

HERIOT-WATT UNIVERSITY  
DEPARTMENT OF MATHEMATICS

ANNUAL REPORT 1988-89

Undergraduate numbers in the Department of Mathematics are at an all-time high following a record entry into the first year. A significant number of mature students have been attracted by the joint degree in Mathematics with Education and for the last two years workshops on "Women in Mathematics" have been held in the department. New degree courses in Mathematics with Economics and Mathematics with a European Language will be available next year.

The department was delighted at the recognition given to the research excellence of two of its members. Dr A Lacey shared the Whittaker Prize of the Edinburgh Mathematical Society, open to young mathematicians with Scottish connections, for his outstanding published work and Professor J M Ball was elected Fellow of the Royal Society at the comparatively young age of 41. There are now two Fellows of the Royal Society in the department, Professor O Penrose having been elected in 1987.

Financial support from SERC within the Nonlinear Systems programme made possible numerous short term visits by research workers from Europe and the U.S.A. and the organization of two meetings; in December the department played host to a conference on Nonlinear Systems and in May Professor R J Knops and Dr A Lacey organized a conference/workshop on "Finite time blow-up and extinction for parabolic and other equations". A further SERC grant of £180,000 has been won to provide a system of SUN computers within the department.

The department has also profited from its collaboration with Nice, Paris, Stuttgart and Utrecht in a research programme on "Mathematical Problems in Nonlinear Mechanics" funded by the European Stimulation Program. As part of this programme several members of the department participated in conferences in Stuttgart and Paris and Professor Ball organized a Winter School for Young Researchers in January and a conference on "Regularity problems in nonlinear elasticity" in March. Dr X Mora, Barcelona, and Dr K Zhang, Shanghai, spent the year in the department as visiting research workers.

The CALM (Computer Assisted Learning in Mathematics) project under the direction of Dr C E Beavers has made significant progress. For the first time all Riccarton-based first year engineers were given computer-based tuition. The project has attracted considerable external recognition in the form of a grant to support activities over the next three years from the DTI, financial support from various industrial companies and the appointment of Dr Beavers to the Management Committee supervising the provision of mathematical software in British universities.

Dr J Howie, a former winner of the Whittaker Prize, was promoted to a readership. Professor J C Elbeek completed a five year term as Head of Department and was succeeded by Dr K J Brown.

K J Brown

Head of Department

STAFF

Head of Department

Professors

Professor Emeritus

Readers

Senior Lecturers

Lecturers

Research Associates

Programmer

Visiting Mathematicians

Secretaries

K J Brown<sup>1</sup>  
 J M Ball  
 J Carr  
 J C Eilbeck<sup>2</sup>  
 R J Knops<sup>3</sup>  
 O Penrose  
 J H Williamson

M van den Berg  
 J Howie  
 A A Lacey

C E Beevers  
 R N Hills  
 A R Prince

L E Nicholas  
 C Noble<sup>5</sup>  
 H U Rahman  
 B Toth<sup>6</sup>  
 D G Wilkinson  
 M A Youngson

Z Li<sup>8</sup>  
 T Qi<sup>13</sup>  
 S Srisaṅkunaraḥ<sup>14</sup>  
 B Toth<sup>5</sup>  
 J M Verosky<sup>16</sup>  
 K Zhang<sup>13</sup>

X Mora<sup>10</sup>  
 H Shariati<sup>17</sup>

Mrs V A McDonald<sup>5</sup>  
 Miss A Sutton-Vane

1 1988-89  
 11 until 31.12.88  
 12 until 31.5.89  
 13 1989-90  
 14 until 30.4.89  
 15 1989-91  
 16 until 31.7.89  
 17 from 1.2.89

Visitors to the Department

E Acerbi (Pisa)  
 S S Antman (Maryland)  
 V I Arnol'd (Moscow)  
 M Atiyah (Oxford)  
 A Avinyo (Catalonia)  
 C Ball (Sydney)  
 E J Balder (Utrecht)  
 S Baldo (Pisa)  
 J Bandle (Basel)  
 J Bebernes (Colorado)  
 L Bernstein (Denmark)  
 W Blyth (Melbourne Inst of Technology)  
 W A Bogley (Tufts)  
 B Braaksma (Utrecht)  
 R K Bullough (UMIST)  
 G Capriz (Pisa)  
 P Coveney (Bangor)  
 A D D Craik (St Andrews)  
 A M Davie (Edinburgh)  
 A Doelman (Utrecht)  
 A Di Liddo (Bari)  
 S Dimova (Bulgarian Academy of Sciences)  
 D Eberly (Texas at San Antonio)  
 M Edjvet (Nottingham)  
 L C Evans (Maryland)  
 W E Fitzgibbon (Houston)  
 J N Flavin (Galway)  
 J Frehse (Bonn)  
 A Friedman (Minnesota)  
 N Fusco (Salerno)  
 V A Galaktionov (Keldysh)  
 R Garlepy (Kentucky)  
 A K Gautesen (Iowa)  
 M Golubitsky (Houston)  
 J Gomatam (Glasgow Technical College)  
 M Grinfel'd (Moscow)  
 M Grueter (Saarlandes)  
 R E Grundy (St Andrews)  
 W S C Gurney (Strathclyde)  
 H Haff (Warwick)  
 M A Hayes (Dublin)  
 D Heggie (Edinburgh)  
 M Herrero (Madrid)  
 S D Howison (Oxford)  
 R Hudson (Nottingham)  
 J Hutchinson (Canberra)  
 R D James (Minnesota)  
 G S Joyce (Kings College, London)  
 W S Kendall (Warwick)  
 B L Keyfitz (Houston)  
 J King (Nottingham)  
 M Kirane (Algeria)  
 R V Kohn (Courant, New York)  
 R E C M Krol (Utrecht)  
 H Le Dret (Paris VI)  
 J T Lewis (Dublin)  
 F Leonetti (Universita di L'Aquila)  
 Lung-an Ying (Beijing)  
 J B McLeod (Oxford)  
 T Matsui (Swansea)  
 A P Mikhailov (Keldysh)  
 A R Mitchell (Dundee)  
 V J Mizel (Carnegie-Mellon)  
 M Moore (Manchester)  
 H Ockendon (Oxford)  
 J R Ockendon (Oxford)  
 M Pang (King's College, London)  
 R L Pego (Michigan)  
 M Penrose (Santa Barbara)  
 Y W Qi (Oxford)  
 D Quinney (Keele)  
 U Reif (Stuttgart)  
 Yu G Reshetnyak (Novosibirsk)  
 R Rionero (Naples)  
 R D Russell (Simon-Fraser)  
 R Russo (Naples)  
 B P Rynne (Dundee)  
 G Schneider (Stuttgart)  
 M E Schonbek (U.C. Santa Cruz)  
 D Schryvers (Antwerp)  
 P Sermon (Darling Downs Inst of Tech)  
 G L Sewell (Q M C London)  
 R Shivaḥi (Mississippi)  
 F Simons (Eindhoven)  
 J Sivaloganathan (Bath)  
 N Stavrakakis (Athens)  
 G Steil (Stony Brook, New York)  
 P Sternberg (Indiana)  
 T Suzuki (Tokyo)  
 V Sverak (Prague)  
 A Tertikas (Univ of the Aegean)  
 F Tomarelli (Pavia)  
 R Toral (Palma de Mallorca)  
 D Tzanetis (Athens)  
 S Vasilovsky (Novosibirsk)  
 J R L Webb (Glasgow)  
 M I Weinstein (Michigan)  
 G J Weir (DSIR, New Zealand)  
 N V Zmitrenko (Keldysh)

Invited Papers and Seminars given by members of staff

Professor J M Ball

- Seminar, University of Cambridge, 16 November 1988, 'Differential equations'.
- Seminar, University College Swansea, 17 February 1989, 'Crystal microstructure and the calculus of variations'.
- Seminar, University of Dundee, 2 March 1989, 'Crystal microstructure and the calculus of variations'.
- Seminar, Università degli Studi, Firenze, 12 April 1989, 'Young measure and crystal microstructure'.
- Seminar, Università degli Studi, Modena, 13 April 1989, 'Variational problems in nonlinear elasticity'.
- Invited lecture, Conference on "Nonconvex problems of continuum mechanics", Bonn, 8 April 1989, 'Young measures and microstructures'.
- Invited lecture, Meeting on "Rational mechanics and analysis" in honour of C. Truesdell's 70th birthday, Pisa 22-26 May 1989, 'Crystal microstructure in the calculus of variations'.
- Invited Lecture, Second Annual Conference on "Mathematical problems in nonlinear mechanics", Paris, May 1989, 'Nonattainment of an energy minimum for elastic crystals'.
- Invited lecture course (3 lectures), International Centre for Theoretical Physics, Trieste, 5 - 7 September 1989, 'Young measures, crystal microstructure, and variational problems of elasticity'.
- Invited lecture, British Association for the Advancement of Science, Annual Meeting, Sheffield, 12 September 1989, 'Crystal microstructure and nonattainment of minimum energy'.

Dr F Bavaud

- Invited lecture, Rencontre de Physique Statistique, Paris, 26-27 January 1989, 'Two dimensional pressure ensembles'.
- Invited lecture, Rencontre in Theoretical and Mathematical Physics, Lausanne (CH), 20-21 January 1989, 'Two-dimensional pressure ensembles'.

Dr C E Beevers

- Invited lecture, Workshop on "Engineering mathematics", Birmingham University, 15 September 1989, 'Educational evaluation of mathematical software'.
- Invited lecture, Mathematics Teaching Conference, Moray House, Edinburgh, 29 September 1989, 'CAL for engineering mathematics'.

Dr M van den Berg

- Seminar, King's College London, 6 October 1988, 'Gaussian bounds for the Dirichlet heat kernel'.
- Seminar, University College Swansea, 7 October 1988, 'Gaussian bounds for the Dirichlet heat kernel'.
- Seminar, State University Utrecht, 15 December 1988, 'Mean curvature and the heat equation'.
- Seminar, State University Utrecht, 15 December 1988, 'Gaussian bounds for the Dirichlet heat kernel'.
- Seminar, Dublin Institute for Advanced Studies, 11 August 1989, 'On the asymptotic distribution of eigenvalues of the Laplace operator'.
- Invited lecture, Informal Statistical Mechanics Workshop, Heriot-Watt University, 24 August 1989, 'Dirichlet-Neumann bracketing and a theorem of Rellich'.
- Invited lecture, Meeting on "Operator algebras and applications", University College Swansea, 10 January 1989, 'Dirichlet-Neumann bracketing and a theorem of Rellich'.
- Invited lecture, Easter meeting on "Probability", Edinburgh University, 10 - 14 April 1989, 'Dirichlet-Neumann bracketing and a theorem of Rellich'.
- Invited lecture, Fourth Gregynog Symposium on "Differential equations", Gregynog 3 - 7 July 1989, 'Dirichlet-Neumann bracketing and a theorem of Rellich'.

Mr J Bree

- Invited lecture, Applied Solid Mechanics III Conference, University of Surrey, 5 - 7 April 1989, 'Elastic-plastic behaviour of thin tubes subjected to internal pressure and cyclic thermal stresses'.

Dr K J Brown

- Seminar, University of Zurich, 9 December 1988, 'Existence and non-existence of solutions for a semilinear elliptic equation arising in population genetics'.
- Seminar, University of Bari, 30 March 1989, 'Uniqueness results for semilinear elliptic boundary value problems'.
- Seminar, University of Bari, 3 April 1989, 'Global bifurcation diagrams for systems of reaction-diffusion equations'.

Professor J Carr

- Seminar, Stuttgart, December 1989, 'Invariant manifolds for metastable solutions'.
- Invited lecture, Conference on "Problems involving change of type", Stuttgart, October 1988, 'Dynamics of cluster growth'.
- Invited lecture, Conference on "Nonlinear systems", Heriot-Watt University, December 1988, 'Slowly varying solutions of partial differential equations'.

Invited lecture, Second Annual Conference on "Mathematical problems in nonlinear mechanics", Paris, May 1989, 'Metastability in partial differential equations'.  
 Invited lecture, Conference on "Differential equations", Dublin, May 1989, 'Geometric models of the flow on the attractor'.  
 Invited lecture, Conference on "Geometric theory of differential equations", Montreal Canada, June 1989, 'Slowly varying solutions of partial differential equations'.

Seminar, Heriot-Watt University, 10 January 1989, 'Infinite unions of cosets in commutative rings'.  
 Seminar, University of Edinburgh, 3 March 1989, 'Infinite unions of cosets and non-zero divisors'.  
 Seminar, University of Sheffield, 8 March 1989, 'Infinite unions of cosets and non-zero divisors'.  
 Splinter group talk, British Mathematical Colloquium, University of Nottingham, 3 - 7 April 1989, 'Coverings of ideals by infinite unions of cosets'.

Seminar, Bristol University, 20 October 1988, 'A self-adaptive moving mesh for the enthalpy formulation of phase change problems'.  
 Seminar, University of Alberta, 15 December 1988, 'A self-adaptive moving mesh for the enthalpy formulation of phase change problems'.  
 Seminar, Strathclyde University, February 1989, 'A self-adaptive moving mesh for the enthalpy formulation of phase change problems'.  
 Seminar, University of Alberta, Applied Mathematics Institute, 15 September 1989, 'Parallel hopscotch solutions of the Ginzburg-Landau equation'.  
 Contributed lecture, Dundee conference on Numerical Analysis, June 1989, 'Parallel hopscotch solutions of the Ginzburg-Landau equation'.

Seminar, Aberystwyth University, 20 October 1988, 'Numerical investigations of bifurcations in reaction-diffusion systems using pseudo-spectral and path-following techniques'.  
 Seminar, University of Swansea, 21 October 1988, 'Classical and quantum chaos in a system of coupled oscillators'.  
 Invited lecture, Meeting on "The dynamics of nonlinear systems", Queen Mary College, 2 November 1988, 'Classical and quantum chaos in a system of coupled oscillators'.

Invited Lecture, Second Annual Conference on "Mathematical problems in nonlinear mechanics", Paris, May 1989, 'Numerical studies of bifurcation of steady-state solutions of reaction-diffusion equations'.  
 Invited Lecture, NATO/MIDIT Advanced Research Workshop on "Self-trapping of vibrational energy in protein", Haustholm, Denmark, 30 July - 5 August 1989, 'Introduction to the discrete self-trapping equation'.  
 Invited lecture, Workshop on "Continuation and bifurcations", K.U. Leuven, 18 - 22 September 1989, 'Bifurcations in the Sel'kov model'.

Seminar, Heriot-Watt University, October 1988, 'Blow-up at the boundary for a semilinear parabolic equation'.  
 Seminar, University of Bath, 24 February 1989, 'Blow-up at the boundary for a semilinear parabolic equation'.

Seminar, Heriot-Watt University, 21 June 1989, 'Some applications of connection matrices'.

Invited lecture, Conference on "Problems involving change of type", Stuttgart, October 1988, 'Remarks on the Cahn-Hilliard equation'.

Seminar, Heriot-Watt University, 21 April 1989, 'Fibonacci groups, the figure eight knot, and hyperbolic structures'.  
 Seminar, Universität Bleiefeld, 24 May 1989, 'Über Fibonacci Gruppen'.  
 Seminar, Universität Bleiefeld, 26 May 1989, 'Über Ein-Relator Gruppen'.  
 Colloquium, University of Manchester, 2 November 1988, 'One relator groups and one relator products'.  
 Colloquium, University College London, 16 November 1988, 'One relator groups and one relator products'.  
 Contributed lectures, British Mathematical Colloquium, Nottingham, 4 - 6 April 1989, 'T(6)-groups, projective planes, and SQ-universality'; 'Fibonacci groups, the figure eight knot, and hyperbolic structures'.

Invited Lecture, meeting on "Rational mechanics and analysis", Pisa, 22-26 May 1989, 'Phragmen-Lindelöf theorems and related results in elasticity'.

- Dr A A Lacey
- Seminar, Universidad Complutense de Madrid, 7 February 1989, 'Complete blow-up for a semilinear diffusion equation'.  
Seminar, University of Southampton, 26 April 1989, 'Blow-up of semilinear diffusion equations'.  
Seminar, University of Bath, 28 April 1989, 'Global blow-up of semilinear diffusion equations'.  
Seminar, University of Colorado, Boulder, September 1989, 'Blow-up of problems with non-local terms'.  
Series of talks; National Technical University Athens, and University of Athens, 5 - 15 April 1989, three on 'Blow-up of non-linear diffusion equations', and two on 'Free boundary problems'.
- Dr Zhiping Li
- Seminar, Heriot-Watt University, December 1988, 'Finite element methods for nonlinear elasticity'.  
Seminar, Heriot-Watt University, March 1989, 'Finite element methods for detecting singular minimizers in variational problems'.  
Invited lecture, Second Annual Conference on "Mathematical problems in nonlinear mechanics", Paris, May 1989, 'Finite element method for detecting singular minimizers in variational problems'.
- Dr G R McGuire
- Invited lecture, Conference on "CAL in support of engineering mathematics", Birmingham University, 15 September 1989, 'The CALM project'.
- Professor O Penrose
- Seminar, University of Edinburgh, 18 November 1988, 'Probability and the theory of metastable states in statistical mechanics'.  
Seminar, St Andrews University, 2 December 1988, 'Metastable states'.  
Seminar, Bures-sur-Yvette, France, 11 January 1989, 'Metastable states for the Becker-Döring cluster equations'.  
Seminar, Ecole Polytechnique Fédérale de Lausanne, Switzerland, 31 January 1989, 'Metastable states for the Becker-Döring cluster equations'.  
Seminar, Heriot-Watt University, 21 March 1989, 'Trying to make sense of quantum mechanics'.  
Invited lecture, Workshop on "Modelling surfactant systems and related topics", University of Strathclyde, 19 December 1988, 'Metastable states for physicists, using the Becker-Döring equations'.  
Invited lecture, 2nd Annual One-Day Conference, "Philosophy of physics", St Andrews, 1 March 1989, 'Trying to make sense of quantum mechanics'.
- Professor O Penrose
- Contributed talk, Ninth Meeting on Statistical Physics, Paris, 26 - 27 January 1989, 'Metastable states for the Becker-Döring cluster equations'.  
Invited lecture, Informal Statistical Mechanics Workshop, Heriot-Watt University, 24 August 1989, 'The patterns produced in spinodal decomposition'.  
Seminar, Heriot-Watt University, 3 March 1989, 'Permutations of quadratic residues and finite projective planes'.  
Invited lecture, Conference on "Finite geometries", Oberwolfach, Germany, 30 April - 6 May 1989, 'Permutations of quadratic residues and finite projective planes'.
- Dr A R Prince
- Seminar, Mathematics Institute of Hungarian Academy of Sciences, December 1988, 'Cluster expansion applied to self avoiding random walks I-II-III'.  
Seminar, Heriot-Watt University, March 1989, 'Hydrodynamics of Ginzburg-Landau lattice models, I-II'.  
Seminar, Heriot-Watt University, April 1989, 'Dynamical theory of Brownian motion - a mechanical model'.  
Seminar, Mathematical Institute of Hungarian Academy of Sciences, July 1989, 'Random walks in dynamical random environment'.  
Invited lecture, Informal Statistical Mechanics Workshop, Heriot-Watt University, 24 August 1989, 'Random walks in dynamical random environment'.
- Dr M A Youngson
- Seminar, University of Edinburgh, 16 January 1989, 'Injective operator spaces'.
- Dr Zhang Kewei
- Seminar, University of Zurich, 9 June 1989, 'Biting convergence in the calculus of variations'.  
Seminar, Ecole Polytechnique Fédérale de Lausanne, 12 June 1989, 'Biting theorems of Jacobians and related topics'.

Research and other grants reported during the year ended 30 September 1989

£160,173 from Science and Engineering Research Council, for the period 26 June 1989 to 25 June 1992, for computing equipment for nonlinear systems programme, under the direction of Professor J M Ball, Professor J Carr and Professor J C Eilbeck.

ECU47,800 from the European Community for a programme for the study of Transport Properties in Nonlinear Condensed Matter Physics, in collaboration with coworkers in Denmark, Greece, France, Italy and Germany (total contract 349,000 ECU) for three years from 1 October 1989, under the direction of Professor J C Eilbeck

£45,000 from Department of Trade and Industry, for three years from 1 October 1989, for further developments in the CALM project, under the direction of Dr C E Beavers and Dr G R McGuire.

£25,801 from Science and Engineering Research Council, for the period from 1 June 1989 to 31 May 1992, for computing equipment for nonlinear systems programme, under the direction of Professor J M Ball, Professor J Carr and Professor J C Eilbeck.

£12,381 from Science and Engineering Research Council from 1 September 1989 to 31 July 1990 for investigation into nonlinear systems, under the direction of Professor J M Ball.

BF360,000 from NATO for the period 1 January 1989 to 31 December 1989 for investigation into Classical and Quantum Chaos in Coupled, Nonlinear Oscillators, in collaboration with coworkers in the Universities of Arizona, Tucson and the Technical University of Denmark, under the direction of Professor J C Eilbeck.

£3,870 from the British Council for the period from 16 September 1988 to 30 July 1989 for investigation in collaboration with K Zhang (Shanghai) into nonlinear systems, under the direction of Professor J M Ball.

£3,500 from Research Machines, for the period 1 July 1989 to 30 June 1992, towards production of mathematical software, under the direction of Dr C E Beavers and Dr G R McGuire

£3,000 from GEC, for the period 1 July 1989 to 30 June 1992, towards production of mathematical software, under the direction of Dr C E Beavers and Dr G R McGuire.

£2,000 from Hughes Electronics, for the period 1 July 1989 to 30 June 1992, towards production of mathematical software, under the direction of Dr C E Beavers and Dr G R McGuire.

£1,500 from the Post Office Training Board, for the period 1 July 1989 to 30 June 1992 towards production of mathematical software, under the direction of Dr C E Beavers and Dr G R McGuire.

£1050 from the British Council for three years to March 1992 to fund collaboration with University of Athens and the National Technical University of Greece, awarded to Dr K J Brown, Professor J Carr, Professor J C Eilbeck and Dr A A Lacey.

£760 from the British Council, for the period 1 April 1989 to 31 March 1990, to cover subsistence costs for Spanish visitors to Britain for a total of four weeks, under the direction of Professor O Penrose.

\$1026 from University of Alberta as a travel grant for a visit to Alberta in July-September 1989, awarded to Dr D B Duncan.

£600 from The Royal Society to cover subsistence costs for a visit to Heriot-Watt by Dr A Tertikas (University of the Aegean) in August 1989, under the direction of Dr K J Brown.

£570 from The Royal Society to attend a research conference on "Diffusion processes and related problems in analysis", at Northwestern University, Illinois in October 1989, awarded to Dr M van den Berg.

£350 from the British Council for a visit to universities in Athens, awarded to Dr A A Lacey.

£300 from Edinburgh Mathematical Society Centenary Fund for a one day meeting on 31 May 1989 'Women in Mathematics', awarded to Dr D B Duncan.

£250 from Edinburgh Mathematical Society Centenary Fund for a one day conference, "Scottish Algebra Day", in March 1989 organized by K A Brown (Glasgow University), J Howie (Heriot-Watt University) and T A Lenagan (Edinburgh University).

£240 from Carnegie Trust for period 21 August 1989 to 29 September 1989 for development of some CAL software for the CALM project, under the direction of Dr C E Beavers and Dr G R McGuire.

£200 from the British Council, Brussels, for a visit to the workshop on continuation and bifurcation at the University of Leuven, 18-22 September 1989, awarded to Professor J C Eilbeck.

£180 from The Royal Society for travel grant to attend a conference in Oberwolfach, West Germany in October 1989, awarded to Dr J Howie.

\$300 from American Mathematical Society to attend a research conference on "Diffusion processes and related problems in analysis" at Northwestern University Illinois, awarded to Dr M van den Berg.

## Theses

- K Duncan (PhD), 'Pseudo-spectral path-following techniques with applications to problems in biology and the gasification of coal.'
- G Friesecke (MSc), 'Some dynamical properties of a class of delay equations.'
- M A Jensen (MSc), 'An investigation of an implicit Runge-Kutta integration method as applied to conservative Hamiltonian systems.'
- M.M.S. Mahmood (PhD), 'Predator-prey, competition and co-operation systems with mixed boundary conditions.'
- Papers
- M Arik, F Neyzi, Y Natku, P J Oliver and J M VEROSKY  
'Multi-Hamiltonian structure of the Born-Infeld equation'. *J. Math. Physics*, 1989, 30, 1338-1345.
- J M BALL and R D James  
'Minimizing sequences and the microstructure of crystals.' In 'Phase Transformations '87', ed. G W Lorimer, The Institute of Metals, 1988.
- C E BEEVERS, B S G Cherry, D E R CLARK, M G FOSTER, G R MCGUIRE and J H RENSHAW  
'Software tools for computer-aided learning in mathematics.' *Int. J. Math. Educ. Sci. Technol.*, 1989, 20, 561-569.
- C E BEEVERS, M FOSTER and G R MCGUIRE  
'Integrating formative evaluation into a learner-centred revision course.' *British J. of Educ. Tech.*, 1989, 20, 115-119.
- C E BEEVERS, M FOSTER and G R MCGUIRE  
'A review of the CALM project.' *Edin. Math. Teaching Group, Math. Teaching 1988 Conference Report*, 1988, 22-23.
- J BREE, A R Halliwell and T O'Donoghue  
'Snaking of floating marine oil hose attached to SPM buoy.' *J. Engrg. Mechanics*, 1989, 115, 265-284.
- K J BROWN and A TERTIKAS  
'On a semilinear parabolic equation arising in optical bistability.' *J. Math. Anal. Appl.*, 1989, 139, 390-407.
- K J BROWN, S S Lin and A TERTIKAS  
'Existence and nonexistence of steady-state solutions for a selection-migration model in population genetics.' *J. Math. Biol.*, 1989, 27, 91-104.
- K R A Brown, J HOWIE and M Lorenz  
'Induced resolutions and Grothendieck groups of polycyclic-by-finite group rings.' *J. Pure Appl. Algebra*, 1988, 53, 1-14.
- J CARR and R Pego  
'Metastable patterns in solutions of  $u_t = \epsilon u_{xx} - f(u)$ .' *Comm. Pure Appl. Math.*, 1989, 42, 523-576.

- R K Dodd, J C EILBECK, J D Gibbon and H C Morris  
'Solitons and Nonlinear Wave Equations.' Russian edition: Mir Press, Moscow, 1988, pp640
- A J DUNCAN and L O'Carroll  
'A full uniform Artin-Rees theorem.' *J. reine angew. Math.*, 1989, 394, 203-207.
- J C EILBECK  
'Pattern formation and pattern selection in reaction diffusion systems.' In 'Theoretical Biology: Epigenetic and Evolutionary Order (Haddington Memorial Conference papers)'. Ed. B Goodwin and P I Saunders, 1989, 31-41.
- J C EILBECK, J E FURTER and M GRINFELD  
'On a stationary state characterization of transition from spinodal decomposition to nucleation behaviour in the Cahn-Hilliard model of phase separation.' *Phys. Lett. A*, 1989, 135, 272-275.
- J E EILBECK, P C Fife, J E FURTER, M GRINFELD and M Mimura  
'Stationary states associated with phase separation in a pure material. I - The large latent heat case.' *Phys. Lett. A*, 1989, 139, 42-46.
- J C EILBECK and A C Scott  
'Theory and applications of the discrete self-trapping equation.' In 'Structure, Coherence and Chaos in Dynamical Systems.' Ed. P L Christiansen and R D Parmentier. Manchester University Press, 1989, 139-159.
- B Fife, J HOWIE and G Rosenberger  
'Ree-Mendelsohn pairs in generalized triangle groups.' *Comm. in Algebra*, 1989, 17, 251-258.
- J N Flavin, R J KNOPS and L E Payne  
'Decay estimates in the constrained elastic cylinder of variable cross-section'. *Quart. Appl. Math.*, 1989, 47, 325-350.
- J FURTER and M GRINFELD  
'Local vs non-local interactions in population dynamics.' *J. Math. Biol.*, 1989, 27, 65-80.
- M GRINFELD  
'Nonisothermal dynamic phase transitions.' *Quart. Appl. Math.*, 1989, 47, 71-84.
- R N HILLS and P H Roberts  
'Healing and relaxation in flows of helium II - V. Thermodynamic potential and applications'. *J. Low Temp. Phys.*, 1989, 74, 185.
- R N HILLS and P H Roberts  
'A generalized Scheil-Pfann equation for a dynamical theory of a mushy zone.' *Int. J. Non-Linear Mech.*, 1988, 23, 327.
- J HOWIE  
'On the SQ-universality of  $T(6)$ -groups.' *Forum Mathematicum*, 1989, 1, 251-272.
- S D Howison, A A LACEY and J R Ockendon  
'Hele-Shaw free-boundary problems with suction.' *Quart. J. Mech. Appl. Math.*, 1988, 41, 183-193.

- R N Hunter and G R MCGUIRE  
'Are texture and density in HRA wearing courses incompatible?' *J. Inst. Asphalt Tech.*, 1988, 40, 29-31.
- R N Hunter and G R MCGUIRE  
'Microcomputer prediction of temperatures in the cooling of chipped hot rolled asphalt wearing course during laying'. *Engineering Comp.*, 1988, 5, 320-326.
- R J KNOPS  
Review of 'Ill-posed problems of mathematical physics and analysis', by M M Lavrent'ev et al. *Transl. of Math. Monographs*, 64 (AMS). *Bulletin of AMS*, 1988, 19, 332-337.
- A A LACEY  
'Prevention of blow-up for some semilinear diffusion problems.' In 'Nonlinear Partial Differential Equations and their Applications: Collège de France Seminar. Vol. IX', Ed. H Brezis and J L Lions, Pitman, London, 1989.
- A A LACEY and D TZANETIS  
'Complete blow-up for a semilinear diffusion equation with a sufficiently large initial condition.' *IMA J. Appl. Math.*, 1988, 41, 207-215.
- Z LI  
'Existence theorem and finite element method for static problems of a class of nonlinear hyperelastic shells.' *Chin. Ann. of Math.*, 1989, 10B, 169-189.
- Z LI  
'The finite element method for nonlinear elasticity.' *Journal of Computational Mathematics (Chinese)*, 1989, 7(1), 1-14.
- L E NICHOLAS  
'Room to wriggle.' *IMA Bulletin*, 1989, 25, 151.
- O PENROSE  
'Metastable states for the Becker-Döring cluster equations.' *Comm. Math. Phys.*, 1989, 121, 527-540.
- A R PRINCE  
'On certain permutation representations of the Hall-Janko group.' *Proc. Roy. Soc. Edinburgh*, 1988, 110A, 287-294.
- Papers submitted for publication 1988-89
- J M BALL  
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