

After completing this lecture, students are expected to be able to identify the equipment components of the five spectroscopic techniques studied, describe how the spectrum is generated from each of these spectroscopic techniques, and explain the information that can be obtained from the spectral measurement results. Students are expected to be able to understand their understanding in reading articles in scientific journals, especially experimental chapters and experimental results. Furthermore, students are expected to choose the appropriate spectroscopic technique to identify the structure of the material, know the limitations and advantages of each of these techniques, and be ready to operate the spectroscopic equipment from the five spectroscopic techniques. (ELO 3,5,6 and 7)

B. Sub-CLOs

1. Describes areas of electromagnetic radiation that correspond to changes in energy resulting from the interaction of electromagnetic radiation with matter that affects changes in molecular vibrational modes, dipole moments, polarizability, electron transitions and electronic structures. (C4)
2. Describes the basic components of the spectroscopic apparatus, the types of electromagnetic radiation sources and the corresponding detectors and their working principles. (C4)
3. Analyzes things that affect the shape, height and width of the measured spectrum, Fourier transforms technique and spectrum processing technique. (C4)
4. Describes the basic components of microwave spectroscopy, especially the sources and detectors used. (C4)
5. Describes the rotation of diatomic and polyatomic molecules. (C4)
6. Analyzes the rigid and non-rigid approaches of molecular bonds as well as the influence of isotopes and electric fields. (C4)
7. Describes the use of microwave spectroscopy to detect molecules. (C4)
8. Operates microwave spectroscopy equipment. (C3)
9. Describes the basic components of infrared spectroscopy, especially the sources and detectors used. (C4)
10. Analyzes the vibrational and rotational modes of diatomic and polyatomic molecules and how these vibrational and rotational modes contribute to the infrared spectrum. (C4)

11. Describes the effect of anharmonic and the effect of rotation on the infrared spectrum. (C4)
12. Describes the use of infrared spectroscopy to detect molecules. (C4)
13. Operates infrared spectroscopy equipment. (C3)
14. Describes the basic components of Raman spectroscopy especially the sources and detectors used. (C4)
15. Describes the quantum and classical theories of the Raman effect. (C4)
16. Analyzes the rotational and vibrational spectra of the Raman spectrum for various molecular shapes. (C4)
17. Describes the use of Raman spectroscopy to detect molecules. (C4)
18. Operates the Raman spectroscopy equipment. (C3)
19. Analyzes differences in the characteristics of molecular vibrations which can be identified by infrared spectroscopy and Raman spectroscopy. (C4)
20. Describes the basic components of luminescence spectroscopy especially the sources and detectors used. (C4)
21. Describes the difference between the electronic transitions of fluorescence and phosphorescence. (C4)
22. Describes the use of luminescence spectroscopy. (C4)
23. Operates luminescence spectroscopy equipment. (C3)
24. Analyzes the basic components of electron spectroscopy, especially the sources and detectors used. (C4)
25. Describes the electronic transition of hydrogen atoms and hydrogen-like atoms, helium atoms and alkaline earth elements. (C4)
26. Describes the electronic transitions and electronic structures of diatomic and polyatomic molecules. (C4)
27. Describes electronic transitions in electron spectroscopy for surface identification of matter (C4)
28. Analyzes the use of electron spectroscopy for the identification of atoms and molecules and the surface of the matter. (C4)
29. Operates electron spectroscopy equipment. (C3)

III. Lesson Plan

Week	Sub-CLO	Study Materials	Teaching Method	Time Required	Learning Experiences (*O-E-F)	Sub-CLO Weight on Course (%)	Sub-CLO Achievement Indicator	References
1	1	The interaction of electromagnetic radiation in matter.	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	6	Describe areas of the electromagnetic radiation corresponding to changes in energy resulting from the interaction of electromagnetic radiation with matter that affects changes in molecular vibrational modes, dipole moments, polarizability, electron transition and electronic structure	[1] Chapter 2 and 3
2	2,3	The interaction of electromagnetic radiation in matter.	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	6	Describe the basic components of spectroscopic equipment, the types of electromagnetic radiation sources and the corresponding detectors and their working principles, matters that affect the shape, height and width of the measured spectrum, Fourier transform technique and spectrum processing techniques.	[3] Chapter 1
3	4,5,6	Microwave Spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	6	Describes the basic components of microwave spectroscopy, especially the sources and detectors used, the rotation of diatomic and polyatomic molecules, the rigid and non-rigid approaches of molecular bonding and the influence of isotopes and electric fields.	[3] Chapter 2

4	7,8	Microwave Spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	6	Describes the use of microwave spectroscopy to detect molecules, applying microwave spectroscopy	[3] Chapter 2
5	9,10,11	IR Spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	6	Describe the basic components of infrared spectroscopy, especially the sources and detectors used, the modes of vibration and rotation of diatomic and polyatomic molecules and how these vibrational and rotational modes contribute to the infrared spectrum, the effects of anharmonic and the effects of rotation on the infrared spectrum.	[1] Chapter 6 [2] Chapter 9 [3] Chapter 3
6	12,13	IR Spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	6	Describes the use of infrared spectroscopy to detect molecules, Operate infrared spectroscopy equipment	[1] Chapter 6 [2] Chapter 9 [3] Chapter 3
7	**Midterm Exam**							
8	14,15,16	Raman Spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Describe the basic components of Raman spectroscopy, especially the sources and detectors used, quantum and classical theories of the Raman effect, Raman rotational and vibrational spectra for various molecular shapes	[1] Chapter 6 [2] Chapter 15 [3] Chapter 4
9	17,18,19	Raman Spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%)	8	Describes the use of Raman spectroscopy to detect molecules, the	[1] Chapter 6

					F : Discussion and Q&A (40%)		differences in the vibrational characteristics of molecules that can be identified by infrared spectroscopy and Raman spectroscopy. Operating Raman spectroscopy equipment.	[2] Chapter 15 [3] Chapter 4
10	20,21	Luminescence spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Describes the basic components of luminescence spectroscopy, especially the sources and detectors used, the difference between electronic transitions of fluorescence and phosphorescence.	[2] Chapter 12 and 13
11	22,23	Luminescence spectroscopy	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Describe the use of luminescence spectroscopy and operating luminescence spectroscopy equipment	[2] Chapter 12 and 13
12	24,25	Electron spectroscopy for atoms and molecules	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Analyze the basic components of electron spectroscopy, especially the sources and detectors used, the electronic transitions of hydrogen atoms and hydrogen-like atoms, helium atoms and alkaline earth elements.	[1] Chapter 7 [3] Chapter 5 and 6
13	26	Electron spectroscopy for atoms and molecules	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Describe the electronic transitions and electronic structures of diatomic and polyatomic molecules	[1] Chapter 7 [3] Chapter 5 and 6
14	27,28	Electron spectroscopy for surface identification of matter	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Describes the electronic transitions in electron spectroscopy for the identification of material surfaces, Analyze the use of electron spectroscopy for the identification of	[1] Chapter 8 [2] Chapter 10 and 11

							atoms and molecules and the surface of matter	
15	29	Electron spectroscopy for surface identification of matter	Interactive Lecture	150 minutes	O : Preface (20%) E : Presentation (40%) F : Discussion and Q&A (40%)	8	Operating electron spectroscopy equipment	[1] Chapter 8 [2] Chapter 10 and 11
16	**Final Exam**							

*) O : Orientation
E : Exercise
F : Feedback

Referencesi:

1. J. Michael Hollas, *Modern Spectroscopy* 4th Ed., John Wiley& Sons, Ltd., Chichester, 2004.
2. DR Vij, Handbook of Applied Solid State Spectroscopy, Springer, New York, 2006
3. Collin N Banwell and Elaine M McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., McGraw-Hill Book Co.,Singapore, 1995.
4. David W. Ball, *The Basic of Spectroscopy,* SPIE Publications, Washington, 2001.
5. James W Robinson, Eillen M Skelly Frame, George M Frame II, Undergraduate Instrumental Analysis 6th. Ed., Marcell Dekker, New York, 2005.

IV. Rancangan Tugas dan Latihan

Week	Assignment Name	Sub-CLO	Assignment	Scope	Working Procedure	Deadline	Outcome
1-2	Discussion and Q&A	1, 2, 3	Question(s)	Characteristics of electromagnetic radiation, area of the electromagnetic radiation spectrum, basic components of spectroscopy, working area and working principle, separating power, width and intensity of the spectra, Fourier transform spectroscopy, spectrum processing.	In class	100 minutes	Notes on discussion results
3-6	Presentation	4,5, 6,7,8	Presentation	The basic components of microwave spectroscopy are mainly the sources and detectors used, diatomic and polyatomic molecular rotation, rigid and non-rigid molecular bonding approaches and the influence of isotopes and electric fields, the use of microwave spectroscopy to detect molecules, microwave spectroscopy applications.	Individual/by group and in class	100 minutes	Student powerpoints, results of presentations and discussions
7	Midterm Exam						
5-11	Presentation	9-23	Presentation	Technique and instrumentation of infrared spectroscopy, modes of vibration and rotation, SHO and AHO approaches, interpretation of infrared spectra, applications of infrared spectroscopy. Techniques and instrumentation of Raman spectroscopy, classical and quantum theory of the Raman effect, interpretation of Raman vibrational and rotational spectra, applications of Raman spectroscopy. Engineering and instrumentation of luminescence spectroscopy, fluorescence and phosphorescence electronic transitions, interpretation of the luminescence spectrum, applications of luminescence spectroscopy.	Individual/by group and in class	100 minutes	Student powerpoints, results of presentations and discussions
12-15	Discussion and Q&A	24-29	Question(s)	Electron spectroscopy techniques and instrumentation, electronic transitions of hydrogen, helium and alkaline earth atoms, electronic transitions of diatomic and polyatomic molecules. Electronic transitions for surface analysis of materials, interpretation of Auger and X-ray Photoelectron spectroscopic curves and their applications.	Individual/by group and in class	100 minutes	Notes on discussion results
16	Midterm Exam						

V. Assessment Criteria (Evaluation of Learning Outcomes)

Evaluation Type	Sub-CLO	Assessment Type	Frequency	Evaluation Weight (%)
Presentation Assignment	4-8, 9-23	Assessment Sheet	2	30
Discussion and Q&A	1-3, 24-29	Assessment Sheet	2	40
Midterm Exam	1-8	Individual Assignment Evaluation	1	15
Final Exam	9-29	Individual Assignment Evaluation	1	15
Total				**100**

VI. Rubric

A. Criteria of Presentation Assessment

Score	Presentation Delivery
85-90	The groups are proficient to convey explanations logically, smoothly, and on time and competent in answering questions from fellow students and lecturers.
75-84	The groups are proficient to convey explanations logically and smoothly and can answer questions from fellow students and lecturer, but cannot manage time well.
65-74	The groups are proficient to convey explanations fluently but cannot convey the logic of their reasoning.
55-64	The groups are less proficient to convey explanations well and on time, and are less able to convey the logic of their reasoning.
<55	

B. Criteria of Essay Assessment

Score	Answers Quality
100	Answers are very precise and all the concept and main component are explained completely
76-99	Answers are fairly precise and the concept and main component are explained fairly complete
51-75	Answers are less precise and the concept and main component are explained less complete
26-50	Answers are poorly precise and the concept and main component are explained poorly complete
<25	Answers are wrong

VII. Attachment: Sample of Examination Papers

UJIAN SPEKTROSKOPI 1

Waktu: 100 menit

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1. Apakah penyeleksi energi/panjang gelombang digunakan dalam spektroskopi AES? Jika ya, alat apa yang digunakan dan bagaimana cara kerjanya?

2. Jelaskan yang dimaksud dengan “XPS Imaging” dan “Angle-resolved XPS”! Apa aplikasi spektroskopi XPS? Sebutkan dan jelaskan!

3. Molekul memiliki 3 momen inersia untuk sumbu rotasi utama-nya. Sebutkan dan jelaskan pengelompokkan molekul berdasarkan hal tersebut!

4. Bagaimana pendekatan *SHO* (*Simple Harmonic Oscillator*) digunakan dalam mempelajari vibrasi molekul diatomik? Jelaskan!

5. a. Bagaimana efek Raman dijelaskan menurut teori kuantum?
   b. Bagaimana teknik dan instrumentasi dalam spektroskopi Raman