Title	Fly, Fly Away with Vectors
Creator:	Plunkett, Holly hplunket@access.k12.wv.us
Source:	2009-2010 Secondary PBL Project
Project Idea:	Many pilots use navigation devices to control their flights from one airport to the next. Some of these devices use GPS information to plan the route. There have been questions about some of the routings defined from a certain flight plan provider. You work for Vector Air, a company that has been contracted by the navigation vendor, to set accurate routings between airports. You will design several routes between major cities, validating their accuracy. You will provide an accurate scale drawing of the various routings along with the mathematical calculations required to determine the flight plans.
Entry Event:	Invite an air traffic controller, pilot, or flight instructor to initiate this project. He may be able to show flight plans, the dangers of a bad flight plan, and other interesting bits about flying. Students will be introduced to LORAN and GPS navigation from the visitor. Videos are available that may help kick off the project. The following enhances excitement with music: http://www.aviationexplorer.com/various_airliners_takeoffs_and_landings.html. Many other videos are also available on that site. The vast number of flights occurring daily is effectively shown on http://users.design.ucla.edu/~akoblin/work/faa/index.html.

Content Standards & Objectives:

Objectives Directly Taught or Learned Through Discovery	Identified Learning Target	Evidence of Success in Achieving Identified Learning Target
M.O.T.3.11 create graphical and algebraic representations for performing vector operations and analyze these to solve real-world problems such as force analysis and navigation.	Knowledge: Represent a vector both algebraically and graphically How to perform operations with vectors, along with algebraic and graphic representations How to properly cite sources within documents Reasoning: Analyze and describe the geometry of vectors Skills: Perform mathematical operations with vectors Use vectors to solve real-world problems	SAS #79: Students will complete the Web Inquiry to a level defined by the teacher. The Web Inquiry Answer Sheet is available on the SAS Curriculum Pathways site after logging in as a teacher to Quick Launch #79, under the Assessment tab of the Lesson Guide. Students will complete the Vector and Projectiles activity sheet from The Physics Classroom to a level of accuracy determined by the teacher. The answer sheet is also available at that site. SAS #75: Students will complete the Web Inquiry to a level defined by the teacher. The Web Inquiry Answer Sheet is available on the SAS Curriculum Pathways site after logging in as a teacher to Quick Launch #75, under the Assessment tab of the Lesson Guide. Teacher-made quiz **Vector Air Project**: Teams will complete the flight plans to a level of accuracy determined by the teacher, citing resources appropriately.

21st Century Skills	Learning Skills & Technology Tools	Teaching Strategies Culminating Activity	Evidence of Success

Information and Communication Skills:	21C.O.9-12.1.LS1 - Student recognizes information needed for problem solving, can efficiently browse, search and navigate online to access relevant information, evaluates information based on credibility, social, economic, political and/or ethical issues, and presents findings clearly and persuasively using a range of technology tools and media. 21C.O.9-12.1.TT4 - Student uses audio, video, pictures, clip art, moviemaker programs, webpage design software, electronic documents and other files to collaborate for the creation of electronic products that inform multiple audiences both inside and outside the school environment.	Teacher will give student teams the opportunity to research airport locations to develop multiple flight plans between cities. Teacher provides students with opportunity to complete techSteps activity; provides needed guidance on use of PowerPoint and drawing tools.	Students will complete **Vector Air Project** with appropriate data to the accuracy level defined by the teacher. Students will successfully complete the techSteps: Force Components activity to a level defined by the teacher.
Thinking and Reasoning Skills:	21C.O.9-12.2.LS3 - Student engages in a problem solving process by formulating questions and applying complex strategies in order to independently solve problems. 21C.O.9-12.2.TT4 - Student uses technology tools and multiple media sources to analyze a real-world problem, design and implement a process to assess the information, and chart and evaluate progress toward the solution.	Teacher will group students before providing the Vector Air scenario; will lead an introductory discussion on the K-W-L chart; will monitor team progress towards goal of solving problem; will steer teams to appropriate resources, when needed. Teacher will provide opportunity for student teams to use various software tools, graphing calculators, drawing tools to plan and present the solution to the Vector Air problem.	Students will submit a **Vector Team Log** each day.
Personal and Workplace Skills:	21C.O.9-12.3.LS3 - Student demonstrates ownership of his/her learning by setting goals, monitoring and adjusting performance, extending learning, using what he/she has learned to adapt to new situations, and displaying perseverance and commitment to continued learning. 21C.O.9-12.3.TT2 - Student works collaboratively to acquire	Teacher will require team logs to be maintained that show team plans and progress; will periodically check on K-W-L charts as teams fill in their knowledge gaps Teacher requires student teams to use Internet resources to complete project; provides students with methods to check validity and cite resources	Each team will submit a **Vector Team Log** daily to show progress on the project tasks. Student will keep track of personal accomplishment with maintenance of the **Vector Task Checklist** Students will complete **Vector Air Project** with validated data and citing all resources.

	works collaboratively to acquire information from electronic resources, conducts online research, and evaluates information as to validity, appropriateness, usefulness, comprehensiveness and bias.	check validity and cite resources.	

Performance Objectives:	**Know:** Represent a vector both algebraically and graphically Perform operations with vectors, along with algebraic and graphic representations **Do:** Analyze and describe the geometry of vectors Perform mathematical operations with vectors Use vectors to solve real-world problems Browse and search the Internet Create electronic documents using graphics Cite sources within documents appropriately Work collaboratively to solve problems with peers
Driving Question:	How do you describe flight using mathematics?
Assessment Plan:	SAS #79: (http://www.sascurriculumpathways.com) Students will work with their teams to work through the Web Inquiry to learn about vectors. They will turn in a team Response Sheet provided by SAS after the lab. Individuals will turn in the homework portion of the Response Sheet for individual assessment. Vector and Projectile Activity Sheet is provided by The Physics Classroom website (http://www.physicsclassroom.com/reviews/vectors/vectorsprint.cfm). Teams will use the Internet, textbooks, other resources available to complete this sheet. Team members should make sure all members understand the problems as a teacher-made quiz will assess individuals on this material. SAS #75: (http://www.sascurriculumpathways.com) Students will work with their teams to complete the Web Inquiry to learn how vectors are use to solve force problems. They will turn in a team Response Sheet provided by SAS after the lab. TechSteps: Force Components: (http://techsteps.com) Students will work individually through this on-line activity available to all West Virginia students. They will complete a PowerPoint activity that uses drawing tools and calculations to break vectors down onto their components. **Vector Air Project**: Many pilots use navigation devices to control their flights from one airport to the next. Some of these devices use GPS information to plan the route. There have been questions about some of the routings defined from a certain flight plan provider. You work for Vector Air, a company that has been contracted by the navigation vendor, to set accurate routings between airports. You will design several routes between major cities, validating their accuracy. You will provide an accurate scale drawing of the various routings along with the mathematical calculations required.

Major Group Products	**Vector Air Project** Vector and Projectile Activity Sheet SAS #79 – Web Inquiry SAS #75 – Web Inquiry
Major Individual Projects	SAS #79 – homework component techSteps: Force Components

Assessment and Reflection:	**Rubric(s) I Will Use:**	Collaboration		Written Communication	
		Critical Thinking & Problem Solving		Content Knowledge **Vector Air Project Rubric**	X

		Oral Communication		Other Rubrics for SAS activities available on teacher side of the lesson, answer key for Vectors and Projectiles also available on-line techSteps rubric available from techSteps	X
	Other Classroom Assessments For Learning:	Quizzes/Tests Teacher-made quiz	X	Practice Presentations **Vector Air Project Draft Rubric**	
		Self-Evaluation		Notes	
		Peer Evaluation		Checklists/Observations **Vector Group Observation Checklist** **Vector Task Checklist**	X
		Online Tests and Exams		Concept Maps	
	Reflections:	Survey		Focus Group	
		Discussion		Task Management Chart	
		Journal Writing/Learning Log **Vector Team Log**	X	Other **Vector Project Debrief** **Vector Self-Reflection**	X

Map The Product:

Vector Storyboard

Product: **Vector Air Project**

Knowledge and Skills Needed	Already Have Learned	Taught Before the Project	
1. Mapping cities according to coordinates			
2. Naming vectors by direction and distance			
3. Solving triangles using trigonometry		X	
4. Adding vectors using triangles			
5. Resolving vector into components			
6. Adding vectors using components			
7. Making scale drawings	X		
8. Using the Internet to research	X		
9. Using PowerPoint	X		
10. Working in collaborative teams	X		
11. Validating and citing Internet resources			

Resources:

School-based Individuals:
Physics Teacher
Technology Coordinator

Technology:
Computer with Internet Access, presentation software
Projector

Community:
Air traffic controller

	Pilot Flight Instructor Civil Air Patrol members National Guard or Air Force representatives **Materials:** Rulers, protractors, graph paper
Manage the Process:	**Vector Storyboard** is provided. Before the project begins: Divide the class into teams of 4. You may want to make sure that each group has an expert on Internet research and an expert on very neat drawings. Both skills will be important to successful completion of the project. You will also want to make the **Vector Resource Center** available to your students. If you can post the list on-line, students will not need to type in long, tedious URLs. A more detailed list is also attached: **Vector Resource Center (teachers).** Lastly, invite the guest for the entry event. A licensed pilot, air traffic controller, flight instructor or flight planner would be an appropriate "expert" to introduce the project to your students. Most of the activities in this project are computer intensive. Some activities may be printed out for use without computers, but most resources listed are Internet-based. A computer lab would be beneficial for this PBL. To differentiate, some teams may be steered to particular websites that are more direct in their instruction. For more advanced teams, you may want to add vector cross-products to their list of tasks. Teams should be able to act very independently through the various activities. Teacher will use **Vector Group Observation Checklist** several times throughout the project to assess collaboration skills. Giving the completed checklist to teams after each observation will help them see their strengths and weaknesses as a group. Teams will submit a daily **Vector Team Log** to help both the teacher and students. Students should take turns submitting this report. The teacher will be able to monitor each team's progress, as well as areas that need to be addressed in the next class. The log should help students stay focused on the tasks and help to schedule outside work, if needed. The SAS Activities are available to all students in West Virginia high schools. If you do not have an account, check with your school or county technology contact for log-in information. Students may work in pairs or teams. TechSteps is also available to West Virginia students. The grading rubrics for both SAS and techSteps activities are available with the lessons, if you log in as a teacher. If SAS or techSteps are not available, NCTM's Illuminations (http://illuminations.nctm.org/)or Thinkfinity (http://www.thinkfinity.org/lesson-plans) may have similar activities. Hand out the Vectors and Projectiles Activity Sheet from The Physics Classroom website, (http://www.physicsclassroom.com/reviews/vectors/vectorsprint.cfm). Use this activity as the basis for team research into solving various types of vector problems. To differentiate, you may want to limit the number of problems on this assignment. Another alternative would be to have certain teams act as experts on certain problems and share their knowledge with the other teams. Do not have students complete the techSteps activity until they already know how to resolve vectors into their horizontal and vertical components. The activity uses this skill. In this activity, students will complete a PowerPoint presentation illustrating resolving vectors into these components. Students should study the rubrics before delving too deeply into the final project: **Vector Air Project**. They will need to use vector addition by triangles as well as by components to validate the flight plans. They should have at least two alternatives to a direct flight between their two cities. The solution should include neat, accurate drawings as well as all calculations necessary to find the headings for the flights. They will need to indicate that they have checked the validity of the sites used, and cite their resources. Websites are available for help on these tasks in the **Vector Resource Center**. A draft solution is presented and discussed with an "expert" before turning in the final proposal. In this manner, students may learn from the experts to better their solutions.
Project Evaluation:	After the projects have been completed, the class will reflect both as a team and individually using the **Vector Project Debrief** and **Vector Self-Reflection** documents. These will not only help the students to reflect, but will inform the teacher about strengths and weaknesses of the project for further revision.

Resource Files Uploaded	**Resource Files** • UP3493WS2.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS2.doc) • UP3493WS3.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS3.doc) • UP3493WS4.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS4.doc) • UP3493WS5.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS5.doc) • UP3493WS6.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS6.doc) • UP3493WS7.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS7.doc) • UP3493WS8.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS8.doc) • UP3493WS9.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS9.doc) • UP3493WS10.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS10.doc) • UP3493WS11.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS11.doc) • UP3493WS12.doc (http://wveis.k12.wv.us/Teach21/CSO/Upload/UP3493WS12.doc)