CHAPTER 7

WEATHER THEORY

INTRODUCTION

Virtually all of our activities are affected by weather, but of all man's endeavors, none is influenced more intimately than aviation. Weather is complex and at times difficult to understand. Our restless atmosphere is constantly in motion as it strives to achieve balance. This never ending balancing act sets up chain reactions which culminate in a continuing variety of weather.

GENERAL CIRCULATION

Every physical process of weather is accompanied by or is the result of a heat exchange. The amount of solar energy received by any region varies with time of day, with seasons, and with latitude. These differences in solar energy create temperature variations. Differences in temperature create differences in pressure. These pressure differences drive a complex system of winds in a perpetual attempt to reach balance.

PRESSURE GRADIENT FORCE

Pressure differences create a force or pressure gradient. This force is exerted across isobars (lines connecting points of equal pressure) at right angles from high pressure to low pressure. The closer the spacing between isobars, the greater the pressure change. A strong pressure gradient means strong winds.

In warm equatorial regions, air is less dense and low pressure areas predominate. The cold polar regions, have dense high pressure areas. A pressure gradient develops from the poles to the equator. If the earth did not rotate, this pressure gradient would be the only force acting on the wind.

Circulation would be two giant hemispheric convective currents. Cold air would sink at the poles; wind would blow straight from the poles to the equator; warm air at the equator would be forced upward; and high level winds would blow directly towards the poles. This circulation is greatly distorted by the earth's rotation.

CORIOLIS FORCE

As an air mass begins to move south across the surface of the earth (in the Northern Hemisphere) the rotation of the earth deflects this movement towards the right. The force deflects air to the right in the Northern Hemisphere and to the left in the Southern Hemisphere.

FRICTION LEVEL

The amount of coriolis force depends on the speed of the wind. If the wind speed decreases so will the coriolis force. The wind below the friction level (approximately 2000 feet AGL) moves more slowly than the winds aloft due to drag caused by the surface. Therefore the surface wind experiences less coriolis effect than the winds aloft.

3.3.3.8.1.A.1 I21

Every physical process of weather is accompanied by, or is the result of, a heat exchange.

3.3.3.8.2.A.1 I21

Unequal heating of the Earth's surface causes variations in altimeter settings between weather reporting points.

3.3.3.9.5.A.1 I23

The wind at 5,000 feet AGL is southwesterly while the surface wind is southerly. This difference in direction is primarily due to friction between the wind and the surface.

RESULTANT CIRCULATION

With pressure gradient causing the air to move from high pressure to low pressure and coriolis turning it to the right, the resultant surface circulation (below the friction level) becomes clockwise and outward around a high pressure system and counterclockwise and inward around a low pressure system.

Above the friction level, coriolis and pressure gradient balance each other. The winds aloft tend to parallel the isobars, clockwise around the highs and counterclockwise around the lows.

STANDARD ATMOSPHERE

Changes of temperature and pressure in the atmosphere create problems for engineers and meteorologists. They require a fixed standard of reference. To arrive at a standard, they determined average conditions throughout the atmosphere for all latitudes, seasons, and altitudes. The result is a standard atmosphere with a specified sea level temperature and pressure and specific rates of change with height. These values are the standard for calibrating altimeters and developing aircraft performance data.

The standard sea-level pressure is 29.92" of Hg. This is the same as 1013.2 millibars. Both of these values refer to the weight of a substance that is equivalent to the weight of the atmosphere. A column of air weighs the same as a column of mercury 29.92 inches tall.

The standard temperature at sea level is 15° Celsius or 59° Fahrenheit.

A lapse rate is defined as a decrease in temperature and pressure with an increase in altitude. The standard lapse rate is 2° C per thousand feet. The standard change in pressure is 1” of mercury per thousand feet.

This applies only to the troposphere, however. This "lower" layer of our atmosphere is surrounded by a boundary layer called the tropopause. Under standard conditions the tropopause begins at 36,000 feet and is characterized by an abrupt change in the temperature lapse rate.

AIR MASS CHARACTERISTICS

When an air mass comes to rest or moves slowly over an extensive area, having fairly uniform properties of temperature and moisture, the air takes on those properties. The air over the area becomes somewhat of an entity and has uniform horizontal distribution.

MOISTURE

Water may exist as a liquid, a gas or a solid. Ice may melt to water which then may evaporate to become water vapor. Water vapor may condense to form fog, clouds, or dew. This liquid may then freeze to form ice. Sublimation describes the process of water changing from solid to gas or from gas to solid without passing through the liquid state. Snow or frost form when water vapor sublimates to a solid. Snow and frost may likewise sublimate to a vapor. Water vapor is present to varying degrees in all air masses.

DETAIL	NOTES
3.3.3.8.6.A.1 I21 The standard temperature and pressure values for sea level are 15°C and 29.92" Hg.	

The amount of water vapor in the air may be expressed as relative humidity or by the dew point. As water vapor is added to an air mass through evaporation or sublimation, the relative humidity increases. When the moisture content of the air reaches a maximum, it is said to be saturated. The relative humidity of saturated air is 100 percent. Unsaturated will have a relative humidity of less than 100 percent.

The amount of water vapor which air can hold largely depends on the air temperature. Warm air can hold more water vapor than cool air. If an air mass is cooled, its ability to hold water vapor will decrease resulting in an increase in relative humidity. If cooled to the point at which the relative humidity is 100%, the air has become saturated. The temperature to which air must be cooled to become saturated is called the dew point. The dew point of an air mass will rise if moisture is added through evaporation or sublimation. Likewise, the dew point will decrease if moisture is removed from the air through condensation or sublimation. The difference or "spread" between the air temperature and its dew point is an indicator of the amount of moisture in the air. A temperature/dew point spread of 4°F or less indicates the possible formation of low clouds and/or fog.

Air that is lifted through convection will undergo a change in temperature and dew point as a result of decompression. Rising air cools at a rate of about 5.4° F/1000 feet while the dew point decreases at a rate of about 1° F/1000 feet. The result is a decrease in the temperature/dew point spread of about 4.4° F/1000 feet. A pilot can estimate the altitude where the temperature and dew point will come together by dividing the temperature/dew point spread at a given height by 4.4 and multiplying by 1000. The answer represents the increase in altitude (in thousands of feet) necessary to bring the spread to zero. This is the altitude at which the cloud bases are likely to form.

Another identifying feature of an air mass is its degree of stability which in turn determines its weather characteristics. Refer to Figure 7-0 for a summary of weather conditions associated with stable and unstable air masses.

UNSTABLE AIR	STABLE AIR
Cumuloform Clouds Showery Precipitation Rough Air (Turbulence) Good Visibility (Except with blowing obstructions) Clear Ice	Stratiform Clouds and Fog Continuous Precipitation Smooth Air Fair to Poor Visibility in Smoke and Haze Rime Ice

Figure 7-0

3.3.4.4.4.A.1 I31
If the temperature/dew point spread is small and decreasing, and the temperature is 62°F, fog or low clouds is most likely to develop.

3.3.3.9.7.A.1 I24
The term "dew point" refers to the temperature to which air must be cooled to become saturated.

3.3.3.9.8.A.1 I24
The amount of water vapor which air can hold depends on the air temperature.

3.3.3.9.9.A.1 I24
Clouds, fog, or dew will always form when water vapor condenses.

3.3.4.0.0.A.1 I24
Evaporation and sublimation are the processes by which moisture is added to unsaturated air.

3.3.4.0.9.A.1 I25
If the surface air temperature at 1,000 feet MSL is 70 °F and the dew point is 48°F, the approximate base of the cumulus clouds is 6,000 feet MSL.

3.3.4.1.2.A.1 I25
Cumuliform clouds and showery precipitation are characteristics of a moist, unstable air mass.

3.3.4.1.3.A.1 I25
Turbulence and good surface visibility are characteristics of unstable air.

3.3.4.1.4.A.1 I25
A stable air mass is most likely characterised as having smooth air.

3.3.4.0.5.A.1 I25
Stratiform clouds are a characteristic of stable air.

3.3.4.0.6.A.1 I25
Moist, stable air flowing upslope can be expected to produce stratus type clouds.

3.3.4.0.7.A.1 I25
If an unstable air mass is forced upward, clouds with considerable vertical development and associated turbulence can be expected.

3.3.4.0.4.A.1 I25
Warming from below would decrease the stability of an air mass.

DETERMINING STABILITY

The actual lapse rate of an air mass determines its stability. While the standard temperature lapse rate is 2° C/1000 feet the actual change is rarely that. Cold air masses generally have much greater lapse rates, especially when heated from below. This results in unstable conditions. Warm air masses often have very slight lapse rates and stable conditions. Occasionally the temperature will even increase with a gain in altitude. This is an inversion and always results in stable conditions.

If freezing rain exists in the upper level of a temperature inversion, one may find ice pellets in the lower level or on the surface.

If the relative humidity is high beneath a low level temperature inversion you can expect smooth air and poor visibility due to fog, haze, or low clouds. The most frequent type of ground or surface based temperature inversion is that produced by terrestrial radiation on a clear, relatively still night.

CLOUD IDENTIFICATION

The stability of the air before lifting occurs determines the structure or type of clouds which will form as a result of air being forced to ascend.

Clouds that result when unstable air is forced aloft are cumulus. They are characterized by their lumpy, billowy appearance. Clouds formed by the cooling of a stable layer are stratus, meaning stratified or layered. These clouds are characterized by their uniform, sheet-like appearance.

Cumulus and stratus clouds are further divided into four families according to their height range. They are high clouds (bases 16,500 to 45,000 feet in the mid latitudes), middle clouds (bases 6,500 to 23,000 feet), and low clouds (bases from the surface to about 6,500 feet), plus clouds with extensive vertical development.

Cirrus Clouds

Stratus Clouds

Cumulus Clouds

3.3.4.0.2.A.1 I24
The presence of ice pellets at the surface is evidence that there is a temperature inversion with freezing rain at a higher altitude.

3.3.4.0.3.A.1 I25
Actual lapse rate can be used to determine the stability of the atmosphere.

3.3.4.0.8.A.1 I25
A stable layer of air is associated with a temperature inversion.

3.3.3.8.3.A.1 I21
A temperature inversion would most likely result in an increase in temperature as altitude is increased.

In addition to the information given in Figure 7-1, the prefix nimbo or suffix nimbus means rain cloud. Thus, stratified clouds from which rain is falling are nimbostratus. A heavy swelling cumulus type cloud which produces precipitation is a cumulonimbus. Both cumulonimbus and towering cumulus are clouds with extensive vertical development. These clouds are formed in very unstable air and indicate the presence of convective turbulence.

	STABLE CONDITIONS	UNSTABLE CONDITIONS	
HIGH	Cirrus & Cirrostratus	Cirrocumulus	Cumulonimbus Extensive Vertical Development
MIDDLE	Altostratus	Altocumulus	
LOW	Stratus	Cumulus	

Figure 7-1

A middle cloud that deserves special attention is an almond or lens-shaped cloud which appears stationary, but which may contain winds of 50 knots or more. These clouds, known as standing lenticular clouds mark the crests of standing mountain waves where turbulence can sometimes be extreme. Avoid flight near these waves.

Standing Lenticular Clouds

Altocumulus Clouds

3.3.3.8.4.A.1 I21
The most frequent type of ground or surface-based temperature inversion is that which is produced by terrestrial radiation on a clear, relatively still night.

3.3.3.8.5.A.1 I21
Smooth air, poor visibility, fog, haze, or low clouds should be expected beneath a low-level temperature inversion layer when the relative humidity is high.

3.3.4.1.5.A.1 I26
The suffix "nimbus," used in naming clouds, means a rain cloud.

3.3.4.1.6.A.1 I26
Clouds are divided into four families according to their height range.

3.3.4.1.7.A.1 I26
An almond or lens-shaped cloud which appears stationary, but which may contain winds of 50 knots or more, is referred to as a lenticular cloud.

3.3.4.1.8.A.1 I26
Crests of standing mountain waves may be marked by stationary, lens-shaped clouds known as standing lenticular clouds.

3.3.4.2.0.A.1 I26
Towering cumulus clouds indicate convective turbulence.

3.3.4.3.3.A.1 I30
The conditions necessary for the formation of cumulonimbus clouds are a lifting action and unstable, moist air.

3.3.4.1.9.A.1 I26
Cumulonimbus clouds have the greatest turbulence.

FRONTS

As air masses move out of their source regions, they come in contact with other air masses of different properties. The boundary between them is called a front. Across this boundary, changes in temperature and humidity often occur rapidly over short distances. One weather phenomenon which will always occur when flying across a front is a change in wind direction (Figure 7-2).

FRONTAL CHARACTERISTICS	
COLD FRONTS	**WARM FRONTS**
Rapid movement (30 kts average)	Slow movement (15 kts average)
Pushes under the warm air	Rides over the cold air
Temperature inversion at and behind surface front	Temperature inversion at and ahead of surface front
Steep frontal slope	Shallow frontal slope
Narrow frontal zone at and behind the front	Wide frontal zone at and ahead the front
Thunderstorms & showers	Drizzle and steady precipitation
Cumuliform clouds	Stratiform clouds
Turbulent	Smooth
Good visibility outside of showers	Poor visibility

Figure 7-2

TEMPERATURE INVERSIONS

Expect turbulence and wind shear at the top of a strong temperature inversion. Turbulence is greatest whenever the wind speed at 2000 to 4000 feet above the surface is 25 knots or more.

PILOT ACTION

Aircraft reaction to turbulence varies with the difference in wind speed and adjacent currents, size of the aircraft, wing loading, airspeed, and aircraft attitude. The first rule in flying in turbulence is to reduce airspeed. Maneuvering speed is the recommended airspeed for penetrating turbulence. The second rule is to maintain a level flight attitude and ride it out.

THUNDERSTORM INGREDIENTS

The conditions necessary for the formation of a thunderstorm are the same as those required for any towering cumulus or cumulonimbus. There must be a lifting force, high humidity, and unstable conditions.

The lift may be provided by mountain ranges, convective heating from the earth's surface, the ramp lift effect from frontal activity, or convergence where the flow of air converges upon itself developing an upward motion.

DETAIL	NOTES
3.3.4.2.1.A.1 I27 The boundary between two different air masses is referred to as a front. **3.3.4.2.2.A.1** I27 One of the most easily recognized discontinuities across a front is a change in temperature. **3.3.4.2.3.A.1** I27 One weather phenomenon which will always occur when flying across a front is a change in the wind direction. **3.3.4.2.4.A.1** I27 Steady precipitation preceding a front is an indication of stratiform clouds with little or no turbulence. **3.3.4.2.8.A.1** I28 A pilot can expect a wind-shear zone in a temperature inversion whenever the windspeed at 2,000 to 4,000 feet above the surface is at least 25 knots. **3.3.4.4.2.A.1** I30 Upon encountering severe turbulence, the pilot should attempt to maintain level flight attitude.	

CUMULUS STAGE

The life cycle of a thunderstorm encompasses three stages. The first is the cumulus stage. Though not all cumulus clouds become thunderstorms, every thunderstorm begins with a cumulus stage. This building stage consists primarily of up drafts that may exceed 3,000 feet per minute. Early during the stage water droplets are quite small but grow to rain drop size as the cloud grows.

Eventually the rain drops become heavy enough to begin to fall in spite of the up draft. As the rain falls down drafts develop.

Cumulus Stage

MATURE STAGE

The start of rain at the surface signals the beginning of the mature stage. Down drafts may exceed 2,500 feet per minute. The down rushing air spreads outward at the surface, producing strong gusty surface winds, a sharp temperature drop, and a rapid rise in pressure. The surface wind surge is called a plow wind and its leading edge is the first gust.

Up drafts during this stage reach a maximum with speeds possibly exceeding 6,000 feet per minute. Up drafts and down drafts in close proximity create strong vertical shear and very turbulent conditions. All thunderstorm hazards reach their greatest intensity during the mature stage.

Mature Stage

3.3.4.3.6.A.1 I30
The conditions necessary for the formation of thunderstorms are high humidity, lifting force, and unstable conditions.

3.3.4.3.4.A.1 I30
Continuous up draft is a feature normally associated with the cumulus stage of a thunderstorm.

3.3.4.3.5.A.1 I30
The weather phenomenon that signals the beginning of the mature stage of a thunderstorm is precipitation beginning to fall.

3.3.4.3.8.A.1 I30
Thunderstorms reach their greatest intensity during the mature stage.

Gust Front

DISSIPATING STAGE

The third stage in the life of a thunderstorm is the dissipating stage. Down drafts characterize this stage and the storm dies rapidly.

HAZARDS

Thunderstorm hazards include tornadoes, turbulence, icing, hail, low ceiling and visibility, and lightning. Actually lightning is not a great hazard to the aircraft but it may cause damage and it is annoying to flight crews. It is the one phenomena that is always associated with thunderstorms. The greatest turbulence can be found in cumulonimbus clouds due to the up and down drafts.

AVOIDING THUNDERSTORM HAZARDS

Avoiding thunderstorms is always the best policy.

1. Don't take off or land in the face of an approaching thunderstorm. Wind shear turbulence is hazardous and invisible.

2. Don't attempt to fly under a thunderstorm even if you can see through to the other side. Turbulence under the storm could be disastrous.

3. Don't try to circumnavigate thunderstorms when more than half of the area is reported involved with thunderstorms.

4. Do avoid by at least twenty miles any thunderstorm identified as severe. This is especially true under the anvil of a large cumulus since hail often falls from the anvil.

5. Do remember that vivid and frequent lightning indicates a severe thunderstorm. It is best to land the airplane and wait until the weather passes.

6. At all costs avoid flying in the vicinity of squall lines. Thunderstorms associated with squall lines generally produce the most severe conditions such as heavy hail and destructive winds.

7. Embedded thunderstorms pose a special hazard. These storms are obscured from sight by massive cloud layers. If you can't see the storms, avoiding them is impossible.

Dissipating Stage

3.3.4.3.7.A.1
During the life cycle of a thunderstorm, the dissipating stage is characterized predominately by down drafts.

3.3.4.3.9.A.1 I30
Thunderstorms which generally produce the most intense hazard to aircraft are squall line thunderstorms.

3.3.4.4.1.A.1 I30
If there is thunderstorm activity in the vicinity of an airport at which you plan to land, you might expect wind-shear turbulence on the landing approach.

3.3.4.4.0.A.1 I30
A non frontal, narrow band of active thunderstorms that often develop ahead of a cold front is known as a squall line.

3.3.4.5.2.A.1 I36
Lightning is the one phenomenon always associated with a thunderstorm.

FOG

Fog is a surface based cloud comprised of either water droplets or ice crystals. It is the most frequent cause of surface visibility below 3 miles and is one of the most common and persistent weather hazards encountered in aviation. The rapidity with which fog can form makes it especially hazardous. It is not unusual for visibility to drop from VFR to less than 1 mile in a few minutes.

A small spread between the temperature and the dew point is essential for fog to form. Therefore, it is prevalent in coastal areas where moisture is abundant. However, fog can occur anywhere. It may form because the air is cooled to a dew point or because moisture is added to the air. Fog is classified by the way it forms.

Radiation Fog

Radiation fog is relatively shallow. It may be dense enough to hide the entire sky or may conceal only part of the sky. "Ground fog" is a form of radiation fog.

The situation most conducive to the formation of radiation fog is warm, moist air over low, flat land areas on clear, calm nights.

Advection Fog

Advection fog forms when moist air moves along colder ground or water. It is most common along coastal areas. Advection fog deepens as wind speed increases up to about 15 knots. Wind much stronger than 15 knots lifts the fog into a layer of low stratus clouds.

The west coast of the United States is quite vulnerable to advection fog. It frequently forms offshore as a result of cold water and then is carried inland by the wind. During the winter, advection fog over the central and eastern United States results when moist air from the Gulf of Mexico spreads northward over the cold ground.

Upslope Fog

Upslope fog forms as a result of moist, stable air being cooled as it moves up sloping terrain. Once the upslope wind ceases the fog dissipates. Unlike radiation fog it can form under cloudy skies. Upslope fog is common along eastern slopes of the Rockies and somewhat less frequent east of the Appalachians. Upslope fog is often quite dense and extends to high altitudes.

Upslope Fog

Radiation Fog

Advection Fog

3.3.4.4.3.A.1 I31
Warm, moist air over low, flatland areas on clear, calm nights is the situation most conducive to the formation of radiation fog.

3.3.4.4.5.A.1 I31
Advection fog most likely to form as the result of an air mass moving inland from the coast in winter.

3.3.4.4.6.A.1 I31
Advection fog and upslope fog depend upon wind in order to exist.

Steam Fog

Steam fog, often called "sea smoke," forms in winter when cold, dry air passes from land areas over comparatively warm ocean waters. Moisture evaporates rapidly from the water surface; but since the cold air can hold only a small amount of water vapor, condensation takes place just above the surface of the water and appears as "steam" rising from the ocean.

This fog is composed entirely of water droplets that often freeze quickly and fall back into the water as ice particles. Low level turbulence can occur and icing can become hazardous.

ICE

Structural icing adversely affects performance by increasing weight, reducing lift, decreasing thrust, and increasing drag. Icing also seriously impairs aircraft engine performance. Icing may also cause false indications on flight instruments, loss of radio communications, and loss of operation of control surfaces, brakes, and landing gear.

Conditions necessary for structural icing in flight are visible moisture and freezing temperatures. Because of aerodynamic cooling, structural ice may occur even if the ambient temperature is plus 2° Celsius. The types of structural icing are clear, rime, and a mixture of the two. Clear ice occurs in cumulus clouds, rime ice in stratus clouds. Freezing rain causes the highest accumulation rate of structural ice.

FROST

Frost may form when the dew point and the temperature of the collecting surface are below freezing.

Frost does not change the basic aerodynamic shape of the wing, but the roughness of its surface spoils the smooth flow of air, slowing the air flow. The slowing of the air causes early airflow separation resulting in a loss of lift.

Even a small amount of frost on airfoils may prevent an aircraft from becoming airborne at normal takeoff speed. Once airborne, an aircraft could have insufficient margin of airspeed above stall so that moderate gusts or turning flight could produce a stall.

WIND SHEAR

Wind shear is an abrupt change in wind direction or speed in a very short distance in the atmosphere. Wind shear is common in and around thunderstorms and fronts, but can occur at any altitude and in any direction. Strong temperature inversions and jet streams also present wind shear hazards.

Steam Fog

3.3.4.2.9.A.1 I28
One in-flight condition necessary for structural icing to form is visible moisture.

3.3.4.3.0.A.1 I29
Aircraft structural ice most likely to have the highest accumulation rate in freezing rain.

3.3.4.0.1.A.1 I24
Frost forms when the temperature of the collecting surface is at or below the dew point of the adjacent air and the dew point is below freezing.

3.3.4.3.1.A.1 I29
Frost is considered hazardous to flight, because it spoils the smooth flow of air over the wings, thereby decreasing lifting capability.

3.3.4.3.2.A.1 I29
Frost may affect the lifting surfaces of an airplane on takeoff by preventing the airplane from becoming airborne at normal takeoff speed.

3.3.4.2.6.A.1 I28
Wind shear occurs at all altitudes, in all directions.

3.3.4.2.7.A.1 I28
Hazardous wind shear can be expected in areas of low-level temperature inversion, frontal zones, and clear air turbulence.

Chapter 7 Quiz

Weather Theory

2.3.2.0.6.A.1 H300
How will frost on the wings of an airplane affect takeoff performance?

A. Frost will cause the airplane to become airborne with a higher angle of attack, decreasing the stall speed.
B. Frost will change the camber of the wing, increasing its lifting capability.
C. Frost will disrupt the smooth flow of air over the wing, adversely affecting its lifting capability.

3.3.3.8.3.A.1 I21
A temperature inversion would most likely result in which weather condition?

A. Clouds with extensive vertical development above an inversion aloft.
B. Good visibility in the lower levels of the atmosphere and poor visibility above an inversion aloft.
C. An increase in temperature as altitude is increased.

3.3.3.8.6.A.1 I21
What are the standard temperature and pressure values for sea level?

A. 15 °C and 29.92" Hg.
B. 59 °F and 29.92 millibars.
C. 59 °C and 1013.2 millibars.

3.3.4.0.2.A.1 I24
The presence of ice pellets at the surface is evidence that there

A. are thunderstorms in the area.
B. is a temperature inversion with freezing rain at a higher altitude.
C. has been cold frontal passage.

3.3.4.0.4.A.1 I25
What would decrease the stability of an air mass?

A. Cooling from below.
B. Decrease in water vapor.
C. Warming from below.

3.3.4.0.7.A.1 I25
If an unstable air mass is forced upward, what type clouds can be expected?

A. Stratus clouds with considerable associated turbulence.
B. Clouds with considerable vertical development and associated turbulence.
C. Stratus clouds with little vertical development.

3.3.4.1.3.A.1 I25
What are characteristics of unstable air?

A. Nimbostratus clouds and good surface visibility.
B. Turbulence and good surface visibility.
C. Turbulence and poor surface visibility.

3.3.4.1.7.A.1 I26
An almond or lens-shaped cloud which appears stationary, but which may contain winds of 50 knots or more, is referred to as

A. a lenticular cloud.
B. an inactive frontal cloud.
C. a funnel cloud.

3.3.4.1.9.A.1 I26
What clouds have the greatest turbulence?

A. Towering cumulus.
B. Nimbostratus.
C. Cumulonimbus.

3.3.4.2.3.A.1 I27
One weather phenomenon which will always occur when flying across a front is a change in the

A. stability of the air mass.
B. type of precipitation.
C. wind direction.

3.3.4.2.4.A.1 I27
Steady precipitation preceding a front is an indication of

A. stratiform clouds with little or no turbulence.
B. cumuliform clouds with little or no turbulence.
C. stratiform clouds with moderate turbulence.

3.3.4.2.9.A.1 I28
One in-flight condition necessary for structural icing to form is

A. small temperature/dewpoint spread.
B. visible moisture.
C. stratiform clouds.

3.3.4.3.5.A.1 I30
Which weather phenomenon signals the beginning of the mature stage of a thunderstorm?

A. The appearance of an anvil top.
B. Precipitation beginning to fall.
C. Maximum growth rate of the clouds.

3.3.4.3.7.A.1 I30
During the life cycle of a thunderstorm, which stage is characterized predominately by downdrafts?

A. Mature.
B. Dissipating.
C. Cumulus.

3.3.4.4.0.A.1 I30
A nonfrontal, narrow band of active thunderstorms that often develop ahead of a cold front is a known as a

A. dry line.
B. prefrontal system.
C. squall line.

3.3.4.4.4.A.1 I31
If the temperature/dewpoint spread is small and decreasing, and the temperature is 62 °F, what type weather is most likely to develop?

A. Freezing precipitation.
B. Fog or low clouds.
C. Thunderstorms.

3.3.4.4.5.A.1 I31
In which situation is advection fog most likely to form?

A. An air mass moving inland from the coast in winter.
B. A light breeze blowing colder air out to sea.
C. A warm, moist air mass on the windward side of mountains.

