PHYSSCIB-CA · Physical Science B — Forces, Energy and Waves (California)

Unit 1: Motion, Forces and Collision Safety

Practice Workbook. The same problems, in the same order, as the Practice sections of the online lessons.

Name ____________________ Period __________

Lesson 1.1 — Crash Cushions at the Off-Ramp

FLUENCY

1. A car moving at 5 m/s speeds up at 2 m/s^2 for 6 s. What is its final speed?

2. A car starting from rest speeds up at 3 m/s^2 for 9 s. What is its final speed?

3. A car moving at 5 m/s speeds up at 4 m/s^2 for 3 s. What is its final speed?

4. Convert 60 °C to kelvin.

5. A runner covers 120 m in 8.0 s. What is her average speed?

6. A skateboarder speeds up from 0 to 8 m/s in 4 s. What is the acceleration?

7. On a velocity-time graph, what does a horizontal line mean? A line sloping down to zero?

APPLICATION

8. A car moving at 25 m/s stops against a crash cushion in 0.50 s. Find its acceleration and the net force on a 70 kg passenger during the stop.

9. Explain with Newton's first law why an unbelted passenger hits the dashboard when a car stops suddenly.

10. A 60 kg cyclist and her 12 kg bike accelerate at 1.5 m/s^2. What net force acts on the cyclist-and-bike system? If friction and air resistance total 20 N, what forward force must the road exert on the tires?

CHALLENGE

11. Sketch the velocity-time graphs for the car hitting concrete (stops in 0.10 s) and the car hitting the cushion (stops in 0.50 s), both from 25 m/s. What feature of each graph shows the acceleration, and what does the area under each graph represent?

REVIEW

12. How many moles are in 100.0 g of O_2?

13. A wood sample has 25% of the carbon-14 of living wood. Using a half-life of 5,730 years, estimate its age.

Lesson 1.2 — Newton's Second Law with Carts

FLUENCY

1. An 8 kg box is pushed with 22 N to the right against 5 N of friction. Find the net force and the acceleration.

2. A 10 kg box is pushed with 76 N to the right against 16 N of friction. Find the net force and the acceleration.

3. A net force of 1.0 N gives an object an acceleration of 0.5 m/s^2. What is its mass?

4. A net force of 6.0 N acts on a 12 kg object. What is its acceleration?

5. A 20 kg box is pushed with 27 N to the right against 13 N of friction. Find the net force and the acceleration.

6. What is the weight of 0.150 kg of washers ($g = 9.8\ m/s^2$)?

7. A cart travels 1.00 m from rest in 0.90 s. Find its acceleration.

APPLICATION

8. Illustrative lab data at a constant total mass of 0.600 kg: net forces 0.49, 0.98, 1.47, 1.96 N gave accelerations 0.73, 1.54, 2.31, 3.13 m/s^2. The best-fit slope is 1.63. What mass does the slope imply, and how close is it to 0.600 kg?

9. Using the same total mass of 0.600 kg and ignoring friction, predict the acceleration when the hanging mass is 0.250 kg, and the time to travel 1.00 m.

10. In a second experiment the hanging force stays at 0.98 N and the total mass is 0.40, 0.60, 0.80 and 1.00 kg. Predict the accelerations (no friction) and describe the shape of the graph of acceleration against mass.

CHALLENGE

11. The best-fit line for the illustrative data is $a = 1.63F - 0.067$. At what pulling force would the line predict zero acceleration, and what does that force represent?

REVIEW

12. A sample has mass 112.0 g and volume 12.5 cm^3. Find its density and, using a density table, suggest what it could be.

13. Balance: $Fe + O_2 \rightarrow Fe_2O_3$

Lesson 1.3 — Momentum Before and After a Collision

FLUENCY

1. A 1200 kg object moving at 20 m/s collides and sticks to a 2200 kg object moving at 4.0 m/s (same line; positive is the first object's direction). Find the total momentum and the velocity just after the collision.

2. A 1500 kg object moving at 20 m/s collides and sticks to a 2200 kg object at rest (same line; positive is the first object's direction). Find the total momentum and the velocity just after the collision.

3. A 0.75 kg object moving at 0.8 m/s collides and sticks to a 1.5 kg object at rest (same line; positive is the first object's direction). Find the total momentum and the velocity just after the collision.

4. A 1800 kg object moving at 15 m/s collides and sticks to a 1400 kg object at rest (same line; positive is the first object's direction). Find the total momentum and the velocity just after the collision.

5. Find the momentum of an 80 kg cyclist and bike moving at 5 m/s.

6. A 3,000 kg truck moves at 10 m/s. How fast must a 1,200 kg car move to have the same momentum?

APPLICATION

7. A 2,500 kg SUV moving at 20 m/s rear-ends a 1,250 kg car stopped at a light, and they lock together. Find their velocity just after the collision.

8. A 50 kg skateboarder at rest throws a 2.0 kg ball forward at 5.0 m/s. Use momentum conservation to find her recoil velocity.

9. A classmate's cart data show total momentum 0.40 kg·m/s before and 0.33 kg·m/s after a sticking collision on a carpeted floor. Evaluate their claim that 'momentum is not conserved.'

CHALLENGE

10. Two equal 0.50 kg carts approach each other at 0.60 m/s each and stick. What is their velocity after? Where did their kinetic energy go?

REVIEW

11. For the balanced reaction $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$, what mass of CO_2 forms from 50.0 g of $C_6H_{12}O_6$, assuming $C_6H_{12}O_6$ is the limiting reactant?

12. Which shifts $N_2 + 3H_2 \rightleftharpoons 2NH_3$ toward ammonia: raising or lowering the pressure?

Lesson 1.4 — Impulse: Stretching the Stop

FLUENCY

1. An object is dropped from rest 10 m above the ground. Ignoring air resistance ($g = 9.8\ m/s^2$), how long does it fall and how fast is it moving at impact?

2. An object is dropped from rest 5 m above the ground. Ignoring air resistance ($g = 9.8\ m/s^2$), how long does it fall and how fast is it moving at impact?

3. A 0.40 kg ball's momentum changes by 4.0 kg·m/s in 0.050 s. What is the average force?

4. If the stopping time of a collision triples while the momentum change stays the same, what happens to the average force?

5. Name three vehicle or sports safety devices that work by lengthening stopping time.

6. A 1,500 kg car at 25 m/s stops in 0.50 s. What is the average force on the car?

APPLICATION

7. A 60 g egg falls 2.0 m. Find its speed and momentum at impact ($v = \sqrt{(2gh)}$), and the average force if it stops in 0.002 s on tile and in 0.050 s on foam.

8. A 5 kg head moving at 6 m/s stops in 0.004 s without a helmet and in 0.012 s with helmet foam (illustrative). Compare the average forces.

9. In the padding test, bare clay dented 6 mm, bubble wrap 3 mm (4 g of padding) and foam 2 mm (10 g). Which gives the larger dent reduction per gram, and which would you choose with a strict mass limit?

CHALLENGE

10. A ball bouncing straight back off a wall has a larger momentum change than one that stops dead against it. Explain why, and use it to explain why crash cushions are designed to absorb rather than bounce a car back.

REVIEW

11. Find the molar mass of MgO.

12. Give the product of the beta decay of carbon-14.

Unit 1 checkpoint

1. A car goes from 10 m/s to 22 m/s in 4.0 s. Its acceleration is
   - A. 2.5 m/s²
   - B. 3.0 m/s²
   - C. 5.5 m/s²
   - D. 8.0 m/s²
2. A net force of 30 N acts on a 6.0 kg object. Its acceleration is
   - A. 0.2 m/s²
   - B. 5.0 m/s²
   - C. 24 m/s²
   - D. 180 m/s²
3. True or false: A straight-line graph of acceleration against net force at constant mass supports Newton's second law.
4. The slope of an acceleration-force graph is 2.5, so the mass is ________ kg.

5. Momentum is
   A. mass times acceleration
   B. mass times velocity
   C. force times distance
   D. half mass times velocity squared
6. A 1.0 kg cart at 4.0 m/s sticks to a 3.0 kg cart at rest. Their speed afterward is
   A. 1.0 m/s
   B. 1.33 m/s
   C. 4.0 m/s
   D. 0.75 m/s
7. True or false: Total momentum is conserved in a collision only if no net outside force acts on the system.
8. Crash cushions reduce the force on a car mainly by
   A. reducing the car's speed before impact
   B. increasing the stopping time
   C. increasing the car's mass
   D. bouncing the car backward
9. A momentum change of 12 kg·m/s over 0.20 s requires an average force of ______________ N.
10. Which is the best example of breaking down a design problem?
   A. Building the whole design at once and hoping it works
   B. Testing padding materials separately before deciding how to attach them
   C. Copying another team's design
   D. Choosing the heaviest materials
11. True or false: A simulation of a collision can help predict a design's performance, but its results must be checked against real tests.
12. A longer cushion stops the cart more gently but breaks the 15 cm limit. This is an example of
   A. a trade-off between a criterion and a constraint
   B. a measurement error
   C. Newton's first law
   D. a failed test

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