Ground Lesson: Weather

Objectives:

1. to understand basic weather theory
2. to understand how weather effects aircraft and pilot

Justification:

1. as a pilot, weather is a constant and critical factor to flight operations
2. develops knowledge to properly judge the environment for safe flight

Schedule:

Activity	Est. Time
Ground	1.5
Total	1.50

Recommended Readings:

PHAK	Chapter 11

Elements Ground:

- atmosphere
- wind
- moisture, clouds, and precipitation
- fronts
- weather hazards

Completion Standards:

1. when the student exhibits knowledge relating to basic weather theory, and how it effects aircraft and pilot

Presentation Ground:

Atmosphere

1. the atmosphere is made up of many gases but most significantly of nitrogen (78%) and oxygen (21%)
2. there are 3 major levels of atmosphere important to us as pilots
   (1) troposphere - from the surface to between 30k-60k feet above the surface of the earth
   (2) stratosphere - above the troposphere, identified by the relatively small changes in temperature as altitude increases
   (3) tropopause(?) - the level between the troposphere and stratosphere which acts as lid on most weather phenomenon
3. as pilots, we are most concerned with the troposphere for 2 reasons
   (1) this is where we will be flying
   (2) most weather occurs in the troposphere

Wind

1. what causes it?
   (1) irregular heating of the earth's surface causes certain parcels of air to rise
   (2) other air must move in to replace the rising parcels of air and yet another parcel of air must move in to replace that air
   (3) this causes wind
2. global patterns
   (1) pressure gradient
      i. force which causes air to flow from high pressure to low pressure
   (2) coriolis force
      i. due to the earths rotation, things traveling long distances in a straight line will end up tracing a curved path due to the earth's rotation
   (3) frictional force
      i. within about 2000 feet of the ground friction reduces the speed of air movement.
      ii. it reduces Coriolis effect but not pressure gradient force.
   (4) 3 areas of circulation
      i. Hadley cell - 0-30° latitude
      ii.Ferrel cell - 30-60° latitude
      iii. Polar cell - 60°-pole latitude
   (5) low pressure vs high pressure circulation
      i. in the northern hemisphere, air flows clockwise around highs
      ii. in the northern hemisphere, air flows counter-clockwise around lows
3. local patterns
   (1) land and see breezes
      i.during the day, land heats up quicker than water, at night land cools quicker than water
         (i) thus, during the day, cooler air from the water flows onshore
         (ii) at night, cooler air from the land flows offshore towards the water
   (2) katabatic winds
      i. any downslope wind, but typically ones greater than basic mountain breezes

Atmospheric Stability

1. *:the atmosphere's resistance to vertical motion*

(1) air that wants to remain where it is is considered stable air
(2) air that wants to rise or fall is considered unstable air
2. if air is heated from below, the lower air wants to rise above the cooler air on top
3. moist air is less dense than dry air (since water vapor is lighter than air)
(1) warm & moist air produces the most unstable air
4.standard atmosphere
(1) pressure
i.29.92" Hg
ii.1013.2 milibars
(i) millibar = 1000 dynes of force per square centimeter
(2) temperature
i. 15° C or
(3) rates
i. temperature decreases at 2°C (5.4°F) per 1000 ft (called the average lapse rate)
ii. pressure decreases at 1" per 1000 ft

Moisture, Clouds, Precipitation

1. moisture
(1) relative humidity
i.*:percentage of water vapor in the air verses the amount it could hold*
ii.hot air can hold more water vapor than cold air
iii.100% relative humidity is called "saturated air"
(2) dew point
i.*:temperature the air would have to be cooled to be saturated*
ii.less water vapor means lower dew point
iii.temperature - dew point spread describes qualitatively how close the air is being saturated
iv.dew point decreases 0.6°C (1°F) per 1000 ft
(i) can calculate approximate cloud base with:
a. ((temp (°C) - dew point (°C))/1.6(°C))x1000
2. clouds
(1) :visible aggregate of minute water or ice particles suspended in air.
(2) if on the ground, a cloud is called fog
(3) clouds form when air becomes saturated
(4) occurs either via cooling temperatures, or increasing dew point
(5) cooling is the predominant and occurs by 3 basic processes
i. air moving over a colder surface
ii. stagnant air overlying a cooling surface
iii.expansional cooling in upward moving air
(6) types
i. low clouds (sfc - 6500)- stratus, stratocumulus, nimbostratus
ii. middle clouds (6500 - 20000)- altostratus, altocumulus
iii. high clouds (20000+)- cirrus, cirrostratus, cirrocumulus
iv. vertical development - cumulus, towering cumulus, cumulonimbus
(i) bases starting at low - middle

(ii) tops may extend well into high cloud altitudes

3. precipitation
   (1) *:any form of particles, whether liquid or solid, that fall from the atmosphere*
   (2) to occur, water or ice particles must grow in size until they can no longer be supported by the atmosphere
   (3) types include drizzle and rain, ice pellets and hail, snow

Fronts

1. overview
   (1) airmass *:large bodies of air with relatively uniform temperature and moisture content*
   (2) front *:boundary between airmasses*
   (3) fronts often produce significant and potentially hazardous weather for flying
   (4) the rapid changes of meteorological characteristics are called frontal discontinuities
      i. they include
         (i) temperature
         (ii) wind
         (iii) pressure
   (5) there are 4 basic types of fronts
      i. cold front - cold air moving to displace warm air
      ii. warm front - warm air is replacing cold
      iii. stationary front - no movement
      iv. occluded front - merging of cold front and warm front
2. cold front
   (1) dense cold stable air displaces warm unstable air
   (2) this causes the warm air to be forced upward, sometimes rapidly
   (3) the rapid cooling of the warm air can cause significant vertical development of clouds
   (4) heavy showers , hail, lighting, thunderstorms can be present during frontal passage
3. warm front
   (1) warm unstable air overtakes and replaces cold stable air
   (2) less severe weather associated with warm fronts as the warm front typically moves slower that a cold front, and upward movement of warm air isn't as rapid
   (3) rain, sleet, and snow can be present
   (4) stratus clouds can extend for hundreds of miles ahead of the front
4. stationary front
   (1) occurs when opposing fronts with relatively similar forces meet
   (2) can influence weather for several days
   (3) usually a mixture of warm and cold front weather
5. occluded front
   (1) occurs when a fast-moving cold front catches up to a slow-moving warm front
   (2) two types:
      i. cold front occlusion - when fast moving cold front is colder than the air ahead of the slow moving warm front
      ii. warm front occlusion - when the fast moving cold front is warmer than the air ahead of the slow moving warm front
   (3) warm front occlusions typically have more severe weather than cold front occlusions

Weather Hazards

1. thunderstorms
   (1) thunderstorms require sufficient water vapor, unstable lapse rate, initial lifting action
   (2) stages
      i. cumulus - continuous updrafts
      ii. mature - beginning of precipitation; can have updraft and downdrafts, strong vertical windshear
      iii. dissipating - downdrafts, precipitation, storm dies quickly in this stage
   (3) additional hazards associated with thunderstorms are:
      i. turbulence
      ii. lighting
      iii.hail
      iv.tornadoes
2. turbulence
   (1) mechanical - caused by obstructions over the ground. i.e. buildings, trees, etc.
   (2) convective - caused by uneven heating of surfaces.
   (3) frontal - caused by to airmasses converging
   (4) wake - caused by aircraft wings producing downward motion of air, resulting in rotary motion off the tips of the wings
      i. the travel downward and outward
      ii. drift with wind
      iii. greatest wake turbulence is created when aircraft is heavy, slow, in clean configuration, and high angles of attack
   (5) clear air - turbulence not associated with clouds. typically at high altitudes, due to high wind velocities
   (6) mountain wave - form of mechanical turbulence that can cause severe turbulence, downdrafts, updrafts, and visible clouds
      i. updrafts typically on the windward side, downdrafts on leeward side
      ii. characterized by rotor clouds and standing lenticular clouds
3. wind shear
   (1) *:sudden drastic shit in wind speed and/or direction that may occur at any altitude in a vertical or horizontal plane*
      i. windshear is most often associated with convective activity.
      ii. microbursts are particularly dangerous as they can produce downdrafts as high as 6000 fpm and headwind changes on the order of 45 kts.
      iii. some visual indications are virga at the base of a cloud, dust rings on the ground
      iv. LLWAS - Low Level Windshear Alert System is installed at certain airports to assist in detecting critical windshear
4. icing
   (1) *:build up of ice on any exposed surface of an aircraft*
   (2) to occur, there must be visible moisture and the surface must be at or below 0°C
   (3) types
      i. rime ice - caused by instantaneous freezing of supercooled water droplets.
         (i) dangerous due to the way it changes the airfoil of the affected surface
         (ii) typically found in status clouds

ii. clear ice - caused by large supercooled water droplets which contact a surface and freeze as flow over the surface

(i) extremely dangerous as it is very hard to remove, and adheres to surfaces tenaciously

(ii)typically occurs in cumulus clouds

iii. mixed ice - a combination of rime and clear ice

5. restrictions to visibility

(1) haze - caused by a high concentration of dust particles

(2) smoke - suspension of combustion particles in the air

(3) smog - combination of fog and smoke

(4) dust - fine particles of soil suspended in the air

(5) volcanic ash - highly abrasive, it can render visibility and aircraft instruments useless (clog pitot tube, windscreens, etc)