Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

DEPARTMENT FAHRZEUGTECHNIK UND FLUGZEUGBAU

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Flugzeugentwurf / Aircraft Design WS 10/11

Datum: 31.01.2011

Bearbeitungszeit: 180 Minuten

Name:	Vorname:
Matrikelnummer.:	
Punkte: von 68	Note:

1. Klausurteil

30 Punkte, 60 Minuten, ohne Unterlagen

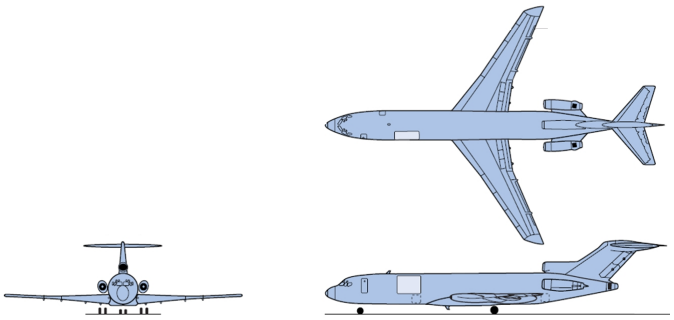
1.1) Please translate to German.
Please write clearly! Unreadable text causes substraction of points!

1. ferry range
2. galley
3. tail-aft configuration
4. baggage
5. canard
6. dihedral
7. take-off field length
8. preliminary sizing
9. T-tail
10. payload
11. flight manual
12. discontinued approach

1.2) Please translate to English!
Please write clearly! Unreadable text causes substraction of points!

1. Spannweite
2. Verkürzte Flugzeugversion
3. Gang (in der Kabine)
4. Sitzschiene
5. Betriebsleermasse
6. Essenswagen
7. Bugfahrwerk
8. Triebwerk
9. Pfeilung
10. Schulterdecker
11. Drei-Flächen-Flugzeug
12. Flugzeug mit verbundenen Flügeln

1.3) Shown is a Boeing 727-200F. Please name 4 Pros and Cons or name things that change flight operation!



1.4) An aircraft for 205 passengers is planned. How many seats for flight attendants have to be put onboard?

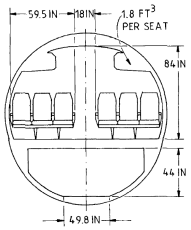
1.5) What about the "range with maximum payload", is it bigger, smaller or the same as the "range with maximum fuel"?

1.6) Please name 5 requirements for a civil passenger aircraft that determine the design point!

1.7) Please name the equation used to calculate MTOW from payload m_{PL}, operating weight empty ratio $\frac{m_{OE}}{m_{MTO}}$ and fuel mass ratio $\frac{m_F}{m_{MTO}}$!

1.8) Which of the certification rules FAR Part 25 or CS-25 has more stringent requirements for the climb gradient after a missed approach.? Please name the requirement?

1.9) Estimate the cabin length for an aircraft with 120 passengers seated in the fuselage depicted here!



1.10) How many emergency exits are required for an aircraft for a maximum of 350 passengers? Minimum a) in the cabin and b) for the whole aircraft.

1.11) Please explain, how it could happen to have "pitch up" for an aircraft with wings swept back!

1.12) Consider a conventional landing gear with nose and main gear. How do you have to arrange the main gear with respect to the center of gravity? How is the rule formulated?

1.13) How are related: Zero lift drag coefficient C_{D0} and induced drag coefficient C_{Di} if you fly with maximum glide ratio E_{max} ?

1.14) Why do some high winged aircraft have a brace? Which pros and cons can you describe?

1.15) How does the tank volume change of a wing, if the aspect ratio is increased (all other parameters are considered to be fixed)?

1.16) How does the mass of the wing change, when the aspect ration of the wing is increased (all other parameters are considered to be fixed)?

1.17) Which three possibilities exist, to increase the static roll stability of an aircraft?

1.18) When flaps are down the moment changes. In which sense?

1.19) Make a sketch of the diagram used to determine the size of the horizontal tail. Please give also the names of the axis!

1.20) Please write down the equation to estimate the zero lift drag coefficient!
Calculation is based on the equivalent skin friction coefficient C_{fe}, the wetted area of the plane S_{wet} and the reference wing area $S_{ref} = S_W$.

1.21) Equipment costs 10000 €. The equipment is written off in 4 years. The residual value is 20%. What is the depreciation (per year)?

Questions to the evening lectures

1.22) Which three features symbolize the current less efficient European Air Traffic Management system?

1.23) What will be introduced in Europa with an aim to defragment the currently fragmented European Air Traffic Management system?

1.24) Please describe the landing gear of the Solar Impulse HB-SIA!

1.25) Make a sketch of the so called ADHF (Adaptive Dropped-Hinge Flap) of the A350-XWB. Show the positions of Flap, Hinge, Spoiler and Wing!

2. Klausurteil

Name:_____

38 Punkte, 120 Minuten, mit Unterlagen und Laptop

Aufgabe 2.1 (18 Punkte)

The task to make a preliminary redesign the short and medium range Airbus A320. This should be done with help of the spread sheet from the lecture.

These are the requirements for the aircraft:

- Payload: 150 passengers with baggage for a flight as given below. Additional cargo: 6,05 t.
- Range 1500 NM with the payload given above (Reserves as given in FAR Part 121 domestic, distance to alternate: 200 NM).
- Take-off field length $s_{TOFL} \leq$ 2200 m (ISA, MSL).
- Landing field length $s_{LFL} \leq$ 1700 m (ISA, MSL).
- Furthermore the requirements from FAR Part 25 §121(b) (2. Segment) and FAR Part 25 §121(d) (missed approach) shall be met.

For you calculation:

- Maximum lift coefficient of the aircraft in landing configuration $C_{L,max,L} = 2{,}9$.
- Correlation factor for landing k_L according to the lecture.
- Maximum lift coefficient of the aircraft in take-off configuration $C_{L,max,TO} = 2{,}07$.
- Find: Glide ratio E in take-off configuration and glide ratio E in landing configuration. With: Aspect ratio $A = 9{,}5$, $C_{D,0} = 0{,}02$ and Oswald factor $e = 0{,}7$.
- The maximum glide ratio in cruise: E_{max} 17,88.
- Oswald factor in cruise: $e = 0{,}85$.
- Mach number in cruise: 0,76.
- The ratio of cruise speed and speed for minimum drag V_{CR}/V_{md} has to be determined so that a favorable matching chart results (determine the ratio to the accuracy of figures after the decimal point)!
- The ratio of maximum landing mass and maximum take-off massis $m_{ML}/m_{MTO} = 0{,}878$.
- The operating empty weight ratio m_{OE}/m_{MTO} is assumed to be 55 % .
- The by-pass ratio (BPR) of the two CFM-56 engines is $\mu = 6$; their thrust specific fuel consumption in cruise and loiter is assumed to be $c = 16$ mg/(Ns).
- USE THESE VALUES as Mission-Segment Fuel Fractions: Engine Start: 0,999; Taxi: 0,996; Take-Off: 0,993; Climb: 0,993; Descent: 0,992; Landing: 0,992.

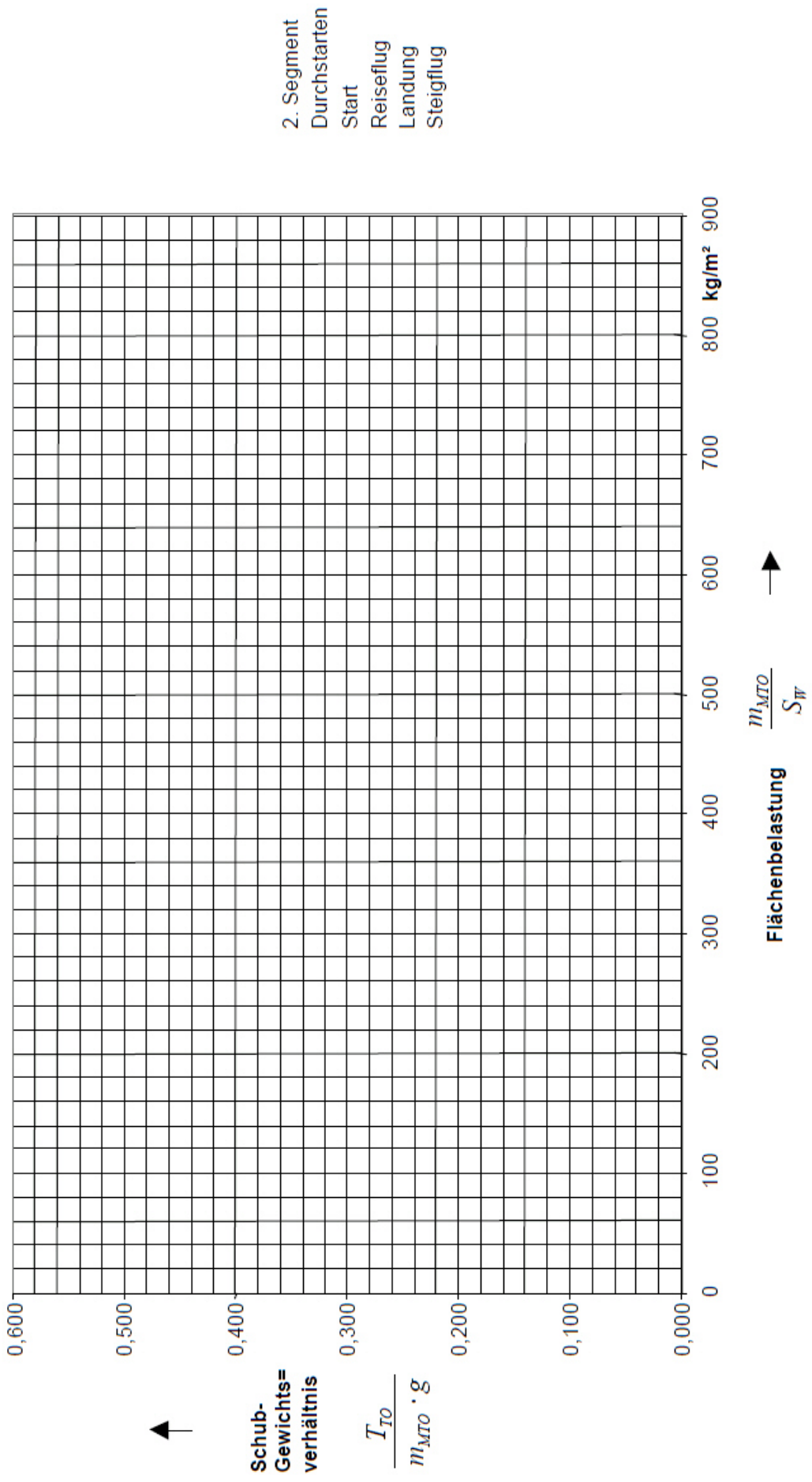
Calculate:

- cruise altitude
- maximum take-off mass
- maximum landing mass
- wing area
- required thrust of one of the two engines
- required tank volume
- Enter your results in the form attached (including all intermediate results that are asked for in the form)! Plot the matching chart!

Ergebnisse zu Aufgabe 2.1

Please insert your results here! Do not forget the units!

- Wing loading from landing field length:
- Thrust to weight ratio from take-off field length:
- Glide Ratio in 2. Segment:
- Glide Ratio during missed approach maneuver:
- Thrust to weight ratio from climb requirement in 2. Segment:
- Thrust to weight ratio from climb requirement during missed approach maneuver:
- V_{CR}/V_{md}:
- Design point
  - Thrust to weight ratio :
  - Wing loading:
- Cruise altitude (**FL**,e.g. 210, 220, 230,…):
- maximum take-off mass **in kg**:
- maximum landing mass **in kg**:
- wing area **in m²**:
- thrust of one engine **in N**:
- required tank volume **in m³**:


2. Segment
Durchstarten
Start
Reiseflug
Landung
Steigflug
0,600
0,500
0,400
0,300
0,200
0,100
0,000
Schub-Gewichts-verhältnis
$\frac{T_{TO}}{m_{MTO} \cdot g}$
0
100
200
300
400
500
600
700
800
900
kg/m²
Flächenbelastung
$\frac{m_{MTO}}{S_W}$

Aufgabe 2.2 (7 Punkte)

Page 9 shows a boxwing based on the Airbus A320. The boxwing was designed from the wing area of the A320 that was split into two wings with equal area. Span remained unchanged.

a) Calculate the aspect ratio of the total aircraft (based on the total wing area) and calculate the aspect ratio of each separate wing.

b) Under *idealized* assumptions: The wings do not interact: What is the ratio of the induced drag of the A320 (*ref*) and the induced drag of the *idealized* boxwing (*BW*)? Hence calculate $\frac{D_{i,BW}}{D_{i,ref}}$!

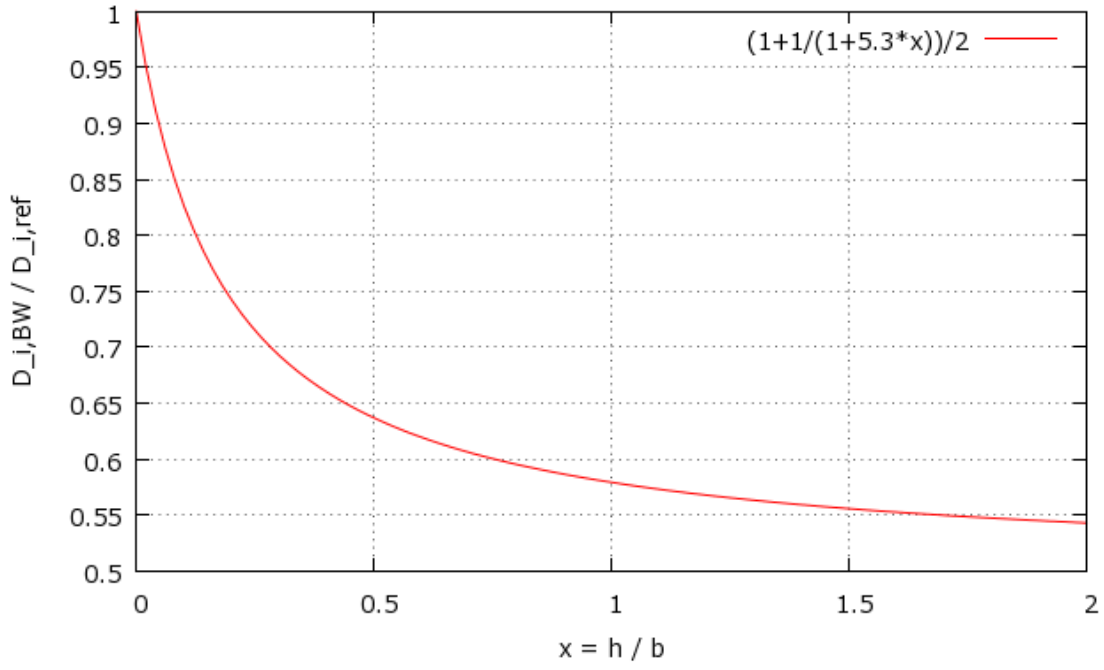
c) The closer the two wings come together, the less is the advantage calculated in b). This is shown in the diagram. Height from one wing to another *h* and span *b* is given, resulting in a ratio $\frac{D_{i,BW}}{D_{i,ref}}$. The equation for $x = h/b$ is printed in the upper right hand corner of the diagram. calculated the ratio of the induced drag of the A320 (*ref*) and the induced drag of the box wing shown on page 9!

d) We assume that the reference aircraft will fly in cruise with maximum glide ratio. What is the ratio of the glide ratios of boxwing and reference aircraft? Find $\frac{E_{BW}}{E_{ref}}$!

i) Calculate this for the ideal case (as in b)!

ii) Calculate this for the case of the boxwing as given on page 9 (as in c)!

Assume: The mass of the two aircraft (*ref* und *BW*) is the same.



Aufgabe 2.3 (3 Punkte)

Compare boxwing versus reference aircraft. Find the ratio of the lift curve slope of the wing at take-off $\frac{C_{L,\alpha,BW}}{C_{L,\alpha,ref}}$! The Mach number at take-off is about $M \approx 0$. The sweep angel at 50% chord line is 20°. Use an equation from the lecture. Which other values depend on the lift curve slope?

Aufgabe 2.4 (3 Punkte)

Compare boxwing versus reference aircraft. Find the ratio of the tank volume of the wing $\frac{V_{tank,BW}}{V_{tank,ref}}$!

Use an equation from the lecture. Argue your case carefully!

Aufgabe 2.5 (3 Punkte)

Compare boxwing versus reference aircraft. Find the ratio of the wing mass $\frac{m_{W,BW}}{m_{W,ref}}$!

Use an equation from the lecture. Argue your case carefully!

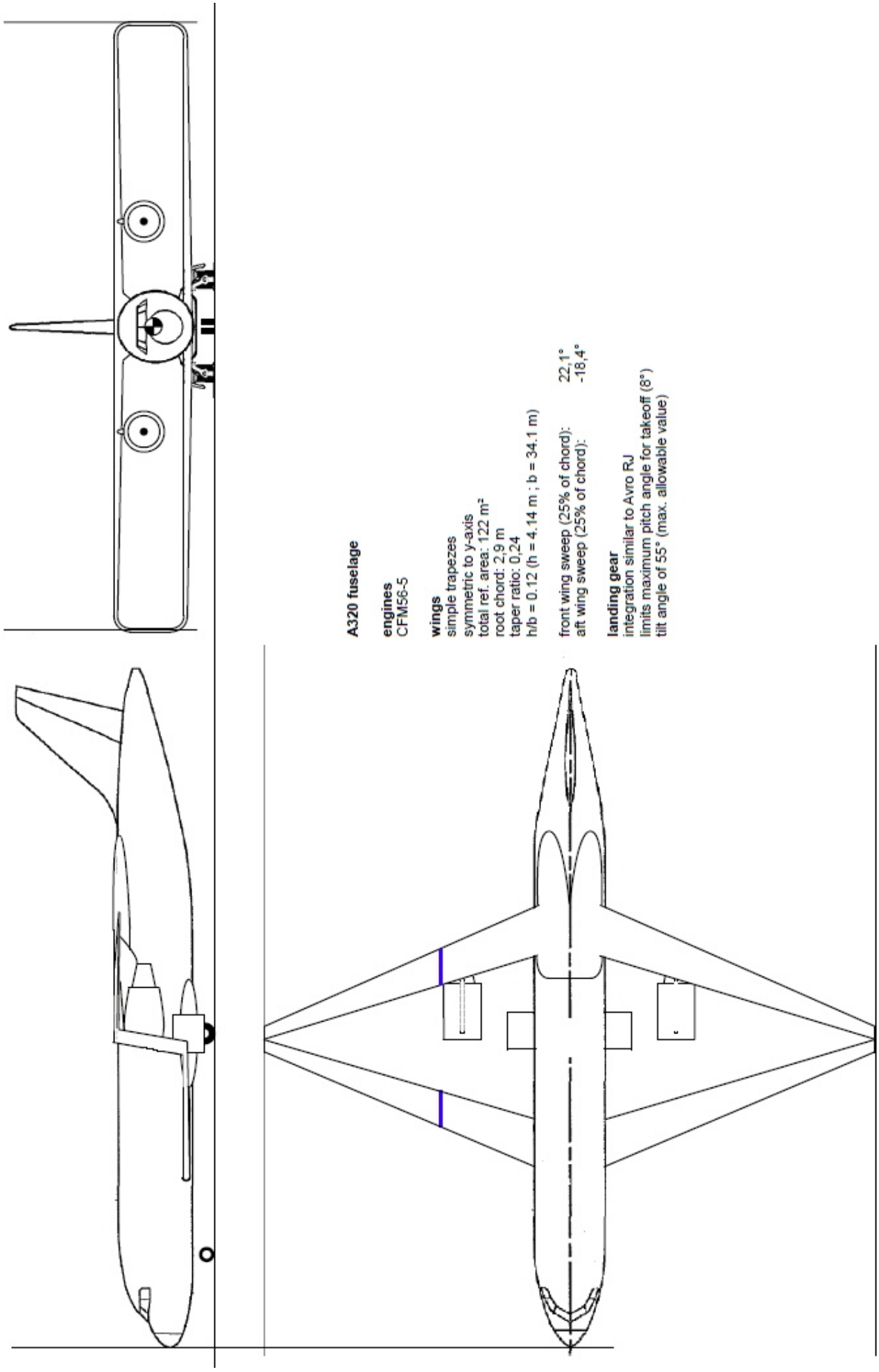
Assume: The vertical connection of the wing of the boxwing will not reduce the loads and does not contribute mass to the wing.

Aufgabe 2.6 (2 Punkte)

The boxwing has a forward swept wing and an aft swept wing. Talk about the stall characteristics including "pitch up". Argue your case carefully!

Aufgabe 2.7 (2 Punkte)

The boxwing from page 9 shows only *one* possibility for engine integration. Show other variants. Discuss pros and cons of your variants? Argue your case carefully!


A320 fuselage
engines
CFM56-5
wings
simple trapezes
symmetric to y-axis
total ref. area: 122 m²
root chord: 2,9 m
taper ratio: 0,24
h/b = 0.12 (h = 4.14 m ; b = 34.1 m)
front wing sweep (25% of chord): 22,1°
aft wing sweep (25% of chord): -18,4°
landing gear
integration similar to Avro RJ
limits maximum pitch angle for takeoff (8°)
tilt angle of 55° (max. allowable value)