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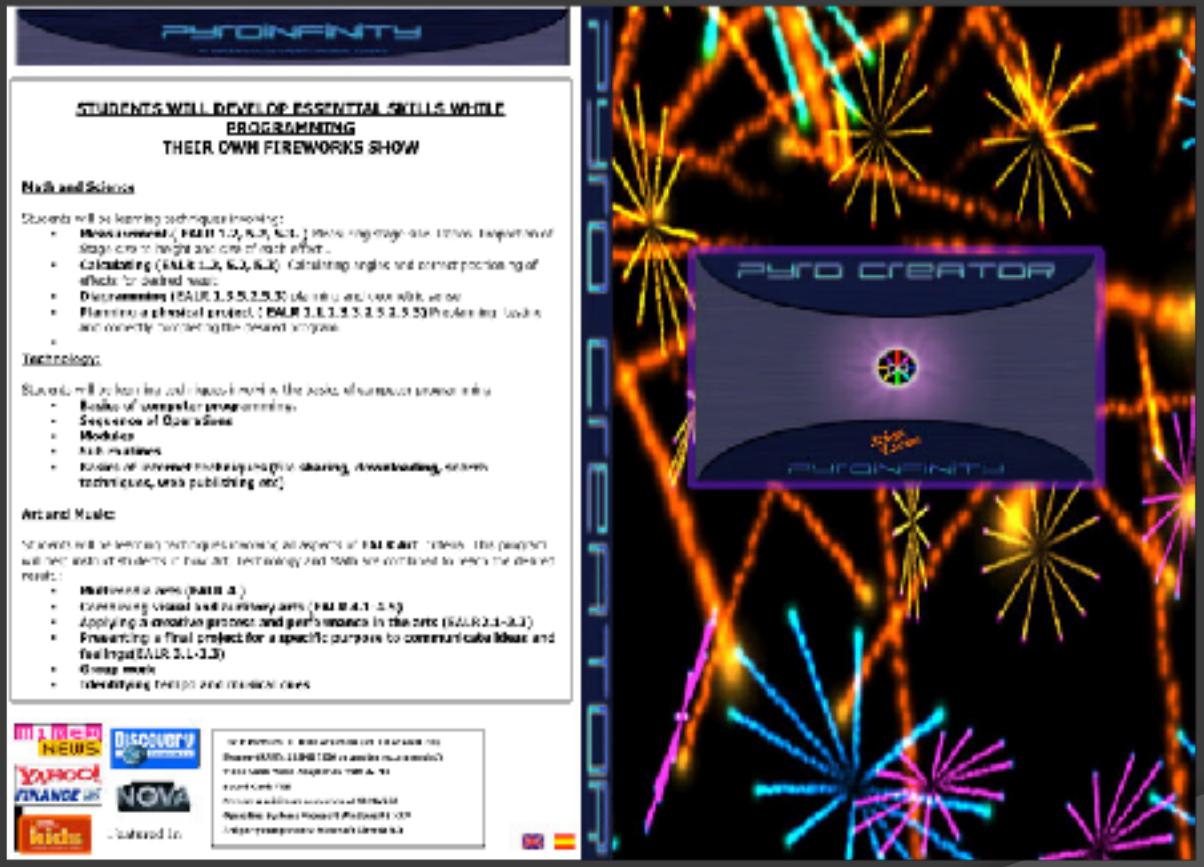
TEACHING MATHEMATICS AND PHYSICS BY DESIGNING PYROTECHNIC DISPLAYS

TEACHING MATHEMATICS AND PHYSICS BY DESIGNING PYROTECHNIC DISPLAYS
Pilot Project Research at Anacortes Middle School, Washington USA, 2004-2005



INTRODUCTION AND HISTORY

- Mathematics is a central topic in science, technology, and mathematics education (STEM).

- Middle school instruction is considered crucial in the development of interest in mathematics.

  However middle school students and girls in particular have been found to lack motivation in learning mathematics at this level.

- Non-traditional learners have been documented as becoming more engaged when using visually stimulating ,non-traditional learning programs.

- Interactive computer programs that will enhance student interest can also be used to provide direct support in mathematics .

INTRODUCTION AND HISTORY

- Project: Test an interactive computer program that will enhance student interest and can also be used to provide direct support in mathematics .
- The program was designed to use simulated fireworks for the creation of virtual fireworks shows.
- The original project was designed and tested in 2004 – 2005 in the Anacortes School District Middle School, WA, USA (AMS).
- The head teacher, William C Parson was also using this project in his Master's thesis "Virtual Fireworks Design in the Middle School Curriculum: Software Development for Technology and Content Integration" (Parson, 2005).

Introduction and History: PyroCreator Student Version Anacortes Middle School

STUDENT ACHIEVEMENT 5

Several Anacortes Middle School students including the five pictured here had the opportunity to create a "virtual fireworks display" recently. Richard Isaac (l. to r.) are seventh graders Leah Hilsey, Jessica Caron, Saige Conway, Ryan Williamson and Cory Crawford

Virtual fireworks show brings middle school students together

Thanks to a computer program created by internationally renowned pyrotechnics designer Alberto Navarro, president of Bellevue-based Infinity Visions Inc., students at Anacortes Middle School have been given the opportunity to create their own "virtual" fireworks shows.

Apple program called "PyroCreator," introduced to students by technology teacher Caleb Parson, offers the thrill of creating a fireworks show – without the risk of burned fingers.

"The students are basically creating a film," said Parson, with sophisticated programs options that call for skills in math, language arts, art and music.

Navarro, whose company has created fireworks displays for locations including Disneyland and the Seattle Space Needle, has reconfigured for educational purposes a software program created for professional pyrotechnicians.

AMS technology teacher Caleb Parson

With the virtual fireworks program as a central focus, Parson recently worked in the computer lab with students in Peng Doh's art class, Anne Chase-Stapleton's language arts class, Kristi Nott's math class and Carole Schmidt's choir class.

"This software was originally designed to create actual fireworks shows," explains Parson. Student creation of virtual fireworks shows calls for a variety of skills:

Math skills can be used to calculate grids, grids of geometry and to tally costs for each element of the show, also teaching students to work within a budget.

Art skills can be used to select a photo background for the virtual show (such as a landscape featuring the Bellevue Arts Museum). Art skills are also valuable in making selection of fireworks patterns and colors.

Language arts skills can be utilized for "voice over" narrations and text elements that can be integrated into the show.

Music skills can be used to synchronize fireworks and musical soundtrack, either original or recorded, into the show.

"Our technology kids worked with this program initially," said Parson, "helping to install the program and trouble-shoot some problems. It's been a great opportunity to see their expanding technical skills in action software development."

Once the decision was made to introduce students on an "integrated curriculum" level Navarro spent a week personally working with AMS teachers and students.

"We had 30 kids in one room with a big screen projector," Parson said. "The level of excitement was infectious."

Parson noted that there are still bugs to be worked out, but tentative plans call for re-peated and expanded creative opportunities for students at AMS. Infinity Visions Vice President/Events Chief is working to create an extended broad integration educational program that will be offered to regional schools after completion of the pilot program in Anacortes.

Because of its original design, the program could be used by students someday to create a real fireworks display. In the mean time, said Parson, "This virtual fireworks program is exciting for us. It is educationally appropriate and at the same time, its creative potential is as open as the kids' imagination."

Student comments:

Paige Conway: "It's really cool. We get to be our own designs and maps."

Leah Hilsey: "You can write stuff with the fire works I wrote my name."

Jess McCann: "I liked making fireworks – making explosions."

Alex Read: "We get to choose what fireworks you wanted, when you wanted."

Katie Hammond: "It was fun. We added music to it and the fireworks changed to the different beat."

Approach: Students learned math techniques while designing and choreographing their own fireworks show to music.

Mathematics : Angles, measurement, height, distance, size,ratio, and perspective to solve problems in Visual Arts and Choreography.
Additional exercise : Budgeting using “pyrodollars”

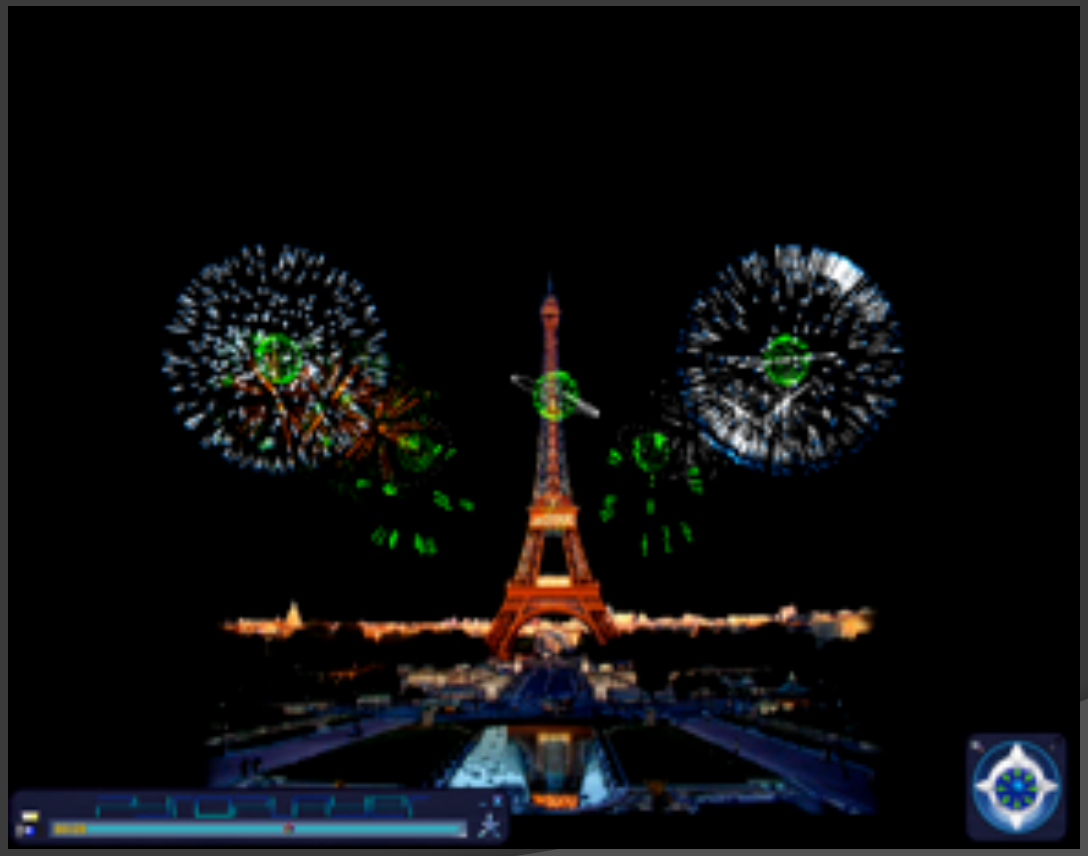


Figure 1 – Stage chosen for the exercise

Specific Math Skills and Concepts learned with the Pyro Creator School Program

Students will practice techniques involving:

Measurement: (EALR 1.2, 5.2, 5.3) Measuring stage size and ratios (Proportion of stage size to height and size of each effect)

Calculating: (EALR 1.2, 5.2, 5.3) Calculating angles and correct positioning of effects for desired result

Diagramming: (EALR 1.3, 5.2, 5.3) Planning and geometric sense

Planning a physical project: (EALR 2.1, 2.3, 3.2, 5.2, 5.3) Preplanning, testing and correctly completing the desired program.

Specific Math Skills and Concepts learned with the Pyro Creator School Program National Council of Teachers of Mathematics (NCTM) standards:

Measurement:

Select and apply techniques and tools to accurately find length, area, volume, and angle measures to appropriate levels of precision.

Geometry:

- Recognize and apply geometric ideas and relationships in areas outside the mathematics classroom, such as art, science, and everyday life.

Representation Standard:

- Use representations to model and interpret physical, social, and mathematical phenomena.

Connections Standard:

- Recognize and apply mathematics in contexts outside of mathematics.

Data Analysis and Probability Standard:

- Use proportionality and a basic understanding of probability to make and test conjectures about the results of experiments and simulations

Applications of Mathematics:

- *Problem Solving*: - Solve problems that arise in mathematics and in other contexts.

Figure 2 – Measurements and scales

Step 1:"Set Stage Size "

Concepts:

- Calculating Measurements: Distances, Perspectives, and Geometry
- *Discussion Points:* Scale Size must take into consideration the scale size of the "Effects" that will be used on that stage.
- Example: If the Acropolis is 300 meters, and you shoot an Effect on the Acropolis that is 300 meters, it will take up the entire stage. If you shoot the same, 300 meter effect, from farther away, 900 m, how much smaller will it appear on the screen?

Concepts:

Measurement - Use Scale measure to set positions at different distances in relation to each other.

Example: *USING SCALE RULER*:

Set Positions 1 and 5 equidistant from position 3.

Set Position 2 equidistant from 1 and 3.

Set Position 4 between 3 and 5.

Step 3: "Placing Effects" Contact between Measuring and Geometry.

Figure 3 – Measuring and Geometry

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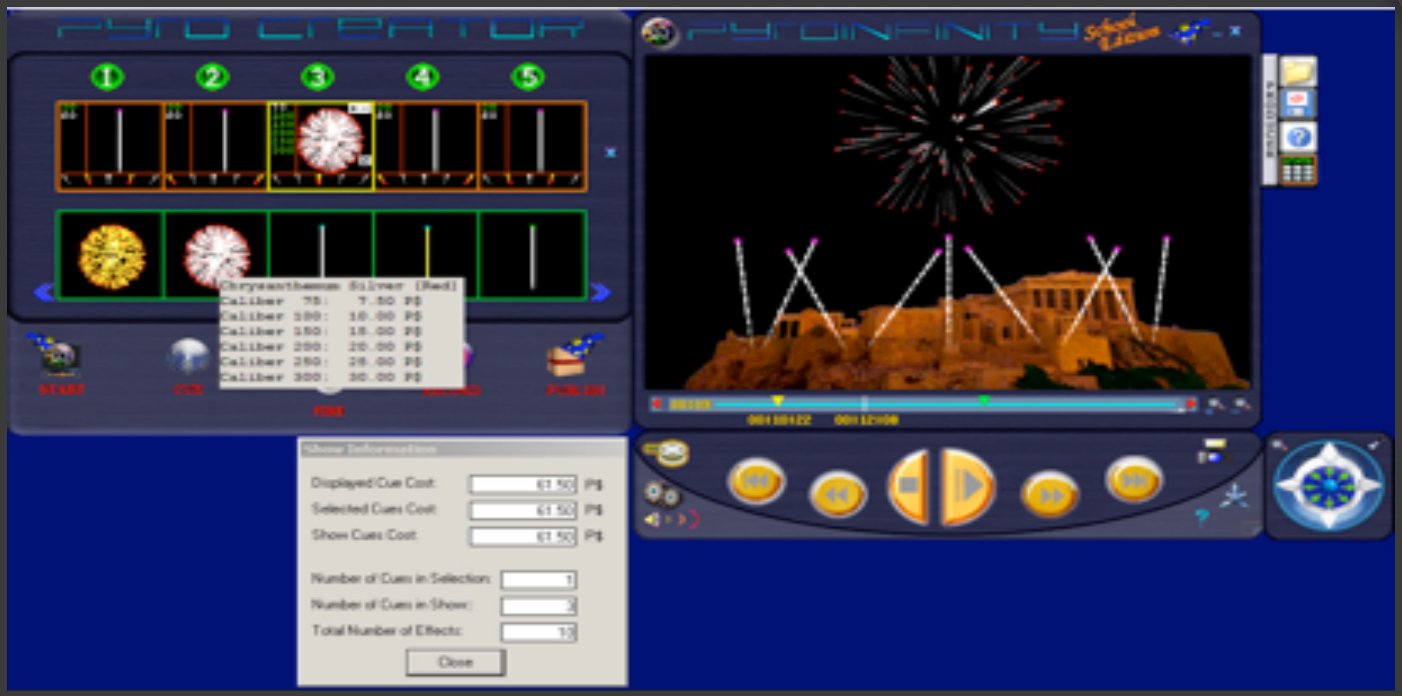

Each Effect has a Diameter range of 75 mm-300 mm . Many different geometrical shapes and patterns of effects can be chosen.

Symmetry: Changing the angle will also change the 'shape' of the symmetry, so you may have to adjust the size "caliber".

Geometry and Measurement: Shoot your effects from a scale of 60-120 in a half circle from position 1 to 5 calculating 15 degree increments, so that you display a semi circle of effects

Effects of Measurement, Symmetry, Patterns
Lesson Discussion and additional exercises

- Symmetry and Sequencing: Explain the difference between positioning effects straight up, having them move in sequence across the sky, or by angles.

- Shoot the 5 positions so that they are all parallel. Change the patterns, only by changing the size of the effects.

Results:
Student samples using parameters in lessons on Geometry, Symmetry, Measurement

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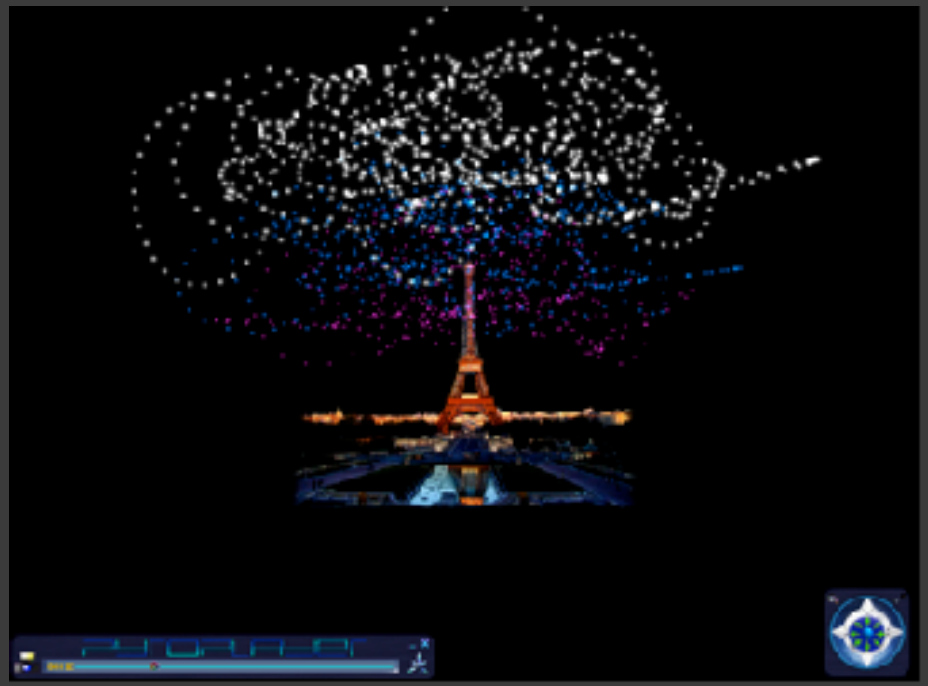


Results:

“Planning a physical project in a 3d environment” Students learn techniques in 3d imaging import and placement.

Results

A Likert Scale instrument was used for evaluation of feedback from teachers and students.

- Results showed high levels satisfaction for both student enthusiasm and participation and for teacher perception of student accomplishment and learning.
- Math, Art, and Band teachers expressed interest in including it in their curriculum as a cross-disciplinary project.
- Girls were particularly engaged in the program, which was not usual for computer-based units in the school.
- The Special Education students remained engaged in the task for long periods of time, and even came in during tutorial to continue working with the program.
- Anacortes Middle School (AMS) continued to use the PyroCreator program in the 2005 and 2006 school year.
- Discussions to include the program in regional educational curriculums and future adaptation by middle schools nationwide.

Results: Student and Educator Comments

STUDENT ACHIEVEMENT 5

Several dozen Anacortes Middle School students including the five pictured here had the opportunity to create a "virtual fireworks display" recently. Pictured here (l. to r.) are seventh graders Leah Heiberg, Jessica Carter, Paige Conway, Ryan Wilkerson and Cory Crawford.

Virtual fireworks show brings middle school students together

Thanks to a computer program created by internationally renowned pyrotechnics designer Alberto Navarro, president of Bellevue-based Infinity Visions, Inc., students at Anacortes Middle School have been given the opportunity to create their own

Student comments:

- Paige : It's really cool. We got to do our own designs and displays.
- Kaila: It was fun. We added music to it so the fireworks changed to the different beat.

Educator Comments:

Dr. Steven Tanimoto,

Professor of Computer Science and Engineering University or Washington:

" Your approach to engaging middle-school students is unique and promising. Fireworks is a medium that remains awe-inspiring despite the continual inflation of visual stimulation that young people experience in our culture. "

Educator Comments:

Dr. Earl Hunt, Professor of Psychology University of Washington:

"PyroCreator is an elegant programming technique for producing a virtual fireworks show. In order to do this the user has to combine mathematical reasoning (geometry, measurement) with a sense of timing and an eye to combining visual and auditory signals into an artistic multimedia presentation… Teachers can use PyroCreator to pose mathematics problems that students will rush to do in their free time."

Goals for future development of the program

- This study was done between 2004 -2006.
- Software and technology have greatly advanced. Students need to learn new skill sets to keep up with the future changing work force.
- Finding new ways to teach these skills through exciting and engaging programs such as designing a virtual fireworks display is a relevant program to continue to develop.

2016-2017

- Research in process at the Universidad Tecnologica del Valle del Mezquital, Mexico (UTVM) to create lesson plans using the advanced version of Visual Show Director Software, FX Generator.
- In Washington State, Dr. James Minstrell, Facet Innovations is advising with lesson plans and educational uses of the software.
- Following are some examples of the work in progress and sample teaching units in Mexico.

Teachers Survey

At UTVM (Universidad Tecnológica del Valle del Mezquital), Infinity Visions introduced 10 professors to the Visual Show Director program. After this we presented a survey to gather their ideas on how it could be used for educational goals at the University.

Results:

-All 10 professors considered the program to be a useful tool for educational goals taught at the University.

The professors hope to achieve the following results after teaching their courses with the aide of Visual Show Director.

-Eng. Abel Roque “The students will use the Simulation tools in order to better understand real world applications.”

-Eng. David Gutiérrez ”The student should observe and have greater understanding of physics and mathematics in every day applications of engineering.”

-Eng. Hector Dirceu “The student will transfer their knowledge from theory to practice by using the simulation tools”

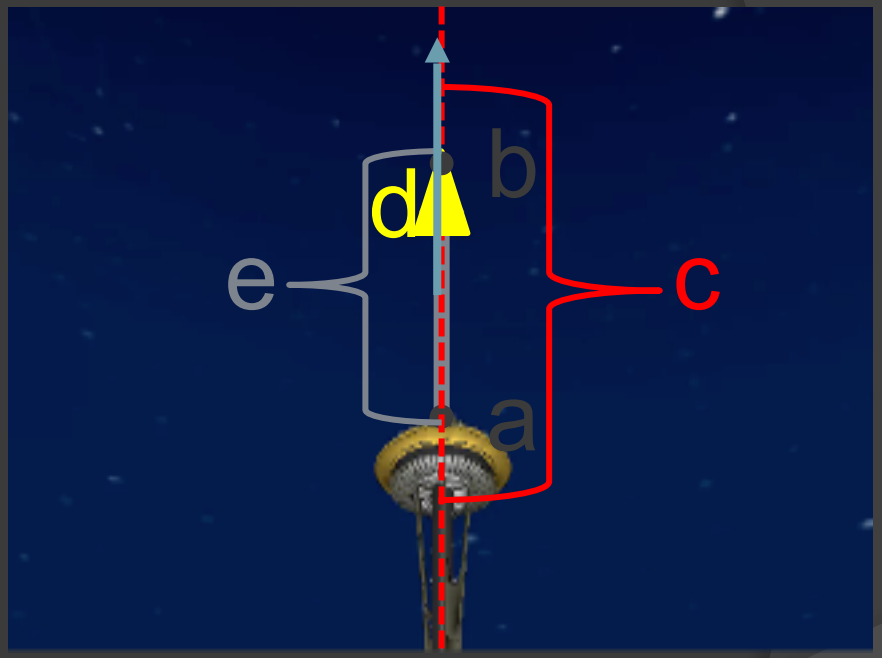
Topics that have been identified by UTVM that can be integrated into their curriculum using Visual Show Director Software

- Interpretation of vectors and spaces
- Vector algebra vector algebra laws
- Conception of cylindrical and spherical coordinates
- Speed and acceleration
- Circular movement
- Particle movement
- Calculation of angular speed
- Newton laws of motion, movement, work, energy and momentum.
- Differential equations (obtained from equations that produce velocity, acceleration, and more.)
- Statics, equilibrium of a particle acceleration and gravity (gravitational system), projectiles mass analysis and static systems
- Spherical and Cartesian coordinates.

Vectors Lesson
After defining the concept of a vector and describing its properties,
we can consider Fireworks as Vectors because they have the same properties.

Definition:

A quantity that has magnitude and direction, whose length represents the magnitude , and whose orientation in space represents the direction, the vector is represented as an arrow on a coordinate axis. And complies with the following properties:



a) Origin: Point from which the arrow begins.

b) End: Point where the arrow ends.

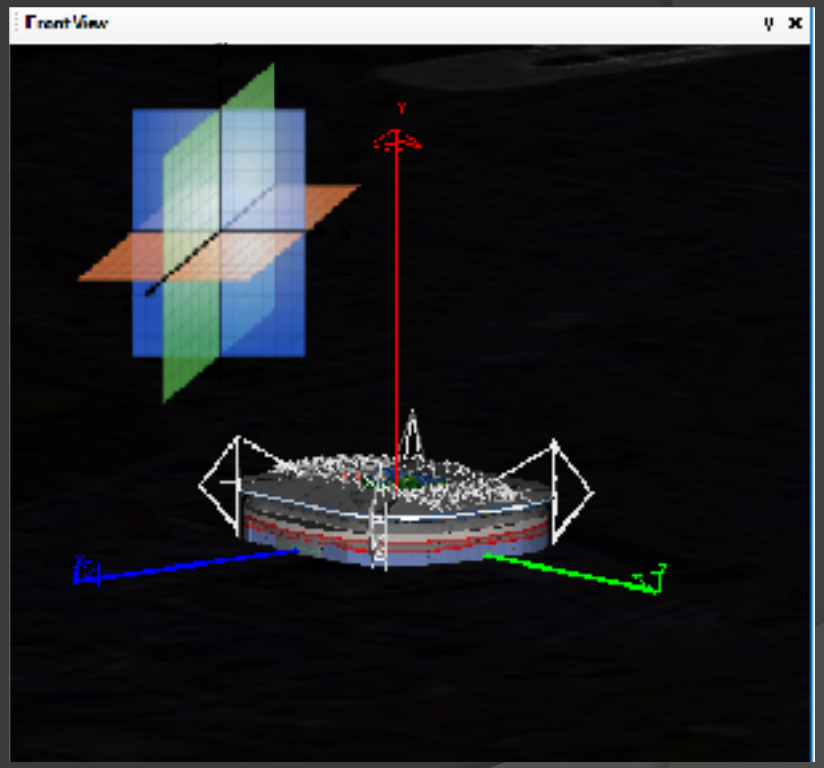
c) Address: The line on which the end point and origin "rest".

d) Sense: The tip of the arrow determines its direction.

e) Magnitude : The distance between the origin and end point corresponds to the module. The greater the distance between them, the greater the length of the module.

Coordinate System

A coordinate system is a set of values and points that allow you to define the position of any point of space. The study of vectors is facilitated if we place them in a Cartesian, polar or spherical coordinate system for greater precision, in order to represent the vectors from an algebraic form into a geometric form.

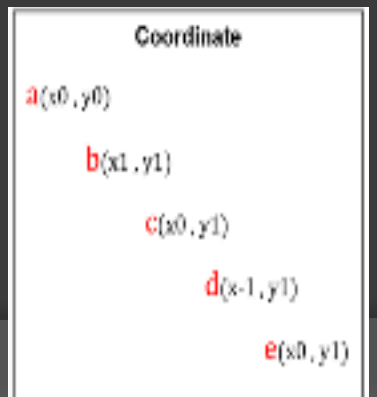


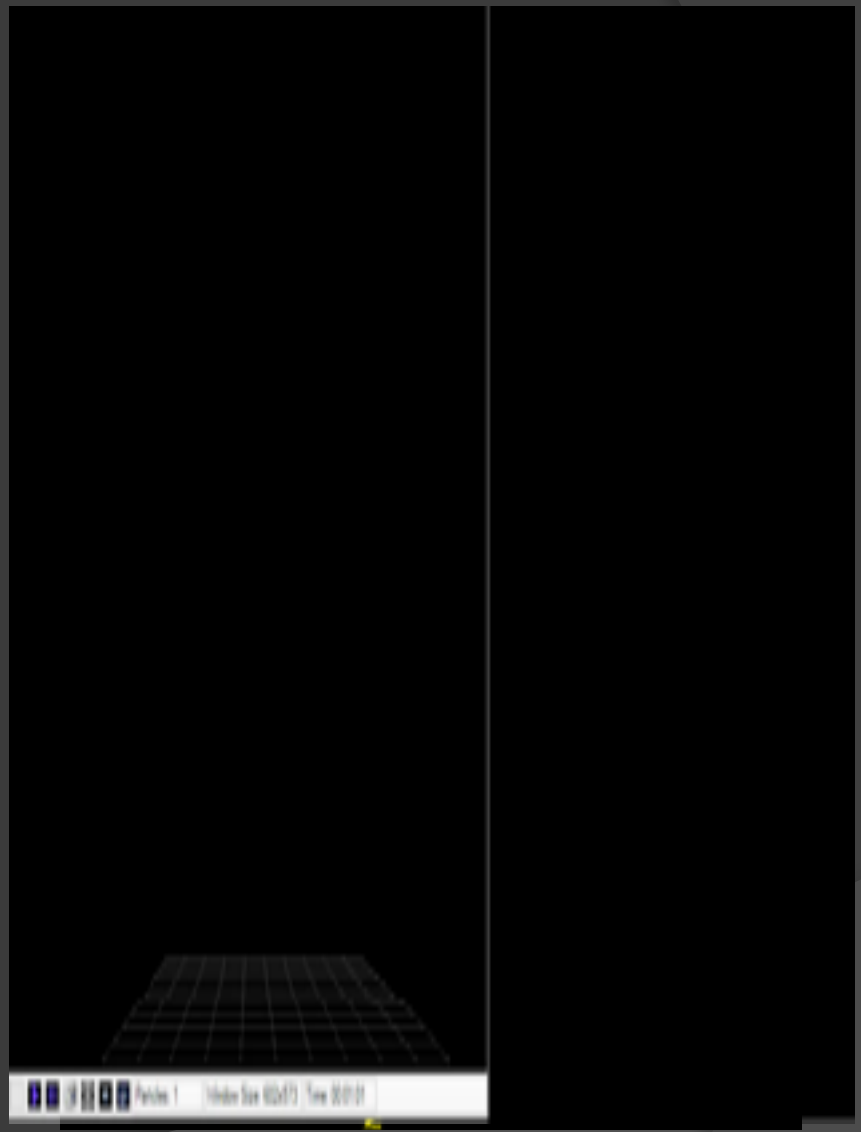
Cartesian coordinate System (x, y, z).

A Cartesian coordinate system is defined by two axes (y, x) in a two-dimensional system and a three-axes (x, y, z) in a three dimensional system, which intersect at the origin.

Example:

In "Particle Generator" draw the following coordinates in order to create a new behavior. Then in "Fx Generator" apply this behavior to a comet and observe the effect created.



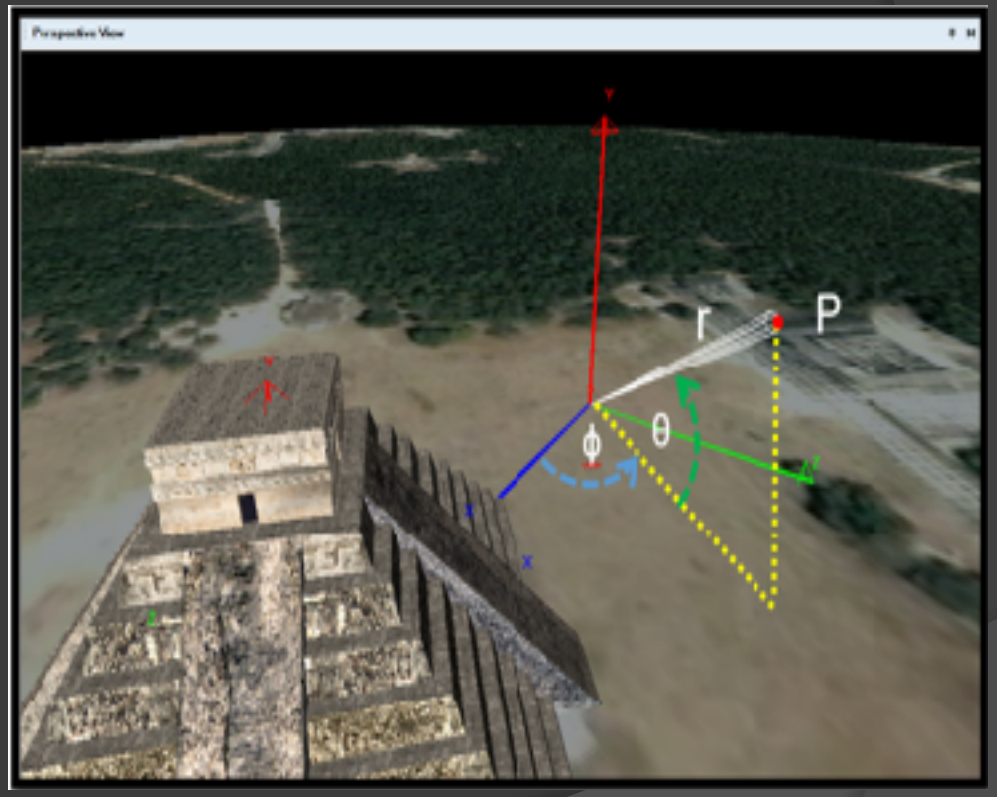


Polar and Spherical coordinate system (r, θ).

Polar coordinate systems can be used to represent points in a two-dimensional plane. In this coordinate system an angle (θ) and a magnitude (r) are used to express the position of a point (P) in space.

The spherical coordinate system is used in a three-dimensional space. Spherical coordinates are a three-dimensional coordinate system based on the same idea as polar coordinates, in this system the location of a point in space is determined by a magnitude (r) and two angles (θ, φ).

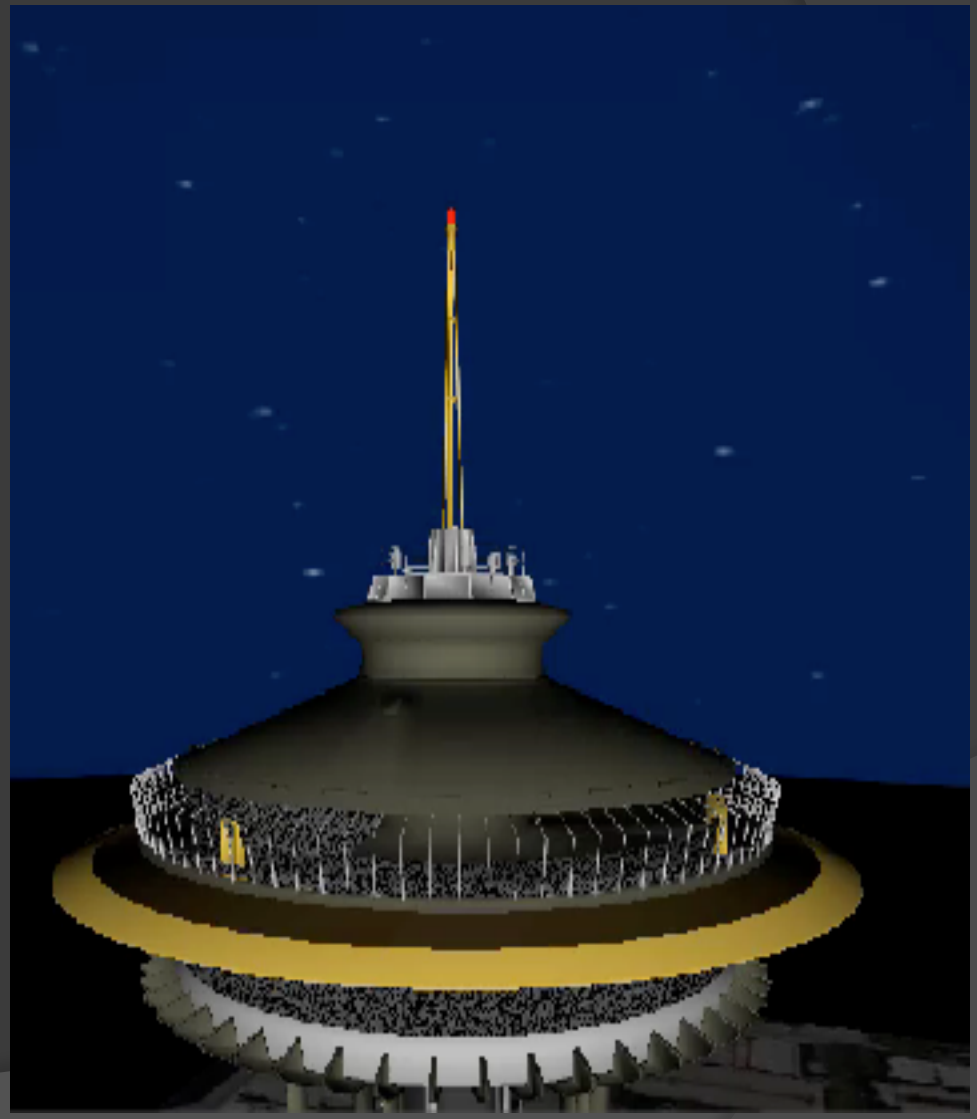
The magnitude (r) is the distance from the coordinate origin to the point (P), θ is the angle that forms (r) with the vertical (Y), and φ is the angle that forms the projection of (r) and the plane XZ with the X axis



Exampe of application of polar and spherical coordinates system in fireworks

In this position fireworks are launched with the following coordinates…

	Long (r)	Tilt (θ)	Pan (ϕ)
1	80	350	10
2	80	10	10
3	80	0	10
4	80	350	350
5	80	10	350
6	80	0	350
7	80	350	0
8	80	10	0



CONCLUSION

- These are only a few examples of how lessons can be created around visualization software for fireworks displays. It is our hope that these ideas and units will be further developed and integrated into school programs by interested teachers who would like to take on this interesting and fascinating task.

- Comparing our study of 2004-2006 with the possibilities available today is very exciting. Technology today is more widespread, with more options, and students and teachers are more tech savvy.
- Students today more than ever are very focused on screen time and technology so that using a Pyrotechnics based educational software program can be readily introduced as a learning device. Along with the enticement and excitement of learning about the fascinating field of Pyrotechnics, students can be engaged, motivated and entertained while learning math, science, art and technology.