

universal gravitation phet lab answer key pdf

universal gravitation phet lab answer key pdf is a highly sought resource for educators and students engaged in physics education, particularly when studying the fundamental forces of nature. This article explores the significance of the Universal Gravitation PhET Lab, a popular interactive simulation tool used to visualize and understand gravitational forces. It also delves into the availability and utility of the answer key in PDF format, which serves as a valuable guide to ensure accurate comprehension and completion of the lab activities. The content covers the lab's objectives, how the simulation enhances learning, and the benefits of having a comprehensive answer key. Additionally, it discusses best practices for using the PhET Lab and integrating the answer key into classroom settings. This detailed overview will assist educators in optimizing teaching strategies and help students achieve mastery in the concepts of universal gravitation. The following sections outline the core aspects of the Universal Gravitation PhET Lab and the role of the answer key in PDF format.

- Overview of the Universal Gravitation PhET Lab
- Importance of the Answer Key PDF
- How to Use the Universal Gravitation PhET Lab Effectively
- Detailed Breakdown of Lab Activities and Expected Answers
- Benefits of the Answer Key for Students and Educators
- Best Practices for Integrating the Lab and Answer Key in Curriculum

Overview of the Universal Gravitation PhET Lab

The Universal Gravitation PhET Lab is an interactive simulation developed by the University of Colorado Boulder's PhET project. It provides an engaging platform for users to explore the principles of Newton's law of universal gravitation by manipulating variables such as mass and distance between objects. The simulation visually demonstrates how gravitational forces operate between two bodies, allowing learners to observe real-time changes in gravitational attraction. This hands-on approach aids in the conceptual understanding of gravitational interactions, which are otherwise abstract and difficult to visualize.

Key Features of the Simulation

The simulation includes adjustable parameters that enable users to vary the masses of two objects and the distance separating them. It also displays quantitative data such as force magnitude and gravitational field strength. Users can experiment with different scenarios, such as changing mass ratios or distances, to see the resulting effects on gravitational force. The visual and interactive elements make it easier to grasp the inverse-square law nature of gravity and the direct proportionality between mass and gravitational attraction.

Educational Objectives

The primary educational objective of the Universal Gravitation PhET Lab is to facilitate deeper understanding of gravitational force concepts through inquiry-based learning. It aims to:

- Illustrate the relationship between mass, distance, and gravitational force.
- Enhance comprehension of Newton's law of universal gravitation.
- Develop skills in data analysis and scientific reasoning.
- Encourage hypothesis testing and experimental design.

Importance of the Answer Key PDF

The universal gravitation phet lab answer key pdf is an essential companion to the simulation, providing educators and students with accurate solutions and explanations for the lab activities. This document ensures that learners can verify their results, clarify misunderstandings, and gain confidence in their grasp of the material. For instructors, the answer key streamlines grading and facilitates consistent feedback. It also serves as a reference guide for preparing lessons and supporting differentiated instruction.

Contents of the Answer Key PDF

The answer key typically includes:

- Step-by-step solutions to lab questions and exercises.
- Explanations of underlying physics principles related to each activity.
- Sample data tables and graphs generated from the simulation.
- Common misconceptions and troubleshooting tips.

Accessibility and Format

Being in PDF format, the answer key is easily accessible across various devices and platforms. The standardized format allows for printing, annotation, and offline use, making it convenient for classroom distribution and individual study. The file size is generally optimized to balance quality and ease of download, ensuring quick access without compromising readability.

How to Use the Universal Gravitation PhET Lab Effectively

Maximizing the learning potential of the Universal Gravitation PhET Lab requires strategic use of

the simulation in conjunction with the answer key PDF. Proper preparation, guided exploration, and reflective review are critical components of effective utilization.

Preparation and Setup

Before starting the lab, students should familiarize themselves with the interface and controls of the PhET simulation. Educators should outline learning objectives and provide clear instructions on lab procedures. Setting specific goals for each session helps maintain focus and promotes purposeful investigation.

Guided Exploration

Students should be encouraged to formulate hypotheses regarding the effects of varying mass and distance on gravitational force. Using the simulation, they can test these hypotheses by adjusting parameters and recording observations. The answer key PDF can be referenced to check accuracy and understand the rationale behind correct responses.

Data Analysis and Interpretation

Analyzing the data collected during the simulation is crucial to developing scientific reasoning skills. Students should be guided to create graphs, calculate forces using formulas, and compare their findings with theoretical predictions. The answer key provides model analyses and explanations that support this process.

Detailed Breakdown of Lab Activities and Expected Answers

The Universal Gravitation PhET Lab contains several activities designed to progressively build understanding of gravitational forces. Each activity targets specific aspects such as the effect of mass, distance, and gravitational field strength. The answer key PDF offers detailed responses to these activities to ensure correct comprehension.

Activity 1: Investigating Mass and Gravitational Force

This activity involves changing the masses of two objects to observe how gravitational force varies. Students typically note that increasing the mass of either object increases the force proportionally, consistent with Newton's equation.

Activity 2: Exploring Distance and Gravitational Force

Here, the focus is on how the distance between objects affects gravitational attraction. The answer key explains the inverse-square relationship, demonstrating that doubling the distance reduces the force to one-fourth.

Activity 3: Calculating Gravitational Fields

Students calculate the gravitational field strength around objects of different masses. The answer key provides sample calculations and clarifies the concept of gravitational fields as vectors.

Benefits of the Answer Key for Students and Educators

Utilizing the universal gravitation phet lab answer key pdf offers numerous advantages for both learners and instructors, enhancing the overall educational experience.

For Students

- Provides immediate feedback to reinforce learning.
- Clarifies complex concepts with detailed explanations.
- Supports independent study and review.
- Reduces errors and promotes accurate data interpretation.

For Educators

- Facilitates efficient grading and assessment.
- Ensures consistency in instructional content.
- Enables targeted intervention based on common difficulties.
- Enhances lesson planning with ready-made solutions.

Best Practices for Integrating the Lab and Answer Key in Curriculum

Effectively incorporating the Universal Gravitation PhET Lab and its answer key PDF into the curriculum requires thoughtful planning and alignment with learning goals.

Aligning with Standards and Objectives

Educators should map the lab activities to relevant educational standards and objectives, ensuring that the simulation complements theoretical instruction and assessments.

Encouraging Active Learning

Promoting student engagement through inquiry, experimentation, and discussion maximizes the pedagogical value of the simulation and answer key. Group work and collaborative analysis can enhance understanding.

Utilizing Formative Assessments

Regular use of the answer key for formative assessments helps monitor student progress and address misconceptions promptly, fostering a supportive learning environment.

Incorporating Technology and Accessibility

Providing access to the PhET Lab and answer key PDF via digital platforms ensures inclusivity and convenience, accommodating diverse learning preferences and needs.

Frequently Asked Questions

What is the Universal Gravitation PhET Lab?

The Universal Gravitation PhET Lab is an interactive simulation developed by the PhET project that allows users to explore the principles of Newton's law of universal gravitation by manipulating masses and distances to observe gravitational forces.

Where can I find the Universal Gravitation PhET Lab answer key PDF?

The answer key PDF for the Universal Gravitation PhET Lab is typically provided by educators or available on educational websites that host PhET activity guides, but it is not officially distributed by PhET. You may find it through teacher resource sites or by contacting your instructor.

Is there an official answer key for the Universal Gravitation PhET Lab?

PhET simulations themselves do not come with official answer keys; however, many teachers create their own answer keys or worksheets to accompany the lab. It's best to check with your instructor or educational platform for a specific answer key PDF.

How can I use the Universal Gravitation PhET Lab effectively for learning?

To use the lab effectively, experiment by changing the masses and distances between objects to see how gravitational force changes. Record observations, complete guided questions, and compare your results with Newton's law formula to deepen understanding.

Can I download the Universal Gravitation PhET Lab for offline use?

Yes, PhET offers downloadable versions of their simulations, including the Universal Gravitation Lab, which can be used offline. Visit the official PhET website to download the simulation for your operating system.

What topics are covered in the Universal Gravitation PhET Lab activities?

The lab covers topics such as Newton's law of universal gravitation, gravitational force calculations, the relationship between mass, distance, and gravity, and how these factors influence planetary motion and satellite orbits.

Are there any additional resources to help understand the Universal Gravitation PhET Lab?

Yes, in addition to the simulation, there are teacher guides, worksheets, video tutorials, and textbooks that explain the concepts behind universal gravitation. These resources can often be found on the PhET website or educational platforms like Khan Academy.

Additional Resources

1. *Exploring Universal Gravitation: Concepts and Applications*

This book provides a comprehensive overview of the principles of universal gravitation, blending theoretical explanations with practical examples. It includes detailed discussions on Newton's law of gravitation, gravitational fields, and orbital mechanics. Ideal for students and educators, the book also offers problem-solving strategies and lab activities to deepen understanding.

2. *Physics Simulations and Labs: Understanding Universal Gravitation*

Focused on integrating technology into physics education, this book explores various simulation tools including PhET labs. It guides readers through interactive experiments related to universal gravitation, helping them visualize gravitational forces and planetary motion. The text also includes answer keys and explanations to enhance learning outcomes.

3. *Newtonian Gravity and Beyond: A Student's Guide*

Designed for high school and early college students, this guide covers fundamental concepts of Newtonian gravity. It presents clear, step-by-step lab instructions, including those from popular PhET simulations, to facilitate active learning. The book also addresses common misconceptions and includes answer keys to support self-assessment.

4. *Hands-On Physics Labs: Universal Gravitation Edition*

This practical manual offers a collection of hands-on lab experiments focused on universal gravitation principles. It emphasizes inquiry-based learning and includes detailed answer keys to help students verify their results. The book is suitable for classroom use and independent study, bridging theory and experiment effectively.

5. *Interactive Physics Learning with PhET Simulations*

This resource highlights the use of PhET interactive simulations in teaching physics topics such as universal gravitation. It provides detailed walkthroughs of lab activities, offering answers and explanations to commonly asked questions. The book supports educators in creating engaging and effective lesson plans.

6. *Gravitation and Orbital Mechanics: Theory and Practice*

Covering both the theoretical framework and practical applications of gravitation, this book delves

into orbital mechanics, gravitational forces, and satellite trajectories. It includes problem sets and lab exercises with comprehensive answer keys, making it a valuable resource for students studying astrophysics and engineering.

7. Fundamentals of Universal Gravitation: A Lab-Based Approach

This textbook emphasizes learning through experimentation, focusing on universal gravitation concepts explored via lab activities. It integrates PhET simulation exercises and provides detailed answer keys to reinforce comprehension. The approach fosters critical thinking and analytical skills in physics learners.

8. Teaching Physics with Simulations: Universal Gravitation Labs

Aimed at educators, this book offers strategies for incorporating simulations like PhET into physics curricula. It includes sample lab activities on universal gravitation, complete with answer keys and assessment suggestions. The book helps teachers create interactive and student-centered learning environments.

9. Mastering Universal Gravitation: Problems and Solutions

This problem-solving guide presents a wide range of exercises related to universal gravitation, from basic concepts to advanced applications. Each chapter includes detailed solutions and answer keys, many of which reference simulation-based labs such as those from PhET. It is an excellent resource for students preparing for exams or deepening their understanding of gravitational physics.

[Universal Gravitation Phet Lab Answer Key Pdf](#)

Universal Gravitation PhET Lab: A Comprehensive Guide to Understanding Newton's Law

This ebook delves into the intricacies of the PhET Interactive Simulations' "Universal Gravitation" lab, exploring its educational value in understanding Newton's Law of Universal Gravitation, its practical applications, and how to effectively utilize the simulation for learning and experimentation. We'll analyze the simulation's features, provide step-by-step guidance for completing common lab exercises, and offer insights for maximizing its pedagogical impact. The ebook also addresses common misconceptions and provides troubleshooting advice.

Ebook Title: Mastering Universal Gravitation: A Complete Guide to the PhET Interactive Simulation

Outline:

Introduction: What is Newton's Law of Universal Gravitation? The PhET Simulation: An Overview.

Chapter 1: Exploring the Simulation Interface: Understanding the controls, variables, and data visualization tools within the PhET simulation.

Chapter 2: Investigating Gravitational Force: Detailed walkthroughs of experiments exploring the relationship between mass, distance, and gravitational force. Includes sample data analysis and interpretation.

Chapter 3: Orbital Mechanics and Kepler's Laws: Using the simulation to explore the concepts of orbital velocity, elliptical orbits, and the relationship between orbital period and distance.

Chapter 4: Advanced Applications and Extensions: Exploring more complex scenarios, including multiple bodies, escape velocity, and potential energy.

Chapter 5: Troubleshooting and Common Errors: Addressing frequently encountered problems and providing solutions for effective use of the simulation.

Chapter 6: Real-World Applications: Connecting the concepts learned in the simulation to real-world phenomena like planetary motion, satellite orbits, and tides.

Chapter 7: Further Exploration and Resources: Suggesting further learning resources, including additional PhET simulations and online tutorials.

Conclusion: Recap of key concepts and emphasis on the importance of hands-on simulations in understanding physics.

Detailed Explanation of Outline Points:

Introduction: This section establishes the foundational knowledge required to understand the simulation. It explains Newton's Law of Universal Gravitation ($F = GmM/r^2$) and introduces the PhET Interactive Simulations platform and the specific "Universal Gravitation" simulation.

Chapter 1: This chapter provides a detailed breakdown of the simulation's user interface. It explains how to manipulate the various controls (mass of objects, distance between them, etc.), how to interpret the displayed data (force, potential energy, etc.), and how to effectively use the simulation's visualization tools.

Chapter 2: This chapter guides users through a series of experiments using the simulation. It details steps for measuring gravitational force under varying conditions (changing masses and distances) and explains how to analyze the resulting data to demonstrate the inverse square law. Sample calculations and data interpretation techniques are included.

Chapter 3: This chapter builds upon the understanding of gravitational force by exploring orbital mechanics. It uses the simulation to demonstrate Kepler's Laws of Planetary Motion, showing how orbital velocity changes with distance, explaining the nature of elliptical orbits, and demonstrating the relationship between orbital period and the semi-major axis of the orbit.

Chapter 4: This chapter challenges users with more complex scenarios. This section might involve adding more celestial bodies to the simulation, calculating escape velocity, and exploring the concept of gravitational potential energy. It pushes students to apply their knowledge to more challenging situations.

Chapter 5: This chapter addresses common issues encountered by users of the simulation. It provides troubleshooting tips for technical problems, explains common misconceptions about the simulation's outputs, and offers solutions to frequently asked questions.

Chapter 6: This chapter connects the abstract concepts learned in the simulation to real-world applications. It uses examples like planetary orbits, satellite launches, and tidal forces to illustrate the practical relevance of Newton's Law of Universal Gravitation.

Chapter 7: This chapter encourages further exploration and provides links to additional learning resources. It suggests other relevant PhET simulations, online tutorials, and educational websites that can supplement the knowledge gained from using the "Universal Gravitation" simulation.

Conclusion: This section summarizes the key learning outcomes of the ebook and reiterates the importance of using interactive simulations like the PhET "Universal Gravitation" lab for enhancing understanding and engaging with complex physical concepts.

SEO Optimized Headings and Content (Example - Further expansion would be needed to create a full 1500+ word ebook):

Mastering Universal Gravitation: A Complete Guide to the PhET Interactive Simulation

Introduction: Understanding Newton's Law and the PhET Simulation

(Content explaining Newton's Law of Universal Gravitation, its formula, and an introduction to the PhET simulation. Keyword integration: Newton's Law of Universal Gravitation, PhET Interactive Simulations, gravitational force, mass, distance, inverse square law.)

Chapter 1: Navigating the PhET Universal Gravitation Interface

(Detailed explanation of the simulation interface, controls, and data visualization tools. Keywords: PhET Universal Gravitation interface, simulation controls, data visualization, mass slider, distance slider, gravitational force display, potential energy display.)

Chapter 2: Experimental Investigation of Gravitational Force

Measuring Gravitational Force: A Step-by-Step Guide

(Step-by-step instructions for conducting experiments, analyzing data, and drawing conclusions. Keywords: experimental design, data analysis, graphical representation, inverse square law, error analysis, uncertainty.)

Analyzing Data and Interpreting Results

(Detailed explanation of how to interpret the results of experiments and draw conclusions about the relationship between mass, distance, and gravitational force. Keywords: data interpretation, scientific method, conclusions, hypothesis testing, error bars.)

(Continue this pattern for remaining chapters, ensuring keyword integration throughout the text.)

Frequently Asked Questions (FAQs)

1. What is the significance of the gravitational constant (G)?
2. How does the PhET simulation handle the limitations of Newton's Law at very small or very large scales?
3. Can I use this simulation to model the orbits of more than two celestial bodies?
4. How accurate are the calculations performed within the PhET simulation?
5. What are some common errors students make when using this simulation?
6. How can I incorporate this simulation into a classroom setting?
7. Are there any alternative simulations or resources that complement the PhET Universal Gravitation lab?
8. How does the concept of escape velocity relate to the simulation?
9. What are the limitations of using a simulation to understand real-world phenomena?

Related Articles

1. Newton's Law of Universal Gravitation: A Deep Dive: A comprehensive exploration of the theory and its historical development.
2. Kepler's Laws of Planetary Motion and their Derivation: An in-depth analysis of Kepler's laws and their relationship to Newton's Law.
3. Understanding Orbital Mechanics: A Beginner's Guide: A simplified explanation of orbital concepts for beginners.
4. Escape Velocity and its Applications: A detailed discussion of escape velocity and its applications in space exploration.
5. Gravitational Potential Energy and its Role in Orbital Dynamics: An in-depth analysis of gravitational potential energy.
6. The Limitations of Newton's Law of Universal Gravitation: A discussion of the limitations of Newton's theory and the emergence of Einstein's theory of General Relativity.
7. PhET Interactive Simulations: A Teacher's Guide: A guide for educators on using PhET simulations effectively in the classroom.
8. Using Data Analysis Techniques in Physics Experiments: A comprehensive guide to analyzing

experimental data in physics.

9. Real-world applications of Newton's Law of Universal Gravitation in satellite technology: A specific exploration of the role of Newtonian gravity in satellite positioning and operation.

(Note: This is a sample framework. A complete ebook would require significantly more detailed content within each section, ensuring a total word count exceeding 1500 words. Thorough keyword research and strategic placement are essential for effective SEO.)

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universal gravitation phet lab answer key pdf: College Physics Paul Peter Urone, Urone, 1997-12

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the requisite administrative and institutional aspects of online and distance teaching, and the relevant educational theory. Delivery of university-level courses through online and distance education is a method of providing equal access to students seeking post-secondary education. Distance delivery offers practical alternatives to traditional on-campus education for students limited by barriers such as classroom scheduling, physical location, finances, or job and family commitments. The growing recognition and acceptance of distance education, coupled with the rapidly increasing demand for accessibility and flexible delivery of courses, has made distance education a viable and popular option for many people to meet their science educational goals.

universal gravitation phet lab answer key pdf: University Physics Samuel J. Ling, Jeff Sanny, William Moebs, 2017-12-19 University Physics is designed for the two- or three-semester calculus-based physics course. The text has been developed to meet the scope and sequence of most university physics courses and provides a foundation for a career in mathematics, science, or engineering. The book provides an important opportunity for students to learn the core concepts of physics and understand how those concepts apply to their lives and to the world around them. Due to the comprehensive nature of the material, we are offering the book in three volumes for flexibility and efficiency. Coverage and Scope Our University Physics textbook adheres to the scope and sequence of most two- and three-semester physics courses nationwide. We have worked to make physics interesting and accessible to students while maintaining the mathematical rigor inherent in the subject. With this objective in mind, the content of this textbook has been developed and arranged to provide a logical progression from fundamental to more advanced concepts, building upon what students have already learned and emphasizing connections between topics and between theory and applications. The goal of each section is to enable students not just to recognize concepts, but to work with them in ways that will be useful in later courses and future careers. The organization and pedagogical features were developed and vetted with feedback from science educators dedicated to the project. VOLUME II Unit 1: Thermodynamics Chapter 1: Temperature and Heat Chapter 2: The Kinetic Theory of Gases Chapter 3: The First Law of Thermodynamics Chapter 4: The Second Law of Thermodynamics Unit 2: Electricity and Magnetism Chapter 5: Electric Charges and Fields Chapter 6: Gauss's Law Chapter 7: Electric Potential Chapter 8: Capacitance Chapter 9: Current and Resistance Chapter 10: Direct-Current Circuits Chapter 11: Magnetic Forces and Fields Chapter 12: Sources of Magnetic Fields Chapter 13: Electromagnetic Induction Chapter 14: Inductance Chapter 15: Alternating-Current Circuits Chapter 16: Electromagnetic Waves

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years, science educators have greatly increased their use of modeling in teaching, especially real-time dynamic modeling, which is central to a scientific investigation. Modeling in science teaching is being used in an array of fields, everything from primary sciences to tertiary chemistry to college physics, and it is sure to play an increasing role in the future of education. Models and Modeling: Cognitive Tools for Scientific Enquiry is a comprehensive introduction to the use of models and modeling in science education. It identifies and describes many different modeling tools and presents recent applications of modeling as a cognitive tool for scientific enquiry.

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universal gravitation phet lab answer key pdf: *3D Immersive and Interactive Learning* Yiyu Cai, 2013-02-12 3D technology is not new; research on 3D started back in early 1960s. But unlike in previous times, 3D technology has now rapidly entered our daily life from cinema to office to home. Using 3D for education is a new yet challenging task. This book will present several innovative efforts using 3D for immersive and interactive learning covering a wide spectrum of education including gifted program, normal (technical) stream, and special needs education. The book will also share experience on curriculum-based 3D learning in classroom setting and co-curriculum-based 3D student research projects. The book is organized as follows. Chapter 1 introduces the fundamentals of 3D educational technology and their applications in immersive and interactive learning. Chapter 2 discusses the use of virtual reality in teaching and learning of Molecular Biology. Chapter 3 presents the daVinci Lab @ River Valley High School. Chapter 4 describes the 3D education development process. Chapter 5 studies the adaption 3D system for learning gains in lower secondary normal (technical) stream. Chapter 6 investigates the effects of virtual reality technology on spatial visualization skills. Chapter 7 showcases a sabbatical program for students to use 3D for Science, Technology, Engineering and Mathematics (STEM) learning. Chapter 8 shares the use of 3D virtual pink dolphin to assist special education. The foreword of this book is written by Dr Cheah Horn Mun, Director, Education Technology Division, Ministry of Education, Singapore.

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of the solar system. "As you turn through the pages, you're hit with true moments of awe, photos that remind you the power of nature extends beyond our own planet." —Houston Chronicle
"Breathtaking pictures show the otherworldly magic of the solar system . . . The images are at once humbling and uplifting: Here in the black void of space is Saturn's frozen moon, Mimas, white and pitted like a galactic golf ball; here is the tiny golden orb called Io, casting a shadow in a perfect inky circle on the marbled surface of Jupiter; here is the great sun, flames spurting from its surface like plumes." —The Wall Street Journal "[A] gorgeous photographic tour of space . . . The collection is a remarkable reminder of how much has been learned about the planets over the past few decades, solving many mysteries yet introducing many more." —Publishers Weekly

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Randall Dewey Knight, 2007

universal gravitation phet lab answer key pdf: Playing the Quantum Field Brenda Anderson, 2010-10-05 Do you often feel you are at the mercy of external forces in your life? If so, this book is for you. Playing the Quantum Field demonstrates that you have the power to shape your own life, showing how your very next choice can change struggle into play. Brenda Anderson presents a fresh approach to everyday life based on the premise that everyone and everything in the universe are interconnected, and she shows you how to play the quantum field to create success and joy at home or on the job. She posits that the old rules no longer apply and presents a new set of rules, which include ten energetic choices you can make to take control of your life and move into what she calls the Power Zone. Once you grasp how easy it is to move among the choices along the energy spectrum, each day will become a dynamic, empowering exploration of the unlimited potential of the Field.

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biology, and closer collaboration with physical, computational, and earth scientists, mathematicians and engineers-be used to find solutions to four key societal needs: sustainable food production, ecosystem restoration, optimized biofuel production, and improvement in human health. The approach calls for a coordinated effort to leverage resources across the federal, private, and academic sectors to help meet challenges and improve the return on life science research in general.

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special education teachers need strategies to support, instruct and engage students with disabilities in STEM education. Students in U.S. schools are academically behind their international peers in STEM areas. Currently, the United States ranks 17th in science and 25th in mathematics among other nations (National Center for Education Statistics, 2011). In the field of engineering, college programs in China and India graduated many more engineers than in the U.S. (Gereffi, Wadhwa, Rissing, & Ong, 2008). For example, in 2011, China's engineering graduates totaled one million (Shammas, 2011), as compared to colleges in the U.S. which graduated 84,599 engineers (Deffree, 2012).

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