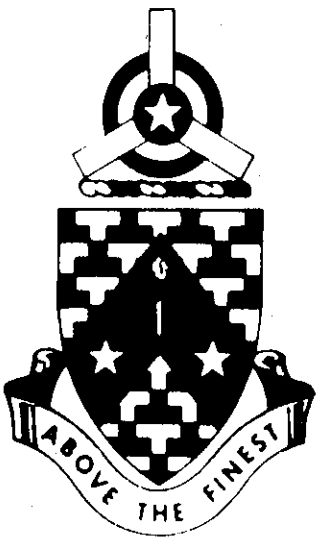
PROGRAMED TEXT

MAIN ROTOR PERFORMANCE

AM-10



JANUARY 1969

UNITED STATES ARMY

PRIMARY HELICOPTER SCHOOL

FORT WOLTERS, TEXAS

PROGRAMED TEXT

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FILE NO: AM-10

PROGRAM TITLE

Main Rotor Performance

POI SCOPE: Define ground effect, determine advantages of ground effect, and detect conditions that affect ground effect. Interpret relationship between relative wind and effective translational lift. Compare articulated, semi-rigid, and rigid rotor systems in regard to feathering, flapping, and hunting.

INSTRUCTOR REFERENCES:

TM 1-260

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Main Rotor Performance

PREFACE

This program will present basic understanding of the performance of a helicopter main rotor system.

Read each frame carefully, write your response, and check your answer at the top of the next page. If your answer is incorrect, read the frame again and confirm the correct answer.

The self evaluation exercise will evaluate knowledge gained on this three part program.

PERFORMANCE OBJECTIVES

Given the definition of ground effect, and shown diagrams and given examples of helicopters in flight, you will be able to:

1. Determine the advantages of operating within ground effect, and detect the conditions which affect or nullify ground effect.

2. Interpret the relationship between relative wind and effective translational lift.

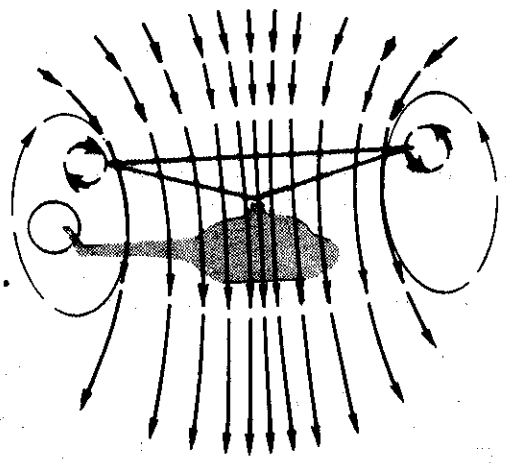
3. Compare the actions of the main rotor blades of an articulated, semi-rigid, and rigid rotor systems in regard to feathering, flapping, and ~~hinting~~ hunting.

FRAME 1

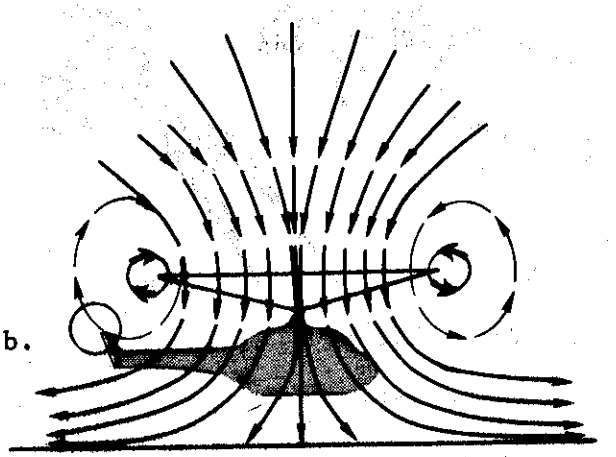
Ground effect may be defined as: The increased efficiency that a rotor system has at a hover due to an unrestricted flow of air through and below the rotor system.

Hovering over a solid, smooth, flat surface will allow the downwind flow of air to be deflected from under the rotor in an unrestricted flow, providing maximum ground effect.

a.



b.



Which helicopter is operating in Ground Effect:

a.

(b.)

ANSWERS: 1. The helicopter will enter effective translational lift as it comes to a hover. A headwind of 25 knots has the same effect as a forward speed of 25 knots.

2. The speed of the relative wind is 15 knots. (10 kts forward speed + 5 kts headwind = 15 kts relative wind)

FRAME 7

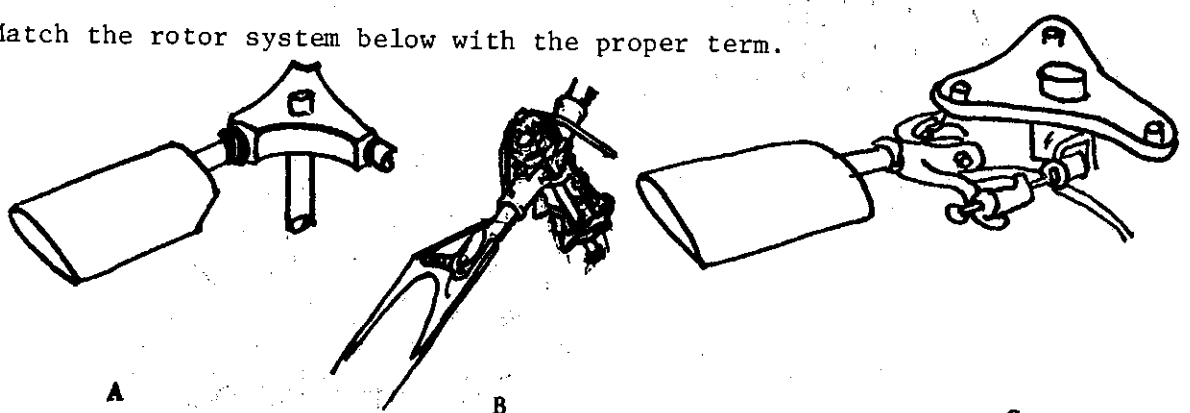
There are 3 types of rotor systems on Army Helicopters; ARTICULATED, SEMI-RIGID, and RIGID.

1. An articulated rotor system consists of three or more individually hinged rotor blades mounted to the hub with the hub fixed to the mast. Example - TH-55.

2. A Semi-rigid rotor system consists of two rotor blades connected to a central hub with the hub universally mounted to the mast. Examples - OH-23 and OH-13.

3. A rigid rotor system consists of two or more rotor blades directly fastened to the hub. Example - AH-56.

Match the rotor system below with the proper term.



A B C

C 1. Articulated

B 2. Semi-Rigid

A 3. Rigid

ANSWER: b. Note that the rotor wash strikes the ground and the outward flow is unrestricted.

FRAME 2

As a rule of thumb, ground effect is present at a hover height (Rotor to ground: NOT skid to ground) of no more than one-half of the rotor diameter. Under proper conditions an observation helicopter will be operating in ground effect at approximately a three foot hover.

Ground effect reduces induced drag and permits a lower angle of attack.

Which of the below are advantages of ground effect?

a. Less power needed to hover.

b. Less fuel consumption

c. Increased load capability

d. Hover at a higher ground elevation

ANSWER: ___c___ 1. Articulated

___b___ 2. Semi-Rigid

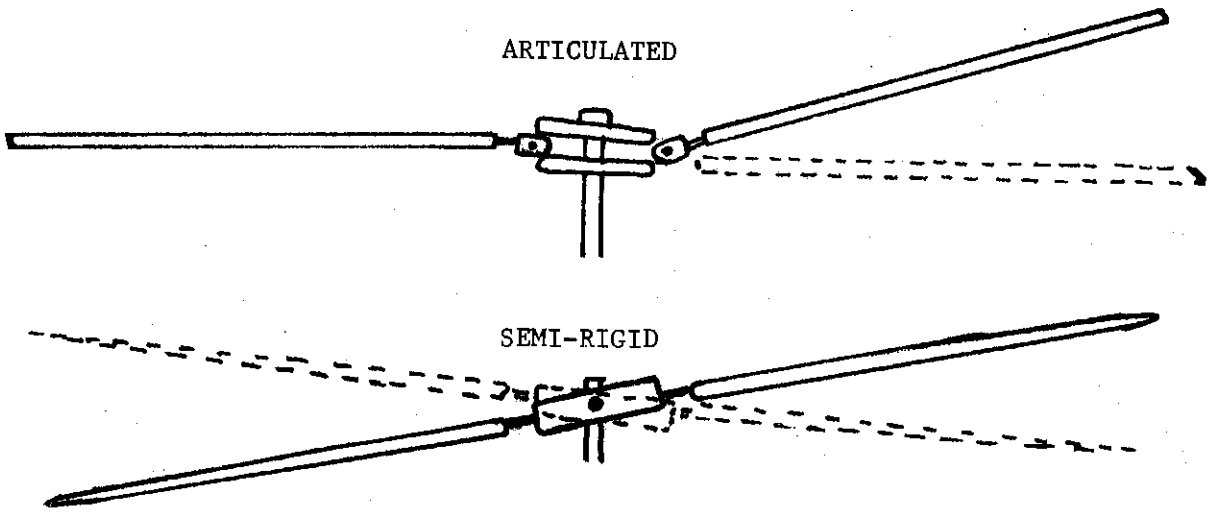
___a___ 3. Rigid

FRAME 8

Depending upon the type rotor system, there are four characteristic blade actions, FLAPPING, FEATHERING, HUNTING, and ROTATION.

FLAPPING in an articulated rotor system compensates for dissymmetry of lift.

The rotor blades FLAP up and down, independent of one another in an articulated system; but in the semi-rigid system, the two rotor blades act like a see-saw (one blade flaps up, the other must flap down). See diagram. In the rigid rotor the blades are directly connected to the rotor mast.



Underline the correct response:

Flapping is a (horizontal, vertical) action.

The advantages of ground effect are:

a. Less power needed to hover
b. Less fuel consumption
c. Increased load capability
d. Hover at a higher ground elevation

FRAME 3

A low hover does not guarantee ground effect will be present. Conditions that restrict the outward flow of the rotor downwash will decrease or destroy ground effect.

Such conditions are:

1. Tall Grass
2. Water
3. Cluttered areas, especially buildings
4. Rough terrain
5. Rotor wash from other helicopters or strong winds

SITUATION: After refueling your heavily loaded aircraft, the flight leader calls for a formation take-off. You are the last aircraft in a flight of five. You observe that your hover area would be over dense four foot elephant grass.

What would be your action?

a. Hover into position for take-off.

b. Inform the flight leader that due to the tall grass, you will join the formation after take-off.

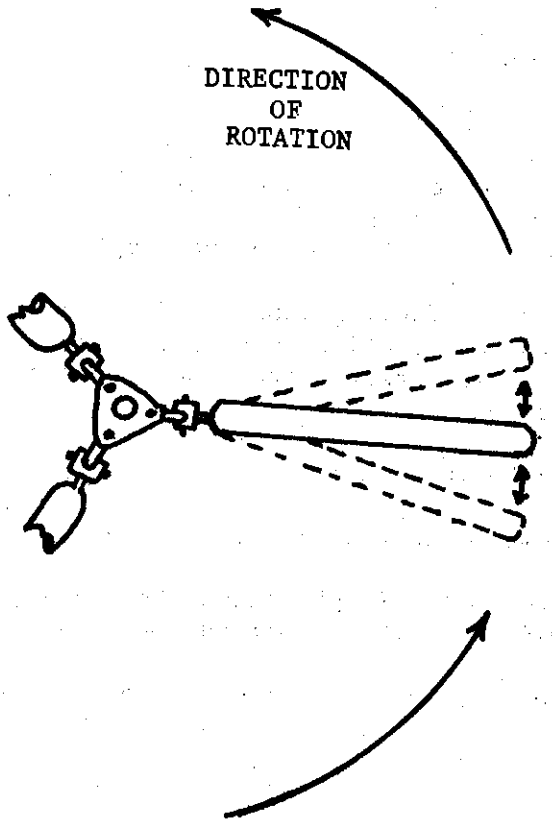
c. Hover at three feet over the elephant grass.

ANSWER: Flapping is a Vertical action.

FRAME 9

HUNTING occurs only with individually mounted rotor blades as in the articulated system.

As the rotor blades rotate, they have a tendency to hunt (lead or lag in the horizontal plane of rotation) their own alignment. See Diagram.

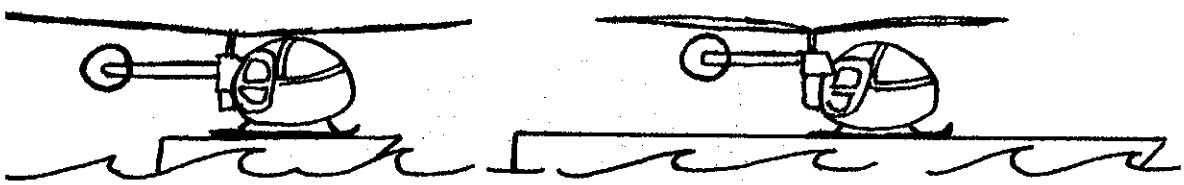


Hunting and flapping occur in:

a. TH-55 Helicopters
b. OH-23 Helicopters

ANSWER: b. If you attempted to hover over the tall grass with full fuel and heavy load, you would be an accident looking for a place to happen. The tall grass and rotorwash from the other aircraft would destroy your ground effect.

FRAME 4



A B

HELICOPTERS OPERATING OFF BARGES

1. Which helicopter can hover longer on 10 gallons of fuel?

a.
(b)

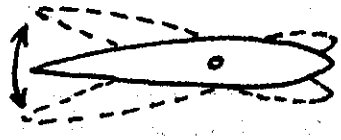
2. Which helicopter can lift the greater load?

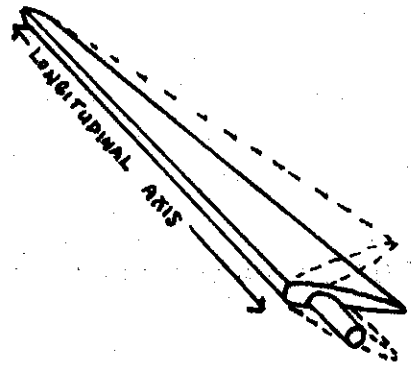
a.
(b)

ANSWER: a. Hunting and flapping occur with the TH-55 because it has an articulated main rotor system, and OH-23 has a semi-rigid system.

FRAME 10

The ability of the rotor blades to change angle of attack during each rotation is called FEATHERING. All rotor systems must FEATHER to provide directional control. See Diagram.





Articulated and semi-rigid systems use a combination of FLAPPING and FEATHERING to provide directional control.

Is this true with a rigid rotor system?

a. Yes
b. No

Why? the blades can not flap

ANSWERS: b. Helicopter b can take full advantage of ground effect.

b. See above

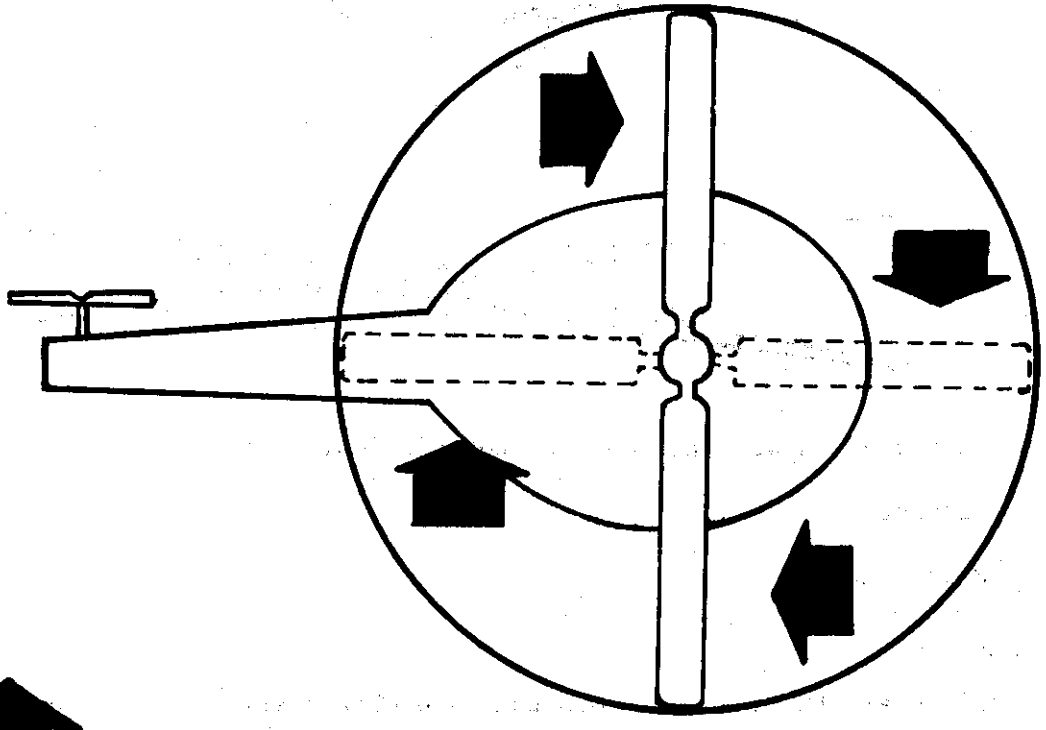
FRAME 5

The efficiency of the hovering rotor system is increased by each knot of incoming wind gained by forward motion and/or surface headwind.

Two factors affect lift - speed of the airflow over the rotor blade (relative wind) and angle of attack.

For a given angle of attack, the greater the relative wind the greater the lift.

Relative wind as it acts on the rotor blades, is always opposite and parallel to the flight path of the rotor blade. See diagram.



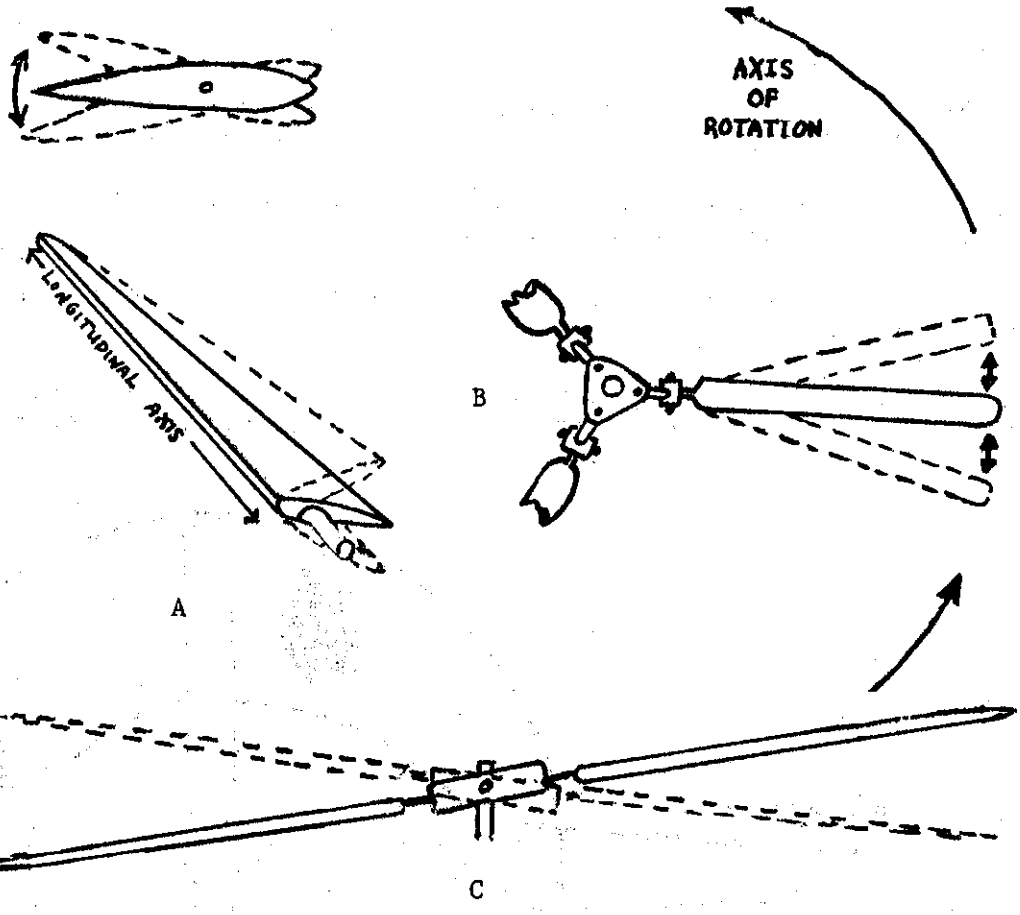
Indicates direction of relative wind.

At a hover, the rotor system encounters no relative wind on a no wind day.

a. True
b. False

ANSWER: b. No, a rigid rotor system will only feather since it is directly connected to the rotor mast. If in doubt see FRAMES 8 thru 10.

FRAME 11



Match the diagram with the correct terms below.

B Hunting

A Feathering

C Flapping

Select all the blade actions that are characteristic of each rotor system.

a b C 1.	Articulated	a. Flapping
b 2.	Rigid	b. Feathering
b a 3.	Semi-Rigid	c. Hunting

CONTINUE TO SELF EVALUATION EXERCISE PAGE 12

ANSWER: b. False

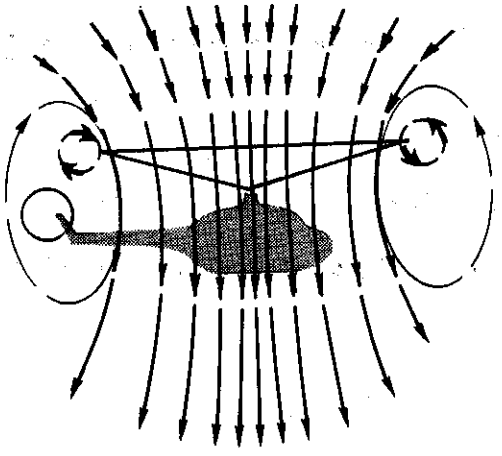
FRAME 6

At a stationary hover (either in or out of ground effect) the rotor system is operating in disturbed air created by the rotor wash.

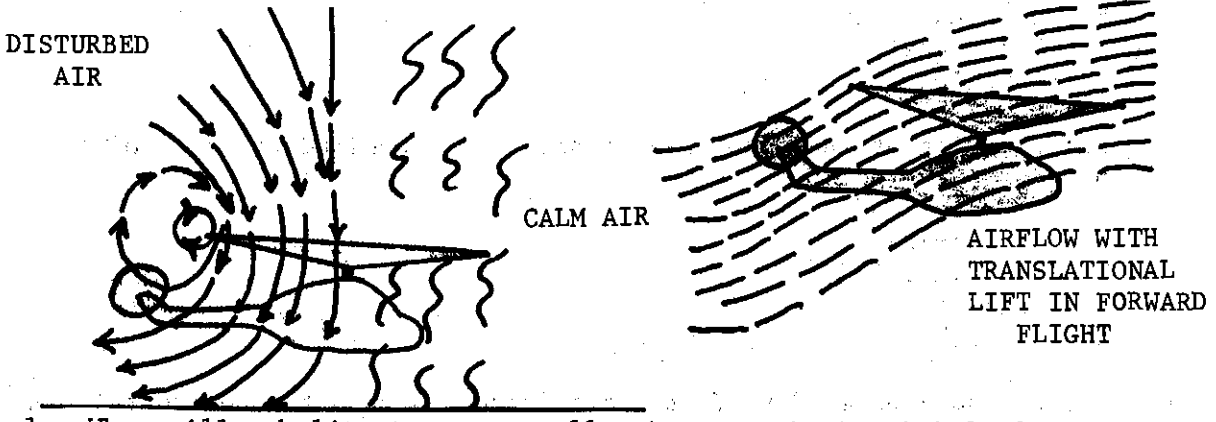
Forward flight and/or an increase in surface headwind introduces undisturbed air into the rotor system.

Just prior to reaching effective translational lift the aircraft will shudder and the nose will pitch up because different portions of the rotor disc work in different air flow velocities. See diagram.

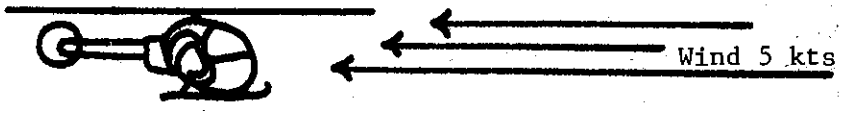
OUT OF GROUND EFFECT



Upon reaching approximately 15 knots, the rotor system operates in undisturbed air and enters effective translational lift; causing the entire aircraft to rise because the rotor is more efficient. See diagram.



1. When will a helicopter enter effective translational lift facing a 25 knot headwind? hover



Forward Speed 10 kts

2. The speed of the relative wind is 15 knots in the above diagram.

CONTINUE ON TO FRAME 7 PAGE 2

ANSWER: 1. a b c 2. b 3. a b

SELF EVALUATION EXERCISE

1. The blades of a fully Articulated system are free to:

   a. flap.
   b. hunt.
   c. feather.
   d. all the above.

2. The blades of a Semi-Rigid rotor system WILL NOT:

   a. hunt.
   b. feather.
   c. flap.
   d. all the above.

3. The blades of a Rigid rotor system will:

   a. flap.
   b. feather.
   c. hunt.
   d. lag.

4. Hunting is a horizontal action.

   a. vertical.
   b. perpendicular
   c. horizontal
   d. parallel

5. The pitching of the rotor blades about the longitudinal axis of the blades is called?

   a. feathering.
   b. flapping.
   c. hunting.
   d. coning.

6. The up and down action of the rotor blades around the horizontal hinge pin is called:

   a. feathering.
   b. hunting.
   c. coning.
   d. flapping.

7. "Ground Effect" can be defined as:

   a. the increased efficiency of the rotor system due to the downward flow of air while at a hover.
   b. the increased efficiency of the air due to being pulled through the rotor system.
   c. the increased efficiency of the rotor system as a result of the air being pulled through the system, striking the ground and being deflected outward without being restricted.
   d. the increased efficiency of the fuel system due to the increased efficiency of the rotor head.

8. Three advantages of operating within "Ground Effect" would be:

   a. less fuel used, less power needed, and less take off area needed.
   b. hover higher above the ground, lift more load, and lower oil consumption.
   c. greater rotor efficiency, less fuel consumption, and increased load capability.
   d. can hover in tall grass, shorter take off area needed, and can hover over water.

9. Which WILL NOT nullify ground effect?

   a. high grass.
   b. rough water.
   c. high temperature
   d. rotor wash from other helicopters.

10. Relative wind is:

   a. the velocity of the air parallel and opposite to the flight path of the object.
   b. direction of the air relative to the ground.
   c. the velocity of the air relative to its downward flow.
   d. the direction and velocity of the air flow relative to its downward thrust.

11. A rotor system will receive sufficient undisturbed air to gain effective translational lift at approximately:

   a. 10 knots.
   b. 15 knots.
   c. 22 knots.
   d. 25 knots.

12. A helicopter needs much more power for a vertical take-off due to the lack of:

a. forward speed.
b. effective translational lift.
c. Both of the above.
d. rotor downwash.

13. Effective Translational lift is obtained by:

a. Increasing power and coning.
b. Increasing forward airspeed and relative wind.
c. Increasing collective pitch and angle of attack.
d. Increasing power and RPM.

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ANSWERS TO SELF EVALUATION EXERCISE

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

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