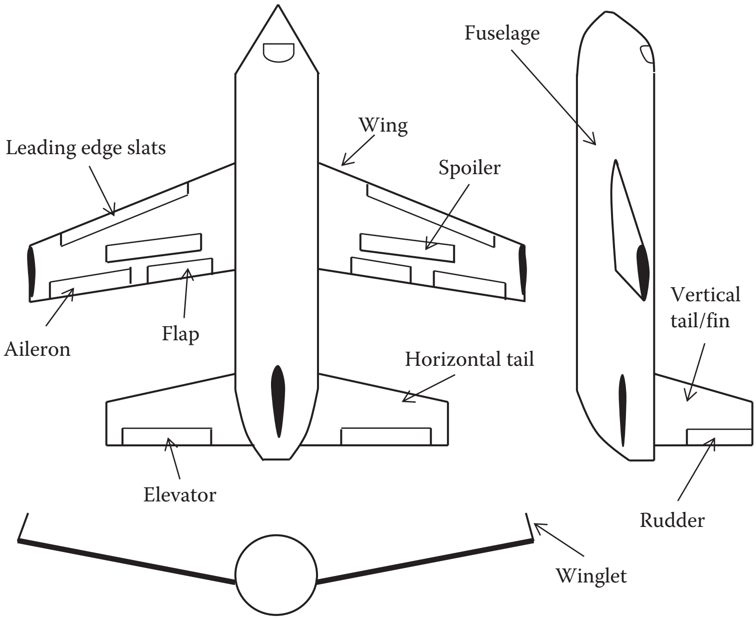

Figure 1.1
Components of an airplane.

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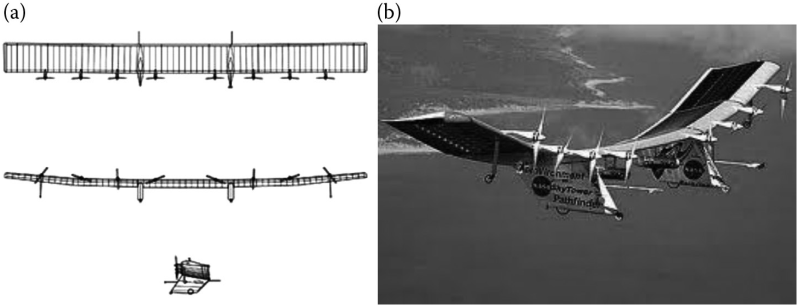

Figure 1.2
(a) Three-dimensional view of the Pathfinder airplane showing the wing in a non-lifting condition on the ground (http://www.nasa.gov/centers/dryden/images/content/107948main_pathfinder_drawing2.jpg) and (b) flexed wing shape in flight (http://www.globalprofitsalert.com/wp-content/uploads/2010/08/solar-powered-plane-pathfinder.jpg, http://www.modelaircraft.org).

Figure 1.3
The outboard spoilers on the Boeing 737. (http://www.b737.org.uk/images/spoilers.jpg)

001x003.tif

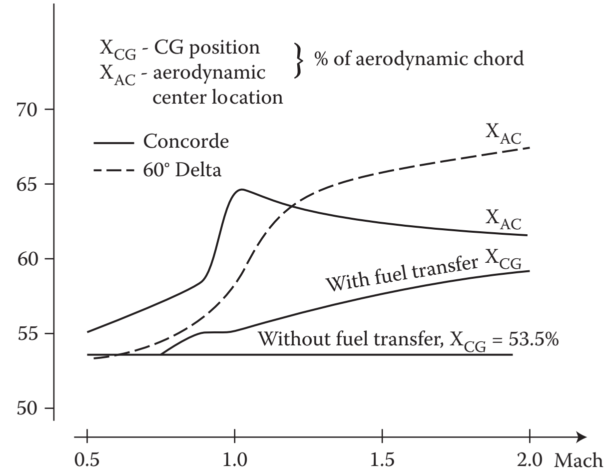

Figure 1.4
A plot showing the variation of X_{CG} (axial location of centre of gravity) and X_{AC} (axial location of aerodynamic centre) for the supersonic transport aircraft Concorde and also for a 60° delta wing (a wing with a triangular planform and semi-apex angle of 60°) for different values of Mach number. (Jean Rech and Clive S. Leyman. *A Case Study by Aerospatiale and British Aerospace on the Concorde*, AIAA Professional Study Series. http://www.dept.aoe.vt.edu/~mason/Mason_f/ConfigAeroSupersonicNotes.pdf; http://flyawaysimulation.com/media/images1/images/concorde-nose.jpg)

Figure 1.5
Image showing various sweep angle settings on the F-111—from high-sweep for supersonic flight (leader) to mid-sweep for high subsonic flight (middle) to low-sweep for low subsonic flight (trailer). (www.thebaseleg.com) (http://www.thebaseleg.com/Aviation/Williamtown-2010-2/13914521_F8CHzK/#!i=1021328031&k=vZ93Sv8)

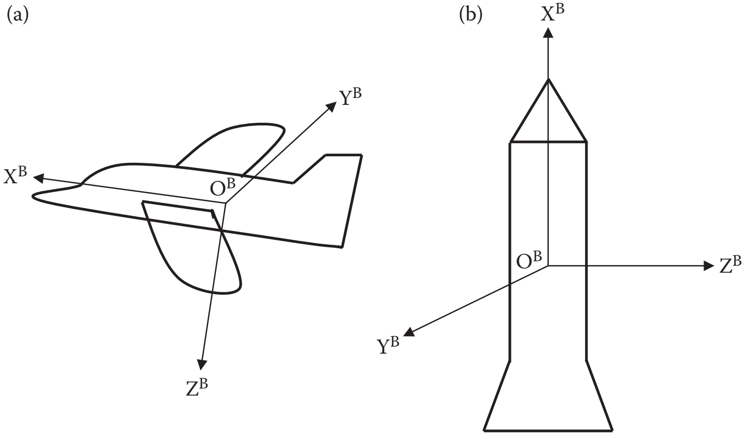

Figure 1.6
Body-fixed axes system attached to the centre of gravity (O^B) for (a) a conventional airplane and (b) a launch vehicle.

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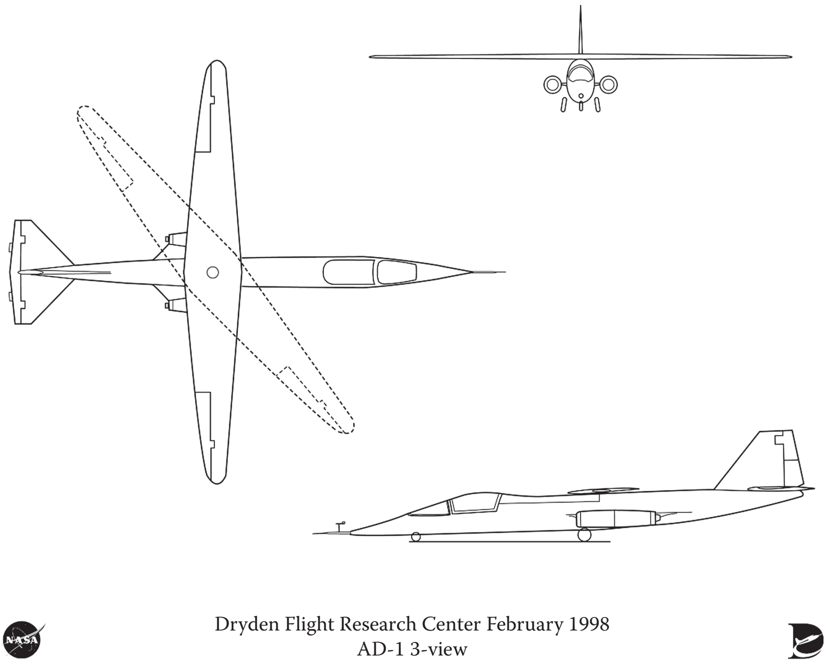

Figure 1.7
A three-dimensional view of the NASA AD-1 oblique wing aircraft whose wing could be swivelled in flight about a central hinge. (http://upload.wikimedia.org/wikipedia/commons/8/88/AD-1_3-View_line_art.gif)

001x007.eps

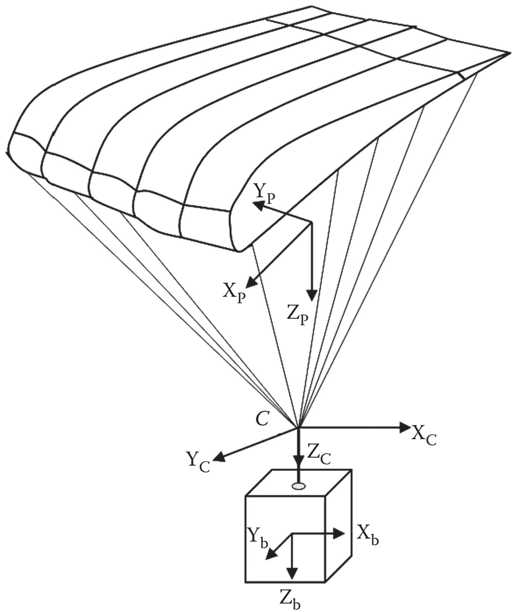

Figure 1.8
Schematic diagram of a parafoil–payload system showing the body-fixed axes $X_PY_PZ_P$ attached to the parafoil and the body-fixed axes $X_bY_bZ_b$ attached to the payload. A third set of axes $X_CY_CZ_C$ is placed at the connecting point *C* where the two bodies are linked.

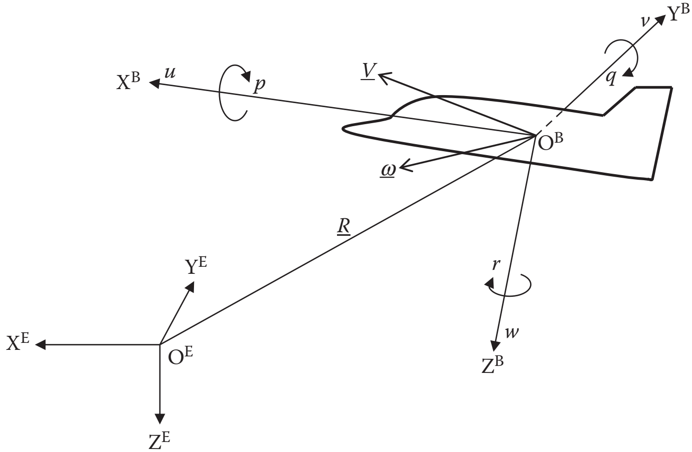

Figure 1.9
Sketch of an aircraft in space with $X^BY^BZ^B$ axes fixed to its centre of gravity (CG) O^B, velocity vector $\underline{V}$ at CG, and angular velocity vector $\underline{\omega}$ about the CG, axes $X^EY^EZ^E$ fixed to Earth, position vector $\underline{R}$ from origin (O^E) of $X^EY^EZ^E$ to aircraft CG (O^B).

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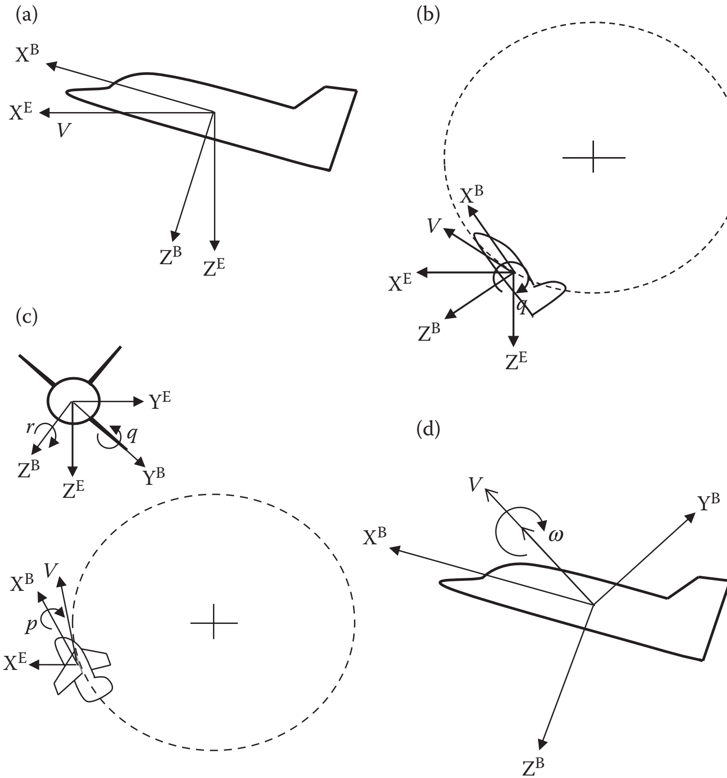
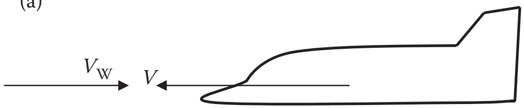


Figure 1.10
Sketch of airplane axes, velocity vector and trajectories for some standard airplane motions: (a) straight and level flight, (b) vertical pull-up, (c) horizontal level turn and (d) roll about the velocity vector.

(a)



Relative wind (or aerodynamic) velocity: $V_\infty = V + V_W$
Ground velocity: V

(b)

Relative wind (or aerodynamic) velocity: $V_\infty = V - V_W$
Ground velocity: V

Figure 1.11
Airplane flight in (a) head and in (b) tail wind conditions.

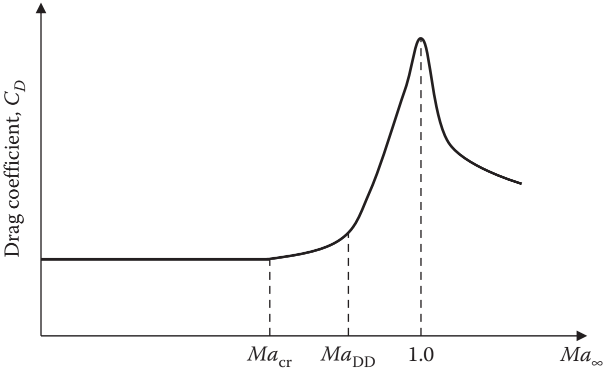


Figure 1.12
Variation of drag coefficient of an airplane as a function of Mach number.

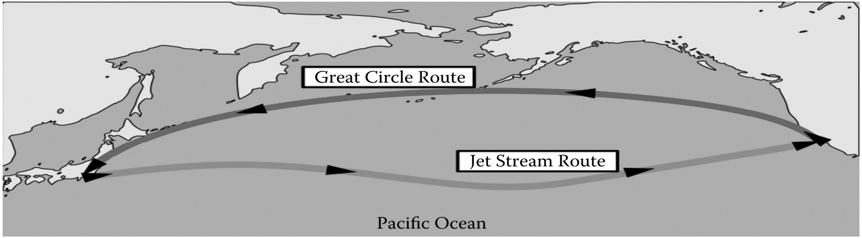


Figure 1.13
Airlines flying westward may choose the 'Great Circle Route', which is geometrically the shortest, but when flying east they may fly along the Jet Stream, which provides a sustained tail wind, gaining time and saving fuel. (http://upload.wikimedia.org/wikipedia/commons/7/79/Greatcircle_Jetstream_routes.svg)

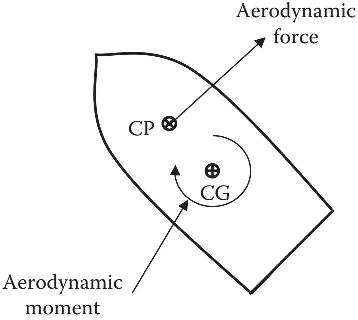


Figure 1.14
Aerodynamic moment caused by aerodynamic force acting at the centre of pressure.

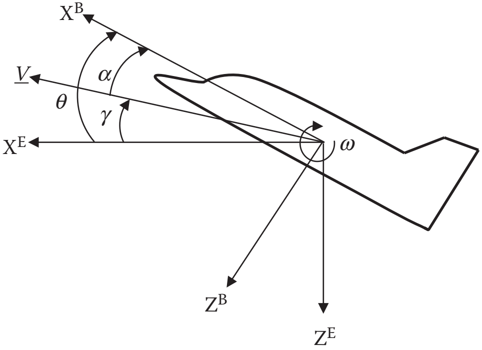


Figure 1.15
Airplane in longitudinal climbing flight showing Earth and body axes, $\underline{V}$ and $\underline{\omega}$ vectors, angles α, γ and θ.

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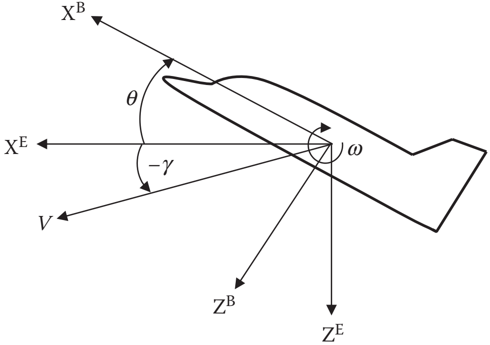

Figure 1.16
Sketch of an aircraft in landing approach showing the axes and various angles.

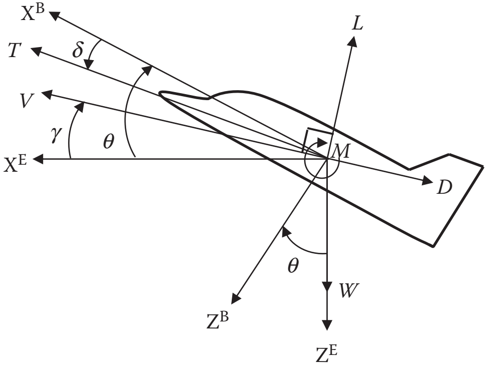

Figure 1.17
Free body diagram of an airplane showing all the forces and moments acting on it.

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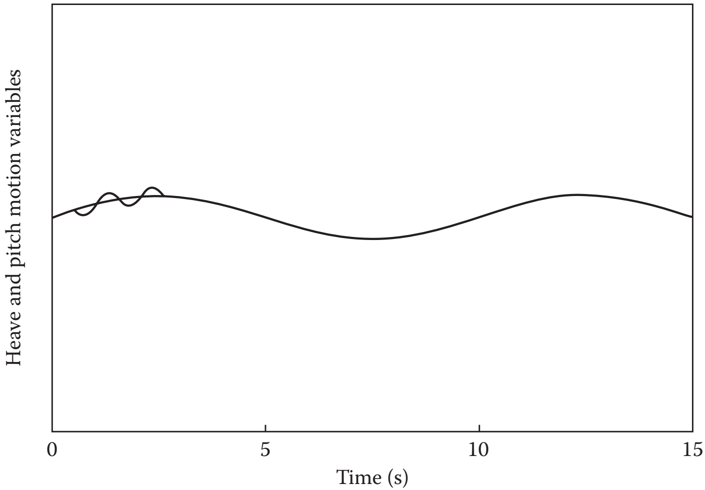

Figure 1.18
Suggestive time history of airplane motion with pitching motion (at quicker timescale) superimposed over heaving motion (slower timescale).

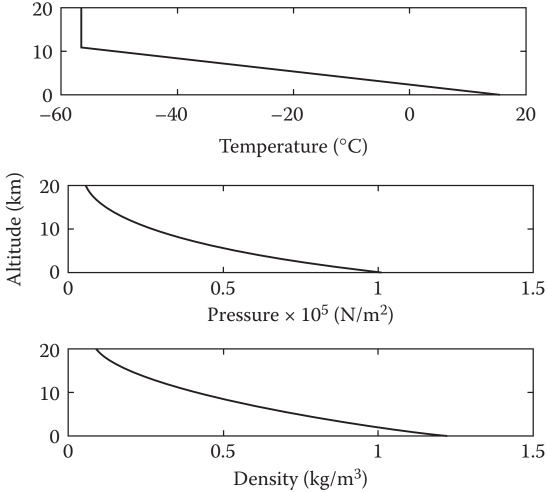

Figure 1.19
Standard atmospheric properties in normal atmospheric flight altitude range.

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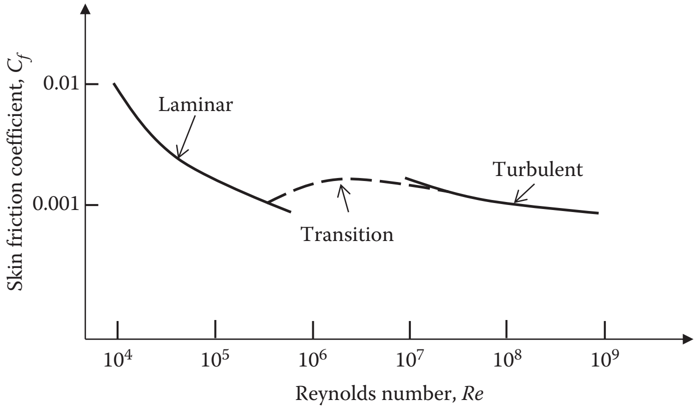

Figure 1.20
Variation of C_f as a function of the Reynolds number for a flat plate. (Adapted from *Fundamentals of Aerodynamics* by John D. Anderson, Jr., Fourth Edition, McGraw Hill Publication, 2007, pp. 77).

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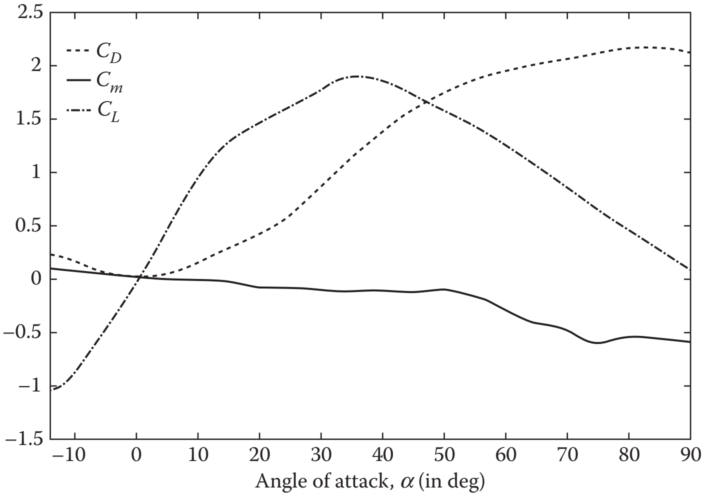

Figure 1.21
Plot of drag, lift and pitching moment coefficients as functions of angle of attack for the F-18/HARV airplane.

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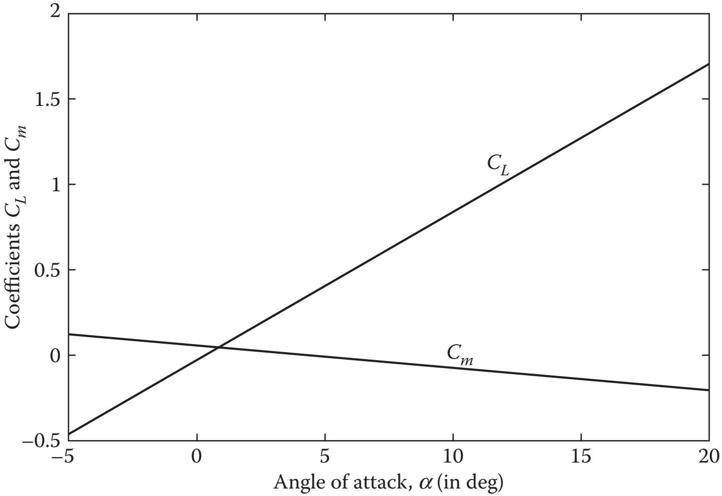

Figure 1.22
Plot of variation of C_L, C_m with angle of attack α for airplane X.

001x022.eps

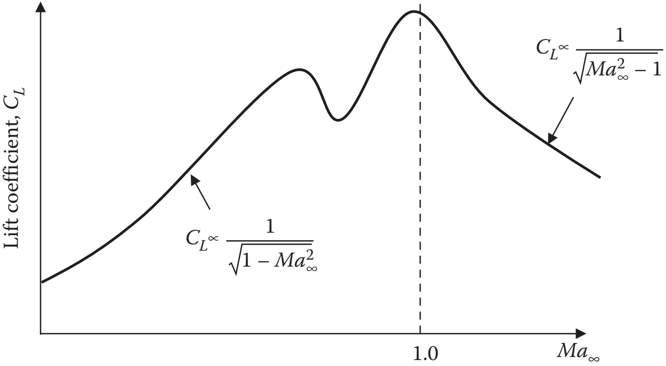

Figure 1.23
Typical variation of airplane C_L with Mach number.

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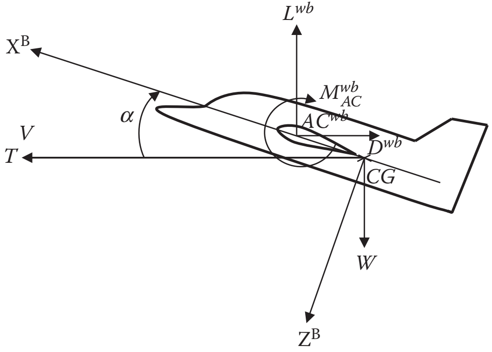

Figure 1.24
Various forces and moments acting on a wing–body combination in level flight.

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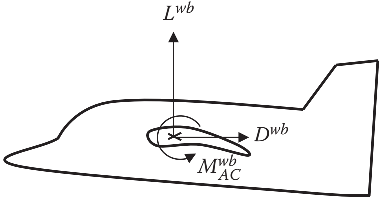

Figure 1.25
An airplane with positively cambered wing at zero lift showing the sense of M_{AC}^{wb}.

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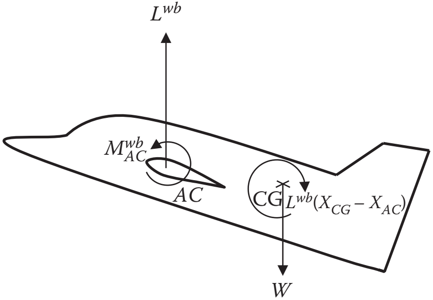

Figure 1.26
Trim condition with moment due to wing lift $L^{wb}(X_{CG} - X_{AC})$ exactly balanced by M_{ac}^{wb} at the CG.

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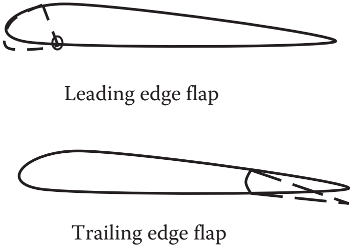

Figure 1.27
Leading edge flaps and trailing edge flaps (also called elevons) on a wing.

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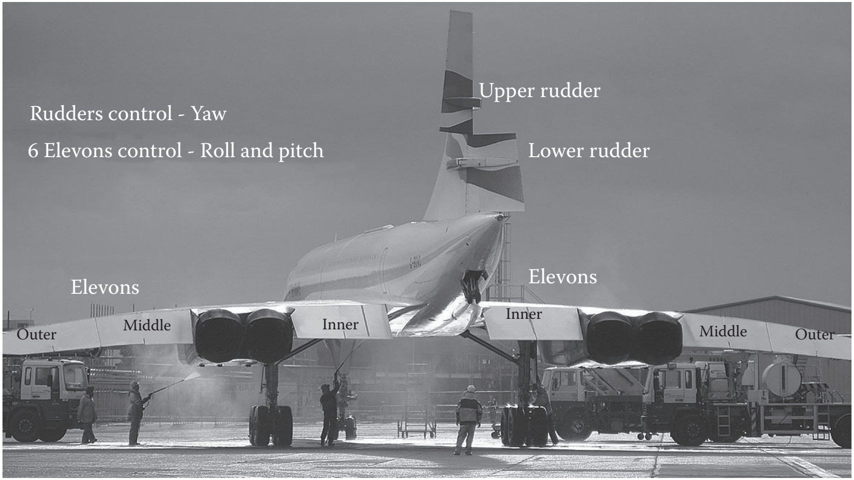

Figure 1.28
Elevons on the Concorde—picture shows inner, middle and outer set of elevons labelled. (heritageconcorde.com) (http://heritageconcorde.com/wp-content/uploads/2012/02/elevon-and-rudders-USE-FOR-WEBSITE1.jpg)

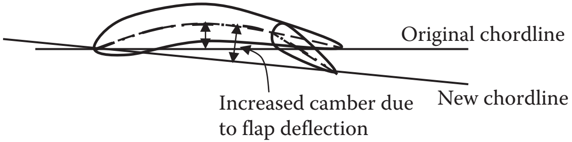

Figure 1.29
Schematic representation of an airfoil with increased camber due to trailing edge flap deflection.

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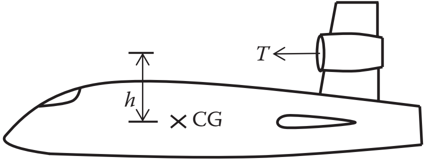

Figure 1.30
An airplane with engine mounted on the vertical tail showing moment due to thrust vertically displaced above the CG line.

001x030.eps

Figure 1.31
Seaplane with engine mounted high above the CG line. (http://www.homebuiltairplanes.com; http://www.homebuiltairplanes.com/forums/attachments/aircraft-design-aerodynamics-new-technology/16078d1329429117-why-seaplanes-doesn-t-fly-ground-effect-long-range-20080913172712_sea_plane.jpg)