Homework

(to return before 03 April 2022, students should write their report in standard **Word** format, and send in **PDF** format)

Dynamic stability of the T-33 jet trainer

"The NT-33A variable stability airplane (Serial No. 51-4120) is an extensively modified T-33 jet trainer. The elevator, aileron and rudder controls in the front cockpit are disconnected from their respective control surfaces and have been connected to separate servomechanisms that make up an 'artificial feel' system.

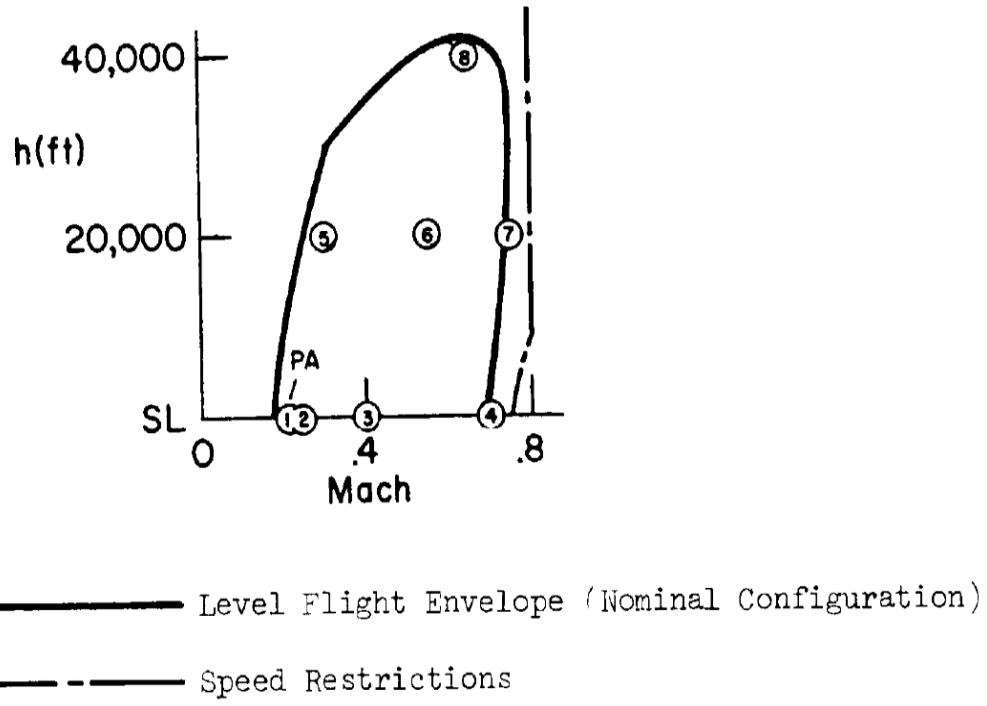
In addition, the elevator, aileron and rudder control surfaces have been connected to individual servos which can be driven by a number of different inputs. These servos receive their electrical inputs from the artificial feel system (pilot's commands, position or force), attitude and rate gyros, accelerometers, dynamic pressure, _ vane and _ probe.

This arrangement, through a response-feedback system, allows the normal T-33 derivatives to be augmented to the extent that the handling qualities of many existing airplanes, future airplanes or hypothetical research configurations, can be simulated.

The original T-33 nose section has been replaced with the larger nose of an F-94 to provide the volume required for the electronic components of the response-feedback system and the recording equipment."*
Aerodynamic data, for the most part, was taken from AFFDL-TR-70-71.
However, longitudinal data for the high lift configuration was obtained from LAL 1 27 and Mach number derivatives from NACA-RM-7116.

NT-33A

Flight Envelope



Nominal configuration :

Aircraft mass m = 6214 kg

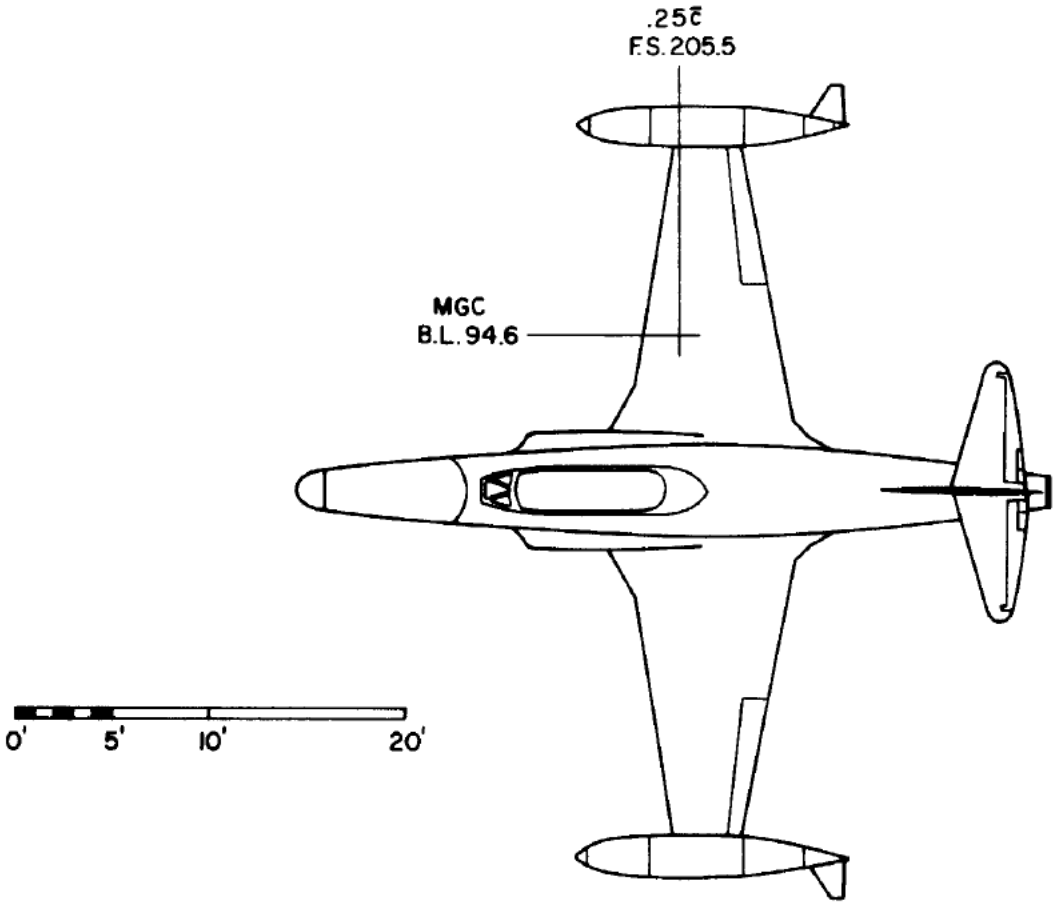
Gravity center location $\overline{X_{CG}} = 0.263$

$I_{XX} = 30048.7\ kg\ m^2$

$I_{YY} = 26639.8\ kg\ m^2$

$I_{ZZ} = 55299.8\ kg\ m^2$

$I_{XZ} = 606\ \ kg\ m^2$



Flight conditions		
Altitude	6096	m
air density	0.653	kg/m^3
speed	94.8	m/s
Mach number	0.3	
initial attitude theta 0	2.2	deg

Geometric data		
wing area	21.81	m^2
wing span	11.44	m
wing mean chord	2.05	m
Aspect ratio	6.00	
Oswald number e	0.89	

Steady state conditions	
C_{L0}	0.813
C_{D0}	0.135
C_{Tx0}	0.025
C_{m0}	0
C_{mt0}	0

Longitudinal Stability Derivatives :

Aerodynamic deravatives	
$C_{m\,u}$	0
$C_{m\,\alpha}$	-0.401
$C_{m\,\alpha\,dot}$	-5
C_{mq}	-10
$C_{m\,t\,u}$	0
$C_{m\,t\,\alpha}$	0
$C_{L\,u}$	0
$C_{L\,\alpha}$	5.22
$C_{L\,\alpha\,dot}$	1.74
C_{Lq}	3.9
$C_{D\,u}$	0
$C_{D\,\alpha}$	0.54
$C_{D\,\alpha\,dot}$	0
$C_{D\,q}$	0
$C_{T\,u}$	0
$C_{L\,\delta e}$	0.34
$C_{D\,\delta e}$	0
$C_{m\,\delta e}$	-0.89

Lateral Stability Derivatives :

Aerodynamic deravatives	
$C_{l\beta}$	-0.127
C_{lp}	-0.57
C_{lr}	0.2
$C_{l\ \delta a}$	0.14
$C_{l\ \delta r}$	-0.002
$C_{n\beta}$	0.049
C_{np}	-0.045
C_{nr}	-0.16
$C_{n\ \delta a}$	-0.009
$C_{n\ \delta r}$	-0.073
$C_{y\beta}$	-0.72
C_{yp}	0
C_{yr}	0
$C_{y\ \delta a}$	0
$C_{y\ \delta r}$	0.17

I- Longitudinal Dynamic Stability of Airplane

The objective of this homework is to study the stability modes of an aircraft which we knew his geometric, inertial, and aerodynamic data.

For attempting this objective, you will find by using Matlab:

1. Equations of longitudinal motion.
2. The matrix A of aircraft
3. The characteristic equation
4. The eigenvalues (roots of equation) of the system
5. Different modes of longitudinal stability
    a. Short period mode (Natural Frequency, Damping Factor)
    b. Phugoid mode (Natural Frequency, Damping Factor)
6. Curves of longitudinal motion:
    a. Axial velocity in function of time
    b. Angle of attack
    c. Pitch rate
    d. Pitch angle
7. Transfer Functions of Each variable

II- Lateral Dynamic Stability of Airplane

The objective of this homework is to study the stability modes of an aircraft which we knew his geometric, inertial, and aerodynamic data.

For attempting this objective, you will find by using Matlab:

1. Equations of lateral motion.
2. The matrix A of aircraft
3. The characteristic equation
4. The eigenvalues (roots of equation) of the system
5. Different modes of lateral stability
    a. Spiral mode
    b. Rolling mode
    c. Dutch roll mode (Natural Frequency, Damping Factor)
6. Curves of lateral motion:
    a. Side velocity in function of time
    b. Roll rate
    c. Yaw rate
    d. Side angle
7. Transfer Functions of Each variable