Basic/Essential Course Information	
Course title	Optoelectronics and Nanotechnologies
Degree Course title	Physics
ECTS	6
Compulsory attendance	No
Course teaching language	ENGLISH

Teacher	Gaetano Scamarcio	gaetano.scamarcio@uniba.it

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

Time management and teaching activity type	Period	Year	lesson type
	2 nd semester	1st	Lessons (40h) Laboratory (15h)

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

Course calendar	Starting date	Ending date
	First week of March	Last week of May

Syllabus	
Prerequisites	Background knowledge on quantum physics, statistical physics and solid state physics at the level of bachelor degree in physics. Knowledge of condensed matter physics and laser physics.
Expected learning outcomes (according to Dublin Descriptors)	**Knowledge and understanding of:** • Light-matter interaction from far-infrared to near-UV ranges. • Relevant properties of semiconductor materials and their quantum structures for the design and fabrication of optoelectronic devices. • Main classes of optoelectronic devices and their state-of-the-art performance. **Applying knowledge and understanding:** • Basic concepts for the design and fabrication of quantum heterostructures with desired properties. • Basic concepts for the design, fabrication and characterization of optoelectronic devices. **Making judgements:** • Ability to choose suitable materials and material structures for the assessment of application concepts. **Transferable Communication skills:** • communication skills in English; • skills in the exposition of physical phenomena and experimental

	results using appropriate scientific language; **Lifelong learning skills:** • ability to learn effective approaches from the critical analysis of crucial inventions in optoelectronics and photonics
Course contents summary	Physics of optoelectronic devices: light emitting diodes, semiconductor lasers, optical fibers, photodetectors. Nanotechnologies for the design and fabrication of optoelectronic devices.
detailed syllabus	Critical review of structural, electronic and optical properties of relevant III-V semiconductors (GaAs, AlxGa1-xAs, In1-xGaxAsyP1-y, InP, GaN). Principles of bandgap engineering using quantum heterostructures. Inter-band and inter-subband transistions. Light emitting diodes (LEDs). Criteria for the choice of materials. Internal quantum efficiency. Spontaneous emission rates as a function of the injection regime. External efficiency. Heterojunction LEDs. L-I-V characteristics. Thermal effects. Temporal response. Semiconductor lasers. Stimulated emission in semiconductor structures. Optical gain. Conditions for population inversion. Double heterojunction laser diodes (LDs). Influence of electrical pumping on the dielectric function of a semiconductor active medium. Laser threshold. Current threshold. L-I-V characteristics. External efficiency. Spectral characteristics. Optical modes of a LD. Solution of the Helmholtz equation in the effective index approximation. Gain guiding and index guiding cavities. Single-mode LDs for telecommunications. Distributed feedback lasers. Quantum well lasers. Influence of Auger effect on the long wavelength limits of LEDs and LDs. Quantum cascade lasers (QCLs). Quantum dot lasers. Vertical cavity surface emitting lasers (VCSELs). Self-mixing in laser diodes: principles and applications. Photolithographic fabrication of LDs. Semiconductor photodetectors. Quantum efficiency and detectivity. Photodiodes. Photoconductors. p-i-n photodiodes. Criteria for the choice of materials. Avalanche photodiodes. Quantum well infrared photodetectors. Basic telecom systems. Wavelength and frequency division multiplexing. Classes of optical fibers. Modal dispersion. Index dispersion. Bandwidth-distance tradeoff.
books	J. Singh, “Semiconductor optoelectronics”, Mc Graw Hill, 1995. G. P. Agrawal, N. K. Dutta, “Semiconductor lasers”, Van Nostrand Rehinhold, 1993. J. Faist, “Quantum Cascade Lasers”, Oxford University Press, 2013. P. Blood “Quantum Confined Laser devices”, Oxford U. Press, 2014.
notes	Selected chapters
Teaching methods	Lectures in the teaching room with the aid of a laptop and a projector. Laboratory visits and demonstrations.
Assessment % of final mark	Oral exam (100%)
Evaluation criteria	Knowing the basic principles of different classes of optoelectronic devices and related figures of merit. Showing the capability to discuss the development of efficient optoelectronic devices with desired functionalities based on the physical properties of relevant material structures, design and fabrication

	strategies.