



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: { Forces - Plus is up and toward tail.
 Moment - Clockwise is positive.
 Distances from c.g. to force - Plus is up and toward tail.

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

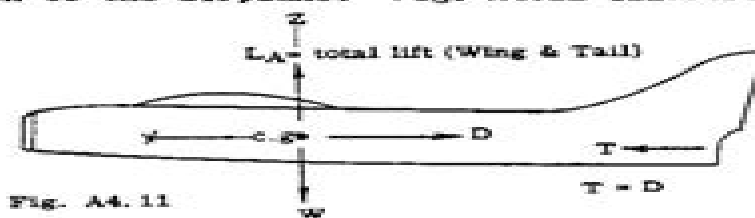


Fig. A4.11

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

Analysis Design Of Flight Vehicle Structures Solution Manual

David Kirk



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1. Understanding the eBook Analysis Design Of Flight Vehicle Structures Solution Manual
 - The Rise of Digital Reading Analysis Design Of Flight Vehicle Structures Solution Manual
 - Advantages of eBooks Over Traditional Books
2. Identifying Analysis Design Of Flight Vehicle Structures Solution Manual
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Analysis Design Of Flight Vehicle Structures Solution Manual
 - User-Friendly Interface
4. Exploring eBook Recommendations from Analysis Design Of Flight Vehicle Structures Solution Manual
 - Personalized Recommendations
 - Analysis Design Of Flight Vehicle Structures Solution Manual User Reviews and Ratings
 - Analysis Design Of Flight Vehicle Structures Solution Manual and Bestseller Lists
5. Accessing Analysis Design Of Flight Vehicle Structures Solution Manual Free and Paid eBooks
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 - Interactive Elements Analysis Design Of Flight Vehicle Structures Solution Manual
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 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Analysis Design Of Flight Vehicle Structures Solution Manual
9. Balancing eBooks and Physical Books Analysis Design Of Flight Vehicle Structures Solution Manual
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Analysis Design Of Flight Vehicle Structures Solution Manual
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Analysis Design Of Flight Vehicle Structures Solution Manual
 - Setting Reading Goals Analysis Design Of Flight Vehicle Structures Solution Manual
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Analysis Design Of Flight Vehicle Structures Solution Manual
 - Fact-Checking eBook Content of Analysis Design Of Flight Vehicle Structures Solution Manual
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
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