Knowledge

For each question, select the best answer from the four alternatives.

1. Which of the following terms is used to describe the vector that is generated when adding two vectors? (2.1) K/U
   (a) compass vector
   (b) resultant vector
   (c) diagonal vector
   (d) general vector
2. Which vector direction is equivalent to N 40° W? (2.1) K/U
   (a) N 50° W
   (b) N 50° E
   (c) E 50° N
   (d) W 50° N
3. For a diagram scale of 1 cm : 10 m, what is the real-world measurement of a 2.5 cm diagram measurement? (2.1) K/U
   (a) 2.5 m
   (b) 25 m
   (c) 25 cm
   (d) 250 m
4. What distance does the vector in **Figure 1** represent in real life? (2.1) K/U

scale 1 cm : 50 m
Figure 1

   (a) 110 m
   (b) 110 cm
   (c) 2.2 m
   (d) 2.2 km
5. What is the x-component of the displacement vector $\Delta\vec{d}_T = 24$ m [S 22° E]? (2.2) K/U
   (a) 9.7 m [S]
   (b) 9.0 m [E]
   (c) 22 m [E]
   (d) 22 m [S]
6. A family on a road trip has to take a detour off the main highway. In doing so, they travel 27 km [N] and then turn to travel 11 km [E]. What is their displacement while on the detour? (2.2) K/U
   (a) 32 km [N 70° W]
   (b) 38 km [N 68° E]
   (c) 29 km [N 22° E]
   (d) 35 km [N 68° W]
7. A projectile is launched from the ground with an initial horizontal velocity of 5.0 m/s [right] and an initial vertical velocity of 6.5 m/s [up]. At what angle from vertical is it launched? (2.2, 2.3) T/I
   (a) 40°
   (b) 50°
   (c) 52°
   (d) 38°
8. A projectile is launched at an initial velocity of 11 m/s from the ground at 30° from the vertical. How long does it take before it reaches its maximum height? (2.3) T/I
   (a) 0.97 s
   (b) 0.56 s
   (c) 0.79 s
   (d) 1.12 s
9. Whose theories was Galileo testing when he performed his falling-body experiments? (2.4) K/U
   (a) Aristotle
   (b) Newton
   (c) Descartes
   (d) Einstein

Indicate whether each of the statements is true or false. If you think the statement is false, rewrite it to make it true.

10. A diagram with a scale of 1 cm : 10 cm means that 10 cm on the diagram represents 1 cm in real life. (2.1) K/U
11. To find the direction of the vector 5 m [E 30° S], point east and then turn 30° to the south. (2.1) K/U
12. To add two vectors on a diagram, join them tip to tip. (2.1) K/U
13. The resultant vector is the vector that results from subtracting the given vectors. (2.1) K/U
14. When given the x- and y-component vectors, the Pythagorean theorem should be used to determine the direction of the displacement vector. (2.2) K/U
15. The resultant vector of an object after travelling 10 km [N] and then 10 km [E] has a direction of [N 45° E]. (2.2) K/U
16. The x-component of the vector 8.0 m [S 45° W] is 8.0 m [W]. (2.2) K/U
17. The amount of time it takes a boat to cross a river is not affected by the current as long as the boat is pointed perpendicular to the direction of the current. (2.2) K/U
18. A beanbag that is launched horizontally will hit the ground at the same time as an identical beanbag that is dropped from the same height at the same time. (2.3) K/U

19. When two objects are dropped from the same height at the same time, the heavier object will land first when there is no air resistance. (2.3) K/U

Match each term on the left with the most appropriate description on the right.

20.

(a) projectile motion	(i) the horizontal distance a projectile travels
(b) range	(ii) the motion of an object that moves in response to gravity
(c) time of flight	(iii) believed that objects fall at constant speeds and that more massive objects fall faster than less massive objects
(d) Galileo	(iv) the time it takes a projectile to complete its motion
(e) Aristotle	(v) proved that all objects have the same constant acceleration in free fall (2.1, 2.2, 2.3, 2.4) K/U

Understanding

Write a short answer to each question.

21. (a) Describe a situation in which a diagram would have a scale that is smaller than the real-world measurement. For example, 1 cm on the diagram would represent a distance larger than 1 cm in real life.
    (b) Describe a situation in which a diagram would have a scale that is larger than that of the real-world measurement. For example, 1 cm on the diagram would represent a distance smaller than 1 cm in real life. (2.1) K/U C

22. For each of the following displacement vectors, determine the vector that has the same magnitude but the opposite direction: (2.1) T/I
    (a) $\Delta\vec{d} = 17$ m [W 63° S]
    (b) $\Delta\vec{d} = 79$ cm [E 56° N]
    (c) $\Delta\vec{d} = 44$ km [S 27° E]

23. Copy and complete **Table 1** using a scale diagram of 1 cm : 50 m. (2.1) K/U

Table 1

Diagram size	Real-world size
3.4 cm	
	37.5 m
85.0 mm	
	1250 m

24. Draw the following displacement vectors to scale using the scale 1 cm : 100 m: (2.1) K/U
    (a) $\Delta\vec{d} = 210$ m [S 45° E]
    (b) $\Delta\vec{d} = 370$ m [N 60° W]
    (c) $\Delta\vec{d} = 560$ m [E 30° N]

25. For each of the following real-world distances, give an appropriate scale such that the equivalent diagram distance would be 2.4 cm. (2.1) T/I
    (a) 120 m
    (b) 360 km
    (c) 1200 m

26. Express each of the following vectors differently by using an equivalent direction: (2.1) K/U
    (a) $\Delta\vec{d} = 566$ m [W 18° N]
    (b) $\Delta\vec{d} = 37$ cm [E 68° S]
    (c) $\Delta\vec{d} = 7150$ km [S 38° W]

27. A woman is travelling home after work and drives her car 750 m due west and then turns right and travels 1050 m before stopping. Use a scale diagram to determine her net displacement. (2.1) T/I

28. A player hits the cue ball in billiards for the opening break. The cue ball initially travels 2.0 m [N], hits the billiard ball formation, and then travels a distance of 0.80 m [N 45° W]. Create a scale diagram for the cue ball, and use it to determine the net displacement. (2.1) T/I

29. Copy and complete **Table 2**, which involves component vectors and the magnitude of their resulting vector. (2.2) T/I

Table 2

d_x	d_y	d_T
3.0	4.0	
8.0		10.0
	5.00	7.81
4.00		8.06

30. Copy and complete **Table 3**, which involves the component vectors and the direction of the resulting vector. (2.2) T/I

Table 3

$\vec{d}_x$	$\vec{d}_y$	ϕ
3.0 [E]	4.0 [N]	
5.00 [W]	7.00 [N]	
82.0 [E]		E 14.4° S
	456 [N]	W 52.4° N

31. Determine the magnitude and direction of the *x*-component and *y*-component for the following displacement vectors: (2.2) K/U
    (a) $\Delta\vec{d}_T = 52$ m [W 72° S]
    (b) $\Delta\vec{d}_T = 38$ km [E 14° N]
    (c) $\Delta\vec{d}_T = 92$ m [S 82° W]
32. For each of the following, add the two component vectors and give the resulting displacement vector: (2.2) K/U
    (a) $\Delta\vec{d}_x = 5.0$ m [W], $\Delta\vec{d}_y = 2.9$ m [S]
    (b) $\Delta\vec{d}_x = 18$ m [E], $\Delta\vec{d}_y = 5.2$ m [N]
    (c) $\Delta\vec{d}_x = 64$ km [W], $\Delta\vec{d}_y = 31$ m [N]
33. Determine the magnitude of the vector in **Figure 2**. (2.2) K/U

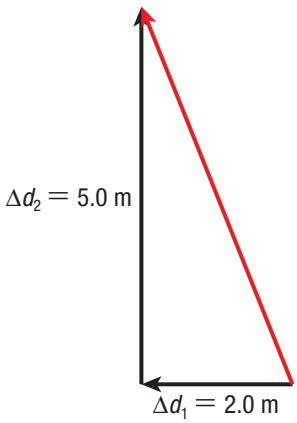

Figure 2

34. Determine the magnitude of the vector in **Figure 3**. (2.2) K/U

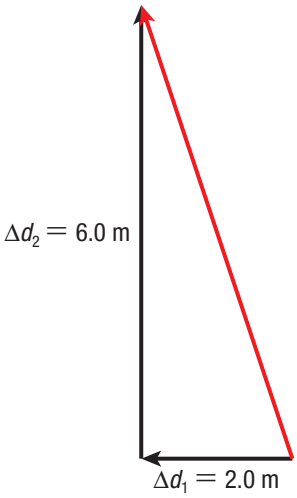

Figure 3

35. Determine the magnitude of the vector in **Figure 4**. (2.2) K/U

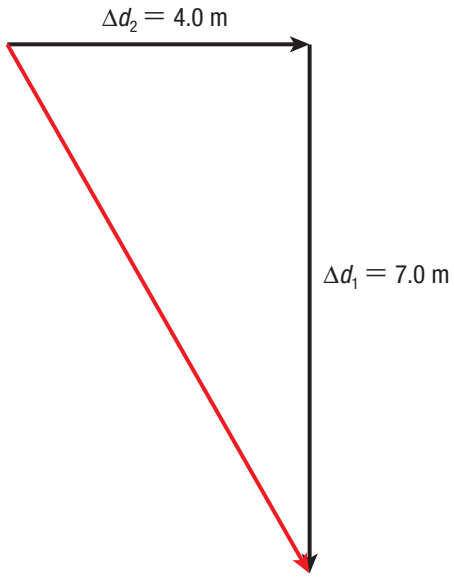

Figure 4

36. You decide to take your dog to the leash-free zone in the park. While playing, the dog runs after a ball and heads 24 m [W 12° S] and then gets distracted by a squirrel and runs 33 m [E 52° S]. Determine the displacement of the dog. (2.2) T/I

37. A student is on the southern bank of a river that is 36 m wide and has a current with a velocity of 6.2 m/s [W]. She needs to get directly across the river and decides to point the motor of the boat due north. The motor can push the boat with a speed of 2.0 m/s. (2.2) T/I
    (a) How long does it take the student to get across the river?
    (b) What is the resulting velocity of the boat?
    (c) When the student lands on the opposite bank, how far is she from her destination?

38. A student throws two beanbags in the air, one straight up and the other one at a 30° angle from the vertical. Both beanbags are thrown with the same initial velocity and from the same height. In your own words, explain which one will come back and hit the ground first and why. (2.3) C

39. During a kickball game, a student kicks the ball from the ground, giving the ball an initial velocity of 15 m/s at an angle of 50° from the horizontal. Determine the initial vertical and horizontal velocity components. (2.3) T/I

40. Students are performing an experiment for their physics class and are testing their predictions for projectile motion. They set up a system so that a beanbag is launched horizontally off one of their desks with an initial speed of 4.2 m/s. They measure the height of the desk to be 1.3 m. (2.3) T/I
    (a) What time of flight should the students predict for the beanbag?
    (b) What range should the students predict for the beanbag?

41. A historical society is testing an old cannon. They place the cannon in an open, level field and perform a few test fires to determine the speed at which the cannonballs leave the cannon. The cannon is placed at a 45.0° angle from the horizontal and placed in a bunker so that the cannonballs are fired from ground level. They measure the flight time of one cannonball to be 3.78 s. (2.3) T/I
    (a) What is the speed of the cannonball as it leaves the cannon?
    (b) What is the horizontal distance that the cannonball travels?

Analysis and Application

42. A man walking through the city travels one block (50 m) north, one block east, and then another block north. (2.1) T/I
    (a) Describe the vectors that would be used to create a diagram of his trip. Be sure to include an appropriate scale.
    (b) Create a diagram for his trip, and use it to determine the total displacement.

43. In a race, a boat travels a distance of 220 m [E 40° N] and then rounds a buoy and travels a distance of 360 m [N 30° W] to the finish line. The whole trip takes 22 s. Create a scale diagram for the boat, and use it to determine the displacement and average velocity of the boat. (2.1) T/I

44. You are told that the three vectors $\vec{a}$, $\vec{b}$, and $\vec{c}$ fit the equation $\vec{a} + \vec{b} = \vec{c}$ but you are only given scale drawings of vectors $\vec{c}$ and $\vec{a}$. (2.1) T/I C
    (a) Describe how you would place the vectors $\vec{c}$ and $\vec{a}$ on a diagram so that you could determine the size and direction of vector $\vec{b}$.
    (b) How would (a) change if you were given vectors $\vec{b}$ and $\vec{c}$ and needed to determine the magnitude and direction of vector $\vec{a}$?
    (c) Does it matter which component vector is given? That is, can either method of (a) or (b) be used no matter which component vector is given first? Explain.
    (d) Given the vectors $\vec{a}$ = 2.1 cm [W] and $\vec{c}$ = 4.3 cm [W 45° N], draw a scale diagram to determine vector $\vec{b}$.

Use **Figure 5** to answer Questions 45 to 50. For all questions, assume that routes must use only the roads (shown in grey).

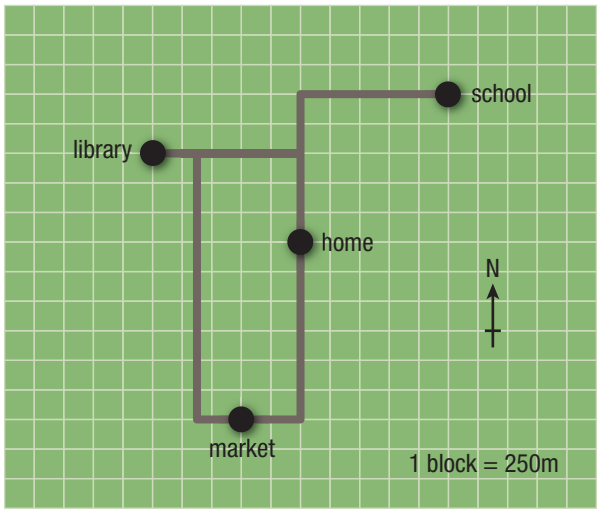

Figure 5

45. A student bikes to school every day from her home. She decides that the safest way to get there is to stay along the roads. Using vectors, describe the path she takes and determine the total distance she travels. (2.1) T/I

46. One night after studying at the library a student decides to stop at the market to pick up some dinner before going home. (2.1) T/I
    (a) Using vectors, describe the shortest path he can take while staying on the roads.
    (b) The speed limit on both of the roads is 40.0 km/h. If the student drives at this speed, how many minutes will it take him to get there?
47. A university student decides to go to the library one evening after returning home from work. What is his net displacement? (2.1) T/I
48. A Grade 12 student decides to go to the market at lunchtime from school. Determine her net displacement. (2.2) T/I
49. A mother is picking up her children from school and will take them home. She drives the speed limit of 25 km/h on each of the roads. (2.2) T/I
    (a) How many minutes does it take her to drive home from the school?
    (b) What is her average velocity from school to home?
50. After school one evening a student decides to head to the library to study for a physics test. He determines that his average speed on the trip was 25.2 km/h. How many minutes did it take him to travel from school to the library? (2.2) T/I
51. A boat travelling close to the coast is heading in an unknown direction. The captain contacts an observer on the shore to help her determine the direction the boat is heading. The observer on the shore reports that the horizontal displacement of the boat is 750 m [E] and that the boat travelled north an unknown distance. The captain has measured a total distance of 1100 m that the boat moved. How far north did the boat travel and in what direction is the boat travelling? (2.2) T/I
52. A football player trying to kick a field goal has determined that he needs to kick the ball in the direction of [N 32° W] in order to make it through the centre of the posts. If he is 13 m [E] of centre field (the field runs north to south), how far does he need to kick the ball in order to make it through the centre of the posts? (2.2) T/I
53. A hockey puck travels a distance of 11 m [N] in 0.55 s and is then hit by another player and travels a distance of 26 m [W 42° N] in 1.2 s. Calculate the average velocity of the puck. (2.2) T/I
54. An ecologist is trying to test for the average speed of a river that runs north to south, but he only has a boat and a stopwatch. He knows that the motor can push the boat with a speed of 5.2 m/s and that the width of the river is 35 m. While sitting in the boat on the eastern bank he points the motor due west. While on the western bank he has to walk a distance of 25 m to get back to the spot where he was aiming. How fast is the river current? (2.2) T/I
55. A student stands on the southern bank of a river that is 50 m wide and has a current with a velocity of 1.1 m/s [E]. The student needs to get directly across the river using her boat. (2.2) T/I C A
    (a) In order for the student to reach her destination, what must be the resulting direction of the velocity of the boat?
    (b) Describe in which direction the student should point the motor so that the net velocity of the boat is the same as the direction you determined in (a). Consider the vector components of the velocity of the boat and how they must add with the velocity of the river.
    (c) If the motor can push the boat with a speed of 3.8 m/s, what direction should the student point the motor to ensure that she reaches her destination?
    (d) How long does it take the student to cross the river?
56. Physics students are performing an experiment and slide a hockey puck off a horizontal desk that is 1.2 m high. The initial speed of the hockey puck is 1.5 m/s. (2.3) T/I
    (a) Determine the range of the hockey puck.
    (b) Determine the final velocity and angle at which it hits the ground.
57. A video game programmer is designing a soccer game and running tests to ensure that the game is as accurate as possible. As a test, a ball is kicked with an initial velocity of 16.5 m/s at an angle of 35° above horizontal. (2.3) T/I
    (a) Calculate the soccer ball's time of flight.
    (b) Calculate the soccer ball's range.
    (c) Calculate the soccer ball's maximum height.
58. The video game programmer runs another test, in which the ball has a flight time of 2.2 s, a range of 17 m, and a maximum height of 5.2 m. (2.3) T/I
    (a) What is the initial speed with which the ball is kicked?
    (b) What is the angle at which the ball is kicked?

Evaluation

59. Explain why solving motion problems in two dimensions by using scale diagrams is not very effective for most situations. (2.2) C

60. We can order events in time. For example, event *b* may precede event *c* but follow event *a*, giving us a time order of events *a*, *b*, *c*. Hence, there is a sense of time, distinguishing past, present, and future. Is time therefore a vector? Explain why or why not. (2.2) T/I

61. Two students are conducting controlled experiments to determine the relationship between the vertical displacement of a projectile and the projectile's time of flight and range. Student A launches her projectile from three different heights and records the horizontal displacement for each launch. Student B launches her projectile from three different heights, but repeats the launch and records the horizontal displacement 10 times for each of the three heights. (2.3) T/I
    (a) What variables are being manipulated in this experiment? What variables are being controlled?
    (b) Which student's data will be the most valid? Explain your reasoning.
    (c) What are some possible sources of error in this experiment? What could the students do to minimize error?

Reflect on Your Learning

62. Use what you have learned about drawing vectors to answer the following questions: K/U C
    (a) Describe in your own words how two vectors should be drawn when added together and how to determine the resultant vector.
    (b) Using the methods you have learned, describe how you would subtract two vectors.
    (c) Which method of vector addition do you prefer, using scale diagrams or breaking vectors down to components? Why?

63. In this chapter, you have learned how to solve some types of motion problems. What questions do you still have about solving motion problems? How could you find out more about solving motion problems? K/U C

Research

GO TO NELSON SCIENCE

64. The compass rose (**Figure 6**) has been used for centuries by sailors and navigators alike. Research the compass rose, and write a few paragraphs describing its origin, development, and how it came to be the prominent symbol for direction and navigation. C A

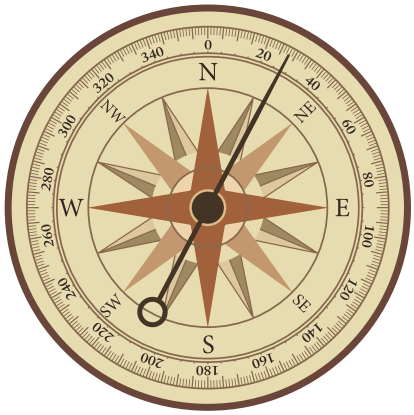

Figure 6

65. The Cartesian coordinate system, which is widely used today not only for plotting vectors but also for graphing equations and geometric problem solving, was developed around the same time Galileo performed his legendary falling bodies experiment. The coordinate system largely contributed to Galileo's and Newton's quest to accurately define the motion of objects. Research the Cartesian coordinate system. Write a paper about the history of the Cartesian coordinate system and how it helped shape our modern understanding of mathematics and physics. Include information about other coordinate systems that are used and how they differ from the standard two-dimensional grid. C A

66. In Section 2.5, you did some research about accelerometers and how they are used in many of the technological devices in our daily life. Aside from technology, accelerometers are also used to study nature, especially in the areas of seismic activity and animal motion. Research some of the ways accelerometers are used to help study nature and write a one-page report on your findings. C A

67. Electronic speed devices are used to measure the speed of objects for various purposes. For example, an electronic speed device may be used to measure the motion of a baseball thrown by a professional pitcher, or the motion of a car driving down the highway. Choose one of these two applications of electronic speed devices, and investigate how the electronic speed device works and how its use affects either the game of baseball or highway safety. T/I A