1. Let $v_1 = (-1, 1)$, $v_2 = (2, 0)$, $v_3 = (1, -1)$, and $v_4 = (0, 2)$ be four support vectors defining a separating line, and let the corresponding coefficients and bias be:

$$
\alpha_1 = -.5 \\
\alpha_2 = .5 \\
\alpha_3 = -.5 \\
\alpha_4 = .5 \\
bias = -1
$$

(a) Draw a plot of the support vectors and sketch (approximately) the hyperplane and margin they define. [You can do this by eye; you don't have to find the equation of the hyperplane.]
(b) Give the resulting SVM’s classification of the new instance \( \mathbf{x} = (1, 1) \). Show your results using both your plot from part (a) and the formula for classification:

\[
h(\mathbf{x}) = \text{sgn} \left( \sum_{k=1}^{M} \alpha_k (\mathbf{x} \cdot \mathbf{x}_k) + b \right)
\]

\[
\text{sgn}(-.5((-1,1) \cdot (1,1)) + .5((2.0) \cdot (1,1)) - .5((1,-1) \cdot (1,1)) + .5((0,2) \cdot (1,1)) - 1) = \text{sgn}(0 + 1 + 0 + 1 - 1) = 1
\]

(c) Find the weight vector \( \mathbf{w} \) associated with the separating hyperplane.

\[
-.5(-1,1) + .5(2,0) - .5(1,-1) + .5(0,2) = (1,1)
\]

(d) Using the weights you obtained in part (c) and the bias \( b \), find the equation of the separating hyperplane: \( \mathbf{w} \cdot \mathbf{x} + b = 0 \). What is the slope of this line?

\[
x_2 = -x_1 + 1
\]

Slope is -1.

2. Consider the following training set:

<table>
<thead>
<tr>
<th>Instance</th>
<th>( x_1 )</th>
<th>( x_2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mathbf{x}_1 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>( \mathbf{x}_2 )</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

and let \( k(\mathbf{y}, \mathbf{z}) \) be the Gaussian kernel: \( k(\mathbf{y}, \mathbf{z}) = e^{-||\mathbf{y} - \mathbf{z}||^2} \). Give the kernel (Gram) matrix for this kernel function using this training set.

\[
\begin{pmatrix}
e^0 & e^{-8} \\
e^{-8} & e^0 \\
\end{pmatrix} = 
\begin{pmatrix}
1 & .0003 \\
.0003 & 1 \\
\end{pmatrix}
\]