# 6.034 Quiz 4
# December 3, 2008

| | |
|---|---|
| Name | |
| EMail | |

Circle your TA and recitation time, if any, so that we can more easily enter your score in our records and return your quiz to you promptly.

| TAs |
|---|
| Sam Glidden |
| Mike Klein |
| Mark Seifter |
| Norman C. N. Quest |

| Thu | |
|---|---|
| Time | Instructor |
| 1-2 | Bob Berwick |
| 2-3 | Bob Berwick |
| 3-4 | Bob Berwick |

| Fri | |
|---|---|
| Time | Instructor |
| 1-2 | Howard Shrobe |
| 2-3 | Howard Shrobe |
| 3-4 | Howard Shrobe |

| Problem number | Maximum | Score | Grader |
|---|---|---|---|
| 1 | 50 | | |
| 2 | 50 | | |
| Total | 100 | | |

**There are 7 pages in this quiz, including this one. In addition, 1 tear-off sheet is provided at the end.**

**As always, open book, open notes, open just about everything.**

# Problem 1: Support Vectors (50 points)

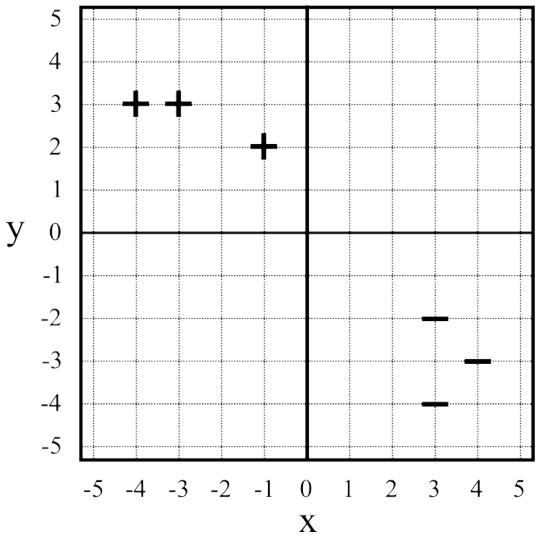
## Part A (30 points)

The following three graphs represent the training data for two-dimensional, linear SVMs. + symbols indicate the coordinates of positive examples, which the classifier should give a value of 1 or more, and – symbols represent the coordinates of negative examples, which the classifier should give a value of -1 or less.

For each graph, you should do the following **three** things:

(a) Circle the support vectors
(b) Draw the "street" produced by the SVM, with solid lines where the classifier outputs 1 or -1 and a dashed line where the classifier outputs 0
(c) Describe the classifier function $h(\mathbf{x}) = \mathbf{w}\cdot\mathbf{x} + b$, by giving the values of $\mathbf{w}$ and $b$

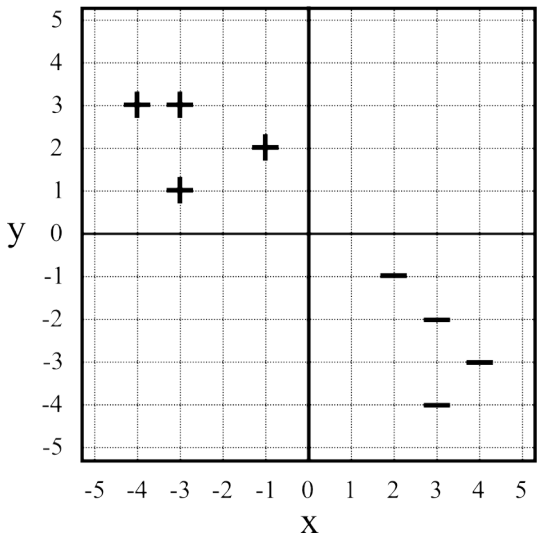
**Graph #1**




$\mathbf{w}$ =

$b$ =

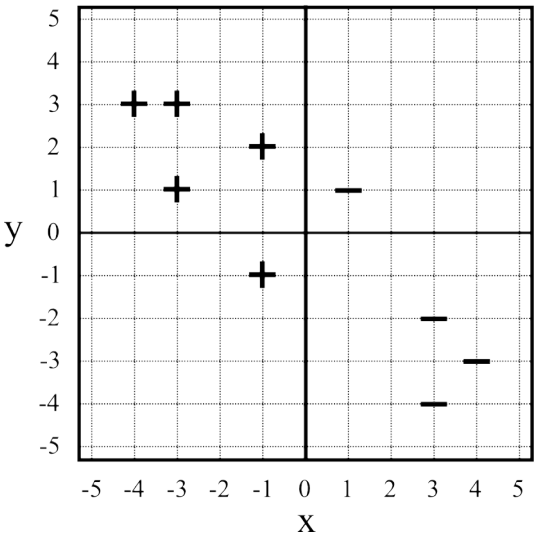
**Graph #2**




**w** =

*b* =

**Graph #3**

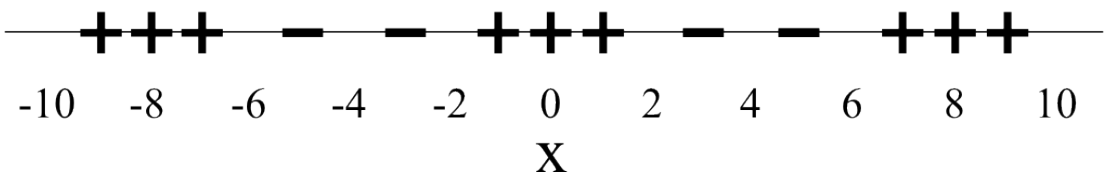



**w** =

*b* =

# Part B (20 points)

Susan Q. Randomstudent is frustrated by the data she is supposed to classify with a support vector machine. It's all on the same line, defined only by an *x*-coordinate, and it switches back and forth from clusters of + points to clusters of – points several times, so it's not at all linearly separable.



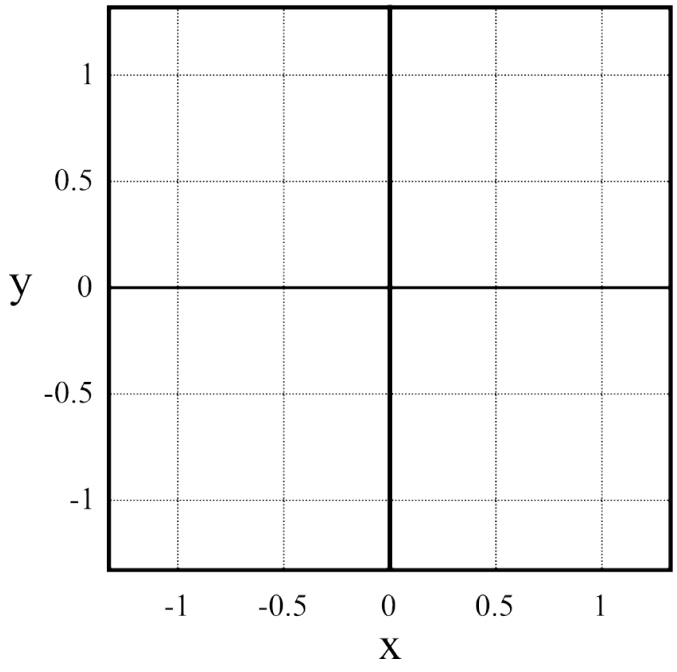

Eventually, though, she figures out a kernel function that she can use to separate the data:

$$K(x_1, x_2) = \cos(\frac{\pi}{4}x_1)\cos(\frac{\pi}{4}x_2) + \sin(\frac{\pi}{4}x_1)\sin(\frac{\pi}{4}x_2)$$

1. What is the Φ function that projects *x* into the new space defined by this kernel? (The function should take in *x* and output a vector with two components.)

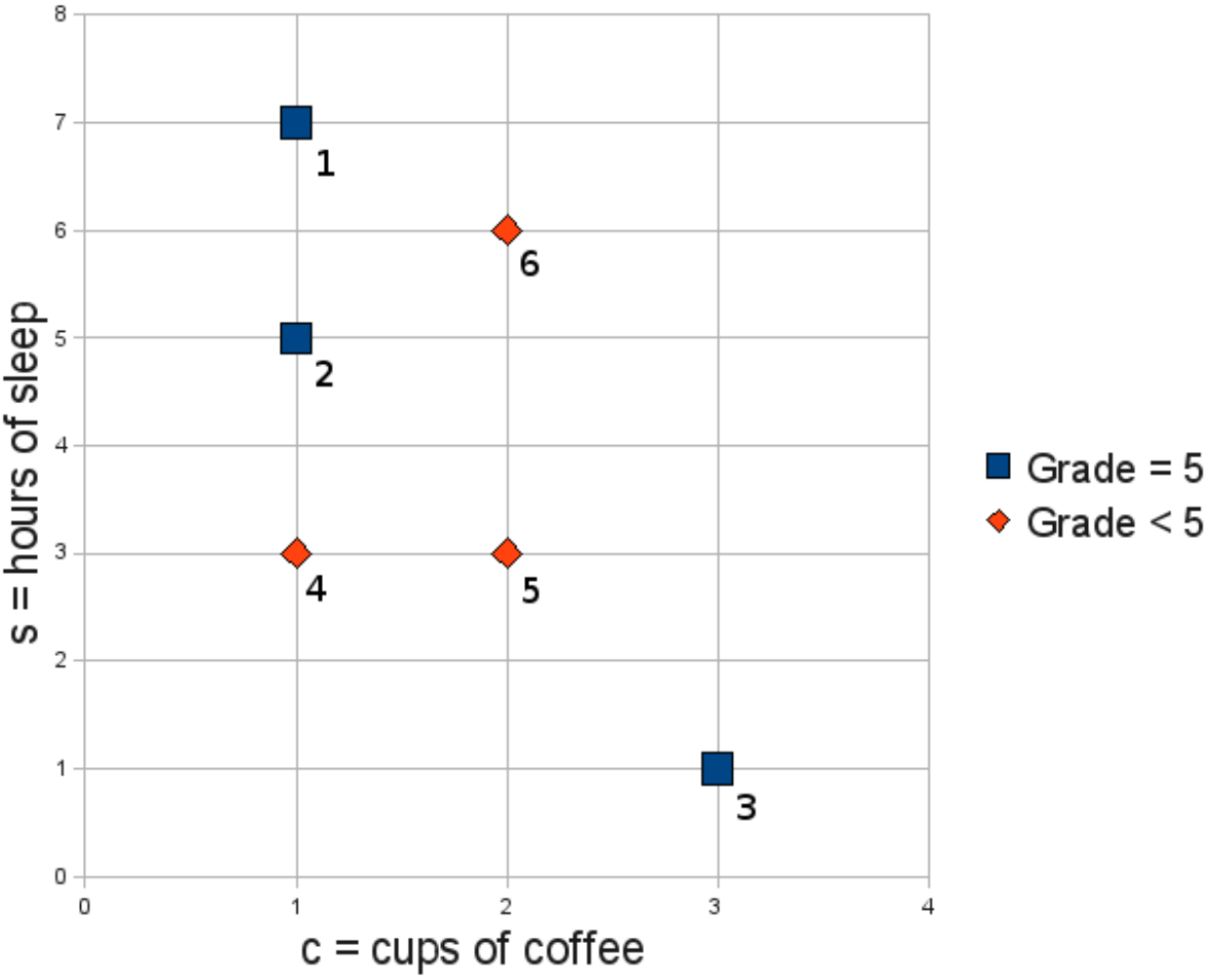
   $\Phi(x) =$

2. On the grid below, draw the + and – points in the new space, and draw the "street" that linearly separates them.



# Problem 2: Boosting (50 points)

Prof. Winston wants you to study the link between sleep, coffee, and 6.034 quiz grades. He gathered 6 data points from the previous quiz for you:




You decide to encode "Grade = 5" as +1, and "Grade < 5" as -1.

For this entire problem, consider only horizontal and vertical classifier stumps halfway between two data points, e.g. h(c,s) = sign(c - 2.5) or h(c,s) = sign(2 – s). You may also use h(c,s) = +1 and h(c,s) = -1.

In case of ties: prefer stumps involving s (horizontal) over stumps involving c (vertical), and prefer lower thresholds (s < 1.5) over higher (s < 2.5). Blanket classifiers h(c,s) = +1 and h(c,s) = -1 come last.

# Part A (30 points)

Use Adaboost for 3 rounds. First update the weights using the results of the previous round, find the best stump h(c,s) and its error ε. The starting weights have been filled in for you.

$w_1 =$ 1/6 $w_2 =$ 1/6 $w_3 =$ 1/6

$w_4 =$ 1/6 $w_5 =$ 1/6 $w_6 =$ 1/6

$h_1(c,s) =$

$\varepsilon_1 =$

---

$w_1 =$ $w_2 =$ $w_3 =$

$w_4 =$ $w_5 =$ $w_6 =$

$h_2(c,s) =$

$\varepsilon_2 =$

---

$w_1 =$ $w_2 =$ $w_3 =$

$w_4 =$ $w_5 =$ $w_6 =$

$h_3(c,s) =$

$\varepsilon_3 =$

# Part B (15 points)

What is the current Adaboost classifier made from combining these first three stumps? How many errors does it make on the training data?

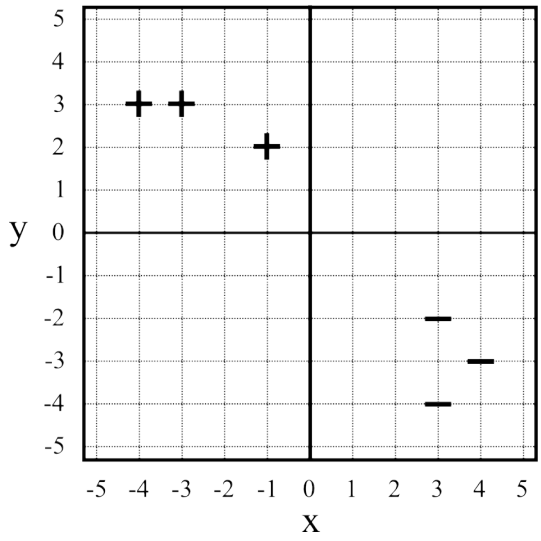
H(c,s) =

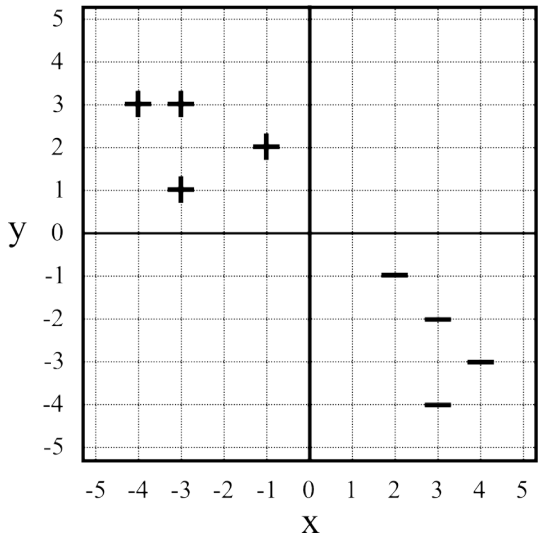
# of errors =

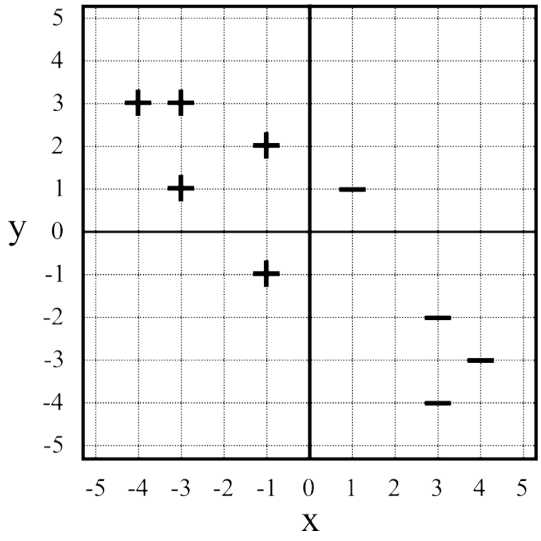
# Part C (5 points)

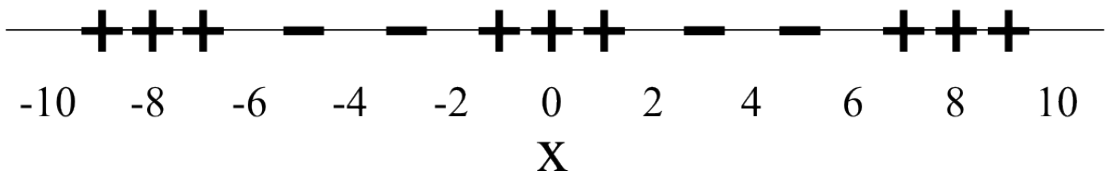
If you were to run Adaboost for 100 more rounds, which data point or data points do you expect to have the **least** weight? Explain briefly. (You may write down another 100 rounds as in Part A in lieu of explanation.)

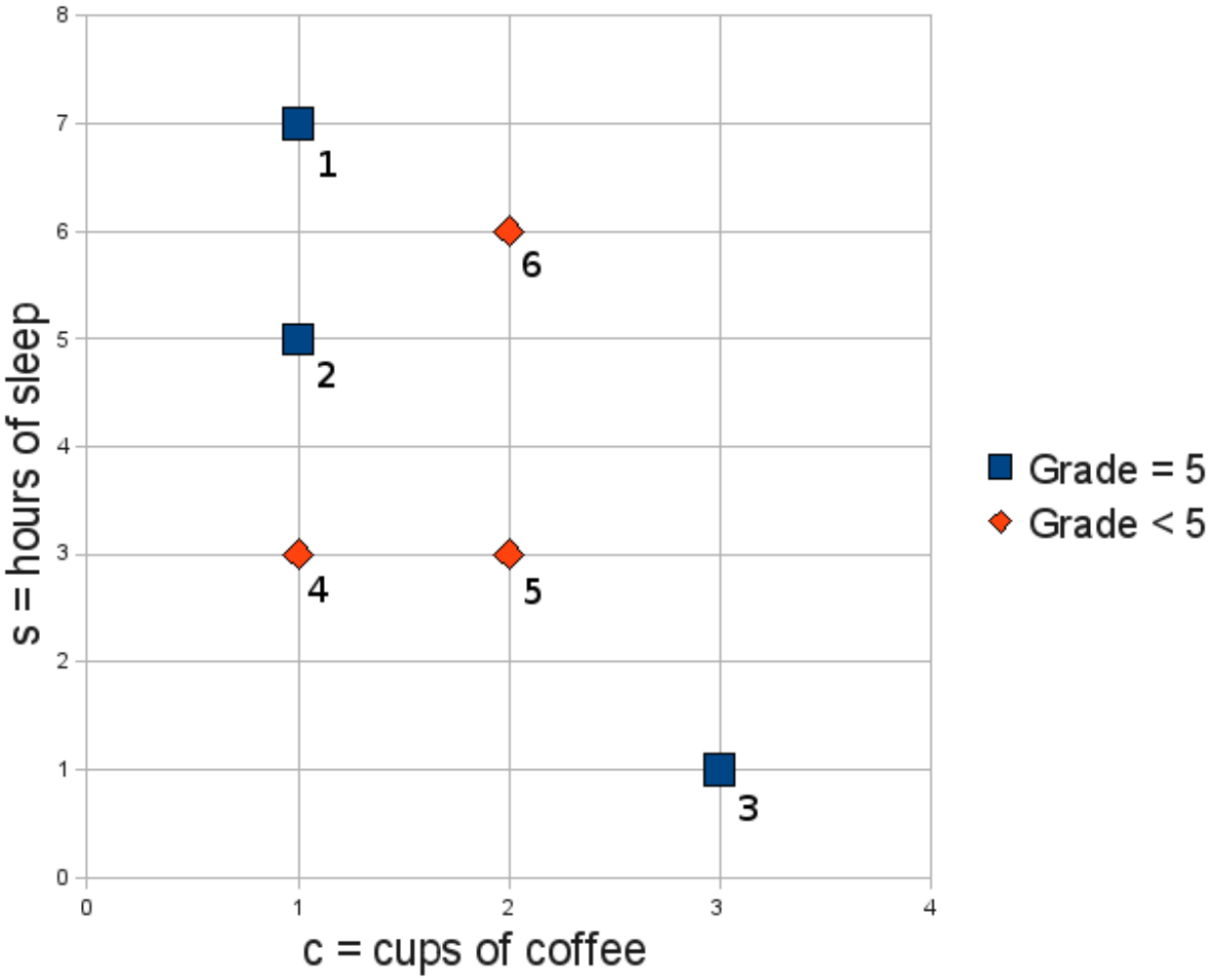
(This page is blank for a very good reason.)


5
4
3
2
1
y 0
-1
-2
-3
-4
-5
-5 -4 -3 -2 -1 0 1 2 3 4 5
x


5
4
3
2
1
y 0
-1
-2
-3
-4
-5
-5 -4 -3 -2 -1 0 1 2 3 4 5
x


5
4
3
2
1
y 0
-1
-2
-3
-4
-5
-5 -4 -3 -2 -1 0 1 2 3 4 5
x


-10 -8 -6 -4 -2 0 2 4 6 8 10
x


s = hours of sleep
c = cups of coffee
0 1 2 3 4
0 1 2 3 4 5 6 7 8
1
2
3
4
5
6
Grade = 5
Grade < 5

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# 6.034 Artificial Intelligence

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