NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI

DEPARTMENT OF PHYSICS

COURSE PLAN – PART I			
Name of the programme and specialization	MSc (Physics)		
Course Title	Atomic and Molecular Spectroscopy		
Course Code	PH-663	No. of Credits	3
Course Code of Pre-requisite subject(s)	NA		
Session	July -2020	Section (if, applicable)	NA
Name of Faculty	Venkata Suryanarayana Mummidi	Department	Physics
Official Email	venkata@nitt.edu	Telephone No.	9686232598
Name of Course Coordinator(s) (if, applicable)	Venkata Suryanarayana Mummidi		
Official E-mail	venkata@nitt.edu	Telephone No.	9686232598
Course Type (please tick appropriately)	☑ Core course	☐ Elective course	

Syllabus (approved in BoS)

1. **Atomic Spectra**

Quantum states of electron in atoms–hydrogen atom spectrum–electron spin–Stern Gerlach Experiment–spin-orbit interaction–Lande interval rule–two electron systems–LS-JJ coupling schemes–fine structure–spectroscopic terms and selection rules–hyperfine structure –exchange symmetry of wave function–Pauli's exclusion principle –periodic table.

2. **Atoms in External Fields and Resonance Spectroscopy**

Zeeman and Paschen-Back Effect of one and two electron systems –selection rules –Stark effect–inner shell vacancy–X-ray–Auger transitions –Compton Effect –NMR –basic principles –classical and quantum mechanical description –spin-spin and spin-lattice relaxation times –magnetic dipole coupling –chemical shift –Knight shift –ESR –basic principles –nuclear interaction and hyperfine structure –g-factor –zero field splitting.

3. Microwave Spectroscopy and IR Spectroscopy

Rotational spectra of diatomic molecules –rigid rotator –effect of isotropic substitution –non-rigid rotator –rotation spectra of polyatomic molecules –linear, symmetric top and asymmetric top molecules –experimental techniques –diatomic vibrating rotator–linear, symmetric top molecule –analysis by infrared techniques –characteristic and group frequencies.

4. Raman Spectroscopy

Raman effect–quantum theory of Raman effect–rotational Raman spectra –vibrational Raman spectra –Raman spectra of polyatomic molecules –Raman spectrometer –hyper-Raman effect –experimental techniques.

5. Electronic Spectroscopy

Electronic spectra of diatomic molecules –Frank-Condon principle–dissociation energy and dissociation products –rotational fine structure of electronic vibration transitions –Fortrat Diagram –pre-dissociation

COURSE OBJECTIVES

To understand the detailed structure of atoms and molecules

MAPPING OF COs with POs

Course Outcomes	Programme Outcomes (PO) (Enter Numbers only)
1. The student will be able to gain sufficient knowledge on most common atomic and molecular spectroscopic methods and properties derived from them.	
2.	

COURSE PLAN – PART II

COURSE OVERVIEW

In this course, we will start out by reviewing probabilistic nature of quantum mechanics and move on to detailed structure of Hydrogen atom including fine structure of the

hydrogen atom.

After gaining intution for one electron atom, complexity of the multi electron atoms is explored, first from the study of the Helium atom and then from the study of the multi electron atom by central field approximation.

How atoms interact with external fields and give rise emission and absorption spectrum(spontaneous emission!) is closely related to the development of quantum mechanics itself. We will discuss very briefly this enormous field by a semi classical model and ponder over statistical arguments given by Einstein. We will derive Zeeman effect and discuss the consequences on the spectrum of the atom.

Molecules are bound states of more than one nucleus and many electron: Why are they stable?, what is the structure of them? . Is there any simplest molecules which can be solved completely!. We will focus our efforts on one very successful approximation method to solve diatomic molecule which is Born-Oppenheimer Approximation. Separation of total energy of the molecule into rotational, vibrational and electronic modes can be understood from Born-Oppenheimer Approximation.

Symmetry of the diatomic molecule: Like Hydrogen atom, by symmetry considerations alone, one can label the energy levels of the molecules of discrete quantum numbers related to symmetry.

After the study of the basic aspects of molecules, we will duly discuss the vibrational and rotational spectroscopy in detailed.

If time permits, Discussion on Raman effect can be extended.

COURSE TEACHING AND LEARNING ACTIVITIES (Add more rows)

S.No.	Week/Contact Hours	Topic	Mode of Delivery
1	Week-1	Review of Quantum mechanics	Online-lecture
2.	Week-2	Single electron atoms	Online-lecture
3.	Week-3	Two electron atoms and multi electron atoms	Online-lecture+ video content
4.	Week-4	Atoms in external fields	Online-lecture
5.	Week-5	Problem solving sessions	Online Tutorial

6	Week-6	Cycle Test-1	--
7	Week-7	Molecular structure: General features of Molecules	Online-lecture
8	Week-8	Molecular structure: Born-Oppenheimer Approximation	Online-lecture
9.	Week-9	Molecular spectroscopy	Online lecture+video content
10.	Week-10	Problem solving sessions	Online tutorial
11.	Week-11	Cycle test-2	
12.	Week-12	Raman spectroscopy	Online lectures
13.	Week-13	Regular class-work is suspended	No class

COURSE ASSESSMENT METHODS (shall range from 4 to 6)

S.No.	Mode of Assessment	Week/Date	Duration	% Weightage
1	Assignments		Approximately every two weeks	20%
2	Quizs		Approximately every 3 weeks	20%
3	Cycle-Test-1		Week-6	15%
4	Cycle-Test-2		Week-11	15%
CPA	Compensation Assessment*		Week-13	
5	Final Assessment *		Week-14 or 15	30%

***mandatory; refer to guidelines on page 4**

COURSE EXIT SURVEY (mention the ways in which the feedback about the course shall be assessed)

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→ Course feed back will be collected at the end of the course.

COURSE POLICY (including compensation assessment to be specified)

→ Attendance mandatory
→ Assesment Internal 70% + Assessment final 30%
→ Cycletest is mandatory.
→ Code of conduct of students & fair practices are encouraged.

ATTENDANCE POLICY (A uniform attendance policy as specified below shall be followed)

- At least 75% attendance in each course is mandatory.
- A maximum of 10% shall be allowed under On Duty (OD) category.
- Students with less than 65% of attendance shall be prevented from writing the final assessment and shall be awarded 'V' grade.

ACADEMIC DISHONESTY & PLAGIARISM

- Possessing a mobile phone, carrying bits of paper, talking to other students, copying from others during an assessment will be treated as punishable dishonesty.
- Zero mark to be awarded for the offenders. For copying from another student, both students get the same penalty of zero mark.
- The departmental disciplinary committee including the course faculty member, PAC chairperson and the HoD, as members shall verify the facts of the malpractice and award the punishment if the student is found guilty. The report shall be submitted to the Academic office.
- The above policy against academic dishonesty shall be applicable for all the programmes.

ADDITIONAL INFORMATION, IF ANY

FOR APPROVAL

Course Faculty M.V. Sya Narayana **CC- Chairperson** M.V. Sya Narayana **HOD** M. Asha