Answers to selected problems from Essential Physics, Chapter 4

1. (a) Point your kayak perpendicular to the riverbank. To cross the river in the shortest time, you need to maximize the component of your velocity that is directed across the river. The current in the river affects only the component of your velocity that is directed parallel to the river, so the current can neither add to nor subtract from your velocity directed across the river. To maximize your velocity across the river, therefore, you must direct as much of your velocity relative to the water across the river, which means aiming your kayak perpendicular to the river.

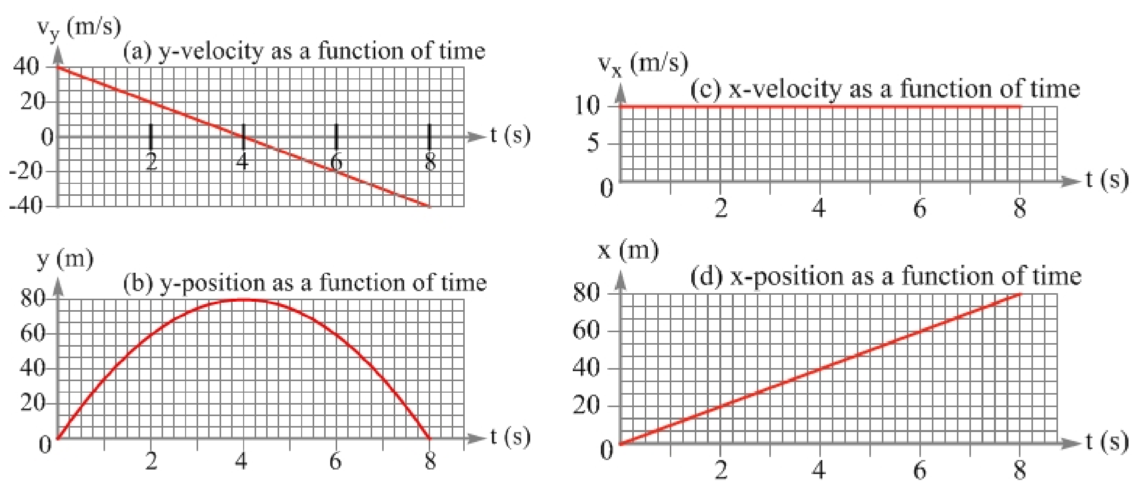
(b) To land directly across from your starting point, you must aim the kayak upstream, so that the component of your velocity relative to the water that is directed parallel to the river exactly cancels the velocity of the water relative to the riverbank (the current, in other words).

3. Any origin can be used to answer the question. Assuming that you both use a traditional coordinate system with coordinate axes directed horizontally and vertically, you would agree on the value of the *x*-coordinate of the initial position, and the *x*-coordinate of the final position. You would disagree on the value of the *y*-coordinate of the initial position, and the *y*-coordinate of the final position, but the key thing is that you would agree on the magnitude of the displacement in the *y*-direction. You would also agree on the answer to the time it takes for the object to reach the water, assuming that you both did the calculations correctly.

5. (a) A=B=C (b) A=B=C (c) C>B>A (d) C>B>A

7. (a) G>F>E (b) G>F>E (c) E>F>G (d) G>F>E

9.



11. (a) 4*H* (b) 2*T* (c) 4*R*

13. (a) 20 km/h north (b) 20 km/h south (c) 210 km/h north (d) 190 km/h south

(e) The answers stay the same even after the vehicles change positions. Finding relative velocities simply involves adding or subtracting two velocity vectors, and the velocity vectors are the same no matter what the relative positions of the car, truck, and motorcycle are.

15. (a) 270 s (b) 279 s

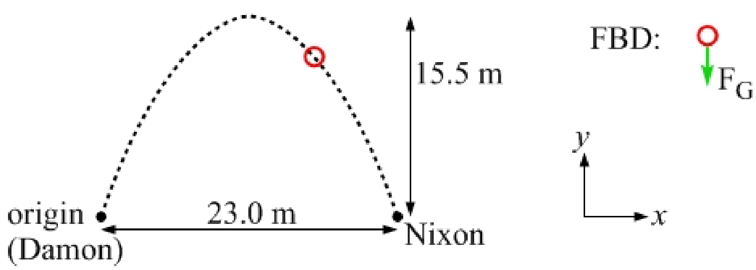
17. (a) 3 m/s east (b) 1 m/s east (c) We can't say. All we have is information about the velocities of these people relative to one another. We have no information about the velocity of any of them with respect to the lamppost.

19. (a) 1.5 hours (b) 150 km/h west (c) You have to fly due east for 4.5 more hours.

21. (a) 2.0 s (b) 2.0 s (c) 2.0 m (east of the base of the mast)

23. (a) 1.8 m (b) 6.0 m/s, directed straight up (c) zero

25.

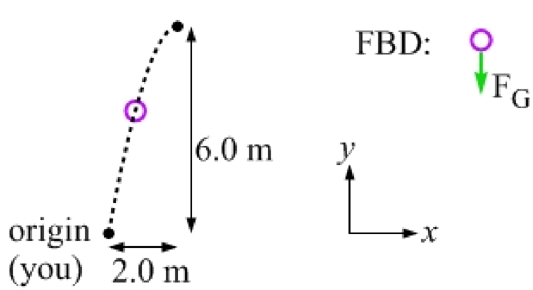


(e)

	x-direction	y-direction
initial position	$x_i = 0$	$y_i = 0$
at max. height		$y_{max} = +15.5$ m
final position	$x_f = +23.0$ m	$y_f = 0$
initial velocity	$v_{ix} = ?$	$v_{iy} = ?$
acceleration	$a_x = 0$	$a_y = -9.81\ \text{m/s}^2$

(f) $v_{iy} = +17.44$ m/s; time of flight is 3.555 s; $v_{ix} = +6.469$ m/s.
This gives an initial velocity of 18.6 m/s at an angle of 69.6° above the horizontal.

27.

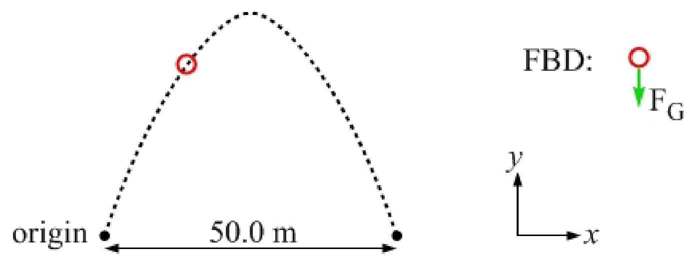


(e)

	x-direction	y-direction
initial position	$x_i = 0$	$y_i = 0$
final position	$x_f = +2.0$ m	$y_f = +6.0$ m
initial velocity	$v_{ix} = ?$	$v_{iy} = ?$
final velocity		$v_{fy} = 0$
acceleration	$a_x = 0$	$a_y = -9.8$ m/s^2

(f) $v_{iy} = +10.84$ m/s; time of flight is 1.11 s; $v_{ix} = +1.81$ m/s.
This gives an initial velocity of 11.0 m/s at an angle of 80.5° above the horizontal.

29.

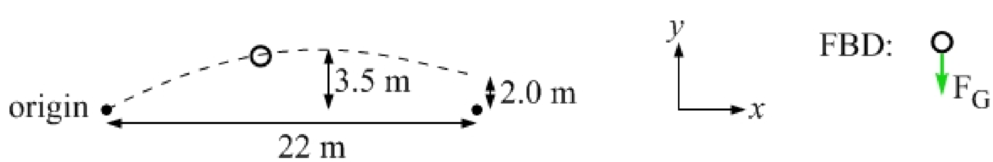


(e)

	x-direction	y-direction
initial position	$x_i = 0$	$y_i = 0$
final position	$x_f = +50.0$ m	$y_f = 0$
initial velocity	$v_{ix} = ?$	$v_{iy} = ?$
acceleration	$a_x = 0$	$a_y = -9.81$ m/s^2
time	4.56 s	4.56 s

(f) $v_{iy} = +22.37$ m/s; $v_{ix} = +10.96$ m/s.
This gives an initial velocity of 24.9 m/s at an angle of 63.9° above the horizontal.

31.

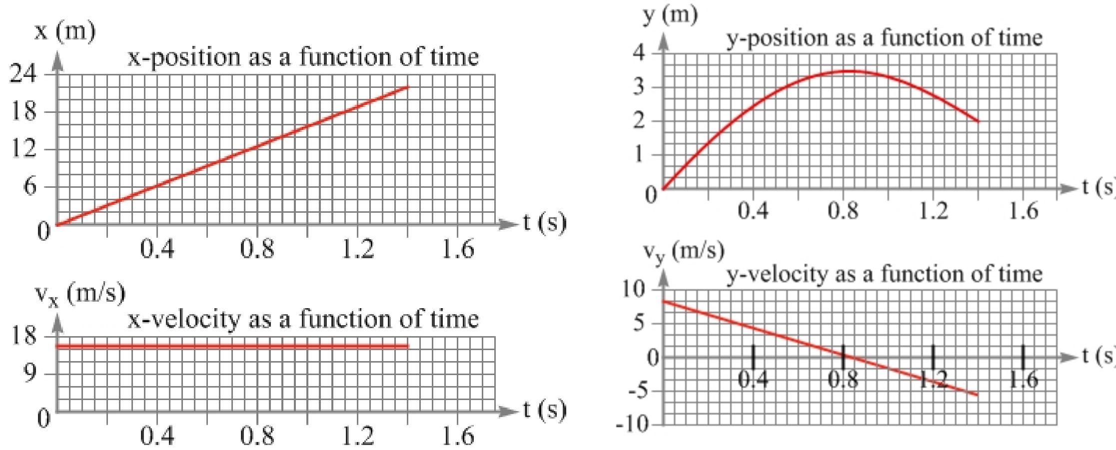


(e)

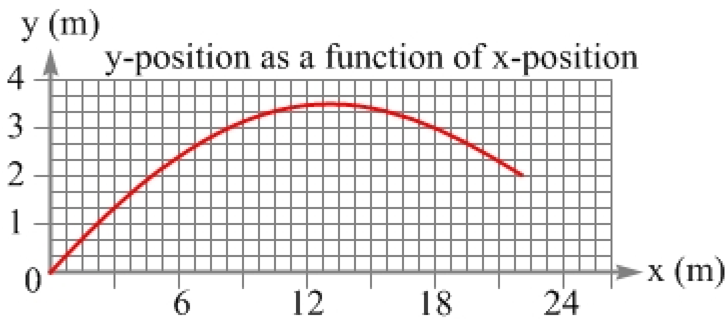
	x-direction	y-direction
initial position	$x_i = 0$	$y_i = 0$
max. height		$y_{max} = +3.5$ m
final position	$x_f = +22$ m	$y_f = +2.0$ m
initial velocity	$v_{ix} = ?$	$v_{iy} = ?$
acceleration	$a_x = 0$	$a_y = -9.8$ m/s^2

(f) $v_{iy} = +8.28$ m/s ; $t = 1.40$ s; $v_{ix} = +15.73$ m/s .

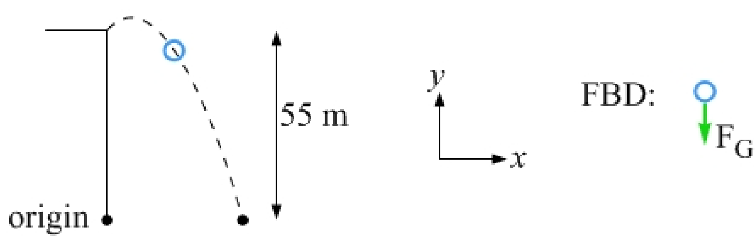
(g)



(h)



33.

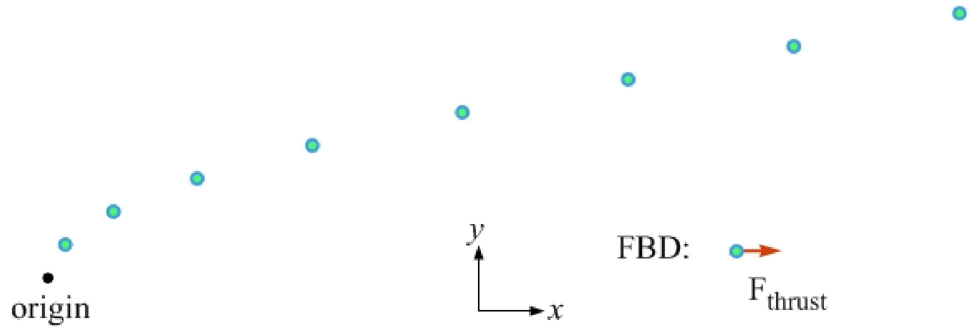


(e)

	x-direction	y-direction
initial position	$x_i = 0$	$y_i = +55.0$ m
final position	$x_f = ?$	$y_f = 0$
initial velocity	$v_{ix} = +(12.0 \text{ m/s})\cos(34.0°)$ $v_{ix} = +9.948$ m/s	$v_{iy} = +(12.0 \text{ m/s})\sin(34.0°)$ $v_{iy} = +6.71$ m/s
acceleration	$a_x = 0$	$a_y = -9.81 \text{ m/s}^2$

(f) $t = 4.10$ s (g) 40.8 m

35.



(e)

	x-direction	y-direction
initial position	$x_i = 0$	$y_i = 0$ m
final position	$x_f = ?$	$y_f = ?$
initial velocity	$v_{ix} = 0$	$v_{iy} = +5.0$ m/s
final velocity (acceleration phase)	$v_{fx} = a_x t = +20$ m/s	$v_{fy} = +5.0$ m/s
acceleration	$a_x = +4.0$ m/s^2	$a_y = 0$

(f) 56 m (g) 160 m

37. (a) 19.6 m/s, up (b) 12.5 m/s, directed downfield
(c) 23.2 m/s, at an angle of 57.5° above the horizontal

39. 10.2°

41. 12 m

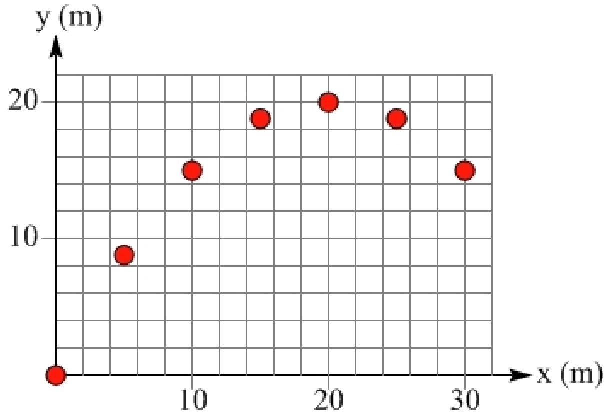
43. (a) 125 km/h at an angle of 28.6° west of north (b) 138 km/h at an angle of 24.8° west of north

45. Powell must have been running at about 9.4 m/s when he took off. World-class sprinters run at about 10 m/s, so Powell's speed is just a little less than that of a world-class sprinter. One part of being a long-jumper, in fact, is excellent speed.

47. 71.6°

49. (a) The ball was caught at a higher level than where it was launched. You can tell this from the asymmetry in the graph of the y-component of the velocity. If the ball came down to the same level from which it was launched, the final speed would have matched the initial speed. Because the final speed is lower than the initial speed, the ball must be higher than the launch point. (b) 30 m (c) At t = 2.0 s. The ball's y-component of velocity is zero at the highest point, and t = 2.0 s is when the y-velocity passes through zero in this case.

51.



53. With these numbers, the ball is 2.8 m below the launch point.

55. (a) The shortest time is zero. The longest time is 4.0 seconds. (b) 20 m (c) 40 m

57. (a) 13.9 m/s (b) 16.0 m/s (c) You can't do it! A launch angle of 45° gets the closest to your friend, but the range in that case is 19.6 m, a little short of reaching your friend. You can't reach your friend at any angle unless you increase the speed of the ball from what it is in (a).

59. 24.1° and 65.9°

61. (a) 1.24 m (b) 1.35 m (c) 1.22 m