

Master of Science Aerospace Engineering



Technische Universität München



NANYANG
TECHNOLOGICAL
UNIVERSITY



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At A Glance

JOINT DEGREE BY

Technische Universität München (TUM)
Nanyang Technological University (NTU)

24 MONTHS FULL TIME PROGRAMME

Coursework in Singapore

PRACTICAL KNOWLEDGE

Compulsory Internship & Dissertation

GLOBAL PROSPECTS

Internationally Recognized Degree

INTAKE

August Every Year

TO APPLY

Apply online from 15th October at
www.tum-asia.edu.sg

1 TUM is ranked as the #1
University in Germany⁺

1 NTU is ranked #1 in Asia
for Engineering⁺⁺

1 NTU is ranked #1 in the
world for industry income
and innovation^{*}

11 TUM ranked #11 in the
Global Employability
Survey[^]

50 Both TUM & NTU[#]
are in the world's
Top 50 Universities





Technische Universität München (TUM)

Technische Universität München (TUM) is one of Europe's leading research universities, with around 500 professors, 10,000 academic and non-academic staff, and more than 37,000 students. Its focus areas are the engineering sciences, natural sciences, life sciences and medicine, reinforced by schools of management and education.

TUM acts as an entrepreneurial university that promotes talents and creates value for society. In that it profits from having strong partners in science and industry. It is represented worldwide with a campus in Singapore as well as offices in Beijing, Brussels, Cairo, Mumbai, and São Paulo.

Nobel Prize winners and inventors such as Rudolf Diesel and Carl von Linde have done research at TUM. In 2006 and 2012 it won recognition as a German "Excellence University." In international rankings, TUM regularly places among the best universities in Germany.

Nanyang Technological University (NTU)

Inaugurated in 1991, Nanyang Technological University (NTU) has grown to become a full-fledged research university, and is ranked as one of the fastest-rising Asian universities in the world's top 50**. Hailing from more than 70 countries, NTU's 3,800 strong teaching and research staff contribute their dynamic perspectives and years of solid industry experience.

NTU's academic and research programmes, with real-world relevance, have reaped dividends in the form of strong support from major corporations and industry leaders, in terms of both research funding and partnerships as well as global internship opportunities for our students.

As the main Science and Technology university in Singapore, NTU has made substantial contributions to Singapore's drive for research and innovation, with the 2014 Quacquarelli Symonds (QS) ranking NTU at 10th in the World for Electrical & Electronic Engineering.

**As rated by 2013/2014 QS World University Ranking

Master of Science

Aerospace Engineering



The joint TUM-NTU **Master of Science in Aerospace Engineering** (MSc in AE) is a programme that caters to highly qualified engineers to meet the ever-increasing demand from a growing aerospace sector in Singapore and the world.

MODULE REQUIREMENTS

19

The student has to complete 19 modules in 3 semesters

(7 Core Modules, 9 Elective Modules & 2 Cross Discipline Modules, 1 Business & Technical English Module)

10

Contact hours for every Cross Discipline Module

45

Contact hours for every Core & Elective Module



JOINT DEGREE

Conferred by Technische Universität München (Germany) and Nanyang Technological University (Singapore)



4 SEMESTERS

Full-time research and application focused programme, inclusive of internship experience and Master Dissertation writing



INDUSTRY RELEVANCE

Our professors are actively involved in research and teaching, allowing them to base the curriculum around the latest technological trends and knowledge



GLOBAL OPPORTUNITIES

You are able to complete your Internship and Dissertation in Munich, Singapore or anywhere in the world, to look for job opportunities globally

Duration of the Programme: 24 months

August



Arrival in Singapore

4 Months



- Business & Technical English
- 7 Core Modules

6 Months



- Elective Modules
- Cross Discipline Modules

2 Months



Break

4 Months



- Elective Modules
- Cross Discipline Modules

2 Months



Internship

6 Months



Master Dissertation at NTU, TUM, a relevant company, or research institute

Graduation



End of Programme

Module Synopsis



Core Modules

Aerodynamics[#]

Introduction, Governing equations, Inviscid & incompressible flows, Viscous boundary layers, Airfoil & wing characteristics, Incompressible flow around airfoils and wings, Dynamics of incompressible flow fields, Compressible subsonic flows, Transonic flows, Supersonic flows, Hypersonic flows, Aerodynamic design considerations.

Flight Performance and Dynamics[#]

Basic fixed-wing aircraft performance, Aircraft stability and control, Fundamentals of airplane aerodynamics and propulsion, Performance consideration and handling qualities on aircraft design.

Structures and Materials[#]

Appropriate structural design and selection of materials, Various structural components of aircraft assembly, Typical loads during flight and structural vibration problems, Various characteristics of aerospace materials and deployment in aerospace structures and aircraft systems.

Propulsion

Revision of thermodynamics, Fundamentals of aircraft propulsion, Propulsion engines and performance analysis, Propeller engines, Gas turbine engines, Compressors and turbines, Combustors, Engine and airframe integration, Scramjets.

Aircraft Design

Current design methods and basic design tools for the conceptual design and analysis of different types of aircraft. Students will acquire knowledge of systematic procedure of the aircraft design process and will be able to design assemblies with focus on the overall aircraft design. Due to that, the required aircraft performance, current safety, economic efficiency, comfort and environmental requirements are the basics of the design process. The connection between requirements and their impact on configuration level will be outlined.

Aerospace Lab[#]

Students will undergo a series of lab exercises from all disciplines of aerospace engineering; Wind tunnel measurements, flight simulator, structures and materials and computational methods.

Design Lab[#]

Students will be given an aerospace related design task. Under the guidance of the lab supervisors, the entire design process will be completed and presented in a final presentation.

Cross Discipline Modules (Choose 2)

- Aspects of Asian and European Relations Today
- Cultural, Social & Economical Aspects of Globalisation
- International Intellectual Property Law
- Selected Topics in Business Administration
- Selected Topics in Business Management

Elective Modules* (Choose 3 from your Primary Focus Area, 2 from your Secondary Focus Area, 2 modules from any unselected modules as your Free Choice modules, 2 modules from any unselected modules as Elective modules)

Focus Area 1: Aerodynamics and Propulsion*

Computational Fluid Dynamics

Governing Equations, Principles of the Solution of Governing Equations, Structured Finite Volume Schemes, Unstructured Finite Volume Schemes, Temporal Discretisation, Turbulence Modelling, Boundary Conditions, Acceleration Techniques, Consistency, Accuracy and Stability, Verification and Validation.

Turbulent Flows[#]

Nature of turbulent flows, Statistical description of turbulence, ReynoldsAveraged Navier-Stokes Equations, Free Shear Flows, Scales of Turbulence, Wall Bounded Flows, Direct Numerical Simulations, Eddy Viscosity Approaches to Modelling, Reynolds-Stress Approaches, Large-Eddy Simulations, Turbulent Combustion.

Boundary Layer Theory

Derivation of the boundary-layer equations from the Navier-Stokes equations, Incompressible boundary-layer equations (flat, 2-dimensional flows), Temperature boundary-layers, Compressible boundary-layers, 3-dimensional boundary-layers, Stability theory, Laminar-turbulent transition, Turbulent boundary-layers, Experimental boundary-layer.

Turbo Compressors

Compressor types and applications, Turbo compressors, Fundamentals of fluid dynamics and calculation methods, Principles of compressor stages, Rotor blades, Stator vanes, Blade profiles, Efficiencies and parameters of compressor stages, Flow similarity and Characteristics, Operating performance, Steady and unsteady operating performance, Measures for stability increase.

Focus Area 2: Structures, Materials and Systems* Plates and Shells[#]

Fundamentals of plate and shell theories, Contemporary analytical methods and powerful numerical techniques for solving challenging plate and shell problems, Fibre-composite materials.

Fracture Mechanics and Non-Destructive Testing[#]

Basics of the metal high and low cycle fatigue methodology, Flaw and damage tolerant approaches, Analysis of aircraft metal components, FAA/JAR requirements, Fracture Mechanics for defect assessment, Several Non Destructive Testing Techniques.

Carbon Fibre Composite Materials

Typical carbon fibre composite materials and structures in military & civilian aircraft, Unidirectional, orthotropic, anisotropic & quasi-isotropic behavior; Classical laminate plate theory; Hygrothermal effects; Introduction to failure criteria; Basics of materials processing; Parameter studies and design steps.

Aero-systems[#]

Fuel and fuel systems, Environmental control system (ECS), Bleed air and avionics cooling, Landing gear and hydraulics, Flight control mechanisms for fixed and rotary wings aircraft, Helicopter power transmission system and other miscellaneous systems.

Lightweight and Aerospace Structures

Overview on actual aerospace structures, Essentials of typical materials, Requirements for aircraft structures, Current and futures design concepts for fuselage and wing structures, Current and future space structures concepts, Design optimisation techniques.

Failure Analysis, Diagnostics and Prevention in Aerospace Engineering

Principles of Failure Analysis, diagnostics and the means to treat/prevent these failures in an interactive manner. The course is specifically targeted to the Aerospace industry by the inclusion of aerospace-related case histories and materials, including failures in composite materials. A balanced mix between the theoretical fundamentals and the practical aspects to failure analysis is taught using lectures. Real cases of aerospace failures will be discussed.

Focus Area 3: Flight Mechanics and Control*

Advanced Flight Dynamics[#]

Advanced treatment of flight dynamics. Linear and nonlinear aircraft equations of motion, Detailed longitudinal and lateral/directional dynamics. Numerical approaches and the application of linear system theory for studying the dynamical properties of flight.

Flight Control Systems

Principles of control/stability augmentation systems and autopilots used in modern airplanes, Fundamentals of classical control theory analysis and design, Basic properties of airplane dynamic properties, Control strategy for various augmentation systems and autopilots.

Advanced Control of Flight Systems

Application of modern control techniques in flight systems, Multivariable state-space and aircraft system representations, Various modern control techniques with applications and implementations.

Spacecraft Technology 1

Rocket Equation, Rocket Ascent, Orbit Mechanics, Chemical/Electrical Propulsion, Kepler Elements, Hohmann Transfer, Re-Entry, Interplanetary Flight, Mission Analysis/Design, Thermal Control, Communication Subsystem.

Helicopter Engineering

The helicopter design process, applicable requirements and design objectives, helicopter flight physics model, practical dimensioning techniques, engine characteristics, evaluation of helicopter configurations regarding expectable flight performance, structural architecture and design

*Disclaimer: Focus Areas and Elective modules available for selection are subject to availability. Unforeseen circumstances that affect the availability of the module include an insufficient number of students taking up the module and/or the unavailability of the professor. TUM Asia reserves the right to cancel or postpone the module under such circumstances. All students are required to have a number of mandatory modules set by both universities. Module selection choices will be subject to this rule.
[#]These modules are offered by NTU, with the rest being offered by TUM.



ADMISSION CRITERIA*

- Holds a minimum 3-year Bachelor Degree in Aerospace Engineering, Mechanical Engineering or a closely related discipline from a reputable university
- Submit **one (1) notarised copy of Official or Provisional Bachelor Degree Certificate**** and **one (1) notarised copy of Official or Provisional Academic Transcript****
- Submit **two (2) Recommendation Letters** from two (2) different Professors or Employers
- Submit **one (1) A4-page Letter of Motivation** that indicates the reason(s) you are interested in the programme you applied for
- Submit **one (1) Curriculum Vitae / Resume**
- Submit **one (1) Passport-sized photograph**** and **one (1) Passport Biodata Page photocopy** (the passport page with your personal particulars)
- **TOEFL / IELTS** (Required for applicants whose native tongue or medium of instruction from previous studies is **not in English**)
- **Akademische Prüfstelle (APS) certificate** (Required for all applicants who hold a degree from **China, Vietnam, or Mongolia**)

TOEFL Requirements: Minimum 605 for the Paper-Based test / 234 for the Computer-Based test / 88 for the Internet-Based Test
IELTS Requirements: Overall IELTS results of at least 6.5

Important: Documents that are not in English must be translated by a sworn translator

* Find out about the full application process on www.tum-asia.edu.sg/application-process

** All applicants are required to submit an additional of three (3) notarised copies of Official or Provisional Bachelor Degree Certificate, three (3) notarised copies of full, Official Academic Transcript, and three (3) passport-sized photographs when you have accepted the offer of admissions and are being matriculated into our programme

TO APPLY

Applications open 15th October. Apply online at www.tum-asia.edu.sg.

TUITION FEES

APPLICATION FEE

S\$79 (inclusive of GST) or **Euro 52** is payable for each application per programme

PAYMENT OF TUITION FEES

A Total of SGD 38,520* (Actual fee split into SGD and EURO)
Tuition fees includes teaching fees, laboratory expenses and cost of mandatory events. Expenses excluded from this fee and are to be borne by students include: airfare, accommodation, living expenses, and NTU miscellaneous fees (inclusive of registration, IT facilities, matriculation, examination, amenities, copy right, sports, insurance and medical). The tuition fee will be paid in 4 installments.

* Tuition fees are accurate as of 1 October 2016. Tuition fees are subject to revision due to currency fluctuations, at the discretion of TUM Asia. Fees quoted are inclusive of 7% Singapore's Government Goods & Services Tax. Please refer to www.tum-asia.edu.sg/MScfees for the latest tuition fees.



Campus of Nanyang Technological University (NTU)



Studying With Us

“Talents Are Our Assets, Reputation Is Our Return”

Entrepreneurial Thinking and Engagement

Globalization is now an inevitable force that is here to stay. At TUM Asia, our classroom reflects this diversity with an enrolment of over 28 nationalities. This means that we foster a vibrant learning environment where the student learns not only from the textbook but also through the lives of their counterparts. Classroom ideas are synthesized across the diverse economic realities and students learn to see from multiple vantage points, creating a capacity to solve problems in creative ways. The unique 24 month joint degree equips the student with not only technical and scientific knowledge, but with an enriched curriculum composed of business and cultural modules.

TUM CREATE - Centre for Electromobility

TUM is known for its research capabilities and strength in innovation. As such, TUM Asia spearheaded the set up of TUM CREATE as a base of research in Singapore. TUM Create is a joint programme between Technische Universität München (TUM) and Nanyang Technological University (NTU). The electromobility institute brings together the expertise and innovation of Germany and Singapore, to drive innovation to shape the future of sustainable mobility by tackling issues ranging from the molecules to the megacity. **Graduates from the TUM Asia Master programmes have the opportunity to apply for positions at TUM Create, especially if your interest lies in research/electromobility.**

Highest International Standards

You will be studying with the world's best professors from TUM and NTU, as well as experts from the industry. Not only will the student benefit from professors who are actively involved in research, one will also receive a holistic learning experience with the engagement of local lecturers from academia and industry. Our TUM modules are covered by professors who fly in from Germany on an exclusive teaching basis, to ensure that students get the undivided attention of their lecturers.

Engineering is not just about learning facts, but being able to understand complex systems and methods, as well as being able to develop original strategies and solutions. The TUM-NTU Aerospace Master programme aims at just that. Become one of the people driving progress in the aerospace industry - Don't be driven by routine tasks.

Prof. Dr.-Ing. Florian Holzapfel

Professor at Technische Universität München,
Institute of Flight System Dynamics

DID YOU KNOW THAT SINGAPORE TOPS IN ASIA FOR AEROSPACE MAINTENANCE, REPAIR, AND OVERHAUL (MRO), LAYING CLAIM TO 25% OF THE ASIAN MRO MARKET?



Singapore: Asia's Aerospace Hub

Singapore has become the leading aviation hub in Asia Pacific today, contributing over a quarter share of the region's Maintenance, Repair, and Overhaul (MRO) output. Despite global uncertainties, the demand for air travel in Asia Pacific countries continues to grow, creating vast opportunities in the region for the aerospace industry. **Singapore is well-equipped to capture the demand for aviation related services, while leveraging off existing capabilities in precision engineering and electronics, to support the production of complex aero-engine components.**

The Aerospace Industry in Singapore

The phenomenal growth of the aerospace industry worldwide and in South-East Asia in particular, has greatly increased the number of aerospace design and manufacturing operations in Singapore. On top of that, Singapore is backed by over 100 aerospace companies. Aircraft manufacturers projected that over a third of worldwide deliveries will go to Asia in the next two decades, with Asia Pacific's fleet tripled to 13,500 aircrafts.

Our Graduates



Our graduates in Aerospace Engineering are employed all over the world, such as in **Singapore (80%), Europe (20%)**



The most commonly accepted positions are **Research Engineer, Project Engineer, Stress Engineer, and Mechanical Design Engineer**



Our graduates are expected to be able to find positions with many companies, such as **ST Aerospace, ST Electronics, and NTU**

1

Singapore is #1 in Asia for MRO. It is also the most comprehensive MRO in Asia

8.7

In 2012, Singapore's Aerospace industry achieved an output of over S\$8.7 billion

10

Singapore's Aerospace industry has grown at a compounded annual growth rate of over 10% since 1990

19

Singapore is quickly establishing itself as a Research & Development Hub. 19 Aerospace companies have made commitments to partner Singapore's A*STAR and its research institutes to jointly conduct Aerospace research

90

The Aerospace industry employs close to 19,900 workers today, of which 90% are skilled

100

Today, Singapore is home to over 100 international companies carrying out MRO activities in Singapore

TUM-NTU is a joint effort between experts from opposite sides of the world. The professors integrate their real world experiences from the industry with the academics and inspire us to perform our best, while helping us to assimilate the ideas and elevate us to their level.

Mohammed Iqbal

Alumni, Master of Science in Aerospace Engineering
PhD Researcher, ThermoPlastic composites Research Center (TPRC) / University of Twente, The Netherlands

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German Institute of Science & Technology - TUM Asia Pte Ltd

CPE Registration No.: 200105229R

CPE Registered Period: 13/06/2011 to 12/06/2017

All information is accurate at the time of printing and is subject to change without prior notice.
Published in October 2016.

⁺ As rated by Academic Ranking of World Universities (Shanghai Ranking) 2011-2013, 2016 and 2015 QS World University Ranking

⁺⁺ As rated by Academic Ranking of World Universities (Shanghai Ranking) 2016

^{*} As rated by the Times Higher Education University Ranking 2013/2014

[^] As ranked in the 2015 Global Employability Survey by The New York Times

[#] As ranked by Academic Ranking of World Universities (Shanghai Ranking) 2013 and 2013/2014 QS World University Ranking