Math 53 Homework 2
Due Wednesday 9/18/13 in section

(The problems in parentheses are for extra practice and optional. Only turn in the underlined problems.)

Monday 9/9 – Vectors, dot product
• Read: sections 12.1, 12.2, 12.3.
• Work: 12.1: (5), (7), (11), (13), (21), (27), 33, 41.¹
  12.2: (3), (5), (17), (19), (25), (29), 33, (35), (43), 45, 51.²

Wednesday 9/11 – Dot product continued; determinant
• Read: section 12.3.
• Work: 12.3: (1), (11), 17, 23, (25), (27), (38), (39), 41, (49), (55), 60, 63, (64).³

Friday 9/13 – Cross product
• Read: section 12.4.
• Work: 12.4: (3), (9), (13), 16, (19), (27), 31, 36, (37), (45), 46, 53.⁴

p. 816 “The geometry of a tetrahedron”, parts 1† and 3.

† Hint: for part 1, don’t introduce coordinates; instead, express everything in terms of the vectors \( \vec{a} = \vec{SP} \), \( \vec{b} = \vec{SQ} \), and \( \vec{c} = \vec{SR} \) and use the properties of cross-product.

Problem 1. The eight vertices of a cube centered at \((0,0,0)\) of side length 2 are at \((\pm 1, \pm 1, \pm 1)\).

a) Find the four vertices of the cube, starting with \((1,1,1)\), that form a regular tetrahedron. Confirm your answer by finding the length of an edge and explaining why all edges have the same length.

(Recall: a tetrahedron is a solid with four triangular faces, like a pyramid with a triangular base; it is regular if all faces are equilateral triangles. Draw pictures and look at cubical objects in order to figure out how equilateral triangles fit on a cube).

b) Use dot product to find the angle between two adjacent edges (edges sharing a common vertex) of the regular tetrahedron; and the angle between two opposite edges (edges that lie on skew lines; even though they don’t intersect, you can still compute the angle made by their directions). Explain your answers using symmetry.

c) A methane molecule CH₄ consists of a hydrogen atom at each of the vertices of a regular tetrahedron and a carbon atom at the center. Find the “bond angle”, i.e. the angle made by vectors from the carbon atom to two hydrogen atoms (use a calculator; round your answer).

¹6th ed: 12.1: (5), (7), (11), 13, (21), (27), 31, 39.
²6th ed: 12.2: (3), (5), (15), (17), (23), (25), 29, (31), (37), 39, 45.
³6th ed: 12.3: (1), (11), 17, 23, (25), (27), (34), (35), 37, (45), (51), 56, 59, (60).
⁴6th ed: 12.4: (3), (9), (13), 16, (19), (27), 31, 36, (37), (43), 44, 49; p. 794 parts 1 and 3.