New Course Code and Title	**MS7320: Physical Analysis of Materials (2AU)**
Course Coordinator	AP Oh Joo Tien
Details of Course	**Rationale for introducing this course** Physical characterisation of materials is the measurement and evaluation of the properties of materials. It is essential for the development of materials, for materials failure investigation and routine assessment. Thermal analysis constituted a group of characterisation techniques in which the thermal properties of materials are characterised. Materials in service are subjected to extreme and fluctuating temperature conditions. As the properties and performance of materials are intimately related to the temperature, a group of thermal analysis techniques covering TGA, DSC, DTA, TMA etc… in which the physical properties of materials are measured as a function of temperature whilst the material is subjected to a controlled temperature are employed to characterise materials. Surface analysis is the study of the surface properties of materials. It is concerned with the study of the structure and binding state of the atoms on the top surface layer (< 10 nanometers). Surface Analysis are routine activities of surface inspection and is employed extensively in areas of research such as corrosion, adhesion, polymer surface treatment and microelectronics fabrication It is therefore important that the materials engineer be exposed to these characterisation techniques. This course introduces thermal analysis and surface analysis techniques to the materials engineer. In the module on thermal analysis, specific characterisation techniques will be covered in depth including Thermo-gravimetric analysis (TGA), Differential scanning calorimetry (DSC) and Differential Thermal Analysis (DTA). Other less common but advanced thermal techniques will also be introduced briefly. In the module on surface analysis, the course will be focussed on X-ray Photoelectron Spectroscopy (XPS) and Auger Electron Spectroscopy (AES).
	Aims and objectives The aim of this course is to introduce to the student advanced characterisation techniques for the analysis of two important physical properties, namely thermal and surface. At the end of this course, the students will: • Select and evaluate physical characterisation techniques, namely thermal and surface analysis, for the investigation of material performance • Develop laboratory facilities for thermal and surface analysis
	Course Syllabus Refer to Page 3 to 4

<table>
<tr><td rowspan="4">Assessment (Individual Assessment)</td><td>Assessment Points</td><td colspan="2">3</td></tr>
<tr><td>Mode of Assessments and weighting</td><td>CA1: MCQs
CA2: MCQs
CA3: Project</td><td>30%
30%
40%

100%</td></tr>
<tr><td>Instructions</td><td colspan="2">CA1: Open book, Randomised Questions and Options
CA2: Open book, Randomised Questions and Options
CA3: Project to describe the techniques to use when presented with a material and the properties one wishes to analyse.</td></tr>
<tr><td>Mapping of assessment to course objectives

• LO1 : Select and evaluate physical characterisation techniques, namely thermal and surface analysis, for the investigation of material performance

• LO2: Develop laboratory facilities for thermal and surface analysis</td><td colspan="2">CA1 : LO1 and LO2
CA2 : LO1 and LO2
CA3 : LO1 and LO2</td></tr>
<tr><td>To be offered with effect from (state Academic Year and Semester)</td><td colspan="3">AY2018/19 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">N/A</td></tr>
<tr><td>Preclusions (if applicable)</td><td colspan="3">N/A</td></tr>
<tr><td>Mode of Teaching & Learning (Lectures, regular tests, Q&A, problem-based learning)</td><td colspan="3">Lectures, expert interviews, MCQ, tutorials, authentic texts, peer discussion</td></tr>
<tr><td>Basic Reading List
Compulsory Reading

Supplementary Reading</td><td colspan="3">Compulsory Reading:

1)Thermal Methods (Analytical Chemistry by Open Learning)
(1987) James W. Dodd, Kenneth H. Tonge
John Wiley & Sons</td></tr>
</table>

	2) Introduction to Surface Analysis by Electron Spectroscopy (1990) John F. Watts Oxford Science Publications **Supplementary Reading** Thermal Methods of Analysis: Principles, Applications and Problems. (1995) by Peter J Haines Thermal Methods Introduction to Surface Analysis by XPS and AES John Watts and John Wolstenholme John Wiley (2005)
Hours of Contact/Academic Units	*26 hours/ 2 AU*

Course Syllabus

The following topics will be covered:

Module 1: Thermal Analysis of Materials

1. Introduction to Thermal Analysis
   Introduction to thermal analysis and thermal methods. The basic principle behind thermal analysis and introduces the use of thermal analysis in industry and research.

2. Thermogravimetry and Differential Thermogravimetry
   The concept of mass loss and enthalpy change in materials during. The TG and DTA/DCS curve. Exotherm and endotherm.

3. Instrumentation and Experimental Procedure for TG/DTG
   Instrumentation for TG and DTG. Description of the critical components for TG and DTG experiments. Experimental procedure.

4. Interpretation of TG and DTG curves
   Interpretation of TG/DTG curves. Quantitative and qualitative treatment in decomposition process.

5. Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) – Instrumentation and Experimental Procedure
   Difference between DTA and DCS instrumentation. Instrumentation. Determination of enthalpy of reaction in DTA. Procedural temperatures and experimental factors

6. Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) – Interpretations and Applications
   Interpretation of DTA/DSC curves. Examples in food processing, research, pharmaceuticals, forensic, textile industries.

7. Multiple Techniques
   Types of multiple techniques in thermal analysis. Application of multiple thermal analysis techniques in materials characterisation. Combining TG with DTA/DSC, TG/Hot stage microscopy, DSC/TMA.

Module 2: Surface Analysis of Materials

1. Introduction to Surface Analysis
   Introduction to surface analysis and requirement of ultra-low pressure. High vacuum pumping system.

2. Spectroscopy
   Electromagnetic radiation interaction with matter. Types of transitions, rotational, vibrational and electronic. Types of spectroscopy

3. Principle of X-ray Photoelectron spectroscopy, Instrumentation (XPS)
   Photoelectric effect, High energy spectroscopy, concept of photoelectron spectroscopy, X-ray photoelectron spectroscopy (XPS).

4. X-ray Photoelectron Spectroscopy, Interpretation of XPS spectrum
   XPS instrumentation. Spin-Orbit coupling, total angular momentum and Siegbahn notation for assigning XPS peaks.

5. Principle of Auger Electron Spectroscopy (AES) and Instrumentation
   Auger effect, auger electron spectroscopy, instrumentation and AES techniques

6. Interpretation of Electron Spectrum from XPS and AES
   Identification of elements, binding state and quantification. Compositional depth profiling

7. Application of XPS and AES in Materials Science
   Applications in metallurgy, corrosion science, ceramic materials, polymers, microelectronics and adhesion science.

8. Other Surface Analysis Techniques
   Secondary ions spectroscopy (SIMS), Scanning Tunnelling Microscopy (STM), Atomic Force Microscopy (AFM) and Field Ion Microscopy (FIM).