PROGRAMED TEXT

HELICOPTER LIMITATIONS

AM-50

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PROGRAMED TEXT

PROGRAM TEXT

FILE NO:

AM-50

PROGRAM TITLE

Helicopter Limitations

POI SCOPE: Recognize causes, indications, and corrective actions for retreating blade stall and power settling. Recognize the effect of exceeding center of gravity limitations on controlled flight.

INSTRUCTOR REFERENCES:

TM 1-260

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PREFACE

This programed text will present a basic understanding of three limitations found in all helicopters.

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

PART I

Given examples and/or diagrams you will be able to:

1. Recognize the cause and indications of retreating blade tip stall conditions.

2. Determine corrective actions for retreating blade stall condition.

PART II

Given examples and/or diagrams you will be able to:

1. Recognize and select indications of power settling.

2. Select the causes of power settling.

3. Determine the corrective actions to recover from power settling.

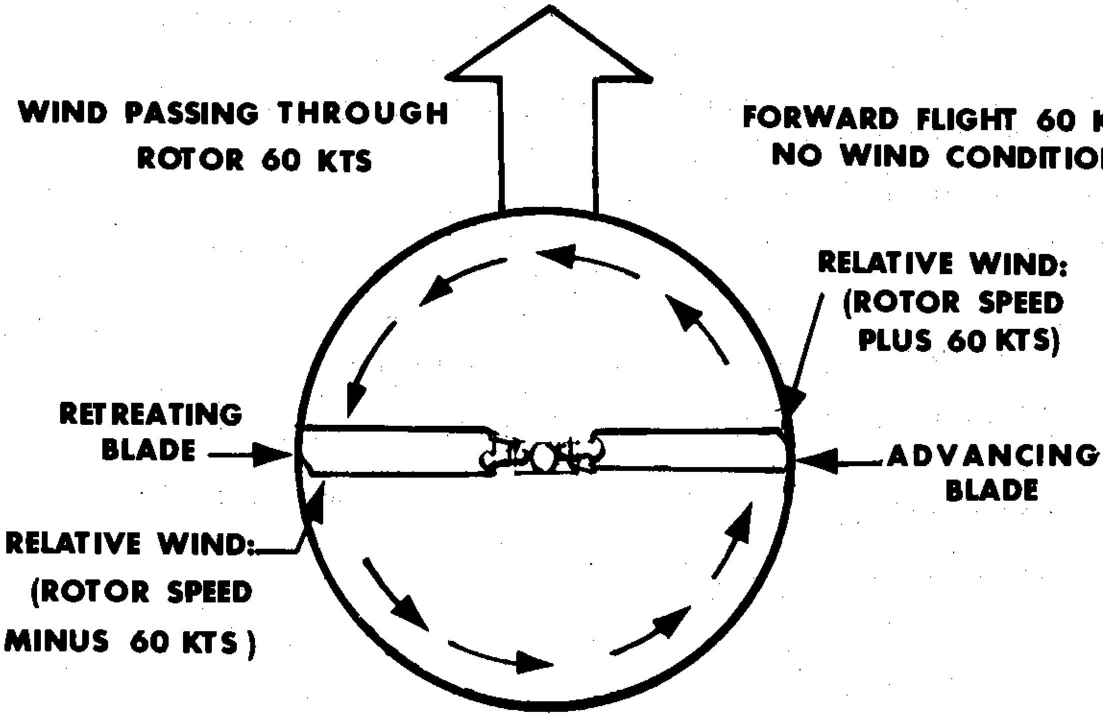
PART III

Given examples depicting a helicopter loaded out of center of gravity limits, (i.e., exceeding center of gravity travel, either forward, aft, left or right) you will be able to select the correct response describing how the helicopter will react.

FRAME 1

Two of the factors that produce lift on an airfoil are the velocity of the relative wind and the angle of attack.

During forward flight the relative wind on the rotor blades is as indicated below. (See Diagram)



1. You can see from the diagram above that in forward flight the speed of the relative wind on the retreating blade is _________________________ the relative wind on the advancing blade.

a. greater than
b. less than
c. the same as

2. As a result of the difference in relative wind on the rotor disc above, which blade would be producing the most lift?

a. the advancing blade
b. the retreating blade
c. neither, the lift is the same on both blades.

FRAME 7

Settling with power, commonly referred to as power settling, is a state in which the helicopter settles in its own rotor downwash. It results in an uncontrolled loss of altitude coupled with high power consumption and reduced cyclic control effectiveness.

The conditions likely to cause "settling" are:

(1) A vertical or nearly vertical rate of descent of at least 300 feet per minute.

(2) The rotor system must be using from 20 to 100 percent of maximum available power.

(3) Loss of translational lift

____

An aviator may experience settling with power while:

a. Making a normal approach at a 12° angle of descent.

b. Making a low speed steep power descent and inadvertently zeroing the airspeed.

c. Making an autorotative descent.

ANSWERS: 1. b. less than
2. a. the advancing blade

FRAME 2

The difference in relative wind across the advancing and retreating blades causes an unequal lift force on the rotor system in horizontal flight. This unequal lift force is called <u>Dissymmetry of lift</u>. Compensation must be made for dissymmetry of lift, otherwise the aircraft will roll to the left in horizontal flight. It may cause the helicopter to roll upside down.

Cyclic feathering compensates for dissymmetry of lift in a semi-rigid rotor system. To compensate for dissymmetry of lift by cyclic feathering, the velocity difference of the relative wind is neutralized by:

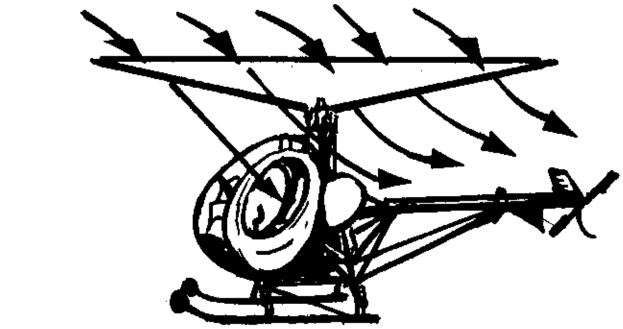
a. Increasing the angle of attack on the advancing blade and decreasing the angle of attack on the retreating blade.

b. Increasing the angle of attack on the retreating blade and decreasing the angle of attack on the advancing blade.

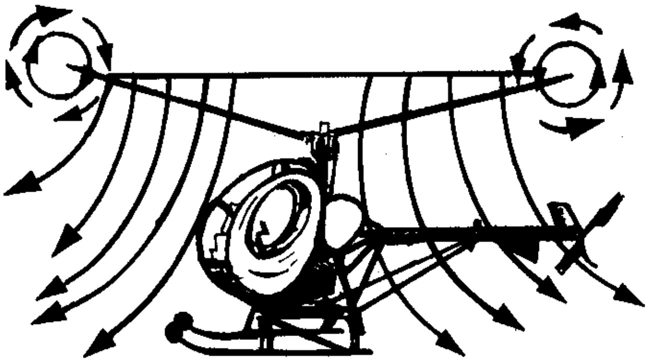
ANSWER: b. making a low speed steep power descent and inadvertently zeroing the airspeed.

FRAME 8

During normal translational flight, the flow of air through the rotor disc would appear as illustrated below:



During settling with power the helicopter descends in air which has just previously been accelerated downward by the rotor blades as in the diagram below.



The reaction of this air on the rotor blades at high angles of attack stalls the blades near the hub and progresses outward along the blade as the rate of descent increases. Since the inboard portions of the blades are stalled, cyclic control response will be reduced.

1. The application of more collective pitch when the helicopter is settling with power will result in:

a. Increasing the angle of attack and decreasing the rate of descent.
b. Stalling more of the blade area and increasing the rate of descent.
c. Decreasing the angle of attack and decreasing the rate of descent.

2. As long as the aviator maintains ________________ he will never be endangered by power settling.

a. Positive control of the aircraft.
b. Minimum power settings while hovering (reduced angle of attack)
c. Translational lift.

ANSWER: b. Increasing the angle of attack on the retreating blade and decreasing the angle of attack on the advancing blade.

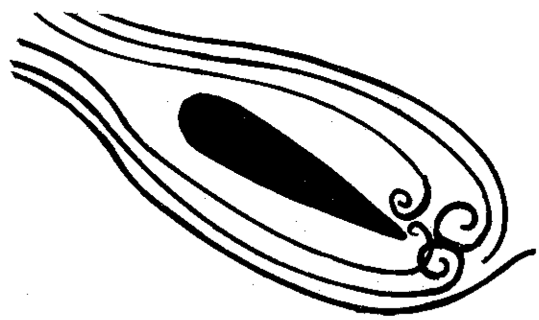
FRAME 3

As the airspeed of the helicopter increases, the angle of attack on the retreating blade increases to compensate for the reduced velocity of the relative wind.

In horizontal flight the retreating blade is ALWAYS operating at a greater angle of attack than the advancing blade.

This angle can be increased up to a point. When the angle of attack of the retreating blade becomes too great, the air no longer flows smoothly over it producing lift. The angle at which this occurs is called the stall angle (See diagram below).

NORMAL AIRFLOW PRODUCING LIFT



WHEN ANGLE OF ATTACK IS TOO GREAT THE BLADE STALLS DESTROYING LIFT

The retreating blade will:

a. reach the stall angle before the advancing blade.
b. reach the stall angle at the same time as the advancing blade.
c. reach the stall angle after the advancing blade.

ANSWER: 1. b. Stalling more of the blade area and increasing the rate of descent.

2. c. translational lift.

FRAME 9

Settling with power can be quite hazardous if inadvertently performed near the ground. Rates of descent exceeding 2200 feet per minute have been recorded during this state of flight. The characteristics of settling are airframe vibrations and an increasing loss of control effectiveness. Recovery from settling with power can be accomplished by re-establishing forward speed and partially lowering the collective pitch.

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1. Select the control application(s) necessary to recover from settling with power.

   a. Apply aft (rearward) cyclic to decrease airspeed.
   b. Apply forward cyclic to increase airspeed.
   c. Reduce collective pitch to decrease angle of attack.
   d. Increase collective pitch to increase lift.
   e. b and c above.

2. Why apply forward cyclic to recover from settling with power:

   a. To regain airspeed and translational lift.
   b. To decrease airspeed and rate of descent.
   c. To increase airspeed and increase rate of descent.

ANSWER: a. reach the stall angle before the advancing blade.

FRAME 4

Retreating blade stall is normally a result of high forward airspeed. When operating at high forward speeds, the following conditions are most likely to produce retreating blade stall:

1. Heavy Load - requires more collective pitch which increases angle of attack.

2. Low Rotor RPM - again requires more collective pitch because velocity is low.

3. High Density Altitude - More power and collective pitch is required. The effect of high density altitude will be explained in another program.

4. Steep or abrupt turns - because in a turn the angle of attack is increased on one half of the rotor.

5. Turbulent air - turbulence will often give a momentary sharp increase in angle of attack because the relative wind has changed.

Why would the conditions listed above contribute to retreating blade stall?

a. They would cause a decrease in the angle of attack on the retreating blade.
b. They could cause an excessive angle of attack on the retreating blade.
c. They could cause an excessive angle of attack on the advancing blade.

ANSWERS: 1. e. b and c above.
2. a. to regain airspeed and translational lift.

PART III

CENTER OF GRAVITY LIMITATIONS

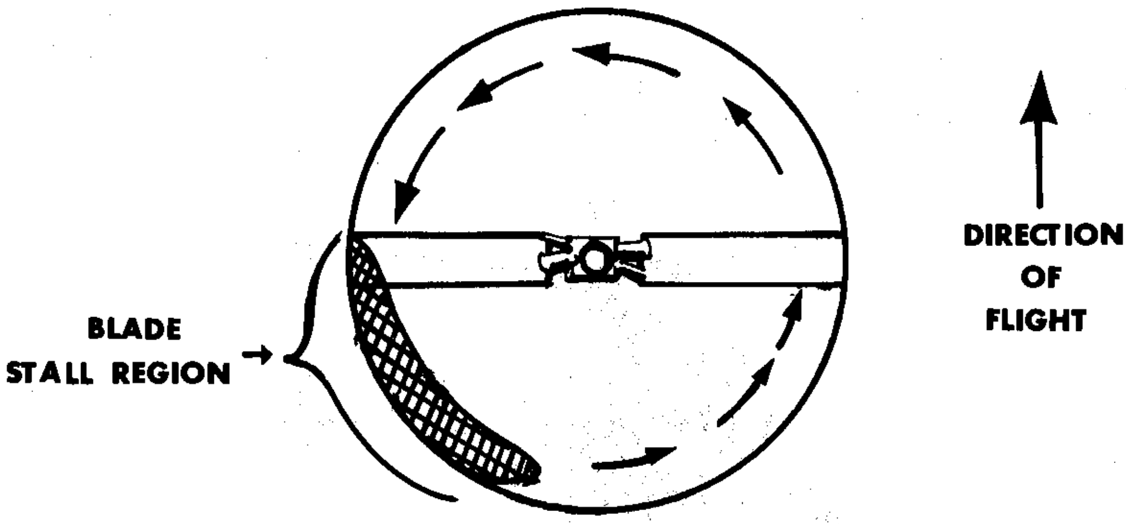
PERFORMANCE OBJECTIVES

Given examples depicting a helicopter loaded out of center of gravity limits, (i.e., exceeding center of gravity travel, either forward, aft, left or right) you will be able to select the correct response describing how the helicopter will react.

ANSWER: b. They could cause an excessive angle of attack on the retreating blade.

FRAME 5

When the retreating blade stalls, the first effect is a noticeable vibration of the helicopter caused by the stalled blade being out of track with the other blade. This is followed by a lifting or pitch up of the nose and a rolling tendency of the helicopter because of the decreased lift in the left rear quarter of the rotor disc. (See diagram below)



The first warning of a retreating blade stall is:

a. aircraft rolls to the left.
b. aircraft nose pitches up.
c. abnormal vibrations.

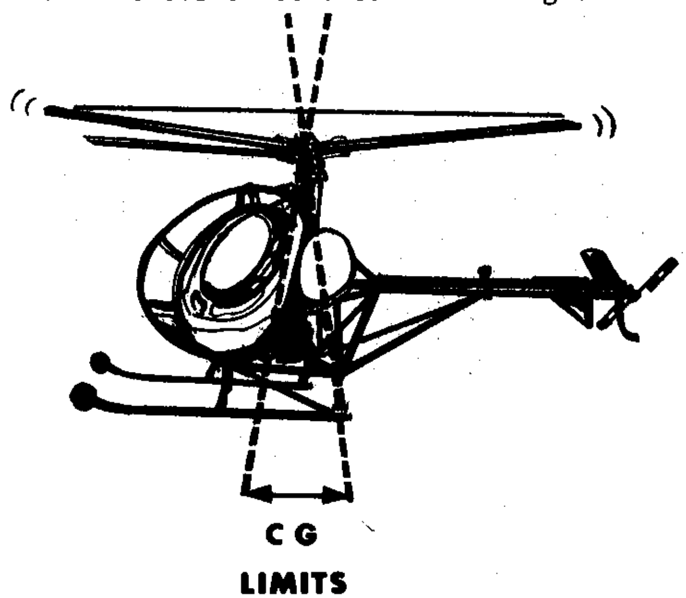
FRAME 10

The Center of Gravity (CG) of an aircraft is the point on the aircraft at which all the forces of gravity are concentrated.

If you could pick the aircraft up at this point the aircraft would be perfectly balanced.

The ideal location for the Center of Gravity (CG) on a single rotor helicopter is in line with the center of rotation of the main rotor, however, due to difference in crew weights, aircraft loads, and the addition and removal of components and passengers, etc; the center of gravity will not remain at any one point on the aircraft.

The Center of Gravity must be allowed to move or the aircraft would be an impractical vehicle. Because of this all aircraft allow some degree of Center of Gravity movement. (See diagram) If the aircraft is loaded with its CG beyond these limits it is unsafe for flight.



If an aircraft is loaded with its Center of Gravity beyond the allowable center of gravity travel (too far forward); how will the aircraft react when picked up to a hover?

a. nose low attitude.
b. nose high attitude.

ANSWER: c. abnormal vibrations

FRAME 6

At the onset of retreating blade stall, the aviator should take the following corrective actions.

(1) Reduce collective pitch
(2) Reduce forward airspeed
(3) Minimize maneuvers
(4) Increase rotor RPM (if applicable).

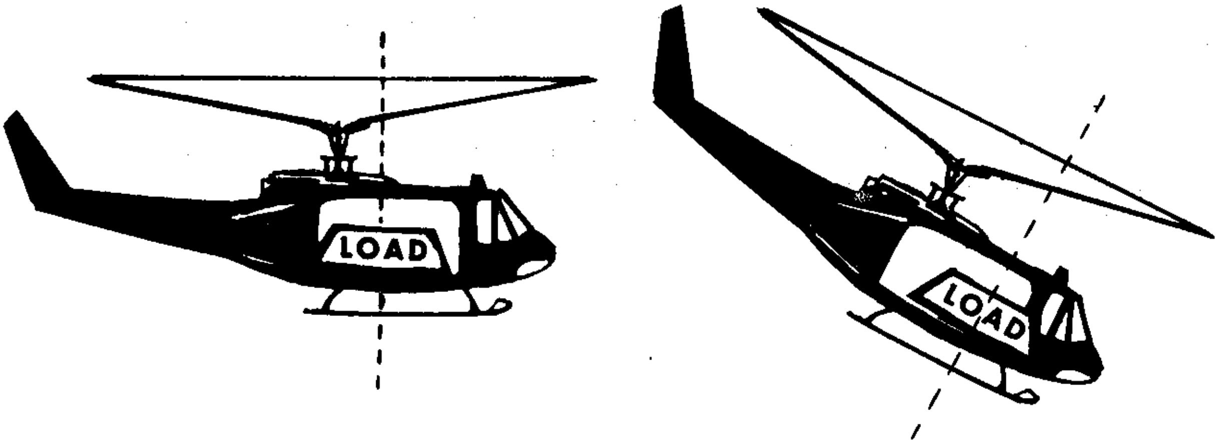
How would reducing the collective pitch correct the cause of retreating blade stall?

a. It would decrease the rotor RPM.
b. It would decrease the angle of attack on the retreating blade.
c. It would increase the angle of attack on the advancing blade.

ANSWER: a. nose low attitude

FRAME 11

If a helicopter is loaded "out of CG limits" (See diagram below) the aviator may find that when he applies corrective cyclic control as far as it will go, the helicopter attitude will remain low on the heavy end or side and may even move in the same direction the CG is located. If the aviator is not able to level the helicopter or perhaps raise the nose in order to decelerate and land, he is obviously in a very dangerous predicament.



If the aircraft center of gravity is beyond the allowable limits, the fuselage will tilt in the direction of the center of gravity, either forward, aft, left, or right. The main rotor will tilt in the same direction as the fuselage.

If the center of gravity is exceeded the aircraft will:

a. Respond in the normal manner as it is impossible to load an aircraft to such an extent that the aviator cannot control the aircraft.
b. Tilt and move in the same direction the center of gravity is located.
c. Tilt in the direction of the center of gravity but a stationary hover can be maintained with controls.
d. Tilt in the direction of the center of gravity is located but more in the opposite direction due to the tilting of the main rotor.

ANSWER: b. It would decrease the angle of attack in the retreating blade.

An aviator recognized a retreating blade stall and took the corrective actions: smoothly lowered collective pitch, increased rotor RPM, and reduced forward airspeed. He did not maneuver the aircraft until he had regained control. Abrupt maneuvering could cause stresses that would exceed the structural limitations of the aircraft.

Remember, when the retreating blade stalls there is a tendency for the aircraft to correct the condition: the nose pitches up and slows the airspeed. However, one must control the aircraft to prevent a recurring stall. This can create problems flying at tree top level under combat conditions.

PART II

PERFORMANCE OBJECTIVES

Given examples and/or diagrams you will be able to:

1. Recognize and select indications of power settling.

2. Select the causes of power settling.

3. Determine the corrective actions to recover from power settling.

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ANSWER: b. Tilt and move in the same direction the center of gravity is located.

FRAME 12

The aviator must know the CG travel limits of his particular helicopter and must exercise great care in loading in order to keep the center of gravity within its allowable limits. However, if your aircraft is loaded "out of CG limits" your first indication will come as you attempt to pick up to to a hover. As the helicopter becomes light on the skids you will have to use an excessive amount of corrective cyclic to raise the heavy end side to keep it from sliding.

Even though you may damage the aircraft, set it back down immediately and adjust your load within CG limits. Attempting a take-off when one is having difficulty at a hover due to the CG being out of limits is an accident looking for a place to happen.

What is the <u>best</u> way to insure your helicopter is within CG limits.

a. never carry a heavy load.
b. attempt to take off.
c. use proper loading procedures

ANSWER: c. use proper loading procedures.

SELF EVALUATION EXERCISE

1. What is the direct cause of a stall?

   a. Excessive angle of attack

   b. Heavy load

   c. High airspeed

   d. Low airspeed

2. Why does retreating blade stall occur on the retreating blade?

   a. To compensate for dissymmetry of lift the retreating blade operates at a smaller angle of attack than the advancing blade.

   b. To compensate for dissymmetry of lift the retreating blade operates at a larger angle of attack than the advancing blade.

   c. In forward flight the airspeed of the retreating blade is greater than the airspeed of the advancing blade.

   d. Due to the rearward motion of the retreating blade the drag has increased causing the blade to stall.

3. When the retreating blade stalls there are three indications to the aviator. Identify these indications with the correct choice below.

   a. The aircraft tries to roll to the right; the nose pitches up and the airframe vibrates.

   b. Excessive airspeed indications; nose of the aircraft tries to tuck under and roll to the right.

   c. Abnormal vibrations; nose of the aircraft pitches up and the aircraft rolls to the left.

   d. None of the above.

4. What is the correction for a stall?

   a. Increase the angle of attack.

   b. Increase collective pitch.

   c. Decrease the relative wind.

   d. Decrease the angle of attack.

5. Select the proper actions to recover from a retreating blade stall.

a. Decrease airspeed, reduce collective, reduce RPM.

b. Apply aft cyclic, increase collective, reduce RPM.

c. Decrease airspeed, decrease collective, increase RPM.

d. Apply forward cyclic, increase collective, reduce RPM.

6. What are the primary causes of Power Settling?

a. Loss of translational lift and high rate of descent.

b. Loss of engine power and high rate of descent.

c. Low rotor RPM.

d. Excessive forward airspeed.

7. Select the indications of Power Settling.

a. Little or no engine power available, airframe vibrations, heavy collective.

b. Nose of the aircraft tucks under, little or no engine power available, airframe vibrations.

c. Loss of control effectiveness, low rotor RPM, light collective.

d. Use of excessive engine power, high sink rate, airframe vibrations.

8. Which of the below will aid you in recovering from Power Settling?

a. Increase engine RPM.

b. Maintain a hover.

c. Regain translational lift.

d. Increase collective pitch to climb above disturbed area.

9. Which control applications would you employ to recover from Power Settling?

a. Apply forward cyclic and decrease collective.

b. Apply aft (rearward) cyclic and decrease collective.

c. Increase collective pitch and apply forward cyclic.

d. Increase power and apply right pedal.

10. Where is the ideal location for the center of graivty in a single rotor helicopter?

a. In line with the center of rotation of the rotor system.

b. Just forward of the center of rotation so the helicopter will always hang in a nose low attitude.

c. Just aft of the center of rotation so the aircraft will always have tendency to slow its airspeed.

d. Any point below the center of rotation as long as its center of gravity lies along the longitudinal axis.

11. If the aircraft is loaded with the center of gravity either too far forward, aft, left, or right, what would be the action of the aircraft when brought to a hover?

a. The aircraft could not be picked up to a hover because the center of gravity is too heavy.

b. Violent movements or feedback into the cyclic control.

c. The aircraft will move in the direction the center of gravity is located and the pilot may not be able to stop this movement with cyclic control.

d. The fuselage of the aircraft will try to spin in the direction the center of gravity is located.

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ANSWERS TO SELF EVALUATION EXERCISE

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

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