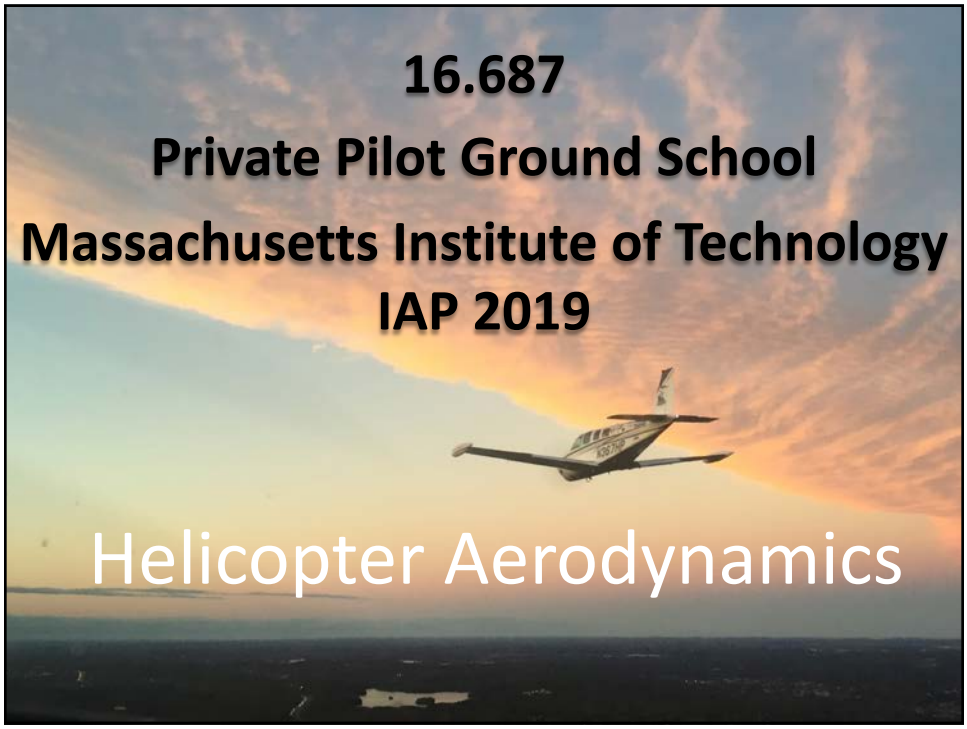
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Massachusetts Institute of Technology
IAP 2019
Helicopter Aerodynamics

Helicopter Parts

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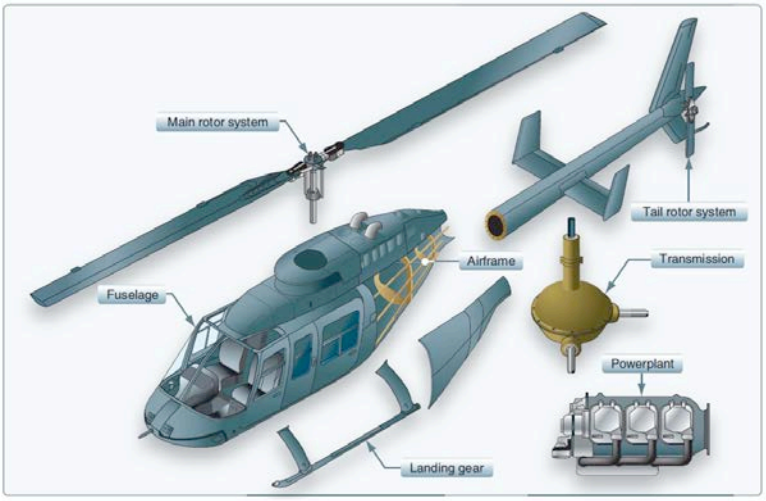

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Turbine helicopter drivetrain

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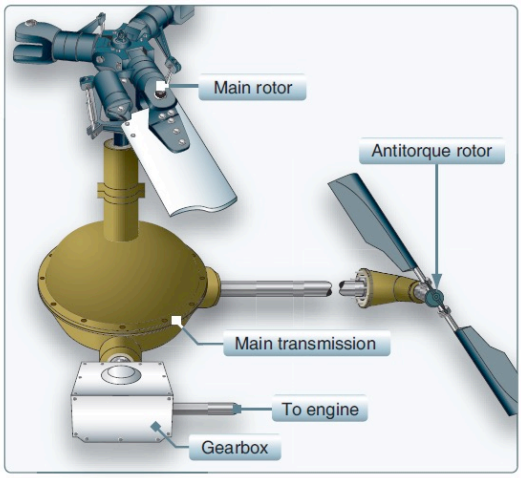

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Piston helicopter drivetrain

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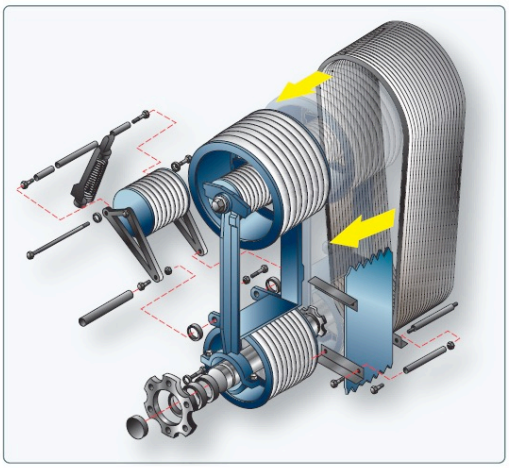

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How does it work?

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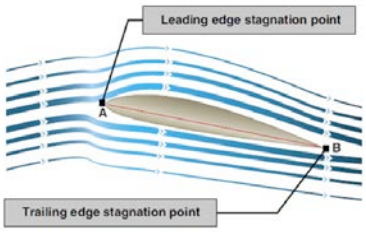
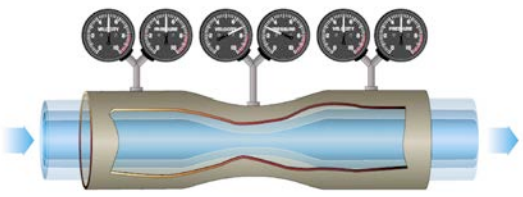
- Lift is a combination of Newton's 3rd Law and Bernoulli Principle
- Sped-up air has more kinetic energy and therefore lower static pressure





6

Lift

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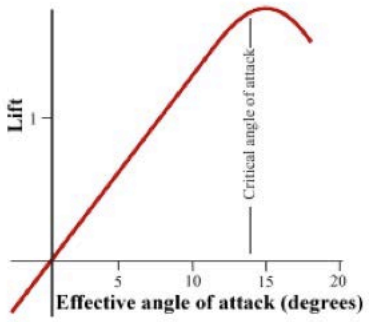

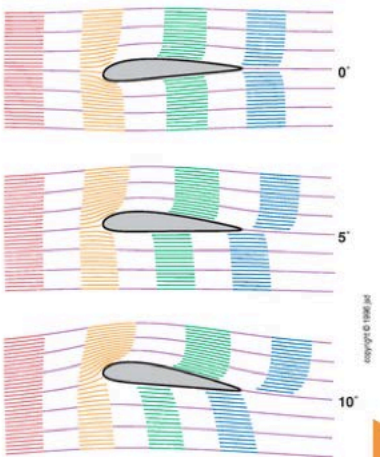

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Angle of Attack I

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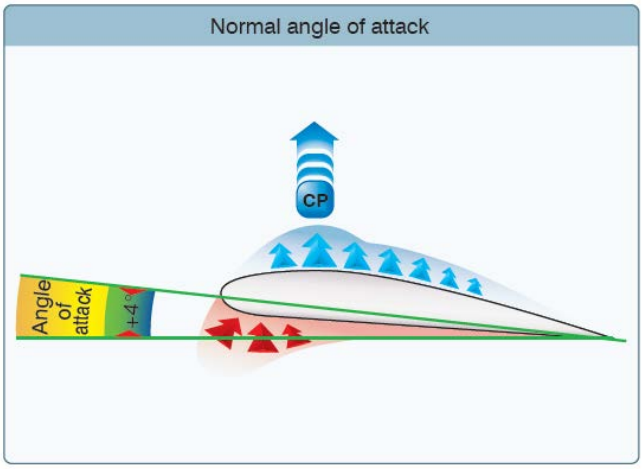

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Angle of Attack III

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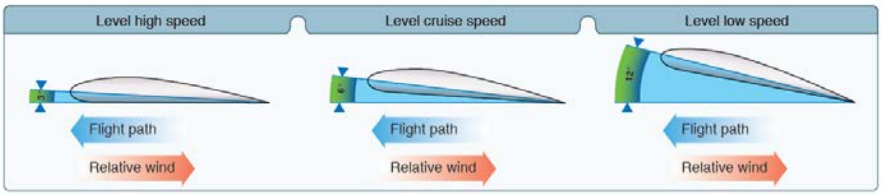

Lift is a function of airspeed squared and varies linearly with angle of attack.

Keep going to the right and find the hovering-in-a-172 angle?

Why Johnny Cessna can't hover

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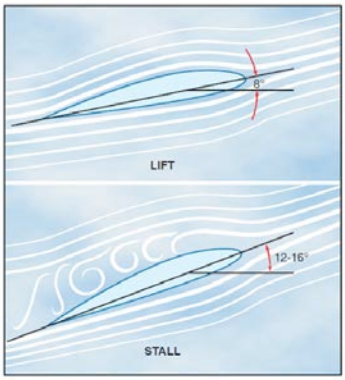

Figure 2-5. As the angle of attack is increased, the separation point starts near the trailing edge of the airfoil and progresses forward. Finally, the airfoil loses its lift and a stall condition occurs.

Rip off and rotate the wing

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Now you have *airspeed* even with no *fuselage speed*. Age of this idea?

- Wright brothers flew in 1903
- French brothers Breguet and Paul Cornu hovered briefly in 1907
- Practical helicopter: Focke-Wulf 61 in 1936.
- Mass production: Sikorsky R-4 (131 from 1942-44)

Spinning on the ramp and hovering

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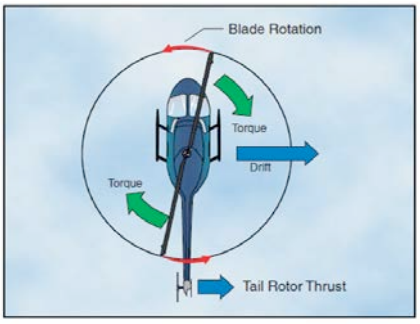
- Spin up the blades to 400 rpm
- How to get more lift so that we rise off the ground?
- What happens to the speed?
- Correlator and governor
- What if we're parked on ice?



Forward Flight

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- Tilt the disc?
- Push on it from where?
- Could the rotor fly itself into a new position?

Figure 9-7. *The helicopter takes several positions during a normal takeoff from hover.*

Where the magic happens: the swashplate

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- We fly the rotor system, not the helicopter.
- Vary overall pitch with **collective.**
- Vary pitch as the blades rotate with the **cyclic**.

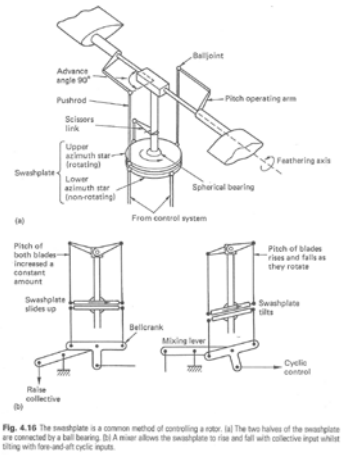

Fig. 4.16 The swashplate is a common method of controlling a rotor. (a) The two halves of the swashplate are connected by a ball bearing. (b) A mixer allows the swashplate to rise and fall with collective input whilst tilting with fore-and-aft cyclic inputs.

Hollywood-style takeoff?

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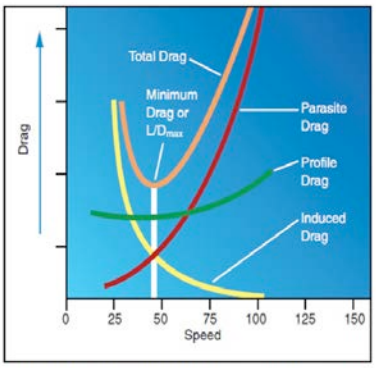
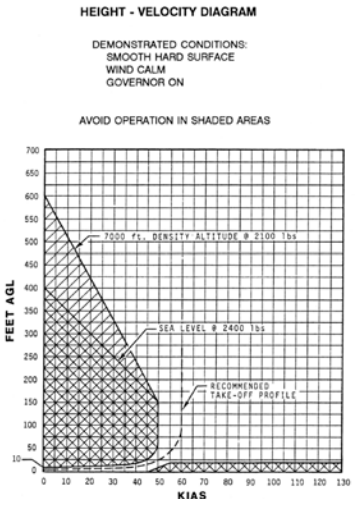


Figure 2-14. The total drag curve represents the combined forces of parasite, profile, and induced drag; and is plotted against airspeed.



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Straight and Level

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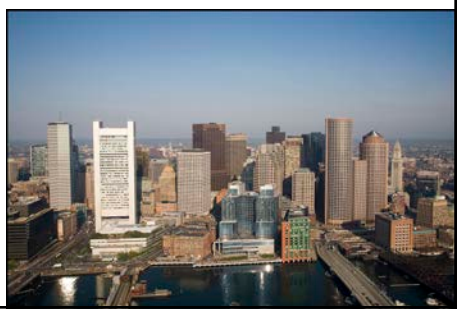
- Performance = attitude plus power
- Pitch down to go faster; up to go slower
- Raise/lower collective to climb or descend
- Attitude indicator = horizon



Straight and Level

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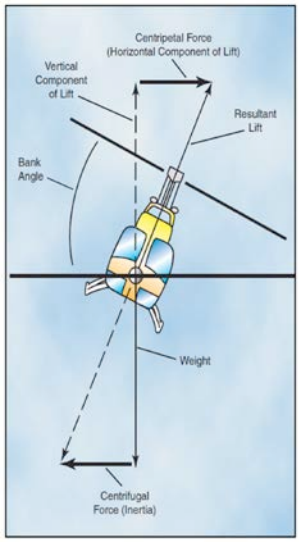
- No need to use the anti-torque pedals ("rudder pedals" to airplane pilots!)
- Bank and wait



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Landing with Power

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- Adjust collective based on spot rising or falling
- Adjust cyclic based on ground rushing by
- Purely visual maneuver except when landing on a pinnacle

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Landing without Power (Autorotation)

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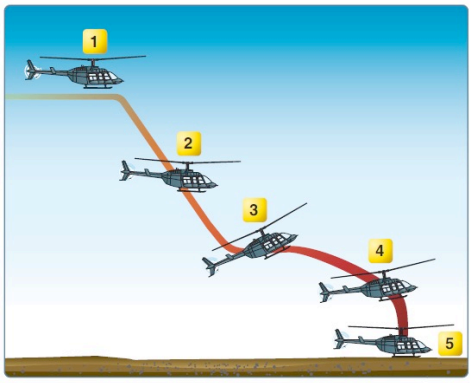
- With no engine, your energy buckets:
  1. Kinetic
  2. Potential
  3. Kinetic

YouTube!



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Helicopter Pilot Careers

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Standard Progression:

1. Flight instructor
2. Sightseeing tours
3. Offshore Oil
4. Medevac (EMS = Earn Money Sleeping)

Summary

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- Fly low and slow legally and safely
- Impress friends who won't say "JetBlue has a nicer plane"
- Land off-airport
- Attitude-flying skills transfer nicely from airplanes.
- About 40 hours of training to add a rating

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