SYE 3801 Aerodynamics Spring 2015

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A Few Concepts

- Stabilator (stabilizer-elevator) is a single-piece movable aircraft stabilizer. It does not have an elevator component, and is controlled with a trim control.
- At high speeds shock waves can cause flow separation over the elevator of traditional horizontal stabilzers.
- Stabiltors can be moved using less control effort, therefore, an anti-servotab is used to create artificial resistance with increasing trim angle

- Rudder is used to redirect the flow past a fuselage or hull producing a yaw motion.

- Canard can be used for several purposes including: stability, lift, flight control, trim, or airflow modification
- Lifting- and controlling-canards
  - Lifting-canard can allow for a smaller main wing and offset downward pitch due to the horizontal stabilizer
  - Controlling-canard is primarily used to control pitch

- Spoilers, or lift dumper, is a trailing edge device on the wing of an aircraft used to reduce the lift of the section of wing behind it.
- Spoilers are usually deployed during landing
- Spoilers also increase drag

- Air brakes are used to slow the aircraft by creating drag

- Straight wing – low speed
- Swept wing – reduce aerodynamic drag at speeds near or above the speed of sound
- Swept forward wing – yields the same effect as swept back wing, but the aerodynamic and structural features tend to cause the wing to twist and fail structurally. X-29 uses composite wings:

- Crosswind Landings

http://youtu.be/b15hsOOcJoQ

Form follows Function

- Aircraft are configured to meet specific requirements.
- Airplane design is an open ended problem.
- Design is a compromise:
  - Stability α 1/Control
- High-speed aircraft → poor landing and takeoff performance
- Optimized structural design → complicated structural design
- Speed of Sound (standard day at sea level, 15° C (59°F):
  - 340 m/s
  - 1115 ft/s
  - 1225 km/hr
  - 761 mph
  - Mach 1

Standard Atmosphere

- The average atmospheric conditions
- Provides tables of common reference conditions that can be
Used in an organized fashion
- ICAO Standard Atmosphere: http://code7700.com/images/isa.png

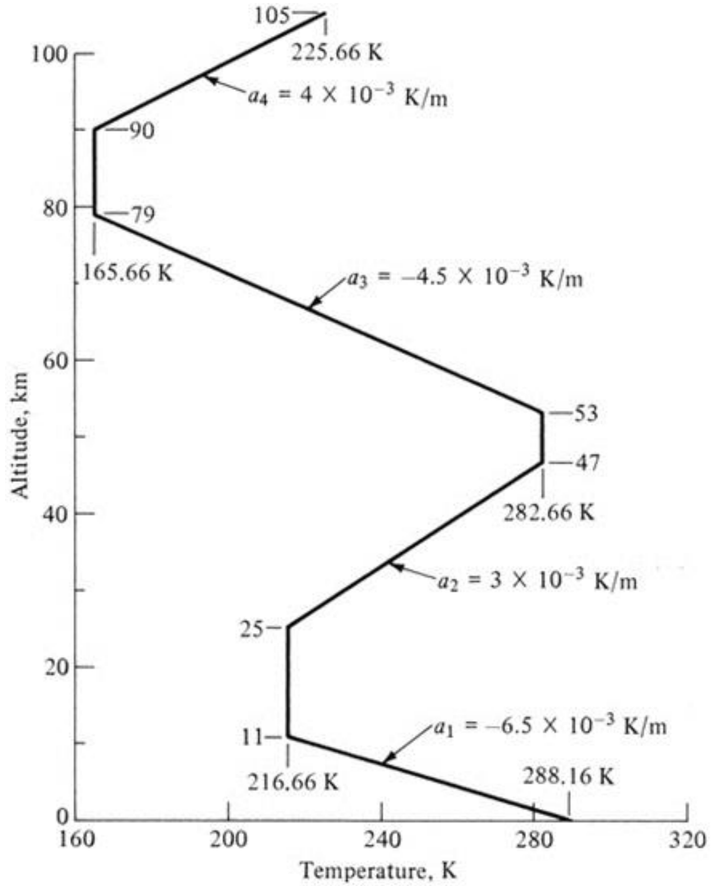
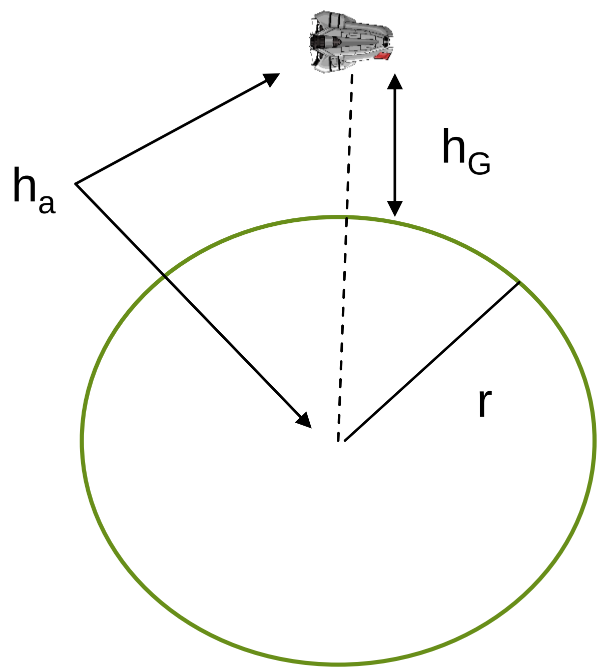


Figure 3.4 Temperature distribution in the standard atmosphere.

Altitude

- Geometric Altitude (h_G): The altitude above the mean sea level (MSL)
- Absolute Altitude (h_a): Distance of an object from the center of the earth:

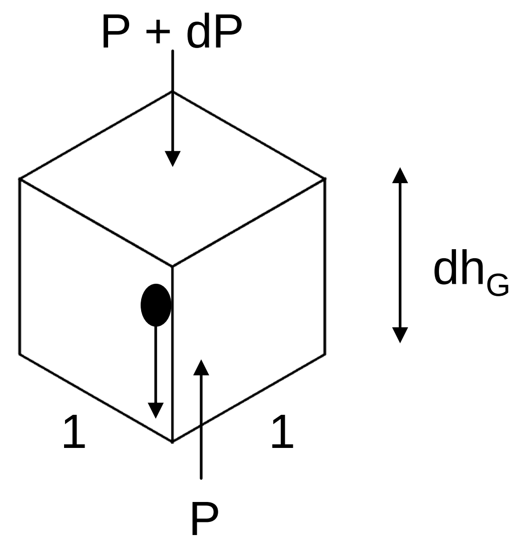
$$h_a = h_G + r$$



- Absolute Altitude (h_a)is important especially for space flight, because the local acceleration due to gravity at *sea level*:

$g = g_0[r/h_a]^2 = g_0[r/(r + h_G)]^2$ ← Hydrostatic Equation

Consider a stationary fluid element:



Volume of element: $1x1xdh_G$
Mass of element: $\rho x1x1xdh_G$
Weight of element: $gx\rho xdh_G$

Three forces are balanced:
$P = P + dP + g\rho dh_G$
$dP = - g\rho dh_G$ ← Hydrostatic Equation (valid for gases and liquids)

Geopotential Altitude

- The value of g changes with altitude. In calculations, a constant value of g_0 is used ($g_0 = g$ at sea level). To compensate for changing g with altitude, we use geopotential altitude.

- Geopotential Altitude (h) is given by: $h = \{r/(r + h_G)\}h_G$
- $h \simeq h_G$ for low altitudes (< 65km, 213,000 ft)
- Aerodynamic heating of NASA Space Shuttle becomes important at about 65 km above MSL: https://www.youtube.com/watch?v=FD9fB2Kl7EA