Group Activity 1: Which Way is North?

I Essentials

(a) Main ideas

- The same physical vector can be written in terms of more than one basis.

(b) Prerequisites

- The geometric definition of vectors as arrows in space.
- The geometric definition of vector addition.

(c) Warmup

- None — this is a nice activity for the first day of class.
- You might need to start off with a discussion of small group activities, and the roles you expect students to play, as discussed at the beginning of Part III.

(d) Props

- whiteboards and pens
- aviation maps if available
- globe

(e) Wrapup

- Need notation that refers explicitly to the basis.
- Discuss reasons for change in notation from $\langle a, b\rangle$ to $a\,\hat{\boldsymbol{\imath}} + b\,\hat{\boldsymbol{\jmath}}$
- $+$ is really *vector* addition.

II Details

(a) In the Classroom

This activity is straightforward; students have few problems with it.

Question 3 asks whether any vector displacement be expressed as the sum of a vector pointing east and one pointing north. Many students are bothered by this, since they don't know whether they can use negative coefficients. We have deliberately left the question ambiguous in order to generate a short discussion about conventions. To the lay person, South is a different direction from North; in mathematics, these are not independent directions. We nonetheless accept both answers, provided a reasonable explanation is given.

Get students to answer the first two questions on the board — on the same diagram. Watch out! The second student often uses a different scale than the first; the resulting vectors won't agree. Not all students realize this is a problem! Asking how many libraries there are usually resolves this.

A good question to ask at the end is which representation of the vector displacement to the library is the most important. (The answer of course is that it depends on the question.)

(b) Subsidiary ideas

- **Multiple bases**
  When working with more than one basis, it is essential to incorporate the basis explicitly into the notation. In particular, using the common notation $\langle x, y, z \rangle$ for the components of a vector should be discouraged, not only because there is no indication of which basis one is using, but also because it makes it difficult for some students to realize the difference between vectors and scalars. [1]

- All 2-dimensional vectors can be written in terms of 2 basis vectors.

- Components can be negative.

- The definitions of orthogonal, normalized, and orthonormal.

[1] This is not helped by the fact that the components of vectors are *not* scalars!

- **Geometric definition of dot product**
  This would be a good place to introduce or reinforce the geometry of the dot product, and especially the fact that $|\vec{\boldsymbol{v}}|^2 = \vec{\boldsymbol{v}}\cdot\vec{\boldsymbol{v}}$; see Section 9.1.

(c) Homework (none yet)

(d) Essay questions (none yet)

(e) Enrichment

- Where is Coriander?
- NOAA has a website which can be used to determine the magnetic deviation for any location:
  `http://www.ngdc.noaa.gov/cgi-bin/seg/gmag/fldsnth1.pl`
- Further information about magnetic declination, as well as links to online maps, can be found at:
  `http://www.geocities.com/magnetic_declination`
- It is an interesting problem in spherical geometry to find the set of points for which the magnetic deviation is constant. A globe helps!
  To the best of our knowledge the solution to this problem is not known.