

2010-2011: OPSCITECH COURSE MODULES at TU DELFT

Code	Name	ECTS	Only for 1 st year
G-phys list	= General optical physics courses		
AP3061 G	Advanced Wave Propagation	6	<i>Compulsory</i>
AP3071 G	Advanced Electrodynamics	6	<i>Compulsory</i>
G-math list	= General mathematics courses		
WI4014TU	Numerical Analysis	6	<i>Choose at least 6 ECTS credits</i>
WI4143TN	Complex Analysis	6	
WI3150TU	Partial Differential Equations I	3	
WI4150TU	Partial Differential Equations II	3	
S-list	= Societal/Non-technical courses		
WM0320TU	Ethics for Engineering	3	<i>Compulsory</i> ¹
	English (level depending on intake test)	3	<i>Compulsory</i> ²
D-list	= Courses at the Department of IST		
AP3111 D	Quantum Electronics and Quantum Optics	6	<i>Choose at least 12 ECTS credits</i>
AP3121 D	Imaging Systems	6	
AP3131 D	Advanced Signal Analysis and Processing	6	
AP3231TU D	Medical Imaging	6	
R-list	= Research course modules		
AP3401	Introduction to charged particle optics	6	<i>Choose at least 12 ECTS credits</i> ³
AP3381	Theoretical optics	6	
AP3391	Geometrical optics	6	
AP3601	Optical Fabrication Technology	6	
ET4283	Advanced Digital Image Processing	6	
WB2433	Humanoid Robots	3	
IN4085	Pattern recognition	6	
AP3361	Medical Physics & Radiation Technology: Imaging	6	
Project	= Research project		
AP3941	In the 1st year: Internship	12	<i>Compulsory</i>
AP3901	In the 2nd year: Master thesis	48	<i>Compulsory</i>

1. The course Ethics for Engineering is offered twice a year, in the first and third period.
2. If your English is exceptionally good, you can also take courses for another language, such as Dutch, German or French. This should be approved by the Delft OpSciTech scientific supervisor. For more information on S-list modules please consult the website of the faculty Technology, Policy and Management www.tbm.tudelft.nl.
3. Should be approved by the internship supervisor or the scientific supervisor.

Look for possible changes on the online study guide of TU Delft: <http://studyguide.tudelft.nl>. OpSciTech can be found under: Year: 2010/2011, Organization: Technische Natuurwetenschappen, Education: Master Applied Physics, Track Optics in Science and Technology. This site also contains a detailed description of each course that can help you in your choices.

2010-2011: OPSCITECH COURSES at FSU JENA

COURSE SCHEDULE (overview):

please consult <http://www.asp.uni-jena.de/Master+Course/Course+Schedule.html>

DETAILED module catalogue:

please consult http://www.physik.uni-jena.de/ordnungen/mc-master-photonics_2009_WS_2009_10_09.pdf

2010-2011: COURSE PROGRAMME at IMPERIAL COLLEGE LONDON

YEAR 1 / 1st term

		Course	ECTS	Professor(s) in charge
6 ECTS		Lasers	6	G. New
		Imaging	6	P. Török
		Optical Communications Physics	6	M. A. A. Neil
		Optical Measurement and Devices	6	K. Weir, C. Paterson
		Laboratory work	7	Mark Neil
		Entrepreneurship	2	Academic staff and external
		Language courses	3	consultants (where appropriate)
	Total			30

YEAR 1 / 2nd & 3rd terms

12 ECTS		Laser Technology	3	M. Damzen
		Laser Optics	3	M. Tarbutt
		Nonlinear Optics	3	J. Tisch
		Biomedical Optics	3	C. Dunsby
		Fibre Technology	3	S. Popov
		Photonic Structures	3	M. McCall, P. Stavrinou
		Optical Displays	3	T. Anthopoulos
		Quantum Physics and Chemistry of Cold Matter	3	B. Sauer, M. Tarbutt
		Experimental Realizations of Controlled Quantum Dynamics	3	D. Segal
		Optoelectronic Components and Devices	3	N. Ekins-Dawkes
		Optical design	6	R. Smith
		Optical Design Laboratory	6	R. Smith, E. Judd
		Laboratory work	5	
		Self Study Project	7	K. Weir, plus the academic members of staff
		Business/Entrepreneurship (including visits)	3	
		Language courses	3	
Total			30	

Course: Imaging

Lecturer: Dr. Peter Török

Aims

This course provides an introduction to geometrical and wave optics and their application to imaging systems.

Syllabus

- Fermat's Principle, Snell's law.
- Gaussian (paraxial) optics, stops and pupils, ray tracing, principal and marginal rays.
- Transverse ray and wavefront aberrations, the aberration polynomial, primary aberrations, Seidel aberrations, Zernike polynomials.
- Chromatic aberration. Finite (exact) ray tracing.
- Complex amplitude.
- Physical theory of diffraction: Huygens-Fresnel approach; Kirchhoff diffraction integral.
- Application to imaging systems. Point spread functions, Airy pattern. Point spread function with defocus and aberrations. Strehl tolerances for aberrations.
- Fourier Transform treatment of the imagery of incoherently illuminated extended objects; line, edge and periodic objects.
- Coherent and incoherent imaging.
- Optical transfer function; effects of aberrations.

Course: Lasers

Lecturer: Prof. Geoff New

Aims

This course provides an introduction to lasers and laser physics covering the basic physics underlying the principles of laser operation. The closely related field of nonlinear optics is reviewed at the end of the course.

Syllabus

- Laser basics: stimulated emission and population inversion, laser materials and pumping schemes, laser beam characteristics.
- Basic radiation theory: the Planck radiation law, Einstein A and B coefficients, transition cross section.
- Laser action: laser rate equations, 3- and 4- level schemes, laser threshold condition, steady state laser power.
- Linewidth characteristics: homogenous and inhomogenous broadening, cavity resonances, spectral and spatial hole burning.
- Typical lasers and laser classes: HeNe, Ar, ion, ruby, neodymium, Ti:S and other solid state materials, excimer lasers, CO₂ lasers, dye lasers, semiconductor lasers.
- Laser cavities: paraxial wave propagation, Gaussian beams, stable and unstable resonators.
- Laser pulses: Q-switching and mode-locking. Nonlinear optics: brief review.

Course: Optical Communications Physics

Lecturer: Dr. M. A. A. Neil

Aims

This course enables the student to understand the nature of information and how it is communicated. Optical communications is at the heart of modern day high bandwidth data transfer and this course outlines the principles and optical fibre technology that underpins this photonics industry.

Syllabus

- Quantifying information; Shannon's formula for channel capacity; digital encoding of analogue signals; sampling theorem; Nyquist rate, quantization; multilevel signalling.
- Information theory; redundancy; data compression; error detection and correction; System limitations: bandwidth, attenuation, noise, dispersion.
- Comparison of transmission media: free-space, twisted pair and coaxial cable, optical fibre. Baseband and modulated carrier transmission; communication networks (LAN, MAN, WAN); multiplexing (TDM, WDM, SDM); packet- and circuit-switched networks; network protocols.
- Fourier series; Fourier transforms; convolution theorem; noise; bandwidth filtering; modulated transmission; demodulation and signal recovery.
- Optical fibres: step index, graded-index, multimode and single-mode; acceptance angle; basic mode theory; attenuation and dispersion.
- Optical telecoms.

Course: Optical Measurement and Devices

Lecturer: Dr. Kenny Weir and Dr. Carl Paterson

Aims

Optical measurement techniques are important to manufacturers and users of optical equipment and in a wide range of applications. This foundation course will include the following underlying generic optical concepts: polarisation of light; interferometers; testing of optical components; and optical thin films.

Syllabus

- Light as a wave; definition of the polarisation state of light; polarisation calculus; devices for the manipulation of polarisation; measurement of polarisation; ellipsometry.
- Principles of interferometry; division of wavefront and division of amplitude; multiple beam interferometers; laser interferometers; practical interferometers. Interferometric and non-interferometric techniques for testing the quality of optical surfaces, optical components and image forming systems; optical techniques for making other types of measurement.
- Optical properties of thin films; design of thin film antireflection coatings, mirrors, beam splitters and polarisers; narrow band optical interference filters; practical techniques for the manufacture of thin film devices.

Course: Laboratory

Lecturer: Dr. Mark Neil and lecturers, post-graduate and PhD students as demonstrators and markers.

Aim

The aim of the laboratory work is to provide students with an introduction and experience of important optical phenomenon, techniques and instrumentation and to develop their practical skills.

Syllabus

Element 1

Compulsory Experiments: Telescope star test. Interpretation of interferograms, Spectrographic investigation of filters, FECO multiple beam fringes, Characteristics of semiconductor light sources, Laser speckle, Fibre optics, Astigmatism and field curvature, Near and far field diffraction, Phase sensitive detection, Polarisation, Illumination of a microscope, What is holography? Modelling a network.

Element 2

Select five from: Twyman Green Interferometer, Moller Wedel Interferometer, Star Test, Laser Modes, Holography, Optical Fibre Communications, Erbium Doped Fibre Amplifier, Knife Edge Test, Modelling of Optical Fibre Networks, Fourier Optics, Spectral Characteristics of sources.

Element 3

Students choose one of the following experiments: CD autofocus system transducer. Optical bar code scanner, Object sorting by colour and size, Length measurement with direction (Optical Ruler), Surface profiling system, A non contact optical fibre displacement sensor, Measuring the properties of thin films, Measuring the refractive index of liquids, Laser Anemometry.

Advanced Option Course: Nonlinear Optics

Lecturer: Dr. John Tisch

Aim

This course will provide the basic insights needed to understand how intense laser light could be used to modify the polarisation of atomic matter and through this modify the pump light, for example, generating new frequencies. The course will allow the student to assess the scope and applicability of nonlinear optics.

Syllabus

- Review of nonlinear optical processes; second-, third- and higher order processes; perturbation theory and nonlinear coefficients.
- Crystal optics and the Pockels effect.
- Frequency mixing processes and coupled wave equations.
- Birefringent phase matching, quasi-phase matching and periodically-poled media; optical parametric generation; four wave mixing and optical phase conjugation.
- Raman processes.
- Nonlinear fibre optics, pulse compression and optical solitons.

Advanced Option Course: Optical Design

Lecturer: Prof. Robin Smith

Aim

This course provides an introduction to optical lens design. Following on from basic geometrical optics, study of the aberrations of optical systems leads to an understanding of why particular optical systems such as telescope, microscope, eyepiece and camera lenses take the form they do and how aberrations are controlled.

Syllabus

- Finite ray tracing. Paraxial ray tracing, principal and marginal rays. Transverse ray and wavefront aberrations, the aberration polynomial, primary aberrations.
- Seidel formulae for primary aberrations, variation of aberrations with stop position. Chromatic aberrations. Conditions for zero Seidel aberration contributions from a surface.
- Petzval field curvature and thin lens treatment of field curvature. Thin lens treatment of correction of longitudinal and transverse chromatic aberrations, secondary spectrum. Astigmatism of a thin lens. Distortion. Spherical aberration and coma for a thin lens at the stop in terms of the lens power and conjugate and shape parameters. Stop shift effects.
- Design of corrected doublets, limitations of doublets, aberration correction using separated doublets, correction of astigmatism.
- Microscope objectives, eyepieces, camera lenses. IR lenses. The use of aspheric surface in refractive, reflective and catadioptric imaging systems. Optical systems of special interest: the Schmidt camera and simple zoom lenses.

Advanced Option Course: Optical Design Laboratory

Lecturer: Prof. Robin Smith, Mr. Eddie Judd

Aims

The student will learn how to design a wide range of optical systems, such as singlets, doublets, eyepieces and magnifiers catadioptric systems, telephoto and inverse telephone lenses, triplets and Tessars, double gauss lenses and infrared optics. The emphasis is on practical, tolerant and economic design.

Syllabus

- Thin lens layout of optical systems.
- Design of particular lens systems such as singlets, doublets, eyepieces and magnifiers catadioptric systems, telephoto and inverse telephone lenses, triplets and Tessars, double gauss lenses and infrared optics.

Advanced Option Course: Optoelectronic Components and Devices

Lecturer: Dr. N. Ekins-Dawkes

Aims

Semiconductor optoelectronic devices are key components in all types of optical systems. Students should have a basic understanding of the principles of operation of these devices.

Syllabus

- Semiconductor materials, hetero-structures and quantum structures (2 lectures).
- Absorption, gain, density of states (1 lecture).
- Principles of amplification and lasing (including small signal dynamics) (3 lectures).
- Practical laser structures including DFB, DBR in-plane, and VCSELs (1 lecture).
- Quantum confined Stark effect and modulators (2 lectures).
- p-i-n and APD detectors (1 lecture).

Advanced Option Course: Fibre Technology

Lecturer: Dr. S. Popov

Aim

This course provides an introduction to optical radiation confined within guided wave dielectric structures. The course intends to explicate the features of guided wave optics and their contrast to bulk optics.

Syllabus

- Guided waves in slab waveguides.
- step-index and graded index fibres.
- ray and propagation models, single-mode and multimode fibres.
- attenuation and dispersion, fibre devices.

Advanced Option Course: Optical Communications Systems

Lecturer: Dr. Mark Neil

Aims

Optical communication systems have been key to the expansion of IT businesses world wide. Students of optics and photonics need to have a good appreciation of the current and future requirements.

Syllabus

- Overview of photonic transport networks introducing concepts of SDH, ATM, IP etc. Concepts of routing.
- Methods of achieving high data capacity: wavelength division multiplexing, soliton systems.
- Key technologies: dispersion management in fibres, wavelength multiplexing and de-multiplexing, amplification (EDFA, Raman and SOAs), digital optical processing in future networks.

Advanced Option Course: Photonic Structures

Lecturer: Dr. Martin McCall, Dr. Paul Stavrinou

Aims

To show how 1-D and 2-D periodic dielectric structures that comprise sub-wavelength features can be used to confine, manipulate and re-direct light for various applications in modern photonics.

Syllabus

• **1-D structures:**

- Concept and origin of a photonic bandgap using symmetry arguments on a 1-D 'unit cell'.
- Quantitative description of 1-D structures via coupled mode theory. Derivation of Bragg wavelength and bandwidth.
- Defects in 1-D structures. Use in VCSEL's and quarter wavelength shifted DFB structures.

• **2-D structures:**

- Introduction and interpretation of photonic band structure diagrams (Bloch modes) Types of lattice structure (square, triangular...). Propagation in the plane, propagation out of the plane (scattering - losses etc).
- Calculations in frequency and time domain. Comparison of computational methods (FEM, FDTD, RCWA, PW).
- Applications and key practical issues (fabrication, PBG guides): super prisms, compact waveguiding, emissive structures.
- Passive - guiding, routing etc.. - Active, especially emitters - density of modes to control emissive properties generally applicable to (1,2 and 3D).

• **Emerging topics based on sub-wavelength diffractive structures**

- Holey fibre (SM operation), Liquid crystals and chiral structures, Meta-materials (sub-sub-wavelength patterns, designer EM materials).

Advanced Option Course: Optical Displays

Lecturer: Dr. T. Anthopoulos

Aims

Display devices are ubiquitous components of most of the machines that we use in our everyday life and they are on their way to becoming the most important element for information presentation. Knowledge of the general characteristics of the technologies in commercial use and those being developed, together with the role of human factors in determining performance of the systems.

Syllabus

- Introduction to Display Characteristics (Brightness, Colour hue and saturation, Contrast, Viewing angle, Efficiency, Response time, Memory, Resolution, Durability).
- Display Devices: Emissive (Cathode ray tube, Vacuum fluorescent, Plasma, Thin film electroluminescence, Field emission, Organic LED, Inorganic LED, Fluorescent liquid crystal) and Non-emissive (Liquid crystal, Micromirror, Electrochromic, Electrophoretic).
- Other Display Issues: Driving Schemes (Active matrix, Passive matrix), Flexible Substrates, Display optics.

Advanced Option Course: Quantum Physics and Chemistry of Cold Matter:

Lecturer: Dr. Ben Sauer and Dr. Mike Tarbutt

Syllabus

In this lecture course the students will learn the physics of cold atoms, ions and molecules. The course will cover both the theory and the modern experimental techniques of the field. The course will begin with lectures on atomic physics and atom-photon interactions, and will then cover a set of advanced topics including laser cooling, magnetic and optical trapping of atoms, formation and manipulation of quantum degenerate gases, ion trapping, cold molecules and collision physics at low temperatures.

Advanced Option Course: Experimental Realizations of Controlled Quantum Dynamics:

Lecturer: Dr. Danny Segal

Syllabus

Building on the introduction in earlier courses, a thorough discussion of a variety of physical implementation for CQD will be taught, including matter based systems such as trapped atoms and ions, superconducting devices, quantum dots and photonic systems such as optical cavities, polarization and photon number degree of freedom of travelling light. Matter-light interfaces and their realizations will be discussed and strategies for combating noise will be discussed.

Advanced Option Course: Laser Technology

Lecturer: Prof. Michael Damzen

Aims

This course introduces the student to the practical aspects of the laser market, including modern laser systems, techniques, technological issues, and applications that are relevant to the industrial, commercial, military and scientific market sectors.

Syllabus

- Semiconductor diode lasers: heterojunction structures, single-mode, broad-stripe, high power arrays, VCSELs, distributed Bragg reflectors, external grating-tuned cavities.
- Diode-pumped solid-state lasers, microchip lasers, tunable solid-state media, ultrafast lasers. Fibre amplifiers, cladding-pumped fibres, fibre lasers.
- High power industrial lasers.

Advanced Option Course: Laser Optics

Lecturer: Dr. M. Tarbutt

Aims

The way laser beams propagate is based on Maxwell's equations however, the particular solutions found that are relevant to the case of many common lasers, have a number of interesting and unique properties. This course provides an in-depth treatment of the mathematical tools required for an understanding of the peculiar kinds of light beams produced by lasers. A firm understanding of this subject is of paramount importance in the design of optical systems that employ laser beams.

Syllabus

- Ray transfer matrices, laser cavities, stable and unstable resonators, modes (longitudinal and transverse), mode frequencies.
- Gaussian beams: waist size, radius of curvature, Rayleigh distance, the Guoy phase.
- Gaussian beam propagation: the ABCD law for Gaussian beams, complex radius of curvature, beam transformation through optical components and systems, focusing and imaging.
- Higher order modes, beam quality, spatial filtering, beam expanders.
- Laguerre Gaussian beams, Bessel beams.
- Applications (optical tweezers, optical spanners).

Advanced Option Course: Biomedical Optics

Lecturer: Dr. Chris Dunsby

Aims

To introduce students to the state-of-the-art of biomedical applications of optical imaging techniques

Syllabus

- Introduction to biomedicine and imaging.
- Optical properties of biological tissue: macroscopic to microscopic.
- Imaging through biological tissue: an overview.
- Diffuse Optical Tomography: imaging through thick tissues.
- Introduction to microscopy: wide-field and confocal. Imaging in the eye.
- Advanced microscopy techniques: nonlinear and multi-photon microscopy; OCT; structured illumination and super-resolution; Fluorescence imaging
- Endoscopic imaging and near field microscopy.
- Optical therapies: surgery via photocoagulation, disruption, ablation; PDT.

Course: Self-study project

Lecturer: Dr. Kenny Weir, plus the academic members of staff.

Aims

The aim of this course is to carry out a research review to provide students with the opportunity of independent study relating to business or technical aspects of optical technology, preparatory to the six month project, under the guidance of a supervisor. No practical work is undertaken.

Course: Project

Lecturer: Dr. Kenny Weir, plus the academic members of staff.

Aims

The project allows the students to apply the academic and practical skills they have developed to a substantial, real-world problem and to gain experience of how to solve technical and professional problems and to gain and practice the skills necessary for a successful career.

Syllabus

The projects are of six months duration and are hosted by a research group or an industrial/research organisation and contribute to the continuing work of the organisation.

Course: Entrepreneurship/Business Skills

Lecturer: Academic Staff at Imperial College and external consultants (where appropriate).

Aims

To develop the personal and business skills necessary for the students to have a challenging and productive career when they leave university.

Syllabus

Imperial College offers postgraduate students a wide variety of courses covering the skills involved in generic areas of research learning, communication and management (personal and professional career development). Some of the courses offered are listed below:

- Information Retrieval Lecture,
- Personal Organisation & Effectiveness Workshop,
- Professional Issues in Science: Research Ethics Workshop,
- Research Skills Development Course.
- Technical Writing Lecture Series.
- Efficient Reading.
- Motivation.
- Myers Briggs.
- Negotiation Skills.
- Networking.
- Presenting with Passion.
- Problem Solving & Ideas Generation.
- Project Management.
- Statistics.
- Stress Management: Postgraduate Study and Beyond.
- Working for the PhD.

The Tanaka Business School offers several courses and programmes to the postgraduates of the College, including the Entrepreneurial Challenge, which the students will undertake as part of their studies.

**2010-2011 OPSCITECH COURSES at
Institut d'Optique Graduate School /Université Paris-Sud 11**

YEAR 1 / 1st semester	ECTS	Professor(s) in charge
<i>Principles of Lasers</i>	3	F. Balembois
<i>Wave optics</i>	3	N. Westbrook, A. Dubois
<i>Ray optics & Optical systems</i>	3	N. Westbrook
<i>Guided and coupled waves</i>	3	JM. Jonathan
<i>Radiometry & detection systems</i>	5	JL. Meyzonnette
<i>Computer science</i>	4	S. Lebrun
<i>Labworks with Labview</i>	1	F. Capmas
<i>Optics Labworks</i>	6	L. Jacubowicz
<i>Language course (French)</i>	2	A. Manco

Total **30**

YEAR 1 / 2nd semester

<i>Electrodynamics</i>	3	T. Minea
<i>Optical design & CAD</i>	3	R. Mercier
<i>Nonlinear optics</i>	2	N. Dubreuil
<i>Semi-conductors and laser diodes</i>	3	G. Lucas-Leclun
<i>Optics Labworks</i>	7	L. Jacubowicz
<i>Language course (French)</i>	2	A. Manco
<i>Project in research laboratory</i>	10	

Total **30**

Course: Lasers physics

Instructor: Prof. François BALEMBOIS

Aims

The course will describe the operational principles of lasers, based on the rate equations of the relevant levels of an amplifying medium. Oscillators and amplifiers are studied in the cw and pulsed regimes. The paraxial transfer matrices are used to study Gaussian beams and the stability of laser cavities. The properties of laser radiation are described, as well as their consequences on laser safety. The course provides insights in the different types of lasers and their applications.

Syllabus

1. Atoms and photons:
interaction processes, examples of absorption lines, effective area of a laser wave, population rate equations.
2. Optical amplification:
Intensity, influence of the origin of spectral broadening, index modulation in the amplifier.
3. laser amplifiers
The oscillation condition, output intensity, case of the linear cavities, optical spectrum of the laser oscillator.
4. Pulsed lasers
Pulsed oscillators and pulsed amplifiers
5. Laser optics
intuitive approach and detailed study of the spherical Gaussian wave, conditions for stable laser cavities, higher order modes.
6. The different types of lasers
7. Laser safety
8. Applications of lasers

References

"Fundamentals of Photonics", B.E.A. Saleh and M.C. Teich Wiley serie in pure and applied optics Eds. J.W. Goodman ISBN 0-471-83965 A4200

Principles of laser ; Titre original : Principi dei laser. / Orazio SVELTO ; Traducteur David C. HANNA. - 2nd ed. - PLENUM PRESS, 1982. - XV - 375p. ISBN 0-306-40862-7

Principles of lasers ; Titre original : Principi dei laser. / Orazio SVELTO ; Traducteur David C. HANNA. - 3rd ed. - PLENUM PRESS, 1989. - XIII - 494p. ISBN 0-306-42967-5

Course: Guided and coupled waves

Instructor: Prof. Jean-Michel JONATHAN

Aims: The course provides the physical bases for some major components of optical communications, such as optical waveguides and fibers, passive or active components. The first section describes (mostly in the weak guidance approximation) the optical modes propagating in guiding optical structures and provides notions such as modal dispersion and losses, central to telecommunications. The second section details the tools for using the electro-optic and acousto-optic effects in their applications for the modulation and the coupling of free space as well as guided optical modes.

Syllabus

Guided optical waves

- 1- The optical modes in planar waveguides. The 1D dielectric (step index and quadratic index) waveguide and its TE and TM modes. Ray optics and electromagnetic description: guiding condition, cut-off frequency, dispersion, confinement, effective refractive index.
- 2- Optical fibres in the weak guidance approximation. Electromagnetic field in step index cylindrical optical fibre. Weak guidance and scalar propagation equation of the LP modes. Gaussian approximation of the LP₀₁ mode and its application in engineering. Introduction to dispersion management, polarization in optical fibres, micro structured optical fibres.
- 3- Introduction to optical fibres technology. Materials and their losses, fibres fabrication, connections, controls and characterization.

The linear coupling of optical waves

- 1- The linear and quadratic electro-optic effects. Its application to the modulation of the polarization of polarization, phase or amplitude of a guided or free space optical mode.
- 2- The acousto-optic effect and its application to the generation of dynamic refractive index gratings.
- 3- The coupled wave theory and its application to the coupling of plane waves through thick gratings. The Bragg condition in isotropic and anisotropic media. Applications of the acousto-optic effect to the deflection and modulation of optical waves, spectrum analyzer, voltage controlled interference filter.
- 4- The coupling between guided modes. Coupling the modes of two close optical waveguides: application to the 3dB optical coupler, wavelength multiplexer, interferometer and electro-optical switch. Coupling two modes of an optical waveguide: co-directional and contra-directional coupling, input and output couplers, Bragg filters in optical fibres.

Text books

- [Optical waves in crystals. Propagation and control of laser radiation.](#) / [YARIV \(Amnon\)](#) ; [YEH \(Pochi\)](#). , 2003. - XI - p589
- Introduction to Fiber optics / [THYAGARAJAN \(K.\)](#) ; [GHATAK \(Ajoy K.\)](#). , 1998. - XVI - p565

Course: Sources & detectors in optical systems

Instructors: Prof. Jean-Louis MEYZONNETTE

Aims

The objective of the course is to provide the basic tools of radiometry, photometry and colorimetry, which are needed for the specification of sources, optical systems, surfaces and propagation media, as well as for the design and use of efficient metrology.

Syllabus

1. Introduction

Geometrical photometry, spectro-radiometry, incandescence radiation, photometric properties of surfaces and media, général methods for photometric measurements.

2. Noise

After a review of the properties of the variables in detection and amplification, their statistical characterization and their experimental approach, a study of the main types of noise is done to justify the performances of different electromagnetic detection systems, in the optical domain from the infra-red to the ultra-violet.

3. Detectors

This part of the course presents

- the general characteristics of optical detectors :spectral response, uniformity, equivalent noise flux, BLIP detectors, specific detectivity.
- thermal detectors (bolometers, pyroelectric detectors) along with their sensitivity and bandwidth,
- quantum detectors : photoemissive (photomultipliers), photoconductors, photovoltaic.
- detectors implementation : direct, heterodyne, lock-in amplifier, linear and arrays (CCD and CMOS)

Course: Optics labworks (first semester)

9 labs, 4^{1/2} hours each lab

Coordinator: Dr. Lionel JACUBOWIEZ

Aims

Labworks have many goals:

- To develop the strong experimental skills necessary in efficient research and development.
- To illustrate concepts, components or systems previously introduced in classes.
- To bring to light the necessity for further acquisition of knowledge and competence.

Syllabus

1. Polarization (4 sessions of 4 hours each)

- Birefringence and polarimetry: 2 sessions
- Initiation to ellipsometry
- Electro-optic modulation

2. Photometry, detection and noise (4 sessions of 4 hours each)

- Measurements of luminance, Intensity
- Measurements of total flux of different kinds of sources
- Photometric study of an objective
- The photomultiplier – Noise and detection.
- Study of an IR camera : NETD, MRTD,...

Course: Optics labworks (second semester)

12 labs, 4^{1/2} hours each lab

Coordinator: Dr. Lionel JACUBOWIEZ

Aims

Labworks have many different goals:

- To develop the strong experimental skills necessary in efficient research and development.
- To illustrate concepts, components or systems previously introduced in classes.
- To bring to light the necessity for further acquisition of knowledge and competence.

Syllabus

Aberrations of optical systems (4 sessions of 4^{1/2} hours each)

Star Test methods to characterize an optical system:

- On axis aberrations: Spherical aberration, chromatism
- Off axis aberrations: Astigmatism and coma

Wavefront measurement methods to characterize an optical system:

- Shack-Hartmann wavefront sensor (HASO)
- Interferometric measurements with a Fizeau interferometer (ZYGO)

Study of several lasers (4 sessions of 4 hours each)

- Helium-Neon laser: longitudinal and transversal modes
- Laser diode
- Diode pumped Nd:YAG laser
- The fiber amplifier and fibre laser

Noise and Detection (4 sessions of 4 hours each)

- Noises in optical detection systems: thermal noise, photon noise, squeezing
- Characterization of an Infrared Detector: Response, Detectivity...
- Laser telemetry
- An optical fibre system: Optical Time Resolved Reflectometer

Course: Language course (French as a foreign language)

Instructor: Annick MANCO

Aims

On the Palaiseau Campus, it will be possible to offer an opportunity for foreigners to follow one or two semesters of French. Different levels can be chosen from. The courses will take place at the Ecole Polytechnique nearby, but not necessarily. In any case access will be easy and coordination with the school ensured. Two hours a week are provided, unless special arrangements are requested.

Course: Wave Optics

Instructors: Prof. Arnaud DUBOIS, Prof. Nathalie WESTBROOK

Aims: The bases of the wave optics theory are established from the electromagnetic theory of light. Diffraction, spatial filtering and image formation are treated under harmonic analysis. Interferometry is studied including the effect of light coherence.

Syllabus

1. Introduction to electromagnetic theory of light

- Maxwell's equations
- The wave equation
- Intensity and power
- Dielectric media

2. Introduction to wave optics

- Complex representation of monochromatic waves
- Helmholtz equation
- Elementary waves
- Fresnel approximation
- Reflection, refraction
- Transmission of optical components

3. Interferometry

- Interference of two waves
- Temporal coherence, spatial coherence
- Fourier-transform spectroscopy

4. Fourier Optics

- Plane wave decomposition, spatial frequencies
- Transfer function of free space
- Impulse-response function of free space
- Optical Fourier transform in the far field, optical Fourier transform using a lens
- Fraunhofer diffraction and Fresnel diffraction
- Spatial filtering
- Image formation with coherent and incoherent illumination
- Impulse-response function and transfer function of an optical system

References

- "Fundamentals of Photonics", B.E.A. Saleh and M.C. Teich Wiley serie in pure and applied optics Eds. J.W. Goodman
- "Introduction to Fourier Optics", Joseph W. Goodman, McGraw Hill Higher Education

Course: Non-linear Optics

Instructor: Dr. Nicolas DUBREUIL

Aims

Since laser was invented, a new dimension was opened in optics, ushering in the non linear world with already numerous applications to light sources and optical processing of information. This course will introduce the students to this domain and enable them to fully master its innovative aspects. It describes the physics of the non linear interaction between light and matter from a perturbation approach and shows its consequences on the propagation of optical waves. It describes in detail the second and third order non linear effects rich in applications.

Syllabus

1. Introduction to non linear optics
2. Non linear propagation of optical waves
Atomistic bases of Maxwell theory. Linear susceptibility, linear propagation. Non linear response and non linear susceptibility. Non linear propagation equations.
3. Second order non linear effects
The Manley-Rowe relations. Second harmonic generation. Frequency mixing, Parametric amplification and oscillation.
4. The microscopic theory of susceptibility.
Local field and polarizability. Dynamics of a system of particles in an electromagnetic field. Description of a system of particles by the density matrix. Simplified calculation of polarizabilities. The 1st order polarizability. 3rd order resonant phenomena. The polarizability mechanism. Calculus of electronic polarizabilities. Influence of the local field. Non linear materials
5. Third order non linear effects
Introduction. 4 wave mixing and phase conjugation. The dynamic Kerr effect (optical bistability, self focusing, self phase modulation and soliton propagation. Spontaneous and stimulated diffusions (Raman, Brillouin, Rayleigh and Rayleigh wing). Two photon absorption.

Reference

Non linear optics, R.W. Boyd, "Nonlinear Optics" (2nd Edition), 2003.

Course: Electrodynamics: Continuous media, Structures and Metamaterials

Instructor:

Aims

This course starts from the electrodynamics of continuous materials, and from there, capacitive and inductive structures, antennas, wave guides and lines are studied. By further assembling these structures, meta materials are considered.

Syllabus

1. Electromagnetic fields:
the Helmholtz, Green and Stokes theorems . Poynting theorem. Active and reactive power.
2. Conducting media:
Free charges, Ohm and Fick law. Charges relaxation. Currents diffusion.
3. Dielectric media:
Dielectric dipoles, polarization, susceptibility and permittivity. Interfacial, ionic and electronic polarization.
4. Magnetic media:
Magnetic dipoles; magnetization, susceptibility and permeability.
5. Capacitive and inductive structures:
Capacitive and inductive structures, capacity and inductance matrices.
Reciprocity theorem, Foster and Slater theorems.
6. Propagative structures:
Theory of transmission lines and wave guides.
7. Radiative structures:
Elements of the antenna theory : gain and impedance. Capacitive and inductive antennas.
8. Meta-materials:
Passive synthesis of impedance. Propagation in periodic media. Meta-materials

References

"classical electrodynamics", J.D. jackson, Wiley

Course: Optical design & CAD

Instructor: Dr. Raymond MERCIER and Yvan SORTAIS

Aims

This course is intermediate between the introduction to aberrations, and the advanced course in optical design, given in the following year. It formalizes methods of paraxial calculus and aberrations, adapted to computers. These methods provide solutions to simple problems which demonstrate the practical principles of computer assisted optical design. CAD is introduced in small classes and through projects.

Syllabus

1. The principles of aberration calculus. Normal deviation. Study of the 3rd order aberrations, variation with the pupil. Siedel sum.
2. Quality criteria, optimization programs, tolerance and off-centering. Conferences on optical systems

Small classes

Paper exercises focus on an important theoretical point or prepare the guide lines for the computer solution of a problem

Computer exercises illustrate the previous predictions (Spot shapes, evolution with the pupil, the field of the aperture).

A tutored project on selected subjects follows.



2010-2011 OPSCITECH COURSES
at Warsaw University of Technology (WUT)

I year, semester 1

		ECTS	Lecture	Lab./Exercises	
1.	Optoelectronics material and technology	4	30	-	dr M. Jozwik
2.	Instrumental optics	4	30	15	dr hab. L. Sałbut
3.	Wave Optics	4	30	-	prof. K. Patorski
4.	Image processing and recognition (with project)	4	30	-	dr R. Sitnik
5.	Technical elective (one):				
	Optical methods of measurements and control (elective)	5	30	15	Prof. M. Kujawinska
	Biophotonics (elective)	4	30	-	Prof. K. Patorski
	Liquid crystals photonics (elective)	4	30	-	Prof. T. Wolinski (Faculty of Physics)
6.	Interfacing labworks with Matlab	4	15	15	dr T. Kozacki
7.	Labworks Full day session	6		75	prof. M. Kujawinska/ PhD students
8.	Polish language course	2		30	
	Min ECTS	30			

I year, semester 2

		ECTS	Lecture	Labs/exercises	
1.	Optomechatronics	5	30	15	prof. K. Patorski
2.	Optical system design	5	15	30	dr inż. M. Lesniewski
3.	Laser techniques	5	30	15	Prof. P. Szczepanski (Faculty of Ei IT)
4.	Fibre optics technology (variants): Telecommunication Sensors	5	30	15	prof. M. Kujawinska
5.	Internship in research laboratory + seminar with presentations	10		6	
6.	Language course (additional)	-	-	15	
	Total ECTS	30			



Course: Optoelectronics materials and technology

Instructor: Dr Michal Jozwik

Aims: The aim of the course is to provide basic knowledge of the optical and optoelectronic materials, their properties and fabrication processes. Second part aims to present applications and state of art several optoelectronics devices.

Syllabus

1. Optical materials.

- **Crystalline materials.** Physical, optical, mechanical, thermal, magneto-optic, electro-optic, elasto-optic and nonlinear optical properties.
- **Glasses.** Commercial and specialty optical glasses. Optical, mechanical, thermal properties. Internal transmittance.
- **Polymeric materials.** Optical plastics. Index of refraction. Thermal properties.
- **Metals.** Physical, optical, mechanical, and thermal properties. Mirror substrate materials.
- **Liquids.** Physical properties (thermal conductivity, viscosity, surface tension, absorption). Water and selected liquids.
- **Gases.** Physical properties. Index of refraction. Nonlinear optical properties.

2. Optoelectronic materials.

- **Semiconductor Physics.** Band gaps, density of states, materials, optical and electronic properties, carrier generation and recombination, mobility and diffusion, low dimensional structures, quantum wells, wires and dots, heterostructures.
- **Materials Growth & Fabrication.** Growth of optoelectronic materials by MBE, MOCVD, Plasma CVD, photochemical deposition. Epitaxy, interfaces and junctions (advantages/disadvantages of growth methods, of interface quality, interdiffusion and doping). Quantum wells and bandgap engineering (examples of structures). Post-growth processing (patterning by photolithography, contacting, annealing).
- **Polymers and Liquid-Crystals.** Semiconducting polymers - photoluminescence and electroluminescence. Factors determining efficiency; light-emitting diodes and field effect transistors. Liquid crystals - nematic, smectic and cholesteric phases; director and order-parameter; operation of twisted nematic display.

3. Fabrication of optical components.

- **History of optical fabrication**
- **Review on optical fabrication technologies**
- **Manufacturability of lenses and mirrors**
- **Optical technical drawings and norms**

4. Optoelectronics technology.

- **Technology of semiconductor devices.** PN junctions, solar cells, LEDs, gain conditions, rate equations, spectra, lasers, waveguides and VCSELs. Detectors.
 - **Optical coating technology.** Functions. Materials. Fabrication.
 - **Fiber-optics technology.** Review. Fabrication techniques and materials.
- MEMS/MOEMS technology.** Introduction. Silicon micromachining. Integration of microsystems with electronics. Process examples.



Course: Instrumental Optics

Instructor: Dr. Eng. Leszek Salbut

Aims

Basic optical elements are introduced and described on the base of geometrical optics. Principles of optical instruments design, their characterization and applications are presented.

Syllabus

- 1. Geometrical optics.** Fundamentals and limitations. Ray tracing. Paraxial optics.
- 2. Optical elements.** Parallel-plane plates, prisms, wedges, lenses and mirrors and their characterization.
- 3. Pencil of rays.** Limitations of the pencil of rays in optical systems. Role of diaphragms.
- 3. Geometrical theory of aberration.** Principles of third order geometrical aberrations. Chromatic aberrations. Testing of optical elements quality.
- 4. Basic optical systems.** Telescopic, microscopic and imaging/projection systems design and characterization.
- 5. Light sources and detectors.** Review and characterization. Photometry.
- 6. Optical instruments.** Review. Instrumentation for adjustment and measurements. Collimators and auto-collimators. Commercial microscopes. Photo-camera (conventional versus digital) and digital light projectors (DLP). Thermo-vision instrumentation.



Course: Wave Optics

Instructor: Prof. Dr. Hab. Eng. Krzysztof Patorski

Aims

The course introduces fundamentals and selected applications of wave optics – polarization, interference, diffraction, coherence and optical imaging under coherent and incoherent illumination.

Syllabus

- 1. Postulates of wave optics.** Complex representation of monochromatic waves. Elementary waves, Gaussian beam. Interaction with basic optical elements.
- 2. Interference.** Two and multiple beam interference. Interferometric coding and decoding of information. Interferometer configurations.
- 3. Transmission and reflection at the boundary between two media.** Fresnel equations. Dielectric and absorbing media.
- 4. Thin film optics.** Fundamentals. Antireflection and high reflectance coatings. Beam splitting coatings. Interference filters.
- 5. Light diffraction.** Fresnel and Fraunhofer approximations. Fraunhofer diffraction patterns for selected objects. Fresnel diffraction. Self-imaging phenomenon and applications.
- 6. Light propagation through coherent optical systems – wave optics approach.** Wave front transformation. Optical Fourier transformation. Spatial frequency filtration. Point object imaging: optical transfer function and pulse response. Resolving power and criteria (Rayleigh, Sparrow).
- 7. Optical imaging under partially coherent illumination.** Partially coherent light propagation. Incoherent illumination imaging. Spatial coherence propagation in free space (Van Cittert-Zernike theorem, stellar interferometry).
- 8. Statistical optics.** Temporal and spatial coherence. Partially coherent light interference. Measurement of light coherence degree.
- 9. Polarized light.** Geometrical and Jones matrix description. Light propagation through anisotropic media. Polarization elements: polarizer, phase plates, compensators, isolators. Analysis of arbitrary state of polarization. Polarized light interferometry. Photo-elasticity. Ellipsometry. Electrooptics.



Course: Image Processing and Recognition (with project)

Instructor: Dr. Eng. Robert Sitnik

Aims

The course introduces fundamentals of digital image processing (DIP). It starts from common detectors characterization (eye, CCD, CMOS) together with different color spaces definitions. Geometrical, arithmetical, morphological and filtering operations in image space are explained. DFT, FFT, Hough and Wavelet transforms are introduced. Basic recognition techniques are presented. Coding and compression methods for images and image sequences are described.

Syllabus

- 1. Introduction.** Definitions. Digital versus analog representation. Sampling and quantization. Eye versus matrix detector (CCD/CMOS). Electromagnetic spectrum. Color spaces.
- 2. Image space operations.** Geometrical operations. Image correction. Camera calibration. Arithmetical operations. LUT. Histogram. Multi image operations. Binarisation. Filtering operations (convolution, statistical, etc.).
- 3. Image transforms.** Fourier transform (DFT, FFT). Wavelet transform. Hough transform. Image space filtering versus transform based filtering.
- 4. Coding and compression.** Image and image sequences coding. Coding and compression versus eye properties. Loss and lossless compression. Basic algorithms. Standards.
- 5. Morphological operations and Segmentation.** Morphological operations (opening, closing, skeleton operators). Segmentation.
- 6. Recognition.** Basing recognition techniques. Features based on geometry, topology, texture. Examples.



Course: Optical methods of measurements and control (elective)

Instructors: Prof. M. Kujawska

Aims

The course introduces optical methods of measurements and control and their applications in science and industry.

Syllabus

- 1. Introduction.** Introducing and characterization of point-wise and full-field optical methods based on coherent and incoherent illumination. Information coding and decoding techniques.
- 2. Laser interferometry for length measurements.** One, two and multiple wavelength interference. Linear displacements and length of gauge blocks measurements.
- 3. Surface characterization.** Micro-shape and roughness measurements. Microinterferometry and profilometry. Scatterometry. Polarized light techniques
- 4. Shape measurements.** Passive and active triangulation techniques. Moiré and fringe projection techniques. Optical and digital holography. Quasi-monochromatic and multi-wavelength interferometry. White light and low coherence interferometry.
- 5. Vibration measurements.** Laser vibrometry. Time average and stroboscopic techniques. Pulse interferometry.
- 7. Optical methods in experimental mechanics and material engineering.** Geometric moiré and moiré interferometry, holographic interferometry, electronic speckle pattern interferometry (ESPI and ESPSI), photoelasticity, image correlation methods and thermography. Laser and video extensometry. Non-destructive techniques.
- 8. Optical elements testing.** Classification of techniques based on geometric and wave optics. Basic configurations of measurement instruments and systems. Exemplary methods and instrumentation for refractive index, flatness and sphericity of optical elements measurements. Methods for optical transfer function measurements.
- 9. Laser spectrometry.** Emission, absorption, fluorescent Fourier transform and other spectrometers and theirs applications.



Course: Biophotonics (elective)

Instructor: Prof. Dr. Hab. Eng. Krzysztof Patorski

Aims

The course introduces applications of laser techniques in medical diagnosis and therapy. Fundamentals of laser generation are treated in short together with laser classification for medical purposes. After introducing various effects of laser radiation interaction with biological tissue, a comprehensive review of modern imaging diagnostic and therapy systems is given together with clinical examples.

Syllabus

- 1. Lasers in medicine.** Historical overview. Optical spectrum. Most important parameters characterizing optical radiation. Fundamentals of laser operation. Basic classification of lasers for medical applications. Preliminary examples.
- 2. Laser light interaction with biological tissues.**
- 3. Laser light dosing.**
- 4. Selected applications of laser therapy.** Low light level therapy (LLL) - biostimulation. Energetic laser applications, including photodynamic therapy (PDT), gastroenterology, blood vessel recanalization, ophthalmology, coronary arterial diseases – angioplasty and stentoplasty.
- 5. Novel imaging modalities in biomedicine.** Light propagation in highly turbid media. Photon sorting techniques. Exemplary modalities: LTPS, Kerr cell method, optical coherence tomography (principles, implementation, application in weakly and highly dispersing media), thermo(opto)acoustics (principles, implementation, applications including oncology).
- 6. Work safety with lasers**



Course: Interfacing labworks with Matlab

Instructor: Dr. Eng. Tomasz Kozacki

Aim

The course will provide students with basic knowledge of Matlab usage. The student will learn how to connect laboratory equipment to Matlab: cameras, IO devices etc. Additionally the typical algorithms assisting laboratory work will be presented: digital holography algorithms, diffraction, numerical focusing and fringe processing.

Syllabus

- 1. Matlab language basics.** Scripts in matlab. Data types. Matrices. Operators. Functions. Graphics in Matlab.
- 2. Mathematics in Matlab.** Approximation and interpolation. Statistical data analysis. Discrete Fourier Transform. Linear algebra.
- 3. External interface in Matlab.** C++ interface to Matlab for efficient algorithms implementation.
- 4. Connection of laboratory devices to matlab:** cameras, io devices (motors, phase shifting devices).
- 5. Diffraction computation in Matlab.** Fresnel diffraction. Angular spectrum of plane waves. Numerical focusing.
- 6. Digital holography.** Algorithm of digital hologram reconstruction (off line holograms, phase-stepping techniques).
- 7. Interferogram analysis with Matlab.** Algorithms for automatic interferogram analysis: phase shifting techniques, filtering, Fourier Transform method.



Course: Optomechatronics

Instructor: Prof. Dr. Hab. Eng. Krzysztof Patorski

Aims

The course introduces fundamentals and applications of optomechatronics – technology integrating mechanical, electrical, optical and computer systems to create intelligent products and industrial processes. A comprehensive review of optomechatronic systems with particular emphasis put on combining optical and mechatronic systems and mutual synergistic effects in macro and micro scale (MOEMS) will be given. The role of optics, optoelectronics and photonics in innovative techniques and technologies will be discussed.

Syllabus

- 1. Introduction: Optomechatronics – its place in science and technology.** History of optomechatronics development. Definitions and features. Basic roles of optics and mechatronics, synergistic effects. Main functions of optomechatronic systems.
- 2. Fundamentals of optics.** Geometrical optics: reflection and refraction, lens imaging systems, aberrations. Wave optics: polarization, coherence, interference, diffraction, fiber optics, Gaussian beam and its propagation.
- 3. Optomechatronic integration.** Fundamentals of integration of optical, electrical and mechanical signals. Functional modules for signal conversion, modulation, detection, transmission and display. Examples of interfaces and optomechatronic integration.
- 4. Basic functional optomechatronic modules.** Photodetectors. Signal displays. Actuators, sensors, automatic focusing systems, acoustooptic modulators, optical scanners, optical switches, zoom systems, imaging systems with automatic focusing, illumination control, visual feedback control, optical signal transmission.
- 5. Applications.** Optical methods of modeling, monitoring and control of semiconductor processes. Optical methods for electronic assembly inspection. Robot control optical systems. Selected optomechatronic devices and technologies.
- 6. Microoptomechatronics.** Fusion of optics, electronics and mechanics in MEMS technology. Device classification depending on laser beam power and position control. Selected problems of microoptomechatronic device control. Nanooptomechatronics and its application in optical memories.



Course: Optical system design

Instructor: Dr inż. M. Lesniewski

Aims

The course gives practical engineering information on optical systems and elements and their designs. During the course students will gain knowledge of design of Optical System using Software OSLO and design of Diffractive Optical Elements.

Syllabus

1. **Image formation using geometrical optics.** Refraction of the light single and several surfaces. Thin lens systems. The optical invariant.
2. **Basic optical system elements:** lenses, prisms, mirrors, fiber optics, GRIN lenses, holographic element etc.
3. **Aberrations.** Polynomial and Seidel Aberrations. Wave Front Aberrations. Aberrations corrections and Residuals.
4. **Stops and Apertures.** The Aperture Stop. Pupils. Field Stop. Vignetting. Depth of focus. Diffraction effect of Aperture. Optical system resolution.
5. **Radiometry and Photometry.** Radiance. Photometry. Illumination Devices.
6. **Image evaluation.** Optical path difference: Focus shift, Spherical Aberrations. Aberration tolerances. Point Spread Function. Modulation Transfer Function. Diffraction Limited Systems.
7. **Optical Computation using Optical Design software OSLO.**
8. **Optical System Design.** Optical imaging and illumination systems: imaging and non imaging illumination systems, telescope objectives, eyepieces and magnifiers, photographic lenses (Triplet Anastigmat, Double-Gauss Lens, telephoto lens, Wide-Angle Lenses), Microscope Objectives, variable focus systems (zoom, optical and mechanical compensation), Head-up Display lenses, IR and UV optical systems, Scanner/f- θ , Optical systems working under extreme conditions (elements resistant for changes of temperature, pressure, under water elements, cosmic elements).
9. **Optical elements design using wave optics.** Diffractive optical elements. Iterative and noniterative methods. Synthetic hologram. Focusing elements. Gratings.
10. **Documentation of optical systems.** Optical scheme. Drawings of optical assemblies, subassemblies and parts. Guidelines for mechanical construction.



Course: Laser techniques

Instructor : Prof. Paweł SZCZEPAŃSKI

Aims

The course will provide the operational principles of lasers, based on the rate equations for atomic like and semiconductor active media. Mode structure is discussed for different type of optical cavities. Oscillators and amplifiers are studied in the cw and pulsed regimes The course provides insights in the different types of lasers and their applications. Nonlinear effects used in light generation are presented.

Syllabus

1. Introduction:

Laser as electromagnetic wave generator, basic elements of laser, basic parameters of laser beam, spatial and temporal coherence. with laser technique

2. Atom and photon interaction:

interaction processes, absorption and luminescent lines, line broadening in different kind of active media

3. Light amplification in atomic like and semiconductor active media:

rate equations, inversion population in atomic like media – two and four level quantum systems, inversion population in semiconductor media – p-n junction effect, gain saturation

4. Laser cavities and mode structure:

open stable and unstable cavities, waveguide cavities: planar, fiber, hollow, distributed feedback and Bragg reflector cavities, fiber cavities, microcavities, photonic crystal cavities

5. Light generation:

threshold conditions, frequency spectrum of generated laser beam, cw operation, single frequency operation, giant and supershort pulse generation,

6. Type of lasers and their applications:

solid state bulk, waveguide and microlasers, semiconductor lasers – single frequency, tuneable and high power laser structures, gas lasers, dye lasers, roentgen lasers

7. Light amplifiers: solid state and semiconductor systems

8. Nonlinear effect in laser technique:

higher order harmonic generation, nonlinear absorption, optical bistability



Course: Optical fibre technology

Instructor: Prof. Małgorzata Kujawińska

Aim of the course:

The course introduces fundamentals and selected applications of optical fibre technology with special focus on FO sensing and telecommunication.

Syllabus

1. Principles. Introduction – history and main problems of FO progress. Definition of main types of fibre optics. Description of E-M wave propagation in FO: analytical and numerical approaches. Dispersion and losses in FO. Photonics fibres.
3. Technology of FO: materials for silica, plastic and nonconventional FO, technology of performs and fibres, FO measurements
4. Elements of FO links: requirements, design, applications: cables, connectors, couplers, regenerators and FO lasers, modulators, polarization elements, isolators, Bragg gratings
5. FO sensors: intensity and interferometric, distributed and quasidistributed, Optical reflectometry, multiplexing and demultiplexing. Homodyne and heterodyne techniques. FO sensors applications. FO based smart structures.
6. FO telecommunication. Standards. The principles of design of a telecommunication link (noncoherent and coherent). Signal modulation, multiplexing, access. Soliton optical telecommunication. Topologies of optical telecommunication networks.

Laboratory:

- Excursion to FO technology laboratories (also production of special photonics fibers)
- Investigation of the main properties of multimode and monomode fibre, coupling of fibres with light sources and detectors.
- Investigation of the selected elements of FO link: connectors, couplers, isolators, polarization controller.
- Building and studies of selected intensity and interference sensors.
- Investigation of polarization maintaining fibre and building a polarimetric sensor
- Transmission of an audio-video signal through FO link

Passing the subject:

0.7 x exam + 0.3 x laboratory