Further Mathematics Support Programme

www.furthermaths.org.uk

Why offer Decision Maths?

Sue de Pomerai
the Further Mathematics Support Programme

Let Maths take you Further…

Topic		AQA	Edexcel	MEI	OCR A
Algorithms	Communicating	D1	D1	D1	D1
	Sorting	D1	D1	D1	D1
	Packing		D1	D1	D1
Graphs	Graphs	D1	D1	D1	D1
Networks	Prim	D1	D1	D1	D1
	Kruskal	D1	D1	D1	D1
	Dijkstra	D1	D1	D1	D1
	Floyd's algorithm			D2	
	TSP	D1	D2	D2	D1
	Route inspection	D1	D1	D2	D1
	Network Flows	D2	D2		D2
Critical Path Analysis	Activity networks	D2 node	D1 arc	D1 arc	D2 arc
Optimisation	Matchings	D1	D1		D2
	Hungarian Algorithm	D2	D2		D2
	Transportation		D2		
	Dynamic Programming	D2	D2		D2
Linear programming	LP graphical	D1	D1	D1	D1
	LP Simplex	D2	D2	D2	D1
	Two stage simplex			D2	
Game Theory	Game Theory	D2	D2		D2
	Using Simplex		D2		D2
Simulation				D1	
Logic and Boolean Algebra				D2	
Decision analysis				D2	

- Decision Maths can often seem like a lot of disconnected ideas put together because they don't fit anywhere else.
- How can you make it into a coherent area of applied maths?

Did you know

- The ideas behind much of Decision Maths are hundreds, even thousands, of years old
- Algorithms are used throughout mathematics
- Things didn't really develop much beyond recreational maths until the 20th Century
- Computer technology made many things worth doing that weren't financially viable previously
- It forms the basis of most business mathematic
- It underlies electronics and computing

A bit of History

- In the 1980s the **Spode Group**, a group of Mathematics educationalists and teachers, of whom David Burgess was a leading member, were developing resources for teaching maths through 'realistic applications' in schools
- One major change was the introduction of **discrete mathematics** (first introduced as an applied maths option on the Oxford Delegacy of Local Examinations in 1986)
- The arguments for this were
  - It is the mathematics behind new technology that is more fundamental than the actual use of new technology.
  - It could play a valuable role in encouraging an investigatory approach in mathematics teaching in schools. This contrasted with other mathematical investigations where it is difficult for many pupils to make any progress at all.

Ref: Decision Mathematics, the Spode group, Ellis Horwood 1986

And yet

- About five years ago a report was published that pointed out that Britain lags behind in developing the new ideas that are important in the modern world
- Money has been put into University projects to develop course to produce people to develop in these areas
- Yet QCA was all set to get rid of Decision at A level ….

MEI 2010

Why "Decision" Mathematics?

- The new area of maths was a mixture of topics from
  - Discrete mathematics
  - Logic
  - Graph theory
  - Combinatorics
  - Operational research
- These all involve high level mathematical knowledge and analytical skills.
- The common ground is that these are all areas that are important in the kind of decision making plays an essential role in business, industry and government

MEI 2010

Computers -

- The need to break German codes in World War II led to the first programmable digital electronic computer being developed at Bletchley Park.
- At the same time, military requirements motivated advances in operational research. Operational research has remained an important as a tool in business and project management.
- The telecommunication industry has also motivated advances in discrete mathematics, particularly in graph theory and information theory.
- Formal verification of statements in logic has been necessary for software development of safety-critical systems, and advances in automated theorem proving have been driven by this need.

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Degrees

- There are many degrees that use the techniques learned in Decision Maths
- Computer Sciences and Programming
- Business and management
- Electronics
- Warwick University have just started a degree in Discrete Mathematics

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Operational research

- Operational Research methods were developed during the second World War as analysts undertook a number of crucial projects that aided the war effort. Britain introduced the convoy system to reduce shipping losses, but while the principle of using warships to accompany merchant ships was generally accepted, it was unclear whether it was better for convoys to be small or large.
  - Convoys travel at the speed of the slowest member, so small convoys can travel faster and may be harder to detect.
  - On the other hand, large convoys could deploy more warships against an attacker. The O.R. teams showed that the losses suffered by convoys depended largely on the number of escort vessels present, rather than on the overall size of the convoy. Their conclusion, therefore, was that a few large convoys are more defensible than many small ones.

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Operational Research

- After the war it soon became evident that O.R. techniques could be applied to similar problems in industry.
- Operational research provides techniques for solving practical problems in business and other fields — problems such as allocating resources to maximise profit, or scheduling project activities to minimise risk.
- Operational research techniques include **network analysis, linear programming, scheduling, Game theory** and **Decision theory among others**

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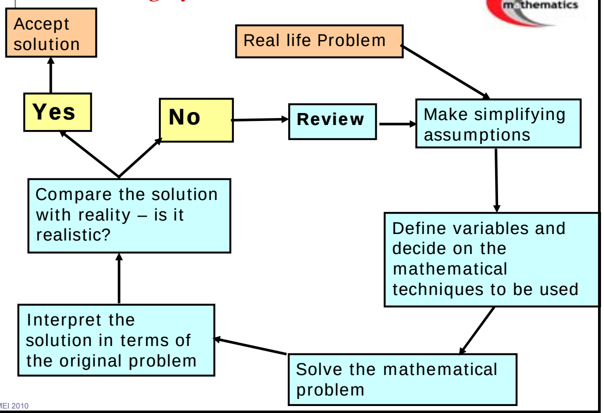
The Modelling Cycle



Graph theory

- Graph theory was until recently considered to be just recreational but is now regarded as a subject in its own right. It has widespread applications in all areas of mathematics and science.
- Many problems can be modelled as graphs (circuit diagrams, molecules in chemistry) or weighted graphs, called networks (distances networks, cost networks, decision trees)
- Graph theory is also widely used in sociology as a way, for example, to measure an individual's prestige or through the use of social network analysis software.

Critical path analysis

- Project planning
- Is a compulsory module on some engineering degrees

Task	Earliest start	Length	Type	Depend ent on...
A. High level analysis	Week 0	1 week	Sequential	
B. Selection of hardware platform	Week 1	1 day	Sequential	A
C. Installation and commissioning of hardware	Week 1.2	2 weeks	Parallel	B
D. Detailed analysis of core modules	Week 1	2 weeks	Sequential	A
E. Detailed analysis of supporting modules	Week 3	2 weeks	Sequential	D
F. Programming of core modules	Week 3	2 weeks	Sequential	D
G. Programming of supporting modules	Week 5	3 weeks	Sequential	E
H. Quality assurance of core modules	Week 5	1 week	Sequential	F
I. Quality assurance of supporting modules	Week 8	1 week	Sequential	G
J.Core module training	Week 6	1 day	Parallel	C,H
K. Development and QA of accounting reporting	Week 5	1 week	Parallel	E
L. Development and QA of management reporting	Week 5	1 week	Parallel	E
M. Development of Management Information System	Week 6	1 week	Sequential	L
N. Detailed training	Week 9	1 week	Sequential	I, J, K, M

Why study it?

- It is very accessible, even for weaker students (providing they are well prepared for the exam)
- It provides useful background for studying OR, business, computer sciences, electronics, statistics (and even some maths courses)
- It is probably the most widely used branch of maths in the "real world"
- It is an area of Maths that many students will meet when they go into work

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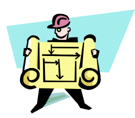

Some examples for students and teachers

- **Business:** Scheduling using Critical Path analysis
- **Nutrition**: optimal mix of ingredients to ensure adequate nutrition for minimum cost
- **Logistics**: transporting goods efficiently (shortest distance, minimum costs etc)
- **Finance:** Lowest bid - electronic auction
- **Health**: Nurse scheduling, reducing queuing times

These examples and others can be found on the OR Society website:

O.R. Inside F1.