



Fig. A4.10

T = engine thrust.
 L = total wing lift plus fuselage lift.
 D = total airplane drag.
 L_a = moment of L and D with reference to wing a.c. (aerodynamic center)
 W = weight of airplane.
 I_L = inertia force normal to flight path.
 I_D = inertia force parallel to flight path.
 I_m = rotation inertia moment.
 E = tail load normal to flight path.

For a horizontal constant velocity flight condition, the inertia forces I_L , I_D , and I_m would be zero. For an accelerated flight condition involving translation but not angular acceleration about its own c.g. axis, the inertia moment I_m would be zero, but I_L and I_D would have values.

Equations of Equilibrium For Steady Flight.

From Fig. A4.10 we can write:-

$$\begin{aligned}
 \Sigma F_x &= 0, & D + W \sin \theta - T \cos \beta &= 0 \\
 \Sigma F_z &= 0, & L - W \cos \theta + T \sin \beta - E &= 0 \\
 \Sigma M_y &= 0, & -M_a - L_a - Db + Tc \cos \beta + Ea &= 0
 \end{aligned}$$

Equations of Equilibrium in Accelerated Flight.

$$\begin{aligned}
 \Sigma F_x &= 0, & D + W \sin \theta - T \cos \beta - I_D &= 0 \\
 \Sigma F_z &= 0, & L - W \cos \theta + T \sin \beta - I_L - E &= 0 \\
 \Sigma M_y &= 0, & -M_a - L_a - Db + Tc \cos \beta + Ea + I_m &= 0
 \end{aligned}$$

Signs used: $\left\{ \begin{array}{l} \text{Forces - Plus is up and toward tail.} \\ \text{Moment - Clockwise is positive.} \\ \text{Distances from c.g. to force - Plus is up and toward tail.} \end{array} \right.$

A4.7 Load Factors.

The term load factor normally given the symbol (n) can be defined as the numerical multiplier. The bar through letter Z has no significance. Same meaning without bar.

multiplying factor by which the forces on the airplane in steady flight are multiplied to obtain a static system of forces equivalent to the dynamic force system acting during the acceleration of the airplane. Fig. A4.11 illustrates

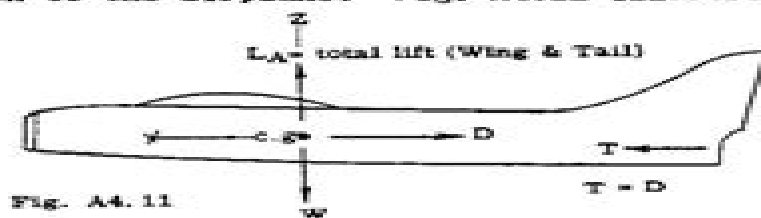


Fig. A4.11

forces in steady horizontal flight. L represents the total airplane lift (wing plus tail). Therefore $L = W$. Now assume the airplane is accelerated upward along the Z axis. Fig. A4.12 shows the additional inertia force $W a_z/g$ acting downward, or opposite to the direction of acceleration. The total airplane lift L for the



Fig. A4.12

unaccelerated condition in Fig. A4.11 must be multiplied by a load factor n_z to produce static equilibrium in the Z direction.

$$\text{Thus, } n_z L - W - \frac{W}{g} a_z = 0$$

Since $L = W$

$$\text{Hence } n_z = 1 + \frac{a_z}{g}$$

An airplane can of course be accelerated along the X axis as well as the Z axis. Thus in Fig. A4.13 the magnitude of the engine thrust T is greater than the airplane Drag D , which



Fig. A4.13

causes the airplane to accelerate forward. It is convenient to express the inertia force in the direction in terms of the load factor n_x and the

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RM Cervero



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