Imperial College London

Module Specification (Curriculum Review)

Basic details

			Earliest cohort	Latest cohort
UID		Cohorts covered	2021-22	
Long title	Complexity and Networks			
New code	PHYS60010	New short title	Complexity & Networks	
Brief description of module *(approx. 600 chars.)*	Stephen Hawking predicted this is ``the century of complexity''. In this module, we will see how interactions between many small interacting parts lead to the emergence of dramatic results on large scales. We will show how systems can organise themselves to show similar patterns on all scales by investigating some simple theoretical models using mathematical numerical tools.			
	378 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 6				

Allocation of study hours

	Hours	
Lectures	16	
Group teaching	0	*Incl. seminars, tutorials, problem classes.*
Lab/ practical	24	
Other scheduled	14	*Incl. project supervision, fieldwork, external visits.*
Independent study	133.5	*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	
Delivery term	Term 2	Other	

Ownership

Primary department	Physics
Additional teaching 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		Kim	Christensen
Lecturer		Tim	Evans

Learning and teaching

Module description

Learning outcomes	On completion of this module you will be able to: 1) Discuss the notion of emergence in a complex system and discuss the sandpile metaphor to illustrate self-organised criticality. 2) State the algorithm for the BTW and Oslo model in 1 dimension and implement this numerically. 3) Perform finite-size scaling, data collapse and moments scaling analysis of probability density functions. 4) Discuss scaling in general and use it to derive useful results in the context of some specific models. 5) Define the different types of network in a variety of ways. 6) Analyse the structure of networks using a variety of basic measures. 7) Create and analyse null models for network analysis. 8) Compare theoretical and numerical results for key network models.
Module content	Complexity •Criticality - basic properties, examples, emergence of macroscopic behaviour from microscopic rules. •Cooperative phenomena, with examples. •Scale invariance. •The concept of scaling. •Scaling arguments for systems at a phase transition. •Numerical exercise: investigating a simple model displaying complexity behaviour. Networks •Definition of network, different types (random, small-world, scale-free, complete, regular), real examples including web pages, social networks, citation networks. •Basic properties - degree, clustering, shortest paths, degree distribution. •Random Graphs - analytic results for phase transitions. •Growing networks - Price (Barabasi-Albert) model, approximate or exact solutions, hubs, fat-tailed distributions. •Analysis of Networks - shortest paths, centrality measures, betweenness, PageRank. •Processes on graphs – broadcasting, eigenvalue centrality, random walks, Markov processes, ranking via PageRank.

Learning and Teaching Approach	The course is given in two halves, one on Complexity and one on Networks, with the same format for each. Each half uses 8 lectures, and 4 three-hour computer lab sessions. One office hour with a lecturer is offered each week along with a second office hour offered during weeks with no computer lab. The lecturer available in the computer labs to discuss any question related to the course in addition to the specific project work covered by the labs. The labs are attended by the relevant lecturer and several postgraduate teaching assistants. The labs allow small group tuition on key points of confusion, working with groups formed informally by the students (typically four or less in number) or with individuals as students prefer. The labs develop all concepts through the lens of numerical work on one exemplary model whose theory is discussed in the lectures. Problem sheets and solutions are also provided allowing independent student learning, supported by office hours and lab sessions. In addition, the lecture material is supported by simple on-line tests aim to give feedback and to encourage student group discussions and interactions as well as individual engagement with lecture material.
Assessment Strategy	Two reports on the numerical projects (one complexity, one networks) each worth 45%. A series of 4 on-line multiple choice questions tests, each worth 2.5%, with randomised questions to cover key concepts in lectures.
Feedback	On-line tests provide instant written feedback. Interaction in the computer labs gives real-time feedback on work associated with projects and wider issues, to individuals or small informal student formed groups. Labs and office hours provide feedback from the lecturer on any aspect of work. Project reports receive individual written feedback, including a rough letter grade to indicate overall performance.
Reading list	No compulsory text. •Christensen and Moloney, "Complexity and Criticality", IC Press, 2005 for first part. •Detailed notes on Networks section by lecturer plus detailed bibliography of free notes and books, plus

Quality assurance

Date of first approval	
Date of last revision	
Date of this approval	
Module leader	Kim Christensen

Office use only

QA Lead	
Department staff	
Date of collection	
Date exported	
Date imported	

Notes/ comments

Template version 16/06/2017

Programme structure

Associated modules

UID	Legacy code	Module title	Requisite type

Programme structure

Associated programmes

UID	Legacy code	Programme title	Core?

Assessment details

		Pass mark
Grading method	Numeric	40%

Assessments

Assessment type	Assessment description	Weighting	Pass mark	Must pass?
Coursework	Report on Complexity	45%	40%	N
Coursework	Report on Networks	45%	40%	N
Examination	4 x MPC Online Tests	10%	40%	N
		100%		