Consider a classifier hypothesis set of squares. A single hypothesis $h$ is a square with a fixed size and location. Four example hypotheses are shown.

And here is examples of $h$ that will help shatter a set of three data points.

For each data set:
- What is a set of 4 shatterable points ("none" is a possible answer)
- What is the VC dimension?

**Example 1:**

**Example 2:**
Example 3:

Consider the following HMM. It uses a thermometer to attempt to predict the weather.

We begin with the following estimate for our HMM parameters:
\[
\begin{align*}
\Pi_{\text{snow}} &= 0.2 & \Pi_{\text{rain}} &= 0.3 & \Pi_{\text{sunny}} &= 0.3 & \Pi_{\text{cloudy}} &= 0.2
\end{align*}
\]

(We COULD actually learn a Gaussian function for the temperature for each state. Here, we’ll just do a discrete probability table.)

We receive a new sequence of temperatures and wish to update our HMM parameters.
Sequence:
Cold  Cold  Hot  Mild  Hot

Correct alpha values are in black. Made-up alpha values are in color parentheses. You will have to find the real values below. You can use the made-up value in calculating $S_t$ values further below.

$\alpha_t(i)$

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow</td>
<td>?? (.11)</td>
<td>.08</td>
<td>0</td>
<td>.00011</td>
<td>0</td>
</tr>
<tr>
<td>Rain</td>
<td>0.15</td>
<td>?? (.04)</td>
<td>.0082</td>
<td>.0017</td>
<td>.00049</td>
</tr>
<tr>
<td>Sunny</td>
<td>?? (.08)</td>
<td>0</td>
<td>.0056</td>
<td>?? (.0033)</td>
<td>.0020</td>
</tr>
<tr>
<td>Cloudy</td>
<td>0.04</td>
<td>.027</td>
<td>?? (.0044)</td>
<td>.0053</td>
<td>.00030</td>
</tr>
</tbody>
</table>

Correct beta values are in black. Made-up beta values are in color parentheses. You will have to find the real values below. You can use the made-up value in calculating $S_t$ values further below.

$\beta_t(i)$

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow</td>
<td>.0067</td>
<td>.0062</td>
<td>.13</td>
<td>.05</td>
</tr>
<tr>
<td>Rain</td>
<td>.0097</td>
<td>?? (.011)</td>
<td>.13</td>
<td>?? (.08)</td>
</tr>
<tr>
<td>Sunny</td>
<td>.0028</td>
<td>.087</td>
<td>?? (.11)</td>
<td>.52</td>
</tr>
<tr>
<td>Cloudy</td>
<td>.0062</td>
<td>.047</td>
<td>.121</td>
<td>?? (.11)</td>
</tr>
</tbody>
</table>

Find the missing values in the tables above.

What are the values:

$S_2(\text{cloudy})$

$S_3(\text{snow,sunny})$
$S_1(\text{rain})$

Now let us presume the following $S$ values (these are made-up values):

\begin{tabular}{|c|c|c|c|c|c|}
\hline
   & t & 1 & 2 & 3 & 4 & 5 \\
\hline
Snow & 0.3 & 0.3 & 0.1 & 0.2 & 0.1 \\
Rain & 0.5 & 0.4 & 0.3 & 0.3 & 0.2 \\
Sunny & 0.1 & 0.1 & 0.3 & 0.1 & 0.4 \\
Cloudy & 0.1 & 0.2 & 0.3 & 0.4 & 0.3 \\
\hline
\end{tabular}

$S_i(i,j)$

\begin{tabular}{|c|c|c|c|}
\hline
   & t & 1 & 2 & 3 \\
\hline
Rain, Cloudy & .1 & .4 & .3 & .2 \\
Sunny, Rain & 0 & 0 & 0 & 0 \\
\hline
\end{tabular}

$\Pi_{\text{rain}} \quad \Pi_{\text{cloudy}}$

$A_{\text{rain,cloudy}} \quad A_{\text{sunny,rain}}$

$\phi_{\text{hot,rain}} \quad \phi_{\text{mild,sunny}}$