Unit 2 – Module 1

Working with displacement vectors (Land Map Activity)

RATIONALE

Vectors provide a useful tool for visualizing motion, force, momentum, fields, and so on. Once the tools for creating, manipulating and interpreting vectors have been created, then students will be able to use the tools to better process problems involving 2-D motion, relative motion, forces, momentum, fields, and so on. In order to develop the vector tools properly, students should be able to visualize the manipulation of arrows and integrate those images with the vocabulary used to describe vector quantities. The use of protractors and rulers to construct vector diagrams to scale takes time, but the experiences help students understand the mathematical treatment of vectors that comes later.

As students answer the questions about the Physics Land Map, they should become more familiar with the cardinal points of the compass, how to use a protractor to measure an angle, how to use a protractor to construct an angle, how to use a scale key on a map, the conventions for describing a vector’s directional information, the process of adding vectors “head to tail,” and resolving (decomposing) vectors to perpendicular components. This worksheet is not intended to teach the process of adding or resolving vectors mathematically, but rather is it intended to provide experiences where the rationale for the rules governing those techniques emerges based on the student’s own intuition about how to solve problems. All of the questions are based on displacement vectors, in that displacements are the easiest to visualize. The expectation is that once the vector tools have been introduced with displacement vectors, the skills can then be readily transferred to manipulate ANY type of vector quantity.

PRIOR KNOWLEDGE AND SKILLS

* how to describe an angle using the points of the compass
* how to use a protractor to measure and construct angles
* how to use a ruler to measure and construct lines of a given length
* how to compute displacement for an object moving at a constant velocity
* how to use scale a measurement based on a map key
* the definition of vector magnitude

CE’s AND PE’s

1. Know the definition of vectors, scalars

2. Know the conventions for defining directions for vectors (degrees away from +x axis, cardinal compass points, compass directions)

4. *Utilize vector arrows to represent vector quantities*

*5. Construct vector scale drawings with a ruler and protractor*

*6. Add vectors head to tail using the graphical method*

*7. Determine resultant vector graphically from multiple component vectors*

PHYSICS CONVENTIONS

* angle measures can be described by naming the angle between a ray and a cardinal compass direction, with the assumption that East is in the positive x direction and North is in the positive y direction

STUDENT GROUPING

Each student should be provided with their own Physics Land Map as well as the questions to be answered. At the discretion of the teacher, students may work in groups. Because students will need to refer to 2 sheets of paper, use a protractor, a ruler, a pencil and perhaps a calculator, the teacher should make sure that there is adequate workspace to accommodate the materials needed.

MATERIALS

FOR EACH STUDENT:

Copy of Physics land map

Copy of questions sheet

Protractor with at least 1º markings

Ruler with at least 1 mm markings

FOR THE CLASS

LCD projection screen (optional)

TIMELINE (about 40 minutes + potential homework)

2-3 minutes – lecture, recalling that vector quantities are those that have both a direction (which way the arrow is pointing) as well as a magnitude (how long the arrow is, or how much of the quantity the vector represents). Inform students that they will be asked to draw vectors on a map of a place called Physics Land, as well as answer questions about some of the places found there. Students should not find the questions to be too difficult, but it will be important to be careful with measurements and to be aware of how they are going about solving some of the problems presented.

2-3 minutes – distribute materials, divide into groups

35-40 minutes – students work on solving problems. The teacher should assess the time constraints and the abilities of the students to determine if all of the questions need to be answered during the class period.

(Homework) - If additional time is needed, the teacher needs to be aware of the fact that students usually do not have access to protractors at home and that therefore it may be impossible to complete the worksheet on their own, regardless of their level of comprehension or motivation. Some of the questions at the end of the worksheet are conceptually redundant with those asked earlier and so can be easily eliminated without affecting the student’s exposure to novel concepts (questions 13-15).

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| **Stage of activity** | **What the students should do** | **Student mistakes** |
| Putting names on the map | Put their name on the map | No name |
| Possible teacher responses:  Students may think that the map is merely to be used as reference material, not realizing that a significant assessment of their understanding is possible by looking at the markings that they make when representing vectors or displacements. As such, it is important that the maps be turned in along with the worksheet questions. | | |
| Calculating scaled distances | Use the map key to convert between real and scaled distances | Overlook the scale information provided |
| Possible teacher responses:  The scale has been designed so that 1cm (map) = 1 km (real). This is to facilitate conversions and place the pedagogical emphasis on drawing vectors rather than converting units. | | |
| Question #4 | Construct a vector with the tail at Dis Place, in a direction measuring 38º below the positive x-axis | Confuse S of E and E of S |
| Possible teacher responses:  Ask the student to point in a direction that is DUE EAST. From then, ask for a direction that is only 5 degrees S of E, then 10 degrees, etc. This terminology is confusing because the reference cardinal direction is the second direction mentioned in the instructions (s of E). | | |
| Question #4 | Construct a vector with the tail at Dis Place, in a direction measuring 38º below the positive x-axis | Fail to use a protractor to accurately measure 38º |
| Possible teacher responses:  Some protractors have 2 sets of angle measures printed on them, increasing from 0º to 180º as well as decreasing from 180º to 0º. If students do not recall the fact that an angle can only be measured at the intersection of 2 lines, they may not realize that they are using the wrong line on the protractor as the 0º reference line. It is sometimes helpful to ask them to define what an angle means, which will force them to recall that it requires 2 lines, not just one. Form there, ask to see a 5º angle, gradually increasing to 38º. | | |
| Question #4 | students use the protractor to mark direction properly on their map | Students struggle to create a vector with both magnitude and direction |
| Possible teacher responses:  When trying to draw a vector, students will sometimes grab the ruler first, make it the proper length, and THEN attempt to make it point in the proper direction, which results in frustration. The technique of placing the protractor first, making a small dot at the vertex and at the angle measure required, and THEN filling in the | | |
| Question #7 | Students convert 45 minutes to seconds or convert 6.71 m/s to m/min. | No conversion |
| Possible teacher responses:  Ask how far the bird would go in 45 seconds? 45 hours? 45 days? | | |

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| Question #8 | Students carefully construct each displacement vector, beginning at the termination of the previous vector | -Sloppy protractor or ruler work  -improper angle measures |
| Possible teacher responses:  Students should conclude that the physicists end up at Coasting. Each vector is given in terms of the compass points, although some students may try to measure angles relative to the previous vector. | | |

POST ACTIVITY DISCUSSION PROMPTS

Students that are able to complete the questions about Physics Land are already in possession of many of the tools needed to manipulate vectors. It may be useful, however, to refer back to specific questions when trying to solve problems later in the course. The process of turning a single vector into 2 mutually perpendicular components (decomposing or resolving a vector) is what students are asked to so in the helicopter problem and in the stingray problem. Vector addition is what is required for the 3-day boat journey and the diamond prospector. The ability to lift and move a vector without altering its magnitude or direction is what is needed to determine the location of the teleporting scientist. While it is not necessary to explain each one of these skills immediately after students perform the Physics Land task, it may be a useful reference for times when the mathematics of a problem threatens to overwhelm their intuition about a situation.