Answers to selected problems from Essential Physics, Chapter 6

1. B > C > A

3. It does not make any difference. As far as you are concerned, the situations are equivalent. It would make a difference if your evil twin was driving a car that had either more mass, or less mass, than your car. Because of the symmetry of this collision with your evil twin, however, the very front of your car stays at rest during both collisions, so the end result is the same, for you.

5. No, it does not. A good example is something circular, like a car tire, a donut, or a bagel. For those objects, the center of mass is at the center of the hole, where there is no actual material.

7. (a) 1 = 2 = 3 > 4 (b) 2 > 1 > 4 > 3 (c) 1 > 2 = 4 > 3 (d) 1 > 2 > 4 > 3

9. (a) $K_A = K_B$ (b) $v_A > v_B$ (c) $p_B > p_A$

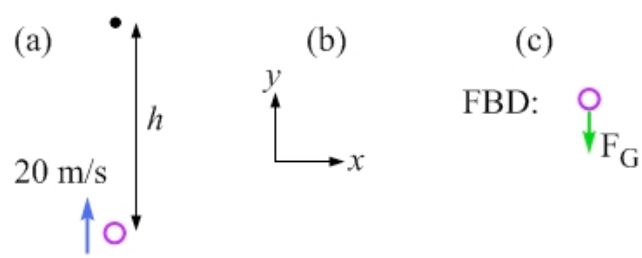
11. (a) Yes. A good example is any uniform circular motion situation, in which the force changes the direction of the velocity but does not change its magnitude – the speed is constant. The momentum changes because momentum is a vector, and the direction of the vector changes. The kinetic energy stays the same, however. (b) No, this is not possible. We'll assume the mass of the object is constant, so changing the kinetic energy produces a change in speed. That produces a corresponding change in momentum, because the magnitude of the momentum is proportional to the speed.

13. (a) 480 kg m/s south (b) 960 kg m/s south (c) $480\sqrt{2} = 680$ kg m/s southeast

15. (a) 0.96 kg m/s to the right (b) 0.64 kg m/s to the right

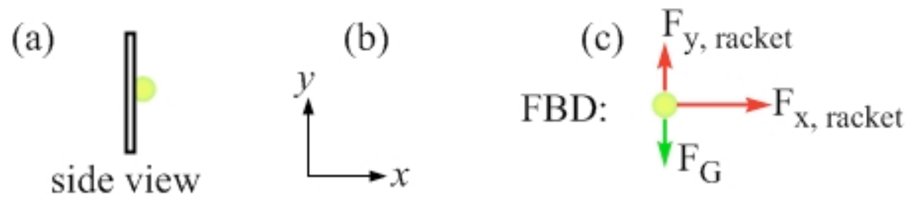
17. (a) 20 N east (b) 10 N west (c) 40 N west

19.



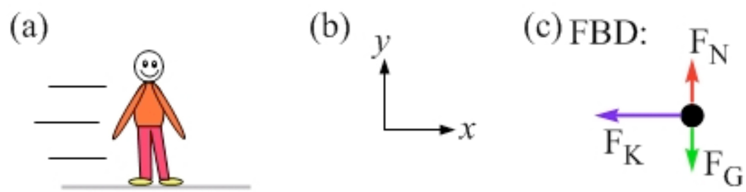
(d) 4.0 kg m/s directed up (e) zero (f) 4.0 kg m/s directed down
(g) mg = 2.0 N directed down (h) 2.0 s

21.



(d) 200 N, in the direction of the ball's velocity when it leaves the racket. (e) Yes. The force of gravity also acts on the ball over this time interval, so if the ball does not acquire a component of momentum directed down, the net vertical force on the ball during this time interval must be zero. The racket must exert an upward vertical force that exactly balances the force of gravity.

23.



(d) $\vec{F}_{net} = -\mu_K mg$ (e) $\Delta\vec{p} = m\Delta\vec{v} = m(v_f - v_i)$

(f) $\vec{F}_{net}\Delta t = \Delta\vec{p} \quad \Rightarrow \quad -\mu_K mg\Delta t = m(v_f - v_i)$

(g) $\mu_K = \dfrac{v_f - v_i}{-g\Delta t} = \dfrac{-2.0 \text{ m/s}}{-(10 \text{ m/s}^2)(2.0 \text{ s})} = 0.10$

25. (a) –16 J (b) In the first 2 seconds, the displacement is +11 m. In the next 5 seconds, the displacement is +5 m. In the final second, the displacement is –3.5 m. This gives a net displacement of +12.5 m, so the cart is at x = +12.5 m at t = 8 s.

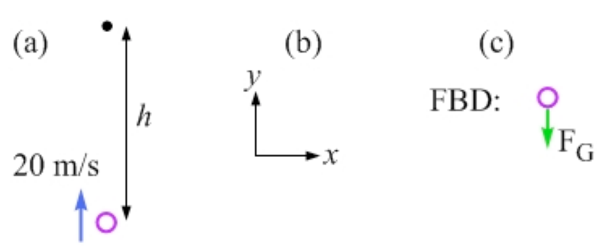
27. (a) at t = 4 s (b) 10 m/s (c) 5 m/s in the $+x$ direction

29. (a) 7.5 m/s in the $+x$ direction (b) 6 m/s in the $+x$ direction (c) 0

31. (a) $X_{cm} = +0.3$ m ; $Y_{cm} = +0.7$ m (b) The center of mass shifts toward the location of ball 3.

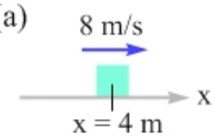
33. 1.0 m

35.

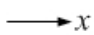


(d) 40 J (e) zero (f) –40 J (g) mg = 2.0 N directed down (h) 20 m

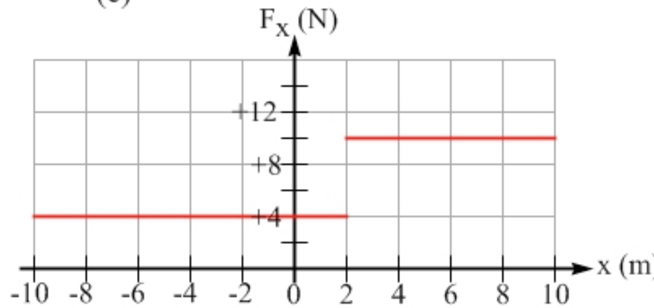
37. (a)



(b)



(c)

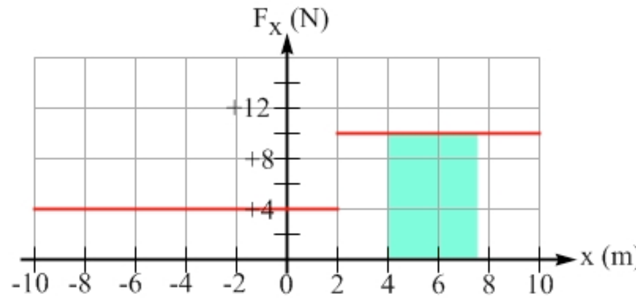


(d) 64 J

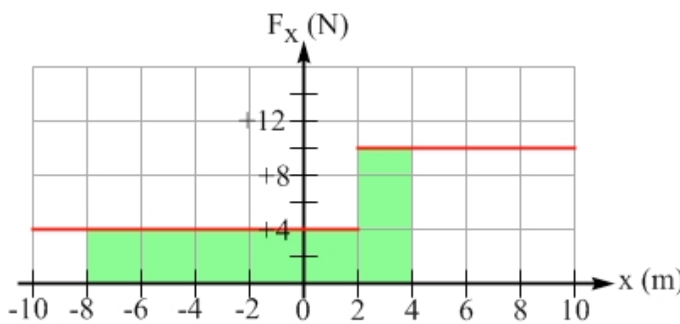
(e) 100 J

(f) +36 J

(g) at $x = +7.6$ m

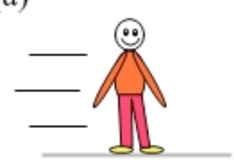


(h) A speed of +2.0 m/s corresponds to a kinetic energy of 4.0 J. Thus, +60 J of work was done from the position where the object had 4.0 J to $x = +4$ m, where it has 64 J of kinetic energy. An area of +60 J on the graph takes the object back to a position of $x = -8$ m.

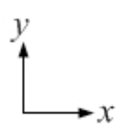


39.

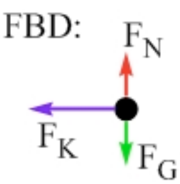
(a)



(b)



(c) FBD:



(d) $\vec{F}_{net} = -\mu_K mg$ (e) $\Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}m(v_f^2 - v_i^2)$

(f) $\vec{F}_{net}\Delta x = \Delta K \quad \Rightarrow \quad -\mu_K mg\Delta x = \frac{1}{2}m(v_f^2 - v_i^2)$

(g) $\mu_K = \frac{v_f^2 - v_i^2}{-2g\Delta x} = \frac{(4.0 \text{ m/s})^2 - (6.0 \text{ m/s})^2}{-2(10 \text{ m/s}^2)(5.0 \text{ m})} = 0.20$

41. (a) 7 m/s in the $+x$ direction (b) 1 m/s in the $-x$ direction (c) 5 m/s, with components of 3 m/s in the $+x$ direction and 4 m/s in the $+y$ direction. This is equivalent to 5 m/s at an angle of 37° above the positive x axis.

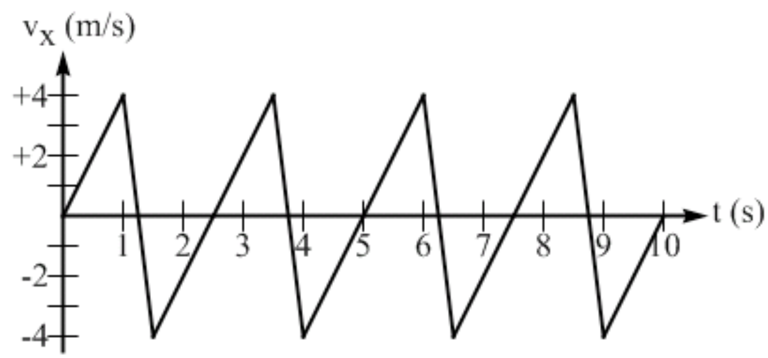
43. The x-component of the initial momentum is 2.0 kg m/s. The y-component of the initial momentum is 2.95 kg m/s. Thus, the net momentum has a magnitude of 3.56 kg m/s, at an angle of 55.9° above the horizontal.

45. (a) 18 m/s (b) 50 m/s, to the right

47. (a) Equal in both cases (b) +225 J (c) More work is done in case 2 (d) No work is done in case 1, while +23.0 J of work is done in case 2.

49. (a) 1.0 s (b) 4.0 m/s (c) 2.5 s

(d)



51. (a) 2.8 m (b) 4.0 m

53. (a) The stopping time is unchanged (b) The stopping time is doubled
(c) The stopping time is halved

55. (a) 160 m, 4 times longer than the original distance (b) The stopping time is twice that of the original case.

57. (a) $2T$ (b) $4T$

59. (a) The kilowatt-hour is a unit of energy. (b) $1 \text{ kW h} = 3.6\times10^{6}$ J (c) About 55 cents.

61. (a) 3.6×10^{29} kg m/s (b) The Sun does no work on the Earth – the Earth's kinetic energy is constant.