1. Given a robust LP with the constraint $\Pr(\bar{\mathbf{c}}_i^T \bar{\mathbf{x}} \leq d_i) \geq \eta$, where $\mathbf{c}_i$ is a Gaussian random vector with mean $\bar{\boldsymbol{\mu}}_i$ and covariance matrix $\mathbf{R}_i = \widetilde{\mathbf{R}}_i \widetilde{\mathbf{R}}_i^T$. This constraint can be equivalently represented as

$$\left\|\widetilde{\mathbf{R}}_i^T \bar{\mathbf{x}}\right\| \leq \frac{(d_i - \bar{\mathbf{x}}_i^T \bar{\boldsymbol{\mu}}_i)}{Q^{-1}(1-\eta)}$$

   Ans c

2. The epigraph form of the optimization problem is

$$\begin{gathered} \min t \\ \text{s.t. } g_0(\bar{\mathbf{x}}) \leq t \\ g_i(\bar{\mathbf{x}}) \leq 0, i = 1,2,\ldots,l \\ \mathbf{a}_j^T \bar{\mathbf{x}} = b_j, j = 1,2,\ldots,m \end{gathered}$$

   Ans b

3. The given optimization problem $\min \left\|\mathbf{A}\bar{\mathbf{x}} - \bar{\mathbf{b}}\right\|_\infty$ can be formulated as the LP below

$$\begin{gathered} \min t \\ -t\bar{\mathbf{1}} \preccurlyeq \mathbf{A}\bar{\mathbf{x}} - \bar{\mathbf{b}} \preccurlyeq t\bar{\mathbf{1}} \end{gathered}$$

   Ans b

4. Given a MIMO communication system with channel matrix $\mathbf{H}$. The optimal transmit and receive beamformers, respectively, for maximum SNR at the receiver, are principal eigenvectors of $\mathbf{H}^H\mathbf{H}$ and $\mathbf{H}\mathbf{H}^H$

   Ans b

5. Given the vectors $\bar{\mathbf{u}} = [1 \quad 1 \quad 1]^T$, $\bar{\mathbf{v}} = [1 \quad 2 \quad 3]^T$. The set of orthnormal vectors spanning the same subspace is $\frac{1}{\sqrt{3}}\begin{bmatrix}1\\1\\1\end{bmatrix}, \frac{1}{\sqrt{2}}\begin{bmatrix}-1\\0\\1\end{bmatrix}$. This can be seen as follows

$$\bar{\mathbf{v}} - \frac{\bar{\mathbf{u}}}{\|\bar{\mathbf{u}}\|}\frac{\bar{\mathbf{u}}^T}{\|\bar{\mathbf{u}}\|}\bar{\mathbf{v}} = \begin{bmatrix}1\\2\\3\end{bmatrix} - \frac{1}{\sqrt{3}}\begin{bmatrix}1\\1\\1\end{bmatrix}\frac{1}{\sqrt{3}} \times 6 = \begin{bmatrix}1\\2\\3\end{bmatrix} - \begin{bmatrix}2\\2\\2\end{bmatrix} = \begin{bmatrix}1\\0\\-1\end{bmatrix}$$

   Corresponding unit-norm vector is $\frac{1}{\sqrt{2}}\begin{bmatrix}1\\0\\-1\end{bmatrix}$

   Ans c

6. Given matrix $\mathbf{A} = 2\begin{bmatrix}1\\1\end{bmatrix}[1 \quad 1] + 3\begin{bmatrix}1\\-1\end{bmatrix}[1 \quad -1]$. It can be seen that $\mathbf{A}$ is PSD, since it is of the form $\sum_{i=1}^n \mathbf{a}_i \mathbf{a}_i^T$. Further, since $\begin{bmatrix}1\\1\end{bmatrix}$ and $\begin{bmatrix}1\\-1\end{bmatrix}$ are orthogonal, these are the eigenvectors. Corresponding eigenvalues are 4, 6. Hence, solution to the optimization problem is the maximum eigenvalue 6

   Ans d

7. The minimum value of $\bar{\mathbf{x}}^T\mathbf{A}\bar{\mathbf{x}}$ for $\|\bar{\mathbf{x}}\| = 1$ is given my the minimum eigenvalue $= 4$.

   Ans c

8. Given the noise vector $\bar{\mathbf{n}} = [n_1 \quad n_2 \quad \cdots \quad n_L]^T$, with its elements i.i.d. zero-mean Gaussian that have variance σ^2. Let $\bar{\mathbf{w}}$ denote a weight vector. The quantity $\bar{\mathbf{w}}^T\bar{\mathbf{n}}$ has variance $\sigma^2\|\bar{\mathbf{w}}\|^2$

Ans b

9. Given the MIMO channel matrix

$$\mathbf{H} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix} \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} 2 & 0 \\ 0 & 4 \end{bmatrix} \begin{bmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix}$$

The largest eigenvalue is $\mathbf{H}^T\mathbf{H}, \mathbf{H}\mathbf{H}^T$ are 4. The corresponding principal eigenvectors are $\begin{bmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{bmatrix}, \begin{bmatrix} \frac{1}{\sqrt{2}} \\ -\frac{1}{\sqrt{2}} \end{bmatrix}$, respectively, which are the optimal transmit and receive beamforming vectors

Ans d

10. For the compressive sensing problem shown, the possible values of k for the l_k norm are $k = 0,1$

Ans b