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Clearing the bar

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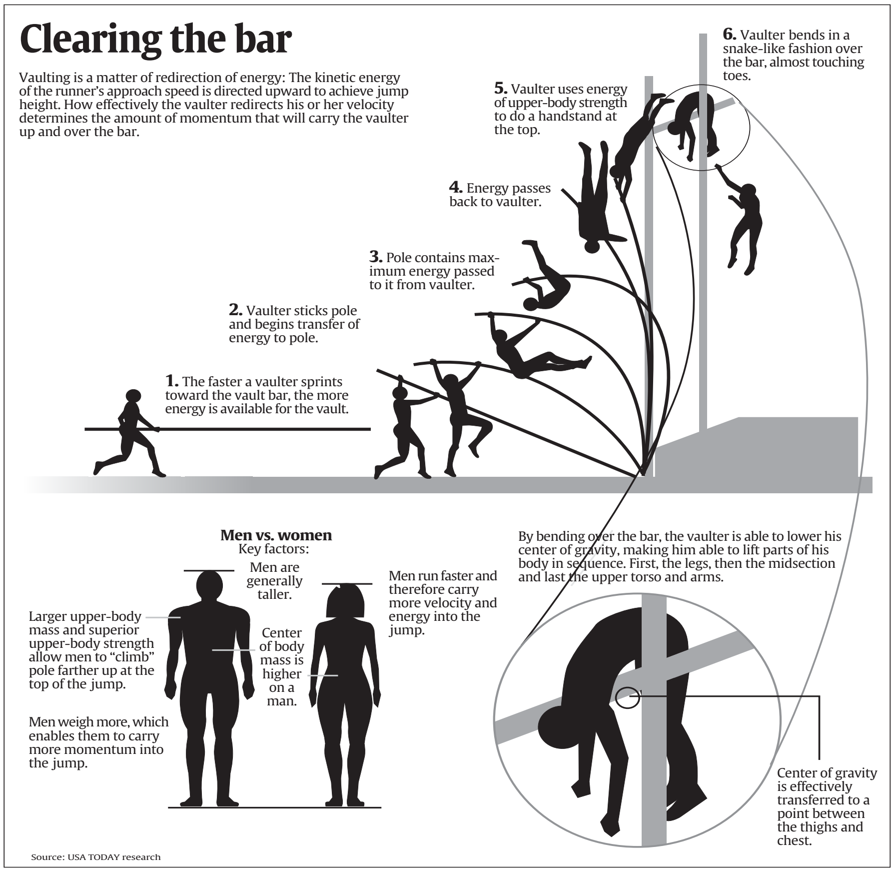

By Sam Ward, USA TODAY

Activity at a Glance:

- Grade level: 9-12
- Subject: Physics, Physical Science
- Estimated time required: 1-2 class periods

Materials:

- TI-83 Plus family or TI-84 Plus family
- Overhead view screen calculator for instruction/demonstration
- Science Tools APP
- Student handout
- Transparency
- Stopwatch
- Tape measure

Prerequisites:

Students should be able to:

- convert units using the SciTools APP on the graphing calculator.
- calculate velocity when given time and distance.
- substitute values into an equation to solve that equation.

Activity Overview:

In this activity, students will explore the effects of two critical physical factors on potential success in the pole vault event in track and field. If possible, it is recommended that the students collect data on themselves and use the data to predict how high they may be able to pole vault. Working in groups of three and using stopwatches, the students will time each other's sprint speed over 20 meters. From this time value, the students will be able to calculate their velocities in meters/second. After they have measured their heights, they can substitute values into the following formulas to make their pole vault predictions. Females will use this formula: **h= 0.55 * [female height] + ½(v^2/g)** and males use this formula: **h= 0.60 * [male height] + ½(v^2/g)**. See the Student Edition of this activity for a complete description of all of the variables in these formulas. If you would rather not have students collect their own data, a hypothetical data table has been provided under "Classroom Management Tips."

This activity works with TI navigator A Classroom Learning System

This activity was created for use with Texas Instruments handheld technology.

Clearing the bar

Concepts:

- Time/distance/velocity
- Using obtained values to solve equations
- Potential and kinetic energy
- Physics of sports
- Unit conversions

Objectives:

Students will:
- calculate velocity from time and distance measurements.
- demonstrate an ability to solve equations with several variables.
- perform unit-to-unit conversions.
- show proficiency with the SciTools APP on the graphing calculator.

Background:

All too often, zealous fans watching sporting events expect perfection. Most people have no idea how much effort, energy, sacrifice and peril are involved in becoming a quality athlete. Of course, some athletic endeavors inherently carry with them a greater degree of risk than others. In track and field, the pole vault would win the "risk award"! In addition, the vault would surely be the event that involves the greatest need for perfect technique. Countless factors go into a quality pole vault attempt, even though it looks virtually effortless when done well. From a pure physical standpoint (and from a physics standpoint), the two most critical factors contributing to how high an athlete can vault are the height and speed of that athlete. The more speed (kinetic energy) a vaulter can generate and the higher the vaulter's center of mass, the higher the vault. In other words, a tall, fast athlete should be able to vault higher than a shorter, slower athlete.

Preparation:

- Provide one graphing handheld for each student.
- Each student should have a copy of the corresponding student activity sheet.
- As an option, have tape measures and stopwatches available for each group of students.

Data Source:

USA TODAY research

National Science Education Standards:

Science Content Standards: 9-12
Science as Inquiry
Use technology and mathematics to improve investigations and communications.
- A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. The use of computers for the collection, analysis, and display of data is also a part of this standard. Mathematics plays an essential role in all aspects of an inquiry. For example, measurement is used for posing questions, formulas are used for developing explanations, and charts and graphs are used for communicating results.

Motions and Forces
- Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

Clearing the bar

Classroom Management Tips:

- Students will have a better understanding of how to read the graphic and retrieve data if you use the transparency for a class discussion before the students start working.
- Remind students to read carefully all parts of the graphic before they start collecting data.
- It is recommended that students work in groups of three for this activity.
- Measure the students' heights before they run.
- Show the students the origin of the equation for determining a person's vault height, based on height and velocity. For a great explanation of this, go to the "Physics of Pole Vaulting" website: www.aip.org/png/html/polevault2.html
- If students will be timing each other to determine their running speed, moving outdoors to a track may be helpful. Alternatives would be to go to a gymnasium or a long hallway.
- Some students may not feel comfortable running while being timed. Arrange groups so that there is at least one student in each group who is willing to run and be timed.
- Even though gathering real data is not necessary to complete this activity, students' interest will be enhanced if they use their own height and running speed to calculate their theoretical vault heights. If you choose to have students gather data on themselves, plan where you will go to gather the data and have stopwatches and tape measures available for the students.
- If you don't want to take the time for the students to collect their own data, you can have them do some vault height calculations using the data table below. However, it is recommended that the students collect their own data. This is much more fun for them!

WOMEN Height	Speed	MEN Height	Speed
1.67 M	8.33 m/sec	1.80 M	10.10 m/sec
1.76 M	7.87 m/sec	1.89 M	9.52 m/sec
1.82 M	8.72 m/sec	1.94 M	9.76 m/sec
1.88 M	8.16 m/sec	2.02 M	9.30 m/sec

Activity Extension:

- Have students research articles in USA TODAY for other topics that involve velocity, mass, momentum, acceleration, etc.
- Ask students to research the history of the pole vault and the progression of the world records in the men's and women's pole vault events. Specifically, have them examine the role that technology has played in the improvement of performance. Some examples of improved technology include better vaulting poles, safer vaulting conditions, improved footwear, faster runways, etc.

Additional Resources:

- Student handout
- Transparency
- TI Technology Guide, for information on the following: TI-83 Plus family, TI-84 Plus family, and SciTools APP
- TI-Navigator™ Basic Skills Guide for information on using the TI-Navigator Classroom Learning System

Curriculum Connections:

- Algebra II
- Pre-calculus
- Human Anatomy & Physiology

Clearing the bar

Assessment and Evaluation:

Q. The 2000 Olympic women's pole vault Gold medalist was Stacy Dragila from the United States. Stacy is 5'8" tall and her sprint speed is 8.33 m/sec. Calculate the height in meters that Stacy should be able to vault. Don't forget to convert Stacy's height to meters. You may wish to use the SciTools APP on your calculator.

A. 4.49 meters

Q. Using the SciTools APP on your graphing calculator, estimate how high Stacy's vault would be in feet and inches?

A. 14'9"

Q. If a man is 6'4" and can run at a velocity of 9.65 m/sec, how high should he be able to vault in meters?

A. 5.91 meters

Q. How high would this be in feet and inches?

A. 19'5"

Q. What are some other factors that would affect the height that someone could vault?

A. Answers may include such things as the length of the pole used, the direction and force of the wind, other weather conditions, and maybe most importantly-the level of mastery of the technique required to be a good vaulter.

Q. What is your estimated vault height?

A. Answers here will depend on each student's individual data.

If you are using the TI-Navigator Classroom Learning System, send the provided LearningCheck assessment to your class to gauge student understanding of the concepts presented in the activity. See the TI-Navigator Basic Skills Guide for additional information on how this classroom learning system may be integrated into the activity.