



## MEMORANDUM

**To:** Executive Committee of Faculty Council (September 15, 2015)  
Faculty Council (October 28, 2015)

**From:** Professor Markus Bussmann  
Chair, Engineering Graduate Education Committee (EGEC)

**Date:** August 26, 2015

**Re:** **Creation of Emphasis in Advanced Manufacturing**

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## REPORT CLASSIFICATION

This is a routine or minor policy matter that has been approved by the Engineering Graduate Education Committee on behalf of Faculty Council<sup>1</sup>. It will be considered by the Executive Committee for endorsing and forwarding to Faculty Council for information.

## BACKGROUND

An Emphasis in Advanced Manufacturing has been developed for MEng students in four graduate units: Aerospace Studies, Chemical Engineering & Applied Chemistry, Materials Science & Engineering, and Mechanical & Industrial Engineering. The Emphasis was devised in consultation with the four graduate units, Professor Hani Naguib, the first Director of the new Toronto Institute of Advanced Manufacturing (TIAM), and Professor of Innovation Stephen Armstrong.

The Emphasis in Advanced Manufacturing will be a pillar of the TIAM educational program. Detailed information on the new Emphasis is presented in the accompanying proposal. MEng students will be expected to complete four courses in advanced manufacturing, including at least one core course. Elective courses are organized into two streams: (1) courses in the Manufacturing Management Stream, which will introduce students to everything from understanding markets, designing products, processes, and organizations to managing complex supply chains, distribution networks and related services; and (2) courses in the Manufacturing Engineering Stream, which will focus on new technologies, advanced materials and processes that enable technology transfer from an idea to a final product. These include advancements currently underway in the fields of nanotechnology, biotechnology, energy and sustainability.

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<sup>1</sup> As a result of the 2005 Task Force on Graduate Education at the University of Toronto, EGEC has delegated authority to “consider and approve on behalf of Faculty Council and/or recommend to Faculty Council and/or SGS, matters relating to graduate curriculum, policy, new initiatives, program and course changes”.

As a Faculty-wide extra-departmental unit C, TIAM strives to broaden student exposure to advanced manufacturing. In addition to the course requirements, students pursuing the Emphasis will be exposed to the full range of activities offered by TIAM, including an ongoing seminar series, and events to introduce students to members of the manufacturing industry.



# University of Toronto Minor Modification – Change to an Existing Graduate Program

*This template should be used to bring forward all proposals for minor modifications to program or admissions requirements for existing graduate programs under the University of Toronto’s Quality Assurance Process.*

<b>Programs being modified</b>	Aerospace Studies, MEng Chemical Engineering & Applied Chemistry, MEng Materials Science & Engineering, MEng Mechanical & Industrial Engineering, MEng
<b>Graduate Units</b>	the above four
<b>Faculty / Academic Division:</b>	Applied Science & Engineering
<b>Dean’s Office Contact:</b>	Markus Bussmann (Vice-Dean, Graduate)
<b>Version Date</b> <i>(please change as you edit proposal)</i>	September 8, 2015

## 1 Summary

<i>Changing Admission Requirements</i>		<i>Renaming Field, Concentration or Emphasis</i>
<i>Changing Program Requirements or Length</i>		<i>Renaming of Program</i>
<i>Changing Timing of Program Requirements</i>	<b>X</b>	<i>Creating a new Emphasis</i>
<i>Adding/Removing Option (i.e. part-time, flex-time)</i>		<i>Changes to programs affecting a MOA</i>

MEng students in four graduate units can earn an **Emphasis in Advanced Manufacturing** by completing four courses, including at least one core course. Elective courses may include other core courses, and courses from either of two streams: Manufacturing Management and Manufacturing Engineering.

**Core Courses**

- AER501H Advanced Mechanics of Structures
- AER1403H Advanced Aerospace Structures
- APS1028H Operations and Production Management for Manufacturing and Services
- CHE1123H Liquid Biofuels
- MIE1740H Smart Materials and Structures
- MIE1742H Composite Materials Design (to be renamed Advanced Manufacturing Technologies)

### **Elective Courses - Manufacturing Management**

Manufacturing Management courses are for students who seek to move into positions of leadership in industry. Students will obtain fundamental knowledge and develop an understanding of the operational complexity of enterprises, innovation management, manufacturing and business process improvement/optimization, and integrated product/process/system design. In addition, students will develop the cognitive skills to critically evaluate the potential benefits of alternative manufacturing strategies; to use virtual/simulated platforms to facilitate and improve business processes; and to analyze enterprise systems as interacting units, components, and subsystems.

APS1420H Technology, Engineering and Global Development  
APS1005H Operations Research for Engineering Management  
APS1011H Concepts and Application of Authentic Leadership  
APS1012H Management of Innovation in Engineering  
APS1013H Applying Innovation in Engineering  
APS1014H Advanced Project Management  
APS1017H Supply Chain Management and Logistics  
APS1020H International Business for Engineers  
APS1023H New Product Innovation  
APS1026H Positive Psychology for Engineers  
APS1088H Entrepreneurship for Business  
APS1501H Leadership and Leading in Groups and Organizations  
CHE567H Risk Based Safety Management  
CHE1434H Six Sigma for Chemical Processes  
MIE1505H Enterprise Modeling  
MIE1514H Systems Design and Engineering - A Product Perspective  
MIE1715H Life Cycle Engineering  
MIE1721H Reliability  
MIE1723H Engineering Maintenance Management  
MIE1727H Statistical Methods of Quality Assurance

### **Elective Courses - Manufacturing Engineering**

Manufacturing Engineering courses focus on advanced and emerging manufacturing technologies and skills that can be deployed to increase the efficiency, productivity and profitability of modern manufacturing industry. Students will obtain an understanding of specific advanced and emerging manufacturing technologies and skills, and how to implement these technologies in the manufacturing sector in Ontario and in Canada, in key industrial sectors such as automotive, aerospace, electronics and biomedical.

AER521H Mobile Robotics and Perception  
AER1415H Optimization Concepts and Applications  
CHE575H Mechanical Properties of Biocomposites and Biomaterials  
CHE1134H Advances in Bioengineering  
CHE1140H Topics in Process Identification and Control  
MIE506H MEMS Design and Microfabrication  
MIE540H Product Design  
MIE1713H Analysis and Design of Joints in Manufactured Products  
MIE1718H Computer Integrated Manufacturing  
MIE1743H Axiomatic Design Principles for Conceptual and Embodiment Design  
MSE558H Nanotechnology in Alternate Energy Systems  
MSE561H Engineered Ceramics  
MSE1013H Growth and Characterization of Semiconductors

MSE1015H Mechanical Properties of Solids I  
MSE1028H Advanced Materials Science  
MSE1029H Electrochemical Synthesis of Nanomaterials  
MSE1031H Forensic Engineering  
ROB501H Computer Vision for Robotics

## 2 Effective Date of Change

September, 2015

## 3 Academic Rationale

The proposed emphasis in Advanced Manufacturing has been designed to be a pillar of the Toronto Institute of Advanced Manufacturing (TIAM) educational program. As a Faculty-wide extra-departmental unit, type C, TIAM strives to broaden student exposure to advanced manufacturing. In addition to the course requirements, students pursuing the Emphasis in Advanced Manufacturing will be exposed to the full range of activities offered by TIAM, including an ongoing seminar series, and events to introduce students to members of the manufacturing industry.

The manufacturing sector has long been a strategic driver of societal wealth creation, and thereby has affected improvements to standards of living and quality of life. Central to this sector are disruptive technologies that will drive forward dramatic changes in manufacturing over the next 10-20 years. Manufacturing is not just about making artifacts in factories. Courses in the **Manufacturing Management Stream** will introduce students to everything from understanding markets, designing products, processes, and organizations to managing complex supply chains, distribution networks and related services. Above all, Manufacturing Management is about building and sustaining an innovative culture in the enterprise. Manufacturing is recognized globally as vital to a strong and successful economy. Manufacturing creates wealth, sustains jobs and is central to economic success. Modern manufacturing is at the frontier of new technologies, products and ways of working.

Courses in the **Manufacturing Engineering Stream** will focus on new technologies, advanced materials and processes that enable technology transfer from an idea to a final product. These include advancements currently underway in the fields of nanotechnology, biotechnology, energy and sustainability, that will lead to value-added products through major themes of advanced manufacturing such as manufacturing of advanced materials and advanced manufacturing processes and systems. Manufacturing of advanced materials encompasses knowledge of the processing, structure, properties, performance, manufacturing and design of advanced materials. Advanced manufacturing processes and systems are the knowledge- and capital-intensive techniques and facilities employed to manufacture classes of materials and structures in a novel, more efficient and/or more effective manner.

## 4 Impact on Students

This Emphasis in Advanced Manufacturing will offer MEng students in four graduate units the opportunity to take a few courses in support of a specialization in Advanced Manufacturing. Completion of the requirements will be acknowledged with a certificate of completion.

## 5 Consultation

This proposal was prepared in consultation with the Executive Committee of the Toronto Institute of Advanced Manufacturing. The proposal was sent to the Graduate Coordinators and Chairs of each of the four graduate units, and was also reviewed by the Engineering Graduate Education Committee (EGEC).

## 6 Resources

None

## 7 Governance Approval

<b>Unit Sign-Off</b> (Committee name and meeting date)	Graduate Coordinators and Chairs of each of the four graduate units - June, 2015.
<b>Dean's Office Sign-Off</b> (Name and Date)	Markus Bussmann, Vice-Dean, Graduate Studies, June, 2015.
<b>Faculty/Division Council Approval (or delegated body) if applicable</b>	Approved by the Engineering Graduate Education Committee (EGEC) on behalf of the Council of the Faculty of Applied Science & Engineering on June 9, 2015, and presented to the Council of the Faculty of Applied Science & Engineering for information on October 28, 2015.

*Template developed by the Office of the Vice-Provost, Academic Programs  
Last updated September 23, 2014*

# Appendix A Calendar Entry

*Please use track-changes to indicate where changes have been made.*

## Emphasis: Advanced Manufacturing

Master of Engineering (MEng) students must successfully complete:

- four courses (2.0 FCEs), including at least one core course.
- elective courses may include other core courses, and courses from either of two streams: Manufacturing Management and Manufacturing Engineering.

## Core Courses

AER501H, AER1403H, APS1028H, CHE1123H, MIE1740H, MIE1742H

## Elective Courses – Manufacturing Management

APS1420H, APS1005H, APS1011H, APS1012H, APS1013H, APS1014H, APS1017H, APS1020H, APS1023H, APS1026H, APS1088H, APS1501H, CHE567H, CHE1434H, MIE1505H, MIE1514H, MIE1715H, MIE1721H, MIE1723H, MIE1727H.

## Elective Courses – Manufacturing Engineering

AER521H, AER1415H, CHE575H, CHE1134H, CHE1140H, MIE506H, MIE540H, MIE1713H, MIE1718H, MIE1743H, MSE558H, MSE561H, MSE1013H, MSE1015H, MSE1028H, MSE1029H, MSE1031H, ROB501H.