Answers to selected problems from Essential Physics, Chapter 3

1. FBD 1 is the correct free-body diagram in all five cases. As far as forces are concerned, "at rest" and "constant velocity" situations are equivalent.

3. (a) FBD 1 (b) FBD 3 (c) FBD 2

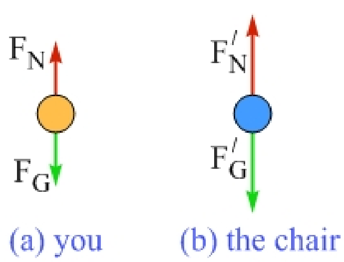
5. The penny and the feather fall at the same rate. In the absence of air resistance, the only force that matters is the force of gravity. Thus, the acceleration of both objects is the acceleration due to gravity, which is the same for any object.

7. (a) The net force on each of the blocks is zero. (b) Both block 2 and block 3 experience three forces. 1 – they both experience a force of gravity, applied by the Earth, which is the same for both blocks. 2 – They both experience a downward normal force, applied by the block above it. The downward normal force applied by block 2 on block 3 is larger than that applied by block 1 on block 2, however, because this normal force is equal to the weight of the blocks sitting on top of the block feeling the normal force. 3 – They both experience an upward normal force, applied by the object immediately below them. The normal force applied by the floor on block 3, however, has a magnitude equal to the weight of three blocks, while the upward normal force applied by block 3 on block 2 has a magnitude equal to the weight of two blocks.

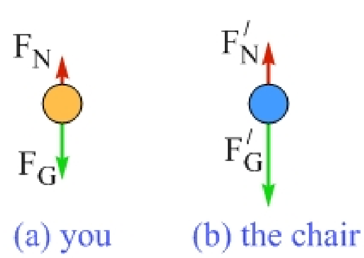
9. (a) Any constant-velocity motion, such as traveling at constant velocity along a straight highway in a car, a hockey puck sliding across a frictionless ice surface, or a space probe drifting through space, trillions of kilometers from anything else. (b) Not possible. (c) This is possible as long as there are 2 or more forces acting on the object, and all the forces cancel. An example could be you sitting on a chair.

11. Yuri could throw the wrench directly away from the space station. To do this, he would exert a force on the wrench in the direction he throws the wrench. By Newton's third law, the wrench would exert an equal-and-opposite force back on Yuri. Once Yuri let go of the wrench, he would drift at constant velocity back toward the space station.

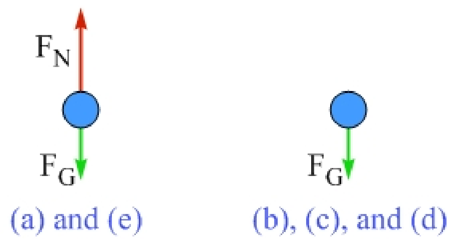
13.



15.

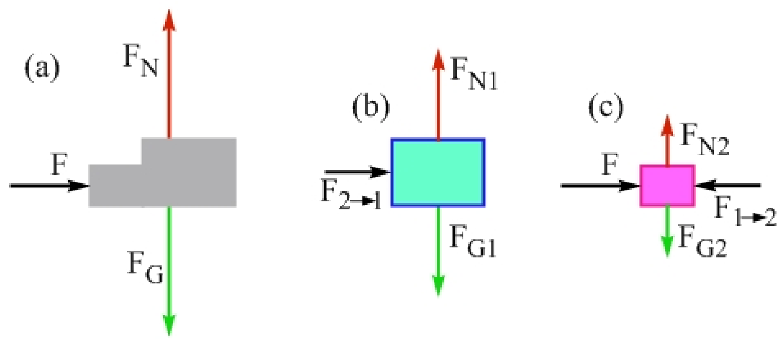


17.

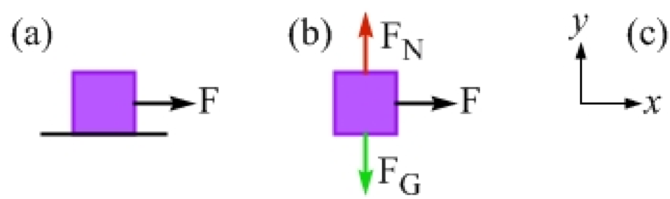


(f) We just need two different free-body diagrams. In both (a) and (e), the ball's acceleration is directed up, so the upward normal force applied by your hand is larger than the downward force of gravity. In (b) – (d), the only thing acting on the ball is the force of gravity, and whether the ball is moving up, down, at instantaneously at rest is irrelevant.

19.



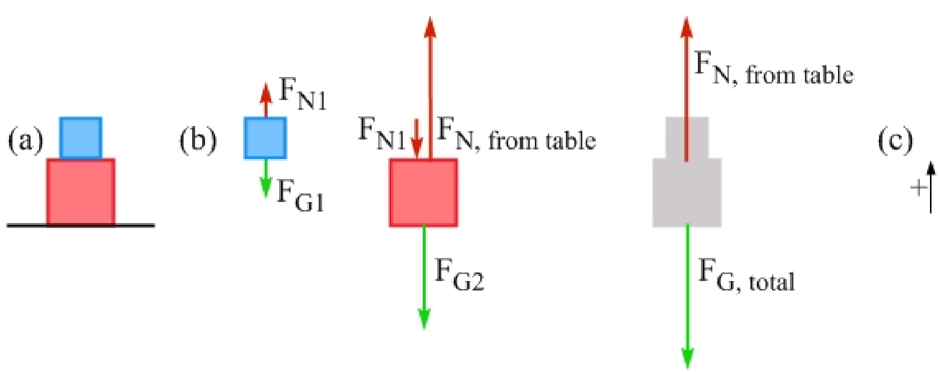
21.



(d)
$$\Sigma \vec{F}_x = m\vec{a}$$
$$+6.0 \text{ N} = m \times (3.0 \text{ m/s}^2)$$

(e) 2.0 kg

23.



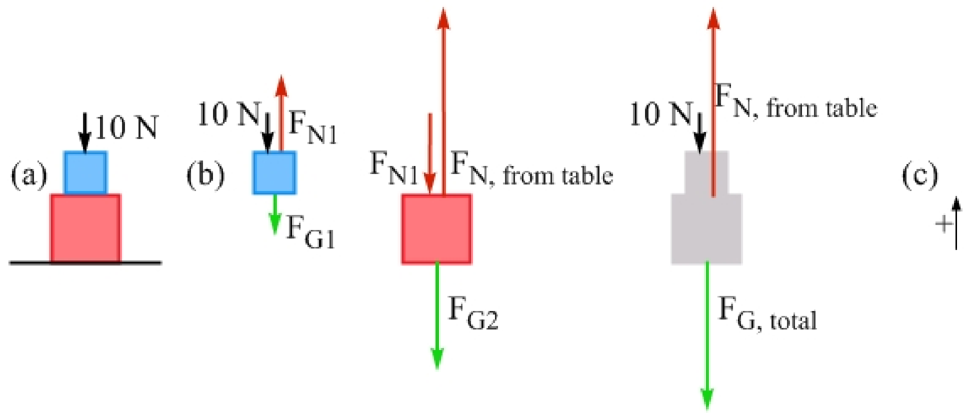
(d) From the third FBD
$$\Sigma \vec{F} = (M+m)\vec{a} = 0$$
$$+F_{N,\text{from table}} - F_{G,\text{total}} = 0$$

From the second FBD
$$\Sigma \vec{F} = (M)\vec{a} = 0$$
$$+F_{N,\text{from table}} - F_{G2} - F_{N1} = 0$$

(e) 10 N, directed down

(f) 50 N, directed up

25.



From the third FBD

(d) $\Sigma\vec{F} = (M+m)\vec{a} = 0$

$+F_{N,\text{from table}} - F_{G,\text{total}} - 10\text{ N} = 0$

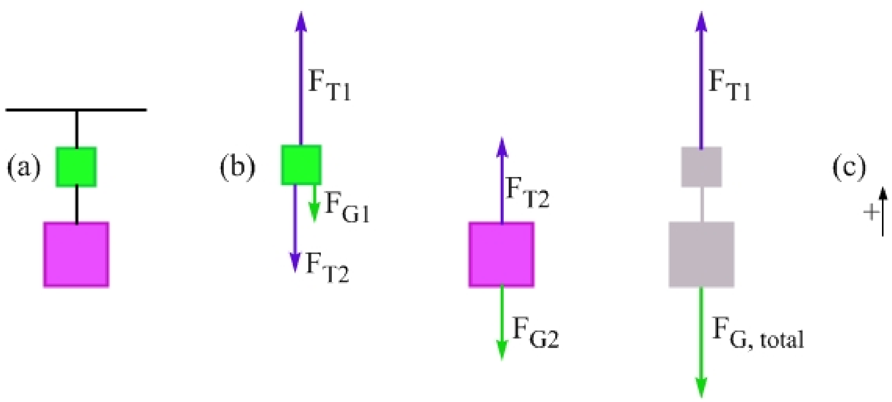
From the second FBD

$\Sigma\vec{F} = (M)\vec{a} = 0$

$+F_{N,\text{from table}} - F_{G2} - F_{N1} = 0$

(e) 20 N, directed down (f) 60 N, directed up

27.



From the third FBD

$\Sigma\vec{F} = (M+m)\vec{a}$

(d) $+F_{T1} - F_{G,\text{total}} = (M+m)\dfrac{g}{4}$

$+F_{T1} - (M+m)g = (M+m)\dfrac{g}{4}$

$F_{T1} = \dfrac{5}{4}(M+m)g$

From the second FBD

$\Sigma\vec{F} = (M)\vec{a}$

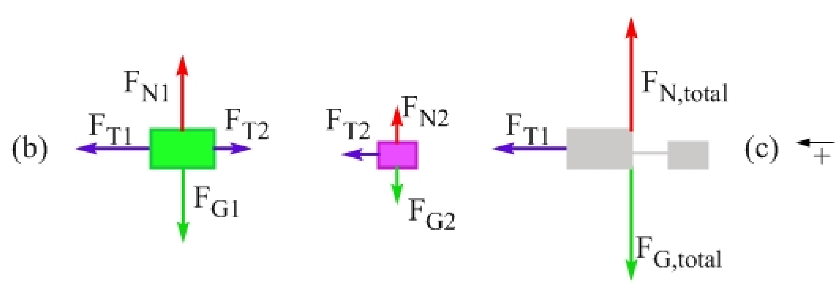
$+F_{T2} - F_{G2} = M\dfrac{g}{4}$

$+F_{T2} - Mg = M\dfrac{g}{4}$

$F_{T2} = \dfrac{5}{4}Mg$

(e) 15 N (f) 10 N

29.



(d)

From the third FBD

$$\Sigma\vec{F} = (2m+m)\vec{a}$$

$$+30 \text{ N} = 3ma$$

$$a = \frac{10 \text{ N}}{m}$$

From the second FBD

$$\Sigma\vec{F} = (m)\vec{a}$$

$$+F_{T2} = m\left(\frac{10 \text{ N}}{m}\right)$$

$$F_{T2} = 10 \text{ N}$$

(e) 10

31. (a) 20 m/s east (b) 30 m/s east (c) 0

33. (a) 3.3×10^4 N (b) 3800 N

35. 28.5 N

37. Up until t = 5 s, there is no net force applied to the object. For 1 s, between t = 5 s and t = 6 s, a constant force directed to the right is applied. After t = 6 s, no net force is applied.

39. 100 N

41. (a) The fifth floor. (b) 20% of g (a little under 2.0 m/s^2)

43. (a) 0.004 m/s^2 (b) 350 m/s (c) 2400 m/s

45. The maximum acceleration, of 3.6 m/s^2, is when all three forces are in the same direction. The minimum acceleration is zero, because the forces can be arranged so that they cancel out.

47. 27 N

49. (a) $8T/5$ (b) $2T$

51. (a) equal in the two cases (b) $F/5$ in both cases (c) in case 2
(d) (i) $F/2$ (ii) $4F/5$

53. (a) 1.0 N (b) 2.0 N (c) 5.0 N

55. (a) No, it's the same free-body diagram. (b) No, it's also the same. In each case, the ball is being acted upon only by gravity.

57. (a) (100 m/s^2) m (b) 2 m/s, in the direction the puck was traveling initially

59. (a) $F_{Mm} = \frac{m}{M+m}F$ (b) $F_{Mm} = \frac{M}{M+m}F$ (c) $\frac{M}{m} = 4$

61. (a) The elevator is at rest for the first 2 seconds, and then accelerates down for 2 seconds. This is followed by a 4-second period of constant velocity, directed down, followed by a 2-second period of upward acceleration, while the elevator is moving down but in the process of coming to rest. The elevator remains at rest after that.

(b) 2.0 m/s^2 (c) The elevator moved down a total distance of 24 m.