King Abdullah University of Science and Technology

KAUST

Stimulating Collaborative Mathematics

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Stimulating Collaborative Mathematics

The forthcoming Oxford Centre for Collaborative Applied Mathematics (OCCAM) will rely on the mutual benefits that accrue when mathematicians and applied scientists collaborate. As long as the collaboration is stimulated, which is not always easy, the resulting mathematics is often stimulating.

Academic Benefits (i) Exciting New Problems

- Recall the “colouring problem” for an atlas in a plane – how many colours do you need so that no two adjacent countries have the same colour?
- Now consider making an office block secure for wireless communication. The problem is equivalent to painting the floors, ceilings and walls so that none has the same colour “front and back”. How many colours?

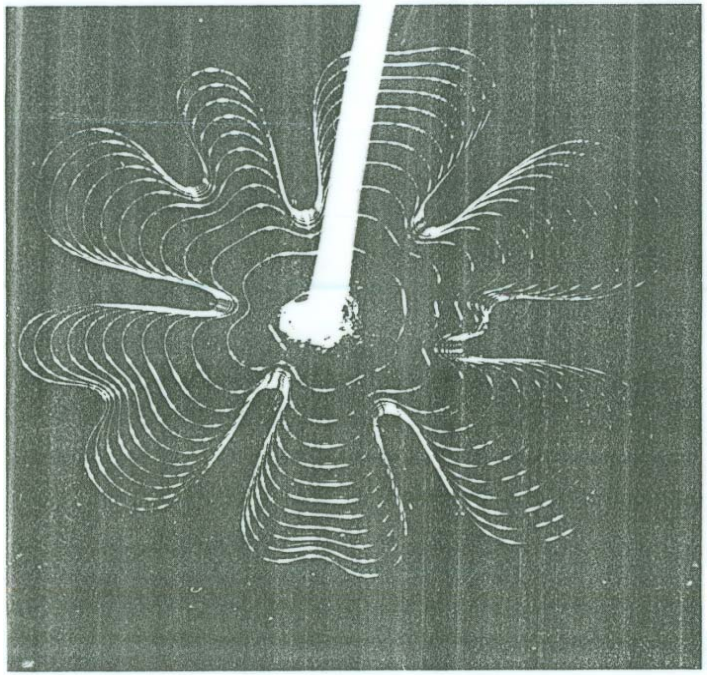
Academic Benefits (ii) Opening New Areas

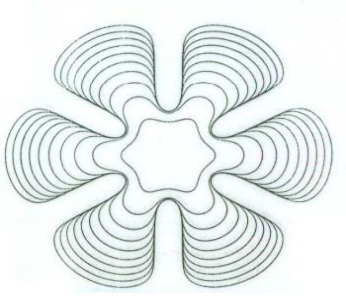
- Problems in Industry, Materials, Science, Chemistry, Biology, Finance, often lead to differential equation models in which the equations have to be solved in regions of space and time that are not known in advance. Such models are called Free Boundary Problems.

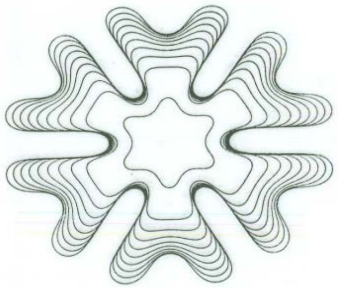
- This is a branch of mathematics that did not exist in 1975 and now there are many thousands of research works on the subject.

Academic Benefits (ii) Opening New Areas

Such Free Boundary Problems (FBPs) are endemic in the Oil Industry. For example, when oil is displaced by another immiscible liquid, we have a complicated FBP for the pressures in the oil and the liquid. But mathematical modelling can be used to relate this problem to a simple experiment (an example of OCCAM's razor):

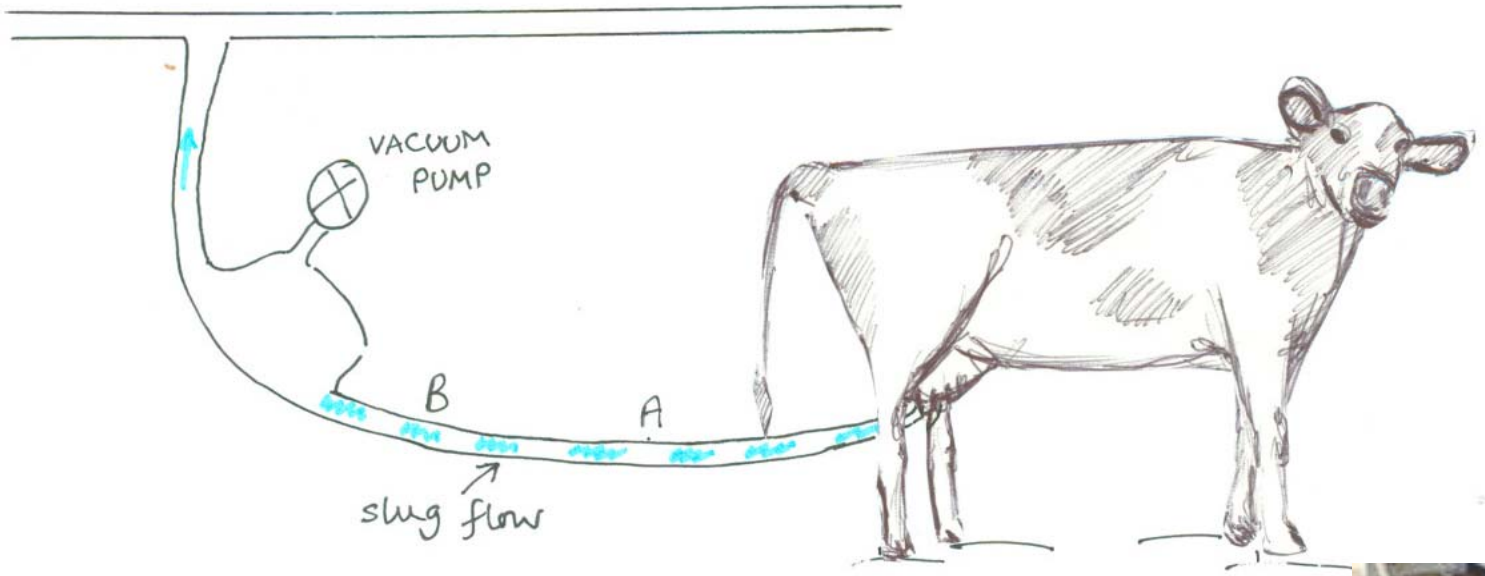






Real World Benefits

Agriculture – Milking Machine Problem



Question: What is the flow rate at A and how can it be measured?
[The same problem occurs in manufacturing of making fizzy drinks.]
NB measurement must be non-invasive and hygienic.

Research Resources

OCCAM will comprise experts in

- Scientific Computation
- Mathematical and Computational Biology

and especially

- Mathematical Modelling

There will be an emphasis on <u>Young Researchers</u>

<u>Interdisciplinarity</u> will be encouraged by

- Collaborative Workshops of all kinds
- Mobilisation of the Global Network of Senior Researchers

OCCAM Projects for 2008-2009

Numerical methodologies

M1 Numerical multiphysics

M2 Design optimisation

M3 Visualization

Materials science and engineering

MSE1 Dislocations

MSE2 Surfactants

MSE3 Electrochemistry

Resources, energy and environment

REE1 Lattice Boltzmann

REE2 Oil reservoir simulation

REE3 Desert landforms

REE4 Oilfield history matching

Biosciences and biomodelling

BB1 Crop growth

BB2 Tear film dynamics

Integration of OCCAM and KAUST

- OCCAM research teams will be linked closely to Oxford's global network of around one hundred problem-solving applied and computational mathematicians.
- The teams and the network will interact intensively at "Study Groups" and "Workshops" around the world. These meetings are problem-driven and designed to allow academics to work on problems that interact there most.
- The first KAUST Study Group will be in 2010.

Study Group Pre-History

Programme for the Fourth Oxford Study Group, 15th-19th March, 1971

	Speaker	*Lecture*
Monday, 15th March		
9.30	Mr Morton	C.E.G.B. Problem
11.15	Mr Reagan	I.C.I. Problem
2.30	Dr Tough and Dr Leigh	B.I.S.R.A. Problem
4.15	Mr Jenkins	Pilkingtons Problem
Tuesday, 16th March		
9.30	Professor L. Fox	Ill conditioned numerical problems and instabilities of numerical methods.
11.15	Discussion Groups	
2.30	Dr J.D. Murray	Mathematical Modelling
4.15	Discussion Groups	
Wednesday, 17th March		
9.30	Dr A.B. Tayler	The use of analytical methods before extensive computation
11.15	Discussion Groups	
2.30	Dr D.F. Mayers and Miss J. Taylor	Numerical methods involving free boundary problems
4.15	Discussion Groups	
Thursday, 18th March		
9.30	Dr J.R. Ockendon and Dr. H. Ockendon	Wave propagation and partial differential equations
11.15	Free	
2.30	Dr Donnelly and Dr Grant	Numerical methods for partial differential equations
4.15	Free	
Friday, 19th March		
9.15	Discussion of B.I.S.R.A. Problem	
10.00	Discussion of I.C.I. Problem	
11.15	Discussion of C.E.G.B. Problem	
12.00	Discussion of Pilkington Problem	
2.30	Further discussion time and review of Study Group organisation.	

Training Implications

- Interdisciplinary skills can only be acquired by hands-on experience.
- The OCCAM research teams and, especially, the OCCAM Workshops and Study Groups will enable students & PDRA's to acquire these skills very rapidly.
- All OCCAM students will participate in daily meetings with other students and faculty at coffee (30 + minutes).
- Experience with real-world problems enhances the appeal of lecture courses, especially for Masters degrees, with rapid acquisition of analytical and numerical problem-solving skills.