Workshop on

Nonlinear Dispersive Waves

University College Cork, April 24-25 2023

Aims:

This two-day international workshop will present recent research developments in the broad field of *Nonlinear Dispersive Waves*, with a particular emphasis on nonlinear waves arising in the ocean and atmosphere.

The workshop will operate on a hybrid basis: participants may attend either in person, or online. Registration is free, and interested participants should register directly with the organiser, Dr. David Henry, by emailing: d.henry@ucc.ie

Speakers:

Didier Clamond	*Université Côte d'Azur*
Adrian Constantin	*University of Vienna*
Olivia Constantin	*University of Vienna*
Joachim Escher	*Leibniz University Hannover*
Delia Ionescu-Kruse	*IMAR*
Rossen Ivanov	*TU Dublin*
David Lannes	*University of Bordeaux*
Bogdan Matioc	*University of Regensburg*
Emilian Parau	*University of East Anglia*
Jens Rademacher	*University of Hamburg*
Raphael Stuhlmeier	*University of Plymouth*
Samuel Walsh	*University of Missouri*

Sponsors:

This workshop is kindly supported by funding from the *School of Mathematical Sciences* (UCC), the *Irish Mathematical Society*, and *Science Foundation Ireland*.

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IMS CMÉ

Science Foundation Ireland sfi For what's next

Workshop Programme

Nonlinear Dispersive Waves

University College Cork

April 24-25.

Schedule

The main venue for this workshop is room **G.01** in the **Western Gateway Building**, which is located just off UCC Main Campus (see the map on page 6). The talks on Monday afternoon, however, will take place in the **Dora Allman** room (with panoramic views of the campus and Cork city!) in the **Hub** building, which is located on the Main Campus.

	Monday	**Tuesday**
Venue:	**WGB G.01**	**WGB G.01**
9.00-9.15	*Registration/Coffee*	*Coffee*
9.15-9.30	*Opening remarks*	*Coffee*
9.30-10.10	Didier Clamond	David Lannes
10.10-10.50	Bogdan Matioc	Jens Rademacher
10.50-11.20	*Coffee*	*Coffee*
11.20-12.00	Rossen Ivanov	Delia Ionescu-Kruse
12.00-14.00	*Lunch*	*Lunch*
Venue:	**Dora Allman room**	**WGB G.01**
14.00-14.40	Joachim Escher	Adrian Constantin
14.40-15.20	Emilian Parau	Samuel Walsh
15.20-15.50	*Coffee*	*Coffee*
15.50-16.30	Olivia Constantin	Raphael Stuhlmeier

Titles and Abstracts

Didier Clamond (Université Côte d'Azur)

***Title:* On the recovery of rotational gravity waves from the seabed pressure**

Abstract: Considering a rotational steady bidimensional water wave with constant vorticity, we show how the free surface and the vorticity can be determined solely from the pressure at the seabed.

This is joint work with Joris Labarbe (U. Côte d'Azur) and David Henry (UCC).

Adrian Constantin (University of Vienna)

***Title:* Frictional effects in wind-driven ocean currents**

Abstract: Surface ocean currents have a significant influence on the climate and their dynamics depend to a large extent on the behaviour of the vertical eddy viscosity. We discuss an analytic approach to the study of wind-driven surface currents for general depth-dependent vertical eddy viscosities.

Olivia Constantin (University of Vienna)

***Title:* A complex analytic approach to some problems in fluid flows**

Abstract: In this talk we discuss several instances where methods from complex and harmonic analysis prove useful to specific problems arising in fluid mechanics.

We first consider irrotational periodic travelling waves and show the logarithmic convexity of certain flow quantities. As a by-product, we deduce, for instance, that the kinetic energy, the time-period of the particle paths, and the length of a streamline are larger near the surface and reduce with increasing depth. We then proceed in a different direction of investigation and obtain a complete solution to the problem of classifying all two-dimensional ideal fluid flows with harmonic Lagrangian labelling maps.

Some of these results are joint work with Maria Jose Martin.

Joachim Escher (Leibniz University Hannover)

***Title:* The Rayleigh–Taylor Condition for the Muskat Problem**

Abstract: Of concern is the moving boundary problem of a two-phase potential flow of two fluids with possible different densities and viscosities. Such problems are known as Muskat problems or two-phase Hele-Shaw flows. Due to the moving interfaces these problems are intrinsically nonlocal and highly nonlinear. A criterion is presented, known as the generalised Rayleigh-Taylor condition, which guarantees that for large classes of initial data these problems are classically well-posed, possibly on a finite time interval only. Away from the Rayleigh-Taylor regime the system becomes unstable and finger-shaped unstable

steady states can occur. A thin film approximation is also discussed. Here the dynamical behaviour is different: global weak solutions exist for any square integrable non-negative initial configuration. In addition, the flat steady state is globally stable in the class of weak solutions.

Delia Ionescu-Kruse (Institute of Mathematics of the Romanian Academy)

Title: **On the short-wavelength stabilities of some geophysical flows**

Abstract: This talk is a survey of the short-wavelength stability method for rotating flows. This method is applied to the specific study of some exact geophysical flows. For Gerstner-like geophysical flows one can identify perturbations in certain directions as a source of instabilities with an exponentially growing amplitude, the growth rate of the instabilities depending on the steepness of the travelling wave profile. On the other hand, for certain physically realistic velocity profiles, steady flows moving only in the azimuthal direction, with no variation in this direction, are locally stable to the short-wavelength perturbations.

Rossen Ivanov (TU Dublin)

Title: **Modelling internal waves over variable bottoms**

Abstract: We employ the Hamiltonian approach in analysing the effects of an uneven bottom on the internal wave propagation in the presence of stratification and underlying non-uniform currents. The presented models incorporate wave–current interactions and a variable bathymetry. A physical example is given by the equatorial internal waves in the presence of the Equatorial Undercurrent (EUC). The interface (physically coinciding with the thermocline and the pycnocline) satisfies in the long wave approximation a KdV–mKdV type equation with depth-dependent variable coefficients.

David Lannes (University of Bordeaux)

Title: **Wave structure interaction in the Boussinesq regime**

Abstract: In this joint work with G. Beck and L. Weynans, we study the motion of a floating object in a fluid governed by the nonlinear dispersive Boussinesq equations. We show that the fluid+structure interaction problem can be reduced to an initial boundary value problem for the Boussinesq equations with nonstandard boundary conditions. We will comment on some mathematical aspects of this system and in particular insist on an hidden trace regularity phenomenon which plays a crucial role un the well-posedness theory; we will also show how this mathematical phenomenon can be exploited numerically, more or less in a similar way as the Riemann invariants for (nondispersive) hyperbolic systems such as the nonlinear shallow water equations. We will finally present some simulations.

Bogdan Matioc (University of Regensburg)

Title: **Stratified Periodic Water Waves with Singular Density Gradients**

Abstract: We discuss the existence of periodic free surface water waves that travel over a fluid whose density is stratified in a regime where both gravity and surface tension effects are included. The density of the fluid is assumed to be continuous, but its gradient maybe be unbounded. This setting is relevant when modeling ocean flows since the water density varies strongly only in thin layers called pycnoclines while it is almost constant in the layers between the pycnoclines.

This is joint work with Joachim Escher, Patrik Knopf, and Christina Lienstromberg.

Emilian Parau (University of East Anglia)

Title: **A dissipative nonlinear Schrodinger model for wave propagation in the marginal ice zone**

Abstract: Sea ice attenuates waves propagating from the open ocean. We propose to model the evolution of energetic unidirectional random waves in the marginal ice zone with a nonlinear Schrodinger equation, with a frequency dependent dissipative term consistent with current model paradigms and recent field observations. We also discuss shortly the scattering of waves by ice floes.

This is joint work with Alberto Alberello (UEA).

Jens Rademacher (University of Hamburg)

Title: **Rotating convection with kinetic energy backscatter**

Abstract: The so-called subgrid parameterisations by kinetic energy backscatter is widely used for large-scale geophysical flow simulations. It consists of damping by hyperviscosoty and driving by negative viscosity to compensate lack of resolution and to stabilize the numerical scheme. Viewed as a PDE, we study the impact of backscatter via specific flows and waves for rotating Boussinesq and shallow water equations. On idealised domains we find that backscatter can generate equilibrium states as well as unboundedly growing flows and waves that take the form of explicit eigenmodes of the linear part in the nonlinear equations. Combined with bottom drag, in the shallow water case, we additionally find unusual spectra and bifurcations of geostrophic equilibria and inertia-gravity waves.

This is joint work with Artur Prugger (Bremen) and Jichen Yang (Zhuhai).

Raphael Stuhlmeier (University of Plymouth)

Title: **A discrete Hamiltonian perspective on the classical instabilities of deep-water waves**

Abstract: The stability of surface waves in deep water has traditionally been approached via linearisation, starting with various model equations, such as the NLS equation or (without restriction to narrow bandwidth) the Zakharov equation. Owing to the form of the deep-water dispersion relation, energy exchange among surface water waves - and thus the possibility of instability - occurs when four or more wavenumbers are involved. We shall employ the compact, Hamiltonian description of four-wave interaction due to Krasitskii.

In the usual mathematical sense, instability requires starting from a solution to a set of equations, and describes the evolution of perturbations to that solution. A handful of such explicit solutions - the monochromatic (Stokes') wave and bichromatic wave train - therefore form the backbone of classical instability results. The simplest, and best known is the Benjamin-Feir (BFI) or modulational instability, which will be presented in some detail. This instability involves three waves (one of which is counted twice) in near resonance, a carrier wave and two side bands. Two other instabilities have been studied extensively, and involve four distinct waves. Type Ia which begins with a bichromatic basic state and type Ib adds to the Benjamin-Feir instability an additional non-resonant satellite.

In all cases the entire non linear dynamics can be described by the level lines of a certain Hamiltonian function. This enables the explicit computation of steady state solutions, which have been the object of much recent interest. These steady state solutions characterise the linear instability of the underlying Stokes wave (for the BFI and type Ib) or the bichromatic sea state (Type Ia). The phenomenon of phase-locking (or phase coherence) is seen to be coincident with instability. In such cases the dynamic phase - a specific combination of the interacting phases - tends initially to a fixed value regardless of the initial configuration of the system. Moreover, certain heteroclinic orbits are identified as new discrete breather solutions, analogous to the famed Akhmediev breather.

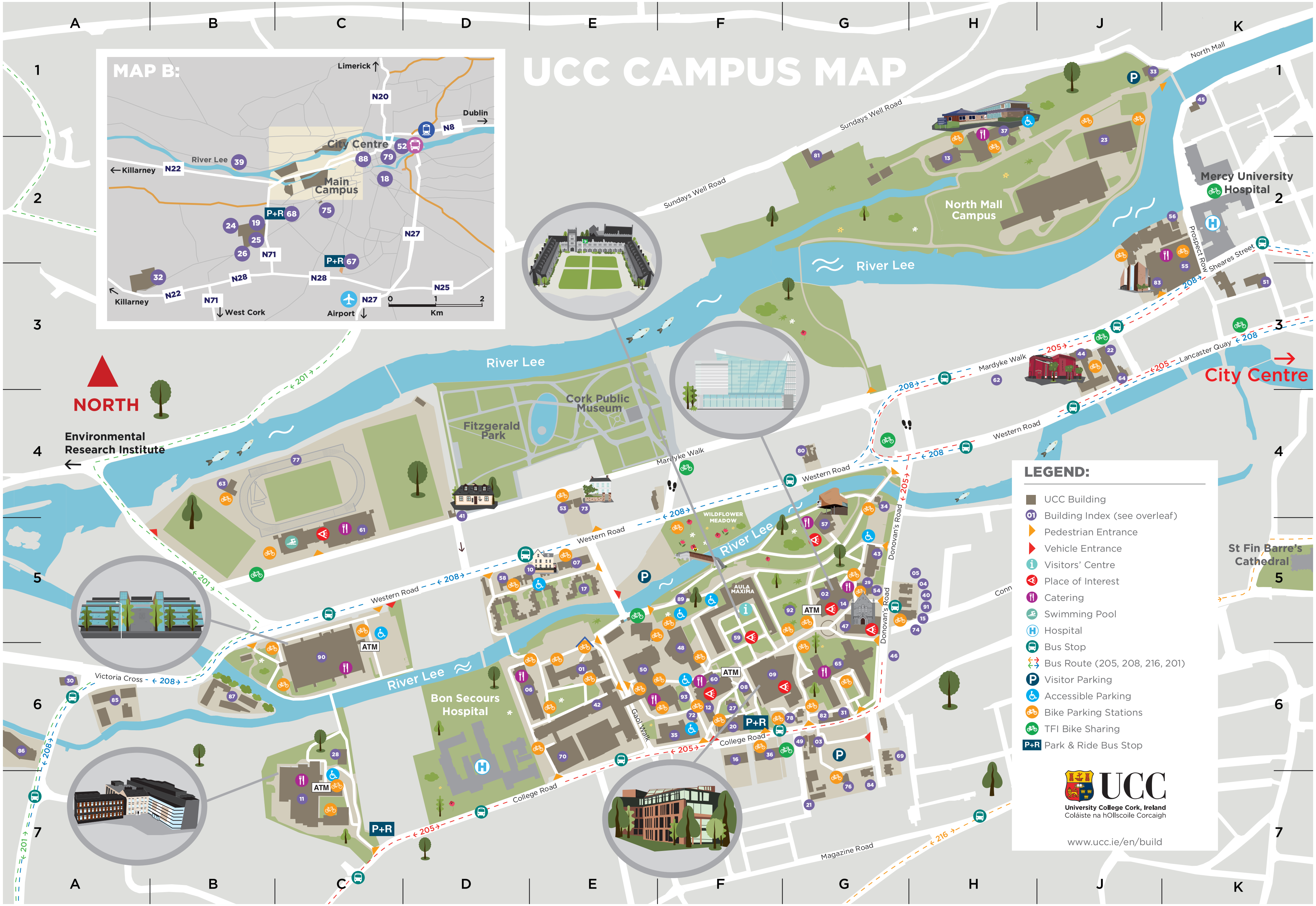
Samuel Walsh (University of Missouri)

Title: **Desingularization and global continuation for hollow vortices**

Abstract: A hollow vortex is a region of constant pressure bounded by a vortex sheet and suspended inside a perfect fluid — think of it as a spinning bubble of air in water. In this talk, I will describe a general method for desingularizing non-degenerate translating, rotating, or stationary point vortex configurations into collections of steady hollow vortices. Through global bifurcation theory, moreover, these families can be extended to maximal curves of solutions that continue until the onset of a singularity. As specific applications, this machinery gives the first existence theory for co-rotating hollow vortex pairs and stationary hollow vortex tripoles, as well as a new construction of Pocklington's classical co-translating hollow vortex pairs. All of these families extend into the non-perturbative regime, and we obtain a rather complete characterization of the limiting behavior along the global bifurcation curve.

This is joint work with Ming Chen (University of Pittsburgh) and Miles H. Wheeler (University of Bath).

UCC CAMPUS MAP



LEGEND:

- UCC Building
- Building Index (see overleaf)
- Pedestrian Entrance
- Vehicle Entrance
- Visitors' Centre
- Place of Interest
- Catering
- Swimming Pool
- Hospital
- Bus Stop
- Bus Route (205, 208, 216, 201)
- Visitor Parking
- Accessible Parking
- Bike Parking Stations
- TFI Bike Sharing
- P+R Park & Ride Bus Stop

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BUILDING INDEX:

	No.	Grid
Áras Na Laoi	01	E6
Áras Na Mac Léinn / Student Centre	02	G5
Ardpatrick	03	G6
Ashford	04	H5
Askive	05	H5
Bioscience Building	06	D6
Bloomfield Terrace	07	E5
Boole Lecture Theatres	08	F6
Boole Library	09	F6
Brighton Villas	10	D5
Brookfield Health Science Complex	11	C7
Building & Estates	12	F6
Butler Building	13	H2
Calm Zone The	14	F6
Carrigbawn	15	H5
Carrigside	16	F6
Castlewhite Apartments	17	E5
Centre For Architectural Education	18	Map B
Clinical Sciences	19	Map B
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College View	21	G7
Connolly Building	22	J3
Cooperage The	23	J2
Cork Dental School & Hospital	24	Map B
Cork University Hospital	25	Map B
Cork University Maternity Hospital	26	Map B
Crawford Observatory	27	F6
Créche Cois Laoi	28	C6
Crossleigh	29	G5
Crows Nest	30	A6
Iris Ashley Cummins Building	31	F6
Curraheen Sports Ground	32	Map B
Distillery House	33	J1
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Elderwood	36	F6
Electrical Engineering	35	F6
Enterprise Centre	37	H1
Eri Beaufort	38	Map B
Ellen Hutchins Building	39	Map B
Fernhurst	40	H5
Ferry Lodge	41	D4
Food Science & Technology	42	E6
Geography Building	43	G5
Granary Theatre	44	J3
Grenville Place 5	45	K1
Hillside	46	H6
Honan Chapel	47	G5
Hub The	48	F6
Iona	49	G6
Kane Building	50	E6
Lancaster Hall	51	K3
Lapps Quay 1	52	Map B
Laurels The	53	E4
Lee Holme	54	G5
Lee Maltings Complex	55	K2
Lee Mills House	56	J2
Lewis Glucksman Gallery	57	G5
Lucan Place	58	D5
Main Quadrangle	59	F5
Main Restaurant	60	F6
Mardyke Arena	61	C5
Mardyke Hall	62	H3
Mardyke Pavilion	63	B4
Muskerry Villas	64	J3
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Park And Ride Pouladuff	67	Map B
P+R Presentation Brothers Sports Ground	68	Map B
Perrott Avenue	69	G6
Pharmacy Building	70	E6
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Reception Centre / Security	72	F6
Roseleigh	73	E4
Safari	74	H5
Sheraton Court	75	Map B
Silverdale	76	G7
Sonia O'sullivan Athletics Track The	77	C4
South Lodge	78	G6
South Mall 13	79	Map B
St Kildas	80	G4
St Vincents	81	G2
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Tyndall National Institute	83	J3
Tyrconel	84	G7
University Hall	85	A6
Victoria Lodge	86	A6
Victoria Mills	87	B6
Wandesford Quay	88	Map B
West Lodge	89	F5
Western Gateway	90	C6
William Thompson House	91	H5

COLLEGES:

Arts, Celtic Studies and Social Sciences
Ground Floor O'Rahilly Building
T +353 (0)21 490 2361/2773
CACSSS@ucc.ie

	No.	Grid
School of Applied Psychology	37	H1
School of Applied Social Studies	91	H5
School of Education	54	G5
• Education	54	G5
• Early Years and Childhood Studies	54	G5
• Sports Studies and Physical Education	58	D5
School of English and Digital Humanities	65	G6
• Digital Humanities	65	G6
• English	65	G6
School of History	69	G6
• History	84	G7
• History of Art	69	G6
• European Studies	84	G7
School of the Human Environment: Geography, Archaeology and Classics		
• Archaeology	22	J3
• Geography	43	G5
• Classics	65	G6
CACSSS Graduate School	65	G6
School of Languages, Literatures & Cultures	65	G6
• Asian Studies	65	G6
• French	65	G6
• German	65	G6
• Italian	65	G6
• Spanish, Portuguese and Latin	65	G6
American Studies	65	G6
School of Irish Learning	65	G6
• Early and Medieval Irish	65	G6
• Folklore and Ethnology	35	F6
• Modern Irish	65	G6
School of Film, Music & Theatre	64	J3
• Film and Screen Media	65	G6
• Music	81	G2
• Theatre	64	J3
School of Society, Politics and Ethics	35	F6
• Philosophy	35	F6
• Government and Politics	65	G6
• Sociology and Criminology	05	H5
• Study of Religions	65	G6

Business and Law
Block A Third Floor O'Rahilly Building
T +353 (0)21 420 5100
businessandlaw@ucc.ie

	No.	Grid
Cork University Business School	65	G6
• Accounting and finance	65	G6
• Business Information Systems	65	G6
• Centre for Policy Studies	07	E5
• Economics	01	E6
• Food Business and Development	65	G6
• Management and Marketing	65	G6
School of Law	01	E6

Medicine and Health
Erinville, Western Road
T +353 21 420 5671/5661
comh@ucc.ie

	No.	Grid
Dental School and Hospital	24	Map B
• Restorative Dentistry		
and School of Dental Hygiene	24	Map B
• Oral Health and Development	24	Map B
• Oral Health Services Research Centre	24	Map B
• Dental Surgery	24	Map B
School of Nursing and Midwifery	11	C7
School of Pharmacy	70	E6
School of Clinical Therapies	11	C7
• Occupational Therapy	11	C7
• Speech & Hearing Sciences	11	C7
School of Medicine	11	C7
• Anatomy & Neuroscience	90	C6
• General Practice	90	C6
• Medicine (Department)	19	Map B
• Obstetrics and Gynaecology	26	Map B
• Paediatrics and Child Health	66	Map B
• Pathology	25	Map B
• Pharmacology and Therapeutics	90	C6
• Physiology	90	C6
• Psychiatry	25	Map B
• Radiology	25	Map B
• Radiography	11	C7
• Surgery	25	Map B
School of Public Health	90	C6

Science, Engineering and Food Science
Block E Level 3 Food Science Building
T +353 (0)21 490 3075
collegeoffice@sefs.ucc.ie

	No.	Grid
School of Biochemistry and Cell Biology	90	C6
School of Microbiology	42	E6
School of Engineering and Architecture	18	Map B
	31	F6
	36	F6
	42	E6
School of Food & Nutritional Sciences	42	E6
School of Mathematical Science	90	C6
School of Computer Science		
& Information Technology	90	C6
School of Biological, Earth		
& Environmental Sciences	37	H1
School of Chemistry	50	E6
Physics	50	E6

CAMPUS INFORMATION:
Switch Board +353 (0)21 490 3000

	No.	Grid
Services		
Accommodation Office	78	G6
Access & Participation	48	F6
Admissions Office	59	F5
Bank	02	G5
Book Shop	02	G5
Career Services	48	F6
Chaplaincy	49	G6
Crèche	28	C6
First Year Experience Co-ordinator	48	F6
Graduate Studies Office	59	F5
Grants	59	F5
Human Resources	42	E6
International Office	73	E4
Language Centre	65	G6
Mature Student Office	48	F6
Reception Centre / Security	72	F6
Skills Centre	09	F6
Sport & Physical Activity	54	G5
Student Advisor & Ombudsman	04	H5
Student Experience Office	48	F6
Student Health & Wellbeing	03	G6
Student Life	78	G6

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	No.	Grid
Student IT Services		
• Boole Basement	08	F6
• 3rd Floor Kane Building	50	E6
Student Records & Examinations	59	F5
Students' Union	20	G6
Visitors' Centre	59	F5
Catering		
Biosciences -Bio Café	06	D6
Brookfield Restaurant	11	C7
Cafe Atrium	61	C5
Café Diem - The Still	37	H1
Club Áras - New Bar	02	G5
Coffee Dock	65	G6
Elements	50	E6
Main Restaurant	60	F6
Oasis Cafe	02	G5
Roots Café - Hub	48	F6
Staff Common Room	59	F5
Staff Dining Room	60	F6
Tyndall Restaurant	83	J3
Western Gateway- Elements & Riverside Café	90	C6
Places of Interest		
Áras na Mac Léinn / Student Centre	02	G5
Aula Maxima	59	F5
Boole Library	09	F6
Crawford Observatory	27	F6
Honan Chapel	47	G5
Lewis Glucksman Gallery	57	G5
The Main Quadrangle	59	F5
Mardyke Arena	61	C5
President's Garden	92	G5
Republican Grave	93	F6
Stone Corridor and Ogham Stone Collection	59	F5
Visitors' Centre	59	F5

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UCC CAMPUS MAP

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