Lesson Objectives

• Learn the causes of various weather conditions, frontal systems, and hazardous weather phenomena.

• Understand how to recognize critical weather situations from the ground and during flight, including hazards associated with thunderstorms.

• Become familiar with the recognition and avoidance of wind shear and wake turbulence.
A-Basic weather theory
- The atmosphere
- Atmospheric circulation
- Atmospheric pressure
- Coriolis force
- Global wind patterns
- Local wind patterns

B-Weather patterns
- Atmospheric stability
- Temperature inversions
- Moisture
- Humidity
- Dewpoint
- Clouds and fog
- Precipitation
- Air masses
- Fronts
Completion Standards

Demonstrate understanding during oral quizzing and exercises.
Basic Weather Theory

Section A
The atmosphere could be defined as an ocean of gases that is constantly in motion.

Consisting of 78% Nitrogen, 21% Oxygen, and 1% other gases (Argon, Radon, Helium and water). Water is responsible for the weather changes that occurs in the atmosphere.
Atmosphere’s Levels

- Thermosphere
- Mesosphere
- Stratosphere
- Tropopause
- Troposphere
Atmosphere’s Levels

- **Troposphere** - Extending from the surface to an average altitude of 36,000 feet.
- **Tropopause** - Above the troposphere which acts as a lid to confined most of the water vapor and associated weather.
- **Stratosphere** - Above the tropopause and has much the same composition as the troposphere with a height of 160,000 feet.
- **Mesosphere & Thermosphere** - Have little practical influence over the weather.
Atmospheric Circulation

- The atmosphere is fixed to the earth by gravity and rotates with the earth. For this reason there is not circulation.

- The dynamic nature of the atmosphere is due to unequal heating of the earth’s surface.
Convection

The solar energy strikes equatorial regions in much greater concentrations, resulting in much higher temperatures than at the poles. As a result, cold dense air from the poles sinks and flows toward the equator, where it displaces rising air that is warmer and less dense.
The unequal heating of the earth surface not only modifies air density and creates circulation patterns, it also causes changes in pressure. This is the reason for differences in altimeter settings between weather reporting stations.
Isobars

- Are measure in millibars and drawn at four-millibars intervals.
- The resulting pattern reveals the pressure gradient or change in pressure over distance.
- A **ridge** is an elongated area of high pressure and a **trough** is elongated area of low pressure.
Coriolis Force deflects the displaced air to the right in the northern hemisphere and towards the left on the southern hemisphere.
Local Wind Patterns

- Local wind patterns influence the earth’s overall weather.

- The force behind these winds - cool air replacing warm air is the same as is for global wind patterns, but on a much smaller scale.
Sea Breeze

Land is usually warmer than water during the day. (Cooling air blowing over the warmer land)
At night, land cools faster than the water. (Cooling air blowing over the warmer water)
As mountain slope is warmed by the sun, the adjacent air is also heated.

(warm air flowing upward & warming the slope)
As the ground cools at night, air flows down the slope.
Weather Patterns

Section B
Atmospheric Stability

- Is the atmosphere’s resistance to vertical motion.
- This instability can lead to significant cloud development, turbulence and hazardous weather.
Adiabatic Heating & Adiabatic Cooling

- Air that moves **upward expands** due to lower atmospheric pressure.

- Air that moves **downward compressed** due to increased pressure at low altitudes.
Lapse Rate

• The rate at which temperature decreases with an increase in altitude is referred to as its lapse rate.

Average Lapse Rate

2 degrees Celsius / 3.5 degrees Fahrenheit for each 1,000 feet
Temperature Inversions

Temperature Inversions exists when the temperatures increases with altitude. Visibility is restricted or poor during the inversion. This kind of condition occurs in stable air with little or no wind and turbulence.
Moisture

Could be defined as a water vapor suspended in the air.

**Moist air** = Poor or severe weather conditions

**Dry air** = Good weather conditions
Change of State

- Evaporation, Condensation, Sublimation
- Deposition, Melting and Freezing
Dewpoint

Is the temperature at which air reaches a state it can hold no more water. The air contains 100% of the moisture for that temperature. Has reached it saturation point.

<table>
<thead>
<tr>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>32° Celsius Temperature</td>
<td>-5° Celsius Temperature</td>
</tr>
<tr>
<td>10° Celsius Dewpoint</td>
<td>-5° Celsius Dewpoint</td>
</tr>
<tr>
<td>26% Relative Humidity</td>
<td>100% Relative Humidity</td>
</tr>
</tbody>
</table>
Calculating Cloud Bases

Temperature (°F) – Dewpoint (°F) × 1,000

4.4 (°F)

= Cloud Base

Example:

32°C → 91°F
10°C → 47°F

44 × 1,000 = 44,000

=44,000 / 4.4 = 10,000 Feet AGL
Clouds are visible moisture in the sky.

- Clouds consist of small droplets of water or ice if the temperature is low enough.
Clouds Classification

- Vertical Development Cloud
- High Clouds
- Middle Clouds
- Low Clouds
Low Clouds

Extend from the surface to about 6,500’ AGL

- Usually consist of water.
- Stratus, Stratocumulus, and Nimbostratus
- Nimbus means rain
- Responsible for fog
Middle Clouds

Extend from 6,500’ to 20,000’ AGL

- Usually consist of water and ice crystals
- Altostratus, Altocumulus, and Cumulus
High Clouds

Extend from 20,000’ AGL.

- Usually white to light gray in color and form in stable air. Consist of ice crystal and turbulence or icing hazard.
- Cirrus, Cirrostratus, and Cirrocumulus
Vertical Development Clouds

These clouds are found at altitudes associated with low middle and high clouds.

- Associated with extreme turbulence and ice
- Cumulus, Towering Cumulus, and Cumulonimbus
Precipitation

- Could be defined as any form of particles, whether liquid or solid, that fall from the atmosphere. **Rain, snow, hail, drizzle, or ice pellets.**

- It can reach the ground or evaporates in the atmosphere.
Streaks of rain which evaporates before reaching the ground are known as virga. At times, falling rain may never reach the ground due to rapid evaporation.
Airmasses

An airmass is a large body of air with fairly uniform temperature and moisture content.

- It may be several hundred miles across and usually forms where air remains stationary.
Source Regions

Source region is the area where an airmass acquires the properties of temperature and moisture that determine its stability.
Airmasses are classified according to the regions where they originate.
As an airmass moves out of its source region, it is modified by the temperature and moisture of the area over which it moves. **Warming From Below**
As an airmass moves out of its source region, it is modified by the temperature and moisture of the area over which it moves. **Cooling From Below**
Fronts are **boundaries between airmasses.** When airmasses moves out of its source region, it comes in contact with other airmasses that have different moisture and temperature characteristics.
# Types of Fronts

<table>
<thead>
<tr>
<th>Front Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Front</td>
<td>Cold air displacing warm air</td>
</tr>
<tr>
<td>Warm Front</td>
<td>Warm air displacing cold air</td>
</tr>
<tr>
<td>Stationary Front</td>
<td>No movement Front</td>
</tr>
<tr>
<td>Occluded Front</td>
<td>Cold and Warm front merging</td>
</tr>
</tbody>
</table>
Frontal Discontinuities

- Outside temperature changes
- Wind direction changes
- Pressure drop regardless of the front

Rapid changes from one airmass into another airmass with different properties.
Weather Hazards

Section C
Thunderstorms

Three conditions must be present:

- Lifting action
- High moisture content
- Instable air
Life Cycle

- **Cumulus Stage** - Updraft
- **Mature Stage** - Updraft and Dissipating
- **Dissipating Stage** - Dissipating
Thunderstorm Hazards

- Turbulence
- Lighting
- Hail
- Tornadoes

If encounter turbulence during flight, establish maneuvering speed and try to maintain a level flight attitude.
Clear Air Turbulence

Occurs when a layer of air slides over the top of another.
Mechanical Turbulence

When obstacles such as buildings or rough terrain interfere with the normal wind flow.
Convective Turbulence

Is typically a daytime phenomena which occurs over land in fair weather. Which develop when air is heated by contact with the warm surface.
Mountain Wave Turbulence

Occurs when stable air moves across the ridge when winds are 40 knots or greater.
Frontal Turbulence

Occurs in the narrow zone just ahead of a fast moving cold front where updrafts can reach 1,000 feet per minute.

30 Knots
Wake Turbulence

- This flow causes rapidly rotating whirlpools of air.
- Only occurs when airplanes operating at low speeds and at high angles of attack in clean configuration.
- During (Take offs and landings)
Jet Blast Turbulence

Stay several hundred feet behind a jet with engines operating, even when its at idle thrust.
Wind Shear (Microburst)

Is a sudden, drastic shift in wind speed or direction that may occur at any altitude in vertical or horizontal plane. Can exist near the surface when there is a frontal system, thunderstorm, or temperature inversion.
Wind Shear vs. Microburst

Wind shear
Contain winds of 25 knots when cold still air is covered by warm air at 2,000 or 4,000 feet above the surface.

Microburst
Contain winds of 25-100 knots and last about 15 minutes with downdraft of 6,000 FPM.
Terminal Doppler Radar

Terminal Doppler Radar systems are being installed at airports with high wind shear potential. These radar use a narrower radar beam and detected thunderstorms and precipitation movement and speed.
Icing

Visible moisture is necessary for structural icing to form.

**Rime Ice** - It has an opaque appearance.

**Clear Ice** - It may develop in areas of large super-cooled water droplets as they freeze.
Restrictions to Visibility

- **Haze** - Salt or dust particles
- **Smoke** - Suspension of combustion particles
- **Smog** - Combination of smoke and fog
- **Dust** - Soil particles
- **Volcanic Ash** - Gases, dust, and ash