

CEE 304 - Linear Algebra, Calculus and Matrix Analysis
Homework 10 Solutions

Q1. Supplemental exercise [p.137] in [1] (Chapman 1974 edition, p.136, 1999)
 (a) Supplemental exercise [p.137] in [1] (Chapman 1974 edition, p.136, 1999)

Consider all four complementary functions, the associated matrix is $\mathbf{M} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$ by [1] (Chapman 1974 edition, p.137) in [1] (Chapman 1974 edition, p.136, 1999).

It is noted that the eigenvalues of \mathbf{M} are $\lambda_1 = 2$ and $\lambda_2 = 0$.

The corresponding eigenvectors are $\mathbf{v}_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $\mathbf{v}_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$.

(b) One can find an equation for the solution $\mathbf{u}(t)$ by substituting $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$.

Substituting $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$ into the system of equations, we get:

$\mathbf{M} \mathbf{u}(t) = \mathbf{M} (\mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}) = \mathbf{M} \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{M} \mathbf{v}_2 e^{\lambda_2 t} = \lambda_1 \mathbf{v}_1 e^{\lambda_1 t} + \lambda_2 \mathbf{v}_2 e^{\lambda_2 t}$

and upon performing an explicit matrix multiplication we get $\mathbf{M} \mathbf{v}_1 = 2 \mathbf{v}_1$ and $\mathbf{M} \mathbf{v}_2 = 0 \mathbf{v}_2$. The above two equations are satisfied if $\mathbf{u}(t) = \mathbf{v}_1 e^{2t} + \mathbf{v}_2 e^{0t}$.

Answer:

Q2. Find $\mathbf{u}(t)$ if $\mathbf{u}(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and the system of equations is $\mathbf{M} \mathbf{u}(t) = \mathbf{M} \mathbf{u}(t)$.

(a) $\mathbf{M} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$, $\mathbf{u}(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(b) $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$, where $\mathbf{v}_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $\mathbf{v}_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$.

(c) $\mathbf{u}(t) = \begin{bmatrix} 1 \\ 1 \end{bmatrix} e^{2t} + \begin{bmatrix} 1 \\ -1 \end{bmatrix} e^{0t}$

Q3. Find $\mathbf{u}(t)$

The system of equations is $\mathbf{M} \mathbf{u}(t) = \mathbf{M} \mathbf{u}(t)$.

It is noted that the eigenvalues of \mathbf{M} are $\lambda_1 = 2$ and $\lambda_2 = 0$.

The corresponding eigenvectors are $\mathbf{v}_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $\mathbf{v}_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. The general solution is $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$. Substituting $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$ into the system of equations, we get $\mathbf{M} \mathbf{v}_1 = 2 \mathbf{v}_1$ and $\mathbf{M} \mathbf{v}_2 = 0 \mathbf{v}_2$. The above two equations are satisfied if $\mathbf{u}(t) = \mathbf{v}_1 e^{2t} + \mathbf{v}_2 e^{0t}$.

$\mathbf{M} \mathbf{u}(t) = \mathbf{M} (\mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}) = \mathbf{M} \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{M} \mathbf{v}_2 e^{\lambda_2 t} = \lambda_1 \mathbf{v}_1 e^{\lambda_1 t} + \lambda_2 \mathbf{v}_2 e^{\lambda_2 t}$

$\mathbf{M} \mathbf{u}(t) = \mathbf{M} (\mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}) = \mathbf{M} \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{M} \mathbf{v}_2 e^{\lambda_2 t} = \lambda_1 \mathbf{v}_1 e^{\lambda_1 t} + \lambda_2 \mathbf{v}_2 e^{\lambda_2 t}$

Substituting $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$ into the system of equations, we get:

Q4. Find $\mathbf{u}(t)$ if $\mathbf{u}(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and the system of equations is $\mathbf{M} \mathbf{u}(t) = \mathbf{M} \mathbf{u}(t)$.

(a) $\mathbf{M} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$, $\mathbf{u}(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(b) $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$, where $\mathbf{v}_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $\mathbf{v}_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$.

(c) $\mathbf{u}(t) = \begin{bmatrix} 1 \\ 1 \end{bmatrix} e^{2t} + \begin{bmatrix} 1 \\ -1 \end{bmatrix} e^{0t}$

Q5. Find $\mathbf{u}(t)$ if $\mathbf{u}(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and the system of equations is $\mathbf{M} \mathbf{u}(t) = \mathbf{M} \mathbf{u}(t)$.

(a) $\mathbf{M} = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$, $\mathbf{u}(0) = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$

(b) $\mathbf{u}(t) = \mathbf{v}_1 e^{\lambda_1 t} + \mathbf{v}_2 e^{\lambda_2 t}$, where $\mathbf{v}_1 = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $\mathbf{v}_2 = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$.

(c) $\mathbf{u}(t) = \begin{bmatrix} 1 \\ 1 \end{bmatrix} e^{2t} + \begin{bmatrix} 1 \\ -1 \end{bmatrix} e^{0t}$

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