Aircraft Performance

READING ASSIGNMENT
PHAK Chapter 11 – *Aircraft Performance*

Study Questions

1. Where can the data pertaining to takeoff, climb, range, endurance, descent, and landing for a specific airplane be found?
    a) The Pilot's Handbook of Aeronautical Knowledge, Chapter 11.
    b) www.faa.gov.
    c) The Airplane Flight Manual (AFM) or Pilot's Operating Handbook (POH).

2. What is true of the performance information published by various manufacturers?
    a) Performance charts are standardized from one airplane to another so that pilots can interpret the information easily.
    b) Operational data is not essential to making practical use of the airplane's capabilities.
    c) Tables, graphs, and other performance data furnished in the POH are not standardized across aircraft manufacturers.

3. Why does it matter how much air is around the airplane at any time?
    a) The amount of oxygen molecules determines how much fuel can be burned and turned into power.
    b) Thrust is generated by the propeller spinning through air molecules and forcing them backwards.
    c) Lift is generated by smoothly turning a flow of air molecules downward by the wings.
    d) All of the above.

4. When the air is less dense, what is the resulting impact on the following aircraft performance factors?

    Engine power ______________________________
    Propeller thrust ______________________________
    Wing (airfoil) lift ______________________________

5. Complete the following formula:

Mass
(amount of air)
______________________ = ______________________
Volume
(space the air takes up)

6. At sea level on a standard day what are the air temperature and pressure?
   ________________________________ and ________________________________

7. In standard conditions, how much does the air temperature and pressure drop with 1,000 feet of altitude?
   ________________________________ and ________________________________

8. Which of the following is not a method of determining Pressure Altitude?
   a) Subtracting the sea level temperature from Density Altitude.
   b) Setting the altimeter to 29.92 and reading the indicated altitude.
   c) Start with field elevation and use an altitude correction tied to the actual sea level pressure setting.

9. Density Altitude is Pressure Altitude corrected for ________________________________ .

10. Identify whether the conditions listed below are usually associated with high or low Density Altitude.

	Low Density Altitude	High Density Altitude
Poorer engine performance	☐	☐
Very dense air	☐	☐
Good propeller thrust	☐	☐
Difficulty breathing	☐	☐
Low density	☐	☐
Lots of lift from the wings	☐	☐
Hot, summer days	☐	☐
Aspen, Colorado	☐	☐

11. An increase in air density means a **higher / lower** density altitude.

12. Using PHAK Figure 11-3, determine the Pressure Altitude at the following airports with conditions as indicated.

Airport elevation	= 2,200 feet MSL	Airport elevation	= 300 feet MSL
Altimeter setting	= 30.50	Altimeter setting	= 29.80
Pressure Altitude	= __________________	Pressure Altitude	= __________________
Airport elevation	= 800 feet MSL	Airport elevation	= 6,000 feet MSL
Altimeter setting	= 30.00	Altimeter setting	= 29.55
Pressure Altitude	= __________________	Pressure Altitude	= __________________
Airport elevation	= Sea level	Airport elevation	= 1,000 feet MSL
Altimeter setting	= 29.85	Altimeter setting	= 30.35
Pressure Altitude	= __________________	Pressure Altitude	= __________________

13. To calculate Density Altitude using a Density Altitude Chart such as in PHAK Figure 11-4, start first at the correct Outside Air Temperature on the bottom axis, and

    a) move straight up until you intersect the correct Pressure Altitude, then read the resulting Density Altitude at the left.
    b) move diagonally until you hit the right border, then add 2,000.
    c) divide by the correct Pressure Altitude.

14. Use Figure PHAK 11-4 to determine the Density Altitude for each of the following conditions.

Air Temperature	= 35 °C	Air Temperature	= 20 °C
Pressure Altitude	= 1,000 feet	Pressure Altitude	= 2,000 feet
Density Altitude	= __________	Density Altitude	= __________
Air Temperature	= 5 °C	Air Temperature	= Standard
Pressure Altitude	= 3,000 feet	Pressure Altitude	= 3,000 feet
Density Altitude	= __________	Density Altitude	= __________
Air Temperature	= 70 °F	Air Temperature	= 40 °F
Pressure Altitude	= 1,000 feet	Pressure Altitude	= 5,500 feet
Density Altitude	= __________	Density Altitude	= __________
Air Temperature	= 20 °C	Air Temperature	= 26 °C
Pressure Altitude	= 3,000 feet	Pressure Altitude	= 4,500 feet
Density Altitude	= __________	Density Altitude	= __________

15. Because of the way the Pressure Altitude lines are angled in PHAK Figure 11-4, which would be true about an increase in outside air temperature?

    a) An increase in air temperature has no impact on Density Altitude.
    b) For the same Pressure Altitude, an increase in air temperature results in a lower Density Altitude.
    c) For the same Pressure Altitude, an increase in air temperature results in a higher Density Altitude.

16. Why does the red dashed Standard Temperature line in PHAK Figure 11-4 angle upward and to the left?

    a) Air temperature increases with altitude, and the line reflects these values.
    b) As altitude increases, outside air temperature decreases.
    c) The line is actually vertical, but appears angled only by optical illusion.

17. As altitude increases, air pressure decreases. Based on the impact of the pressure change alone we would expect the air density to ______________.

    a) increase
    b) stay the same
    c) decrease

18. As altitude increases, air temperature decreases. Based on the impact of the temperature change alone we would expect the air density to ______________________.

    a) increase
    b) stay the same
    c) decrease

19. Given these two conflicting phenomenon, which will dominate and have a greater impact on air density?

    a) The decrease in air pressure dominates, resulting in an overall decrease in air density with altitude.
    b) The decrease in air temperature dominates, resulting in an increase in air density with altitude.
    c) The two effects cancel each other out, and the density of the air does not change with altitude.

20. Moisture has the effect of decreasing the air density. This is because

    a) water vapor is lighter than air.
    b) extra water in the air pulls the air more strongly downward to the center of the earth.
    c) water molecules repel oxygen molecules.

21. Which can hold more water vapor, warm air or cold air?

    ____

22. Do performance charts typically show how to calculate the influence of the moisture content of the atmosphere on airplane performance?

    a) Yes.
    b) No.
    c) Approximately half of them do.

23. Select the answers below that make the statement true.

    There <u>are / are no</u> rules-of-thumb to compute the effects of humidity on Density Altitude, so pilots should know to expect <u>an increase / a decrease</u> in aircraft performance when flying in high humidity.

24. The thrust required by an airplane in level flight is the sum of the power needed to overcome

    a) the initial climb.
    b) the parasite drag and induced drag.
    c) the rotational drag of the propeller.

25. An airplane needs only 110 horsepower to maintain level flight, but the engine and propeller can produce 195 horsepower. What can the reserve power be used for?

    a) Improved engine-out glide distance.
    b) Left-turning tendencies.
    c) Climbing.

26. An unusual flight condition exists while flying in the region of reversed command. At low airspeeds near the stall or minimum controllable airspeed, the power setting required for steady level flight is
    a) minimal.
    b) reduced.
    c) quite high.

? 27. Which phrase would you guess is occasionally used by pilots to refer to the region of reversed command?
    a) Soft spot.
    b) Critical angle.
    c) Backside of the power curve.

28. In each of the following, circle the runway surface condition that is assumed by most of the performance charts found in airplane POHs.

unpaved	or	paved
dry	or	wet
inclined	or	level
smooth	or	uneven

29. Any change in runway condition from the assumed conditions in performance charts will result in a(n) ______________________________ in the required takeoff or landing distance.

30. What is meant by a runway slope indication of "1.1% up"?
    a) The runway rises 1.1 foot for every 100 foot of runway length.
    b) Pilots should increase takeoff distance estimates by 1.1%.
    c) The runway is mostly level, but slopes up in the last 1.1%.

31. What can result if pilots do not check that their airplane tires are adequately inflated prior to takeoff?
    a) At higher altitudes, where the pressure is lower, the tires could expand and rupture.
    b) Poorly inflated tires are at increased risk of hydroplaning in wet runway conditions.
    c) Suspension or revocation of any pilot certificate, and denial of applications for up to 1 year.

32. The effect of gross weight on takeoff distance is significant and can be considered to produce a threefold negative effect on takeoff performance. What are the three ways in which an increase in gross weight impairs takeoff performance?

____

____

____

33. Select the answers below that make the statement true.

The effect of wind on takeoff and landing distance is large / negligible . On takeoff, the effect of a headwind is to allow the airplane to reach lift-off speed at a lower / higher groundspeed. Thus, the airplane will require more / less ground roll to build up the required speed. Taking off with a headwind / tailwind , however slight, will require an increased ground roll.

On landing, because the airspeed at which the airplane approaches and touches down is dependent on / independent of the wind, a tailwind will mean the aircraft touches down at a higher / lower groundspeed and will require additional runway length to slow and stop.

34. How do Pressure Altitude and temperature affect runway takeoff and landing distance?

a) Increases in Pressure Altitude and temperature will result in a greater required takeoff speed, decreased thrust, and reduced accelerating forces. All of which contribute to longer takeoff and landing distance.
b) As Pressure Altitude increases, temperature decreases and the two factors balance each other out. Takeoff and landing distances do not change.
c) Increases in Pressure Altitude result in increased engine performance and shorter takeoff and landing distance.

35. The worst-case scenario for takeoff is a combination of ________________ gross weight, ________________ altitude, ________________ outside air temperature, and ________________ wind.

36. Define the following terms:

V_{S0} ____

V_{S1} ____

37. Although "interpolation" sounds like a bit of complex mathematics, pilots regularly use interpolation when interpreting airplane performance charts in POHs. In your own words, how would you define interpolation?

____

____

____

____

?

38. Why is the chart in PHAK Figure 11-23 sometimes called a Combined Takeoff Distance Graph?

a) It combines the performance of several airplanes.
b) The answers it shows must be combined with runway length information in the Airport/Facility Directory.
c) It has charts that show the impact of pressure altitude, temperature, weight, wind, and obstacle clearance combined onto a single graph.

39. Describe the function of the leftmost graph portion of the combined takeoff distance graph in PHAK Figure 11-23.

a) The leftmost graph calculates density altitude which is approximately equal to runway takeoff distance.
b) At higher pressure altitudes, the graph shows that less runway distance is required.
c) Outside air temperature and pressure altitude are used to determine a baseline takeoff distance.

40. Use the Takeoff Distance graph in PHAK Figure 11-23 to determine the baseline takeoff distance required in each of the following conditions. (In other words, ignore adjustments for gross weight, wind, and obstacles).

Air Temperature = 18 °C
Pressure Altitude = 10,000 feet
Baseline takeoff distance = ____________________

Air Temperature = 11 °C
Pressure Altitude = 6,000 feet
Baseline takeoff distance = ____________________

Air Temperature = -10 °C
Pressure Altitude = 4,000 feet
Baseline takeoff distance = ____________________

Air Temperature = 80 °F
Pressure Altitude = Sea level
Baseline takeoff distance = ____________________

41. Select the answers below that make the statement true about PHAK Figure 11-23.

The second section of the Combined Takeoff Distance Graph is used to calculate how much less / more runway distance is needed for airplanes that weigh less than maximum gross weight. The baseline takeoff distance determined in the section on the left assumes that the airplane was at maximum / minimum gross takeoff weight. To adjust for lower / higher airplane weights, the pilot follows the lines on the graph diagonally down / straight across until reaching the actual takeoff weight of the airplane. For airplanes flying with less than maximum gross weight, this step should reduce / increase the distance required for takeoff.

42. How would a pilot use the sloping lines in the second section of a Combined Takeoff Distance Graph, if the airplane is loaded to its maximum gross weight?

a) The pilot would draw a line connecting the weight in pounds with pressure altitude.
b) Using a calculator, the pilot would subtract the gross takeoff weight from the overall takeoff distance required.
c) The pilot would ignore this section as it is only used to decrease takeoff distance for planes at lighter than maximum gross weight.

43. Use the Takeoff Distance Graph in PHAK Figure 11-23 to determine the new takeoff distance required after adjusting from the airplanes' gross takeoff weights.

Baseline takeoff distance = 1,100 feet
Airplane weight = 2,600 lbs
New takeoff distance = ____________________

Baseline takeoff distance = 2,500 feet
Airplane weight = 2,800 lbs
New takeoff distance = ____________________

Baseline takeoff distance = 1,800 feet
Airplane weight = 2,400 lbs
New takeoff distance = ____________________

Baseline takeoff distance = 1,500 feet
Airplane weight = 2,840 lbs
New takeoff distance = ____________________

44. The third section of PHAK Figure 11-23 shows the impact of headwind. How will an increase in headwind affect the required takeoff distance?

____

____

45. How would calm, no-wind conditions affect the way a pilot used a Combined Takeoff Distance Graph?

____

46. A pilot using PHAK Figure 11-23 determines that the runway distance required to takeoff on a calm day was 1,800 feet (no obstacles). What would be the distance required for takeoff in the same conditions but with a 20 knot headwind?

a) 1,650 feet
b) 1,450 feet
c) 1,300 feet

47. Using PHAK Figure 11-23, you determine the distance required to takeoff with an 18 knot headwind is 2,000 feet (no obstacles). If just prior to takeoff the wind calms completely (0 knots), what will be the new takeoff distance required?

____

48. The last section shows how much of a(n) ____________________ in takeoff distance will be required if the airplane has to climb above a 50 foot obstacle at the end of the runway.

49. If there are no obstacles at the departure end of the runway, how would a pilot use the last section of combined takeoff distance graph shown in PHAK Figure 11-23?

a) Ignore the last section.
b) Use the distance required to climb the 50 foot obstacle anyway, just to be safe.
c) With no obstacles, the pilot would not need to calculate runway takeoff distance at all, and would not be using PHAK Figure 11-23 in the first place.

50. Where do manufacturers get the data shown in the climb and cruise performance charts in Pilot's Operating Handbooks?

a) Complex molecular models developed by theoretical physicists to predict air flow patterns over each square inch of the airplane.
b) Standard sample data on the FAA website.
c) Actual flight tests conducted in an airplane of the same type.

51. In a chart like PHAK Figure 11-25 or table like PHAK Figure 11-26, how would the amount of fuel required to climb be determined?

a) By the height of the curve of the Fuel line.
b) By the difference between the fuel value determined for the cruising altitude, and the fuel value determined for the departure airport.
c) By taking the distance to climb divided by the time in minutes.

52. In the Fuel, Time, and Distance-to-Climb Table in PHAK Figure 11-26, how much fuel is burned during engine start, taxi, and takeoff?

____

53. How many gallons of fuel does that represent?

____

54. In the Fuel, Time, and Distance-to-Climb Table (PHAK Figure 11-26), why does Note 2 say to increase climb amounts for higher air temperatures?
    a) Higher temperatures increase the Density Altitude and decrease climb performance.
    b) Fuel expands at higher temperatures, and increases the gross weight of the airplane.
    c) FAA regulations require increased fuel burn on warmer than standard days.

55. In the Cruise Power Setting Table (PHAK Figure 11-28), which of the three big column groups would a pilot use when the outside air temperature at a sea level airport was 37 °C?
    a) Left group.
    b) Middle group.
    c) Right group.

56. Which column group would a pilot use for an airport at 2,000 feet MSL where the air temperature was 55 °F?

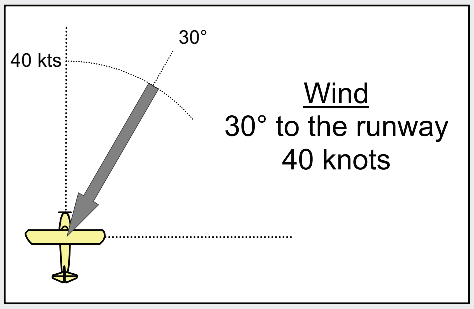
    ____

57. Using the Cruise Power Setting Table (PHAK Figure 11-28), determine the cruise performance for the following conditions.

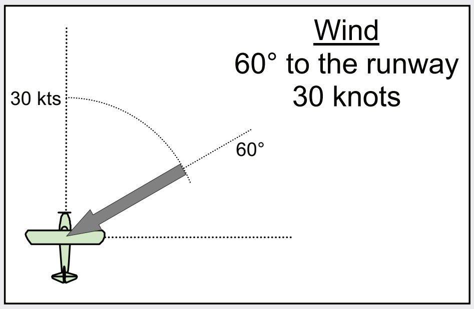
Air Temperature	= 26 °C	Air Temperature	= -19 °C
Pressure Altitude	= 6,000 feet	Pressure Altitude	= 8,000 feet
Fuel Flow	= __________GPH	Fuel Flow	= __________GPH
True Airspeed	= __________KTS	True Airspeed	= __________KTS
Air Temperature	= 55 °F	Air Temperature	= -2 °C
Pressure Altitude	= 2,000 feet	Pressure Altitude	= 10,000 feet
Fuel Flow	= __________GPH	Fuel Flow	= __________GPH
True Airspeed	= __________KTS	True Airspeed	= __________KTS
Air Temperature	= Standard	Air Temperature	= Standard °C
Pressure Altitude	= 4,000 feet	Pressure Altitude	= 5,000 feet
Fuel Flow	= __________**PSI**	Fuel Flow	= __________GPH
True Airspeed	= __________**MPH**	True Airspeed	= __________KTS
Air Temperature	= ISA + 20 °C	Air Temperature	= 12 °C
Pressure Altitude	= 9,000 feet	Pressure Altitude	= 2,500 feet
Fuel Flow	= __________GPH	Fuel Flow	= __________GPH
True Airspeed	= __________KTS	True Airspeed	= __________KTS

58. Notice that the values in the True Airspeed columns of PHAK Figure 11-28 first increase with altitude, but above a certain point, the values decrease with altitude. Why?
    a) Above a certain altitude, ice forms on the wings, increasing drag and slowing down the aircraft.
    b) Most of the fuel available has been burned off in the climb.
    c) At first, true airspeed increases with altitude because the thinner air creates less drag. However, eventually the decreased oxygen available to the engine limits engine power and airspeed drops.

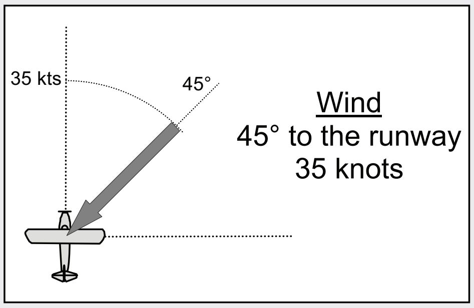
59. Use the Crosswind Component Chart (PHAK Figure 11-31 (mistakenly labeled as 10-31)) to determine how much crosswind the airplane would experience in each of the wind conditions below.



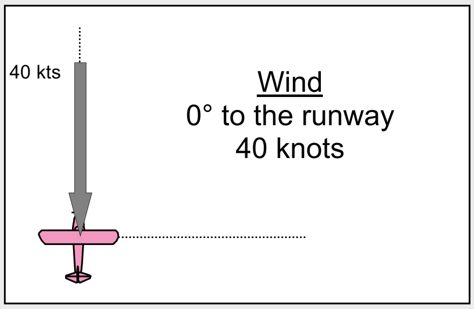
Crosswind component: ___________



Crosswind component: ___________



Crosswind component: ___________



Crosswind component: ___________

60. What crosswind value is published in an airplane's AFM/POH?

____

61. What angle of wind should a pilot experience when taking off on Runway 6, if the wind is coming from 080°?

a) 20°.
b) 60°.
c) 80°.

62. Use the Crosswind Component Chart (PHAK Figure 11-31 (mistakenly labeled as 10-31)) to determine how much crosswind the airplane would experience in each of the wind conditions below.

Runway in use: 13
Wind: 090° at 20 knots
Crosswind Component: ________________

Runway in use: 35
Wind: 290° at 22 knots
Crosswind Component: ________________

Runway in use: 28
Wind: 300° at 15 knots
Crosswind Component: ________________

Runway in use: 2
Wind: 070° at 29 knots
Crosswind Component: ________________

63. In your own words, define the following landing terms:

Ground roll ______________________________

Total landing distance ______________________________

64. Some POHs show the required landing distance using a Landing Distance Table like the one shown in PHAK Figure 11-32. How would you estimate the required the landing distance at an airport with pressure altitude other than values shown in the column headings?

____

65. Using PHAK Figure 11-32, what landing distance is required when landing at an airport at a pressure altitude of 5,000 feet and an air temperature of 41 °F with no obstacles?

____

66. Use the Landing Distance Table (PHAK Figure 11-32) to distance required to land for each of the conditions below. (Note: There is an error in the FAA text. The second column heading should be "At 2,500 ft & 50 °F".)

Pressure altitude:	2,500 feet	Pressure altitude:	Sea level
Air temperature:	50 °F	Air temperature:	59 °F
Wind:	Calm	Wind:	Calm
Obstacle:	No obstacle	Obstacle:	50 foot obstacle
Landing Distance:	__________	Landing Distance:	__________
Pressure altitude:	3,750 feet	Pressure altitude:	3,750 feet
Air temperature:	Standard	Air temperature:	45 °F
Wind:	Calm	Wind:	Calm
Obstacle:	No obstacle	Obstacle:	50 foot obstacle
Landing Distance:	__________	Landing Distance:	__________

67. How will the distance-to-land estimates taken from the Landing Distance Table in PHAK Figure 11-32 need to be adjusted if the wind goes from calm to a 4 knot headwind?

____

68. How would the landing distance be adjusted if the air temperature was 30 °F above standard air temperature?

____

69. The interpretation and use of the Landing Distance Graph (PHAK Figure 11-33) is very similar that of the

a) Combined Takeoff Distance Graph.
b) Crosswind Component Chart.
c) Cruise Power Setting Table.

70. What distance is calculated using the leftmost portion of the Landing Distance Graph (PHAK Figure 11-33)?

a) The total distance required to land.
b) A baseline distance that assumes no wind, maximum gross weight, and no obstacles.
c) The minimum landing distance for a short-field landing.

71. Use the Landing Distance graph (PHAK Figure 11-33) to determine the baseline distance required to land in each of the following conditions.

Air temperature	= 30 °C	Air temperature	= 32 °F
Pressure altitude	= 6,000 feet	Pressure altitude	= 10,000 feet
Baseline landing distance = ____________________		Baseline landing distance = ____________________	
Air Temperature	= -6 °C	Air temperature	= 70 °F
Pressure altitude	= Sea level	Pressure altitude	= 8,000 feet
Baseline landing distance = ____________________		Baseline landing distance = ____________________	

72. (Refer to PHAK Figure 11-33.) If the baseline landing distance calculated is 1,640 feet for an airplane at maximum gross weight, what would be the adjusted landing distance for the airplane if the gross weight was only 2,600 pounds?

____

73. How will a tailwind affect the distance required to land?

a) The distance required would decrease.
b) The distance required would not change.
c) The distance required would increase.

74. (Refer to PHAK Figure 11-33.) How much landing distance is required in the following conditions?

Outside air temperature:	20 °C
Pressure altitude:	2,000 feet
Gross weight:	2,700 lbs
Wind:	10 knot headwind
Obstacle:	50 foot obstacle

a) 1,850 feet
b) 1,550 feet
c) 1,300 feet

75. (Refer to PHAK Figure 11-33.) How much landing distance is required in the following conditions?

Outside air temperature:	20 °C
Pressure altitude:	2,000 feet
Gross weight:	2,700 lbs
Wind:	20 knot headwind
Obstacle:	50 foot obstacle

a) 1,400 feet
b) 1,175 feet
c) 750 feet

Answers to Study Questions

1. c
2. c
3. d
4. decreases
   decreases
   decreases
5. Density (mass per volume)
6. 15 °C and 29.92 inches of mercury
7. approximately 2 °C and 1 inch of mercury
8. a
9. non-standard temperature
10.

	High
Low	
Low	
	High
	High
Low	
	High
	High

11. lower
12.

1,670 feet	410 feet
725 feet	6,345 feet
65 feet	605 feet

13. a
14.

3,700 feet	3,000 feet
2,500 feet	3,000 feet
2,000 feet	5,500 feet
4,250 feet	6,600 feet

15. c
16. b
17. c
18. a
19. a
20. a
21. warm air
22. b
23. are no
    a decrease
24. b
25. c
26. c
27. c
28. paved
    dry
    level
    smooth
29. increase
30. a
31. b
32. higher lift-off speed is needed
    greater mass to accelerate
    increased retarding forces (both ground friction and induced drag)
33. large
    lower
    less
    tailwind
    independent of
    higher
34. a
35. high
    high
    high (hot)
    unfavorable (tail)
36. speed at which airplane stalls in landing configuration
    speed at which airplane stalls in a specified configuration (usually flaps up and landing gear retracted)
37. Something to the effect of "estimating a middle value by taking a proportional distance from one or both end points."
38. c
39. c
40.

2,500 feet	1,500 feet
1,000 feet	1,000 feet

41. less
    maximum
    lower
    diagonally down
    reduce
42. c
43.

800 feet	2,400 feet
1,150 feet	1,500 feet

44. It will decrease takeoff distance
45. The pilot would ignore the section of the Combined Takeoff Distance Graph that adjusts for headwind component.

Answers to Study Questions

46. b
47. Approximately 2,400 feet
48. increase
49. a
50. c
51. b
52. 16 pounds
53. 2.7 gallons
54. a
55. c
56. Middle column (Standard Day)
57. 11.5 GPH 11.5 GPH
    161 KTS 157 KTS

    11.5 GPH 11.5 GPH
    153 KTS 163 KTS

    6.6 PSI 11.5 GPH
    180 MPH 157 KTS

    11.45 GPH 11.5 GPH
    165 KTS 154 KTS
58. c
59. 20 knots 26 knots
    25 knots 0 knots
60. Maximum demonstrated crosswind component
61. a
62. 14 knots 19 knots
    5 knots 22 knots
63. distance from touchdown to complete stop
    distance from obstacle to touchdown to complete stop
64. interpolation
65. 495 feet
66. 470 feet 1075 feet
    482.5 feet 1165 feet
67. Landing distance would decrease by 10%.
68. Landing distance would increase by 5%.
69. a
70. b
71. 1,450 feet 1,500 feet
    1,000 feet 1,500 feet
72. 1,450 feet
73. c
74. b
75. b