Reg. No. 200604393R

COURSE OUTLINE FOR STUDENTS AT NTU

Academic Year	2019	**Semester**	1
Course Coordinator	Dr Sellakkutti Rajendran		
Course Code	MA2701		
Course Title	Flight Performance		
Pre-requisites	MA1001 Dynamics & MA1700 Aerospace Discovery Course		
No of AUs	2		
Contact Hours	Lectures: 26 hours		
Proposal Date	November 2018		

Course Aims

The course aims to teach you the theory behind flight performance analysis and its connection to aircraft design. Knowledge of mechanics as well as fundamental concepts from aerodynamics and propulsion will be applied to develop mathematical models describing the motion of an aircraft. These models together with the atmospheric model will be used to predict and analyse various aircraft performance characteristics as a way to gain insight into the physics of flight.

Intended Learning Outcomes (ILO)

Upon the successful completion of the course, you would be able to:

1) Combine concepts from mechanics, International Standard Atmosphere, aerodynamics and propulsion to model various flight conditions such as takeoff flight, climbing flight, cruise flight, turning flight, landing flight, etc.
2) Calculate performance characteristics of an aircraft under a given flight condition.
3) Analyse how aircraft parameters affect the flight performance characteristics.
4) Determine the best aircraft parameters for optimal performance of the aircraft.

Course Content

	Topic	Hours
1.	**Introduction to Flight Performance** An overview of the course. A glimpse into the topics covered in this course. Performance data of typical aircrafts.	**1**
2.	**Atmosphere, Altitude and Flight Speed** Atmosphere and flight performance. International Standard Atmosphere Model. Altitude definitions. Flight speed definitions.	**2**
3.	**Review of Aerodynamics** Airfoillift and drag characteristics. Airfoil drag polar. Wing lift and drag characteristics. Aircraftlift and drag characteristics. Aircraft drag polar.	**5**
4.	**Review of Aircraft Propulsion** Types of aircraft engines. Choice of engine type for different altitudes and speeds. Working principle of various engines. Thrust generation. Propeller driven aircraft vs. jet propelled aircraft. Fuel consumption definitions.	**2**

	Variation of engine thrust/power and fuel consumption with flight speed and altitude. Thrust/power model assumed for this course.	
5.	**Level Flight Performance** Point-mass model of aircraft. Straight and level flight equations. Thrust and power required for propelling the aircraft. Differences between propeller-driven and jet-powered aircrafts. Minimum and maximum level flight speeds. Stall speed. Level flight envelope. Speed stability.	**2**
6.	**Climb Performance** Climb flight equations. Excess power. Rate of climb. Angle of climb. Maximum climb rate and maximum climb angle, and the corresponding climb speeds. Hodograph for climb flight. Absolute and service ceilings. Time to climb.	**2**
7.	**Gliding Performance** Gliding flight equations. Range and endurance. Maximum-range gliding flight. Maximum-endurance gliding flight. Hodograph for gliding flight.	**1**
8.	**Level Turn Performance** Coordinated level-turn. Turning flight equations. Turn radius and turn rate. Load factor. Propulsive, aerodynamic and structural constraints on load maximum achievable load factor. V-n diagram. Corner point. Minimum turn radius. Maximum Turn rate.	**2**
9.	**Pull-up and Pull-down Maneuver** Pull-up and pull-down equations. V-n diagram. Maneuver speed. Red-line speed.	**1**
10.	**Takeoff Performance** Ground run phase and airborne phase. Takeoff distance calculation. Ground effect and landing gear considerations. Balanced Field Length. Wind effects on takeoff ground run.	**2**
11.	**Landing Performance** Airborne phase and ground run phase. Landing distance calculation. Wind effects on landing braked ground run.	**3**
12.	**Range and Endurance** Definitions of range. Breguet's range equation. Range expression for propeller/jet aircraft. Endurance expression for propeller/jet aircraft. Maximum range and endurance estimation. Graphical method for maximum range speed and maximum endurance speed. Wind effects on range.	**2**
13.	**Energy Methods in Accelerated Climb** Concept of energy height. Energy height curves. Zoom climb/dive. Specific excess power and energy climb rate. Specific excess power curves. Altitude climb. Energy height climb. Best strategy to minimize climb time.	**1**

Assessment (includes both continuous and summative assessment)

Component	Course ILO Tested	Related Programme LO or Graduate Attributes	Weighting	Team/Individual	Assessment rubrics
1. Final Examination (2.5 hrs; Restricted Open Book – 1	1-4	a,b,c (see Appendix 1)	60%	Individual	N.A

double-sided A4 reference sheet)					
2. Continuous Assessment 1: Quiz 1	1-4	a,b,c (see Appendix 1)	20%	Individual	N.A
3. Continuous Assessment 2: Quiz 2	1-4	a,b,c (see Appendix 1)	20%	Individual	N.A
Total			100%		

Formative feedback

- CA Quiz results will be announced in NTULearn and feedback on the overall performance of students in the quizzes will be posted in NTULearn. The right approach to common mistakes committed by the students will be pointed out.
- A general feedback on students' performance in the final exam will be posted in NTULearn.
- You are also welcome to consult the instructor throughout the course and get a feedback on whether your understanding of the concepts is right.

Learning and Teaching approach

Approach	**How does this approach support students in achieving the learning outcomes?**
Lecture	You will be introduced to basic concepts, terminologies, analytical methods and graphical methods. Example problems will be solved where appropriate.
Exercise Problems	Exercise problems will be posted in NTULearn. Solution to exercise problems will be posted periodically. You are required to first attempt the exercise problems yourself and then compare your solutions with the posted solutions so that you can correct your mistakes (if any) and unlearn any wrong concepts you have picked up.
Tutorial	There are no formal tutorial classes for this course. Exercise problems are meant to serve as self-paced tutorial problems.

Reading and References

Textbook

1. John D. Anderson, Aircraft Performance and Design, WCB/McGraw Hill, 1999.

References

1. David Hull, Fundamentals of Airplane Flight Mechanics, Springer, 2007.
2. Warren Phillips, Mechanics of Flight, Wiley, 2004.
3. Antonio Filippone, Flight Performance of Fixed and Rotary Wing Aircraft, AIAA, 2006.

Course Policies and Student Responsibilities

As a student of the course, you are required to abide by both the University Code of Conduct and the Student Code of Conduct. The Codes provide information on the responsibilities of all NTU students,

as well as examples of misconduct and details about how students can report suspected misconduct. The university also has the Student Mental Health Policy. The Policy states the University's commitment to providing a supportive environment for the holistic development of students, including the improvement of your mental health and wellbeing. These policies and codes concerning students can be found in the following link.
http://www.ntu.edu.sg/SAO/Pages/Policies-concerning-students.aspx

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, and 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. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Course Instructors

Instructor	Office Location	Phone	Email
Dr Sellakkutti Rajendran	N3 -02c-78	6790 6891	msrajendran@ntu.edu.sg
Prof James Wang Ming	N3.2-01-17	6790 6825	james.wang@ntu.edu.sg

Planned Weekly Schedule

Week	Topic	Course ILO	Readings/ Activities
1	Introduction to Flight Performance Atmosphere, Altitude and Flight Speed	1-4	Study lecture slides. Solve related exercise problems.
2	Atmosphere, Altitude and Flight Speed Review of Aerodynamics	1-4	Study lecture slides. Read Chapter 2 of text book. Solve related exercise problems.
3	Review of Aerodynamics	1-4	"
4	Review of Aerodynamics	1-4	"
5	Review of Aircraft Propulsion	1-4	Study lecture slides. Read Chapter 3 of text book. Solve related exercise problems.
6	Level Flight Performance	1-4	Study lecture slides. Read Chapter 5 (sec 5.1-5.9) of text book. Solve related exercise problems.
7	Climb Performance	1-4	Study lecture slides. Read Chapter 5 (sec 5.10 - 5.12) of text book.

			Solve related exercise problems.
8	RECESS WEEK		
9	Gliding Performance Level Turn Performance	1-4	Study lecture slides. Read Chapter 5 (sec 5.10.3) and Chapter 6 (sec 6.1-6.2) of text book. Solve related exercise problems.
10	Level Turn Performance Pull-up and Pull-down Maneuver	1-4	Study lecture slides. Read Chapter 6 (sec 6.1-6.5) of text book. Solve related exercise problems.
11	Takeoff Performance	1-4	Study lecture slides. Read Chapter 6 (sec 6.7) of text book. Solve related exercise problems.
12	Landing Performance	1-4	Study lecture slides. Read Chapter 6 (sec 6.8) of text book. Solve related exercise problems.
13	Landing Performance Range and Endurance	1-4	Study lecture slides. Read Chapter 6 (sec 6.8) and Chapter 5 (sec 5.13-5.15) of text book. Solve related exercise problems.
14	Range and Endurance Energy Methods in Accelerated Climb	1-4	Study lecture slides. Read Chapter 5 (sec 5.13-5.15) and Chapter 6 (sec 6.6) of text book. Solve related exercise problems.