Flight Lab: Determination of Neutral Point and Maneuvering Point from Flight Tests

Group D

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Aim of the Experiment

To find Neutral Point and Maneuvering Point of NAL Hansa-3 aircraft by performing flight experiments.

Introduction

In this experiment our aim is to determine the stick fixed (Elevator Fixed) neutral point from flight test. Neutral Point is the center of gravity position where the pitching moment is independent of the angle of attack. It is called airplane aerodynamic center, when the C.G. is at this point the airplane is neutrally stable.

Estimation of the Neutral point (Stick Fixed)

$$\delta_{etrim} = \delta_{e0} + \left(\frac{\partial \delta_e}{\partial C_{L_{trim}}} \right)$$

$$\frac{\partial \delta_e}{\partial C_{L_{trim}}} = \frac{-\partial C_m}{C_{m\,\delta_e}}$$

N.P. is the C.G. location where,

$$\frac{\partial \delta_e}{\partial C_{L_{trim}}} = 0$$

Instruments Used

1. Airspeed indicator
2. Elevator angle indicator
3. Altimeter
4. OAT gauge
5. Bank Angle Indicator

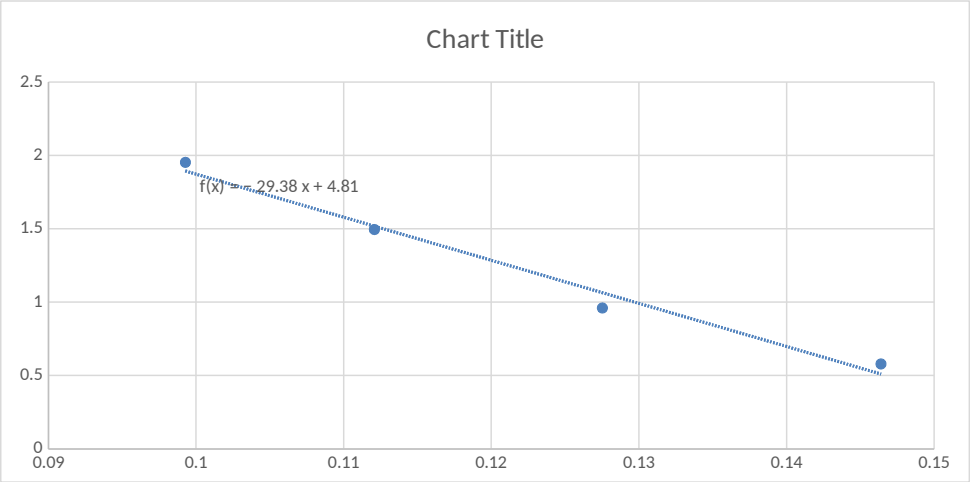
Procedure

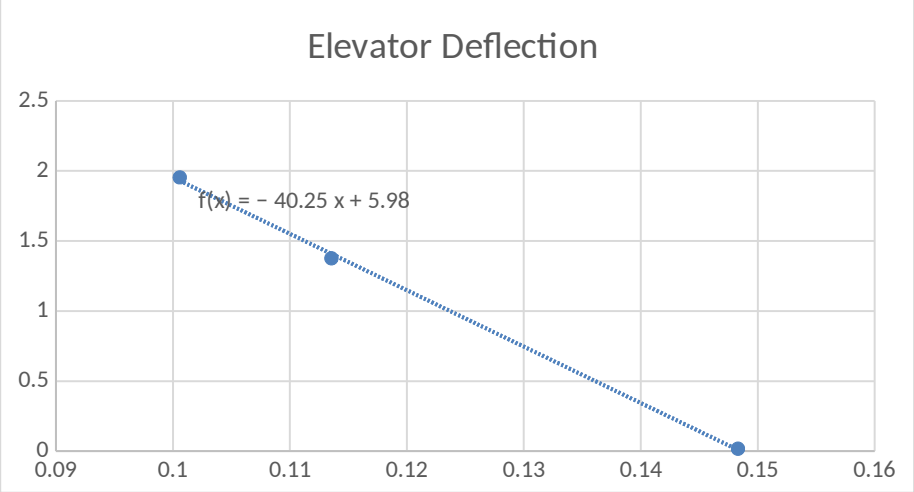
1. Fly at different center of gravity configuration and execute cruise.
2. Estimate corresponding $C_{L_{trim}} = \frac{2W/s}{0.5\rho V^2}$ and record δ_e.
3. Plot $\delta_{e_{trim}}$ vs $C_{L_{trim}}$
4. Cross plot $\left[\frac{\partial \delta_e}{\partial C_L} \right]_{trim}$ vs $\acute{x}_{cg}$ to get neutral point

Observations and Results

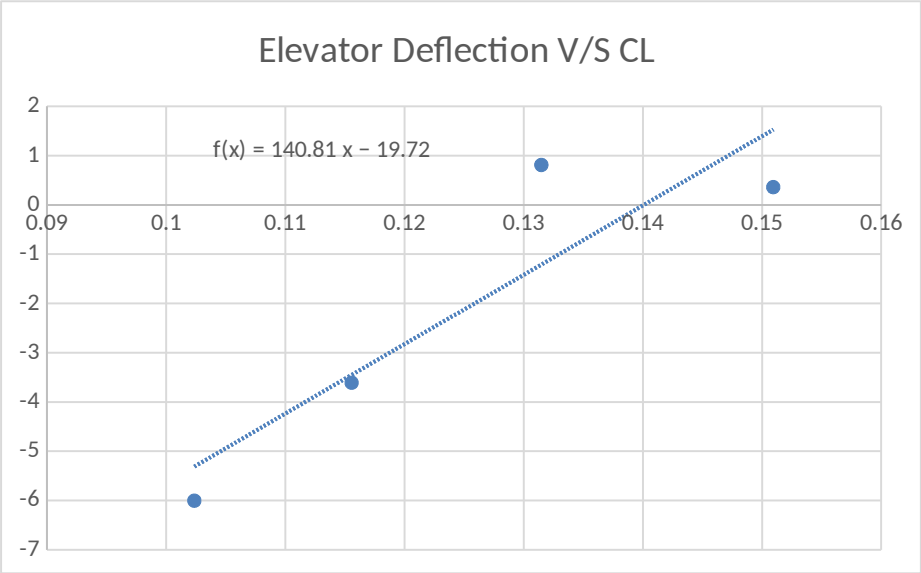
Take-off Total Weight (Kg)	727			
Landing Total Weight (Kg)	723			
Average Weight (Kg)	725			
Pilot Weight (Kg)	85			
Student Weight (Kg)	71			
Label	**Mass**	**Weight (Kg)**	**Moment Arms (mm)**	**Moment (N-mm)**
Plane Structure	550	5401	1027.52	5549635.52
Pilot+ Student	156	1531.92	1130	1731069.60
Fuel (Average)	19	186.58	1800	335844.00
	Total Weight	**7119.5**	**Total Moment**	**7616549.12**
			CG	**1069.82**

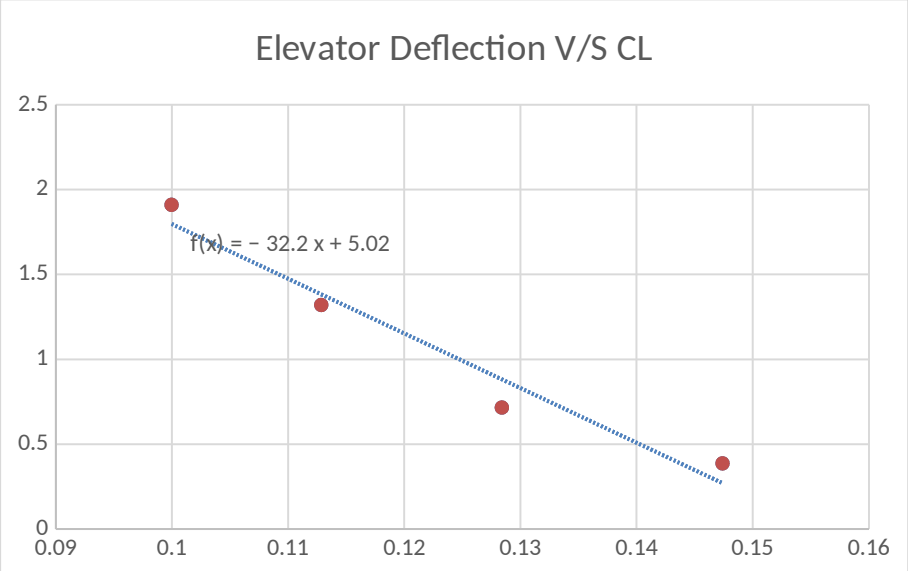
Velocity (Knots)	Velocity(m/s)	CL (Trim)	Elevator Deflection (degrees)
70	36.01108	0.146393961	0.5788
75	38.5833	0.127525406	0.96037
80	41.15552	0.112082877	1.495
85	43.72774	0.099284486	1.9529

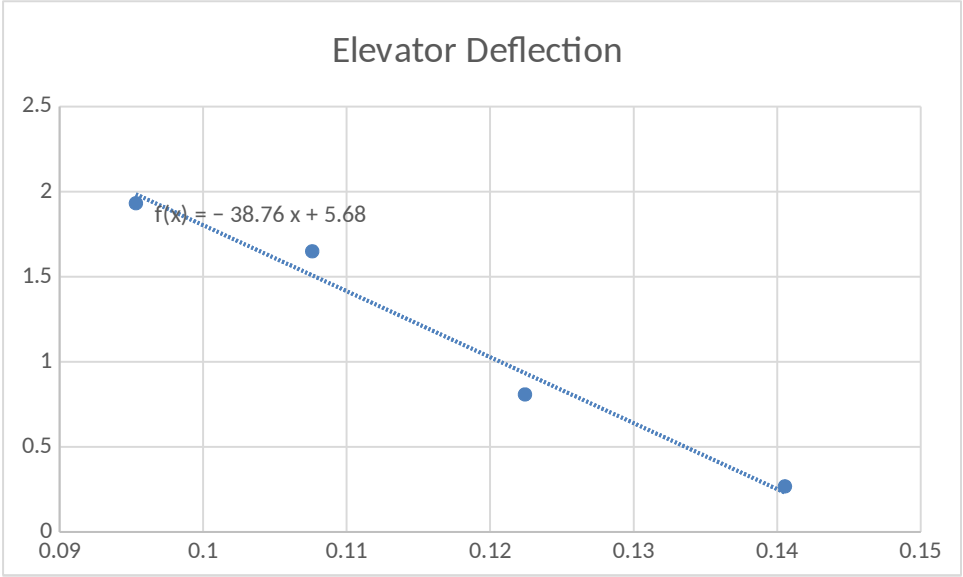


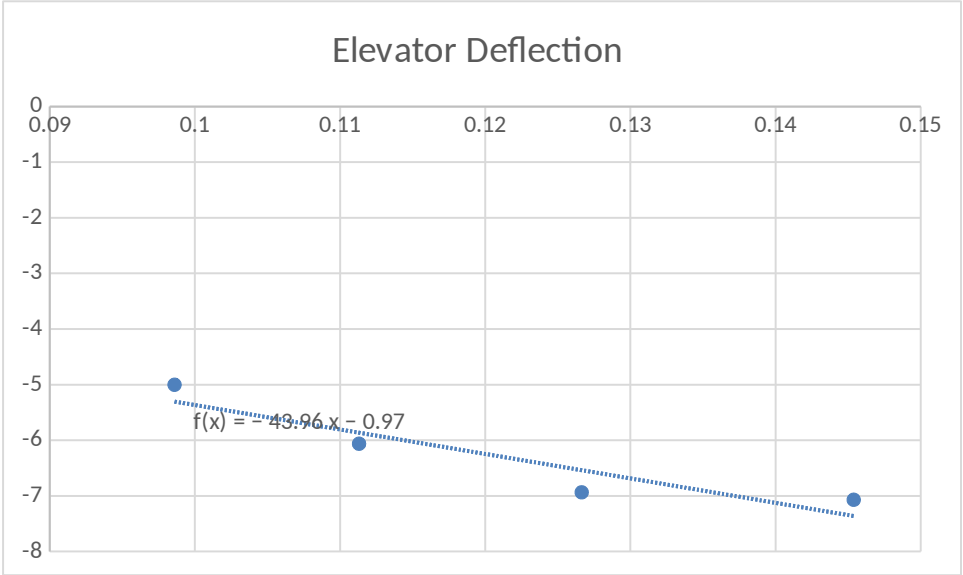


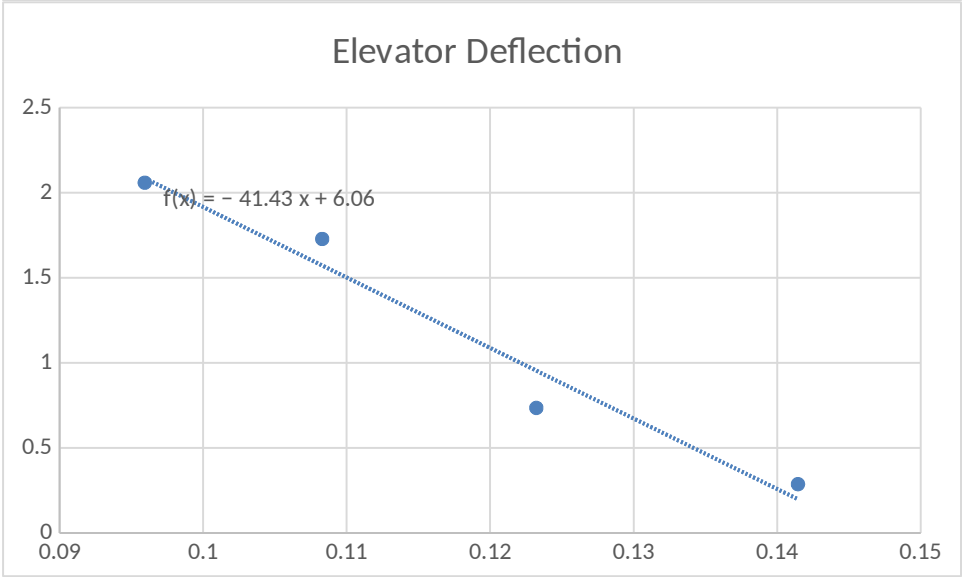
All Groups graphs:


Elevator Deflection V/S CL
f(x) = 140.81 x − 19.72
2
1
0
-1
-2
-3
-4
-5
-6
-7
0.09
0.1
0.11
0.12
0.13
0.14
0.15
0.16


Elevator Deflection V/S CL
f(x) = − 32.2 x + 5.02
2.5
2
1.5
1
0.5
0
0.09
0.1
0.11
0.12
0.13
0.14
0.15
0.16


Elevator Deflection
2.5
2
1.5
1
0.5
0
0.09
0.1
0.11
0.12
0.13
0.14
0.15
f(x) = − 38.76 x + 5.68


Elevator Deflection
0
-1
-2
-3
-4
-5
-6
-7
-8
0.09
0.1
0.11
0.12
0.13
0.14
0.15
f(x) = − 43.96 x − 0.97


Elevator Deflection
2.5
2
1.5
1
0.5
0
0.09
0.1
0.11
0.12
0.13
0.14
0.15
f(x) = − 41.43 x + 6.06

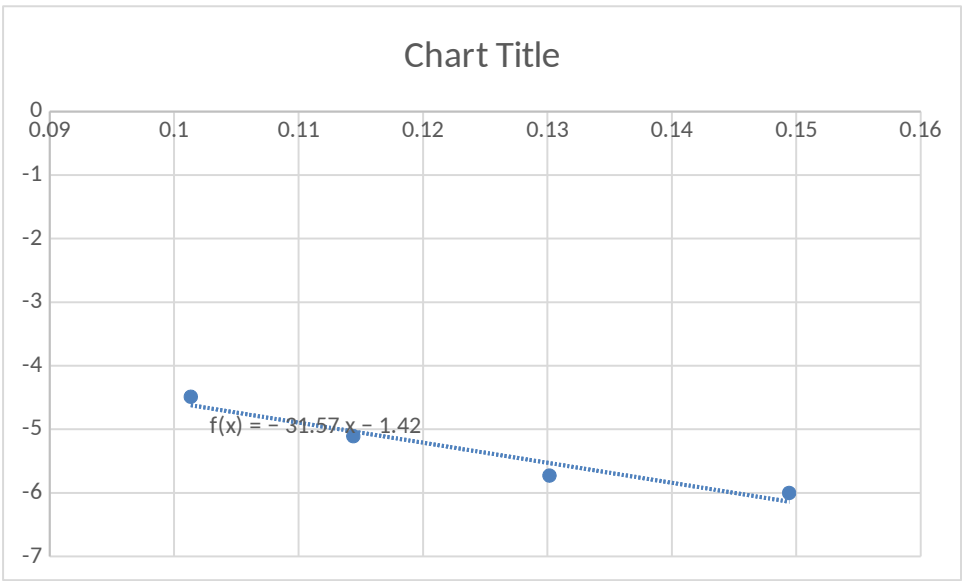


Fig 1: Graph – δe vs CL (at trim)

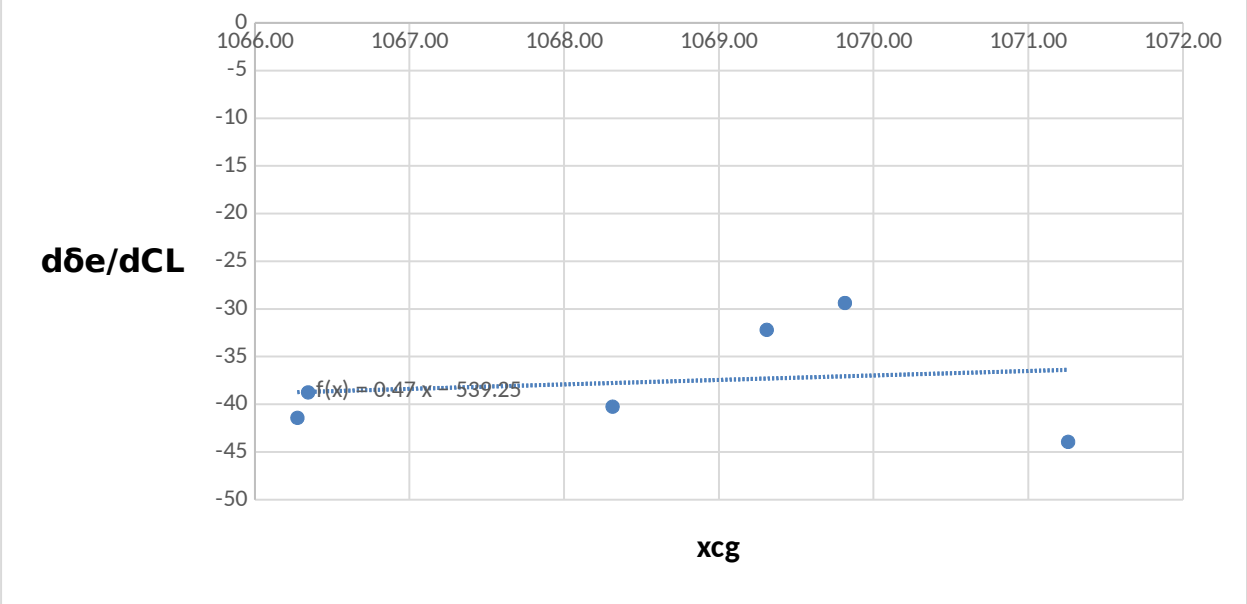


Fig 2: Graph – dδe/dCL vs different cg locations

Equation of the straight line $y = 0.469x - 539.25$

Neutral point is the x location when y=0, thus **Neutral point is at x=1148.8 mm.**

Discussions

1. Was there any incident related to this experiment ?

   The experiment was performed carefully in NAL Hansa and therefore there was no report of any accident.

2. Why is V' is used instead of V_∞ for relative wind at tail ?

   Tail aerodynamics is influenced by two inference points. Due to the finite wing, the airflow at the tail was deflected downwards by the downwash.
   Due to the retarding force of skin friction and pressure drag over the finite wing, the airflow reaching the tail got slowed.

3. What is the physical relevance of this experiment ?

   For static longitudinal stability, the neutral point and thus the static margin are very important factors. If an aircraft in flight suffers a disturbance in pitch that causes an increase (or decrease) in angle of attack, it is desirable that the aerodynamic forces on the aircraft cause a decrease (or increase) in angle of attack so that the disturbance does not cause a continuous increase (or decrease) in angle of attack. This is longitudinal static stability. Static margin is a concept used to characterize the static longitudinal stability and controllability of aircraft.

4. What is the significance of the experiment for commercial flying ?

   The knowledge of static margin and point of neutral stability is a must for any aircraft. For the stick fixed stability, elevator trim angle, Coefficient of Lift at trim etc are required.