$$M = \begin{pmatrix} 1 & 3 \\ 3 & b \end{pmatrix}$$

(a) Symmetric $\Rightarrow M_{ij} = M_{ji}$, which is true for any choice of b. Alternatively, with the understanding that standard terminology is to reserve "symmetric" to refer to real matrices, you might instead have (correctly) said that b can be any real number.

(b) Antisymmetric $\Rightarrow M_{ij} = -M_{ji}$, which is not possible for any choice of b.

(c) Orthogonal $\Rightarrow \tilde{M} = M^{-1}$ (it's transpose equals its inverse). Thus, if M is orthogonal, M times $\tilde{M}$ gives the identity matrix. But

$$M \cdot \tilde{M} = \begin{pmatrix} 10 & 3+3b \\ 3+3b & 9+b^2 \end{pmatrix}$$

so M is not orthogonal for any b.

(d) Normal $\Rightarrow [M, M^\dagger] = 0$, i.e. M commutes with its complex-conjugate transpose. If b is real, this is clearly true since then M and $M^\dagger$ are the same matrix. If b is complex, however, M is not normal since

$$M \cdot M^\dagger = \begin{pmatrix} 1 & 3 \\ 3 & b \end{pmatrix} \begin{pmatrix} 1 & 3 \\ 3 & b^\star \end{pmatrix} = \begin{pmatrix} 10 & 3+3b \\ 3+3b & 9+|b|^2 \end{pmatrix} \neq \begin{pmatrix} 10 & 3+3b \\ 3+3b^\star & 9+|b|^2 \end{pmatrix} = M^\dagger \cdot M$$

(e) Hermitian $\Rightarrow M = M^\dagger$ which is true for any real value of b.

(f) Unitary $\Rightarrow M^\dagger = M^{-1}$. We can check by seeing if M times $M^\dagger$ is the identity matrix. In part (d) we computed this product, and can see that M is not unitary for any value of b.

(g) For $M = \begin{pmatrix} 1 & 3 \\ 3 & 1 \end{pmatrix}$, the eigenvalues satisfy

$$\begin{vmatrix} 1-\lambda & 3 \\ 3 & 1-\lambda \end{vmatrix} = 0 \qquad \Rightarrow \qquad \lambda^2 - 2\lambda - 8 = 0 \qquad \Rightarrow \qquad \lambda = -2, 4$$

(h) The eigenvector for $\lambda = -2$ satisfies

$$\begin{pmatrix} 1 & 3 \\ 3 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = -2 \begin{pmatrix} x \\ y \end{pmatrix} \qquad \Rightarrow \qquad \begin{matrix} x & + & 3y & = & -2x \\ 3x & + & y & = & -2y \end{matrix} \qquad \Rightarrow \qquad x = -y$$

so we can take the eigenvector to be any non-zero constant times $\begin{pmatrix} 1 \\ -1 \end{pmatrix}$.

Meanwhile, since M is symmetric, the eigenvectors are mutually orthogonal, so the eigenvector corresponding to $\lambda = 4$ is any (non-zero) constant times $\begin{pmatrix} 1 \\ 1 \end{pmatrix}$.