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## Georgia Performance Standards Framework for Science – Physics

### **Unit One Organizer: “Forces”** **(Approximate Time 7 weeks)**

**OVERVIEW:** This unit provides the students with an opportunity to develop an understanding of the physical ideas and concepts that were developed during the seventeenth century by Sir Isaac Newton. Throughout the unit the students are constantly asked to explain familiar phenomena and situations by utilizing the concepts of force, momentum, work, mass, acceleration, and velocity. Furthermore, embedded in the unit is the goal of strengthening skills that allow students to be able to read popular scientific literature and write scientific papers.

This unit has a strong emphasis on students doing science by providing multiple opportunities for them to measure and observe different phenomena through laboratory settings or classroom activities. Furthermore, the unit takes the students on a fast trip towards the contemporary understanding of the different forces that shape our universe and to think about scenarios on how the universe would look if one of those forces were not present. The importance of making this connection is to prepare students for a deeper understanding of how our universe is put together not just at the macroscopic level (understanding of stars, solar systems and galaxies) but also at the microscopic level (understanding of atomic interactions that make the things that we commonly use work).

The culminating activity gives the students the opportunity to use their understanding of the concepts studied thorough out the unit to proposed solutions to some of the challenges that future engineers and architects will have to solve as they design and build structures on the Moon or Mars.

### **STANDARDS ADDRESSED IN THIS UNIT**

#### **Focus Standard:**

#### **SP1. Students will analyze the relationships between force, mass, gravity, and the motion of objects**

- a. Measure and calculate the magnitude of frictional forces and Newton’s three Laws of Motion.
- e. Measure and calculate the magnitude of gravitational forces.
- g. Measure and calculate centripetal force.
- h. Determine the conditions required to maintain a body in a state of static equilibrium.

#### **SP3. Students will evaluate the forms and transformations of energy.**

- c. Measure and calculate the vector nature of momentum.
- e. Demonstrate the factors required to produce a change in momentum.

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### **Supporting content Standards**

**SP6. The students will describe the correction to Newtonian physics given by quantum mechanics and relativity when matter is very small, moving fast compared to the speed of light, or very large.**

- d. Describe the gravitational field surrounding a large mass and its effect on a ray of light.

**SP2. Students will evaluate the forms and transformations of energy.**

- a. Analyze, evaluate, and apply the principle of conservation of energy and measure the components of work-energy theorem by
  - describing total energy in a closed system.
  - identifying different types of potential energy.
  - calculating kinetic energy given mass and velocity.
  - relating transformations between potential and kinetic energy.
- b. Explain the relationship between matter and energy.

**SP1. Students will analyze the relationships between force, mass, gravity, and the motion of objects.**

- a. Calculate average velocity, instantaneous velocity, and acceleration in a given frame of reference.

### **Characteristics of Science Standards**

**SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.**

- a. Exhibit the above traits in their own scientific activities.
- b. Recognize that different explanations often can be given for the same evidence.
- c. Explain that further understanding of scientific problems relies on the design and execution of new experiments which may reinforce or weaken opposing explanations.

**SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.**

- a. Follow correct procedures for use of scientific apparatus.
- b. Demonstrate appropriate technique in all laboratory situations.
- c. Follow correct protocol for identifying and reporting safety problems and violations.

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### **SCSh3. Students will identify and investigate problems scientifically.**

- a. Suggest reasonable hypotheses for identified problems.
- b. Develop procedures for solving scientific problems.
- c. Collect, organize and record appropriate data.
- d. Graphically compare and analyze data points and/or summary statistics.
- e. Develop reasonable conclusions based on data collected.
- f. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

### **Characteristics of Science Standards (continuation)**

### **SCSh4. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.**

- a. Develop and use systematic procedures for recording and organizing information.
- b. Use technology to produce tables and graphs.
- c. Use technology to develop, test, and revise experimental or mathematical models.

### **SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.**

- a. Trace the source on any large disparity between estimated and calculated answers to problems.
- b. Consider possible effects of measurement errors on calculations.
- c. Recognize the relationship between accuracy and precision.
- d. Express appropriate numbers of significant figures for calculated data, using scientific notation where appropriate.
- e. Solve scientific problems by substituting quantitative values, using dimensional analysis and/or simple algebraic formulas as appropriate.

### **SCSh6. Students will communicate scientific investigations and information clearly.**

- a. Write clear, coherent laboratory reports related to scientific investigations.
- b. Write clear, coherent accounts of current scientific issues, including possible alternative interpretations of the data.
- c. Use data as evidence to support scientific arguments and claims in written or oral presentations.
- d. Participate in group discussions of scientific investigation and current scientific issues.

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### **The Nature of Science Standards**

#### **SCSh7. Students will analyze how scientific knowledge is developed.**

- a. The universe is a vast single system in which the basic principles are the same everywhere.
- b. Universal principles are discovered through observation and experimental verification.
- c. From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Major shifts in scientific views typically occur after the observation of a new phenomenon or an insightful interpretation of existing data by an individual or research group.
- d. Hypotheses often cause scientists to develop new experiments that produce additional data.
- e. Testing, revising, and occasionally rejecting new and old theories never ends.

#### **SCSh8. Students will understand important features of the process of scientific inquiry.**

Students will apply the following to inquiry learning practices:

- a. Scientific investigators control the conditions of their experiments in order to produce valuable data.
- b. Scientific researchers are expected to critically assess the quality of data including possible sources of bias in their investigations' hypotheses, observations, data analyses, and interpretations.
- c. Scientists use practices such as peer review and publication to reinforce the integrity of scientific activity and reporting.
- d. The merit of a new theory is judged by how well scientific data are explained by the new theory.
- e. The ultimate goal of science is to develop an understanding of the natural universe which is free of biases.
- f. Science disciplines and traditions differ from one another in what is studied, techniques used, and outcomes sought.

### **Reading Standard**

#### **SCSh9. Students will enhance reading in all curriculum areas by:**

- a. Reading in all curriculum areas
  - Read technical texts related to various subject areas.
- c. Building vocabulary knowledge
  - Demonstrate an understanding of contextual vocabulary in various subjects.
  - Use content vocabulary in writing and speaking.
  - Explore understanding of new words found in subject area texts.
- d. Establishing context
  - Explore life experiences related to subject area content.

Determine strategies for finding content and contextual meaning for unknown words.

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### ENDURING UNDERSTANDINGS

1. Newton's laws are the expression of the relationships of forces, mass and motion.
2. Acceleration has a direct relationship to force and an inverse relationship to mass.
3. Mass is a measure of the inertia of an object. An equivalent statement is mass is the amount of matter of which an object is made.
4. Weight is defined as of the force of gravity on an object.
5. In order for work to be done on an object, movement must occur in the direction of a net force.
6. Friction can exist between objects that are not moving with respect to each other (static) as well as between objects that are moving (kinetic) unless it is a frictionless environment.
7. Net force is the vector sum of the applied forces on an object.
8. Momentum is a vector quantity that is directly proportional to the product of the mass and the velocity of an object.
9. Centripetal force is a force that keeps an object traveling in a circular path.
10. Torque is an angular equivalent of force and is a vectorial quantity.
11. An object is in equilibrium when the sum of forces acting on it is zero.
12. An object is in static rotational equilibrium when the sum of torques acting on it is zero.
13. A gravitational force exists between any two masses. The magnitude of this force is directly proportional the product of the two masses and inversely proportional to the square of the distance between the centers of the two masses.
14. Gravity is a force.
15. Light in space is affected by a gravitational field.
16. The velocity of an object in a circular trajectory is always changing. Therefore the object is accelerating.
17. The momentum of a particle changes if a force acts on it for some length of time. The product of this force times the time that the force acts on the object is called the impulse.

## Georgia Performance Standards Framework for Science – Physics

### ESSENTIAL QUESTIONS:

1. Why do objects start or stop moving?
2. How is it that we stay on the surface of the Earth instead of being crushed against it by the force of gravity or fly into space?
3. Why is friction a good thing and bad thing for motion when motion occurs?
4. Why don't structures like buildings and towers collapse?
5. Why does work require motion?
6. How does an object's momentum affect a collision?
7. Why do you stay in your seat on a roller coaster when it goes upside down in an inverted loop?
8. How does torque affect motion?

### CONCEPTS:

Newton's first law, Newton's second, and Newton's third law, momentum, impulse, friction, centripetal force, acceleration, frequency, period, torque, static equilibrium, Newton's law of universal gravitation, work, center of gravity, equilibrium, normal force, tangential velocity, angular velocity, acceleration, mass, matter, work, weight.

### LANGUAGE:

Resultants, equilibrants, clockwise torque, counterclockwise torque, lever arm, significant figures, calculate, experiment, precision measure, accuracy, SI units, describe, scientific notation, conclusion, hypothesis, data, contrast, compare, variable, infer, analyze, predict, interpret, percent difference, static friction, kinetic friction, coefficient of friction, vector quantity, scalar quantity.

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### EVIDENCE OF LEARNING:

By the conclusion of this unit, students should be able to demonstrate the following competencies:

**Culminating Activity:** Have students work in small groups. Provide the students with the handout “Constructing a Bridge” and ask them to design a bridge. Have the students draw their plans on large sheets of paper and begin the building of their models. The students should write a short paper explaining their design.

#### Constructing A Bridge

##### Introduction:



##### **What's the secret of suspension?**

A suspension bridge's cables are beautiful to look at, but they also enable the bridge to cross large spans. Make a model suspension bridge to see how it works.

##### **Materials:**

drinking straws  
masking tape  
dental floss or thread  
scissors  
large paper clips  
construction paper

##### **Procedure:**

Design a scale model of the Akashi Kaikyo Bridge between Kobe and Awaji-shima. The Akashi Kaikyo Bridge central span is 1991 meters long while the two spans at each side are 960 meters long. The width of the deck is 35.5 meters.

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**Explain It**

Using construction paper, identify the position of the forces acting the loaded suspension bridge. Which parts of the bridge are in compression? Which parts are in tension?

**Build on It**

Can you design and build a straw suspension bridge that spans a gap twice as wide and supports the same amount of weight? What parts of the bridge design need to change? Try it.

**EVIDENCE OF LEARNING (continuation):**

Construction in Space

**Building a Bridge in Mars**

**Instructions:**

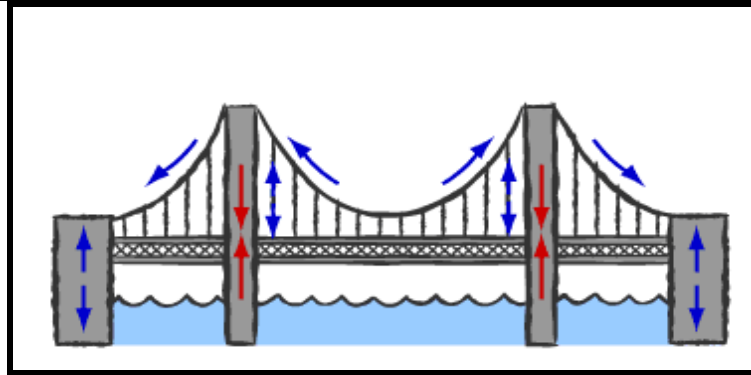
Use the information on the largest built bridge on Earth, the Akashi Kaikyo Bridge between Kobe and Awaji-shima Japan to design an equivalent bridge on Mars. Remember, that the gravity on Mars is just 0.375 the gravity on Earth.

Earth's Largest Bridge

On all suspension bridges the roadway hangs from massive steel cables, which are draped over two towers and secured into solid concrete blocks, called anchorages, on both ends of the bridge. The cars push down on the roadway, but because the roadway is suspended, the cables transfer the load to the two towers. The two towers support most of the bridge's weight.



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The Akashi Kaikyo Bridge central span is 1991 meters long while the two spans at each side are 960 meters long. The width of the deck is 35.5 meters. The weight per meter square of the bridge structure and deck is  $1282.05 \text{ N/m}^2$ . The main materials used in the construction were steel and cement.

### Mars Bridge

How would you scale the parameters of the largest bridge on Earth to build a bridge that will allow you to cross one of Mars regular size canyons? The canyon in question is Loire Valles. The Loire Valles is about 704 kilometers long (the Grand Canyon of Arizona is about 480 kilometers long) and in some place as much as 96 kilometers wide.

1. How far apart would your support towers will have to be to support the weight of the Martian bridge?
2. How many towers would you need to build?
3. Suppose that you are able to build the bridge using the same materials used on Earth. What concerns would you have about the stability of these materials?

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<b>MISCONCEPTIONS AND PROPER CONCEPTIONS</b>	
<b>MISCONCEPTIONS</b>	<b>PROPER CONCEPTIONS</b>
Motion follows the path of the stronger force on an object.	The direction of motion of an object is dictated by the direction of the net force in combination with the direction of the pre-existing motion.
Action-reaction forces act on the same object.	The paired action-reaction forces act on different objects.
All object can be moved with equal ease in the absence of gravity	To change the state of motion or rest of an object a force proportional to its mass must be applied.
Faster moving objects have larger forces acting on them; slower moving objects have smaller forces acting on them.	For objects of the same mass, acceleration will vary directly with an applied force. Changes in velocity are proportional to the force, but the actual velocity is not proportional to the force.
If the acceleration is zero, there is no force.	If the acceleration is zero, the net force is zero.
The normal force on an object is equal to the weight of the object.	The normal force on an object is equal to the weight of the object only if it's on a horizontal surface.
Equilibrium means all the forces on an object are equal.	Equilibrium means the sum of all the forces is zero.
Once an object is moving, objects with greater mass push more than objects with less mass.	Once an object is moving, objects with greater change in momentum push more than objects with less change in momentum. The pushing depends on mass and velocity and the rate at which they change.
Newton's third law is not always true.	Newton's third law is always true.
The Moon is not experiencing free fall.	Because the Moon is attracted by Earth's gravitational force, the Moon is free falling towards Earth. However, due to the Moon's orbital velocity, the moon revolves around the Earth on a nearly circular orbit.

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MISCONCEPTIONS AND PROPER CONCEPTIONS (continuation)	
MISCONCEPTIONS	PROPER CONCEPTIONS
The force that acts on apple that falls to the ground is not the same as the force that acts on the moon.	The same gravitational force that makes the apple fall attracts the Moon towards Earth.
Gravitational force is the same on all falling bodies.	Gravitational force (weight) varies inversely with the square of the distance between the centers of the two masses and the force is directly proportional to the mass of the object falling. However, the gravitation is the same.
Gravitational forces do not exist in space.	Gravitational forces do exist in space. The gravitational force varies as the inverse of the square of the distance from the object. Therefore, as objects move away from Earth the gravitational force becomes smaller and smaller both does not completely disappears. For example the reason that planets orbit stars is the gravitational attraction that the stars exert on the planets.
An object moving in a circle with constant speed has no acceleration.	Acceleration is the rate of change of velocity and velocity is a vector. In a circular motion the <i>direction</i> of the velocity is always changing, hence there is always acceleration.
An object moving in a circle will continue in circular motion when released.	Once released, the object will initially move in a trajectory tangential to the original circular path according to Newton's First Law.
Light always travels in straight lines.	Light can be bent by the action of the gravitational field of a very massive object.
Weight and mass are the same.	Weight is a force that is the gravitational force on object. Mass is the amount of matter of an object.

## Georgia Performance Standards Framework for Science – Physics

### TASKS

The collection of the following tasks represents the level of depth, rigor and complexity expected of all students to demonstrate evidence of learning.

**Task:**

**Description:**

**Discussion, Suggestions for use:**

**Possible Solution :**

### SAMPLE OF STUDENT WORK