DEAR EDUCATOR,

FMA Live! Forces in Motion is the award-winning, traveling hip-hop science education show from Honeywell Hometown Solutions and NASA.

Designed for students in grades 5-8, FMA Live! Forces in Motion teaches Newton's Universal Law of Gravity and Three Laws of Motion.

With **FMA Live!**, middle school students will never look at science and engineering the same way again!

Named after Newton's Second Law of Motion (Force = Mass x Acceleration), the show connects science and engineering to everyday life. It also demonstrates how studying Newtonian physics can lead to interesting, competitive careers.

Developed by Honeywell and NASA, this National Science Standards-based resource guide includes:

- Preview activities designed to help introduce your students to the principles behind Newton's Three Laws of Motion
- Links to NASA-developed lesson plans that explore the Three Laws of Motion and how they apply in the development of planetary rover technology
- A catalog of multimedia resources excerpted from **FMA Live!** that you can use to bring physics to life in your classroom
- Tips for encouraging students to pursue careers in the STEM disciplines, including links to online interviews with NASA engineers
- A reproducible **FMA Live!** information letter to parents

We hope that you and your students enjoy the **FMA Live!** show, and that these resources help you channel that excitement toward long-term learning and an interest in STEM careers.

Let us know what you think at **fmalive.com**. We depend on your feedback to continue to provide free teaching materials that make a real difference in students' lives.

Honeywell Hometown Solutions

NASA

TEACHER'S RESOURCE GUIDE

These National Science Standards-based resources will help you teach the principles of Newton's Laws of Motion before and after the show as well as provide your students with information about careers in science and technology.

PREVIEW ACTIVITIES

Prepare your students for the **FMA Live!** learning experience by having them try demonstrations of Newton's Three Laws of Motion. Each demonstration takes only a few minutes and requires minimal preparation.

Newton's First Law of Motion: Inertia

An object at rest will stay at rest unless acted on by an outside force. An object in motion will continue in motion at the same speed and in the same direction unless acted on by an outside force.

- Place a book on a piece of paper at the edge of a desk, and quickly pull the paper away to illustrate how an object at rest remains at rest unless acted on by an outside force. Ask students to suggest variations on this demonstration.
- Next, push a stack of books along the desk toward a book held in place by a student to demonstrate how objects in motion (the books at the top of the stack) remain in motion unless acted on by an outside force.
- Ask students how this law could apply to a skateboarder or cyclist who runs into a curb.

Newton's Second Law of Motion: Force = Mass x Acceleration (F=ma)

Acceleration occurs when a force acts on a mass. The greater the mass of the object, the greater the force needed to increase its acceleration.

- Ask students to place a playing card at the edge of a desk and flick it with a finger to send it flying. Explain that it takes only a small amount of force to accelerate a small mass.
- Then ask students to repeat the demonstration with a book this time. Can a finger flick accelerate the mass of a book? How much force would be required to accelerate this greater mass?
- Finally, ask students to consider how this Law of Motion applies in sports — suppose the mass of a baseball or basketball varied from game to game?

Newton's Third Law of Motion: Action and Reaction

For every action, there is an equal and opposite reaction. If object A pushes object B, object B will push back in the opposite direction with a force equal to object A.

- Create a lever using a ruler and pencil to demonstrate that action downward on one end of the lever produces an upward reaction at the other end of the lever.
- Experiment with different amounts of force on the downward end and different amounts of mass on the upward end to gauge whether the action and reaction are equal.

Sir Isaac Newton and His Universal Law of Gravitation

$F = Gm_1m_2/r^2$

Download this short biography of Sir Isaac Newton to introduce students to the "man behind the motion" at **fmalive.com** (log-in required).

For more about Newton's Universal Law of Gravitation, check out these links from NASA Education:

- **nasa.gov/audience/foreducators/diypodcast/newtons-laws-index.html**
- **nasa.gov/centers/glenn/shuttlestation/station/microgex.html**

FORCES AND MOTION MADE EASY!

Use these resources to enhance your students' learning.

FMA LIVE! DEMONSTRATION BREAKDOWNS

Recreate the excitement of the show and science with these videos featuring the cast of **FMA Live!** and the interactive on-stage demonstrations. For example, use the videos to review Newton's Laws or pause the action and ask students to predict the outcome of a demonstration and name the laws. All videos are available for online viewing at **fmalive.com** (log-in required).

Law #1: Inertia Road Case and Velcro Wall Demonstrations.

Law #2: Force = Mass x Acceleration Giant Soccer Ball and Extreme Wrestling Demonstrations.

Law #3: Action/Reaction Bottle Rocket Demonstration.

MUSIC VIDEOS

Let the music of **FMA Live!** inspire your students to write their own rap or hip-hop lyrics about Newton's Three Laws of Motion and how STEM learning can help put their future in motion. Students can sing along using downloadable lyric sheets, or create their own music videos for posting on your school website!

- **Everything's in Motion** The **FMA Live!** theme song encourages students to put their future in motion.
- **What's Inertia?** A musical demonstration of Newton's First Law of Motion.
- **F = ma** decodes the equation expressing Newton's Second Law of Motion.
- **Action / Reaction** Musical examples of the relationship behind Newton's Third Law of Motion.

ADDITIONAL RESOURCES

Check out these links for great classroom activities and reference materials for your students:

NASA Educator Guides that use Newton's Laws of Motion:

- **Rockets Guide** (**nasa.gov/audience/foreducators/topnav/materials/listbytype/Rockets.html**)
- **Mass vs. Weight** (**nasa.gov/audience/foreducators/topnav/materials/listbytype/Mass_vs_Weight.html**)
- **Spaced Out Sports** (**nasa.gov/audience/foreducators/topnav/materials/listbytype/Spaced_Out_Sports.html**)

NASA Activities & Resources:

- **How Rockets Work** (**nasa.gov/audience/foreducators/topnav/materials/listbytype/How_Rockets_Work.html**)
- **Flight Testing Newton's Laws** (**nasa.gov/audience/foreducators/topnav/materials/listbytype/Flight_Testing_Newtons_Laws.html**)
- **Applying Newton's Laws** (**nasa.gov/audience/foreducators/topnav/materials/listbytype/Applying_Newtons_Laws.html**)
- **Newton's Laws from Glenn Research Center** (**grc.nasa.gov/WWW/K-12/airplane/newton.html**)

U.S. Space and Rocket Center:
Developed by the U.S. Space and Rocket Center, this hands-on lesson plan can be downloaded at **fmalive.com** (log-in required).

- **The Science of Space Flight**
  An interactive lesson plan for Newton's Three Laws of Motion designed to be done in one class period.

FORCES IN MOTION FMA LIVE!

STEM CAREERS

FMA Live! was developed in partnership by Honeywell and NASA to inspire students to pursue careers in Science, Technology, Engineering, and Math (STEM).

CAREER VIDEO DISCUSSION GUIDE

Several hundred people make the Mars Exploration Rover Mission possible. Introduce your students to some of the engineers who work on NASA's *Curiosity* mission to Mars. Filmed on location at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California, the engineers share their stories about how they became part of the NASA team and offer students advice for exploring their interest in science and engineering. This guide includes a discussion question for each interview to help you get the conversation started. The interviews are available for online viewing at **fmalive.com** (log-in required).

Bobak Ferdowsi A flight director on the *Curiosity* mission exploring Mars, Ferdowsi explains how his team sent a rover from Earth to a precise location more than a million miles away on Mars and describes how the rover analyzes rocks on the red planet.

- **Discussion Question:** Ferdowsi encourages students to pursue a career doing what they love and explains how all kinds of talents contribute to the success of an engineering team like the one at NASA. Ask students to suggest ways their special talents or interests might lead them to a career in engineering.

Matt Heverly A mobility systems engineer, Heverly remotely drives the *Curiosity* rover around the surface of Mars. He explains how NASA applied Newton's Law of Gravity to create a smaller version of the rover for test drives on Earth, and how scientists and engineers work together on the *Curiosity* mission.

- **Discussion Question:** Heverly says that asking questions is the key to understanding science, and he encourages students to investigate how things work to develop the skills for a career in engineering. Ask students how they would find out how a cell phone, a flat-screen TV, or a GPS navigator works. What questions would they ask? What steps would they follow to get answers?

Jessica Samuels The engineering operations team chief, Samuels takes students into the Dark Room at JPL, where engineers track all the data from every NASA mission. She explains the importance of teamwork for the success of the *Curiosity* mission and how women are playing a larger role in engineering.

- **Discussion Question:** Samuels recalls how her interest in science kits and science projects led to her career as an engineer. Ask students how their hobbies could develop into an engineering career. Have they been excited by school projects that might indicate a career path for their future?

Jennifer Trosper The mission operations manager for the Mars Science Laboratory, Trosper relays the commands that tell *Curiosity* what to do on Mars. She explains how the hundreds of scientists and engineers involved in the mission must work as a team every day to coordinate all their objectives into a single set of commands.

- **Discussion Question:** Trosper says she grew up as a farm girl, and had an interest in math, science, and music. Talk with students about how stereotyping can limit our horizons — who would have ever thought that a farm girl could lead a mission to Mars? Have students imagine they have made a similar transition and ask them to write stories describing how they found a career in engineering.

Daniel Maas A digital animator, Maas has created animations that show the *Curiosity* mission in flight to Mars and the *Curiosity* rover exploring the planet. He explains how he gathers data from scientists and engineers to ensure the accuracy of his animations, and how his fascination with Hollywood special effects led to his career at NASA.

- **Discussion Question:** This interview includes animations that Maas created while still in high school. Ask students what they have created — or would like to create — that could lead to a career in engineering.

CURIOUS ABOUT NASA'S MARS EXPLORATION PROGRAM AND THE ROVER CURIOSITY?

Learn more about the mission and Curiosity at **mars.jpl.nasa.gov/**

DEAR PARENT OR GUARDIAN,

This week your child attended Honeywell and NASA's award-winning hip-hop science education show, **FMA Live!** Forces in Motion.

FMA Live! teaches students about the 17th century physicist, Sir Isaac Newton, and his Universal Law of Gravity and Three Laws of Motion—a subject that aligns with National Science Education Standards for students in grades 5-8. By teaching Forces and Motion, **FMA Live!** connects physics to everyday life and shows students how physics and engineering can lead to amazing careers!

Talk with your child about how the classes they take can lead to the exciting worlds of science, technology, engineering, and math (STEM). To start the conversation, visit the **FMA Live!** website at **fmalive.com** with your child and explore the education resources at **nasa.gov**.

With **FMA Live!**, your child will never look at science and engineering the same way again!

ESTIMADO PADRE DE FAMILIA O TUTOR,

Esta semana su hijo tuvo la oportunidad de ver el galardonado concierto de hip-hop de Honeywell y la NASA, **FMA Live!** enfocado a la educación en ciencias.

FMA Live! enseña a los estudiantes sobre el físico del siglo 17, Sir Isaac Newton y su Ley Universal de la Gravedad y las Tres Leyes del Movimiento – un tema que se alinea con las Normas Nacionales de Educación Científica para estudiantes de 5to y 8vo grado. Enseñando la aplicación de Fuerza y Movimiento, **FMA Live!** conecta la física con la vida diaria y muestra a los estudiantes como la física e ingeniería pueden guiarlos a una carrera increíble.

Lo invitamos a que hable con su hijo sobre como las clases que toman pueden llevarlos a los mundos apasionantes de la ciencia, tecnología, ingeniería y matemáticas (*Science, Technology, Engineering, and Mathematics* – STEM por sus siglas en inglés). Para iniciar la conversación, visite con su hijo el sitio web de **FMA Live!** **fmalive.com** y explore los recursos educativos en **nasa.gov**

Con **FMA Live!** su hijo nunca verá la ciencia e ingeniería de la misma forma.

Honeywell
Hometown Solutions

NASA

FORCES IN MOTION FMA® LIVE!

THE MATERIALS IN THIS PROGRAM ALIGN WITH:

NATIONAL SCIENCE STANDARDS FOR GRADES 5-8

National Science Standards

- **Unifying Concepts and Processes**
  - Evidence, models, and explanation
  - Change, constancy, and measurement
- **Science as Inquiry**
  - Abilities necessary to do scientific inquiry
  - Understandings about scientific inquiry
- **Physical Science**
  - Motions and forces
- **Earth and Space Science**
  - Earth in the solar system
- **Science and Technology**
  - Abilities of technological design
  - Understandings about science and technology




Next Generation Science Standards for Grades 5-8

- **Space Systems: Stars and the Solar System**
  - Support an argument that the gravitational force exerted by Earth on objects is directed down.
- **Engineering Design**
  - Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
  - Generate and compare multiple possible solutions to a problem based on how well each meets the criteria and constraints of the problem.
  - Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- **Forces and Interactions**
  - Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
  - Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.
  - Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
  - Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- **Energy**
  - Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
  - Construct, use, and present arguments to support the claim that when the motion energy of an object changes, energy is transferred to or from the object.
- **Engineering Design**
  - Define the criteria and constraints of a design problem.
  - Evaluate competing design solutions.
  - Analyze data from tests to determine similarities and differences among design solutions.
  - Develop a model to generate data for iterative testing.