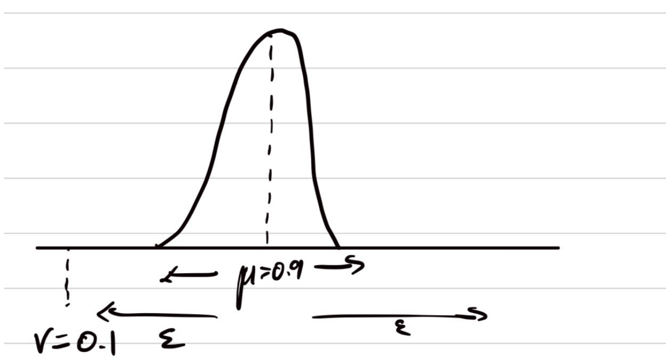
1. Exercise 1.8 in LFD

binomial distribution tells us

$$
\begin{aligned}
p_x &= \binom{n}{x} p^x q^{n-x} \\
n &= 10 \\
x &= 0 \text{ and } x = 1 \\
p &= 0.9 \\
q &= 1 - p = 0.1 \\
p_0 &= \binom{10}{0} 0.9^0 0.1^{10} = 0.1^{10} = 1 \times 10^{-10} \\
p_1 &= \binom{10}{1} 0.9^1 0.1^9 = 10 \times 0.9 \times 0.1^9 = 9 \times 10^{-9} \\
p &= p_0 + p_1 = 9.1 \times 10^{-9}
\end{aligned}
$$

2. Exercise 1.9 in LFD



we want 0.1 = v to happen, so $\varepsilon = |0.9 - 0.1| = 0.8$

Using $P[|\nu - \mu| \geq \epsilon] \leq 2e^{-2\epsilon^2 N}$, we can find the following bounds:
Using $\epsilon = 0.8$ and $N = 10$, we can derive $2e^{-2\epsilon^2 N} = 2e^{2(0.8)^2 \times 10}$, which equals 5.52×10^{-6}.
Since this is a bound, it is reasonable for it to be greater than our answer in exercise 1.8

3. Exercise 1.10 in LFD

   (a) $\mu = 0.5$

   (b) **FINISH HERE**

(c) **FINISH HERE**

(d) c_1 and c_{rand} obey the Hoeffding bound, c_{min} does not because $c1$ and c_{rand} were selected without looking at the data, while c_{min} looks at the data before selecting. c_{min} represents the "unlucky" choice

(e) **FINISH HERE**

4. Exercise 1.11 in LFD

(a) **FINISH HERE**

(b) **FINISH HERE**

(c) **FINISH HERE**

(d) **FINISH HERE**

5. Exercise 1.12 in LFD

(a) We don't know anything about the sample, so we can't make any assumptions of how well our g can approximate f, in addition, the problem says "guarantee", which will never happen.

(b) No, in order to have a high probability that our g approximates f well out of sample, we need our $E_{out} \approx E_{in} \approx 0$. With 4000, which is a small data point, we can say $E_{in} \approx 0$, but we can't say anything about $E_{out} \approx E_{in}$ since that requires N to be large.

(c) **This is the best choice**, more likely than not we will declare that we have failed, we don't have enough data to say anything about outside the $N = 4000$ data points.

6. Problem 1.3 in LFD

(a) w^* separates the data, so $x_n = y_n$, let $A_n = x_n = y_n$ and $p = \min_{1 \le n \le N} A_n^2 w^*$, A_n^2 will always be a positive number, so $p > 0$

(b) Assume

$$
\begin{aligned}
w^T(t)w^* &\ge w^T(t-1)w^* + p \\
w^T(t) &= w(t-1) + y_* x_* \text{ update rule} \\
(w^T(t-1) + y_* x_*)w^* &\ge w^T(t-1)w^* + p \\
w^T(t-1)w^* + y_* x_* w^* &\ge w^T(t-1)w^* + p
\end{aligned}
$$

Here, we see that $w^T(t-1)w^*$ are the same on both side of the inequality, so we need to prove that $y_* x_* w^* \ge p$, but we already know that $p \le y_n(w^{*T} x_n)$ from part (a), so the statement is true ■

prove $w^T(t)w^* \ge tp$ by induction:

base case: $t = 0$, $w(0) = 0$, so $0 \geq 0$ is true
induction step: assume $k = t$ and create our induction hypothesis $w^T(k)w^* \geq kp$
Prove $w^T(k+1)w^* \geq (k+1)p$

$$(w^T(k) + y_* x_*)w^* \geq (k+1)p \text{ update rule}$$
$$w^T(k)w^* + y_* x_* w^* \geq kp + p$$

Our induction hypothesis says $w^T(k)w^* \geq kp$, and we know that $y_* x_* w^* \geq p$ from part (a), so the statement is true ■

(c) with the update rule, we get

$$||w(t-1) + x(t-1)y(t-1)||^2 \leq ||w(t-1)||^2 + +||x(t-1)||^2$$

We can solve LHS, so

$$||[w(t-1) + x(t-1)y(t-1)]^2|| = ||w(t-1)^2 + 2w(t-1)x(t-1)y(t-1) + x(t-1)^2 y(t-1)^2||$$

$y(t-1)^2 = 1$ since y $\in \{-1, 1\}$

$$= ||w(t-1)^2 + 2w(t-1)x(t-1)y(t-1) + x(t-1)^2||$$
$$= ||w(t-1)^2 + x(t-1)^2|| \text{ is in both sides of the inequality}$$

On the LHS, we have $2w(t-1)x(t-1)y(t-1)$, which, when $x(t-1)$ is misclassified by $w(t-1)$, becomes < 0, so

$$||w(t-1)^2 + x(t-1)^2 + \text{ negative number }|| < ||w(t-1)^2 + x(t-1)^2||$$

We know $||w(t-1)^2 + x(t-1)^2|| \leq ||w(t-1)||^2 + ||x(t-1)||^2$ by subadditivity, so $||w(t)||^2 \leq ||w(t-1)||^2 + ||x(t-1)||^2$ ■