2018/19年机械工程及相关专业的衔接课程 @新加坡国立大学苏州研究院

GE4000	Scientific writing and communication in English	（2018年9月）	4学分
GE4100	Science, Technology & Entrepreneurship Seminar	（一次/月）	4学分
ME4200	Microsystem Design and Application	（2018年12月）	4学分
ME4300	Modern Control System	（2018年10月）	4学分
ME4400	Automation in Manufacturing	（2019年2月）	4学分
ME4500	Fundamentals of Product Design and Development	（2018年11月）	4学分
ME4600	Robot Mechanics and Control	（2019年3月）	4学分
ME4700	Final Year Project (FYP-毕业论文)	（2018年10月至2019年4月）	16学分

总计： 44学分

衔接课程 @ 新加坡国立大学苏州研究院

- 苏研院提供两门通用课程 （**必修**）：“英语学术写作与交流”以及“科学&技术系列研讨会（每月一次）” 。
- 学习三至五门机械工程相关的专业课程，由新加坡国立大学机械系老师在苏州研究院授课（**英文**），以符合国内大学本科学位毕业要求。
- 在衔接课程期间，学生在新加坡国立大学苏州研究院的相关实验室完成**毕业论文及答辩（英文）**，以符合国内大学本科学位毕业要求。
- 学生在完成衔接课程和毕业论文且同时符合国内大学的毕业要求后，**将获得原校的本科毕业文凭和学士学位**。同时获得新国大苏州研究院的衔接课程证书。

英语学术写作与交流（一）

Course Title: GE4000 Scientific writing and communication in English
Module Lecturer: New Lecturers for 2019

Syllabus:

- Applying the IPA/using the dictionary/syllabic stress/punctuation/word stress.
- Listening skills/processing/tone and register/key words.
- Grammar in written English/verbs/nouns/adjectives/ESP(English for Specific Purposes).
- Writing Exercise/Listening Exercise/Read a presentation.
    - Homework: Google Academic English/print out academic paper.
- What is Academic English-writing style, vocabulary, structure/present printed out Academic paper.
- Academic paper guided writing practice/language/clarity/describe a process.
- Read what you have written/punctuation/enunciation/basic voice culture.
- Grammar revisited: connecting verbs, articles, tense accuracy, countable-uncountable nouns, subject-verb agreement.

英语学术写作与交流（二）

Syllabus:

- The Essay: Body, paragraphing, idiomatic English, Standard English.
    - Homework: Essay 500 words
- Presenting a paper: effective introductions and conclusions, defining the audience , paralanguage, punctuation, delivery.
- Read part of your essay: pacing, enunciation, punctuation, style, paralanguage, voice quality, connecting with an audience (peer evaluation).
- How to mark a script for pacing, word stress and punctuation.
- Re-read script with annotation (peer evaluation).
- Re-visit: IPA, Academic English style.
    - Homework: Google Preparing for IELTS
- IELTS Writing component.

英语学术写作与交流（三）

Assessment

- Homework.
- Group Presentation (Peer evaluation).
- Individual Presentation.

课程安排：

授课时间：一个月，4小时/天。计 4 学分，经原学校批准可以转回学分，相当于一门公共选修课。

2018年的安排是: 各专业学生英文课程分三个班进行：**英文学术写作班**（已通过英文考试的学生）；**英文提高班**（想进一步提高英文考试成绩的学生）；**雅思考试班**（没有英文成绩或成绩暂不合格的学生）。（2019年可能会根据学生的实际情况作相应的调整）。

科学和技术系列研讨会

- 学生要求参加每月一次的研究院组织的科学和技术研讨会。
- 苏州研究院每月邀请学术届，企业，公司的相关人士，教授等到院里提供一系列的学术，创新和发展的讲座。
- 这些讲座为学生们提供新的思维和知识。
- 共有约为6-8次讲座，学生参加完所有的讲座，完成相关报告，计为一门公共课 4 学分。

苏研院机械工程相关的专业课程

- 在新加坡国立大学苏州研究院进行的衔接课程中与机械工程专业相关课程的教学大纲，主要根据新加坡国立大学机械工程系已有的 ME3000 和ME4000 系列专业选修课程中的机械工程专业课的教学大纲制定，**由新加坡国立大学机械工程系的老师到苏研院进行英文授课**。
- 同时，为满足国内大学的毕业要求，课程也会在新加坡国立大学制定的教学大纲基础上做出相应的调整。
- 每门课课时为一个月集中授课，约**40小时**的授课时间，学分为 **4 学分**。
- 学生要求至少学**三门课**，但可以多学并把多学的学分转到新国大硕士课程中去（条件是本科没用这些学分）。但如果某个学生的学分已经够了而不需要学三门课，经原学校批准证明也可少学课程。
- 下面举例说明一些机械工程系的专业选修课程的安排（红体字为2018年已开设的课程， 其他为2019年计划可能开设的课程 - 视招生情况而定）。

苏研院机械工程相关的专业课程举例

机械工程相关课程@NUSRI	新加坡国大机械工程系本科相关课程
Microsystems Design and Applications	ME3281 - Microsystems Design and Applications
Modern Control System	ME4246 - Modern Control System
Automation in Manufacturing	ME4262 - Automation in Manufacturing
Fundamentals of Product Design and Development	ME4263 - Fundamentals of Product Development
Robot Mechanics and Control	ME4245 - Robot Mechanics and Control
Finite Element Analysis	ME4291 – Finite Element Analysis
Numerical Method in Engineering	ME3291 – Numerical Method in Engineering
Materials Failure	ME4255 – Materials Failure

Microsystems Design and Applications (ME3281 @ NUS,ME)

This module will give a broad introduction to microsystems technology, and will cover the principles, fabrication techniques and system-level design and applications of microsystems to a variety of engineering fields such as aerospace, mechanical, electrical, telecommunications and bioengineering. Major topics include properties of semiconductors, fundamentals of dynamics and vibration, microfabrication techniques, piezoresistivity and applications in sensors, thermal sensors, electrostatics and capacitance, microsensors and microactuators, microfluidics and lab-on-a-chip, and optical microsystems.

1. **Introduction (3hrs):** Overview of Microsystems Technology and Applications; Scaling law and performance; Markets for MEMS devices; Information resources.
2. **Microfabrication fundamentals (5hrs):** Photolithography; Thin film deposition and etching; Surface-micromachining; Bulk-micromachining; SOI processes; Bonding.
3. **Materials for microsystems (2hrs):** Overview of materials used in microsystems; Material properties of single crystalline silicon; Miller indices and wafer identification; Mechanical, thermal, and electrical properties of other commonly used materials.
4. **Beams and diaphragms for microsystems (2hrs):** Introduction to static behavior of elementary beams and membranes.
5. **Microactuators (6hrs):** Overview of actuation methods; Electrostatic actuation; Parallel-plate microactuator; Comb-drive microactuator; Pull-in and stable travel range; Fundamentals of dynamics and vibration; Damping in microactuators; Thermal actuation; Basic motion control in microsystems.
6. **Microsensors (6hrs):** Piezoresistive sensing and signal processing; Capacitive sensing and signal processing; Force feedback; Micromachined microaccelerometers; MEMS gyroscopes; MEMS pressure sensors.
7. **Optical MEMS (6hrs):** Basic building-blocks for optical microsystems; Microhinges and free-space micro optical bench; Micromirrors and micromirror arrays; MEMS optical switches, attenuators, and tunable lasers for fiber optical communication; MEMS based projection displays; Optical MEMS for adaptive optics.
8. **Microfluidics and Bio-MEMS (6hrs):** Basic fluidic concepts; Laminar flow; Micro-valves, micro pumps and micro mixers; Micro-channels; Soft lithography; Electro-wetting; Droplet generators; Micro flow sensors; Lab-on-a-chip.

Modern Control System (ME4246@NUS, ME)

This module focuses on analysis and synthesis of controllers in the time domain. The module introduces students to the techniques and analysis of dynamical systems using state-space models. The major topics covered are: Introduction to State-Space Model; Solution of State-Space Model; Canonical Forms of State-Space Model; Controllability and Observability; State Feedback and State Estimation; Linear Quadratic Optimal Control, Stability; Discrete Time Systems; Controller Design of Discrete-Time Systems. Students are required to have knowledge of basic classical control theory and linear algebra.

1. **Review of Classical Control and Linear Algebra (3hr):** Review of Classical Control Theory. Review of Linear Algebra.
2. **Introduction to State-Space Model (3hr):** Motivation for space-space model. Examples of state-space representation of dynamical systems. Linearisation of non-linear systems. Concept of state of a system and definitions.
3. **Solution of State-Space Model (3hr):** Time solution of linear-invariant state-space model. Properties of state-transition matrix. Methods to compute state-transition matrix. Relation to transfer function representation. Review of matrix and linear algebra.
4. **Canonical Forms of State-Space Model (2hr):** Similarity transformation. Controllable and Observable canonical forms and their realisations.
5. **Controllability and Observability (3hr):** Definitions of Controllability and Observability. Algebraic conditions for controllability and observability of systems. Stabilisability and detectability. Minimality of realisation. Duality.
6. **Stability (2hr):** Introduction to Lyapunov stability theorem. BIBO stability. Lyapunov equation for linear time-invariant systems.
7. **Simulation Tools - MATLAB (2hr):** Introduction to MATLAB simulation language.
8. **Overview of Digital Control Systems (4hr):** Difference equations and z-transforms. Discrete models of sampled-data systems. Transfer functions with z-transforms. State-space model.
9. **State Feedback and State Estimation (4hr):** Pole-placement design for SISO system. Design of linear observer. Compensatior design by separation principle.
10. **Linear Quadratic Optimal Control (3hr):** Introduction and formulation of the LQR problem. Derivation of Ricatti equation solution to the LQR problem. Steady-state solution. Effects of choices of Q and R matrices. Properties of the LQR
11. **Digital Control System Design (3hr):** Control design specifications. Dynamic responses. Design using emulation and discrete equivalents of continuous-time controllers. Direct digital design in state-space (combined with continuous time)

Fundamentals of Product Design and Development (ME4263@NUS)

This is an intensive module covering the following topics relating to the basic product development process: global design perspectives, identifying customer needs and conceptual design, industrial design, design for reliability and product testing, prototyping and design for manufacturing, and product testing economics. Students will propose a product to be developed and work in a team to go through the process via a series of guided exercises relating to the above topics.

1. **Introduction & Global Design Perspectives:** Overview of techniques and tools to facilitate and shorten product design and development; emerging trends.

2. **Identifying Customer Needs:** Scoping; data gathering and interpretation; prioritizing needs; specification.

3. **Conceptual Design:** Concept generation and selection.

4: **Industrial Design:** Visualization and communication methods; form design basics; aesthetics; usability.

5. **Design for Reliability and Product Testing:** Robust design; related US and Singapore standard.

6. **Prototyping and Design for Manufacturing:** Types and uses of prototypes; rapid prototyping technologies; understanding impact of design on manufacturing; basic manufacturability evaluation.

7. **Product Design Economics:** Product economics; net present value base case; sensitivity and trade-off analysis for development decisions; consideration of other quality factors.

在新国大，这门课一般是在暑假期间为从中国和其他国家来的学生举办，为期两周到三周，参加的学生要求设计并做出某个产品。国内学校如西工大，重庆大学，南方科大等都曾送学生参加过这个课程，其他国家包括美国，韩国等的学生。

Automation in Manufacturing (ME4262@NUS, ME)

This module provides a comprehensive introduction to automation technologies applied in discrete part manufacturing. It also introduces essential principles and provides analytical tools for manufacturing control. Major topics covered include: Economic justification of automated systems; Fixed and transfer automation; Automated material handling and automated storage/retrieval systems, Flexible manufacturing systems, Internet-enabled manufacturing, Group technology, Process planning, Automated assembly and Automated operation planning for layered manufacturing processes.

1. Economic justification of automated systems;
2. Fixed and transfer automation;
3. Automated material handling
4. Automated storage/retrieval systems,
5. Flexible manufacturing systems,
6. Internet-enabled manufacturing,
7. Automated assembly,
8. Group technology,
9. CA Process planning,
10. Automated operation planning for layered manufacturing processes.

Robot Mechanics and Control (ME4245@NUS,ME)

The module facilitates the learning of the fundamentals of robotic manipulators for students who are interested in their design and applications. Successful completion allows students to formulate the kinematics and dynamics of robotic manipulators consisting of a serial chain of rigid bodies, and design, analyze and implement control algorithms with sensory feedback. The module is targeted at upper level undergraduates who have completed fundamental mathematics, mechanics, and control modules. Students will also gain a basic appreciation of the complexity in the control architecture and manipulator structure of new-generation robots.

Topics covered include: Introduction, Spatial Descriptions and Transformations, Manipulator Forward and Inverse Kinematics, Mechanics of Robot Motion, Robot Dynamics, Static Forces and Torques, Trajectory Planning, Robot Control.

1. **Introduction, Spatial Descriptions and Transformations (5hr):** Robot definition. Robot classification. Robotics system components. Notations. Position definitions. Coordinate frames. Different orientation descriptions. Free vectors. Translations rotations and relative motion. Homogeneous transformations.
2. **Manipulator Forward and Inverse Kinematics (6hr):** Link coordinate frames. Denavit-Hartenberg convention. Joint and end-effector Cartesian space. Forward kinematics transformations of position. Inverse kinematics of position. Solvability. Trigonometric equations. Closed-Form Solutions. Workspace.
3. **Mechanics of Robot Motion (6hr):** Translational and rotational velocities. Velocity Transformations. The Manipulator Jacobian. Forward and inverse kinematics of velocity. Singularities of robot motion.
4. **Static Forces and Compliance (3hr):** Transformations of static forces and moments. Joint and End-Effector force/torque transformations.
5. **Robot Dynamics and Trajectory Planning (10hr):** Lagrangian formulation. Model properties. Newton-Euler equations of motion. Joint-based motion planning.
6. **Robot Control (9hr):** Independent joint control. Feedforward control. Inverse dynamics control. Robot controller architectures. Implementation problems.

Finite Element Analysis (ME4291@NUS, ME)

This course introduces the fundamental concepts of the finite element method, practical techniques in creating an FEM model, and demonstrates its applications to solve some important stress and thermal analysis problems in Mechanical Engineering. Some necessary background in mechanics will be briefed before the foundations of the FEM theory, concept and procedures are covered. Various formulations and applications to one- two- and three-dimensional problems in solid mechanics and heat transfer will be covered to reinforce the theory and concepts. The precautions in the actual practice of FE analysis such as mesh design, modeling and verification will also be covered. Some instruction in the use of a commercial FEM software package will be given and students are expected to carry out one or more projects with it independently. This module should give students a good foundation for numerical simulation, and basic skills for carrying out stress and thermal analysis for a mechanical system.

- **INTRODUCTION** (1.5 hour): Physical problems, mathematical model, numerical methods, computational implementation procedures.; **BRIEFING ON MECHANICS FOR SOLIDS AND STRUCTURES (reading material for students, but give 1 hours briefing in class):** System equations for solids, truss, beam, and plates;
- **THE FUNDAMENTALS OF FINITE ELEMENT METHOD** (4 hours): Hamilton's principle, minimum potential energy principle, shape functions, discretized
- System equations.; **FEM FOR TRUSSES (3 hours):** Shape functions for truss elements, strain matrix, FE equations, coordinate transformation, global equation assembly, reproducing property of FEM.; **FEM FOR BEAMS (3 hours):** Shape functions for beams, strain matrix, FE equations, reproducing and convergence property of FEM.; **FEM FOR FRAMES (2 hours):** FE equations for frames, superimposition techniques. Coordinate transformation in three dimensions.; **FEM FOR 2-D SOLIDS (5 hours):** Triangular element, rectangular element, high order elements, Gauss integration, coordination transformation, isoperimetric element, crack tip elements, infinite elements.; **FEM FOR PLATES AND SHELLS (4.5 hours):** Shape function for plates, FE equations for plates and shells, superimposition techniques. Coordinate transformation in three dimensions.; **FEM FOR 3-D SOLIDS (1 hour):** Shape functions for 3-D solids, FE equations.; **Modeling techniques (4 hours):** Geometry creation, multi-point constraints, modeling of rigid body, loading, boundary condition, mesh design, mesh distortion, compatibility issues, assessment of results, adaptive analysis.; **FEM FOR heat transfer problems (6 hours):** Weighted residual method, divergence theorem, one-dimensional heat conduction fin, composite wall, 2D problems, boundary conditions, case studies.; **Use of FEM packages (4 hours):** Hands-on session using a commercial software package.

Numerical Methods in Engineering (ME3291@NUS, ME)

This elective course introduces students to fundamental concepts of numerical analysis as a powerful tool for solving engineering problems. Basic concepts of errors arising from discretization, Taylor series, von-Neumann stability analysis, and curve-fitting techniques will be introduced, with emphasis on simple examples and applications derived from engineering disciplines. Solution methods in terms of direct or indirect approach will be discussed. Brief introductions to the finite difference and finite element methods will be given. The treatment will primarily use the Laplace and Diffusion equations as illustrations of analysis familiar to mechanical engineers. The course will also introduce the use of software MATLAB as a tool for the solution of numerical problems.

Describe Classification of PDE; Discretization of differential equations; Consistency/Compatibility of a numerical scheme; Parabolic PDE: Explicit scheme, Stability Analysis, Implicit scheme, Types of boundary conditions; Elliptic differential equations; Solution of system of linear algebraic equations: Direct methods, Iterative methods – Jacobi, Gauss-Seidel, SOR, SSOR; Hyperbolic differential equations: Use of method of characteristics for 1st order equation, Use of method of characteristics for 2nd order equation, Finite difference method for 1st order equation; Finite Element Analysis: Direct approach – truss analysis, Green Gauss theorems, Strong & weak formulations: 1D heat flow, Strong & weak formulations: 2D heat flow, Weighted residual method, Approximating functions, FEM for 1-D heat flow, FEM for 2-D & 3-D heat flow

Material Failure
(ME4255@NUS, ME)

This module addresses the failure of engineering systems governed by the end service conditions. Commonly encountered service conditions are introduced in this module, including their impact on the service life of the individual components as well as the assembly of components. This module enables students to understand the deterioration of materials due to service conditions and how to minimize them.

The topics are covered: introduction to failure of materials; service failure analysis practice; failure due to overloading; failure due to cyclic loading; failure due to corrosion, failure due to friction and wear; failure at elevated temperatures; failure of weld joints; inspection and remaining life prediction techniques; and case studies.

1. **Introduction to Materials Failure**: Introduction, Examples of engineering disasters, Failure investigation procedure, Modes of failure, Case study.

2. **Failure due to overload**: 3-dimensional stress state and principal stresses, Failure criterion for both yielding and fracture; Ductile and brittle fracture, Plastic deformation mechanism, Yielding in polymers, Factors affecting yield stress of polymers, Case study.

3. **Failure due to cracking**: brief introduction of fracture mechanics, stress concentration, stress intensity factor and their application in design and analysis, fracture toughness, R-curve behaviors, plastic zone correction, energy principle of fracture, fracture toughness measurement.

4. **Failure due to friction and wear**: Definitions, Type applications involving wear failure, Types of wear, abrasive wear, adhesive wear, fatigue wear, fretting, wear failure preventions, Empirical model for zero wear.

5. **Failure due to cyclic loading**: Definitions in cyclic loading, Fatigue fracture surface marks, Types of fatigue, S-N curve, Fatigue life prediction, Mechanism of fatigue failure in metals and polymers, Statistical nature of fatigue failure, Factors affecting fatigue life, Variable amplitude fatigue, strain-based fatigue approaches, Fatigue crack growth under constant amplitude and variable amplitude loading, fatigue of welded members, fretting fatigue. Case study.

6. **Failure at elevated temperatures**: Introduction and definitions, Creep, Mechanisms of creep, Creep behaviour predictions, Creep fracture mechanisms, Creep in polymers, Dynamic and cyclic loading, Time-temperature superposition, Creep failure mechanisms in polymers, Long-term creep life prediction, Case study.

7. **Failure due to environmental effects**: Important environmental effects, Principles of corrosion, Corrosive conditions, Different forms of corrosion, Theory of aqueous corrosion, Pitting, Crevice corrosion, Stress-corrosion cracking, Corrosion fatigue, Hydrogen damage failures and preventions.

8. **Flaw detection**: Use of non-destructive testing, Visual examination, Microscopy, Dye penetrant test, Magnetic particle testing, Eddy current testing, Ultrasound testing, Radiographic testing, Acoustic emission, testing, general principle of fractography, and case studies.

在苏研院跨专业选课

- 苏研院 3+1+1 项目目前共有机械工程，电机和计算机工程，食品科技三个专业。

- 机械系和电机系经过协商，2018年我们允许两系的学生以先到先得的方式互相跨专业选课（每门课最多十人）：

  - EE4205/ME4710 Silicon Power Devices and Circuits
  - EE4300/ME4720 Digital Media Technologies
  - EE4400/ME4730 Microwave Communications
  - EE4500/ME4740 Semiconductor Optoelectronics