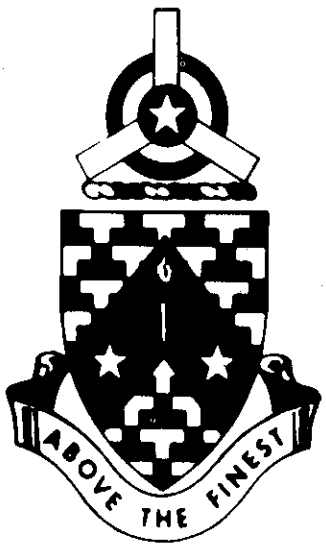
PROGRAMED TEXT

THUNDERSTORMS

AM 74



DECEMBER 1968

UNITED STATES ARMY
PRIMARY HELICOPTER SCHOOL
FORT WOLTERS, TEXAS

PROGRAMED TEXT

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FILE NO: AM 74

PROGRAM TITLE

THUNDERSTORMS

POI SCOPE: Factors necessary for thunderstorm formation, structures, types and dangers of thunderstorms, flight techniques.

INSTRUCTOR REFERENCES:

TM 1-300
Chapt 10

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Thunderstorms

PREFACE

Thunderstorms constitute one of the greatest flight hazards to the aviator. In order to take proper action in the vicinity of thunderstorms, the aviator must understand the conditions under which thunderstorms occur; the various stages of thunderstorm development; the types of thunderstorms; and the recommended flight procedures in and around existing thunderstorms.

Start with frame 1 and work each frame in succession. Each frame will usually ask you a question. The correct answer is printed on the top of the next frame. If you were incorrect, turn back and restudy the information before continuing on to the next frame. When you have finished the text, complete the self evaluation exercise. Now begin by studying the performance objectives on page iv.

PERFORMANCE OBJECTIVES

Upon completion of this programed text and without the aid of notes or references, you will be able to:

1. Identify the factors necessary for the development of a thunderstorm.

2. Recognize the types of thunderstorms.

3. Identify the stages of thunderstorm development and associated flight hazards.

4. Recognize the recommended flight procedures when encountering a thunderstorm.

FRAME 1

Three factors are necessary for thunderstorm development:

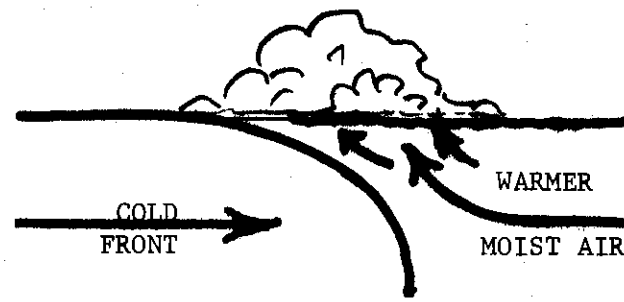
1. lifting action.
2. conditionally unstable air.
3. moisture.

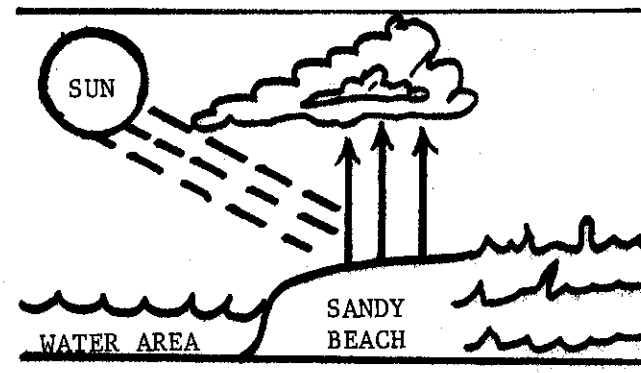
Lifting devices include:

1. terrain features
   mountain force "moving air" upslope. If wind has sufficient velocity; clouds may develop. These are called orographic thunderstorms.

2. frontal slopes
   applies to all types of fronts. If the front moves rapidly and its slope is sufficiently steep, storm clouds will form.

3. convection currents
   non-uniform surface characteristics result in unequal heating of the earth. Air above the "moist heated" portions rises and produces vertical cooling.





Air is lifted as a result of

a. uniform heat transfer over the earth.
b. unequal heating of the earth.
c. high moisture content.

Front can cause thunderstorms development if

a. the front moves rapidly over the surface.
b. the frontal slope is relatively steep.
c. both of the above.

TURN TO PAGE 3 FOR FRAME 2

ANSWER: c. Temperature and dewpoint close together indicating sufficient moisture. Winds are gusty (unstable) Towering cumulus clouds are present.

NOTE: (Insufficient moisture at a & b (high temp - dewpoint spreads.) Freezing drizzle & fog with light winds indicate stable air at d.)

FRAME 5

Thunderstorms form in association with:

1. Fronts.
2. Air Masses.

Frontal thunderstorms occur in association with all types of fronts. They are caused by the lifting of moist, unstable air over a frontal surface. These thunderstorms occur before, during and after frontal passages, and normally exist in lines of thunderstorm clouds.

Often, these lines of thunderstorms constitute an impassable barrier to the aviator.

Air Mass thunderstorms are typically scattered or isolated over a large region. They result from orographic, or convective lifting of air.

Since they can often be circumnavigated, they constitute less of a hazard to the aviator than the frontal thunderstorms. (Orographic thunderstorms form near mountain peaks and are jokingly referred to as cumulo-granite clouds - best to stay away from these!

Lines of thunderstorms are generally associated with:

a. mountain slopes
b. sandy beaches
© frontal slopes

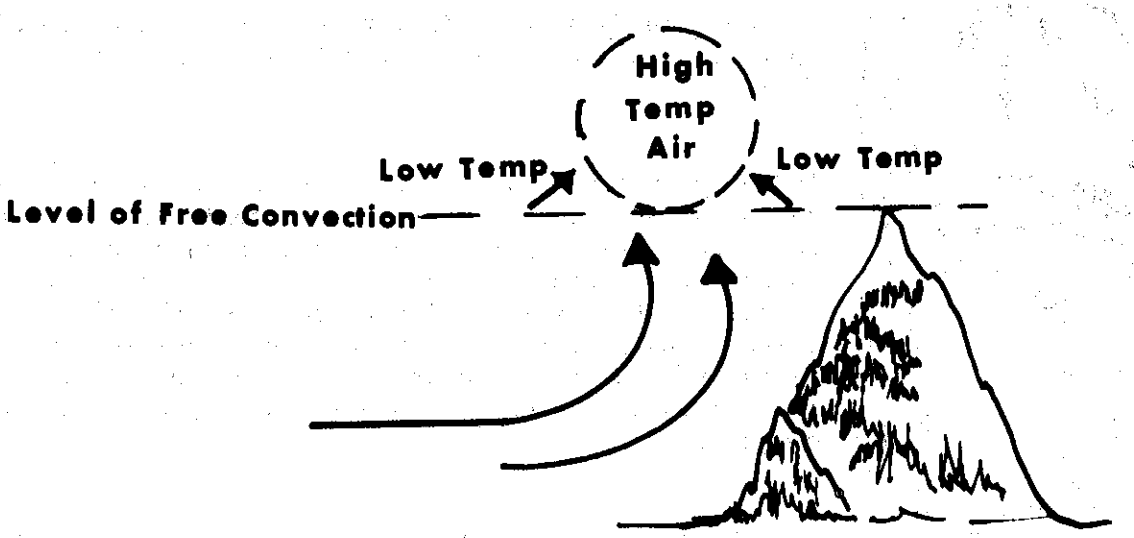
Air Mass thunderstorms generally exist as:

a. isolated thunderstorm clouds
b. lines of storms
c. pre-frontal squall lines

ANSWERS: b. unequal heating of the earth.
c. both of the above.

FRAME 2

Conditionally unstable air is the second factor for thunderstorm development. It is defined as: Air that, upon being lifted to a critical height (level of free convection) will continue to rise due to the difference in its temperature and that of the surrounding air.



As shown in the above diagram, the warmer air continues to rise without the assistance of terrain lifting because warm air rises in a cooler mass of air.

The level of free convection is:

a. an altitude at which the air continues to rise because of momentum gained from the initial lifting force.
b. an altitude at which air will continue to rise in the absence of its initial lifting force.
c. an altitude equivalent to the height of the mountain top.

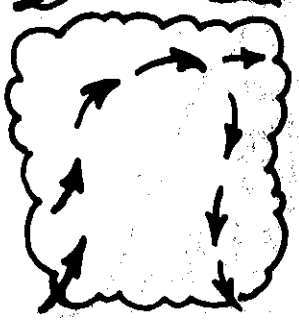
ANSWERS: c. frontal slopes
a. Isolated thunderstorm clouds

FRAME 6

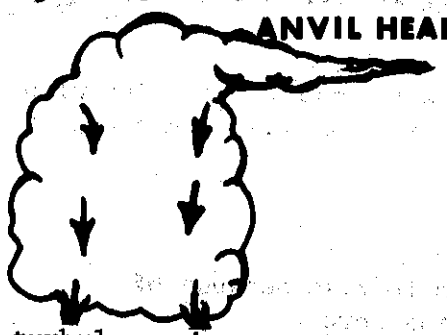
Thunderstorms do not manifest the same characteristics throughout their existence. They develop through stages wiich are divided into:

1. cumulus stage
2. mature stage
3. dissipating or "anvil" stage

In the cumulus stage, air movement is in the form of updrafts. Water droplets grow in size and raindrops form.



In the mature stage, air movement occurs as updrafts and downdrafts which increase in severity as this stage develops. Freezing rain falls and is carried back through the cloud forming hailstones. These increase in size as they are carried up and down the cloud in the circulation pattern. Turbulence increases and resulting winds are characterized by "shear" action. (Abrupt changes in direction due to existence of updrafts and downdrafts.)



In the dissipating stage, air movement is in the form of downdrafts. The cloud loses its moisture as rain and dissipates.

Hazards to aircraft in flight are associated with all stages of thunderstorm development, but are most pronounced in the mature stage. It is in this stage where "shear" action is encountered, hailstones are present, and turbulence is greatest. These factors can overstress an aircraft and cause structural damage within a very short period of time.

The cumulus stage of thunderstorm development has:
(a) updrafts
b. downdrafts
c. all of the above

Aircraft damage can occur in:
a. mature stage
b. dissipating stage
(c) all stages

ANSWER: b. an altitude at which air will continue to rise in the absence of its initial lifting force.

FRAME 3

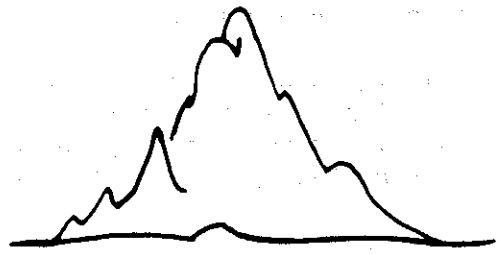
Moisture in the air is essential for thunderstorm development. The more moisture in the air, the less initial lifting action will be required to reach the level of free convection.

In which of the following examples will thunderstorms most likely occur? (Circle correct answer.)

NOTE: T° = Temperature, T°d = dew point

a. *(T°=72) (T°d=63)
270°@5K=wind

b. *(T°=42) (T°d=33)
090° @10K =wind



c. *(T°=72) (T°d=70)
270° @15K=wind

ANSWERS: a. updrafts
c. all stages

FRAME 7

When encountering tuunderstorms in flight, the best procedure is to avoid them. This can be done through circumnavigation (flying around them) or by flying below the cloud base. It is generally impossible to fly over-the-top as thunderstorms extend up to 60,000 feet.

Penetration of the thunderstorm may, under some circumstances, be the only alternative. If this is the case, observe the following principles:

1. altitude - 4000--6000 ft AGL
2. airspeed - as indicated in the -10 (Operator's Manual)
3. constant: attitude, power and heading
4. fly between storm centers (thin spots)

The best procedure when encountering thunderstorms is:

a. hold constant altitude, power and heading.
b. fly as slowly as possible.
c. fly "low level".
d. avoid them if possible.

Penetration is accomplished by:

a. flying through storm centers.
b. holding constant altitude.
c. accelerating to top speed to get through as quickly as possible.
d. flying through soft area with constant power and attitude.

ANSWER: c. (T° = 72) (T°d = 70)
270° @ 15K = wind

FRAME 4

Keeping in mind the factors necessary for thunderstorm development, which of the following sample teletype sequence reports from Denver show a probability of developing thunderstorms?

a. DEN O15 129/84/67/1405/991/CU DSPTG

b. DEN /-012 134/84/65/1306/992

c. DEN M6007 998/82/80/2420G35/942/TCU NW-SW

d. DEN -XM201/4ZL-F 000/33/31/2703/948 F8

STOP. RETURN TO PAGE 2 FOR FRAME #5

ANSWERS: d. avoid them if possible
d. flying through soft area with constant power and attitude.

SUMMARY:

A thunderstorm is a spectacular display of the physical forces of nature. If you can imagine that a mature thunderstorm releases energy roughly equivalent to that of an atomic bomb being exploded every two minutes, it makes a helicopter or even a large aircraft seem very small. Do not penetrate a thunderstorm unless it is impossible to avoid.

CONTINUE ON TO THE SELF EVALUATION EXERCISE

SELF EVALUATION EXERCISE

1. Factors necessary for thunderstorm development:

   a. Standard lapse rate, stable air, and high moisture
   b. Moist, conditionally unstable air, lifting action
   c. Thermal convection, high air density, temperature
   d. Ice crystals, moisture, condensation nuclei

2. Thunderstorms are associated with

   a. convective air currents.
   b. cold, warm, and occluded fronts.
   c. windward side of mountain.
   d. all of the above.

3. Lifting action refers to the movement of air as a result of

   a. convection, terrain, and fronts.
   b. convection, stability, and density.
   c. stability, temperature, and pressure.
   d. moisture, temperature, and pressure.

4. Thunderstorms are associated with

   a. drizzle and fog.
   b. stratiform clouds and light winds.
   c. areas of extremely high pressure.
   d. fronts and air masses.

5. Air forced up slopes of mountains

   a. may cause thunderstorms to form.
   b. decreases in moisture content.
   c. increases in temperature.
   d. increases in pressure.

6. Stages of thunderstorm development include

   a. downdraft, updraft, and precipitation.
   b. mature, condensation, and precipitation.
   c. cumulus, mature, and dissipating.
   d. cumulus, anvil, and precipitation.

7. A anvil head on a thunderstorm means that the

   a. thunderstorm is in mature stage.
   b. storm is entering the dissipating stage.
   c. rainfall has subsided.
   d. air movement is in the form of up drafts.

8. Primary hazards of thunderstorms are:

   a. rime icing and poor visibility.
   b. static electricity, snow, and hail.
   c. turbulence, hail and shear action.
   d. low visibility, downdrafts, and rain.

9. The recommended flight procedure when encountering thunderstorms is:

   a. fly through the center.
   b. fly over the top.
   c. land at all cost.
   d. avoid them, if at all possible.

10. When penetrating a thunderstorm, it is important to:

   a. enter at 4000-6000 ft. above ground.
   b. get as much airspeed as possible.
   c. vary attitude and power to maintain altitude.
   d. juggle controls so the aircraft becomes accustomed to violent movement.

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ANSWERS TO SELF EVALUATION EXERCISE

1. b
2. d
3. a
4. d
5. a
6. c
7. b
8. c
9. d
10. a

L2566 Army--Ft. Sill, Okla.