<table>
<tr><td>New Course Code and Title</td><td colspan="3">MS7220 Processing and Processability of Organic Materials (Polymers)</td></tr>
<tr><td>Course Coordinator</td><td colspan="3">Prof Hu Xiao and Prof Gad Marom</td></tr>
<tr><td rowspan="3">Details of course</td><td colspan="3">Rationale for Introducing this course
Processing and Processability of Polymers aims to link intrinsic polymer properties to product performance through the fundamental processing techniques commonly used in modern manufacturing of thermoplastic and thermosetting polymeric products.

The effects of fillers and stabilizers on properties of the polymer materials are introduced. Factors of polymer processing are correlated with structure and morphology and in turn – to product properties.</td></tr>
<tr><td colspan="3">Aims and Objective
The aim of this course is to provide students with the tools to critically link the material properties of polymers with modern manufacturing techniques and subsequently design, select, and tailor polymers for production of a wide range of products.

The course is intended to develop the following points of understanding:
1. Describe intrinsic properties and how they are determined by polymer composition. Explain Van Krevelen’s Additive Molar Function model and apply it for a range of properties.
2. Design and assess product properties in terms of its mechanical properties and physical performance.
3. Describe how processing parameters and conditions generate specific structures and morphologies, which in turn determine properties.
4. Explain the fundamental aspects of polymer properties, viz., phase transitions, viscoelasticity, stress-strain behaviour, which are manifested in product properties.
5. Describe the basic industrial polymer processing technologies, including those of composite materials.
6. Describe emerging materials and technologies including nanocomposites, biomimetics, 3D printing and electrospinning.</td></tr>
<tr><td colspan="3">Course Syllabus
Refer to page 2 to 3</td></tr>
<tr><td>Assessment
(Individual Assessment)</td><td>Assessment Point</td><td colspan="2">6</td></tr>
<tr><td></td><td>Mode of Assessment and Weighting</td><td>2x Continuous Assessments -
2x Essays/Presentations (Instructor + Peer Assessed) -
Course participation (online chat)</td><td>50%

40%
10%</td></tr>
<tr><td></td><td>Instructions</td><td colspan="2"></td></tr>
<tr><td></td><td>Mapping of Assessment</td><td colspan="2">CA1 – modules 1 & 2
CA2 – modules 3 & 4
Essay/presentation – module 5
Course participation (e.g., online chat) – modules 1 to 6</td></tr>
<tr><td>To be offered with effect from
(state Academic Year and Semester)</td><td colspan="3">AY 2019-20, Semester 1</td></tr>
<tr><td>Cross Listing (if applicable)</td><td colspan="3">N/A</td></tr>
<tr><td>Prerequisites (if applicable)</td><td colspan="3">Basic knowledge of polymer science and engineering preferred</td></tr>
</table>

Mode of Teaching & Learning (Lectures, regular tests, Q&A, problem-based learning)	Lectures, CA, Q&A, problem-based self-learning, site visits, structured presentation, discussion
Basic Reading List Compulsory Reading –NIL Supplementary Reading	1. D.W. van Krevelen, Properties of Polymers, Elsevier, 1997. 2. L.H. Sperling, Introduction to Physical Properties of Polymers, Wiley, 2005. 3. R.J. Young and P.A. Lovell, Introduction to Polymers, Taylor & Francis, 1991. 4. Other prescribed papers and/or chapters.
Hours of Contact/Academic Units	39 hours/3 AUs

Course Syllabus

The following topics will be covered:

MODULE 1: GENERAL INTRODUCTION

1.1: Introduction: Course objective and overview
Course plan; instructors; modes of learning and methods for assessment; pre-required knowledge and link to other courses; learning expectations and outlook.

1.2: Introduction: Processability vs processing
Introduce polymers/plastics and their current uses in manufacturing, as determined by the following causative chain: composition/structure – processability – processing – properties.

MODULE 2: PROCESSABILITY- DEPENDENT PROPERTY

2.1: Concept of intrinsic properties (Van Krevelen)
Explain the essential role of chemical composition in determining chemical, physical and mechanical properties.

2.2: Intrinsic Property Model
Present the Additive Group Contribution model (Van Krevelen) and show how properties are predicted based on the composition of the repeat unit of the polymer. Modern techniques: computational approach (Guest interview and/or video).

2.3: Product Properties
Underline the essential product properties (mechanical, optical, physical, etc.), which determine performance. (Highlighted examples: case study of flexible food packaging products).

2.4: Processing Properties
A general explanation of how processing conditions dominate intrinsic properties in determining product properties (Van Krevelen's overlapping circles), through factors such as orientation, crystallization, crosslinking.

2.5: Structure related to Processing
Relate specific conditions such as heat, force field flow, confinement to physical structure (orientation, crystallinity, crosslinking) and performance.

2.6: Role of Additives
Plasticizers, antioxidants and various fillers. Requirements of additives of food grade and medical grade polymers. (Self-driven learning topic to know (i) the main types of additives and their functions, (ii) emerging new additives, such as nano-particle.)

2.7: Composites and Manufacturing Thereof
Polymer composites are presented and the main unit operation technologies for their production (lay-up, filament winding, pultrusion) are presented. (Site visit).

MODULE 3 - MECHANICAL PROPERTIES

3.1: Phase Transitions of Polymers
Define 1st and 2nd order phase transitions in polymers and discuss how they lead to selecting an appropriate industrial processing.

3.2: Deformation Behaviour
A short introduction to the mechanical behaviour of polymers by presenting an idealized 'stress-strain' curve from which strength, stiffness and toughness are derived. Fundamental factors affecting mechanical properties of polymers.

3.3: Impact Resistant Materials and Design
Dynamic mechanical response - the energy absorption of advanced fibre composites. Case study of ultra-high molecular weight polyethylene fibre composites and their applications.

MODULE 4 – EMERGING MATERIALS AND TECHNOLOGIES

4.1: Nanocomposites and Hybrids
Motivation; Distinction from micro-composites; Range of nanoparticles, such as CNT, VGCF, graphene, GNP, is exemplified as means to upgrade specific polymer properties with examples of electrical conductivity, fracture toughness and stiffness.

4.2: Additive Manufacturing (3D printing)
A variety of 3D printing techniques is presented including photo-polymerization based stereo-lithography (SLA) and fused deposit modelling (FDM). Challenges and opportunities. (Site visit)

4.3: Electrospinning and Related Processes
The electrospinning fibre production method is presented as source of nanofibers of a wide range of compositions for a wide range of biomedical applications, including tissue engineering and drug delivery.

4.**4: Biomimetic or Bio-inspired Engineering**
Biomimetics based engineering is defined with examples of how polymer nanocomposites are designed for combined high stiffness and fracture toughness. (Site visit)

4.5: Porous Polymers
Porous polymer structures: micropores, mesopores and macropores. Porous polymer preparation via advanced technology, including template method, self-assembly.

MODULE 5 – GUIDED STUDENT-DRIVEN TEACHING AND LEARNING

5.1: Videotaped Student Presentations
Short online presentations on topics suggested by the students and peer reviewed under close supervision. This peer teaching exercise aims to train and assess the students' ability to use the learnt knowledge to discern, analyse, evaluate and design concerning the selected advanced polymer systems, frontline concepts and new applications. Nominally 5 such sessions are planned subject to variation depending on the number of students enrolled. Example topics are: polymers and environmental challenges; stimuli responsive polymers; polymer and energy; electronically and optically active polymers and organic materials; biomedical polymers; membrane technology and other emerging topics.

MODULE 6 – CLOSURE

6.1: Summary and feedback
Review, revision, reflection and outlook (Can be in a form of written feedback or roundtable discussion or small group discussion).