Imperial College London

Module Specification (Curriculum Review)

Basic details

UID		Cohorts covered	Earliest cohort: 2025-26	Latest cohort:

Long title: Semiconductor and Device Physics

New code: PHYS70003

New short title:

Brief description of module *(approx. 600 chars.)*: This module builds on the Solid State Physics core module, to develop an understanding of semiconductor physics, including charge transport and optoelectronic properties. The semiconductor physics background will then be used to delve into device physics at the micro- and nano-scale. We will explore how optoelectronic and quantum devices are designed and give insights into some of the latest research developments in semiconductor and device physics.

454 characters

Available as a standalone module/ short course? N

Statutory details

	ECTS	CATS	Non-credit
Credit value	7.5	15	N

HECOS codes:

FHEQ level: Level 7

Allocation of study hours

	Hours	
Lectures	24	
Group teaching	0	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	3	
Other scheduled	0	*Incl. project supervision, fieldwork, external visits.*
Independent study	160.5	*Incl. wider reading/ practice, follow-up work, completion of assessments, revisions.*
Placement	0	*Incl. work-based learning and study that occurs overseas.*
Total hours	187.5	
ECTS ratio	25.00	

Project/placement activity

Is placement activity allowed? No

Module delivery

Delivery mode	Taught/ Campus	Other	3 hour-session online
Delivery term	Term 1	Other	Exam in term 3

Ownership

Primary department: Physics

Additional teaching: None

departments	

Delivery campus	South Kensington

Collaborative delivery

Collaborative delivery?	N

External institution	N/A
External department	N/A
External campus	N/A

Associated staff

Role	CID	Given name	Surname
Module Leader	1002541	Malcolm	Connolly
Topic Leader	782964	Julie	Euvrard

Learning and teaching

Module description

Learning outcomes

By the end of this module, students will be able to:
1. identify what properties of a material makes a semiconductor
2. explain the key principles ruling charge transport and optoelectronic properties in semiconductors
3. design simple electronic and optoelectronic devices using the building blocks of microelectronics
4. describe how to fabricate nanoelectronic devices and explain the role of components such as ohmic contacts and gates.
5. describe the formation of two-dimensional electron gases in quantum well heterostructures in terms of doping and band bending and give examples of how to measure ballistic electron transport.
7. derive the Landauer-Buttiker formula for conductance and use it predict transport properties of low-dimensional quantum nanoelectronic devices.
8. utilise the Divincenzo criteria to compare different semiconductor platforms for spin-based quantum computation.

Module content	• Semiconductor physics: Reminder from Solid State Physics: Electronic bandstructure and basics of semiconductors. Introduction to various families of semiconductors. Charge transport (e.g., band and hopping transport, polarons, phonons), electronic (e.g., defects, doping) and optoelectronic properties (e.g., charge generation and recombination, excitons) of semiconductors. • Device physics: Building blocks of micro and nanoelectronic devices (e.g., metal-semiconductor contacts, pn, pnp, pin, MOS). Basics of electronic (e.g., transistors) and optoelectronic (e.g., solar cell) devices. • Quantum Devices: formation of two-dimensional electron systems in heterojunctions, experiments probing particle-like motion of electrons, describing quantum transport in 1-D conductors using the Landauer theory of conductance, electrons in high magnetic field, quantum Hall effect and edge channels in multi-terminal devices, transport in quantum dots, introduction to Coulomb blockade phenomena, DiVincenzo criteria, introduction to spin qubits.
Learning and Teaching Approach	Students will be taught over one term using a combination of lectures, office hours, exercises, and one practical session using simulation tools.
Assessment Strategy	Summative assessment is based on a final exam (80%): written exam of 2 hours that will competences in the learning outcomes. Summative assessment (20%) is based on a 3-hour practical session using simulation tools.
Feedback	Problems are provided with each individual lecture allowing students to apply the material. Model solutions are provided. Office hours are provided each week to allow for direct interaction between students and the module lecturers. The 3-hour practical session will allow for direct interaction between students, the module lecturers and a GTA.
Reading list	Lecture notes are provided to students. The notes are designed to be self-contained, and there is no designated textbook required for this module. There are however also some excellent textbooks, that are suggested as supplementary or complementary reading for those of you wishing to explore further some aspects of the module. All those textbooks are fully optional. The module mainly follows the following two core textbooks: •Solid state electronic devices / Ben G. Streetman and Sanjay Kumar Banerjee. •Physics of semiconductor devices / S.M. Sze and Kwok K. Ng. Other useful textbooks: •Silicon nanoelectronics / S. Oda and D. K. Ferry. • Transport in Nanostructures / D. K. Ferry • Organic Electronics: Foundations to Applications / S. R. Forrest •Quantum Engineering: Theory and Design of Quantum Coherent Structures /A. M. Zagoskin

Quality assurance

Office use only

Date of first approval		QA Lead	

Date of last revision		Department staff	
Date of this approval		Date of collection	
		Date exported	
Module leader	Malcolm Connolly	Date imported	
Notes/ comments			

Template version 16/06/2017

Programme structure
Associated modules

UID	Legacy code	Module title	Requisite type

UID	Legacy code	Module title	Requisite type

Assessment details

Grading method	Numeric	Pass mark	50%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
			50%	
Examination	2 hour written examination.	80%	50%	N
Practical	Simulation session\	20%	50%	N
		100%		