Name Renee Sweeney **Date** 04/15/10

Class AP Physics

Topic: Gauss's Law

Reference to MA Science Framework and/or NSES:

(From National Science Education Standards)

1. *Science as Inquiry (Content standard A)*
    a. *Formulate and Revise Scientific Explanations and Models Using Logic and Evidence*
    b. *Recognize and Analyze Alternative Explanations and Models*
2. *Physical Sciences (Content Standard B)*
    Understanding the microstructures of matter

(From Mass DOE Science and Technology/ Engineering Curriculum Framework)

1. *Simulate physical processes and phenomena using different kinds of representation*
2. *Address student's prior knowledge and misconceptions*

Reflective Introduction:

Computer simulations have brought a new tool into the classroom and much research is being done on how they can be most effectively integrated with instruction. There are some clear benefits to using simulations: students are more likely to play an active role in learning and discussion and have the enhanced ability to generate and test hypotheses in a short time without the problems of mechanical equipment (Finklestein, 2005); simulations support constructivist ideals and are in line with the National Science Education Standards (National Research Council, 1996), which focus on " student understanding and use of scientific knowledge, ideas, and inquiry processes" (p. 52); viewers can speed up or slow down the display and can review the different parts, making simulations suitable for many different learners; viewers have the capability of animating a dynamic system (Hegarty, 2004); depending on the complexity of the interface, multiple simultaneous representations can enhance the development of mental models and learning potential (Hestenes, 1996).

In my classroom, I follow a lab driven curriculum, where students generate graphical and mathematical models through experiments done in the lab. This works very well in a mechanics based physics class, since the events are macroscopic, but I encounter some difficulty when teaching the electricity and magnetism portion of my AP physics class. Electricity and magnetism require students to develop mental models of phenomena they find difficult to explain. Compounding the difficulty, they have to think in three dimensions.

Gauss's Law has always been a difficult topic to teach, and I have yet to find a lab that demonstrates this method of determining an electric field. We do not have measurement tools or apparatus that can make this tangible to students. I have found that in addition, students have a very difficult time thinking of electric fields as three dimensional. A field is an abstract concept…Now imagine placing an imaginary surface around the field so that it passes through perpendicular to the surface…No wonder they have a difficult time with this!

I have developed a series of three dimensional simulations to help students visualize the implications of Gauss's Law. Students can control the charge or charge density and observe changes in the electric field which is represented by arrows. Graphs of Flux v. Radius and Electric Field v. Radius allow for quantitative measurements and enable students to see graphical relationships. The simulations start simply with a point charge and then progress to the spherical conductor, sphere with uniform volumetric charge distribution, and line of charge. The accompanying worksheet leads them to several revelations:

1. *The electric field points away from positive charges and towards negative charges.*

2. *The strength of the field is proportional to the amount of charge.*

3. If all of the charge is enclosed, the flux through the surface is independent of radius.

4. The field due to a point charge is inversely proportional to the square of the radius.

5. The field inside a conductor is zero.

6. Outside the conducting sphere and sphere with uniform chare distribution, the field acts like that of a point charge.

5. Inside the uniform sphere, the flux increases proportional to the radius.

6. The field due to a line of charge is inversely proportional to the radius and flux is independent of radius.

My hope is that from working with these simulations, students will have a better visual sense for what Gauss's Law entails and why it is very useful for certain cases. They will also learn how to choose surfaces(sphere/ cyilinder) and get a sense for what the field graph should look like. I also want them to recognize that as long as the charge enclosed by the Gaussian surface is not changing, the flux will remain constant.

Global and Curricular objectives for students:

Global –

1. *Work cooperatively towards a common goal.*
2. *Develop oral presentation and persuasive argument skills.*
3. *Communicate effectively with others, both in and out of the classroom.*

Curricular-

1. *Develop a model for determining and visualizing electric fields around uniform charge distributions.*
2. *Realize the importance of supporting statements with evidence.*
3. *Use multiple methods of representation to explain solution (written, oral and pictorial).*

Brief description of lesson (include start, middle, and end)

First: Introduce Gauss's Law and use it to derive the equation for the electric field of a point charge, which should be familiar to students as Coulomb's Law.

Middle: Students will work in groups of two with the simulations, using the accompanying worksheet as a guide. The teacher will circulate and interact with students as needed. My hope is that in using the simulation, students will think of additional questions and experiment with the simulation beyond what is called for in the worksheet. It is a guide which highlights what I think is most important, but student curiosity can open up discussion in many directions.

End: Student will prepare and present a whiteboard which will highlight the major discoveries. Anything that is missed can be brought up by the teacher at this time.

Timing:

Time	Teacher activity	Student activity
15 min	Introduce Gauss's Law with a brief lecture and example. Student ideas should be elicited as often as possible.	Take notes, participate in discussion.
5 min	Pass out worksheet. Assign groups and computers.	Write predictions, discuss initial ideas.
40 min	Circulate among groups, ask questions to elicit ideas and help groups that are struggling.	Work with simulations, answer questions on worksheet.
15 min	Circulate among groups, ask questions to elicit ideas and help groups that are struggling.	Prepare whiteboard with findings.
15 min	Discuss final conclusions, relate to previous class findings.	Discuss final conclusions, relate to previous class findings

Homework:

Use Gauss's Law to derive the equation for the electric field as a function of radius for the spherical conductor and sphere with uniform charge distribution.

Lesson evaluation (Identify successful management, learning, enjoyment and the evidence of it. Refer to objectives. Areas for development.)

The lesson will be successful if students are actively involved in the discussion. .

Student assessment (Knowledge, skills, and understanding)

Students will be assessed based on the quality of their responses on the worksheet as well as formative assessment based on the whiteboard presentations.

Adjustments for special needs students:
The format of the simulations provide multiple representations which allow students with learning difficulties a better opportunity for learning. In addition, the small group atmosphere allows for verbal communication opportunities and peer support.

Materials, equipment and supplies:
Computers with access to simulations.

Safety concerns: *None*

Based on Turner, T. and DiMarco, W. (1998). Learning to Teach Science in the Secondary School. NY: Routledge.