CHAPTER 3 PROBLEM WORKBOOK

A FINDING RESULTANT MAGNITUDE AND DIRECTION

1. An ostrich cannot fly, but it is able to run fast. Suppose an ostrich runs east for 7.95 s and then runs 161 m south, so that the magnitude of the ostrich's resultant displacement is 226 m. Calculate the magnitude of the ostrich's eastward component and its running speed.
2. The pronghorn antelope, found in North America, is the best long-distance runner among mammals. It has been observed to travel at an average speed of more than 55 km/h over a distance of 6.0 km. Suppose the antelope runs a distance of 5.0 km in a direction 11.5° north of east, turns, and then runs 1.0 km south. Calculate the resultant displacement.
3. Kangaroos can easily jump as far 8.0 m. If a kangaroo makes five such jumps westward, how many jumps must it make northward to have a northwest displacement with a magnitude of 68 m? What is the angle of the resultant displacement with respect to north?
4. In 1926, Gertrude Ederle of the United States became the first woman to swim across the English channel. Suppose Ederle swam 25.2 km east from the coast near Dover, England, then made a 90° turn and traveled south for 21.3 km to a point east of Calais, France. What was Ederle's resultant displacement?
5. The emperor penguin is the best diver among birds: the record dive is 483 m. Suppose an emperor penguin dives vertically to a depth of 483 m and then swims horizontally a distance of 225 m. What angle would the vector of the resultant displacement make with the water's surface? What is the magnitude of the penguin's resultant displacement?
6. A killer whale can swim as fast as 15 m/s. Suppose a killer whale swims in one direction at this speed for 8.0 s, makes a 90° turn, and continues swimming in the new direction with the same speed as before. After a certain time interval, the magnitude of the resultant displacement is 180.0 m. Calculate the amount of time the whale swims after changing direction.
7. Woodcocks are the slowest birds: their average speed during courtship displays can be as low as 8.00 km/h. Suppose a woodcock flies east for 15.0 min. It then turns and flies north for 22.0 min. Calculate the magnitude of the resultant displacement and the angle between the resultant displacement and the woodcock's initial displacement.

B. RESOLVING VECTORS

1. A common flea can jump a distance of 33 cm. Suppose a flea makes five jumps of this length in the northwest direction. If the flea's northward displacement is 88 cm, what is the flea's westward displacement?
2. The longest snake ever found was a python that was 10.0 m long. Suppose a coordinate system large enough to measure the python's length is drawn on the ground. The snake's tail is then placed at the origin and the snake's body is

stretched so that it makes an angle of 60.0° with the positive *x*-axis. Find the *x* and *y* coordinates of the snake's head. (Hint: The *y*-coordinate is positive.)

3. A South-African sharp-nosed frog set a record for a triple jump by traveling a distance of 10.3 m. Suppose the frog starts from the origin of a coordinate system and lands at a point whose coordinate on the *y*-axis is equal to –6.10 m. What angle does the vector of displacement make with the negative *y*-axis? Calculate the *x* component of the frog.
4. The largest variety of grasshopper in the world is found in Malaysia. These grasshoppers can measure almost a foot (0.305 m) in length and can jump 4.5 m. Suppose one of these grasshoppers starts at the origin of a coordinate system and makes exactly eight jumps in a straight line that makes an angle of 35° with the positive *x*-axis. Find the grasshopper's displacements along the *x*- and *y*-axes. Assume both component displacements to be positive.
5. The landing speed of the space shuttle *Columbia* is 347 km/h. If the shuttle is landing at an angle of 15.0° with respect to the horizontal, what are the horizontal and the vertical components of its velocity?
6. In Virginia during 1994 Elmer Trett reached a speed of 372 km/h on his motorcycle. Suppose Trett rode northwest at this speed for 8.7 s. If the angle between east and the direction of Trett's ride was 60.0°, what was Trett's displacement east? What was his displacement north?
7. The longest delivery flight ever made by a twin-engine commercial jet took place in 1990. The plane covered a total distance of 14 890 km from Seattle, Washington to Nairobi, Kenya in 18.5 h. Assuming that the plane flew in a straight line between the two cities, find the magnitude of the average velocity of the plane. Also, find the eastward and southward components of the average velocity if the direction of the plane's flight was at an angle of 25.0° south of east.
8. The French bomber *Mirage IV* can fly over 2.3×10^3 km/h. Suppose this plane accelerates at a rate that allows it to increase its speed from 6.0×10^2 km/h to 2.3×10^3 km/h in a time interval of 120 s. If this acceleration is upward and at an angle of 35° with the horizontal, find the acceleration's horizontal and vertical components.

C. ADDING VECTORS ALGEBRAICALLY

1. For six weeks in 1992, Akira Matsushima, from Japan, rode a unicycle more than 3000 mi across the United States. Suppose Matsushima is riding through a city. If he travels 250.0 m east on one street, then turns counterclockwise through a 120.0° angle and proceeds 125.0 m northwest along a diagonal street, what is his resultant displacement?
2. In 1976, the Lockheed SR-71A *Blackbird* set the record speed for any airplane: 3.53×10^3 km/h. Suppose you observe this plane ascending at this speed. For 20.0 s, it flies at an angle of 15.0° above the horizontal, then for another 10.0 s its angle of ascent is increased to 35.0°. Calculate the plane's total gain in altitude, its total horizontal displacement, and its resultant displacement.

3. Magnor Mydland of Norway constructed a motorcycle with a wheelbase of about 12 cm. The tiny vehicle could be ridden at a maximum speed of 11.6 km/h. Suppose this tiny motorcycle travels in the directions d_1 and d_2, where d_1 is 30˚ with the horizontal (upward and right) and d_2 is 45˚ with the vertical (down and to the right). Calculate d_1 and d_2, and determine how long it takes the motorcycle to reach a net displacement of 2.0×10^2 to the right.
4. The fastest propeller-driven aircraft is the Russian TU-95/142, which can reach a maximum speed of 925 km/h. For this speed, calculate the plane's resultant displacement if it travels east for 1.50 h, then turns 135° north-west and travels for 2.00 h.
5. In 1952, the ocean liner *United States* crossed the Atlantic Ocean in less than four days, setting the world record for commercial ocean-going vessels. The average speed for the trip was 57.2 km/h. Suppose the ship moves in a straight line eastward at this speed for 2.50 h. Then, due to a strong local current, the ship's course begins to deviate northward by 30.0°, and the ship follows the new course at the same speed for another 1.50 h. Find the resultant displacement for the 4.00 h period.

D. PROJECTILES LAUNCHED HORIZONTALLY

1. Florence Griffith-Joyner of the United States set the women's world record for the 200 m run by running with an average speed of 9.37 m/s. Suppose Griffith-Joyner wants to jump over a river. She runs horizontally from the river's higher bank at 9.37 m/s and lands on the edge of the opposite bank. If the difference in height between the two banks is 2.00 m, how wide is the river?
2. The longest banana split ever made was 7.320 km long (needless to say, more than one banana was used). If an archer were to shoot an arrow horizontally from the top of Mount Everest, which is located 8848 m above sea level, would the arrow's horizontal displacement be larger than 7.32 km? Assume that the arrow cannot be shot faster than 100.0 m/s, that there is no air resistance, and that the arrow lands at sea level.
3. The longest shot on a golf tournament was made by Mike Austin in 1974. The ball went a distance of 471 m. Suppose the ball was shot horizontally off a cliff at 80.0 m/s. Calculate the height of the cliff.
4. Recall Elmer Trett, who in 1994 reached a speed of 372 km/h on his motorcycle. Suppose Trett drives off a horizontal ramp at this speed and lands a horizontal distance of 40.0 m away from the edge of the ramp. What is the height of the ramp? Neglect air resistance.
5. A Snorkel fire engine is designed for putting out fires that are well above street level. The engine has a hydraulic lift that lifts the firefighter and a system that delivers pressurized water to the firefighter. Suppose that the engine cannot move closer than 25 m to a building that has a fire on its sixth floor, which is 25 m above street level. Also assume that the water nozzle is stuck in the horizontal position (an improbable situation). If the horizontal speed of the water emerging from the hose is 15 m/s, how high above the street must the firefighter be lifted in order for the water to reach the fire?

6. The longest stuffed toy ever manufactured is a 420 m snake made by Norwegian children. Suppose a projectile is thrown horizontally from a height half as long as the snake and the projectile's horizontal displacement is as long as the snake. What would be the projectile's initial speed?
7. Libyan basketball player Suleiman Nashnush was the tallest basketball player ever. His height was 2.45 m. Suppose Nashnush throws a basketball horizontally from a level equal to the top of his head. If the speed of the basketball is 12.0 m/s when it lands, what was the ball's initial speed? (Hint: Consider the components of final velocity.)
8. The world's largest flowerpot is 1.95 m high. If you were to jump horizontally from the top edge of this flowerpot at a speed of 3.0 m/s, what would your landing velocity be?

E. PROJECTILES LAUNCHED AT AN ANGLE

1. In 1993, Wayne Brian threw a spear a record distance of 201.24 m. (This is not an official sport record because a special device was used to "elongate" Brian's hand.) Suppose Brian threw the spear at a 35.0° angle with respect to the horizontal. What was the initial speed of the spear?
2. April Moon set a record in flight shooting (a variety of long-distance archery). In 1981 in Utah, she sent an arrow a horizontal distance of 9.50×10^2 m. What was the speed of the arrow at the top of the flight if the arrow was launched at an angle of 45.0° with respect to the horizontal?
3. In 1989 during overtime in a high school basketball game in Erie, Pennsylvania, Chris Eddy threw a basketball a distance of 27.5 m to score and win the game. If the shot was made at a 50.0° angle above the horizontal, what was the initial speed of the ball?
4. In 1978, Geoff Capes of the United Kingdom won a competition for throwing 5 lb bricks; he threw one brick a distance of 44.0 m. Suppose the brick left Capes' hand at an angle of 45.0° with respect to the horizontal.
    a. What was the initial speed of the brick?
    b. What was the maximum height reached by the brick?
    c. If Capes threw the brick straight up with the speed found in (a), what would be the maximum height the brick could achieve?
5. In 1991, Doug Danger rode a motorcycle to jump a horizontal distance of 76.5 m. Find the maximum height of the jump if his angle with respect to the ground at the beginning of the jump was 12.0°.
6. Michael Hout of Ohio can run 110.0 meter hurdles in 18.9 s at an average speed of 5.82 m/s. What makes this interesting is that he juggles three balls as he runs the distance. Suppose Hout throws a ball up and forward at twice his running speed and just catches it at the same level. At what angle, θ, must the ball be thrown? (Hint: Consider horizontal displacements for Hout and the ball.)

F. RELATIVE VELOCITY

1 In 1933, a storm occurring in the Pacific Ocean moved with speeds reaching a maximum of 126 km/h. Suppose a storm is moving north at this speed. If a gull flies east through the storm with a speed of 40.0 km/h relative to the air, what is the velocity of the gull relative to Earth?

2. George V Coast in Antarctica is the windiest place on Earth. Wind speeds there can reach 3.00×10^2 km/h. If a research plane flies against the wind with a speed of 4.50×10^2 km/h relative to the wind, how long does it take the plane to fly between two research stations that are 250 km apart?

3. Turtles are fairly slow on the ground, but they are very good swimmers, as indicated by the reported speed of 9.0 m/s for the leatherback turtle. Suppose a leatherback turtle swims across a river at 9.0 m/s relative to the water. If the current in the river is 3.0 m/s and it moves at a right angle to the turtle's motion, what is the turtle's displacement with respect to the river's bank after 1.0 min?

4. California sea lions can swim as fast as 40.0 km/h. Suppose a sea lion begins to chase a fish at this speed when the fish is 60.0 m away. The fish, of course, does not wait, and swims away at a speed 16.0 km/h. How long would it take the sea lion to catch the fish?

5. The spur-wing goose is one of the fastest birds in the world when it comes to *level* flying: it can reach a speed of 90.0 km/h. Suppose two spur-wing geese are separated by an unknown distance and start flying toward each other at their maximum speeds. The geese pass each other 40.0 s later. Calculate the initial distance between the geese.

6. The fastest snake on Earth is the black mamba, which can move over a short distance at 18.0 km/h. Suppose a mamba moves at this speed toward a rat sitting 12.0 m away. The rat immediately begins to run away at 33.3 percent of the mamba's speed. If the rat jumps into a hole just before the mamba can catch it, determine the length of time that the chase lasts.