

Airplanes

Question:

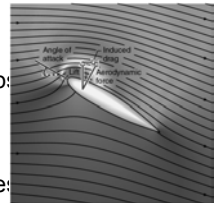
- As you ride in a jet airplane, the clouds are passing you at 600 mph. The air just in front of one of the huge jet engine intake ducts is traveling
 - much faster than 600 mph.
 - much slower than 600 mph.
 - about 600 mph.

Observations About Airplanes

- They support themselves in the air
- They seem to follow their tilt, up or down
- They need airspeed to fly
- They can only rise so quickly
- Their wings often change shape in flight
- They have various propulsion systems

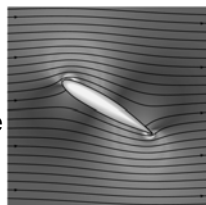
Lifting Wing

- Under the wing,
 - air follows outward bend
 - pressure rises, speed drops
- Over the wing,
 - air follows inward bend
 - pressure drops, speed rises
 - Wing experiences strong upward lift, little drag



At Take-Off

- Wing starts with symmetric airflow
- Wing starts with no lift
- Airflow becomes unstable at the trailing edge bend
- The wing sheds a vortex
- After the vortex leaves, the wing has lift

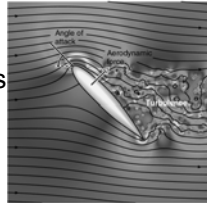


Angle of Attack

- A wing's lift depends on
 - shape of the airfoil
 - angle of attack
- Since wing is attached to plane body, the whole plane tilts to change angle of attack
- Too large an angle of attack causes the wing to "stall" – airflow separation

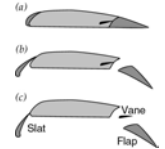
Stalled Wing

- Upper boundary layer stops heading forward
- Upper airstream detaches from wing's top surface
- Lift is reduced
- Pressure drag appears
- Wing can't support plane



Wing Shape

- Asymmetric airfoils produce large lifts
 - well suited to low-speed flight
- Symmetric airfoils produce small lifts
 - well suited to high-speed flight
 - can fly inverted easily
- High-speed planes often change wing shape in flight

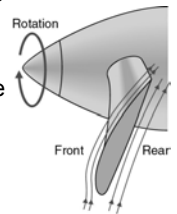


Orientation Control

- Three orientation controls:
 - Angle of attack controlled by elevators
 - Left-right tilt controlled by ailerons
 - Left-right rotation controlled by rudder
- Steering involves ailerons and rudder
- Elevation involves elevators and engine

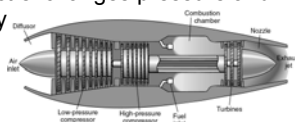
Propellers

- Propellers are spinning wings
 - They deflect air backward
 - Do work on air (add energy)
 - Pump air toward rear of plane
- Action-Reaction
 - They push the air backward
 - Air pushes them forward



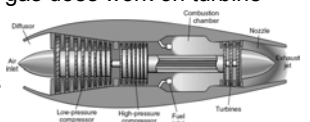
Jet Engines Part 1

- Jet engines pump air toward rear of plane
 - Engine consists of an oval ball with a complicated duct or passageway through it
 - Air inside the duct exchanges pressure and speed repeatedly
 - Engine adds energy to air inside the duct



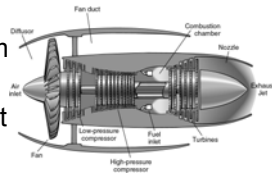
Jet Engines Part 2

- Air entering diffuser slows and pressure rises
- Compressor does work on air
- Fuel is added to air and that mixture is burned
- Expanding exhaust gas does work on turbine
- As exhaust leaves nozzle it speeds up and pressure drops



Jet Engines Part 3

- Turbojet moves too little air and changes that air's speed too much
- Too much energy
- Too little momentum
- Turbofan moves more air and gives it less energy



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2. much slower than 600 mph.
3. about 600 mph.

Summary About Airplanes

- Airplanes use lift to support themselves
- Propulsion overcomes induced drag
- Speed and angle of attack affect altitude
- Extreme angle of attack causes stalling
- Propellers do work on passing airstream
- Jet engines do work on slowed airstream