What is Operational Research?

Why chemists should consider a PhD in O.R

Introduction

- Why am I here?
  - To introduce you to Operational Research (O.R.)
  - To show you how O.R. is used to help solve problems in lots of everyday situations
  - To prove that there are plenty of options for future research after an MSc/MChem

Operational Research

- Operational Research (O.R.) is the application of mathematical methods to tackle the real-life problems associated with decision-making in businesses and other enterprises.

- It's very expensive to make a wrong decision!

- O.R. combines

A way of thinking & communicating

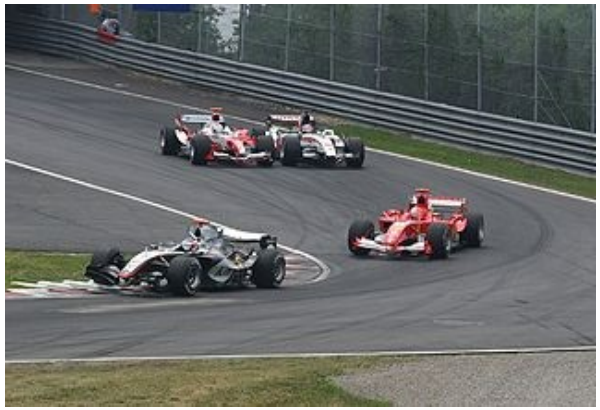
+

Analytical techniques

to provide the means to make more informed and better decisions.

How is maths applied in the real world?

How do you think maths is used in supermarkets?



How do you think maths is used in sport?

How do you think maths is used by airlines?

Operational Research is:
the application of maths in the real world

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- O.R. is the maths used in supermarkets, e.g.
  - Understanding people's buying patterns
  - Determining the number of staff needed on checkouts and at what times
  - Calculating how many of each product to be ordered and when to be delivered

- O.R. is the maths used in sport, e.g.
  - Formula One pit stop strategy
  - Scheduling football games
  - Designing a stadium

- O.R. is the maths used by airlines, e.g.
  - Calculating the number of staff required at check-in & bag drop desks
  - Scheduling the cabin crew
  - Setting the prices of tickets to reflect changing demand

O.R. is used all around us

- your supermarket
- low cost airlines
- your telephone tariff
- your gas supply
- your local factory
- one-day cricket
- your pint of milk
- English football
- a 999 call
- your doctor's surgery
- satnav
- new sports stadiums
- factories and distribution channels

Examples of O.R. techniques

- Optimisation is a way to solve problems in which one seeks to achieve the best outcome (such as maximum profit or lowest cost with limited resource).
- Simulation allows you to try out different approaches by simulating events numerous times and answer the “What if…?” question.
- Queuing theory is used to approximate a real queuing situation or system, so the queuing behaviour can be analysed mathematically.

- Other techniques include:

System Dynamics

Heuristics

Soft Systems Methodology

Cognitive Mapping

Forecasting

Multi-criteria methods

Statistics

Data Mining

When is O.R. useful?

- When it's not clear what the main problem is
- When it's uncertain what the outcome of different actions will be
- When you think things could work better
- When you don't know how well things are working
- When you are worried about risks
- When you need to take account of the views of different stakeholder groups
- When you feel you are not making best use of the data you have
- Whenever you are faced with a complex decision

OR and Chemistry?

- Chemical Engineering
- Process Systems Engineer (PSE)
- Many key algorithms developed by Chem Engineers
- Strong numerical skills
- Modelling
- Balancing Inputs and Outputs
- New opportunities
- “Chemists make good OR’s because they can understand abstract models but also keep the inputs/outputs balanced” – Gene Woolsey
- Optimal design of plants
- Planning/scheduling
- Fault detection

Petroleum Refinery

- Three types of petrol (minimum Octane rating: 85, 90, 95)
- Four types of raw oils (Octane rating: 68, 86, 91, 99)
- Blending oils $\rightleftharpoons$ petrol, with proportional Octane rating
- Objective: How much of each petrol to make?

The Blending Problem

Raw oil	OcR	Available amount (barrels/day)	Cost/barrel
1	68	4000	31.02
2	86	5050	33.15
3	91	7100	36.35
4	99	4300	38.75

Petrol Type	Min OcR	Selling Price	Demand (barrels/day)
1 (Premium)	95	45.15	≤ 10,000
2 (Super)	90	42.95	No limit
3 (Regular)	85	40.99	≥ 15,000

What do we need to consider?

- How much raw oil is available?
- Does our petrol meet the minimum OcR?
- Do we have enough Regular petrol?
- Do we have too much Premium petrol?
- What exactly are we trying to maximise?
- What are the constraints?

Your turn

x_{ij} = number of barrels/day of oil i used to make petrol j

In terms of x_{ij}, write down:

- Total amount of premium petrol made each day
- What we are trying to maximise
- The raw oils constraints
- The demand constraints
- The OcR constraints

Total amount of premium petrol made each day

Total premium petrol per day = $x_{11} + x_{21} + x_{31} + x_{41}$

Objective Function

Maximize [

$$45.15(x_{11} + x_{21} + x_{31} + x_{41}) +$$

$$42.95(x_{12} + x_{22} + x_{32} + x_{42}) +$$

$$40.99(x_{13} + x_{23} + x_{33} + x_{43})]$$

Available raw oil constraints

$x_{11} + x_{12} + x_{13} \leq 4000$ Amount of Oil 1 available

$x_{21} + x_{22} + x_{23} \leq 5050$ Amount of Oil 2 available

$x_{31} + x_{32} + x_{33} \leq 7100$ Amount of Oil 3 available

$x_{41} + x_{42} + x_{43} \leq 4300$ Amount of Oil 4 available

Demand for petrol constraints

$x_{11} + x_{21} + x_{31} + x_{41} \leq 10{,}000$ Demand for Premium petrol

$x_{13} + x_{23} + x_{33} + x_{43} \geq 15{,}000$ Demand for Regular petrol

Minimum OcR constraints

Octane Rating for Premium Petrol: $\dfrac{68x_{11} + 86x_{21} + 91x_{31} + 99x_{41}}{x_{11} + x_{21} + x_{31} + x_{41}} \geq 95,$

$$68x_{11} + 86x_{21} + 91x_{31} + 99x_{41} - 95(x_{11} + x_{21} + x_{31} + x_{41}) \geq 0$$

$$68x_{12} + 86x_{22} + 91x_{32} + 99x_{42} - 90(x_{12} + x_{22} + x_{32} + x_{42}) \geq 0$$

$$68x_{13} + 86x_{23} + 91x_{33} + 99x_{43} - 85(x_{13} + x_{23} + x_{33} + x_{43}) \geq 0$$

Maximize:

$$45.15(x_{11} + x_{21} + x_{31} + x_{41}) + 42.95(x_{12} + x_{22} + x_{32} + x_{42}) + 40.99(x_{13} + x_{23} + x_{33} + x_{43})$$

Subject to:

$$68x_{11} + 86x_{21} + 91x_{31} + 99x_{41} - 95(x_{11} + x_{21} + x_{31} + x_{41}) \geq 0$$

$$68x_{12} + 86x_{22} + 91x_{32} + 99x_{42} - 90(x_{12} + x_{22} + x_{32} + x_{42}) \geq 0$$

$$68x_{13} + 86x_{23} + 91x_{33} + 99x_{43} - 85(x_{13} + x_{23} + x_{33} + x_{43}) \geq 0$$

$$x_{11} + x_{12} + x_{13} \leq 4000$$

$$x_{21} + x_{22} + x_{23} \leq 5050$$

$$x_{31} + x_{32} + x_{33} \leq 7100$$

$$x_{41} + x_{42} + x_{43} \leq 4300$$

$$x_{11} + x_{21} + x_{31} + x_{41} \leq 10{,}000$$

$$x_{13} + x_{23} + x_{33} + x_{43} \geq 15{,}000$$

$x_{ij} \geq 0$ for I = 1, 2, 3, 4, and j = 1, 2, 3.

Where can O.R. take you?

- O.R. is a profession where initiative, creativity and enthusiasm are every bit as important as technical ability. There is great scope for you to make your mark and, consequently, your future is very much in your own hands.

- O.R. teams are involved in projects which draw on a wide range of business skills and have dealings with anyone from shop floor to boardroom.

- As an Operational Researcher you will have the opportunity to undertake a variety of roles including:
  - Analytical/consultancy
  - Project management
  - General management
  - Lecturer/researcher

Why OR - summary

- You can help solve real problems
- You can make a difference
  - To the way things are run
  - To the way people think
  - To improve the use of resources or to increase profit
- Your skills are potentially valuable in a wide range of organisations
- OR Post Graduates are highly sought after
- You can make use of a range of skills
  - Analytical skills
  - Communication skills
  - Ability to see the big picture and to focus on detail
  - Adaptable, flexible, “can do”
  - Quick to learn
- And you can have fun

Are you interested in OR?

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excellence with impact