Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year (New format)	AY2026-2027
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Visiting Professor John Vincent Hanna
Course Author Email	john.hanna@ntu.edu.sg
Course Title	Basic Introduction to the Solid State NMR Technique
Course Code	MS6017
Academic Units	3
Contact Hours	39
Research Experience Components	

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	MS7072 Principles & Applications of Solid State NMR
Replacement course to	
Remarks (if any)	Coursework students who have previously completed MS7072 Principles & Applications of Solid State NMR will not be allowed to read MS6017 Basic Introduction to the Solid State NMR Technique.

Course Aims

This course will be introducing the basic theory and practice of the solid state NMR technique to the taught course MSc candidates. It will explore the basic spin physics that underpins all NMR concepts, and then it will expand this introduction to encompass the more complex scenarios and interactions encountered in solids, in comparison to its more basic/simpler solution NMR genesis. A comprehensive treatment of the basic solid state NMR experimentation will be delivered, highlighting the application of rf pulses and the relaxation processes involved characterising to materials solid systems under study. The course delivery will be highly orientated to materials systems characterisation and will thus explore relevance to a broad cross-section of the NMR Periodic Table, and it will emphasize relevance and application to prominent research projects currently explored in MSE.

This course be highly beneficial to all Masters/MSc level in Materials Science & Engineering (MSE) as it will teach the candidates to think analytically and structurally in a simultaneous manner. It will also highlight the great complimentary of the solid state NMR technique to other mainstream materials characterisation methods such as diffraction, vibrational spectroscopies and microscopy in order to generate holistic thinking pertaining to structure and function in materials research at the beginner level.

Apart from the immediate underpinning knowledge delivered by this course to taught MSc candidates, this course is highly recommended to those students aiming to explore research options at the Masters and PhD levels. The knowledge delivered in this course is commensurate with that delivered in other Materials Science departments throughout the world, and it will equip all research-based candidates with the right tools, thinking and strategies to compete in academic environments.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	You will be able to explain the foundations underpinning basic spin physics and the influence that magnetism exerts on simple one-spin and larger ensemble systems.
ILO 2	You will develop an understanding of the basic NMR experiment and the data generated by this process.
ILO 3	You will develop an understanding of the fundamental NMR interactions, and be able to determine specific influences that are broadening the linewidth of the solid state NMR resonance.
ILO 4	You will be able to analyse the function of more complex 2D NMR experiments and use them to interrogate finer aspects molecular structure and connectivity.

Course Content

1. Basic principles of spin physics and magnetism
2. Effect of an rf pulse, nutation & relaxation
3. The free induction decay
4. Fourier transformations & data processing
5. Magic angle spinning
6. The chemical shielding interaction
7. The dipolar (or direct) interaction
8. The quadrupolar interaction
9. The scalar (or indirect) interaction
10. Other magnetic interactions
11. Magic angle spinning
12. The single and spin-echo experiments
13. The cross-polarisation experiment
14. Basic principles of 2D NMR
15. The MQMAS experiment
16. Other 2D MAS NMR experiments

Reading and References (if applicable)

Prescribed course readings:

1. K. J. D. MacKenzie & M. E. Smith, Solid State NMR of Inorganic Materials (Pergammon)
2. M. H. Levitt, Spin Dynamics (Wiley)
3. D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress (Wiley)

Relevant references to NTU-based research across several materials systems involving the solid state NMR technique:

1. "The Crystal Chemistry of Vanadium-Bearing Ellestadite Waste Forms."

Y. Fang, S. J. Page, G. J. Rees, M. Avdeev, J. V. Hanna, T. J. White.

Inorganic Chemistry 59, 9122-9132 (2018)

2. "Crystal Chemistry and Antibacterial Properties of Cupriferous Hydroxyapatite."

A. Bhattacharjee, Y. Fang, T. J. Hooper, N. L. Kelly, D. Gupta, K. Balani, I. Manna, T. Baikie, P. T. Bishop, T. J. White, **J. V. Hanna**.

Materials 12, 1814 (2019)

3. Cesium Copper Iodide Tailored Nanoplates and Nanorods for Blue, Yellow and White Emission."

P. Vashishtha, G. V. Nutan, B. E. Griffith, Y. Fang, D. Giovanni, M. Jagadeeswararao, T. C. Sum, N. Mathews, S. G. Mhaisalkar, **J. V. Hanna**, T. J. White.

Chemistry of Materials 31, 9003-9011 (2019)

4. "Synergistic Voltaglue Adhesive Mechanisms with Alternating Electric Fields."

M. Singh, C. S.Yin, S. J. Page, Y. Liu, G.Wicaksono, R. Pujar, S. K. Choudhary, G. U. Kulkarni, J. Chen, J. V. Hanna, R. D. Webster, T. W. J. Steele.

Chemistry of Materials 32, 2440-2449 (2020)

5. "Heavy Water Additive in Formamidinium: A Novel Approach to Enhance Perovskite Solar Cell Efficiency."

Solanki, M. M. Tavakoli, Q. Xu, S. S. H. Dintakurti, S. S. Lim, A. Bagui, J. V. Hanna, J. Kong, T. C. Sum.

Advanced Materials 32, 1907864 (2020)

6. "Investigating the structure-function relationship in triple cation perovskite nanocrystals for light-emitting diode applications."

P. Vashishtha, S. A. Veldhuis, S. S. H. Dintakurti, N. L. Kelly, B. E. Griffith, A. A. M. Brown, M. S. Ansari, A. Bruno, N. Mathews, Y. Fang, T. J. White, S. G. Mhaisalkar, **J. V. Hanna**.

Journal of Materials Chemistry C 8, 11805-11821 (2020)

7. "Supersaturated 'Water-in-Salt' Hybrid Electrolyte Towards Building High Voltage Na-Ion Capacitors with Wide Temperature Operation."

P. Sennu, R. Chua, S. S. H. Dintakurti; J. V. Hanna, R. O. Ramabhadran, V. Aravindan, S. Madhavi.

Journal of Power Sources 472, 228558 (2020)

8. "CaproGlu: A Multifunctional Tissue Adhesive Platform."

Djordjevic, O. Pokholenko, A. H. Shah, G. Wicaksono, L. Blancafort, J. V. Hanna, S. J. Page, H. S. Nanda, C. B. Ong, S. R. Chung, A. Y. H. Chin, D. McGrouther, M. M. Choudhury, F. Li, J. S. Teo, L. S. Lee, T. W. J. Steele.

Biomaterials 260, 120215 (2020)

9. "Performance Enhanced Light-Emitting Diodes Fabricated from Nanocrystalline CsPbBr3 with *In Situ* Zn2+ Addition."

P. Vashishtha, B. E. Griffith, A. A. M. Brown, T. J. N. Hooper, Y. Fang, M. S. Ansari, A. Bruno, S, H. Pu, S. G. Mhaisalkar, T. J. White, **J. V. Hanna**.

ACS Applied Electronic Materials 2, 4002-4011 (2020)

10. "The Classification of 1D 'Perovskites'."

W. P. D. Wong, J. V. Hanna, A. C. Grimsdale.

Acta Crystallographica Section B - Structural Science Crystal Engineering & Materials 77, 408-415 (2021)

11. "The Effect of Organic Cation Dynamics on the Optical Properties in (PEA)2(MA)[Pb2I7] Perovskite Dimorphs."

Y. Lekina, S. S. H. Dintakurti; B. Febriansyah, D. G. Bradley, J. X. Yan, X. Y. Shi, J. England, T. J. White, **J. V. Hanna**, Z. X. Shen.

Journal of Materials Chemistry C 9, 17050-17060 (2021)

12. "Elucidation of the Structural and Optical Properties of Metal Cation (Na+, K+, and Bi3+) Incorporated Cs2AgInCl6 Double Perovskite Nanocrystals."

P. Vashishtha, B. E. Griffith, Y. Fang, A. Jaiswal, G. V. Nutan, A. P. Bartók, T. J. White, **J. V. Hanna**.

Journal of Materials Chemistry A 10, 3562-3578 (2022)

13. "A Powder XRD, Solid State NMR and Calorimetric Study of the Phase Evolution in Mechanochemically Synthesized Dual Cation (Csx(CH3NH3)1-x)PbX3 Lead Halide Perovskite Systems."

S. S. H. Dintakurti, D. Walker, T. A. Bird, Y. Fang, T. J. White, **J. V. Hanna**.

Physical Chemistry Chemical Physics 24, 18004-18021 (2022)

14. "Navigating Surface Reconstruction of Spinel Oxides for Electrochemical Water Oxidation."

Y. Sun , J. Wang, S. Xi, J. Shen, S. Luo, J. Ge, S. Sun, Y. Chen, J. V Hanna, S. Li, X. Wang, Z. Xu.

Nature Communications 14, 2467 (2023)

15. "The Impact of Inter-Grain Phases on the Ionic Conductivity of Li1.5Al0.5Ge1.5(PO4)3 Solid Electrolyte Material Prepared by Spark Plasma Sintering."

S. Cretu, L. L. Nguyen, D. G. Bradley, L. P. W. Feng, T. T. Nguyen, O. U. Kudu, B. Fleutot, A. Jamali, J. N. Chotard, V. Seznec, **J. V. Hanna**, A. Demortière, M. Duchamp.

ACS Applied Materials & Interfaces 15, 39186-39197 (2023)

16. "Unravelling the Dynamic Crosslinking Mechanism in Polyborosiloxane."

Kurkin; Y. Lekina; D. G. Bradley; G. L. Seah; K. W. Tan, V. Lipik, J. V. Hanna, X. Zhang, A. L. Y. Tok.

Materials Today Chemistry 33, 101677 (2023)

17. "Conformational Disorder in 2D Hybrid Perovskites Incorporating Long Aliphatic Chain Cations Under Pressure."

Y. Lekina, H. S. Soo, D. G. Bradley, J. V. Hanna, Z. X Shen.

Journal of Materials Chemistry C 127, 16496-16507 (2023)

18. "Organic Functionalization of Ti3C2Tx MXene for Urea Adsorption in Aqueous Solutions."

Z. H. Yen, D. G. Bradley, Y. M. Wang, **J. V. Hanna**, Y. M. Lam.

ACS Applied Nano Materials 7, 7430-7441 (2024)

19. "Formation of 1D ‘Perovskitoid’ (API)2Pb3Br10 Instead of Layered <110> Oriented 2D-Perovskite (API)PbBr4 Under Different Dissolution Temperatures."

W. P. D. Wong, F. Chen, X. Wang, X. Li, X. Zou, J. V. Hanna, A. C. Grimsdale.

Inorganic Chemistry 64, 2574-2582 (2025)

20. "Functional Time-Lapsed In Situ Mechanosynthetic Studies on Metal Halide Perovskite Systems."

Y. Xiao, D. G. Bradley, W. X. Chan, X. Hu, L. Xiao, Z. Liu, Z. Y. Tan, X. Zhao, C. Li, M. Sadek, V. K. Ravi, Y. H. Tam, X. Wang. F. García, H. Sun, S. C. Low, P. B. Phua, T. C. Sum, X. Zhou, Y. F. Lim, **J. V. Hanna**, H. S. Soo.

Nature Communications 16, 1362 (2025)

21. "Democratizing Self-Driving Labs: Advances in Low-Cost 3D Printing for Laboratory Automation."

S. Doloi, M. Dasa, Y. Li, Z. H. Choa, X. Xiaoa, J. V. Hanna, M. Osvaldo, L. W. T. Ng.

Digital Discovery, DOI: 10.1039/d4dd00411f (2025)

22. "Multi-Technique Detection of Lead Iodide Hybrid Perovskite Degradation Pathways Under Varying Electric Fields."

L. Lan Nguyen, Q. Zhang, D. G. Bradley, T. Salim, P. L. W. Feng, P. Misha, A. D. Mueller, S. Mondal, K. S. Chong, T. C. Sum, **J. V. Hanna**, M. Duchamp, Y. M. Lam.

ACS Nano, DOI: 10.1021/acsnano.4c10370 (2025)

23. "A Multi-Technique and Materials Modelling Approach to Study Clustering Phenomena in NbxSryTiO3 and TaxSryTiO3 Thermoelectric Materials."

Y. Fang, B. E. Griffith, T. Baikie, A. P. Bartók, T. J. White, **J. V. Hanna**.

Journal of Materials Chemistry A, in preparation

24. "Structural Engineering of <110> Broadband Emitting Hybrid Organic-Inorganic Perovskite and Non-Perovskite Systems Based on Imidazolium Derived Cations."

W. P. D. Wong, A. J. Carver, D. Walker, G. Clarkson, A. C. Grimsdale, J. Lloyd-Hughes, A. P. Bartók, **J. V. Hanna**.

Chemical Science, in preparation

Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	Basic principles of magnetism	1	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 - 4
2	Basic principles of spin physics and quantisation	1	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 - 4
3	Extending spin physics form one spin to an ensemble of spins; Boltzmann statistics	1	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 - 4
4	The effect of an RF pulse; nutation and relaxation	2	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 - 4
5	Basic RF pulse experimentation and acquisition of the free induction decay (FID)	2	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 - 4
6	Fourier transformation and data processing	2	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
7	Fundamentals of magic angle spinning (MAS)	2	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress
8	The chemical shift/shielding interaction (CSA)	3	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress
9	The dipolar interaction	3	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress
10	The quadrupolar interaction	3	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
11	Combinations of NMR interactions	3	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 D. C. Apperley, R. K. Harris & P. Hodgkinson, Solid State Nuclear Magnetic Resonance, Basic Principles & Progress
12	Basic principles of 2D NMR experimentation	4	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 M. H. Levitt, Spin Dynamics
13	The MQMAS and other 2D MAS NMR experiments	4	In-person	Lectures, class questions and discussions	K. J. D. MacKenzie & M. E. Smith Solid State NMR of Inorganic Materials, Chapters 1 – 4 M. H. Levitt, Spin Dynamics
14	Continual Assessment 1 (CA1): Individual MCQ Quiz	1,2,3,4	In-person	Continual Assessment 1 (CA1): Individual MCQ Quiz	N/A

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Scheduled classroom lecture	The classroom lecture will deliver the key points for the learning and explain the related knowledge points by using real-world examples and real applications. Course materials used in the class cover all the knowledge points that are required for your learning.
Technology-enhanced learning (TEL)	Design online learning materials to facilitate your learning. Online materials will be highly relevant to lectures that are delivered in class.
Essay writing	This will allow the technical knowledge acquired in this course to be applied to a topic of specific interest to the student and apply design principles from the course.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Continual Assessment 1 (CA1): Individual MCQ Quiz)	1-4	N/A	100	This course will be graded on a pass/fail basis. The assessment of this course will be by an open-book exam. You will be expected to answer thirty (30) multiple choice questions within a two (2) hour time limit. There is no limit to what written/hardcopy material can be brought into the exam; however, the use of computers and mobile phones is prohibited.	Individual	Holistic	Extended Abstract

Description of Assessment Components (if applicable)

This course will be graded on a pass/fail basis.

Formative Feedback

All students will receive verbal feedback throughout the course via constant questioning of understanding of concepts, and through continuous recapping/revisiting of all theoretical aspects. In addition, you will receive both written and verbal feedback about your exam results explaining all aspects that were handled incorrectly.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Transdisciplinarity	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

Policy (Others, if applicable)

Last Updated Date: 02-03-2026 17:54:52

Last Updated By: Tan Yong Lay Hayden