QuarkNet **Stories from the classroom**

At Matawan Regional High School the QuarkNet Program has played an integral part of our Physics Program. I discuss this first. Below that I also discuss the QuarkNet summer program that we have been running at Rutgers for a number of years.

1) **Physics/Honors Physics Program**

We devote 5 enrichment days for Modern Physics topics, distributed throughout the year, to help with tie-ins to the learnings in our classes. All Physics students in our school are exposed to these "specials". The following are the main ideas of our special days.

1	Special Relativity (primarily focusing on time dilation and length contraction)
2	$E = mc^2$ and General Relativity
3	Symmetry in Physics and Tie-In to conservation laws: Energy, Momentum, Charge, Angular Momentum
4	Quantum Physics: (Wave-particle duality, Uncertainty, Bound State Energies, Tunneling, Antimatter)
5	Particle Physics: This is the culminating special day. We start by talking about the invariant rest mass and some other properties and how most of mass is actually kinetic and potential energy. We show the early discoveries of cosmic particles and show some samples of data from our actual equipment to show how we can observe these in our classroom with our QuarkNet detector equipment. We then focus on some descriptions of current state- of-the-art accelerators. The students are shown dynamically-viewed particle tracks from CERN using the tools that we obtained at QuarkNet sessions and some energy spectrum to show how new particles are discovered.

2) **Physics of the 21st Century Class (our name for the modern physics class)**

Students who have successfully completed a year of physics may take this class. We cover the areas of modern physics with much greater depth. Below are some of the areas that tie into the QuarkNet program.

Particle accelerators and detectors (great for reviewing Physics)	~2.5 weeks
History of $E = mc^2$, Understanding Special Relativity	~4 weeks
Quantum Physics, Including Fermions and Bosons, parity, and antimatter	~8 weeks
Nuclear Physics including Fission and Fusion	~6 weeks
Particle Physics	~5 weeks

During the unit on particle physics the students will use the QuarkNet Detector Set to a) observe muon flux, b) measure muon lifetime and c) measure muon time of flight to observe speed. All of the students will participate in analyzing the data. Some of the students will be more directly involved in hands on data collection.

We also utilize many of the QuarkNet-provided lab materials throughout the year, such as Rolling with Rutherford, Analyzing the invariant mass of the Z boson with paper copies of particle tracks, the analyzing particle tracks with interactive displays.

3) **Rutgers Summer QuarkNet Program**

We have had students participate in this program for many years. Usually it is from our rising Junior population. Many of these students go on to take our Physics of the 21st century class and then become the leaders in that class during the activities described above.

This has been a very successful program, with outreach to a number of high schools within driving range of Rutgers University. Many of the students who have attended have gone on to pursue college physics degrees, in Rutgers and elsewhere. This program has been particularly good for students to firm up their interest in Physics and to increase their self confidence in higher levels of learning in Physics.

Our program utilizes much of the materials provided by QuarkNet. We also supplement that with teaching the students to do significant statistical analysis of particle data. All students are involved in hands-on data collection using our QuarkNet kits. Furthermore, students get enhanced insight into topics in particle physics through breakout discussion sessions with Professor Steve Schnetzer.

We take advantage of the fact that by being at Rutgers we have some outstanding demonstration equipment that is not generally available in a high school setting.

Students work in small teams that collect and analyze muon data, analyze large quantities of data from CERN, and produce interesting group presentations that tie into the materials that we cover in this program. Students are also exposed to many special presentations by Rutgers faculty, special tours of different areas of research at Rutgers, and some special guest speakers.

At the end of the program we give the students an opportunity to express their feeling about the impact of the program on them personally. The students are eloquent in describing how much they have gained from this experience. The feedback that we get is so amazingly supportive, encouraging us to want to continue to provide this opportunity for additional students.

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