Aeronautics & Mechanics AENG11301

Lecture 18

What is in the exam?

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SpaceX Falcon 9

Outline for today

- Description of how likely different topics will be in the exam
- Discussion of format of the exam
- Pointers on how to approach exam questions
- Go over example exam question
- Develop a deep and profound sense of satisfaction for all of the cool stuff you learned in this class and the ninja like-skills you have developed for solving interesting aeronautics problems

Aims for today

- Have an idea of the relative standing of different topics covered in this course
- Know the format of the exam
- Be able to choose questions to answer and know how to allocate time in exam
- Have experience answering an Aeronautics exam question

Review Tier Scheme

- Tier 1
  - Tier 1 topics are most likely to be on exam
  - Plus, topics that you should know anyway
  - If you are comfortable with all these topics, you can do reasonably well on the exam
- Tier 2
  - Some Tier 2 topics will be on the exam
  - Plus, more topics you should know anyway
  - Covering these topics well, plus tier 1 topics, and you will score very well.
- Tier 3
  - Tier 3 topics don’t need to be reviewed

Lecture block 1 - Geometry definitions

- Tier 1
  - Names of airplane and wing parts
  - Definitions of AR, SMC and λ
  - Aerofoil terminology
- Tier 2
  - Planform descriptions
  - Aircraft controls surfaces and their effects
- Tier 3
  - Different Reference Areas

Lecture block 2 - Aero Forces

- Tier 1
  - Coefficients of Lift and Drag and the ability to manipulate them
  - Lift Curve
    - Linear region
    - Slope
    - Stall
    - Effects of camber
    - Effect of Reynolds number
  - Drag Polar
    - Fitting drag equation to experimental data
    - Graphical determination of max L/D ratio

$$C_L = \frac{L}{\frac{1}{2}\rho_\infty V_\infty^2 S}$$

$$C_D = \frac{D}{\frac{1}{2}\rho_\infty V_\infty^2 S}$$

Aero Forces

- Tier 2
  - Coefficient of Moment
  - Aerodynamic center
  - Reynolds number
  - Stall Characteristics
  - Trailing edge high-lift devices
  - Leading edge high-lift devices
- Tier 3
  - Physical description of Lift

$$C_M = \frac{M}{\frac{1}{2}\rho_\infty V_\infty^2 Sc}$$

$$Re = \frac{\rho V_\infty c}{\mu}$$

$$\frac{x_{ac}}{c} = 0.25$$

Drag

- Tier 1
  - Types of drag
    - Skin
    - Form
    - Induced
    - Wave
  - Drag Polar
- Tier 2
  - Tip vortices
  - Transonic effects

$$C_D = C_{D_0} + KC_L^2$$

$$K = \frac{1}{\pi eAR}$$

Standard Atmosphere

- Tier 1
  - Troposphere/Tropopause/Stratosphere
- Tier 2
  - ISA sea level values
  - Density ratio $\sigma = \frac{\rho}{\rho_{SL}}$
  - Absolute temperature ratio
  - Static pressure ratio
- Tier 3
  - Formulae for calculating ISA values (as would use table in practice)

Lecture block 3 - Forces on an aircraft

- Tier 1
  - Equivalent airspeed
  - The Drag curve
  - The Power curve
  - Minimum drag relationships
  - Minimum power relationships
  - Minimum glide angle
  - Minimum descent rate
  - Force balance in glide
  - Force balance in climb

  The Magic Table!

$$V_E = V\sqrt{\frac{\rho}{\rho_0}} = V\sqrt{\sigma}$$

$$P = TV = DV$$

$$C_{L_{MD}} = \sqrt{C_{D0}/K}$$

$$C_{L_{MP}} = \sqrt{3C_{D0}/K}$$

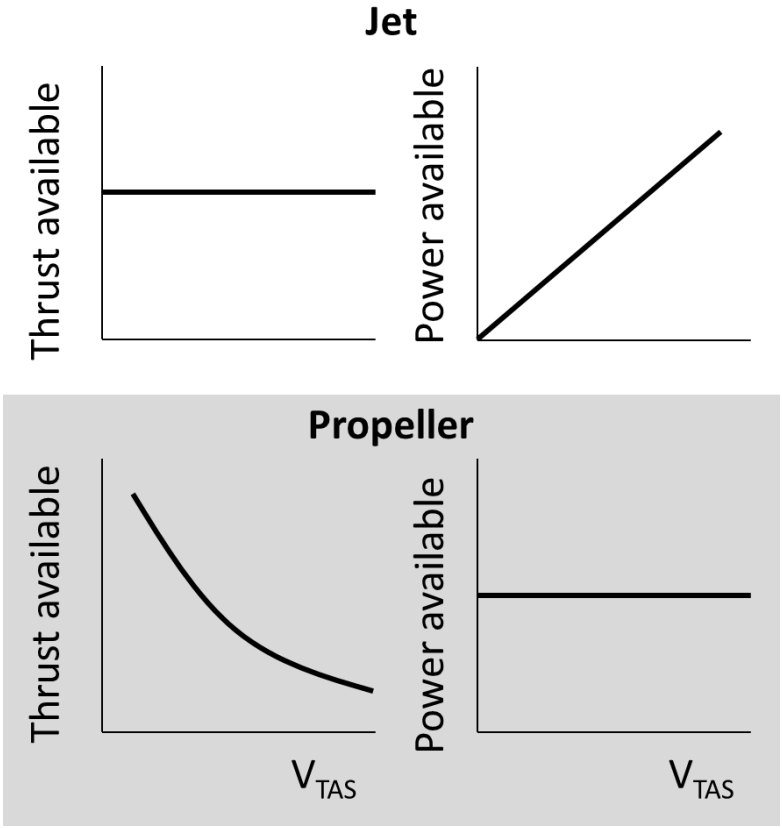
$$\tan\theta = \frac{1}{L/D} = \frac{1}{C_L/C_D}$$

Forces on an aircraft

- Tier 2
  - Wing loading relationships
  - Effects of altitude on drag
  - Effects of altitude on power
  - Effects of weight on drag
  - Effects of weight on power
  - Glide polar

Propulsion and cruise

- Tier 1
  - Jet engine thrust and power
  - Propeller thrust and power
- Tier 2
  - Absolute/service ceilings
  - Cruise flight performance



Range

- Tier 1
  - Breguet Range (cruise-climb for a jet)
  - Payload-Range diagrams
- Tier 2
  - Breguet Range for a propeller
  - Breguet Range for jet at constant altitude
  - Endurance equations

$$\frac{dW}{dt} = -fgT$$

$$\frac{dW}{dt} = -fgP$$

Maneuvering

$$n = \frac{L}{W}$$

- Tier 1
  - Maneuver flight envelope (V-n diagram)
  - Steady banked turns
    - Turn radius
    - Turn time
    - Limits
    - Power
- Tier 2
  - Gust flight envelope
  - Gust loading

$$V^* = \sqrt{\frac{2n_{\max}W}{\rho S C_{L\max}}}$$

$$\cos\phi = \frac{1}{n}$$

$$R = \frac{V^2}{g\sqrt{n^2-1}}$$

$$n = \frac{\rho a_1 v}{2W/S}V + 1$$

$$\omega_t = \frac{g\sqrt{n^2-1}}{V}$$

Exam format

AERONAUTICS AND MECHANICS

AENG11301

This paper contains *six* questions, *four* in Section A and *two* in Section B.

Answer *five* questions only.
Answer *all four* questions in Section A, and *one* question in Section B.

All questions carry 20 marks each.
The maximum for this paper is 100 marks

ALL ANSWERS TO QUESTIONS MUST BE PROVIDED USING S.I. UNITS.

$\rho_0 = 1.225$ kg/m^3

1 kg = 2.2046 lbm

1 m = 3.281 ft

1 nm = 1852 m

$\sigma = \dfrac{20 - H}{20 + H}$ where H is the altitude in km

CALCULATORS MUST HAVE THE FACULTY SEAL OF APPROVAL
PLEASE DO NOT REMOVE THIS EXAM PAPER FROM THE EXAM ROOM
TURN OVER WHEN TOLD TO START WRITING

Exam format

- Section A – Required questions – 4 questions
- Section B – Pick your poison– 2 questions
- Must answer all 4 questions in Section A, and answer one of the two questions in Section B
- You must therefore answer a total of 5 questions
  - DO NOT answer more than 5 questions. Marker will either mark first 5 questions or randomly select 5 questions to mark

Exam pointers

- 100 marks total, 20 marks per question, over 3 Hours
  = mean of 36 minutes per question

- Exam questions normally structured with multiple parts with first parts being easiest marks and last being harder marks

- If you haven't finished all of a question in 36 minutes, normally much better off moving onto the next question to get the easier marks at the beginning of that question and then returning to the other question if you have time at the end
  DON'T GET "STUCK" ON A QUESTION – MOVE ON

Exam pointers

- Make sure to state assumptions and to clearly show your working, this allows the marker to give you some credit for carried errors if you make a mistake early in a calculation

- Make sure you carefully read each question and give everything that is asked for.
  - Eg. If asked to list effects and explain reasons for these effects, be sure to give a list AND an explanation

Where to find past exam papers?

- On Black Board
  - My Organisations
  - Queens School of Engineering
  - Past Exam Papers
- But don’t forget the format has changed (slightly)

a) Explain the concept of equivalent air speed. Why is it used in defining the flight envelope of an aircraft in preference to true airspeed? (5 marks)

As aircraft is designed with the following parameters:

Maximum positive load factor:	4
Maximum negative load factor:	-2
Design diving speed (EAS):	250 m/s
Design cruising speed (EAS):	200 m/s
Aircraft weight:	50 kN
Wing area:	20 m2
Maximum lift coefficient for positive incidence:	1.5
Maximum lift coefficient for negative incidence:	-1.0
Drag polar:	$CD = 0.015 + 0.04C_L^2$

b) Accurately sketch the velocity-load factor (V-n) plot for this aircraft, giving values on the plot. (5 marks)

c) Find the maximum rate of turn that this aircraft can achieve at sea level. Find also the speed at sea level for which the thrust required to maintain a steady turn at maximum load factor is a minimum. What is the rate of turn at this speed? (10 marks)

Follow-up materials

To help with exam technique:

- http://www-users.york.ac.uk/~dajp1/Exam_Hints/Exams.html

See Black board for past exam papers and solutions