UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2007/2008 Academic Session
Peperiksaan Semester Kedua
Sidang Akademik 2007/2008

April 2008
April 2008

ESA 362/3 – Aircraft Flight Control
Kawalan Penerbangan Pesawat

Duration : 3 hours
[Masa : 3 jam]

INSTRUCTION TO CANDIDATES
ARAHAN KEPADA CALON

Please ensure that this paper contains **NINETEEN (19)** printed pages including attachment and **FIVE (5)** questions before you begin examination.
*Sila pastikan bahawa kertas soalan ini mengandungi **SEMBILAN BELAS (19)** mukasurat bercetak termasuk lampiran dan **LIMA (5)** soalan sebelum anda memulakan peperiksaan.*

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

Student may answer the questions either in English or Bahasa Malaysia.
Pelajar boleh menjawab soalan dalam Bahasa Inggeris atau Bahasa Malaysia.

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

Appendix : Page 9 to 19
Lampiran : Mukasurat 9 hingga 19

1. (a) List 3 kinds of automatic flight control system?

Senaraikan 3 jenis sistem kawalan automatik?

(10 marks/*markah*)

(b) Mention the autopilot modes for aircraft and their functions.

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

(10 marks/*markah*)

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

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

(10 marks/*markah*)

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

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

(10 marks/*markah*)

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

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

(10 marks/*markah*)

(f) Please write the linear model for Longitudinl motion in the form of state space representation.

Sila tuliskan model lelurus gerak pesawat longitudinal dalam bentuk perwakilan keadaan ruang.

(10 marks/*markah*)

(g) What are the differences between "short period mode", and "phygoid"?

Apakah perbezaan di antara "short period" dan "phygoid"?

(10 marks/*markah*)

(h) Write the approximated transfer function describing

Tuliskan fungsi pindah yang menggambarkan

(i) elevator the response of angle of attack due to the elevator deflection

sambutan sudut serang disebabkan oleh pesongan sudut

(ii) "throttle" the response of airspeed due to the lever throttle

sambutan halaju udara di sebabkan oleh kedudukan

(10 marks/*markah*)

(i) Please draw the signal flow diagram (SFD) of simplified Short periodmode.

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

(10 marks/*markah*)

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

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

(10 marks/*markah*)

2. 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

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:

Mass of the aircraft	m = 100,000.00 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
Jisim pesawat	*m = 100,000.00 kg*
Kelajuan pesawat	*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*

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:

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

$$\alpha_0 = 0.0925 = 5.3^0$$
$$C_{L,0} = 0.74$$
$$C_{D,0} = 0.045$$
$$C_{m,0} = -0.0182$$
$$C_{\mu,0} = 0.0455(thrust\,coefficient)$$
$$i_{H,0} = -0.0068 = 0.39^0$$

(a) Calculate the following dimensional aerodynamic derivatives:

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

Kira terbitan dimensi aerodinamik yang berikut:

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

(50 marks/*markah*)

(b) Determine the following dimensional control derivatives:

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

Tentukan terbitan dimensi kawalan yang berikut:

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

(50 marks/*markah*)

3. Represent the linear equation of motion for longitudinal flight

Sila nyatakan persamaan lelurus gerak penerbangan membujur

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

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

(b) signal diagram block

gambarajah blok isyarat

(100 marks/*markah*)

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

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

(a) the transfer function $f_{\alpha\eta}$

fungsi pindah $f_{\alpha\eta}$

(b) the damping ζ and natural frequency ω_0 of short period

redaman ζ *dan frekuensi tabii* ω_0 *kalaan pendek*

(c) initial – and stationary characteristics of α due to step input of η

ciri-ciri awalan dan akhiran kepegunan α *yang disebabkan oleh input langkah* η

(100 marks/*markah*)

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

Berdasarkan persamaan terdekat untuk mod phugoid, tentukan yang berikut:

(a) the transfer function f_{uf}

fungsi pindah f_{uf}

(b) the damping ζ and natural frequency ω_0 of phugoid mode

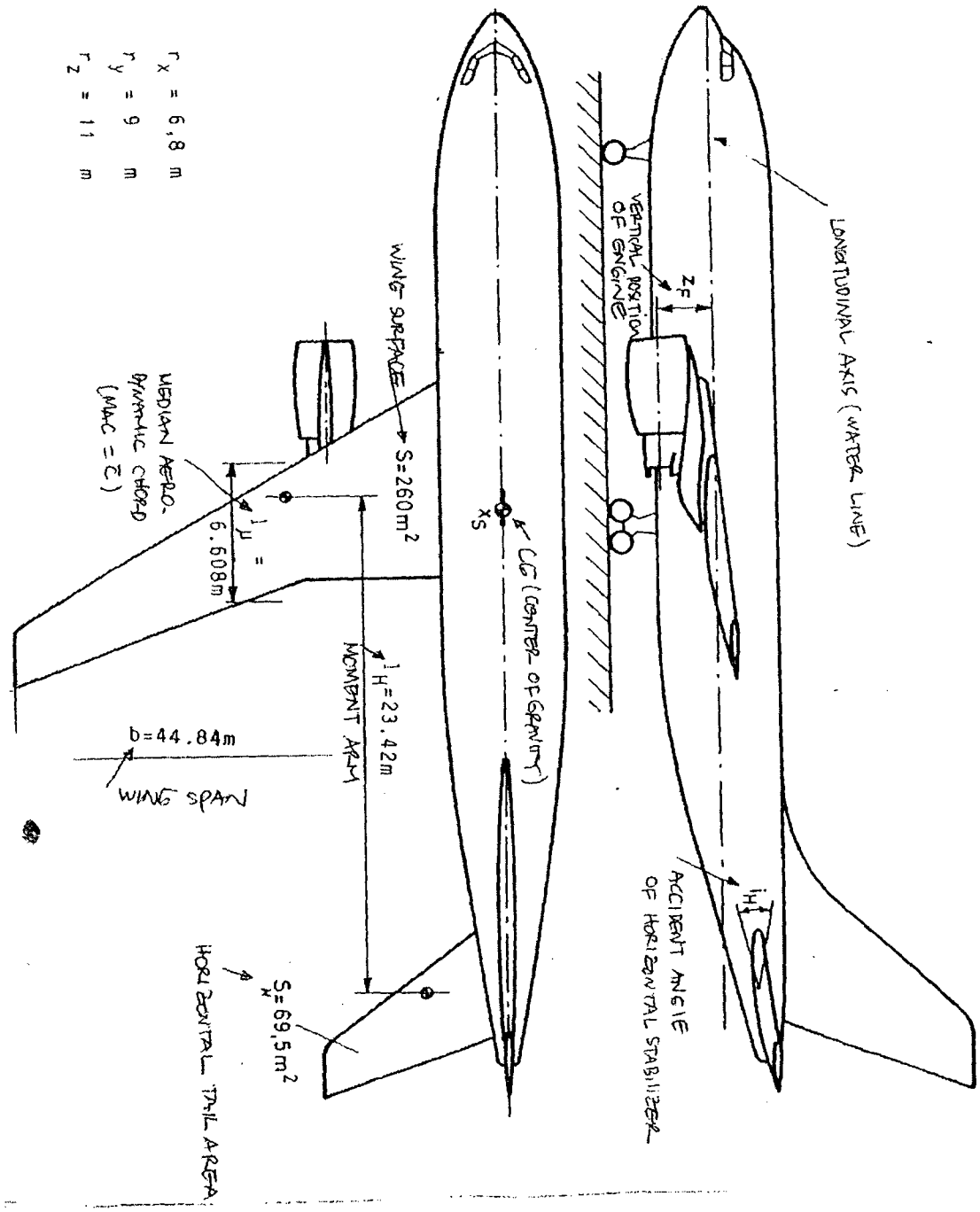
redaman ζ *dan frekuensi tabii* ω_0 *mod phugoid*

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

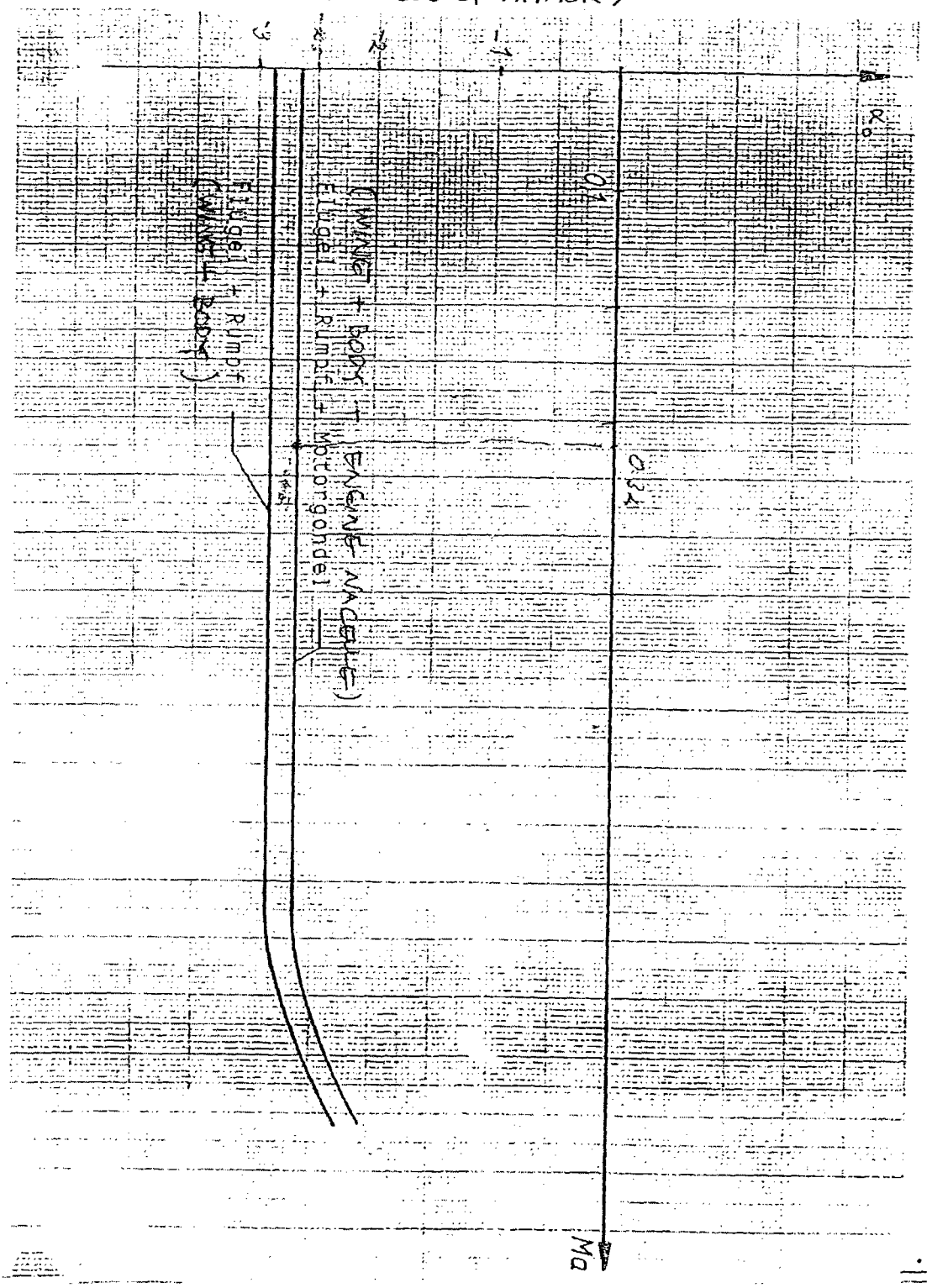
ciri-ciri awalan dan akhiran kepegunan u yang disebabkan oleh input langkah pengesetan pengawal imbang f

(100 marks/*markah*)

LAMPIRAN/*ATTACHMENT*

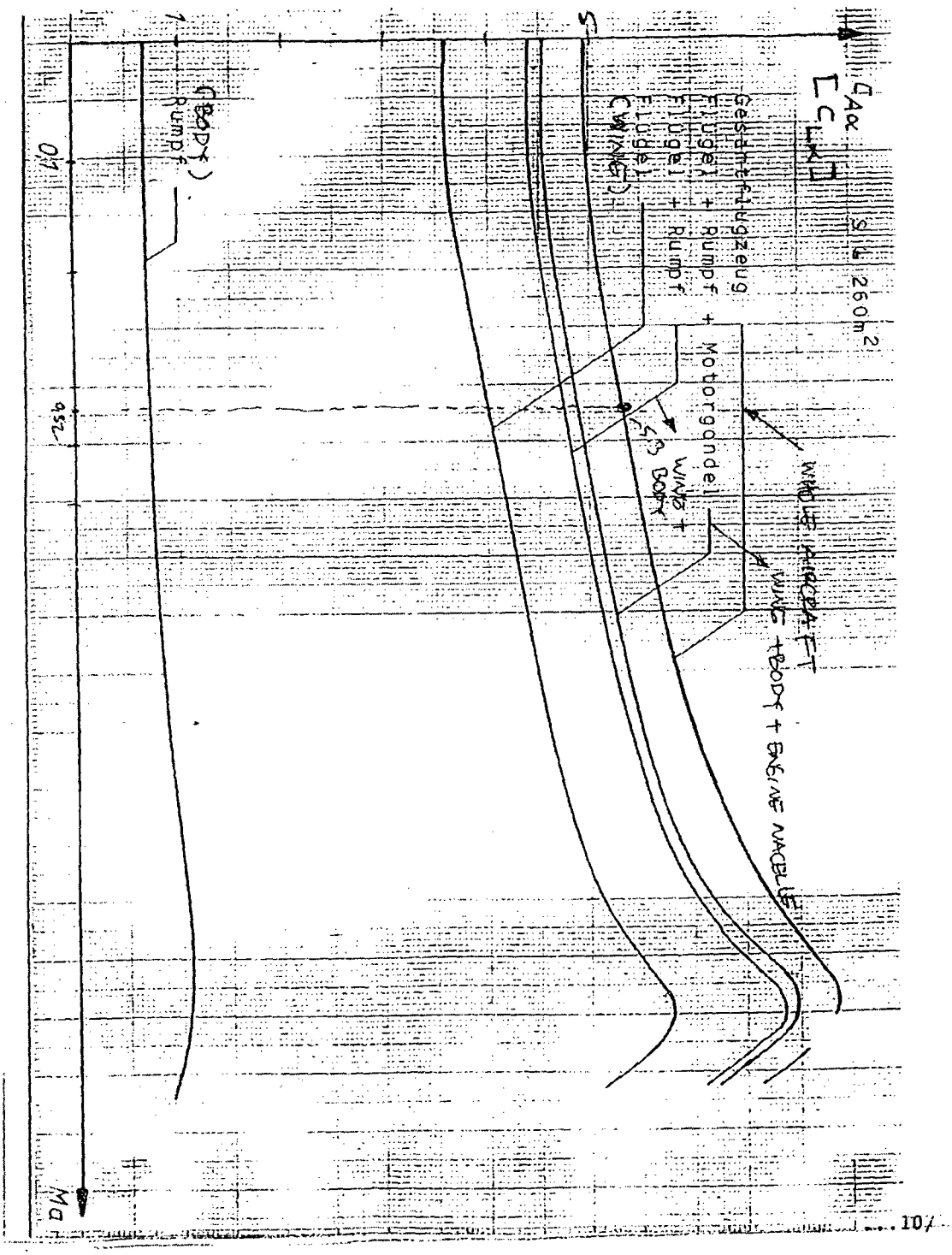


Anstellwinkel bei Auftrieb Null
(ZERO LIFT ANGLE OF ATTACK)



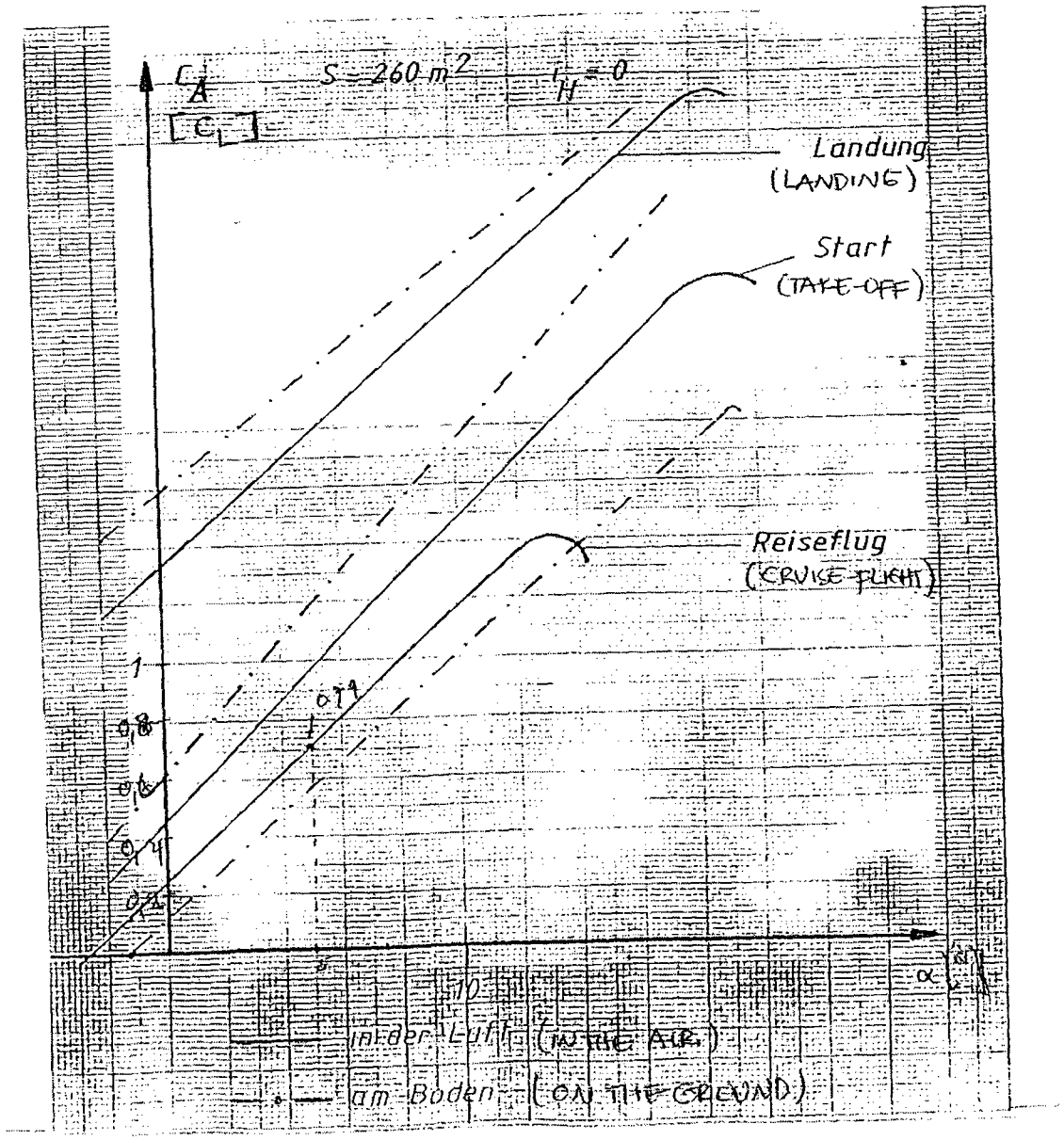
Auftriebsanstieg als Funktion der Machzahl

(LIFT-SLOPE AS FUNCTION OF MACH-NUMBER)

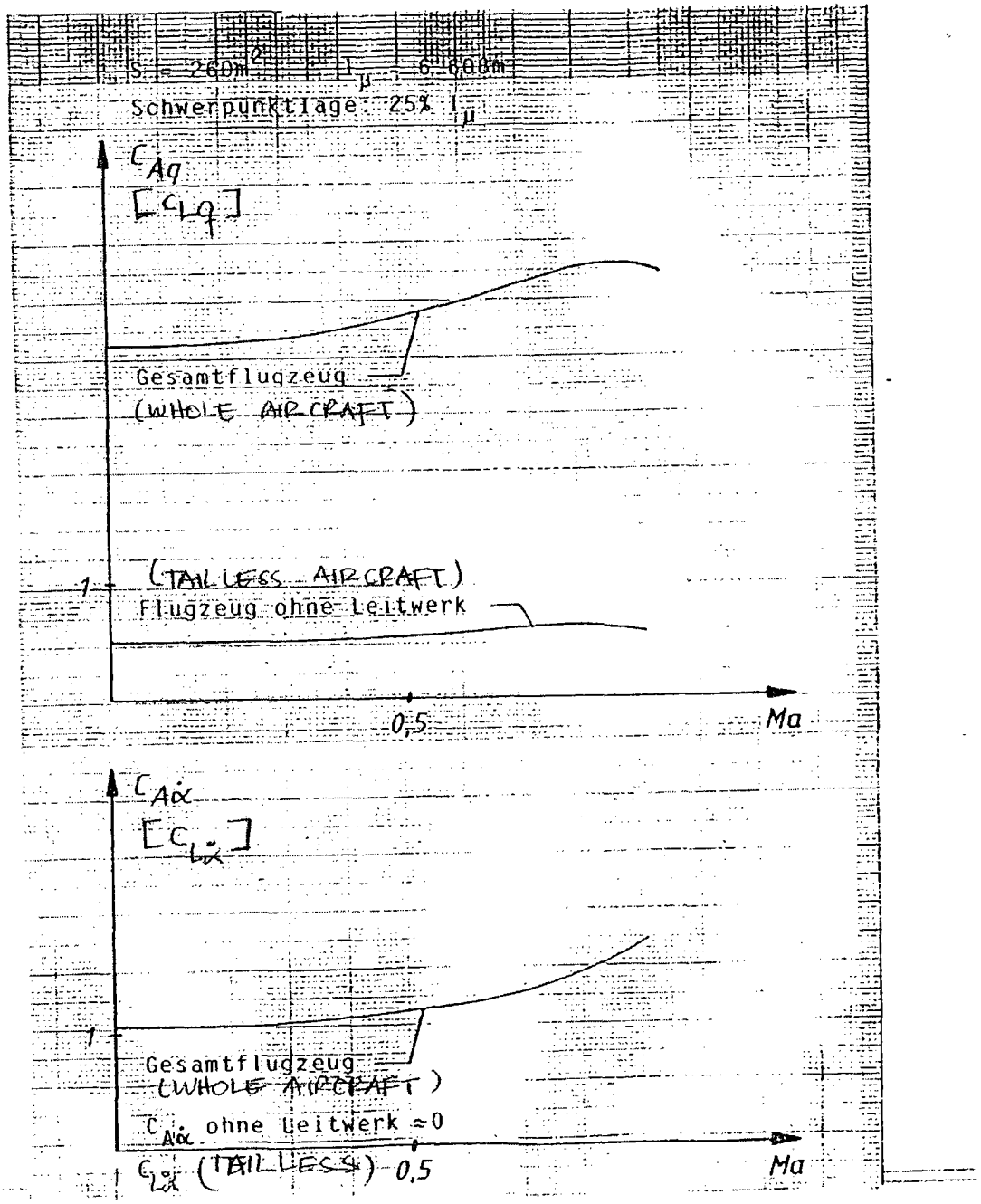


(LIFT-COEFFICIENT OF WHOLE AIRCRAFT AT SLOW AIRSPEEDS)
Auftriebsbeiwert des Gesamtflugzeugs

bei niedrigen Geschwindigkeiten

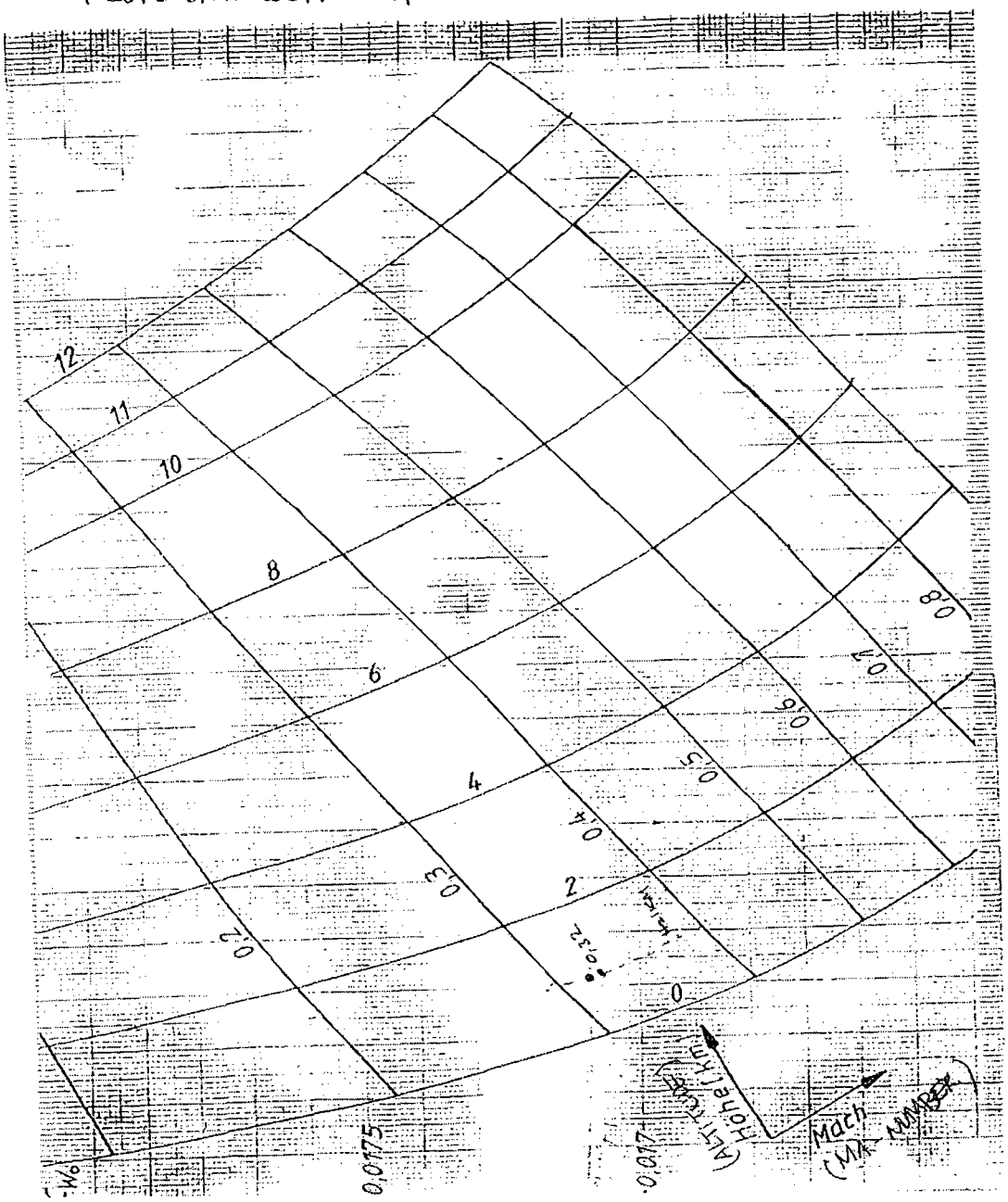


(LIFT-SLOPE DUE TO PITCH-RATE)
Auftriebsanstieg infolge Nickgeschwindigkeit
(LIFT-SLOPE DUE TO AOA-CHANGE)
Auftriebsanstieg infolge Anstellwinkeländerung



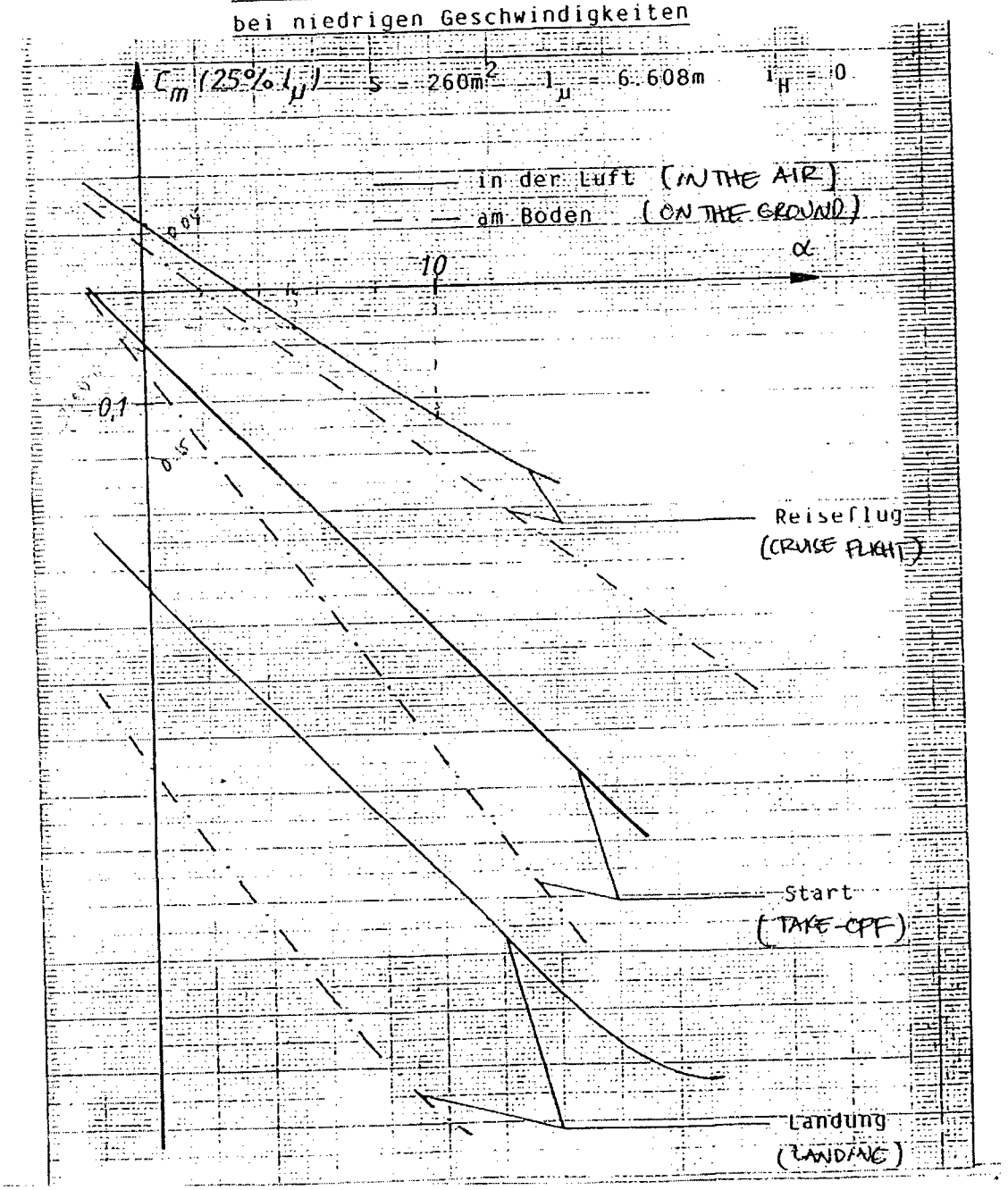
Nullwiderstandsbeiwert als Funktion von Höhe und Machzahl

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

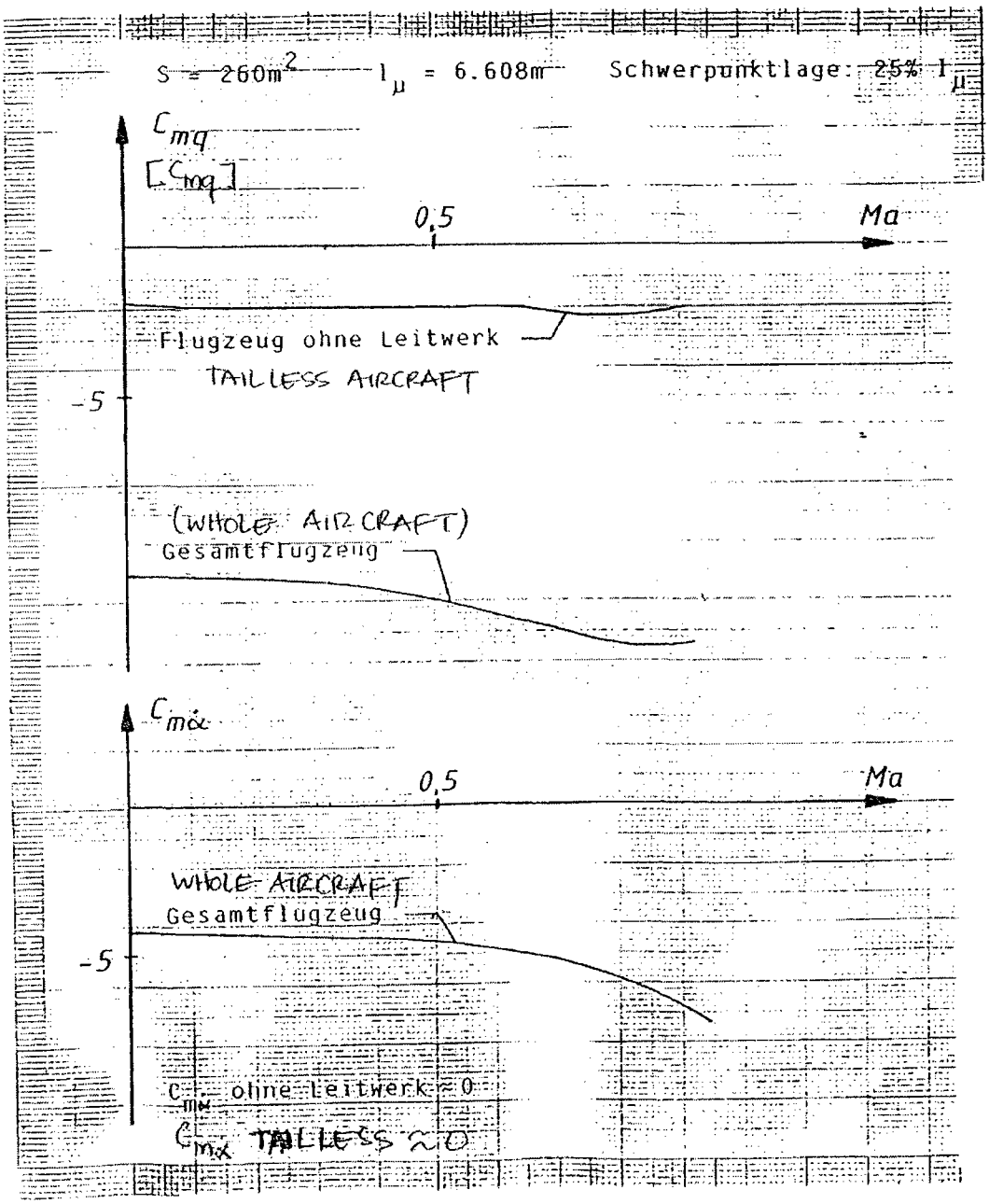


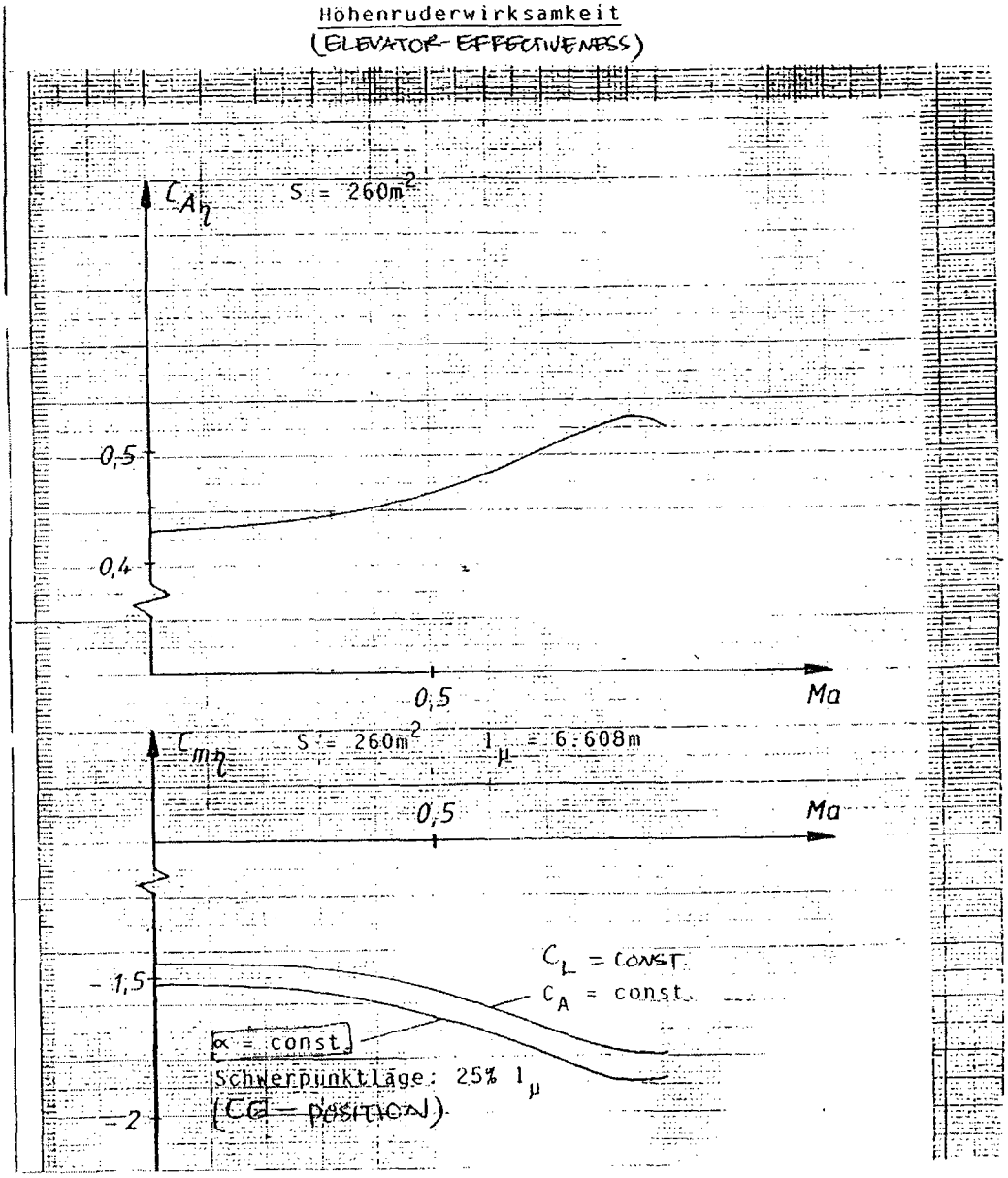
PITCH MOMENT COEFFICIENT OF WHOLE AIRCRAFT AT LOW AIRSPEEDS

Nickmomentenbeiwert des Gesamtflugzeugs bei niedrigen Geschwindigkeiten

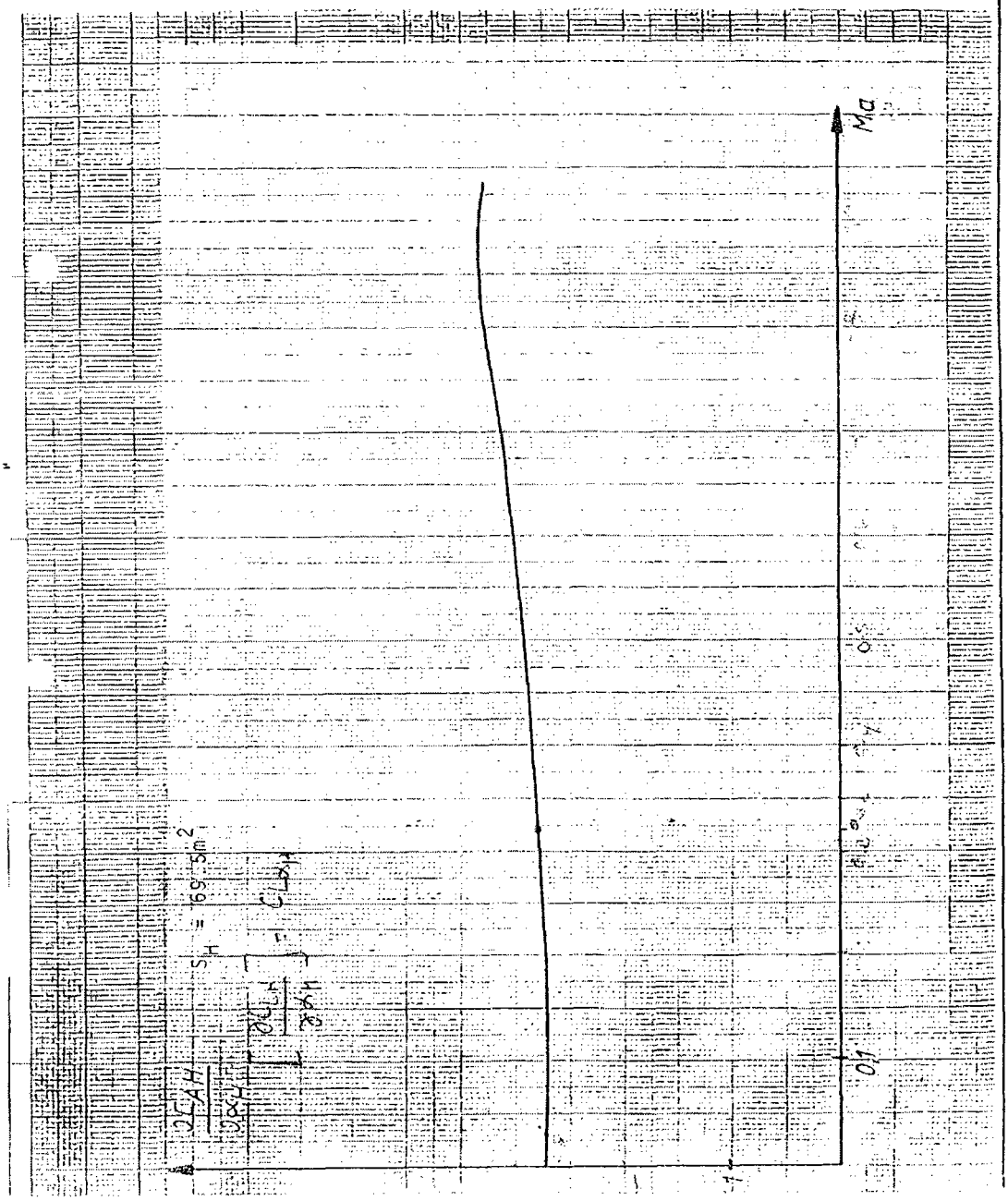


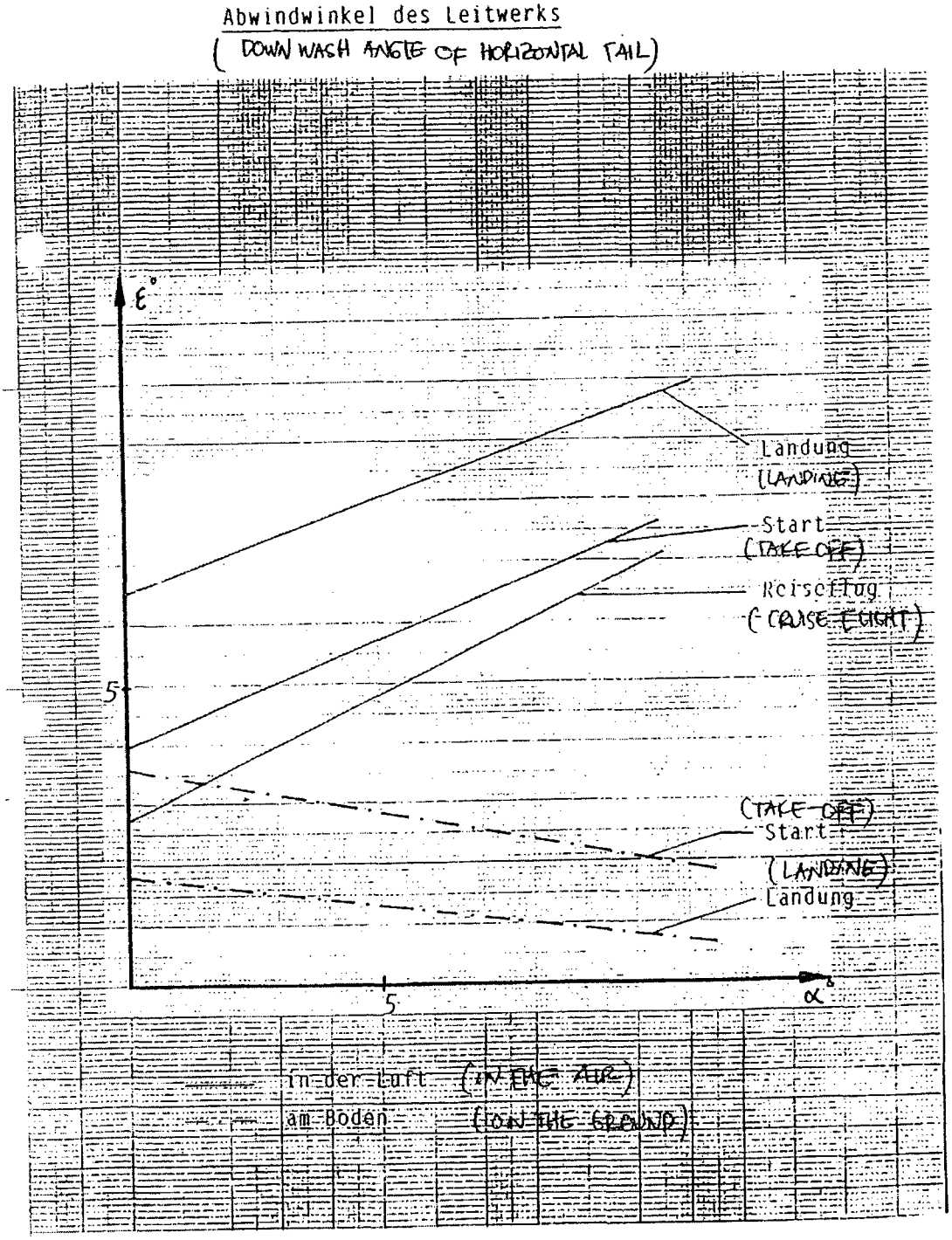
Nickdämpfung und Abwindverzögerung
PITCH DAMPING & UPWIND LAG)




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.
Schwerpunktlage: 25% l_μ
(CG-position)
-1,5
-2

Auftriebsgradient des Höhenruders
(LIFT COEFFICIENT OF ELEVATOR)




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

- oooOooo -