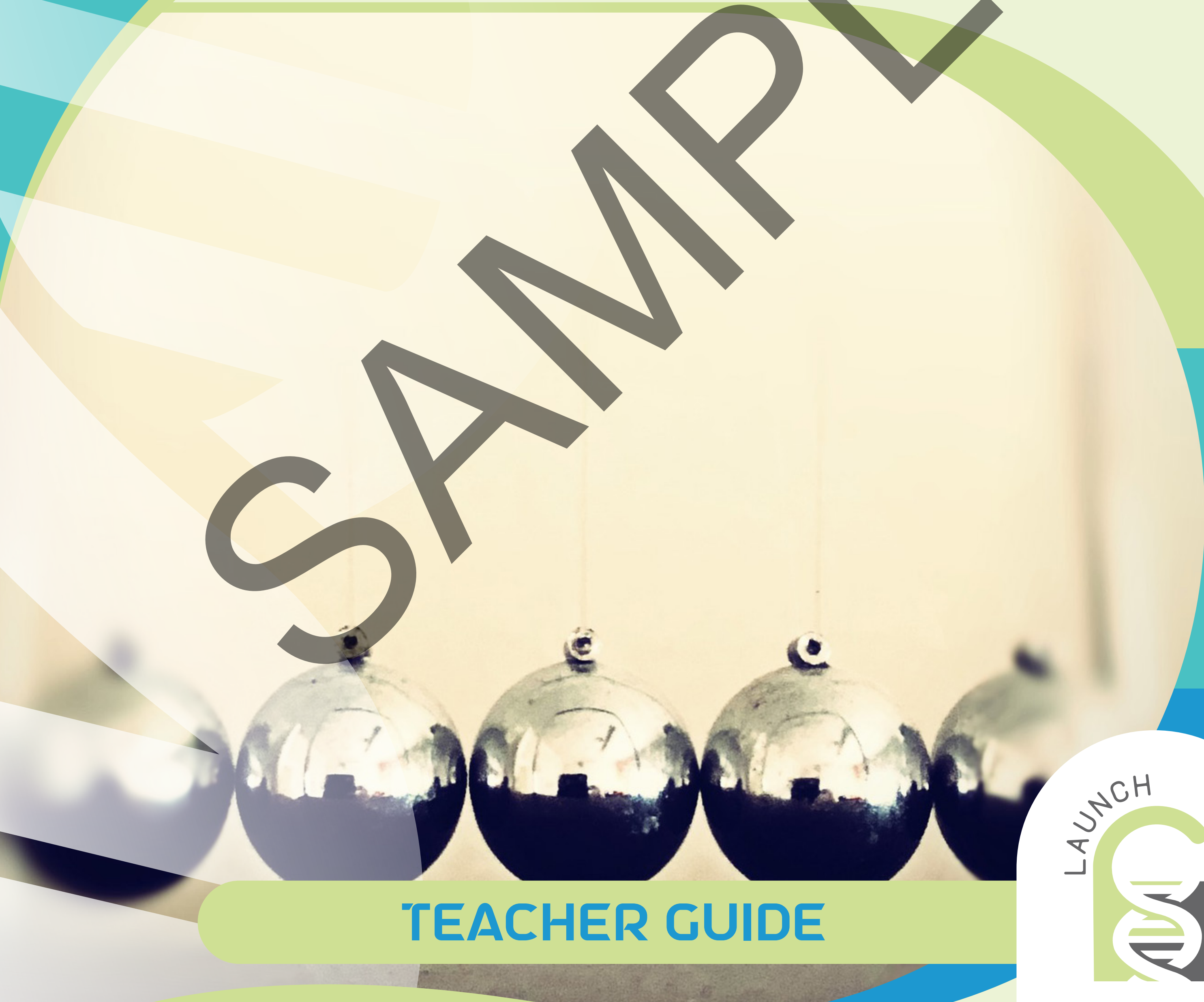
NEWTON'S NOTIONS



TEACHER GUIDE

LAUNCH

PLANNING

Here's a suggested schedule for this kit! The activities should be completed in order, but you can choose when the lessons take place over time. Time required for each lesson may vary.

ACTIVITY INFORMATION	SECTION (S)	TIME REQUIRED	DAY/ LESSON
ACTIVITY 1: SURPRISING SPIN Watch what happens to objects in a spinning water-filled tube, and begin a KWLQA chart. **Time required: 1 h**	· Spin It Around! · Put Your Own Spin On It	30 Minutes	Day 1
	· Is Your Head Spinning?	30 Minutes	Day 2
ACTIVITY 2: INERTIA DROP Use the magic, nay, science of inertia to explain why some objects just stay put, practicing Newton's First Law. **Time required: 2 h**	· Get To Know Newton	45 Minutes	Day 3
	· Put Inertia To The Test	30 Minutes	Day 4
	· Show What You Know	45 Minutes	Day 5
ACTIVITY 3: NEWTON'S...TUBE? It's not Newton's cradle, but it works the same way and is a great introduction to Newton's Second Law. **Time required: 2 h 45 min**	· Connecting Energy And Force	60 Minutes	Day 6
	· Momentum In A Tube · Manipulating The Momentum	60 Minutes	Day 7
	· Show What You Know	45 Minutes	Day 8
ACTIVITY 4: RAMP RUNS Race different balls down ramps to learn about gravity and how it fits into Newton's Second Law. **Time required: 2 h 15 min**	· Ramp It Up	30 Minutes	Day 9
	· How Attractive!	60 Minutes	Day 10
	· Show What You Know	45 Minutes	Day 11
ACTIVITY 5: WHAT A DRAG Explore a new type of force – friction – as you measure the drag on a weighted balloon. **Time required: 1 h 30 min**	· Drag It Along · Two Types Of Friction	60 Minutes	Day 12
	· Show What You Know	30 Minutes	Day 13
ACTIVITY 6: BLAST-OFF BALLOONS Use the power of air to make balloons into simple rockets and learn about Newton's Third Law. **Time required: 1 h 30 min**	· 3-2-1 – Whoosh! · Equal And Opposite	60 Minutes	Day 14
	· Show What You Know	30 Minutes	Day 15
ACTIVITY 7: FLOATING DISC Investigate buoyancy and density while making an easy hovercraft toy, and find out how they're related to forces. **Time required: 1 h 45 min**	· Make The Disc "Float" · Staying Afloat	60 Minutes	Day 16
	· Show What You Know	45 Minutes	Day 17
ACTIVITY 8: NON-STOP NEWTON Choose any or all of these extension activities to keep the physics fun going! **Time required: 3+ h**	· Defy Gravity · Take A Deep Dive	30 Minutes	Day 18
	· Get To Know More "Great Thinkers"	60 Minutes	Day 19
	· Make Your Own Newton's Cradle	60 Minutes	Day 20
	· Fascinate With Friction · Spring A Leak · Perform A Stick Trick	60 Minutes	Day 21

Total time: 15+ hours

3 activity

NEWTON'S...TUBE?!

Here, your student will make a simple version of a Newton's cradle to demonstrate how energy is conserved in moving objects. This will help them learn more about why the objects in the spinning water tube moved the way they did.

LEARNING GOALS:

- I can use mathematical models to show that the total momentum of two objects moving in one dimension stays the same unless there is a net force.
- I can use data to show that Newton's Second Law of Motion describes the relationship between net force, mass, and acceleration of an object.

CONNECTING ENERGY AND FORCE

CONTENT

13

- Follow along with your student, or allow them to work independently, as they read about the connections between energy, momentum, and force.
- The terms energy, momentum, and velocity are defined.
- The following equations are introduced: momentum **($p=m \times v$)** and the force-momentum relationship **($F=\Delta p/\Delta t$).**
- They will also see an example of a word problem that uses the equations for momentum and force to solve a problem. Make sure they pay close attention to the worked example because the questions that follow are similar.

THINK ABOUT IT

14

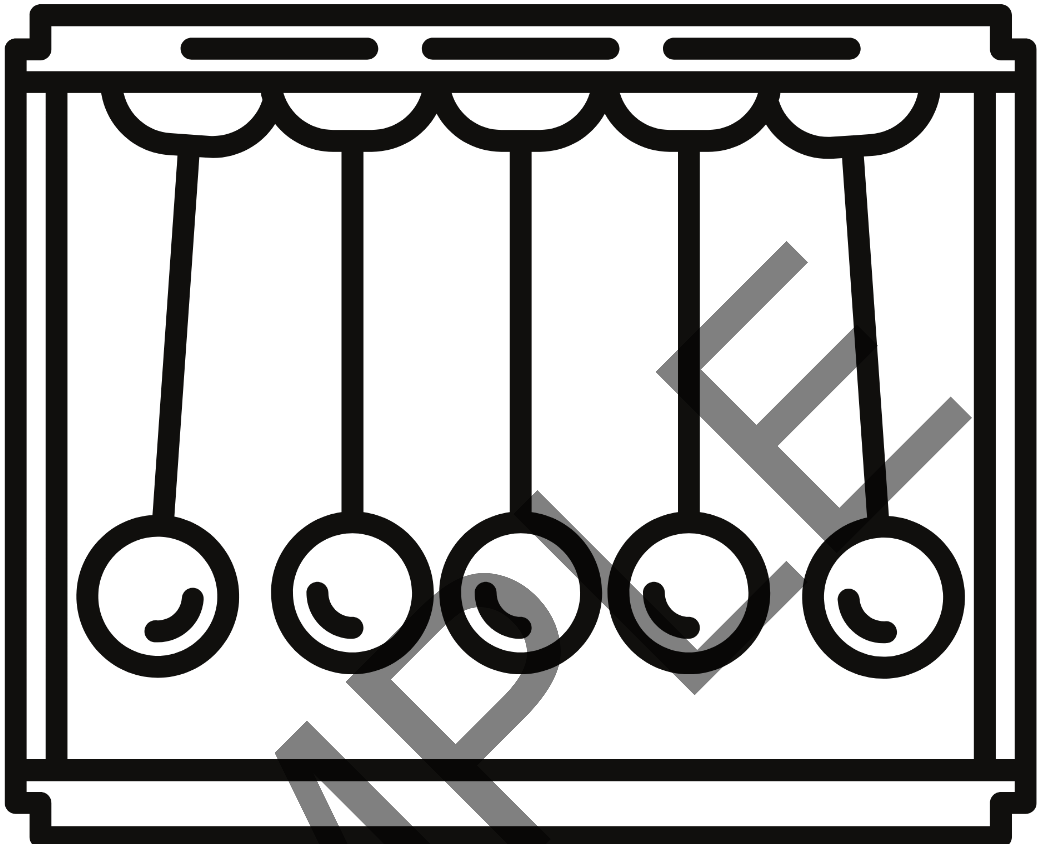
- Your student will use the relationship (equation) of momentum, mass, and velocity to solve three word problems.

MULTIPLE AGES AND ABILITIES:

The ability to do these word problems using equations is valuable, especially for older students, but it is not necessary to move on to the next section. You can do them and have your student listen, or you can skip them altogether. It is more important that your student understands the conceptual relationships between the variables in the equations; for example, increasing mass or velocity will increase the momentum, and changing a momentum over a short period of time requires more force than doing so over a long period of time.

There are several instances of using equations to solve problems throughout this kit; however, you can treat them all this way and still get a complete conceptual experience if the math is out of reach. On the other hand, please don't avoid the problems just because they involve math. The required math understanding is Algebra I level, which is commonly used in secondary school physics courses. With your guidance, these types of problems can be excellent confidence builders.

JUST FOR FUN



Question 1: A car with a mass of 1,500 kg and a freightliner semi-truck with a mass of 45,000 kg are traveling at the same velocity of 30 m/s west. How do their momentums compare?
Answer: The mass of the truck is 30 times greater than the mass of the car.
How to Help: *Help your student use the process shown in the examples earlier in this section of the Student Workbook.*

1). Find the momentum of the car, p_c

$p = m \cdot v$ ← *Use the equation for momentum.*
$p_c = 1500\ kg \cdot 30\ m/s$ ← *Plug in the values from the problem.*
$p_c = 45000\ kg \cdot m/s$ ← *Multiply to get the answer.*

2). Find the momentum of the semi-truck, p_t

$p = m \cdot v$ ← *Use the equation for momentum.*
$p_t = 45000\ kg \cdot 30\ m/s$ ← *Plug in the values from the problem.*
$p_t = 1350000\ kg \cdot m/s$ ← *Mulitply to get the answer.*

3). Compare the two momentums.

$p_t \div p_c =$ ← *Divide to find the ratio.*
$1350000 \div 45000 = 30$ ← *Plug in the momentum of each vehicle.*
The truck has 30 times the momentum of the car (their velocities are equal but the truck's mass is 30 times greater than that of the car).

Question 2: You use a 5-kg bowling ball and your friend uses one that is 4 kg. If you roll the ball down the lane with a velocity of 6 m/s, how fast would your friend have to roll their ball to make it hit the pins with the same amount of force as yours?
Answer : The ball would have to be rolled at 7.5 m/s down the lane.
How to Help: *The equation for momentum can be used in this two-step problem.*

1) First, find the momentum of the ball, p, rolled by the first person.

$p = m \times v$ ← *Use the equation for momentum.*
$p = 5\ kg \times 6\ m/s$ ← *Plug in the values from the problem.*
$p = 30\ kg \cdot m/s$ ← *Multiply to get the answer.*

2) Next, find the velocity needed to have the same momentum (since momentum and force are equivalent when time is the same) by rearranging the momentum equation.

$p = m \times v$ ← *Use the equation for momentum.*
$p \div m = (m \times v) \div m$ ← *Divide both sides by m.*
$v = p \div m$ ← *Simplify to solve for v.*
$p = 30\ kg \cdot m/s \div 4\ kg$ ← *Plug in the values from the problem.*
$p = 7.5\ m/s$ ← *Multiply to get the answer.*

Question 3: Refer back to the car in Question 1. How much force must be applied by the brakes to stop the car in 2 seconds if it's traveling at 10 m/s?
Answer: The brakes must apply 7,500 N of force.
How to Help: *This is a multi-step problem in which the student must first find the change in momentum, and then the force it takes to make that change in the given time.*

1) Find the change in momentum for the car coming to a complete stop from 10 m/s.
a) Find the momentum when the car is moving 10 m/s, p_1.

$p_1 = m \times v$ ← *Use the equation for momentum.*
$p_1 = 1{,}500\ kg \times 10\ m/s$ ← *Plug in the values from the problem.*
$p_1 = 15{,}000\ kg \cdot m/s$ ← *Multiply to get the answer.*

b) Find the momentum when the car is stopped, p_2.

$p_2 = m \times v$ ← *Use the equation for momentum.*
$p_2 = 1{,}500\ kg \times 0\ m/s$ ← *Plug in the values from the problem.*
$p_2 = 0\ kg \cdot m/s$ ← *Multiply to get the answer.*

c) Find the change in momentum

$\Delta p = p_2 - p_1$ ← *A change is a difference between final and initial.*
$\Delta p = 0 \text{ kg} \cdot \text{m/s} - 15{,}000 \text{ kg} \cdot \text{m/s}$ ← *Plug in the values previously calculated.*
$\Delta p = -15{,}000 \text{ kg} \cdot \text{m/s}$

If your student doesn't use the negative sign here, that's okay. They just need to know the difference in the momentum. On the other hand, it may be worth reminding them that a negative sign means that it's in the opposite direction of the motion (it's moving forward, but the force is slowing it down).

2) Determine the force for the calculated change in momentum and the change in time.

$F = \Delta p \div \Delta t$ ← *Use the equation related force, momentum, and time.*
$F = 15{,}000 \text{ kg} \cdot \text{m/s} \div 2 \text{ s}$ *Plug in the values calculated and from the problem.*
$F = 7{,}500 \text{ kg} \cdot \text{m/s}^2$ ← *Divide to get the answer.*
$F = 7{,}500 \text{ N}$ ← *Change the units to newtons to represent force.*

MOMENTUM IN A TUBE

15

CONTENT

- A Newton's Cradle is a popular demonstration of Newton's laws. Follow along as your student makes a simpler version using the plastic tube and steel balls from the kit.

PREPARATION AND SUPERVISION

- The most difficult step is making sure the balls don't move before they should; the wooden dowels are helpful, but success will depend on how level the surface is.

PREDICT

Question: How will the steel balls move? Draw the positions you think the steel balls will be in after you hit the four balls in the tube with the fifth (rolling) ball.
Answer: The student should draw balls inside the tube diagram in whatever positions they think they will be in right after the collision occurs.

THINK ABOUT IT!

Question: How did the steel balls move? Draw the positions the steel balls were in after you hit the four balls in the tube with the fifth (rolling) ball.
Answer: The student should have observed that the only ball that moved was the one furthest from where the rolling ball hit the row of balls. The other three that were already in the tube should be mostly stationary, and the rolling ball should also be in line with them (though they might observe some bouncing back).

GLOSSARY

Acceleration – change in velocity over time.

Buoyancy – upward force on an object floating in a fluid.

Density – amount of mass in a certain volume.

Energy – the ability to cause a change.

Force – an interaction between two objects.

Force of kinetic friction – resistance to the motion of two objects sliding over each other.

Force of static friction – the friction force that opposes the initial movement of an object.

Friction force – the resistance to the motion of two objects sliding over each other.

Free fall – a state of motion in which the only force acting on an object is gravity.

Gravity – the force of attraction between two objects.

Inertia – resistance to change in motion for an object.

Mass – amount of matter in an object.

Momentum – quantity of motion of an object based on its velocity and mass.

Newton's First Law – an object at rest will stay at rest, and an object in motion will continue that motion, unless acted on by a new force.

Newton's Second Law – the force acting on an object is equal to the product of the mass and acceleration of the object.

Newton's Third Law – for every force, there is an opposite but equal reaction force.

Physics – the study of matter, energy, and the interactions between them.

Thrust – an applied force that causes an object to move in the opposite direction of the force.

Velocity – change in position of an object over time.

Volume – amount of space an object takes up.

Weight – the force of gravity acting on an object.

REFERENCES

1. Westfall, Richard S. Never at Rest: A Biography of Isaac Newton. Cambridge University Press, 1983.

LAUNCH

SCIENCE UNLOCKED®

Contact us at: www.homesciencetools.com/customer-service/

A product of

HOME SCIENCE TOOLS®

Kit	SU-NEWTON
Instructions	IN-NEWTONT
Revision Date	3/2023