MSc Communications Programmes

Module Name: Advanced Photonic Devices

Module Acronym: APD

Undergraduate Code: ELECGT26; Masters Code: ELECMT26

Module Manager: Dr David R. Selviah; Module Lecturers: Dr David R. Selviah, Dr Tony Kenyon, Professor Huiyun Liu, Dr Sally Day, Dr Ioannis Papakonstantinou

Course Summary:

To provide an in-depth understanding of the design, operation and performance of advanced photonic devices including light emitting diodes, LEDs, a range of semiconductor lasers, photodetectors, liquid crystal devices, photovoltaic solar cells for a variety of applications including optical communications and solar power generation.

Intended Learning Outcomes

On completion of this course, students should be able to:

- Know and understand the scientific principles and methodology of light generation, detection and modulation and to use this to understand the operation and evolution of advanced photonic devices so that they can appreciate historical, current, and future developments and technologies.
- Have a comprehensive understanding of the scientific principles of light generation, detection and modulation and to use this to understand the operation and evolution of advanced photonic devices and their use in telecommunications and in solar power generation;
- Know and understand the mathematical principles necessary to underpin their education in advanced photonic devices and apply mathematical methods, tools and notations proficiently in the analysis and solution of engineering problems.
- Be aware of developing technologies related to advanced photonic devices.
- Apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline.
- Know and understand mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.
- Understand concepts from a range of areas including some outside engineering such as from physics and chemistry, and the ability to apply them effectively in engineering projects.
- Understand engineering principles and have the ability to apply them to analyse key engineering processes.
- Use fundamental knowledge of particular device materials and device fabrication to investigate new and emerging technologies.
- Identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques.
- Apply mathematical and computer-based models for solving problems in engineering, and the ability to assess the limitations of particular cases.
- Apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems.
- Extract data pertinent to an unfamiliar problem, and apply in its solution using computer based engineering tools when appropriate.
- Understand and apply a systems approach to engineering problems.
- Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues;
• Have a wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations;
• Understand customer and user needs and the importance of considerations such as aesthetics;
• Generate an innovative design for products, systems, components or processes to fulfil new needs.
• Identify and manage cost drivers;
• Use creativity to establish innovative solution and understand how creativity can be used to establish innovative solutions and designs for components to fulfil new needs ensuring that the device performance meets the required specifications;
• Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal;
• Manage the design process and evaluate outcomes.
• Know and understand the commercial and economic context of engineering processes;
• Understand the requirement for engineering activities to promote sustainable development;
• Aware of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues;
• Understand the need for a high level of professional and ethical conduct in engineering.
• Know the characteristics of particular materials, equipment, processes, or products.
• Understand current practice and its limitations, and some appreciation of likely new developments;
• Have an extensive knowledge and understanding of a wide range of engineering materials and components and fabrication techniques.
• Understand the contexts in which engineering knowledge can be applied (e.g. operations and management, technology development, etc).
• Apply engineering techniques taking account of a range of commercial and industrial constraints.
• Understand the use of technical literature and other information sources.
• Be aware of nature of intellectual property and contractual issues.
• Be aware of quality issues.
• Work with technical uncertainty.

Course Content:

Photonic materials and properties
Glass; Crystals; Rare Earth-doping; Semiconductors; Bulk; Multiple Quantum Wells, MQW; Quantum dots; Liquid Crystal
Photon absorption; Spontaneous emission; Stimulated emission; Non-radiative decay; Birefringence; Energy bands; Temperature Dependence; Density of states; Fermi level; Quasi-Fermi levels; Direct and Indirect Bandgaps
States in the gap; impurities and defects; Carrier recombination; Non-Radiative recombination; Radiative recombination; Radiative efficiencies; Lifetimes; Electro-optic refractive index modulation: CIE, Plasma effect, QCSE; Non-linearities
LEDs, lasers, amplifiers and optical filters
Gratings; Fabrication techniques (Fibre and Semiconductors); Photonic Band gap structures
The rate equation model; spectral linewidth; LEDs; Amplifiers;
Lasers; Fabry Perot cavity; Ring cavity; Laser Noise, Laser examples: VCSEL, DFB, DBR (including SG, SSG and DS-DBR), External; Laser direct modulation;
Semiconductor laser fabrication (Waveguide, vertical cavity)

Photodetectors
PIN photodiode; Solar Cells; Photo-multipliers; Fabrication Techniques (Mesa, capacitance, waveguide or vertical structure)

Liquid Crystal Photonic Devices

Assessment:
A 2.5 hour unseen written examination is held under UCL MSc examination regulations at UCL.

Tutorials/Workshops:
An afternoon tutorial is held on the Friday afternoon of the week following the module delivery or as specified by the timetable.