

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

and

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

Substituting 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

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

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

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

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

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

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 $-1 \leq \cos(\theta_1 - \theta_2) \leq 1$,

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

and

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

1.56. (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,

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

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

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

(d) We may write

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

1.57. (a) The desired sum is

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

□

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

$$e^{j2\theta} = \cos 2\theta + j \sin 2\theta$$

$$(1) \quad e + e^{j\theta} = \cos \theta + j \sin \theta + \cos 2\theta + j \sin 2\theta = 2\cos \theta + j 2\sin \theta$$

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

$$(3) \quad (e + e^{j\theta})^2 = \cos^2 \theta - \sin^2 \theta + j 2\cos \theta \sin \theta + \cos^2 2\theta - \sin^2 2\theta + j 2\cos 2\theta \sin 2\theta = e^2 + e^{j2\theta}$$

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

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

For $n < 0$, $n = -|n|$. Therefore,

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

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

$$\left(\frac{e}{2}\right)^2 = \frac{e^2}{2} + \frac{e^{j2\theta}}{2} = \frac{e^2 + e^{j2\theta}}{2} = \frac{e^2}{2}$$

(e) From (c), we get

$$N = \left(\frac{e}{2}\right)^2 = \frac{1}{2} \left[\left(\frac{e}{2}\right)^2 + \left(\frac{e}{2}\right)^2 \right].$$

Using (d) in this, we get

$$N = \left(\frac{e}{2}\right)^2 = \frac{1}{2} \left[\left(\frac{e}{2}\right)^2 + \left(\frac{e}{2}\right)^2 \right] = \frac{1}{2} \left[\frac{e^2 + e^{j2\theta}}{2} + \frac{e^2 + e^{j2\theta}}{2} \right].$$

1.59. (a) $(e^{j\theta})^2 = e^{j2\theta}$ and $(e^{j\theta})^2 = e^{j2\theta} + e^{-j2\theta}$.(b) Let $x_1 = x_2 = e^{j\theta}$ and $x_3 = e^{-j\theta}$. Then,

$$\begin{aligned} x_1 x_2 + x_1 x_3 + x_2 x_3 &= e^{j\theta} + e^{-j\theta} = 2\cos \theta = 2\cos \theta + j 0 \\ &= e^{j\theta} + e^{-j\theta} = 2\cos \theta = 2\cos \theta + j 0 \end{aligned}$$

(c) $|z| = |e^{j\theta}| = 1$ and $|e^{j2\theta}| = |e^{j\theta}|^2 = 1$.(d) $|z_1 z_2| = |e^{j\theta} e^{j\theta}| = |e^{j2\theta}| = |e^{j\theta}|^2 = 1$ and $|z_1 z_3| = |e^{j\theta} e^{-j\theta}| = |e^0| = 1$.(e) Since $a = e + j\sin \theta$, $|a| = \sqrt{e^2 + \sin^2 \theta}$. By the triangle inequality,

$$|N - 1| = |e + j\sin \theta - 1| \leq \sqrt{e^2 + \sin^2 \theta} = |a|$$

and

$$|N + 1| = |e + j\sin \theta + 1| \leq \sqrt{e^2 + \sin^2 \theta} = |a|.$$

(f) $|z_1 z_2 + z_1 z_3| = |2\cos \theta| \leq |2\cos \theta| + |j 0| = 2|\cos \theta| \leq 2|e + j\sin \theta| = 2|a|.$

□

(a) The desired sum is

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

(b) The desired sum is

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

(c) The desired sum is

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

(d) The desired sum is

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

(e) The desired sum is

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

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

$$\int_0^{\infty} e^{-\theta} d\theta = \frac{e^{-\theta}}{-1} \Big|_0^{\infty} = -1 + 1 = 0 = \frac{0}{2}.$$

(c) The desired integral is

$$\int_0^{\infty} e^{-\theta} d\theta = \frac{e^{-\theta}}{-1} \Big|_0^{\infty} = -1 + 1 = 0 = -\frac{0}{2}.$$

(d) The desired integral is

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

□

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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

Nonlinear Dynamics and Chaos with Student Solutions Manual Steven H. Strogatz, 2018-09-21 This textbook is aimed at newcomers to nonlinear dynamics and chaos especially students taking a first course in the subject The presentation stresses analytical methods concrete examples and geometric intuition The theory is developed systematically starting with first order differential equations and their bifurcations followed by phase plane analysis limit cycles and their bifurcations and culminating with the Lorenz equations chaos iterated maps period doubling renormalization fractals and strange attractors

Signal Processing Techniques for Communication K.C. Raveendranathan, 2024-10-30 The reference text discusses signal processing tools and techniques used for the design testing and deployment of communication systems It further explores software simulation and modeling tools like MATLAB GNU Octave Mathematica and Python for modeling simulation and detailed analysis leading to comprehensive insights into communication systems The book explains topics such as source coding pulse demodulation systems and the principle of sampling and aliasing This book Discusses modern techniques including analog and digital filter design and modulation principles including quadrature amplitude modulation and differential phase shift keying Covers filter design using MATLAB system simulation using Simulink signal processing toolbox linear time invariant systems and non linear time variant systems Explains important pulse keying techniques including Gaussian minimum shift keying and quadrature phase shift keying Presents signal processing tools and techniques for communication systems design modeling simulation and deployment Illustrates topics such as software defined radio SDR systems spectrum sensing and automated modulation sensing The text is primarily written for senior undergraduates graduate students and academic researchers in the fields of electrical engineering electronics and communication engineering computer science and engineering

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 mathematics Students work

through example problems electronically and are encouraged to experiment with problems and data in an electronic lab setting Each BookWare Companion features a software script for the electronic examples based on a popular applications software package for the IBM PC or the Macintosh and a printed volume containing computer based exploration exercises and a variety of learning aids and hints The text bolstered by illustrative examples 200 problems and MATLAB exploration exercises on the accompanying data disk should enable students to work with linear systems problems in a virtual laboratory at the computer changing problem values at will in a what if fashion

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Table of Contents Exercises Signals And Systems Oppenheim Solutions

1. Understanding the eBook Exercises Signals And Systems Oppenheim Solutions
 - The Rise of Digital Reading Exercises Signals And Systems Oppenheim Solutions
 - Advantages of eBooks Over Traditional Books
2. Identifying Exercises Signals And Systems Oppenheim Solutions
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Exercises Signals And Systems Oppenheim Solutions
 - User-Friendly Interface
4. Exploring eBook Recommendations from Exercises Signals And Systems Oppenheim Solutions

- Personalized Recommendations
 - Exercises Signals And Systems Oppenheim Solutions User Reviews and Ratings
 - Exercises Signals And Systems Oppenheim Solutions and Bestseller Lists
5. Accessing Exercises Signals And Systems Oppenheim Solutions Free and Paid eBooks
 - Exercises Signals And Systems Oppenheim Solutions Public Domain eBooks
 - Exercises Signals And Systems Oppenheim Solutions eBook Subscription Services
 - Exercises Signals And Systems Oppenheim Solutions Budget-Friendly Options
 6. Navigating Exercises Signals And Systems Oppenheim Solutions eBook Formats
 - ePub, PDF, MOBI, and More
 - Exercises Signals And Systems Oppenheim Solutions Compatibility with Devices
 - Exercises Signals And Systems Oppenheim Solutions Enhanced eBook Features
 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Exercises Signals And Systems Oppenheim Solutions
 - Highlighting and Note-Taking Exercises Signals And Systems Oppenheim Solutions
 - Interactive Elements Exercises Signals And Systems Oppenheim Solutions
 8. Staying Engaged with Exercises Signals And Systems Oppenheim Solutions
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Exercises Signals And Systems Oppenheim Solutions
 9. Balancing eBooks and Physical Books Exercises Signals And Systems Oppenheim Solutions
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Exercises Signals And Systems Oppenheim Solutions
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Exercises Signals And Systems Oppenheim Solutions
 - Setting Reading Goals Exercises Signals And Systems Oppenheim Solutions
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Exercises Signals And Systems Oppenheim Solutions

- Fact-Checking eBook Content of Exercises Signals And Systems Oppenheim Solutions
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning
- Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
14. Embracing eBook Trends
- Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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