Mathematica Labs | Denis Shubleka

Subject: Calculus

Topic: Dot Product

Goal: Use *Mathematica* to explore the operation of dot product between two vectors.

Task 1

A vector in 2-space is represented as a list of length 2. For higher dimension spaces, simply define a vector as a longer list. We start with a simple vector addtion in 2-space:

```
{1, 9} + {-3, 1}
```

Scalar multiplication in 3-space works as one would expect:

```
3 {-1, 1, 1}
```

We can also define a few vectors and perform operations on them, such as, for
example, a linear combination:

```
u = {1, 1, 1};
v = {-1, 2, 4};
2 u + 3 v
```

Task 2

Mathematica computes the dot product operation between two vectors when we place a period in between them:

```
{a, b}.{c, d}
```

Feel free to try it it with two specific vectors in 3-space.

The norm (or length) of a vector is determined using the Norm command:

```
Norm[{x, y, z}]
```

To find the angle between two vectors we first define them, and then ask
Mathematica to compute the arc cosine:

```
u = {1, 1, 1}; v = {1, 0, 0};
ArcCos[u.v / (Norm[u] Norm[v])] // N
```

The output is in radian measure, so we convert the result (%) to degrees:

```
% / Degree
```

We conclude this task by showing how *Mathematica* displays vectors in 2-space:

```
Graphics[{Arrow[{{0, 0}, {1, 1}}], Arrow[{{0, 0}, {-1, 3}}]}, Axes → True]
```

Note that rendering vectors in 3-space requires the Graphics3D package. For
example, to plot vectors (1, 1, 1) and (-1, 1, -1) execute the following:

```
Graphics3D[{Arrow[{{0, 0, 0}, {1, 1, 1}}], Arrow[{{0, 0, 0}, {-1, 1, -1}}]},
 Axes → True, Boxed → False]
```

Related Exercises/Notes: