Skill and Practice Sheet Answers

4A Applying Newton's Laws of Motion

Table answers are:

Newton's laws of motion	Write the law here in your own words	Example of the law
The first law	An object will continue moving in a straight line at constant speed unless acted upon by an outside force.	A seat belt in a car prevents you from continuing to move forward when your car suddenly stops. The seat belt provides the "outside force."
The second law	The acceleration (a) of an object is directly proportional to the force (F) on an object and inversely proportional to its mass (m). The formula that represents this law is $a = \frac{F}{m}$	A bowling ball and a basketball, if dropped from the same height at the same time, will fall to Earth in the same amount of time. The resistance of the heavier ball to being moved due to its inertia is balanced by the greater gravitational force on this ball.
The third law	For every action force there is an equal and opposite reaction force.	When you push on a wall, it pushes back on you.

1. The purse continues to move forward and fall off of the seat whenever the car comes to a stop. This is due to Newton's first law of motion which states that objects will continue their motion unless acted upon by an outside force. In this case, the floor of the car is the stopping force for the purse.
2. Newton's third law of motion states that forces come in action and reaction pairs. When a diver exerts a force down on the diving board, the board exerts an equal and opposite force upward on the diver. The diver can use this force to allow himself to be catapulted into the air for a really dramatic dive or cannonball.
3. Newton's second law

4. The correct answer is b. One newton of force equals 1 kilogram-meter/second^2. These units are combined in Newton's second law of motion: F = mass × acceleration.

5.

$$0.3\frac{m}{s^2} = \frac{F}{65\text{ kg}}$$

$$F = \frac{0.3m}{s^2} \times 65\text{ kg} = 20\frac{\text{kg}\cdot\text{m}}{s^2}$$

6.

$$a = \frac{2N}{10kg} = \frac{\frac{2(kg\cdot m)}{s^2}}{10kg} = 0.2\frac{m}{s^2}$$

7. The hand pushing on the ball is an action force. The ball provides a push back as a reaction force. The ball then provides an action force on the floor and the floor pushes back in reaction. Another pair of forces occurs between your feet and the floor.

8. A force

4B Momentum

1.

$$\text{momentum} = 4{,}000\text{ kg} \times \frac{35\text{ m}}{s} = 140{,}000\text{ kg}\cdot\frac{m}{s}$$

2.

$$\text{momentum} = 1{,}000\text{ kg} \times \frac{35\text{ m}}{s} = 35{,}000\text{ kg}\cdot\frac{m}{s}$$

3.

$$8\text{ kg} \times \text{ speed} = 16\text{ kg}\cdot\frac{m}{s}$$

$$\text{speed} = 2\frac{m}{s}$$

4.

$$\text{mass} \times \frac{0.5\text{ m}}{s} = 0.25\text{ kg}\cdot\frac{m}{s}$$

$$\text{mass} = 0.5\text{ kg}$$

5.

$$45{,}000\text{ kg}\cdot\frac{m}{s}$$

6. 30 m/s
7. The 4.0-kilogram ball requires more force to stop.
8. 980 kg
9.

$$4.2\text{ kg}\cdot\frac{m}{s}$$

10. 15 m/s
11.

$$0.01\text{ kg}\cdot\frac{m}{s}$$

4C Impulse

1. Time = 1 second
2. Answers are:
   a. Change in momentum = 30 kg·m/s
   b. The value for the impulse would equal the change in momentum: 30 kg·m/s (or 30 N·s).
   c. 40 N × (time) = 30 N·s; time = 30 N·s/40 N = 0.75 s
3. Answers are:
   a. Impulse = 60,000 N·s
   b. The value for change in momentum equals impulse, therefore the answer is 60,000 N·s (or 60,000 kg·m/s)
   c. Initial speed = 30 m/s

4. Answers are:
   a. Change in momentum = 300 kg·m/s
   b. 300 N
5. Final speed = 20 m/s
6. 3,240 N [Note to teachers: Remember that the change of velocity of the batted ball is greater (94 m/s) because it changes from a positive 44 m/s to a negative 50 m/s.]
7. 4.8 seconds
8. When taking off or landing, a net force must be applied to a person's body to accelerate them at the same rate as the accelerating airplane. When moving at constant speed, no net force is applied to a passenger's body.
9. In order to break wood with the hand, a large force is applied in a short time. If the hand bounces, an even greater impulse is applied because there is a greater change in momentum. The martial artist must take care to strike the wood with the fleshy side of the hand so that there is a smaller force applied to the hand than there would be if the fingers or knuckles were to hit the piece of wood.
10. Because the barrel of a rifle is longer than a pistol's barrel, the bullet from the rifle is acted upon by the expanding gases of the exploding gunpowder for a longer time. This causes the bullet of the rifle to reach a higher speed.
11. If the force applied by the opponent's punch can be extended over a longer time, the force of the blow is reduced, minimizing the chances of a knockout punch being delivered to the boxer.
12. Newton's 2nd law expressed as an equation is $F = ma$; since acceleration (a) is $\Delta v/\Delta t$, $F = m(\Delta v/\Delta t)$. Multiplying both sides of the equation by Δt, the equation becomes $F\Delta t = m\Delta v$, the expression impulse equals the change in momentum
13. Some activities that people do involve impacts that occur either on purpose or by accident. Soft objects extend the time over which the force of an impact is felt. This means that the force felt by the person is less than it would be if the impact time was short. In other words, given the momentum of an impact situation, it's important to increase time so that force is small.

4D Momentum Conservation

1. $m = p/v$; m = (10.0 kg·m/s) / (1.5 m/s); m = 6.7 kg
2. $v = p/m$; v = (1000 kg·m/s) / (2.5 kg); v = 400 m/s
3. $p = mv$
   (mass is conventionally expressed in kilograms)
   p = (0.045 kg)(75.0 m/s)
   p = 3.38 kg·m/s
4. $p_{\text{(before firing)}} = p_{\text{(after firing)}}$
   $m_1v_1 + m_2v_2 = m_3v_3 + m_4v_4$
   400 kg(0 m/s) + 10 kg(0 m/s) = 400 kg (v_2) + 10 kg(20 m/s)
   0 = 400 kg(v2) + 200 kg·m/s
   (v_2) = (-200 kg·m/s)/400 kg
   (v_2) = -0.5 m/s
5. $p_{\text{(before throwing)}} = p_{\text{(after throwing)}}$
   $m_1v_1 + m_2v_2 = m_3v_3 + m_4v_4$
   0 = m_1(0.05 m/s) + 0.5 kg(10.0 m/s)
   m_1 = (-0.5 kg)(10.0 m/s)/ (0.05 m/s)
   Eli's mass + the skateboard (m_1) = 100 kg
6. Answers are:
   a. $p = mv + \Delta p$; $p = mv + F\Delta t$
      p = (80 kg)(3.0 m/s) + (800 N)(0.30 s)
      p = 480 kg·m/s
   b. $v = p/m$; v = (480 kg·m/s)/80 kg; v = 6.0 m/s
7. Answers are:
   a. $p = mv$; p = (2000 kg)(30 m/s); p = 60,000kg·m/s
   b. $F\Delta t = m\Delta v$
      $F = (m\Delta v)/(\Delta t)$; F = (60,000 kg·m/s)/(0.72 s)
      F = 83,000 N
8. Answers are:
   a. P = (# of people)(mv); p =(2.0×10^9)(60 kg)(7.0 m/s);
      $p = 8.4 \times 10^{11}$ kg·m/s
   b. $p_{\text{(before jumping)}} = p_{\text{(after jumping)}}$
      $m_1v_1 + m_2v_2 = m_3v_3 + m_4v_4$

$0 = 8.4 \times 10^{11}$ kg·m/s + $5.98 \times 10^{24}(v_4)$;

$(v_4) = (-8.4 \times 10^{11}$ kg·m/s)/ 5.98×10^{24}
Earth moves beneath their feet at the speed
$v_4 = -1.4 \times 10^{-13}$ m/s

9. Answers are:
   a. $p = mv$; $p = (60\text{ kg})(6.00\text{ m/s})$; $p = 360$ kg·m/s
   b. $v_{av} = (v_i + v_f)/2$; $v_{av} = (6.00\text{ m/s} + 0\text{ m/s})/2 = 3.00$ m/s

      $\Delta t = d/\Delta V$; $\Delta t = 0.10\text{ m}/3.00\text{ m/s}$; $\Delta t = 0.033$ s
      $F\Delta t = m\Delta V$; $F = (m\Delta V)/\Delta t$;
      $F = (60\text{ kg})(6.00\text{ m/s})/(0.033\text{ s})$; $F = 11{,}000$ N
10. Since the gun and bullet are stationary before being fired, the momentum of the system is zero. The "kick" of the gun is the momentum of the gun that is equal but opposite to that of the bullet maintaining the "zero" momentum of the system.
11. It means that momentum is transferred without loss.

4E Work

1. Work is force acting upon an object to move it a certain distance. In scientific terms, work occurs ONLY when the force is applied in the same direction as the movement.
2. Work is equal to force multiplied by distance.
3. Work can be represented in joules or newton·meters.
4. Answers are:
   a. No work done
   b. Work done
   c. No work done
   d. Work done
   e. Work done
5. 100 N·m or 100 joules
6. 180 N·m or 180 joules
7. 100,000 N·m or 100,000 joules
8. 50 N·m to lift the sled; no work is done to carry the sled
9. No work was done by the mouse. The force on the ant was upward, but the distance was horizontal.
10. 10,000 joules
11. Answers are:
    a. 1.25 meters
    b. 27 pounds
12. 2,500 N or 562 pounds
13. 1,500 N
14. 54 N·m or 54 joules
15. 225 N·m or 225 joules
16. 0.50 meters
17. Answers are:
    a. No work was done.
    b. 100 N·m or 100 joules
18. Answers are:
    a. No work is done
    b. 11 N·m or 11 joules
    c. 400 N·m or 400 joules (Henry did the most work.)

4F Potential and Kinetic Energy

1. First shelf: 5.0 newton-meters
   Second shelf: 7.5 newton-meters
   Third shelf: 10. newton-meters
2. Answers are:
   a. 588 newtons
   b. 1.7 meters
   c. 5.8 m/s
3. Answers are:
   a. 450 joules
   b. 450 joules

c. 46 meters
4. 25,000 joules
5. 4 m/s
6. 75 kilograms

4G Conservation of Energy

1. 0.20 meters
2. 3.5 m/s
3. 39.6 m/s
4. 196,000 joules
5. 10. meters
6. 30. meters
7. Answers will vary.

4H James Prescott Joule

1. Perhaps because he thought that the pursuit of science was worthwhile.
2. His father hired one of the most famous scientists of his time to tutor his sons.
3. His interest was based upon his desire to improve the brewery. He wanted to make a more efficient electric motor to replace the old steam engines that they had at the time.
4. His goal had been to replace the old steam engines with more efficient electric motors. He was not able to do that, however, he learned a great deal about electromagnets, magnetism, heat, motion, electricity, and work.
5. Electricity produces heat when it travels through a wire because of the resistance of the wire. Joule's Law also provided a formula so that scientists could calculate the exact amount of heat produced.
6. Joule believed that heat was a state of vibration caused by the collision of molecules. This contradicted the beliefs of his peers who thought that heat was a fluid.
7. Joule knew that the temperature of the water at the bottom of the waterfall was warmer than the water at the top of the waterfall. He thought that this was true because the energy produced by the falling water was converted into heat energy. He wanted to measure how far water had to fall in order to raise the temperature of the water by one degree. Joule used a large thermometer to measure the temperature at the top of the waterfall and the temperature at the bottom of the waterfall. The experiment failed because the water did not fall the right distance for his calculations and there was too much spray from the waterfall to read the instruments accurately.
8. Refrigeration
9. The joule is the international measurement for a unit of energy.
10. Answers will vary.

4I Collisions and Conservation of Momentum

1. $p = mv$; $p = (100.\text{kg})(3.5\text{m/s})$; $p = 350\text{kg}\cdot\text{m/s}$
2. $p = mv$; $p = (75.0\text{kg})(5.00\text{m/s})$; $p = 375\text{kg}\cdot\text{m/s}$
3. Answer:

   $p_{(\text{before coupling})} = p_{(\text{after coupling})}$

   $m_1v_1 + m_2v_2 = (m_1 + m_2)(v_{3+4})$

   $(2000\text{ kg})(5\text{m/s}) + (6000\text{ kg})(-3\text{m/s}) = (8000\text{ kg})(v_{3+4})$
   $v_{3+4} = -1\text{m/s}$ or 1m/s west
4. Answer:

   $p_{(\text{before collision})} = p_{(\text{after collision})}$
   $m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$
   $(4\text{ kg})(8\text{m/s}) + (1\text{ kg})(0\text{m/s}) = (4\text{ kg})(4.8\text{m/s}) + (1\text{kg})v_4$
   $v_4 = (32\text{kgm/s} - 19.2\text{kg}\cdot\text{m/s})/(1\text{kg})$; $v_4 = 12.8\text{m/s}$ or 13m/s
5. Answer:

   $p_{(\text{before shooting})} = p_{(\text{after shooting})}$

   $m_1v_1 + m_2v_2 = (m_1 + m_2)(v_{3+4})$
   $(0.0010\text{ kg})(50.0\text{ m/s}) + (0.35\text{ kg})(0\text{ m/s}) = (0.351\text{kg})(v_{3+4})$
   $(v_{3+4}) = (0.050\text{kg}\cdot\text{m/s})/(0.351\text{kg})$; $(v_{3+4}) = 0.14\text{ m/s}$

6. Answer:

   $p_{(\text{before tackle})} = p_{(\text{after tackle})}$
   $m_1v_1 + m_2v_2 = (m_1 + m_2)(v_{3+4})$
   $(70\text{ kg})(7.0\text{ m/s}) + (100\text{ kg})(-6.0\text{ m/s}) = (170\text{ kg})(v_{3+4})$
   $(v_{3+4}) = (490\text{kg·m/s} - 600\text{kg·m/s})/\ (170\text{kg})$
   $(v_{3+4}) = -0.65\text{ m/s}$
   Terry is moved backwards at a speed of 0.65 m/s while Jared holds on.
7. Answer:

   $p_{(\text{before hand})} = p_{(\text{after hand})}$
   $m_1v_1 + m_2v_2 = (m_1 + m_2)(v_{3+4})$
   $(50.0\text{ kg})(7.00\text{ m/s}) + (100.\text{ kg})(16.0\text{m/s}) = (150\text{ kg})(v_{3+4})(v_{3+4}) =$
   $(350\text{ kg·m/s} + 1{,}600\text{ kg·m/s})/150\text{ kg}$
   $(v_{3+4}) = 13\text{ m/s}$
8. Answer:

   $p_{(\text{before jump})} = p_{(\text{after jump})}$
   $m_1v_1 + m_2v_2 = (m_1 + m_2)(v_{3+4})$
   $(520\text{ kg})(13.0\text{ m/s}) + (85.0\text{ kg})(3.00\text{ m/s}) = (605\text{ kg})(v_{3+4});$
   $v_{3+4} = (7{,}015\text{ kg·m/s})/(605\text{ kg})$
   $v_{3+4} = 11.6\text{ m/s}$
9. Answer:

   $p_{(\text{before jumping})} = p_{(\text{after jumping})}$
   $m_1v_1 + m_2v_2 + m_3v_3 = m_1v_4 + m_2v_5 + m_3v_6$
   $(45\text{ kg})(1.00\text{ m/s}) + (45\text{ kg})(1.00\text{ m/s}) + (70\text{ kg})(1.00\text{ m/s}) = (45\text{ kg})(3.00\text{ m/s}) - (45\text{ kg})(4.00\text{ m/s}) + (70\text{ kg})(v_6)$
   $160\text{ kg·m/s} = (-45\text{ kg·m/s}) + (70\text{ kg})(v_6)$
   $(v_6) = (205\text{ kg·m/s})(70\text{ kg})$
   $(v_6) = 2.9\text{ m/s}$
10. Answers are:
    a. Answer:

       $p_{(\text{before toss})} = p_{(\text{after toss})}$
       $m_1v_1 + m_2v_2 = (m_3 + m_4)(v_{3+4})$
       $(0.10\text{ kg})(v_1) + (0.10\text{ kg})(0\text{ m/s}) = (0.20\text{ kg})(15\text{ m/s});$
       $(v_1) = (0.30\text{ kg·m/s})(0.10\text{ kg})$
       $(v_1) = 30.\text{ m/s}$
    b. Answer:

       $p_{(\text{before collision})} = p_{(\text{after collision})}$
       $m_1v_1 + m_2v_2 = m_1v_3 + m_2v_4$
       $(0.10\text{ kg})(30\text{ m/s}) + (0.10\text{ kg})(0\text{ m/s}) = (0.10\text{ kg})(v_3) + (0.10\text{ kg})(-30\text{ m/s})$
       $(v_3) = (3.0\text{ kg·m/s} + 3.0\text{ kg·m/s})/(0.10\text{ kg})$
       $(v_3) = 60\text{ m/s}$
       The block slides away at a much higher speed of $v_3 = 60$ m/s. The "bouncy" ball, by rebounding, has experienced a greater change in momentum. The block will experience this change in momentum as well.

4J Rate of Change of Momentum

1. Force = 200,000 N. At this level of force, after a couple of hits with a wrecking ball, any impressive-looking wall crumbles to pieces.
2. 3 seconds
3. 250 N
4. 750 N
5. 75 million N
6. The answers are:
   a. The force created on the egg is about:
   $$\frac{0.05\text{ kg} \times 10\text{ m/s}}{0.001\text{ s}} = 500\text{ N}$$
   b. The force created on the egg by the person is:
   $$50\text{ kg} \times 9.8\text{ m/s}^2 = 490\text{ N}$$
   c. The force created by the person is close to the amount of force that broke the egg. Therefore, if the person fell on the egg, it would probably break.
   d. As a result the force will be 500 times smaller:
   $$\frac{0.05\text{ kg} \times 10\text{ m/s}}{0.5\text{ s}} = 1\text{ N}$$
   e. The egg would probably not break if it fell on the pillow because the force is 500 times smaller than if it fell on the hard floor.