Basic/Essential Course Information	
Course title	Physics of Sensors and Laboratory of Spectroscopy
Degree Course title	Physics
ECTS	6
Compulsory attendance	No
Course teaching language	ENGLISH

Teacher	Pietro Patimisco	pietro.patimisco@uniba.it

ECTS Details	Disciplinary area/broad field:	SSD	ECTS
	Characterizing	FIS/01	6

Time management and teaching activity type	Period	Year	lesson type
	1st semester	2nd	Lessons (32h) Laboratory (30h)

Time management	Total hours	in-class/in-lab study hours	out-of-class study hours
	150	55	95

Course calendar	Starting date	Ending date
	Third week of September	Third week of December

Syllabus	
Prerequisites	Background knowledge on quantum mechanics, statistical physic and basic optics.
Expected learning outcomes (according to Dublin Descriptors)	**Knowledge and understanding.** The student will be able to account for spectroscopic methods in different energy intervals, be able to describe the most common components in spectroscopic equipment, be able to more elaborately explain light-matter interaction in quantum mechanics. **Applying knowledge and understanding** of basic principles of laser spectroscopic techniques. Give practical skills to work with advanced experimental equipments in a scientific lab. Give the competence to perform extended experimental investigations, critically analyses of the data and write proper scientific reports. **Making judgements.** Given a specific problem and project in the field of optical measurements, students should be able to analyze the problem, highlight the peculiar requirements and characteristics, and to compare autonomously different choices in terms of spectroscopic techniques and system performance. **Transferable Communication skills.** The students should be able to

	assess which spectroscopic methods, be able to assess magnitudes for many physical phenomena, be able to work practically with optical components and lasers. The student will be able to access the state-of-the-art scientific literature of the reference topics, in terms of understanding the employed experimental methodologies and the related scientific results. **Lifelong learning skills.** The students will increase experience to work in a small group for a joint aim, will increased ability to present project that they have carried out in the form of a scientific paper, and will look after and integrate knowledge from English reference literature.
Course contents summary	Absorption and Emission of Light. Widths and Profiles of Spectral Lines. Spectroscopic Instrumentations. Doppler-Limited Absorption Laser Spectroscopic Techniques. Physics of Sensors. How to Prepare a Scientific Paper. Laboratory Activities.
detailed syllabus	**Absorption and Emission of Light.** Discrete and Continuous Absorption and Emission Spectra. Transition Probabilities. Lifetimes. Spontaneous and Radiationless Transitions. Semiclassical Description. Basic Equations. Weak-Field Approximation. Transition Probabilities with Broad-band Excitation. Phenomenological Inclusion of Decay Phenomena. Problems. **Widths and Profiles of Spectral Lines.** Natural Linewidth. Lorentzian Line Profile of the Emitted Radiation. Relation between Linewidth and Lifetime. Natural Linewidth of Absorbing Transitions. Doppler Width. Collision Broadening of Spectral Lines. Phenomenological Description. Theoretical Treatment of Anelastic Collisions. Saturation Broadening. Problems. **Spectroscopic Instrumentations.** Spectrographs and Monochromators. Figures of Merit. Speed of Spectrometer. Spectral Transmission. Spectral Resolving Power. Free Spectral Range. Prims Spectrometer. Grating Spectrometer. Interferometers. Basic Concepts. Michelson Interferometer. Mach-Zehnder Interferometer. Multiple-Beam Interference. Fabry-Perot Interferometer. Multilayer Dielectric Coatings. Problems. **Doppler-Limited Absorption Laser Spectroscopic Techniques.** Advantages of Laser Spectroscopy. Direct Absorption Spectroscopy. Modulation Techniques. Amplitude Modulation. Wavelength Modulation. Lock-in detection. Multipass Cell Absorption Spectroscopy. White Multipass Cell. Herriott Multipass Cell. Cavity Enhanced Absorption Spectroscopy. Longitudinal TEM00 cavity modes. Finesse and spectral bandwidth. Mode matching of the laser beam to the cavity. Cavity Ring-Down Absorption spectroscopy. Photoacoustic Spectroscopy. Light absorption and heat generation. Sound wave generation and detection. Quartz-enhanced photoacoustic spectroscopy. Quartz tuning forks: flexural modes. Pressure influence on damping and natural frequencies. Comparison of different gas detection techniques. Minimum absorption coefficient. Normalized noise equivalent absorption. **Physics of Sensors.** Sensor Characteristics. Transfer Function and Dynamic Range. Accuracy. Hysteresis. Saturation. Repeatability.

	Resolution. Dynamic Characteristics. Reliability. Calibration of a gas sensor. Physical Principles of Sensing. Piezoelectric Effect. Pyroelectric Effect. Seebeck Effect. Peltier Effect. **How to Prepare a Scientific Paper.** Overview. Structure and organization of a scientific paper. Introduction. Method. Results and discussion. Conclusions. Abstract. Scientific Style. Basics on HITRAN Database. Basics on Data Analysis with OriginLab. **Laboratory Activities.** Light-Current-Voltage Characterization of a Quantum Cascade Laser. Spectral Characterization of a Quantum Cascade Laser by using a FT-IR. Direct Absorption Spectroscopy. Wavelength Modulation Spectroscopy. Quartz-Enhanced Photoacoustic Spectroscopy.
books	W. Demtroder – *Laser Spectroscopy – Basic Concepts and Instrumentation*, Springer. J. Fraden – *Handbook of Modern Sensors – Physics Designs and Applications*, Springer.
notes	Selected chapters
Teaching methods	Lectures in the teaching room with the aid of a laptop and a projector.
Assessment % of final mark	Oral exam (100%)
Evaluation criteria	Capability to knowledge and discuss state-of-the-art spectroscopic techniques. Adequate comprehension and global knowledge of concepts and arguments described throughout the course.