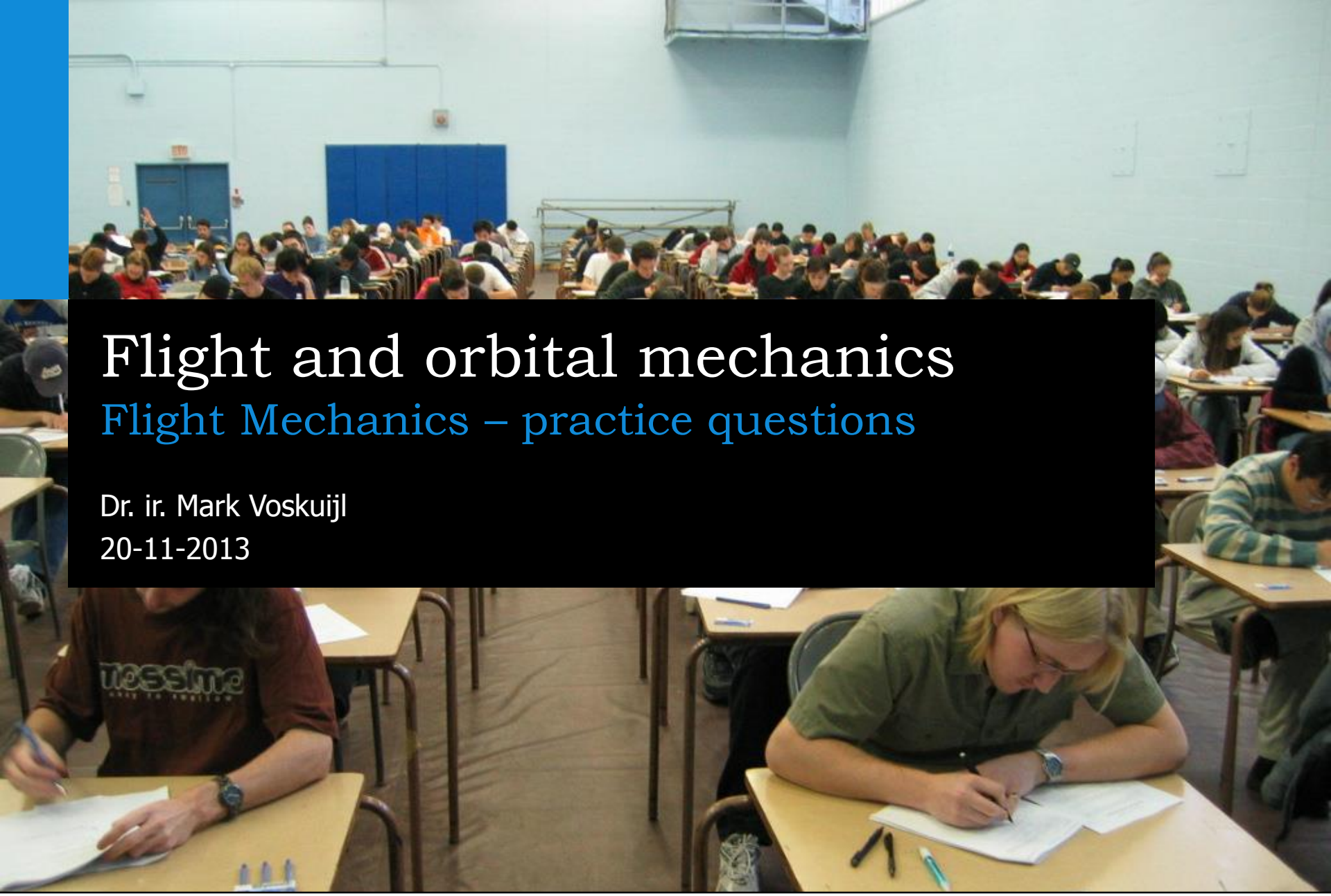
Flight and Orbital Mechanics

Lecture slides



Flight and orbital mechanics

Flight Mechanics – practice questions

Dr. ir. Mark Voskuijl

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27.&28

Practice questions – Flight mechanics

Contents

General information

- Closed book exam
- Pre programmed calculator → FRAUD… (serious consequences)
- Practice questions on blackboard
- The lecture sheets are most important
- Use the book for background reading
- Questions? I am available in person, over email and phone

(*Do not expect me to reply on the evening/day before the exam*)

Contents

Example question 1

The Bede BD-5J is a small jet aircraft which can be bought and built at home. Data for this aircraft are given:

$$W = 4.27\ [\text{kN}]$$

$$S = 3.51\ [\text{m}^2]$$

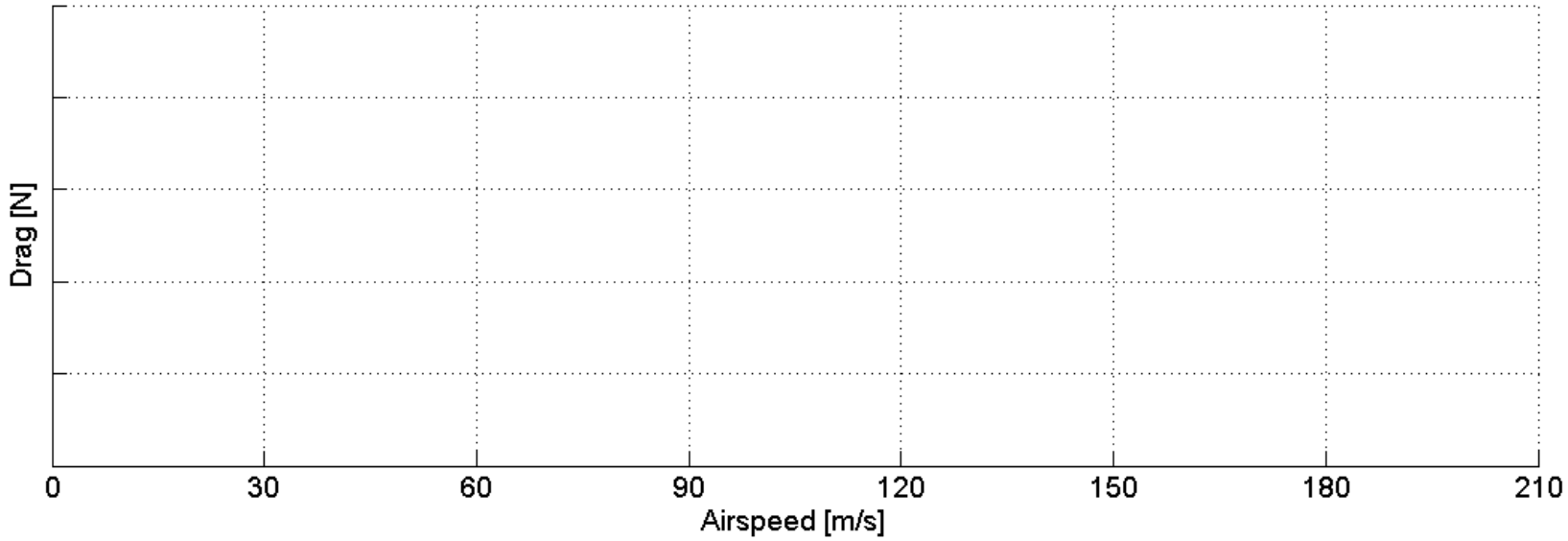
$$A = 7.65$$

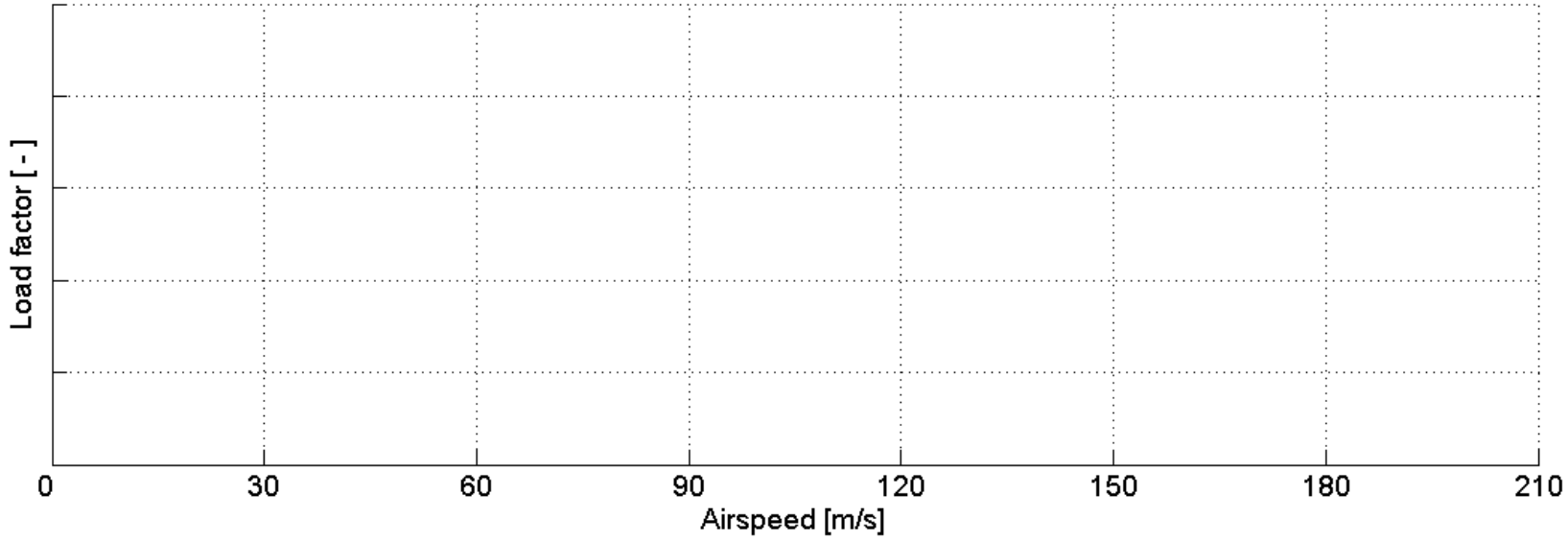
$$e = 0.67$$

$$C_D = 0.02$$

$$C_D = C_{D_0} + \frac{C_L^2}{\pi A e}$$

a. For steady horizontal symmetric flight at 8000 m altitude (ρ = 0.5252 kg/m^3) determine the aerodynamic drag of the BD-5J for the following airspeeds: V = 60, 90, 120 and 180 m/s. Draw the drag as function of the airspeed in the provided diagram


Drag [N]
0
30
60
90
120
150
180
210
Airspeed [m/s]


Load factor [-]
0
30
60
90
120
150
180
210
Airspeed [m/s]

The aircraft is now flying a **steady, horizontal, coordinated** turn

b. What do the terms steady, horizontal and coordinated mean?

c. Draw a clear FBD and a clear KD. Use at least two views of the aircraft to make these drawings. All forces, accelerations and relevant angles should be drawn appropriately.

d. Derive the three equations of motion for this aircraft based on the free body diagram and kinetic diagram in the previous question

The maximum thrust of this aircraft at sea level is 900 [N]. Since this is a jet aircraft, thrust can be assumed independent of airspeed. However, it decreases with altitude via the following relationship:

$$T_{\max} = T_{\max,sea-level}\left(\frac{\rho}{1.225}\right)^{0.6}$$

e. Calculate the aerodynamic drag when a turn at an aerodynamic roll angle of 50 degrees is performed for the same airspeeds and altitude as in question a. Draw your results in the provided diagram. Also draw the maximum thrust in this figure

f. Describe how the performance diagram changes during a turn and explain the physical effect

g. The condition for maximum load factor at given C_L is the following:

$$n = \frac{T_{\max}}{W} \frac{C_L}{C_D}$$

Give a clear definition of the load factor and derive the above equation from the equations of motion.

h. For the following values of C_L: 0.3, 0.5, 0.9 and 1.5, determine the achievable load factor and the corresponding airspeeds. Draw your results in the provided diagram

i. Is the figure of the achievable load factor in agreement with the performance diagram? Give a thorough explanation with your answer

j. At a certain moment, the aircraft is flying 100 m/s at sea level. Air traffic control asks the pilot to perform a rate one turn. Determine the aerodynamic angle of roll required to perform this rate one turn.

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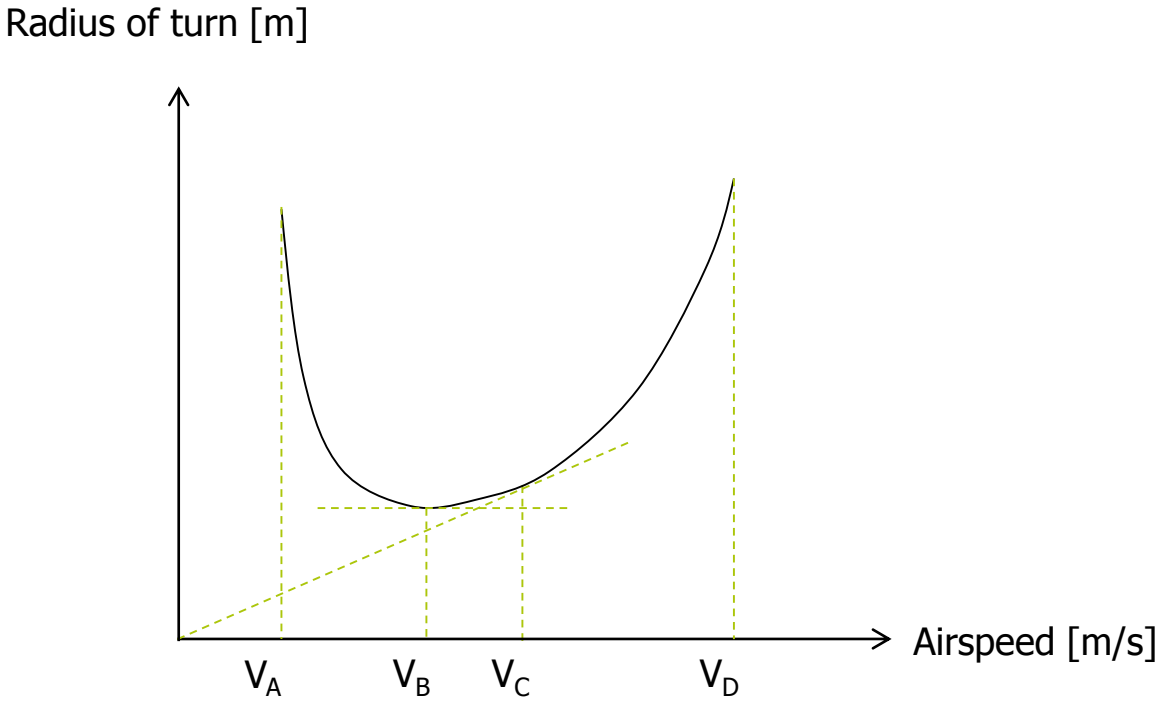
Multiple choice questions

The turning performance of an aircraft is presented in the figure below.



The **minimum time** to turn can be achieved at which airspeed?:

a. V_A
b. V_B
c. V_C
d. V_D

Multiple choice questions

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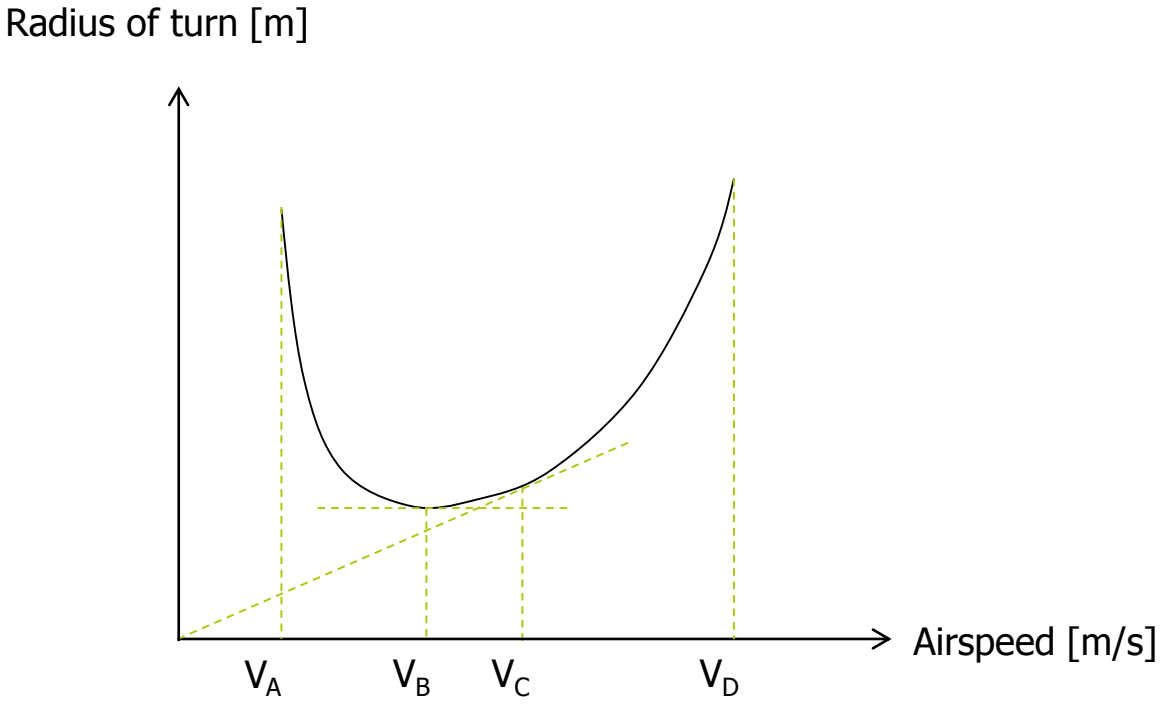

The **minimum time** to turn can be achieved at which airspeed?:

a. V_A
b. V_B
c. V_C
d. V_D

Multiple choice questions

An aircraft has a true airspeed (TAS) of 200 m/s and is performing a climb at a climb angle γ of 15 deg. The aircraft is experiencing a tail wind of 10 m/s. Calculate the horizontal ground speed of this aircraft.

a. 183.2 [m/s]
b. 190 [m/s]
c. 200 [m/s]
d. 203.2 [m/s]
e. 210 [m/s]

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d. 203.2 [m/s]
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Multiple choice questions

An aircraft is flying at Mach 0.5 at 3000 m. The following data are given:
What is the energy height of this aircraft?

$\rho_{3000} = 0.9091$ *[kg/m^3]*

$T_{3000} = 268.65$ *[K]*

$W = 20000$ *[N]*

a. 4376 [m]
b. 87513 [kJ]
c. 42925 [J/kg]
d. 60000 [kJ]
e. 3000 [m]

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Example question 2

The following data is known for a small propeller aircraft (Cessna 172)

P_a = 100 kW (independent of airspeed)
W = 10 kN
S = 15 m^2

The maximum rate of climb in steady symmetric flight of this aircraft equals 6 m/s when operating at sea level (0 m) in the International Standard Atmosphere.

a. Calculate the maximum load factor and corresponding bank angle of this aircraft in a horizontal steady turn when operating at the same altitude, power setting and angle of attack

GOOD LUCK WITH YOUR EXAM!