

1.51. (a) We have

$$e^{i\theta} = \cos \theta + j \sin \theta, \quad (E1.51-1)$$

and

$$e^{-i\theta} = \cos \theta - j \sin \theta. \quad (E1.51-2)$$

Summing eqs. (E1.51-1) and (E1.51-2) we get

$$\cos \theta = \frac{1}{2}(e^{i\theta} + e^{-i\theta}).$$

(b) Subtracting eq. (E1.51-2) from (E1.51-1) we get

$$\sin \theta = \frac{1}{2j}(e^{i\theta} - e^{-i\theta}).$$

(c) We now have $e^{i\theta} e^{-i\theta} = e^{i\theta} e^{i\theta}$. Therefore,

$$\begin{aligned} \cos \theta + j \sin \theta + j \sin \theta + \cos \theta &= (2 \cos \theta \cos \theta - \sin \theta \sin \theta) + j(2 \sin \theta \cos \theta + \cos \theta \sin \theta) \\ &= 2(\cos^2 \theta - \sin^2 \theta) + j(2 \sin \theta \cos \theta + \cos \theta \sin \theta). \end{aligned} \quad (E1.51-3)$$

Putting $\theta = \theta$ in eq. (E1.51-3), we get

$$\cos 2\theta = \cos^2 \theta - \sin^2 \theta.$$

Putting $\theta = -\theta$ in eq. (E1.51-3), we get

$$1 = \cos^2 \theta + \sin^2 \theta.$$

Adding the two above equations and simplifying,

$$\cos^2 \theta = \frac{1}{2}(1 + \cos 2\theta).$$

(d) Repeating the real parts in eq. (E1.51-3) with arguments $(\theta + \phi)$ and $(\theta - \phi)$ we get

$$\cos(\theta + \phi) = \cos \theta \cos \phi - \sin \theta \sin \phi$$

and

$$\cos(\theta - \phi) = \cos \theta \cos \phi + \sin \theta \sin \phi.$$

Subtracting the two above equations, we obtain

$$\sin \theta \sin \phi = \frac{1}{2}[\cos(\theta - \phi) - \cos(\theta + \phi)].$$

(e) Repeating imaginary parts in eq. (E1.51-3), we get

$$\sin(\theta + \phi) = \sin \theta \cos \phi + \cos \theta \sin \phi.$$

□

(a) Since $r_1 > 0, r_2 > 0$ and $-1 \leq \cos(\theta_1 - \theta_2) \leq 1$,

$$\begin{aligned} |z_1 - z_2|^2 &= |r_1 e^{j\theta_1} - r_2 e^{j\theta_2}|^2 \\ &= r_1^2 + r_2^2 - 2r_1 r_2 \cos(\theta_1 - \theta_2) \\ &\geq r_1^2 + r_2^2 - 2r_1 r_2 \cos(\theta_1 - \theta_2) \\ &= (r_1 - r_2)^2 \end{aligned}$$

and

$$|z_1| + |z_2|^2 = r_1^2 + r_2^2 + 2r_1 r_2 \geq (r_1 + r_2)^2.$$

1.52. (a) For $a = 1$, it is fairly obvious that

$$\sum_{n=0}^{\infty} a^n = N.$$

For $a \neq 1$, we may write

$$(1 - a) \sum_{n=0}^{\infty} a^n = \sum_{n=0}^{\infty} a^n - \sum_{n=0}^{\infty} a^{n+1} = 1 - a^{\infty}.$$

Therefore,

$$\sum_{n=0}^{\infty} a^n = \frac{1 - a^{\infty}}{1 - a}.$$

(b) For $|a| < 1$,

$$\lim_{n \rightarrow \infty} a^n = 0.$$

Therefore, from the result of the previous part,

$$\lim_{n \rightarrow \infty} \sum_{k=0}^n a^k = \sum_{k=0}^{\infty} a^k = \frac{1}{1 - a}.$$

(c) Differentiating both sides of the result of part (b) w.r.t. a , we get

$$\begin{aligned} \frac{d}{da} \left(\sum_{k=0}^{\infty} a^k \right) &= \frac{d}{da} \left(\frac{1}{1 - a} \right) \\ \sum_{k=0}^{\infty} k a^{k-1} &= \frac{1}{(1 - a)^2}. \end{aligned}$$

(d) We may write

$$\sum_{k=0}^{\infty} k a^k = a^2 \sum_{k=0}^{\infty} k a^{k-2} = \frac{a^2}{1 - a} \quad \text{for } |a| < 1.$$

1.53. (a) The desired sum is

$$\sum_{n=0}^{\infty} j^n e^{j\theta} = \frac{j e^{j\theta}}{1 - e^{j\theta}} = 1 + j.$$

□

1.53. (a) $e^{j\theta} = \cos \theta + j \sin \theta$ and $e^{-j\theta} = \cos \theta - j \sin \theta$

(b) $e^{j\theta} = \cos \theta + j \sin \theta$ and $e^{-j\theta} = \cos \theta - j \sin \theta$

(c) $e^{j\theta} + e^{-j\theta} = \cos \theta + j \sin \theta + \cos \theta - j \sin \theta = 2 \cos \theta$

(d) $e^{j\theta} - e^{-j\theta} = \cos \theta + j \sin \theta - \cos \theta + j \sin \theta = 2j \sin \theta$

(e) $(r_1 + r_2)^2 = (R_1 \cos \theta + R_2 \cos \theta + j R_1 \sin \theta + j R_2 \sin \theta)^2 = (R_1 + R_2)^2 \cos^2 \theta - (R_1 - R_2)^2 \sin^2 \theta + j 2(R_1 + R_2)(R_1 - R_2) \sin \theta \cos \theta$

(f) Consider $\cos n\theta$ for $n > 0$.

$$\cos n\theta = \frac{1}{2}(e^{jn\theta} + e^{-jn\theta}) = \frac{1}{2}(e^{j(n-1)\theta} + e^{-j(n-1)\theta}) \cos \theta + \frac{1}{2}(e^{jn\theta} - e^{-jn\theta}) \sin \theta$$

For $n < 0$, $n = -(n-1)$. Therefore,

$$\cos n\theta = \frac{1}{2}(e^{jn\theta} + e^{-jn\theta}) = \frac{1}{2}(e^{j(n-1)\theta} + e^{-j(n-1)\theta}) \cos \theta + \frac{1}{2}(e^{jn\theta} - e^{-jn\theta}) \sin \theta$$

(g) For $\cos \theta > 0$,

$$\left(\frac{1}{2}\right)^n = \frac{1}{2^n} e^{jn\theta} + \frac{1}{2^n} e^{-jn\theta} = \frac{1}{2^n} \left[\frac{1}{2} + \frac{1}{2} \right]$$

(h) From (g), we get

$$N \cos \left(\frac{\theta}{2}\right) = \frac{1}{2} \left[\left(\frac{1}{2}\right)^n + \left(\frac{1}{2}\right)^n \right]$$

Using (g) in this, we get

$$N \cos \left(\frac{\theta}{2}\right) = \frac{1}{2} \left[\left(\frac{1}{2}\right)^n + \left(\frac{1}{2}\right)^n \right] = \frac{1}{2} \left[\frac{1}{2} \frac{1 + e^{j\theta}}{1 + e^{j\theta}} + \frac{1}{2} \right]$$

1.54. (a) $e^{j\theta} e^{-j\theta} = e^{j\theta} e^{j\theta} = e^{j2\theta} = e^{j\theta}$

(b) Let $x_1 = r_1 e^{j\theta}$ and $x_2 = r_2 e^{j\theta}$. Then,

$$\begin{aligned} x_1 x_2 &= r_1 r_2 e^{j\theta} = r_1 r_2 e^{j\theta} + 2j r_1 r_2 \sin \theta - 2R_1 r_2 \cos \theta \\ &= r_2^2 e^{j\theta} + 2j r_1 r_2 \sin \theta - 2R_1 r_2 \cos \theta \end{aligned}$$

(c) $|z| = |e^{j\theta}| = 1 = |e^{j2\theta}| = |z^2|$

(d) $\sin \theta = \frac{1}{2j}(e^{j\theta} - e^{-j\theta}) = \frac{1}{2j}(e^{j\theta} - e^{-j\theta}) = \frac{1}{2j}(e^{j\theta} - e^{-j\theta})$

(e) Since $a = a + j\theta$, $|a| = \sqrt{a^2 + \theta^2}$. By the triangle inequality,

$$|a - j\theta| = a \leq \sqrt{a^2 + \theta^2} = |a|$$

and

$$|a + j\theta| = a \leq \sqrt{a^2 + \theta^2} = |a|.$$

(f) $\sin \theta = \frac{1}{2j}(e^{j\theta} - e^{-j\theta}) = \frac{1}{2j}(e^{j\theta} - e^{-j\theta}) = \frac{1}{2j}(e^{j\theta} - e^{-j\theta}) = \frac{1}{2j}(e^{j\theta} - e^{-j\theta})$

□

(a) The desired sum is

$$\sum_{n=0}^{\infty} j^n e^{j\theta} = \frac{j e^{j\theta}}{1 - e^{j\theta}} = 1 + j.$$

(b) The desired sum is

$$\sum_{n=0}^{\infty} \cos n\theta e^{j\theta} = \frac{1}{1 - e^{j\theta}} = \frac{1}{2} + j \frac{1}{2}$$

(c) The desired sum is

$$\sum_{n=0}^{\infty} \cos n\theta e^{j\theta} = \cos \theta e^{j\theta} \sum_{n=0}^{\infty} \cos n\theta e^{j\theta} = -\frac{1}{2} \left[\frac{1}{2} + j \frac{1}{2} \right].$$

(d) The desired sum is

$$\sum_{n=0}^{\infty} \cos(n\theta) = \frac{1}{2} \sum_{n=0}^{\infty} e^{jn\theta} + \frac{1}{2} \sum_{n=0}^{\infty} e^{-jn\theta} = \frac{1}{2}(1 + 2) + \frac{1}{2}(1 - 2) = 1.$$

(e) The desired sum is

$$\begin{aligned} \sum_{n=0}^{\infty} \cos n\theta \cos(n\theta) &= \frac{1}{2} \sum_{n=0}^{\infty} \cos n\theta e^{jn\theta} + \frac{1}{2} \sum_{n=0}^{\infty} \cos n\theta e^{-jn\theta} \\ &= \frac{1}{2} + j \frac{1}{2} + \frac{1}{2} - j \frac{1}{2} = 1. \end{aligned}$$

1.56. (a) The desired integral is

$$\int_0^{\infty} e^{-\theta} d\theta = \frac{e^{-\theta}}{-1} \Big|_0^{\infty} = -1.$$

(b) The desired integral is

$$\int_0^{\infty} e^{-\theta} \cos \theta d\theta = \frac{e^{-\theta} (-\sin \theta + \cos \theta)}{-1} \Big|_0^{\infty} = 1 - \frac{1}{2}.$$

(c) The desired integral is

$$\int_0^{\infty} e^{-\theta} \sin \theta d\theta = \frac{e^{-\theta} (-\cos \theta - \sin \theta)}{-1} \Big|_0^{\infty} = -\frac{1}{2}.$$

(d) The desired integral is

$$\int_0^{\infty} e^{-\theta} \cos \theta d\theta = \frac{e^{-\theta} (-\sin \theta + \cos \theta)}{-1} \Big|_0^{\infty} = \frac{1}{2} + \frac{1}{2} = 1.$$

□

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Discrete-Time Signals and Systems Oktay Alkin, 2025-03-27 Drawing on author's 30 years of teaching experience Discrete Time Signals and Systems A MATLAB Integrated Approach represents a novel and comprehensive approach to understanding signals and systems theory Many textbooks use MATLAB as a computational tool but Alkin's text employs MATLAB both computationally and pedagogically to provide interactive visual reinforcement of fundamental concepts important in the study of discrete time signals and systems In addition to 204 traditional end of chapter problems and 160 solved examples the book includes hands on MATLAB modules consisting of 108 MATLAB based homework problems and projects coordinated with the traditional end of chapter problems 44 live scripts and GUI based interactive apps that animate key figures and bring core concepts to life Downloadable MATLAB code for most of the solved examples 92 fully detailed MATLAB exercises that involve step by step development of code to simulate the relevant signal and or system being discussed including some case studies on topics such as real time audio processing synthesizers electrocardiograms sunspot numbers etc The ebook version includes clickable links that allow running MATLAB code associated with solved examples and exercises in a browser using the online version of MATLAB It also includes audio and video files for some of the examples Each module or application is linked to a specific segment of the text to ensure seamless integration between learning and doing The aim is to not simply give the student just another toolbox of MATLAB functions but to use the development of MATLAB code as part of the learning process or as a litmus test of students understanding of the key concepts All relevant MATLAB code is freely available from the publisher In addition a solutions manual figures presentation slides and other ancillary materials are available for instructors with qualifying course adoption [Computer Explorations in Signals and](#)

Systems Using MATLAB John R. Buck, Michael M. Daniel, Andrew Singer, 2002 For undergraduate courses on Signals and Linear Systems This book contains a comprehensive set of computer exercises of varying levels of difficulty covering the fundamentals of signals and systems The exercises require the reader to compare answers they compute in MATLAB R with results and predictions made based on their understanding of the material The book is compatible with any introductory course or text on signals and systems

Introduction to Random Signals and Applied Kalman Filtering with Matlab Exercises and Solutions Robert Grover Brown, Patrick Y. C. Hwang, 1997 In this updated edition the main thrust is on applied Kalman filtering Chapters 1-3 provide a minimal background in random process theory and the response of linear systems to random inputs The following chapter is devoted to Wiener filtering and the remainder of the text deals with various facets of Kalman filtering with emphasis on applications Starred problems at the end of each chapter are computer exercises The authors believe that programming the equations and analyzing the results of specific examples is the best way to obtain the insight that is essential in engineering work

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Contemporary Linear Systems Using MATLAB Robert D. Strum, Donald E. Kirk, 1994 This is a title in the PWS series BookWare Companion Series It is a set of correlated self contained courseware modules covering fundamental concepts in engineering and applied

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Multirate Filtering for Digital Signal Processing: MATLAB Applications Milic, Ljiljana, 2009-01-31 This book covers basic and the advanced approaches in the design and implementation of multirate filtering Provided by publisher *Symbolic and Knowledge-based Signal Processing* Alan V. Oppenheim, Syed Hamid Nawab, 1992 Aimed at signal processors and computer scientists this book of self contained discussions explores how computer science can enhance the performance of signal processing systems and their design

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