Engineering Tripos Part IB, 2P8: Manufacturing and Management, 2025-26

Leader

Dr L Mortara [1]

Lecturers

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Timing and Structure

Easter Term in the Constance Tipper Lecture theatre : 13 lectures + 1 Industrial case + 1 example paper

Aims

The aims of the course are to:

- Examine the journey from invention to market
- Explore how new technologies are commercialised, either through the creation of new ventures or within established organisations, and the strategic, organisational, and operational choices that shape this process.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the likely stages of development from innovation to profit
- Appreciate modern production technologies, advanced manufacturing, and operations management involved
- Understand the funding, protection, and exploitation of intellectual assets alternative routes for financing innovation across the development and commercialisation stages
- Describe how firms adapt their innovation and operations strategies in response to external pressures (such as the need for sustainability), uncertainty, and contextual disruptions.
- Describe the main features of how a business works

Content

Given the aims above, what are the choices that accompany those who attempt this effort along the way?
Each lecture is organised around a key decision question faced when identifying and executing a route to market for a technological innovation.
Lecture-specific objectives and applied examples are used to assess student learning against these outcomes.

Please refer to Moodle (for the Handouts and extra material)

Where do inventions come from?

We start by examining the source of inventions and the conditions in which they are likely to occur. By the end of the lecture, students should be able to:

- List at least six strategies by which new inventions are found
- Give at least one example for each strategy
- Understand the difference between invention and innovation
- Describe the structure of this course

Is there a market?

Two major sources of invention are ‘push’ – the inventor thinks of something new and must establish a market; and ‘pull’ – there is a clearly defined market demand. In both cases, successful exploitation depends on understanding of the potential market for the new product. By the end of the lecture, given a proposed new technology or concept, students should be able to:

- Apply the concept of the 'design mix' determine how a product might be differentiated.
- Map the whole market for a potential new product, identifying and naming viable market segments comprising clusters of like-minded customers.

How do you design the right solution? From needs to prototypes

It is important that any design meets the requirements of potential users, customers, and any other stakeholder who might be influenced by the design, from maintenance to distribution. There are a number of different ways in which these requirements might be captured and considered. By the end of the lecture, students should be able to:

- Identify the stakeholders who are influenced by the design
- Propose a ‘persona’ of a specific user or stakeholder
- Apply the Kano model to the benefits to the user of different product features
- Understand the importance of prototyping in the design process

How to select the production processes to make your product?

This session will provide an introduction to the most common manufacturing processes used in industry today. We will examine the core principle of operation and think about their benefits and challenges. With this in mind, we will think about how to select an appropriate process or sequence of processes for a new product. Finally, there will be a brief introduction into where production process operation can benefit from integration of AI. Objectives are:

- Understand the principle of operation for a range of common manufacturing processes.
- Appreciate the advantages and limitations of different common manufacturing processes.
- Explore the first steps towards selecting production processes for a new product.
- Understand where AI can contribute towards efficient manufacturing.

How to scale up new technologies?

We will look at the challenges of taking a brand new product design through to manufacturing and how these challenges are addressed locally and nationally. We will focus on medical technologies as a case study to consider the broader materials, production processes and post-processing requirements and how they are balanced with aspects of safety, regulations, sustainability and ethics. The objectives are:

- Appreciate the range of influences when selecting materials and production processes.
- Understand the specific challenges of the medical technology sector.
- Consider the role of quality control and post-processing when selecting materials and production processes.
- Understand the challenges in moving a new idea through to a defined production process.

How does a factory work?

This session introduces to key concepts in the way factories are planned, designed and operated to be able to make the products we use in everyday life. How factories are configured to be able to produce at different

combinations of product volume and variety? The ways in which customers order are decomposed into tasks and examined, and some of the key equipment in a typical manufacturing environment is introduced in this context. Challenges for the modern factory will be discussed and examples of production outside the factory introduced list at least six strategies by which new inventions are found. the objectives are:

- Understand different types and configurations of factories used to make products we use in everyday life
- Explore the way a order (of products) is decomposed into more elementary tasks which are to be completed within the factory
- Identify some key operations, machines and devices in factory operations.

How to control and manage factory operations?

The session starts with the simplest control loops in a factory and shows that a hierarchy of nested loops are implicitly used in the management of different levels of factory operations. The session will also introduce the concept of industrial automation and examine the scope, rationale and typical technologies used. The related concept of operations management is also introduced. Advances in industrial automation and control such as Industry 4.0, Industrial Internet of Things and AI will be briefly examined. The objectives are:

- Appreciate the hierarchy of control systems in use in the management of a typical factory
- Explore the different ways automation can be applied to factory operations
- Understand key features of industrial control and operations management.
- Understand the role of emerging technologies in the control and management of a factory

How do supply chains and industrial logistics work?

We will introduce key concepts in supply chains and logistics, and examine their implications for modern manufacturing and society. We will explore current forces shaping supply chains and discuss the role of engineering led, quantitative approaches in addressing contemporary issues such as supply chain resilience, security and sustainability. The objectives are:

- Appreciate the role of supply chains within modern manufacturing and explore the objectives of supply chain management
- Explore the different types supply chains and current challenges facing companies in operating and coordinating them
- Introduce the role and function of logistics operations within supply chain operations
- Appreciate the range of quantitative decision-making models in addressing supply chain optimisation and coordination

AI and Data science in manufacturing and supply chains

A range of contemporary Analytics and Artificial Intelligence methods are used in industrial systems. The structure of the session builds on the previous lectures on processes involved in product design, factory systems and operations, and supply chain management, to map the ways in which data driven methods may be used to improve them. In doing so, the session describes methods such as predictive analytics, generative AI, optimisation, and agent-based systems; and explores the technical, managerial and ethical challenges involved in collecting and analysing industrial datasets. The objectives are:

- Understand the range of AI approaches applied to product design, manufacturing, and supply chain and logistics management
- Explore the challenges of developing AI and data science approaches in industrial environments
- Appreciate how advanced AI and data science is transforming industries

How can your assets be protected?

Before any public disclosure of an innovation, an inventor must decide how to prevent competitors copying the new features. By the end of the lecture, students should be able to:

- Develop an awareness of the importance of intellectual property rights in today's knowledge- and innovation-driven economies.
- Develop an initial understanding of the fundamentals of selected intellectual property rights that are of particular relevance for engineers.
- Understand where and how further, more detailed knowledge on intellectual property can be accessed.

How does the innovation make money? How to get investment?

This lecture focuses attention onto two related issues: how an innovation could be turned into profits via the different types of business models and how to obtain investments to support the business. By the end of this lecture, the students will be able to:

- Explain what is meant by a 'business model' as a way of structuring the value creation and value capture activities of the business.
- Understand that there are different types of business model, and be able to describe the pros and cons of different models for achieving different outcomes.
- Describe the different types and sources of investment available for businesses, and the suitability of each for different business models and stages of the development of a business.

What are the issues in managing growth through continuous innovation?

One good idea is not sufficient to ensure the long-term survival of a company. Companies need to innovate if they are to continue to grow. In this lecture, we will review the challenges of managing a portfolio of innovation projects in a growing business and we will consider the new management challenges that need to be addressed. By the end of the lecture, students should be able to:

- Describe some of the challenges of managing a portfolio of 'old' and 'new' projects, radical versus incremental innovations
- Compare the characteristics of a start-up versus, long established company and the different management challenges resulting from these different characteristics
- Understand the evolution patterns across markets and industry, and the threat of disruption.

How to deal with sustainability in industrial settings?

Through innovation and large-scale production, civilisation has achieved significant progress, delivering economic stability and substantial improvements in quality of life. However, the optimisation of industrial manufacturing has also contributed to rising greenhouse gas emissions and environmental degradation. As a major source of these impacts, industry has a critical role to play in reversing this trend.How are principles of industrial sustainability integrated in companies approaches? By the end of the lecture, students should be able to:

- Discuss the impact of sustainability on the competing needs of industry
- Demonstrate that there are different ways of measuring the impact of industry (in the context of sustainability)
- Understand some of the different ways that sustainability can be implemented for industrial processes.

Div E website

IfM Design Management Group website: https://www.ifm.eng.cam.ac.uk/ [2]

Booklists

Please refer to the Booklist for Part IB Courses for references to this module, this can be found on the associated Moodle course.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA3

Comprehend the broad picture and thus work with an appropriate level of detail.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

D2

Understand customer and user needs and the importance of considerations such as aesthetics.

D3

Identify and manage cost drivers.

S1

The ability to make general evaluations of commercial risks through some understanding of the basis of such risks.

S3

Understanding of the requirement for engineering activities to promote sustainable development.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

P5

Awareness of nature of intellectual property and contractual issues.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US3

An understanding of concepts from a range of areas including some outside engineering, and the ability to apply them effectively in engineering projects.

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:lm367@cam.ac.uk
[2] https://www.ifm.eng.cam.ac.uk/
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec