UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Kedua
Sidang Akademik 2005/2006
Second Semester Examination
2005/2006 Academic Session

April/Mei 2006
April/May 2006

ESA 362/3 – Kawalan Penerbangan Pesawat
Aircraft Flight Control

Masa : [3 jam]
Hour : [3 hours]

ARAHAN KEPADA CALON :
INSTRUCTION TO CANDIDATES:

Sila pastikan bahawa kertas soalan ini mengandungi **DUA PULUH (20)** mukasurat termasuk lampiran dan **LIMA (5)** soalan sebelum anda memulakan peperiksaan.
*Please ensure that this paper contains **TWENTY (20)** printed pages including attachment and **FIVE (5)** questions before you begin examination.*

Jawab **EMPAT (4)** soalan. Soalan nombor **1, 2 dan 3** mesti dijawab. Sila pilih salah satu soalan nombor **4 atau 5.**
*Answer **FOUR (4)** the questions. Question number **1, 2 and 3** must be answered. Please choose one question number **4 or 5**.*

Soalan boleh dijawab dalam Bahasa Inggeris kecuali satu soalan mestilah dijawab dalam Bahasa Malaysia.
The question can be answered in English but one question must be ansawered in Bahasa Malaysia.

Setiap soalan mestilah dimulakan pada mukasurat yang baru.
Each questions must begin from a new page.

1. (a) Sila senaraikan enam langkah dalam merekabentuk pengawal (hukum kawalan) untuk sistem kawalan automatik penerbangan.

Please list down six steps in designing the controller (control law) for an automatic flight control system.

(10 markah/*marks*)

(b) Senaraikan 3 jenis sistem kawalan automatik?

List 3 kinds of automatic flight control system?

(10 markah/*marks*)

(c) Sebutkan jenis-jenis mod pandu automatik bagi pesawat udara dan fungsi-fungsinya.

Mention the autopilot modes for aircraft and their functions.

(10 markah/*marks*)

(d) Sila berikan empat jenis persamaan yang membentuk persamaan tidak linear gerak pesawat dan fungsi-fungsinya.

Please give four equations which form the nonlinear equations of motion of the aircraft and their functions.

(10 markah/*marks*)

(e) Mengapakah kita perlu menentukan keadaan mantap penerbangan trim sebelum memulakan proses lelurus dan simulasi penerbangan.

Why do we need to determine a steady-state, trimmed flight condition before starting the linearization process and flight simulation.

(10 markah/*marks*)

(f) Sila tuliskan model lelurus gerak pesawat membujur dalam bentuk perwakilan keadaan ruang.

Please write the linear model for longitudinal motion in *the form of state space representation.*

(10 markah/*marks*)

(g) Apakah perbezaan di antara "short period mode" dan "phugoid mode"?

What are the differences between short period and phugoid modes?

(10 markah/*marks*)

(h) Tuliskan fungsi pindah yang menggambarkan

Write the approximated transfer function describing

(i) sambutan kadar anggul disebabkan oleh pesongan sudut elevator

the response of pitch rate due to the elevator deflection

(ii) sambutan halaju udara di sebabkan oleh kedudukan "throttle"

the response of airspeed due to the lever throttle

(10 markah/*marks*)

(i) Sila lukiskan gambarajah aliran isyarat (SFD) bagi tempoh mod “short period” yang dipemudahkan.

Please draw the signal flow diagram (SFD) of simplified Short period-mode.

(10 markah/*marks*)

(j) Sila lukiskan gambarajah aliran isyarat (SFD) bagi mod-'phygoid' yang dipemudahkan.

Please draw the signal flow diagram (SFD) of simplified phygoid - mode.

(10 markah/*marks*)

2. Pesawat penumpang jenis A 300 sedang membuat penerbangan di dalam keadaan atmosfera tidak terganggu (udara tenang dan tiada angin). Keadaan penerbangan yang pegun dan secara simetri diberi seperti berikut:

A passenger aircraft of Type A 300 is performing level flight in the undisturbed atmosphere (still air , no wind). The stationary, symmetrical flight condition is given below

Jisim pesawat	m = 140,000.00 kg
Kelajuan Angin	V = 120 m/s
Kedudukan pusat graviti	(Xs- 0.25) = 0.05
Kedudukan menegak tujahan enjin	Z_E = 2.65 m
Sudut condong enjin	σ = 2.2 degree

Mass of the aircraft	*m = 140,000.00 kg*
Airspeed	*V = 120 m/s*
Position of the centre of gravity	*(Xs- 0.25) = 0.05*
Vertical position of engine thrust	Z_E *= 2.65 m*
The Inclination angle of engine	σ *= 2.2 degree*

Selepas mendapatkan persamaan gerakan bagi penerbangan secara membujur dan penentuan keadaan mantap penerbangan trim, data penerbangan dalam keadaan ini diberi seperti yang berikut:

After setting up equation of motion for longitudinal flight and determining the steady-state trimmed flight condition, the data of that trim flight condition is provided as follows:

$$\alpha_0 = 0.0925 = 5.3^0$$

$$C_{L,0} = 0.74$$

$$C_{D,0} = 0.045$$

$$C_{m,0} = -0.0182$$

$$C_{\mu,0} = 0.0455 (thrust\, coefficient)$$

$$i_{H,0} = -0.0068 = 0.39^0$$

(a) Kira terbitan dimensi aerodinamik yang berikut

$M_q, M_\alpha, M_u, Z_\alpha, Z_u, X_\alpha, X_u$

Calculate the following dimensional aerodynamic derivatives:

$M_q, M_\alpha, M_u, Z_\alpha, Z_u, X_\alpha, X_u$

(100 markah/*marks*)

(b) Tentukan terbitan dimensi kawalan yang berikut:

$M_\eta, M_f, Z_\eta, Z_f, X_\eta, X_f$

Determine the following dimensional control derivatives:

$M_\eta, M_f, Z_\eta, Z_f, X_\eta, X_f$

(100 markah/*marks*)

3. Sila nyatakan persamaan lelurus gerak penerbangan membujur

Represent the linear equation of motion for longitudinal flight

(a) dalam bentuk perwakilan keadaan ruang $\underline{\dot{X}} = \underline{\underline{A}}\,\underline{X} + \underline{\underline{B}}\,\underline{U}$

in form of the state – space representation $\underline{\dot{X}} = \underline{\underline{A}}\,\underline{X} + \underline{\underline{B}}\,\underline{U}$

(b) gambarajah blok isyarat

signal diagram block

(100 markah/*marks*)

4. Berdasarkan persamaan hampir bagi mod kalaan pendek, tentukan yang berikut:

Based on the approximate equation for short-period mode, determine the following:

(a) fungsi pindah $f_{q\eta}$

the transfer function $f_{q\eta}$

(b) redaman ζ dan frekuensi tabii ω_0 kalaan pendek

the damping ζ *and natural frequency* ω_0 *of short period*

(c) ciri-ciri awalan dan akhiran kepegunan q yang disebabkan oleh input langkah η.

initial – and stationary characteristics of q *due to step input of* η

(100 markah/*marks*)

5. Berdasarkan persamaan terdekat untuk mod phugoid, tentukan yang berikut:

Based on the approximate equation for phugoid mode, determine the following:

(a) fungsi pindah f_{uf}

the transfer function f_{uf}

(b) redaman ζ dan frekuensi tabii ω_0 mod phugoid

the damping ζ *and natural frequency* ω_0 *of phugoid mode*

(c) ciri-ciri awalan dan akhiran kepegunan u yang disebabkan oleh input langkah pengesetan pengawal imbang f

initial – and stationary characteristics of u due to step input of throttle setting f

(100 markah/*marks*)

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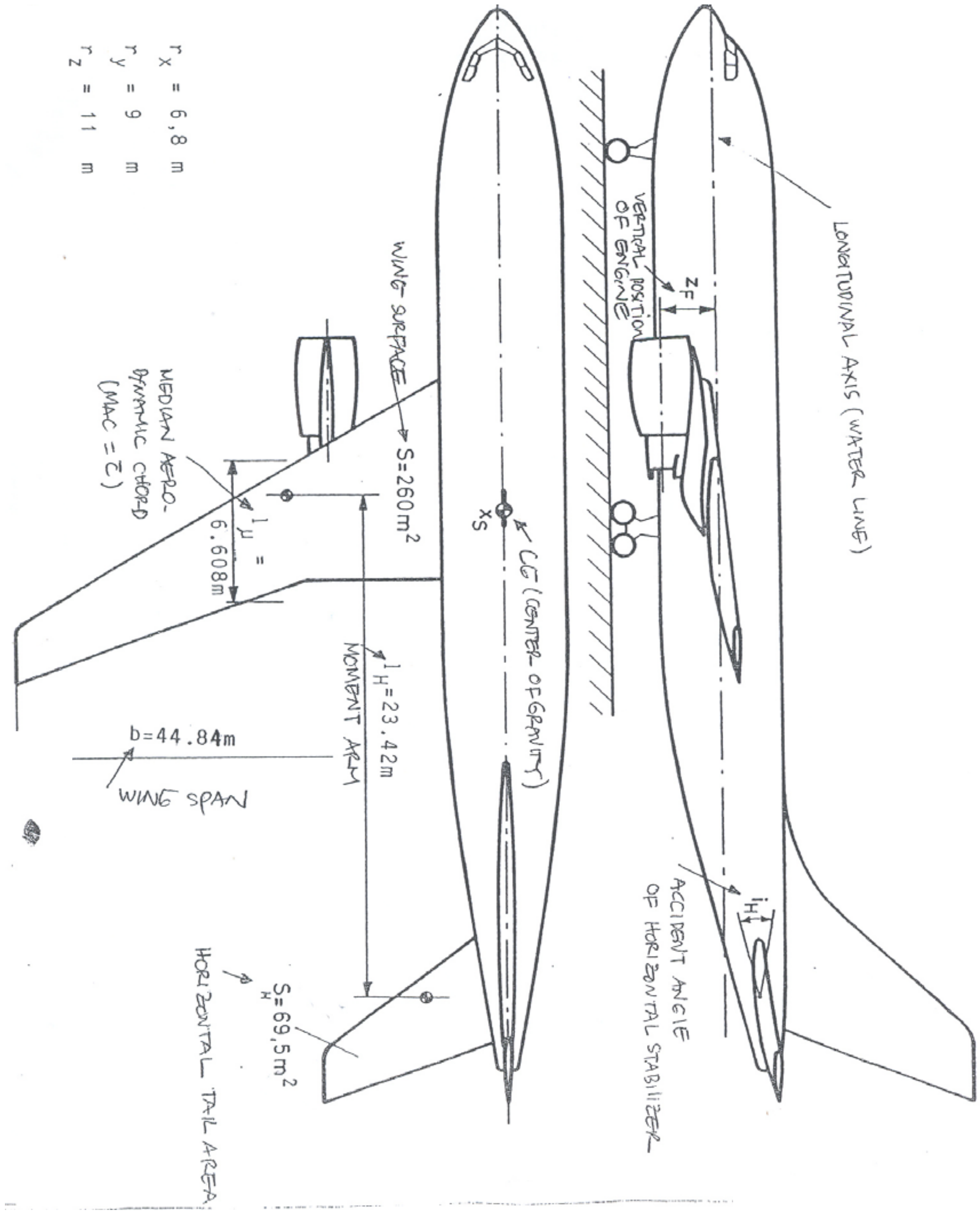
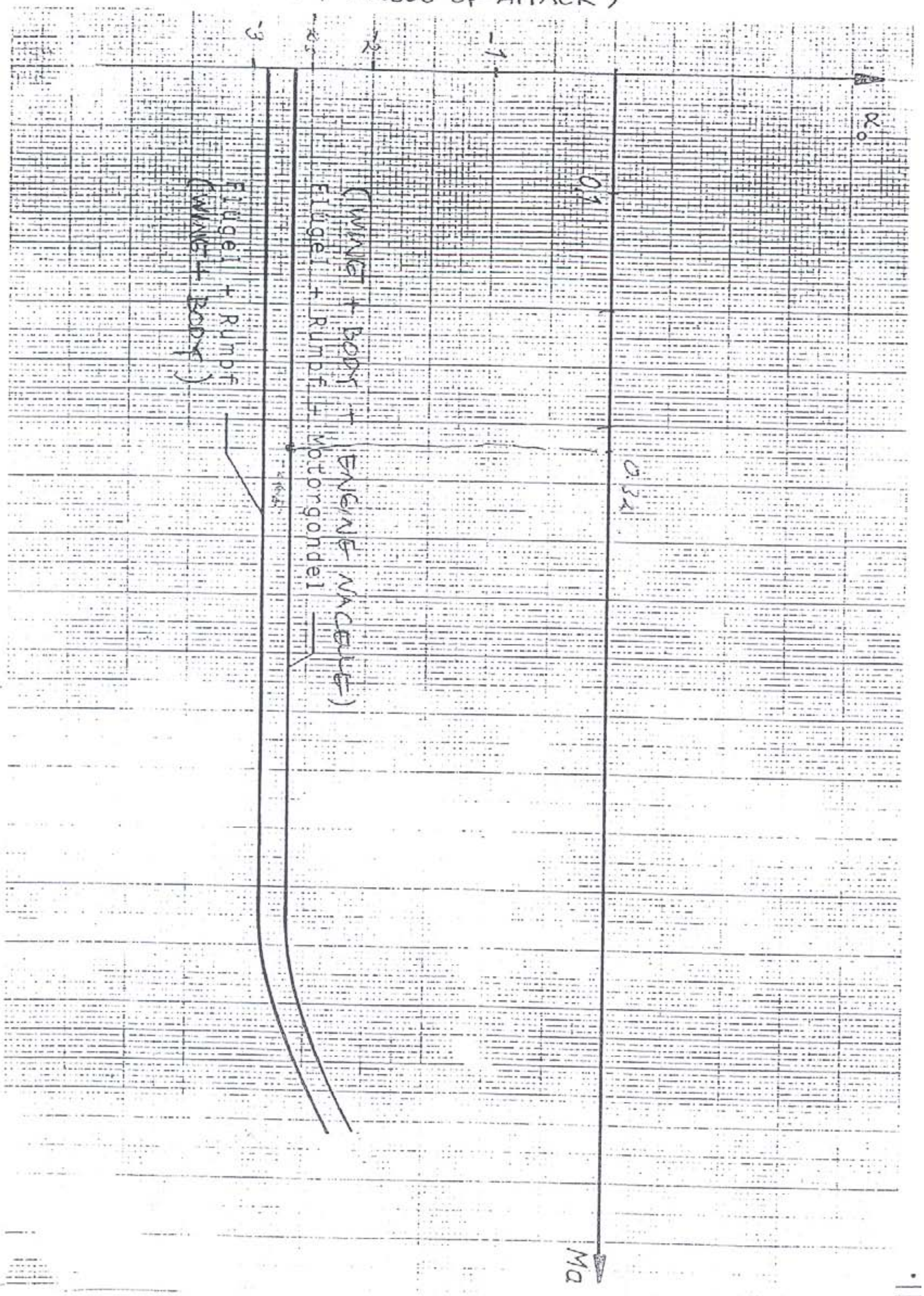
LAMPIRAN/*ATTACHMENT*



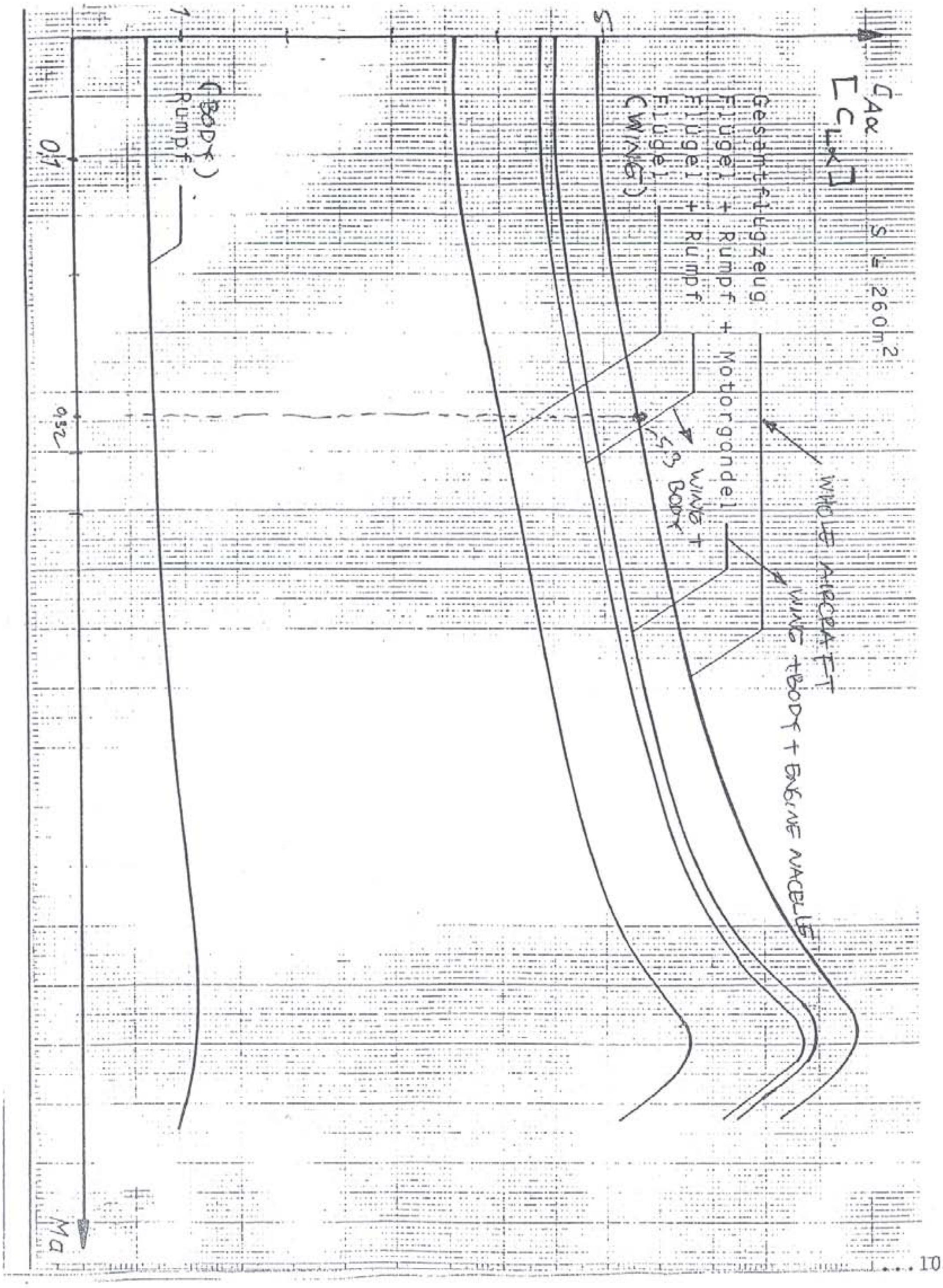
Anstellwinkel bei Auftrieb Null

(ZERO LIFT ANGLE OF ATTACK)

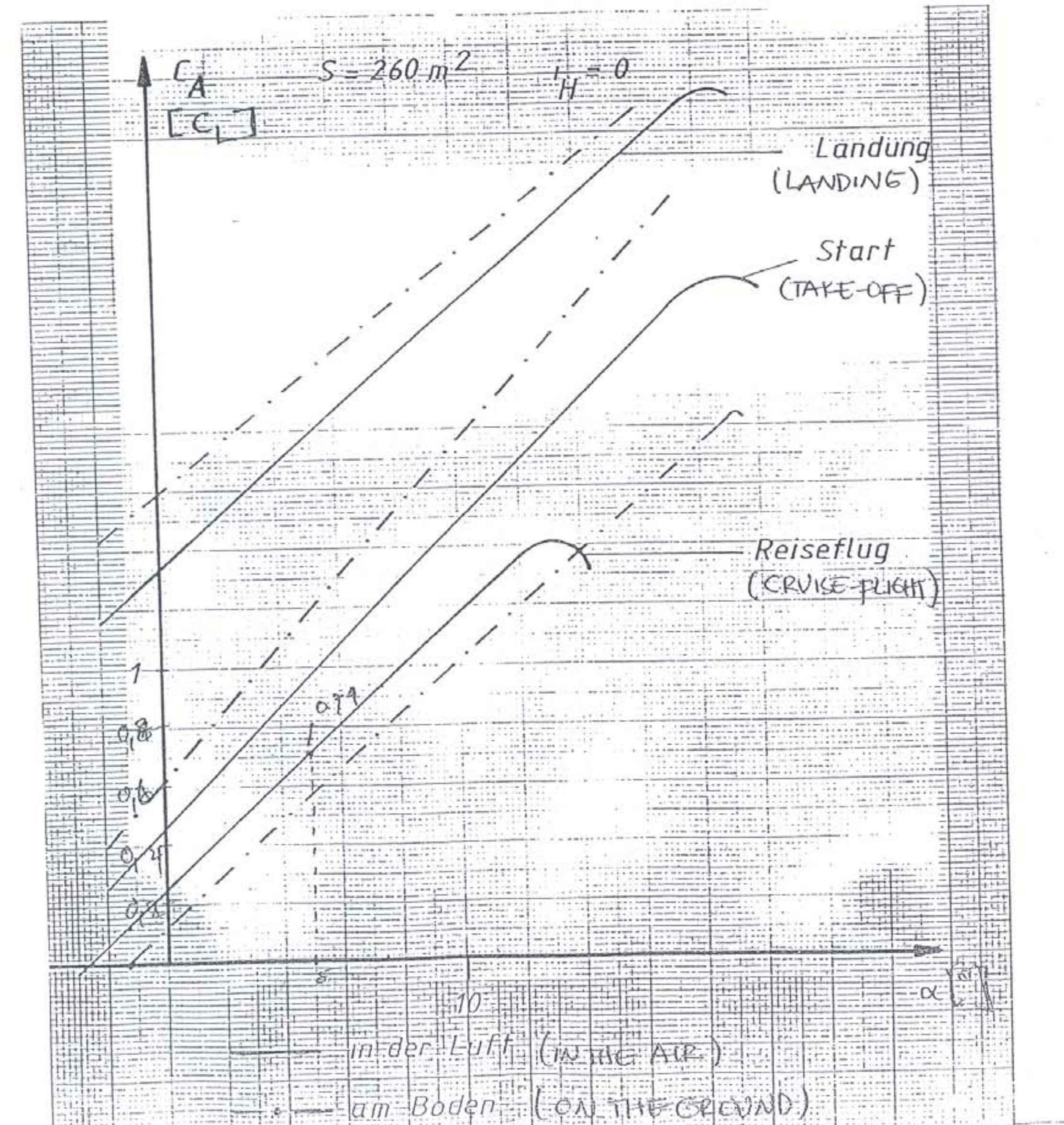


Auftriebsanstieg als Funktion der Machzahl

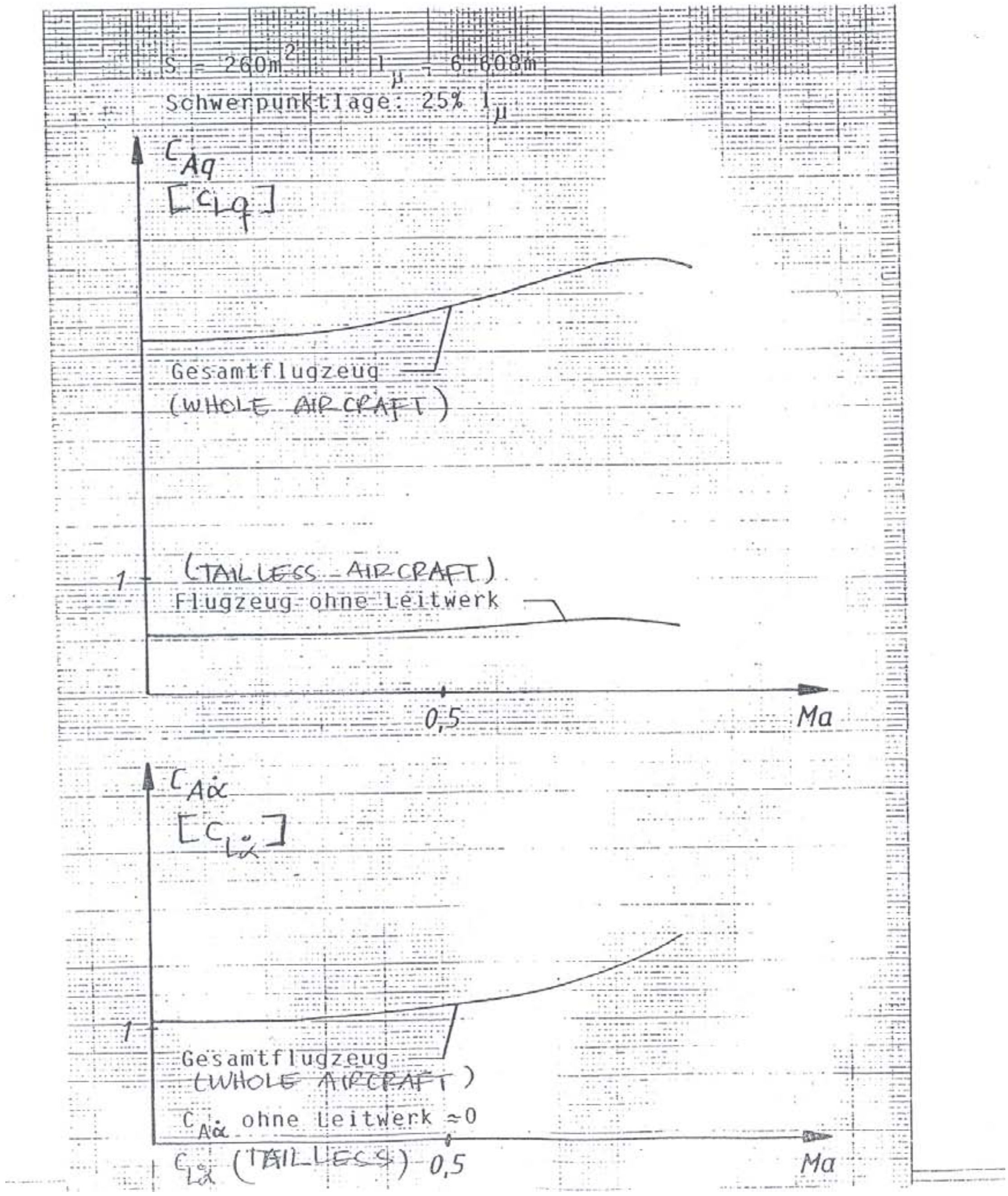
(LIFT-SLOPE AS FUNCTION OF MACH-NUMBER)



(LIFT-COEFFICIENT OF WHOLE AIRCRAFT AT SLOW AIRSPEEDS)
Auftriebsbeiwert des Gesamtflugzeugs bei niedrigen Geschwindigkeiten

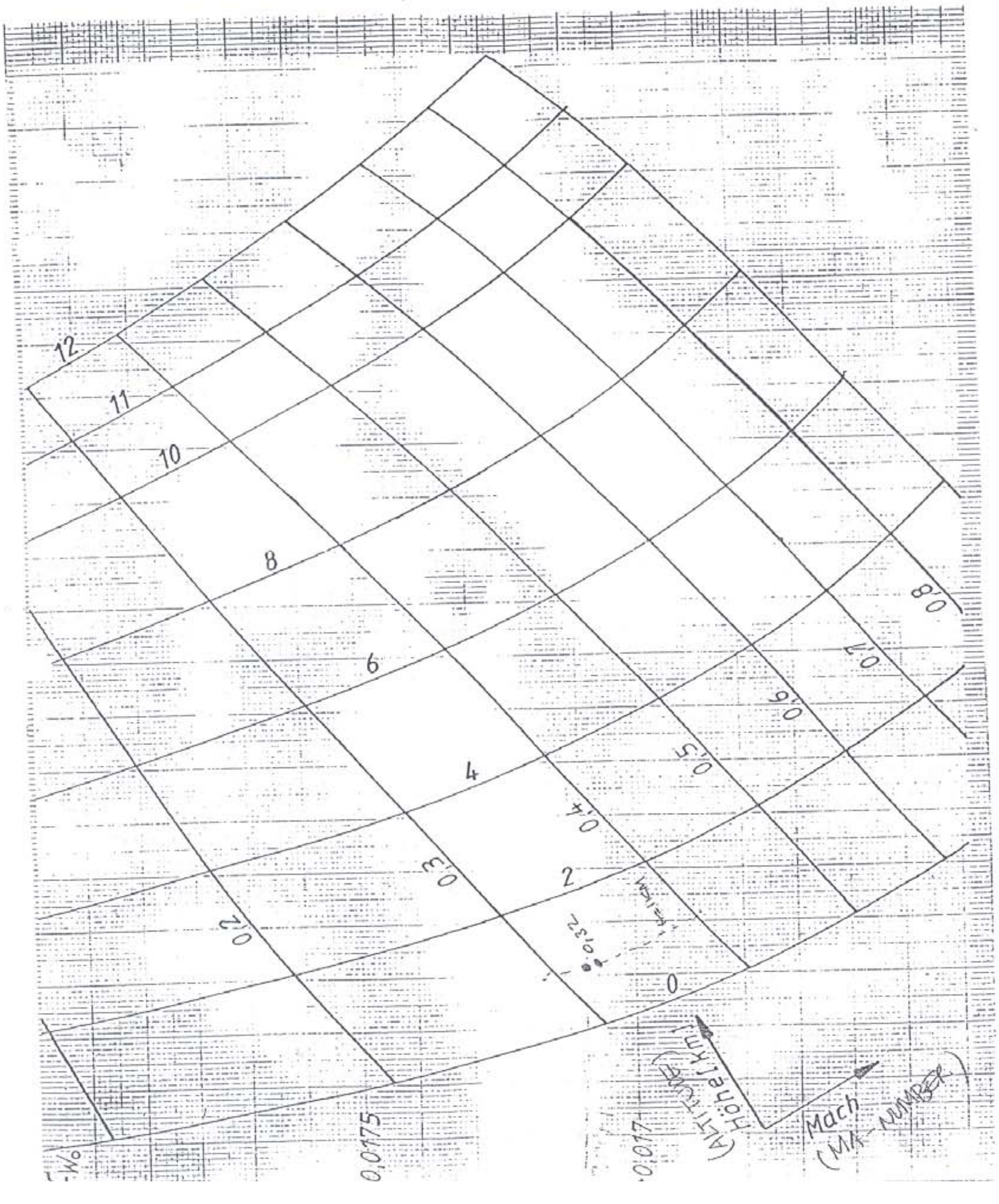


(LIFT-SLOPE DUE TO PITCH-RATE)
Auftriebsanstieg infolge Nickgeschwindigkeit
(LIFT-SLOPE DUE TO AOA-CHANGE)
Auftriebsanstieg infolge Anstellwinkeländerung



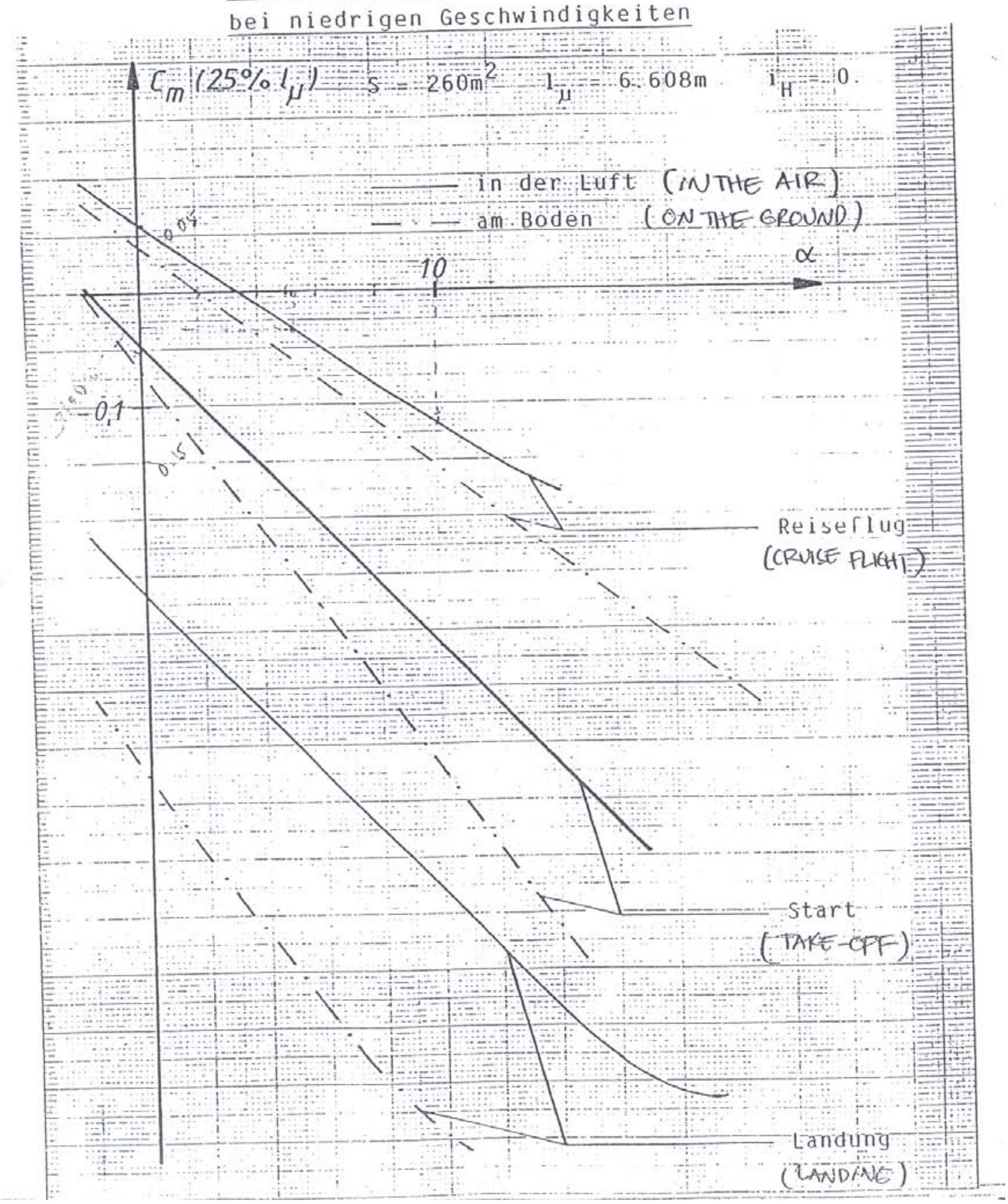
Nullwiderstandsbeiwert als Funktion von Höhe und Machzahl

(ZERO DRAG COEFFICIENT ALS FUNCTION OF ALTITUDE & MA-NUMBER)

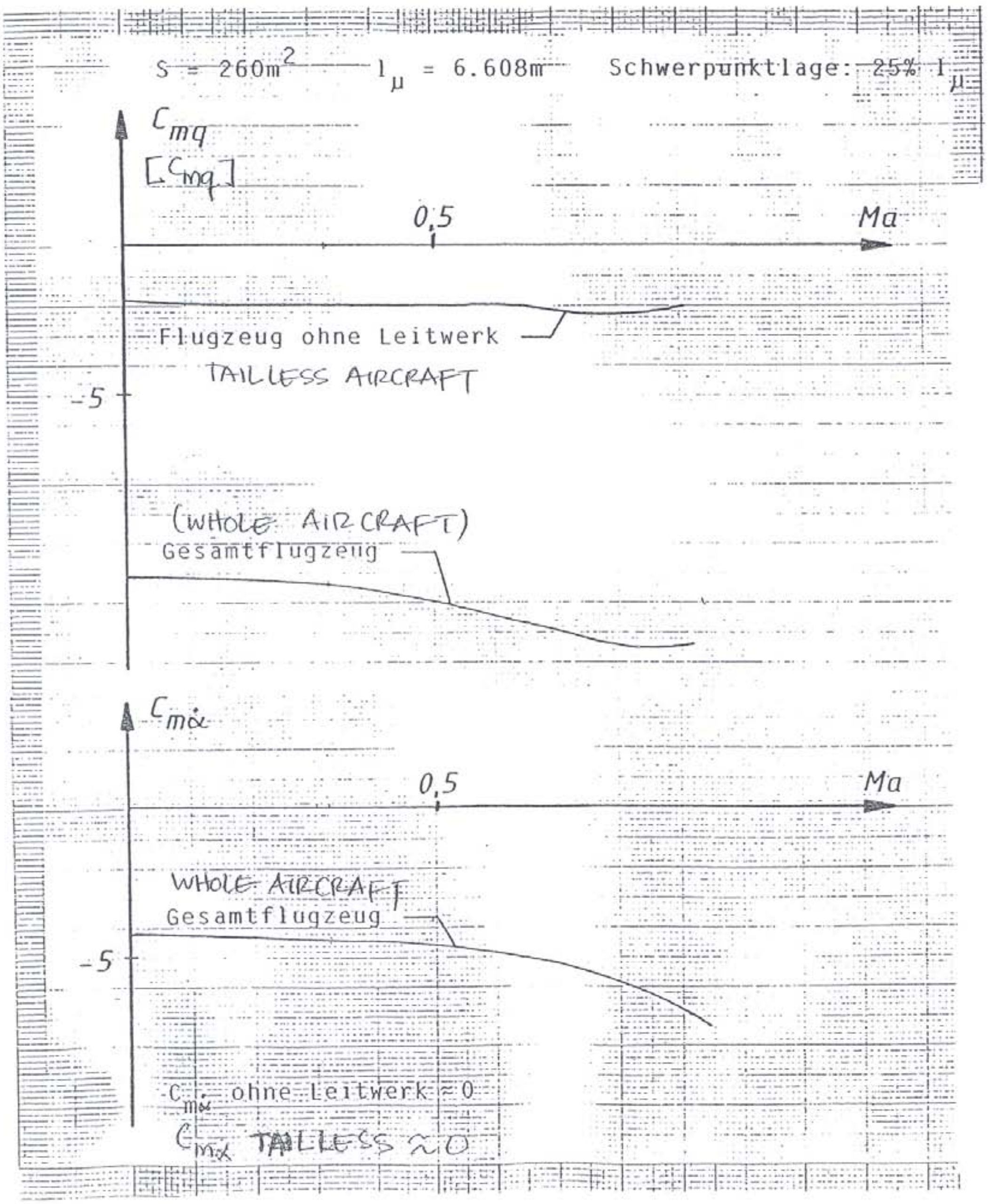


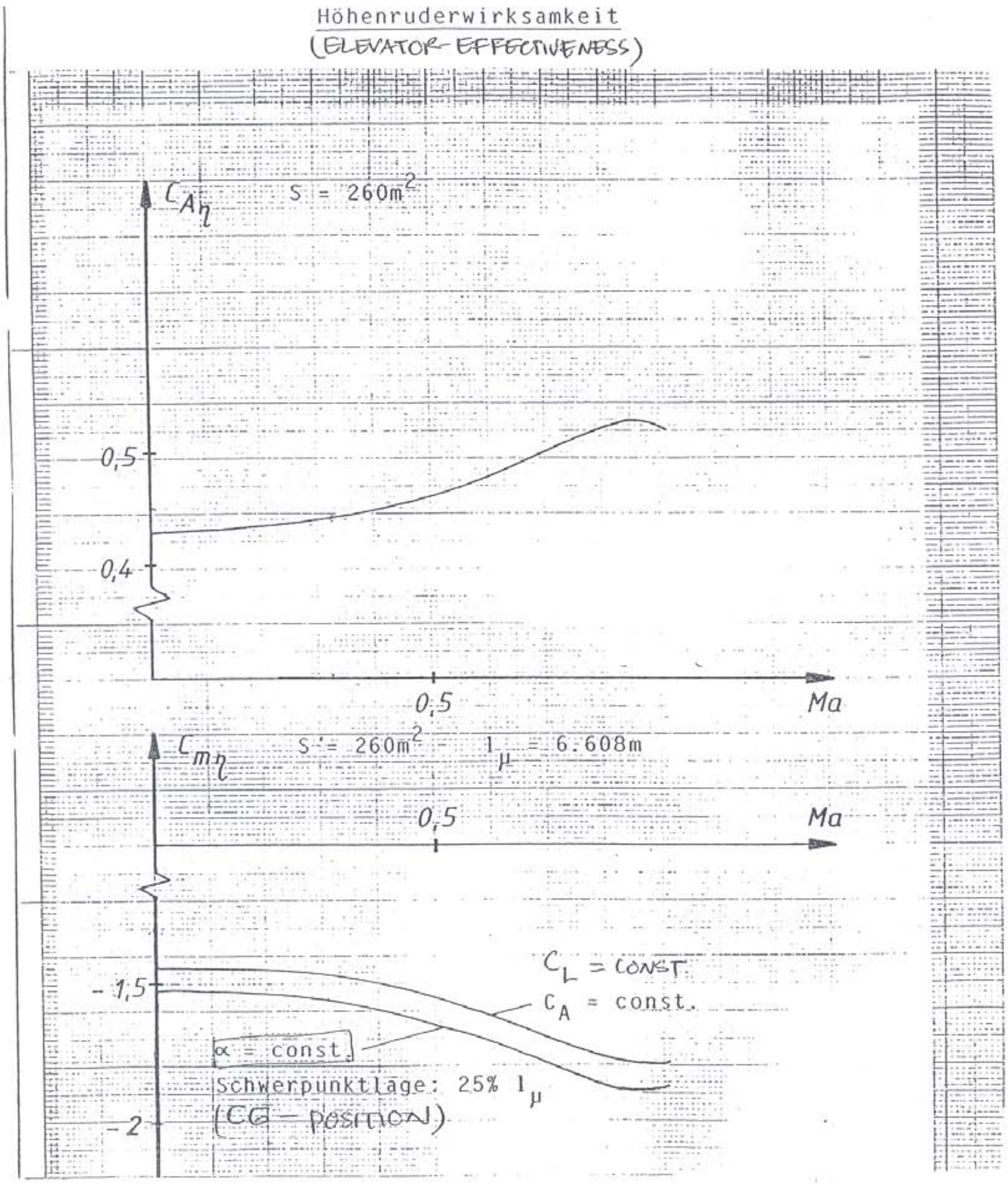
PITCH MOMENT COEFFICIENT OF WHOLE AIRCRAFT AT LOW AIRSPEEDS

Nickmomentenbeiwert des Gesamtflugzeugs bei niedrigen Geschwindigkeiten

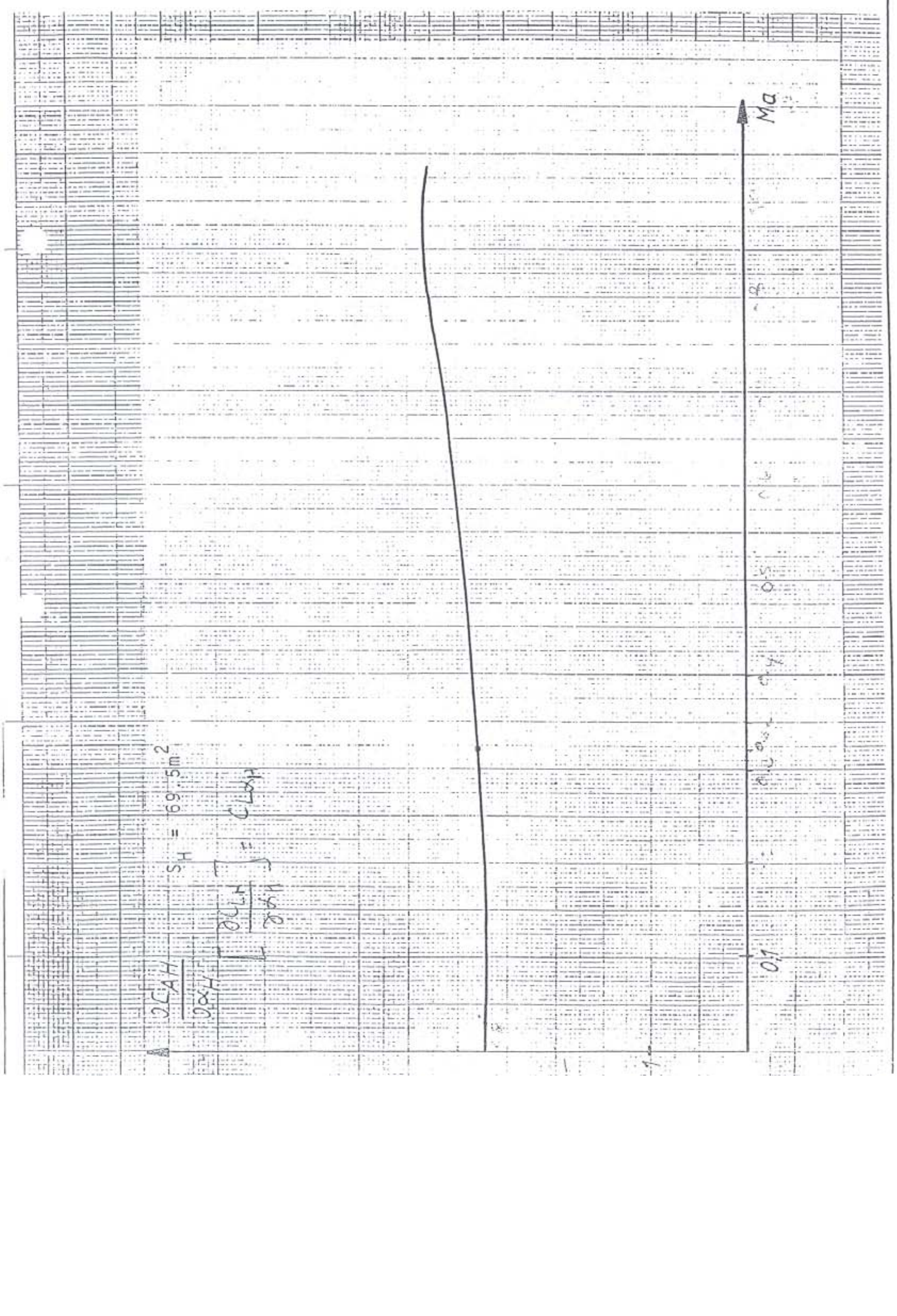


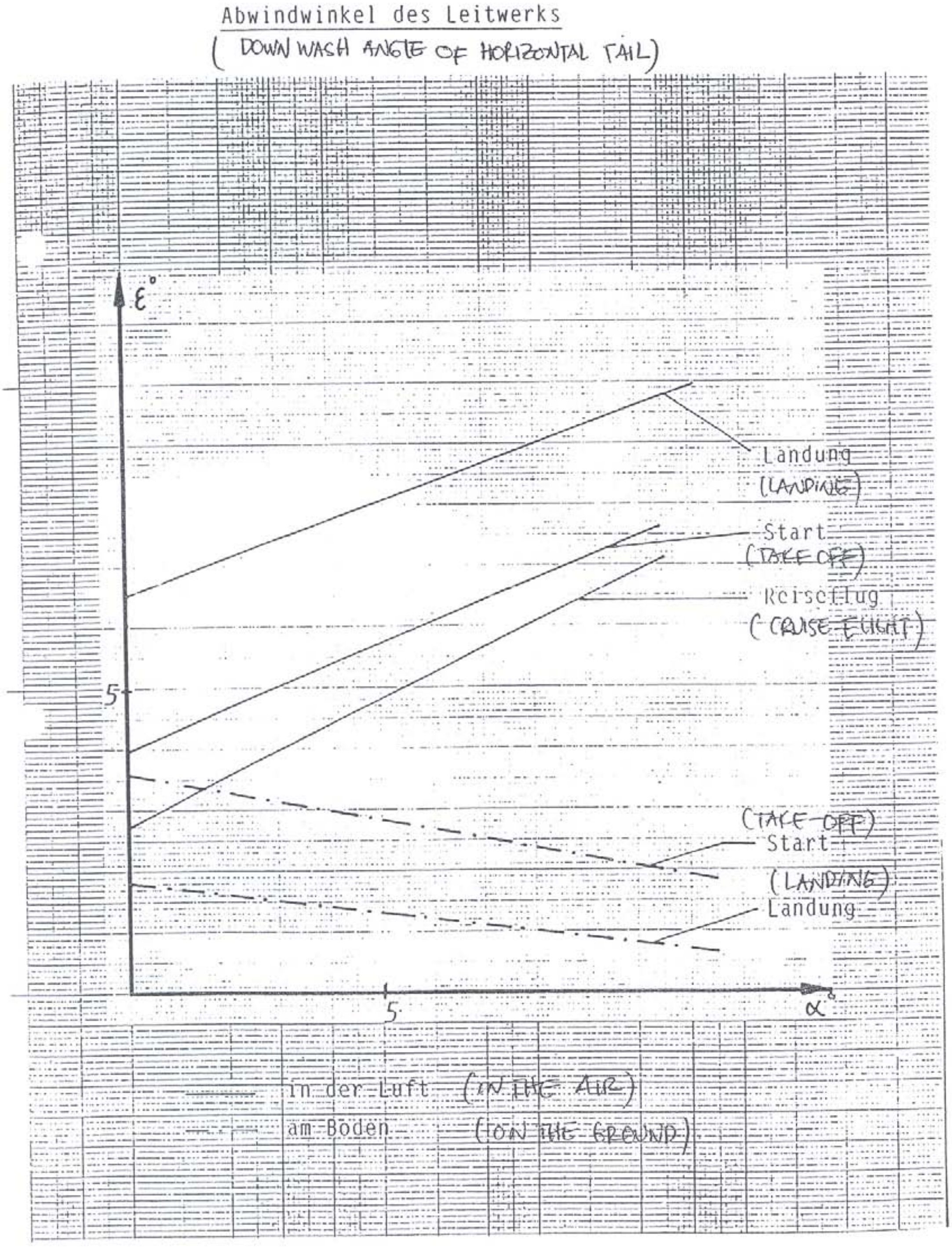
Nickdämpfung und Abwindverzögerung
PITCH DAMPING & UPWIND LAG)




Höhenruderwirksamkeit
(ELEVATOR-EFFECTIVENESS)
C_{A_η}
S = 260m²
0,5
0,4
0,5
Ma
C_{m_η}
S = 260m²
l_μ = 6.608m
0,5
Ma
C_L = CONST.
C_A = const.
α = const.
-1,5
Schwerpunktlage: 25% l_μ
(CG – POSITION)
-2

Auftriebsgradient des Höhenruders
(LIFT COEFFICIENT OF ELEVATOR)




Abwindwinkel des Leitwerks
(DOWN WASH ANGLE OF HORIZONTAL TAIL)
ε°
5
Landung
(LANDING)
Start
(TAKE OFF)
Reiseflug
(CRUISE FLIGHT)
(TAKE-OFF)
Start
(LANDING)
Landung
5
α°
in der Luft (IN THE AIR)
am Boden (ON THE GROUND)

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