<table>
<tr><td>New Course Code and Title</td><td colspan="2">MS7410 Nanomaterials</td></tr>
<tr><td>Course Coordinator</td><td colspan="2">Prof Jason Xu (Course Coordinator)
AP Xue Can</td></tr>
<tr><td rowspan="3">Details of Course</td><td colspan="2">Rationale for introducing this course
This course will cover the subject of nanomaterials and provide students with the basic concepts and advanced knowledge of nanomaterials, including the preparation, characterization, physical properties and applications. The main objective of this course is to understand how the nanomaterials are distinguished with their bulk counterparts (size effect on various properties). This course will also introduce several applications through the case study to explain how nanomaterials impact the industry and human life.</td></tr>
<tr><td colspan="2">Aims and objectives

The aim of this course is to understand how the nanomaterials are distinguished with their bulk counterparts in terms of structures, properties and applications.

At the end of this course, the students will:
• Explain how size affects the properties of materials
• Given a type of nanomaterial, recommend appropriate preparation methods
• Given a problem, propose appropriate nanomaterials solutions</td></tr>
<tr><td colspan="2">Course Syllabus
Refer to page 2 to 4</td></tr>
<tr><td rowspan="3">Assessment</td><td>All components are assessed Individually.</td><td></td></tr>
<tr><td>CA1: MCQs
CA2: MCQs
CA3: Short structured essay
CA4: Project</td><td>20%
20%
30%
30%</td></tr>
<tr><td>Total:</td><td>100%</td></tr>
<tr><td>To be offered with effect from
(state Academic Year and Semester)</td><td colspan="2">AY2018/19 Semester 1</td></tr>
<tr><td>Cross Listing (if applicable)</td><td colspan="2">N/A</td></tr>
<tr><td>Prerequisites (if applicable)</td><td colspan="2">N/A</td></tr>
<tr><td>Preclusions (if applicable)</td><td colspan="2">N/A</td></tr>
<tr><td>Mode of Teaching & Learning
(Lectures, regular tests, Q&A, problem-based learning)</td><td colspan="2">Online lectures, online assessments, and project.</td></tr>
</table>

Basic Reading List • **Compulsory Reading - NIL** • **Supplementary Reading**	1. *Nanomaterials: An Introduction to Synthesis, Properties and Applications by Dieter Vollath, WILEY, 2008.* 2. *The Physics and Chemistry of Nanosolids by Frank J. Owens and Charles P. Poole Jr., Wiley, 2007.* 3. *Optical Properties and Spectroscopy of Nanomaterials by Jin Zhong Zhang, World Scientific, 2009* 4. *Nanomaterials, Nanotechnologies and Design by Michael F. Ashby, Paulo J. Ferreira and Daniel L. Schodek, Elsevier, 2009* 5. *Introduction to Nanoscience by Cabor L. Hornyak, H.F Tibbais, Joydeep Dutta, Anil Rao, CRC Press, 2008*
Maximum Class Size	*30*
Hours of Contact/Academic Units	*39 hours/ 3 AUs*

Course Syllabus
The following topics will be covered:

Module 1: Size Effect

1. Why are Nanomaterials Different?
- Quantum and surface effect

2. Quantum Confinement
- Density of state
- discrete band energy level
- Size dependent bandgap
- Confinement of surface electron motion

3. Surface Effect
- Surface atom ratio
- Surface energy
- Crystal facet effect
- Surface adsorption and reactivity

MODULE 2: Synthesis of Nanomaterials

1. Creating Films by Physical Vapour Deposition (PVD)
   - Evaporation
   - Pulsed laser deposition
   - Sputtering
2. Nanolithography for Nano-Patterning
   - Photo and e-beam lithography,
   - Etching
   - Nanoimprint lithography
   - Microcontact printing
3. Chemical Vapour Deposition (CVD)
   - Principles
   - Different CVD setup
   - Vapour-liquid-solid growth
4. Nucleation and Growth for Colloidal Nanoparticles
   - General plot for nucleation and growth
   - Nucleation process

   - Growth model
5. Synthesis of Metal Nanoparticles
   - Chemical reduction
   - Seed-mediated growth
6. Synthesis of Quantum Dots
   - Chalcogenide quantum dots
   - Metal clusters
7. Sol-Gel Methods for Oxide Nanomaterials
   - Sol-gel chemistry: hydrolysis and condensation
   - Sol-gel process for oxide nanoparticles
8. Electrochemical synthesis of nanostructures
   - Synthesis of nanotube/porous templates
   - Templated electrochemical deposition
9. Preparation of nanostructure assemblies
   - Layer-by-layer assembly
   - Langmuir-Blodgett process
   - Self assemble

MODULE 3: Nanoparticle Stability

1. Importance of Stabilisation
   - Colloid systems
   - Stability
2. Charge Stabilisation: Electric Double Layer
   - Surface charge
   - Surface potential
   - Electric double layer
3. Charge Stabilisation: DLVO Theory
   - Colloid behaviour
   - Total potential energy
4. Steric Stabilisation
   - Advantages
   - Mechanism and factors of steric stabilisation

MODULE 4: Optical Properties of Nanomaterials

1. SPR of Metal Nanostructures
   - Basic concept of surface plasmon
   - Localised SPR of metal nanoparticles
   - SPR coupling
2. Enhancement of SPR of Metal Nanostructures
   - Subwavelength transmission
   - Metal-enhanced fluorescence
   - Surface-enhanced Raman scattering
3. Fluorescence Emission of Quantum Dots
   - Band energy levels and absorption
   - Size and surface effect on emission
   - Core-shell quantum dots
4. Fluorescence of Metal Clusters

- Absorption of metal clusters
- Fluorescence emission of metal clusters

5. Heterojunctions of Hybrid Nanostructures
   - Metal semiconductor hybrid nanostructures,
   - Quantum dot-semiconductor hybrid nanostructures

MODULE 5: Magnetic Nanomaterials

1. Size Dependence
   - Magnetic nanoparticles
   - Size matters
   - Magnetic properties
2. Synthetic Methods
   - Co-precipitation
   - Thermal decomposition
3. Surface Modification and Applications
   - Organic and inorganic modification
   - Bio-separation
   - MRI imaging
   - Tumour therapy

MODULE 6: Catalytic Applications

1. Automobile Exhaust Gas Treatment
   - Nobel metal as catalyst
   - Low temperature activity
2. Fuel Cell Catalysis
   - Typical fuel cell
   - History of PEMFC
   - Catalyst challenge and nano
3. Size Effect on Pt Catalyst
   - Fuel cell power loss
   - Oxygen reduction reaction
   - Pt surface

MODULE 7: Safety Issues of Nanomaterials

1. Safety Issues
   - Sources and impact of nanomaterials
   - Cytotoxicity of nanosized carbon materials
   - Nanomaterial toxicity