Reduced Gravity Education Flight Week Opportunity

Johnson Space Center

Teaching From Space (TFS), a NASA Education office, is seeking high quality applications from teams of K-12 educators who desire to participate in a Reduced Gravity Flight Week program offered through a joint project between NASA Johnson Space Center's (JSC) Reduced Gravity Education Flight Program and TFS. NASA reduced gravity flight experiences offer educators the opportunity to propose, design and fabricate a reduced gravity experiment of their choice; fly the experiment; conduct research in a microgravity environment; and evaluate the results of the experiment.

Fourteen teams of 4-5 educators from a single school or school district will be selected from this application process to travel to JSC in Houston, TX, to participate in the Reduced Gravity Flight Week **June 24 – July 2, 2011**, and fly their own experiments aboard NASA's Reduced Gravity Aircraft. All participants must be **current K-12 classroom teachers and U.S. citizens.**

Selected participants will begin their involvement with the project beginning in April 2011 by participating in a series of web seminars and initiating work on creating their experiment with NASA. Post-flight participation activities occur through Fall 2011. **Applications for participation in this Flight Week are due on March 14, 2011.**

NASA is interested in teams composed of teachers from:

- Different schools within a district
- Different grade levels and/or
- Different subject areas

Additional consideration will be given to teams composed of all first-time fliers.

About the Application

The purpose of the application is for you to provide NASA with the relevant information needed to evaluate your proposed experiment and other pertinent details. All prospective teams must submit a completed application to jsc-rgeducator@mail.nasa.gov no later than 11:59pm Pacific on **March 14, 2011.**

- Respond to **every item** on the application. Do not leave items blank. Do not change the format of the application. Incomplete applications will not be considered.
- A committee evaluates applications during a formal review process. Final scores will be primarily based on technical (60%) and outreach (30%) components. An additional 10% of the score will be based on team composition (see above). Following the review, teams will be informed of the evaluation committee's decision. If your team is selected to participate in the Flight Week, you will be provided with additional contact information and instructions.
- Participants are required to submit evaluation forms to the NASA Office of Education Performance Measurement (OEPM) system. TFS will provide evaluation forms or online links for each participant.

For more information or questions regarding the application, please contact jsc-rgeducator@mail.nasa.gov

Teaching From Space Flight Week Application

Overclocking a Pendulum

Simple Harmonic Motion in a simple pendulum

FIRST Team 246 Overclocked

Boston University Academy
One University Road, Boston , MA
Phone:617-353-9000
Fax:617-353-8999

<table>
<tr><td colspan="2">Team Lead Contact Information (Flyer 1)
Name: Gary Garber
School: Boston University Academy
Grade(s) Taught: 9-12
Subject(s) Taught: Physics, Astronomy, Engineering, Math, Senior Thesis Research, Junior STEM Research Seminar
Email: Gary_Garber@buacademy.org
Phone: 617-353-9000</td></tr>
<tr><td>Flyer 2 Contact Information
Name: Rose White
School: Boston University Academy
Grade(s) Taught: 9-12
Subjects Taught: Chemistry, Forensics, Senior Research
Email: Rose_White@buacademy.org</td><td>Flyer 3 Contact Information
Name: James Berkman
School: Boston University Academy
Grade(s) Taught: 9-12
Subjects Taught: English, Senior Thesis Research
Email: James_Berkman@buacademy.orgs</td></tr>
<tr><td>Flyer 4 Contact Information
Name: Laurie Glenn
School: Boston University Academy
Grade(s) Taught: 9-12
Subjects Taught: Latin, Greek
Email: Laurie_Glenn@buacademy.org</td><td>Alternate Flyer Contact Information (OPTIONAL)[1]
Name: Nick Dent
School: Boston University Academy
Grade(s) Taught: 9-12
Subjects Taught: Math, Physics, Computer Science
Email: nick_dent@buacademy.org</td></tr>
</table>

If a team member has previously flown on a Reduced Gravity Flight, please identify the team member(s) with an asterisk (*) and provide the date of the program below.

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Click here to enter text.

[1] Teams may consist of four flyers and one alternate flyer. Should a primary member of the flight team be unable to fly, the alternate may take their place on the flight crew. Teams do not have to have an alternate flyer.

By signing this document, you are indicating that you are a citizen of the United States and currently hold a position as a K-12 classroom teacher. You are also agreeing to the following terms:

- I understand that I am not guaranteed a flight onboard the reduced gravity aircraft. Many factors, such as aircraft maintenance and weather, could prevent a flight from occurring.
- I understand that I will be part of the school or school district's flight team at JSC's Ellington Field. I will fully participate in all scheduled events.
- I understand that I could be denied the opportunity to fly after arriving at JSC if I do not pass on-site physiological training requirements.
- I understand that, if selected to fly, I am required to participate in a series of pre- and post-flight web seminars as part of this opportunity.

Please have each team member sign and date below. Signatures may be electronic (i.e. scanned into the document).

____

Team Lead/Flyer 1

____

Flyer 2

____

Flyer 3

____

Flyer 4

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____

Alternate Flyer

The Experiment/Investigation

1. How did your team come up with this investigation?

We discussed various ideas among ourselves and with the students and with consultation of some mechanical engineering professors at Boston University. One of the professors gave us his acceleration data from a KC-135 flight which he used for his own experiments to be a basis for our work. The students who we had the discussion with are all members of the Boston University Academy robotics team, which is a FIRST robotics team, called Overclocked. Overclocking refers to running a computer component at a higher speed than it was designed for. The students thought it is interesting that one could "overclock" a pendulum by running it in hyper-gravity.

2. What scientific concepts are being tested?

Does the period of a pendulum in simple harmonic motion depend on gravitational acceleration as predicted by theory? How does the acceleration change as the pendulum swings? What affect does changing g have on the conservation of energy in the enclosed system?

3. How is gravity a variable relevant to this investigation?

Gravity will affect the period of a pendulum, and the acceleration of the pendulum. Gravity is well known as a variable is the small angle approximation for a pendulum, and continues to be a roll for the large angle approximation.

4. List the tasks or phases of the project and explain how students will be involved (Examples: building the experiment, scientific research, planning a trip to Houston, post-flight analysis, publishing final report).

Members of the Boston University Academy FIRST Robotics team will build the experiment in our machine shop. They will come up with a list of items which need to be ordered from MSC Direct, McMasterCarr, and Vernier Software. We will need to order some bearings, but much of the remaining parts of the experiment will be built with VEX and Tetrix structural aluminum robotics kit parts. After the investigation, they will be responsible for producing MP4 files for distribution on the student web-sites, blogs, etc. Both of these tasks are routinely done by the students on the robotics team. The students in 9th grade physics at the Academy will perform a video analysis of this experiment using Vernier LoggerPro. This will integrate well into our physics program. Normally, in our unit on Simple Harmonic motion, the students use motion sensors, force probes, and accelerometers from Vernier to analyze SHM. The students in our math classes will analyze the approximations involved in the small angle approximation for the pendulum and how this related to the extended Taylor series approximation.

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5. Describe your testing procedure. What steps will you perform when the plane is in free fall (0 g)? What steps will you perform when the plane is in hyper-gravity (2 g)?

We will examine a series of pendulums. There is a series of several simple pendulum experiments.
For all experiments, the key element is to take video footage of the experiment with visible accelerometer data in the video screen. The students will do post-lab analysis with LoggerPro to measure the period of the pendulums. However, as the accelerometer data will be displayed in the video frame, students from other schools could use other software such as ***LabView*** or ***Physics Glasses*** to analyze the experiment.

1. The main pendulum will have a 3-axis Vernier accelerometer attached. The pendulum will be a string pendulum. The 3-axis Vernier accelerometer will take acceleration data as the pendulum swings. The readings on the accelerometer change even in a land based experiment as the pendulum swings. The acceleration data will be collected with a portable Vernier LabPro unit and downloaded onto a laptop between trials.
2. This experiment with the 3 axis accelerometer will be repeated with a rigid rod pendulum. Not only does the rigid rod change the moment of inertia of the system (and thus the equations for the period of the pendulum) but the rigid rod will allow additional analysis in zero-g. The rigid rod experiment will be attached with industrial level bearings to allow free motion in 360 degrees around the axle.
3. The secondary experiment will consists of three rigid rod pendulums all with bobs of different lengths. Again, the rigid rods will be attached with bearings allowing for 360 degree motion. There will be no accelerometers attached. This will add a further variable for analysis for the students to compare. Ideally, the pendulums will all swing at the same time. One open ended question for the students to predict will be what will the 360 degree circular motion period of the rigid rod pendulums. Does gravity have an effect on the circular motion period? Does length have an effect on this period?
4. A fourth variable will be to run the three rigid rod pendulums with the same length but different masses. How does this affect the period in hyper-g. How does this affect the micro-g period?
5. A fifth experiment will be to observe if the pendulum is already in motion during the 1-g portion of the flight, what happens to motion when it transition to the hyper-g or micro-g portion? How does this depend on the boundary conditions such as the length of the transition between sections of flight?

6. What do you expect will happen (hypothesis)?

During hyper g, the period of the pendulums should be reduced. Additionally, the measurements made by the accelerometers should be proportionally increased.
During micro-g, the rigid rod pendulums may continue to move 360 degrees around the rods. The accelerometer values should decrease.
The observations of what happens to the pendulum when it transitions between 1-g, low g, and hyper –g will vary with at what stage the pendulum is at during its swing. If at the lowest part where energy is all kinetic, the energy will be conserved. If at the highest point, where the energy is all gravitational potential energy, the energy of the system will be reduced.

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7. How will you utilize this opportunity in your classroom and/or school and how does/will it support your classroom and/or school goals?

The students on my robotics team will build and assemble all of the parts for this experiment in our machine shop. We have a stockpile of bearings, rods, and couplings which will be used.

The actual analysis of the data will be performed by students in the physics classroom using the same software they use to analyze Earth based experiments. Physics is taught in 9th grade at our school. In our classroom, the students use Vernier ultrasonic motion sensors, accelerometers, and force probes in their experiments. They use Vernier LoggerPro software to analyze the motion of springs and pendulums. This will be merely an exciting addition to experiments the students at my school have already been performing for several years. Using video analysis will only be an extension of what we are doing with other physics experiments such as measuring g of falling pumpkins (from the roof of the Physics Department) on Halloween.

This will support the goals of the students on the BUA FIRST robotics team, which is to publicize the projects that BUA FIRST students are doing when they are not building robots. Some of the other off season projects my students have worked on have included building a water filter and bicycle powered generator for the local chapter of Engineers Without Borders and refurbishing a large piece of Kinetic Art by famous Artist George Rhoads.

8. How will the success of this opportunity be measured in the classroom and/or school and what criteria will be used to measure this success?

The success of this opportunity will be measured by the student work on lab reports to analyze the video stream data. I have attached two example lab reports that students have written on ground based SHM experiments. We will use Google Analytics to determine how many hits we are getting for our posted video files and lesson plans.

9. Please provide a sample lesson plan related to your experiment/investigation that team members could use in the classroom to get students involved. You may attach the lesson plan as an addendum to this application.

See attached examples of lab reports and lesson plans

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Outreach Efforts

It is required that selected flight team members disseminate information about their experience to their community and other education professionals. Flight Week participants also engage in a series of web seminars and online community experiences to present and share their results with their peers and communities.

1. How will the community be involved with this investigation/experiment? What steps will you take to ensure their involvement?

Members of the Boston University Academy Robotics Team will design and build all of the equipment for this experiment. This includes 40 high school students (1/4 of the entire school) and several BU engineering undergraduate students who act as mentors. The analysis will be required of the entering physics students at Boston University Academy in the fall. In his reflections on this experience, James Berkman, our head of school and English teacher plans to write three poems about our adventure: One a Shakespearean sonnet form, one a Haiku form, and one free (from gravity) form. These will be shared with the larger University community and in particular his English classes. Ms. Glenn will write a comparison of our adventures with the flight of Icarus to be discussed with our students who all study ancient classical history and Latin or Greek. We are collaborating with the Tufts University Center for Education Engineering and Outreach for software other than LoggerPro which could be used to analyze the experiment. This will open up the experience to a larger audience.

2. Upon completion of this opportunity, how will you share this experience and information with other educators and the community (Examples: in-service opportunities, production of video, presentation at workshops)?

As a board member of the New England Section of the American Association of Physics Teachers, I am involved with the planning of local science conferences, and thus will be able to arrange to present on this experience. I am co-chair of the AAPT Physics Day at the Eastern Regional National Science Teachers Association conference in October in Hartford. I am also co-chair of the New England AAPT Fall Conference in September in Massachusetts. Thus I will make arrangements for presentations and/or hands on workshops to analyze the data. I will make arrangement for a link to the video footage room the New England Section of the AAPT web-site. The video footage will also be posted my site on iTunes University, on my blog and on YouTube. We will also post the video footage on our robotics team web site along with the lesson plans. Since we plan to use Vernier products, we will ask to post the video footage and lesson plans on their web site where they have a section for innovative uses of their products. The experience will be shared with the entire Boston University community through the BU TODAY web-site. An experience such as this would also be highlighted in the Boston University magazines and publications, and WBUR (and NPR affiliate). James Berkman, has been a head of school for over 20 years and frequently speaks at national Independent School Conferences, which gives his opportunities to share this experience.

3. List all names of anticipated volunteers and partners that may help during the entire process. Include any educational, community or business-related partnerships that may be used to support or enhance your investigation. Please also list the reason for including the person/organization/business. Note: These

partnerships are only included as support. The students, flight team and NASA mentor (each selected team will be assigned a NASA mentor) should perform the investigation, design, development and construction.

The Boston University College of Engineering will be used as a support for this investigation. Boston University Academy is a unique high school which takes advantage of its hybrid nature as a high school embedded in a major research university. This project was developed with consultation with Mechanical Engineering Professor Glynn Holt, a former NASA Shuttle Astronaut (mission specialist) whose work with bubbles has flown on KC-135 flights. Several of my students each year work with Professor Theodore Fritz for the BU Student Satellite Applications and Training Project each year who we are also consulting. The College of Engineering also lets Boston University Academy have its own machine shop which it uses for our FIRST Robotics Team. This is where the device for this investigation will be constructed. The Boston University Public Relations office will help us to publicize this investigation. The BU IT department will help us to post the appropriate files onto iTunes University and perform Google Analytics to keep track of the success of our postings. The Tufts University Center for Engineering Education and Outreach will assist us with software for doing Video Analysis.

4. Please provide contact information for your school district's public information office. If there is a primary point of contact, please include their name, email and phone number.

Katey Sullivan, Katey_Sullivan@buacademy.org 617-353-9000

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Letter of Commitment
Support from your school and/or district administration is extremely important to the success of this project. A letter from your school or district's administrator(s) stating support for the items below must be sent in as part of the application. Applications are considered incomplete without a Letter of Commitment. It is understood that the school and/or district will:

- be responsible for funding substitute teachers for all flight team members including the alternate while participants are in Houston if the Flight Week dates conflict with the school's in-session calendar. (This Flight Week is June 24 – July 2, 2011.)

- be responsible for securing funding for the hardware construction and any necessary costs of shipping the investigation to Houston.

- provide additional planning time for those involved with this opportunity, if possible.

- provide some release time for the team members to conduct professional development sessions for local/regional teachers and community programs as well as to participate in online professional development and dissemination activities.

- coordinate media relations/outreach with NASA's Public Affairs Office and the local school system's Public Information Office.

Please ensure that the single Letter of Commitment covers all flight team members and all items listed above. If necessary, please attach additional Letters of Commitment from team member's schools to ensure all items and team members are covered.

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By signing this document, you are indicating that you are a citizen of the United States and currently hold a position as a K-12 classroom teacher. You are also agreeing to the following terms:

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- I understand that I will be part of the school or school district's flight team at JSC's Ellington Field. I will fully participate in all scheduled events.
- I understand that I could be denied the opportunity to fly after arriving at JSC if I do not pass on-site physiological training requirements.
- I understand that, if selected to fly, I am required to participate in a series of pre- and post-flight web seminars as part of this opportunity.

Please have each team member sign and date below. Signatures may be electronic (i.e. scanned into the document).

3/8/11
Team Lead/Flyer 1

3/8/11
Flyer 2

03/08/11
Flyer 3

3/8/11
Flyer 4

3/8/2011
Alternate Flyer

Boston University
Academy

Head of School

March 8, 2011

Dear NASA,

It is with great pleasure that I commit Boston University Academy to supporting our flight team members as outlined by NASA expectations, below:

- Be responsible for funding substitute teachers for all flight team members including the alternate while participants are in Houston if the Flight Week dates conflict with the school' insession calendar. (This Flight Week is June 24 -July 2, 2011.)

- Be responsible for securing funding for the hardware construction and any necessary costs of shipping the investigation to Houston.

- Provide additional planning time for those involved with this opportunity, if possible.

- Provide some release time for the team members to conduct professional development sessions for local/regional teachers and community programs as well as to participate in online professional development and dissemination activities.

- Coordinate media relations/outreach with NASA' Public Affairs Office and the local school system' Public Information Office.

All flight team members are full-time faculty in good standing for whom I have the authority to provide the above institutional commitments.

Sincerely,

James S. Berkman

James S. Berkman

Nil Doctis Arduum • Nothing Daunts a Scholar

One University Road • Boston, Massachusetts 02215 • P: 617.353.9000 • F: 617.353.8999 • www.buacademy.org

Overclocking a Pendulum
Simple Harmonic Motion in Pendulums
Length: 2-3 class periods

Overview and Purpose

Students will measure the period of a pendulum as a function of several variables. They will do a physical experiment where they will vary the length, mass, and angle of a pendulum. They will do a image analysis to measure the period of a pendulum in a NASA microgravity and hypergravity airplane ride to determine the influence of gravity on the period of a pendulum.

Address how this instructional plan is innovative.

This lesson plan is innovative because it has taken a traditional physics experiment and will incorporate gravity as a variable as opposed to being a constant value.

Description of the larger context (unit) in which the instruction will occur along with the goals for the 'unit'.

This experiment will take place in the unit on vibrations and simple harmonic motion. The goals for this units are to explore the influences on Simple Harmonic Motion.

Educational Standards Addressed

This lesson addresses the following standards which are part of the State of Massachusetts Frameworks for High School Physics.

1. Motion and Forces

Central Concept: Newton's laws of motion and gravitation describe and predict the motion of most objects.

2. Conservation of Energy and Momentum

Central Concept: The laws of conservation of energy and momentum provide alternate approaches to predict and describe the movement of objects.

4.1 Describe the measurable properties of waves (velocity, frequency, wavelength, amplitude, period) and explain the relationships among them. Recognize examples of simple harmonic motion.

SIS1. Make observations, raise questions, and formulate hypotheses.

SIS2. Design and conduct scientific investigations.

SIS3. Analyze and interpret results of scientific investigations.

SIS4. Communicate and apply the results of scientific investigations.

Objectives

Students will experimentally develop (through hands on inquiry based learning) the relationship between the period of a simple pendulum and traditional experimental independent variables such as mass, length, and angle. After a formal presentation of the theoretical concepts and equations involved with this system, students will extend the experiment using the acceleration due to gravity as a variable. This is accomplished using image analysis of pendulum experiments performed on a NASA Reduced Gravity Flight.

Assessment Strategies

All students are required to write a formal lab report on this set of experiments. In the introduction of the report, students are expected to explain the main concepts and derive the key equations used in this experiment, which are kinematics, inertia, force, Newton's Law of gravitation, and Simple Harmonic Motion. They must also research the historical development of the ideas of vibrations and gravity. Students present their calculations in this report, and explain their errors. Most reports on this topic range from 10 to 20 pages in length. I have included one sample lab report in the additional documents.

Materials

Ring Stand
String
Masses
Stop Watch, Photogate, or Motion Sensor.
LoggerPro or other Image Analysis Software
MP4 files of Pendulums in NASA Flight

Procedures

Students will create a pendulum system with a ring stand, string, and masses. Students can measure the period of the pendulum with a stop watch, photogate, or ultrasonic motion sensor. Students will vary the length, mass, and angle of the pendulum.

Students will graph in various ways the relationship between period and the independent variables. Students should find a linear relationship between the square root of the length and the period of the pendulum.

After a full explanation of the theory, students will observe video footage of pendulum experiments performed in a Reduced Gravity Flight. The video footage will have the acceleration of gravity displayed. Using image analysis software, students will analyze the motion in reduced gravity, normal gravity, and 2g parts of the flight.

Activities outside the classroom that reinforce the lesson plan.

Ride aboard a Reduced Gravity Education Flight