

Chapter 1 Answers

- 1.1. Converting from polar to Cartesian coordinates:

$$\begin{aligned} \frac{1}{\sqrt{2}}e^{j\pi} &= \frac{1}{\sqrt{2}}\cos\pi + j\frac{1}{\sqrt{2}}\sin\pi = -\frac{1}{\sqrt{2}} \\ e^{j\pi/4} &= \cos\left(\frac{\pi}{4}\right) + j\sin\left(\frac{\pi}{4}\right) = \frac{1}{\sqrt{2}} + j\frac{1}{\sqrt{2}} \\ e^{j\pi/2} &= \cos\left(\frac{\pi}{2}\right) + j\sin\left(\frac{\pi}{2}\right) = j \\ e^{j3\pi/4} &= \cos\left(\frac{3\pi}{4}\right) + j\sin\left(\frac{3\pi}{4}\right) = -\frac{1}{\sqrt{2}} + j\frac{1}{\sqrt{2}} \\ e^{j\pi} &= \cos\pi + j\sin\pi = -1 \\ e^{j5\pi/4} &= \cos\left(\frac{5\pi}{4}\right) + j\sin\left(\frac{5\pi}{4}\right) = -\frac{1}{\sqrt{2}} - j\frac{1}{\sqrt{2}} \\ e^{j3\pi/2} &= \cos\left(\frac{3\pi}{2}\right) + j\sin\left(\frac{3\pi}{2}\right) = -j \\ e^{j7\pi/4} &= \cos\left(\frac{7\pi}{4}\right) + j\sin\left(\frac{7\pi}{4}\right) = \frac{1}{\sqrt{2}} - j\frac{1}{\sqrt{2}} \end{aligned}$$

- 1.2. Converting from Cartesian to polar coordinates:

$$\begin{aligned} 1 &= 2e^{j0} & -2 &= 2e^{j\pi} \\ 1 - j &= \sqrt{2}e^{j\pi/4} & 1 + j &= \sqrt{2}e^{j\pi/4} \\ -1 - j &= \sqrt{2}e^{j5\pi/4} & 1 - j &= \sqrt{2}e^{j7\pi/4} \end{aligned}$$

- 1.3. (a) $E_{\text{avg}} = \int_{-\infty}^{\infty} e^{-2t} dt = \frac{1}{2}$. $P_{\text{avg}} = 0$, because $E_{\text{avg}} < \infty$.

(b) $x_1(t) = e^{j\pi t} = 1$, $x_2(t) = 1$. Therefore, $E_{\text{avg}} = \int_{-\infty}^{\infty} |x_1(t)|^2 dt = \int_{-\infty}^{\infty} 1 dt = \infty$, $P_{\text{avg}} = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T |x_1(t)|^2 dt = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T 1 dt = \lim_{T \rightarrow \infty} \frac{1}{2T} (2T) = 1$.

(c) $x_3(t) = \cos(2t)$. Therefore, $E_{\text{avg}} = \int_{-\infty}^{\infty} |x_3(t)|^2 dt = \int_{-\infty}^{\infty} \cos^2(2t) dt = \infty$.
 $P_{\text{avg}} = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T \cos^2(2t) dt = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T \left(\frac{1 + \cos(4t)}{2} \right) dt = 1$

(d) $x_4(t) = (1/2)^t e^{j\pi t}$, $|x_4(t)|^2 = (1/2)^{2t}$. Therefore, $E_{\text{avg}} = \sum_{n=-\infty}^{\infty} |x_4(n)|^2 = \sum_{n=-\infty}^{\infty} (1/2)^{2n} = \frac{1}{1 - 1/4} = 4/3$, $P_{\text{avg}} = 0$, because $E_{\text{avg}} < \infty$.

(e) $x_5(t) = e^{j\pi t} e^{j\pi t} = 1$. Therefore, $E_{\text{avg}} = \sum_{n=-\infty}^{\infty} |x_5(n)|^2 = \infty$.
 $P_{\text{avg}} = \lim_{T \rightarrow \infty} \frac{1}{2T} \sum_{n=-T}^T |x_5(n)|^2 = \lim_{T \rightarrow \infty} \frac{1}{2T} \sum_{n=-T}^T 1 = \lim_{T \rightarrow \infty} \frac{1}{2T} (2T) = 1$.

(f) $x_6(t) = \cos(t)$. Therefore, $E_{\text{avg}} = \sum_{n=-\infty}^{\infty} |x_6(n)|^2 = \sum_{n=-\infty}^{\infty} \cos^2(n) = \infty$.
 $P_{\text{avg}} = \lim_{T \rightarrow \infty} \frac{1}{2T} \sum_{n=-T}^T \cos^2(n) = \lim_{T \rightarrow \infty} \frac{1}{2T} \sum_{n=-T}^T \left(\frac{1 + \cos(2n)}{2} \right) = \frac{1}{2}$

- 1.4. (a) The signal $x(t)$ is shifted by 3 to the right. The shifted signal will be zero for $t < 1$ and $t \geq 7$.
 (b) The signal $x(t)$ is shifted by 4 to the left. The shifted signal will be zero for $t < -4$ and $t > 8$.

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- 1.5. (a) $\Re\{x_1(t)\} = -2 + 2e^{j\pi t} \cos(2t) + e^{j\pi t}$
 (b) $\Re\{x_2(t)\} = \sqrt{2} \cos(t) \cos(2t + 2\pi) = \cos(2t) = e^{j2\pi t} \cos(2t + \pi)$
 (c) $\Re\{x_3(t)\} = e^{-t} \sin(2t + \pi) = -e^{-t} \sin(2t) = \frac{1}{2}j(e^{j2\pi t} - e^{-j2\pi t})$
 (d) $\Re\{x_4(t)\} = -e^{j2\pi t} \sin(100t) = e^{j2\pi t} \sin(100t + \pi) = e^{j2\pi t} \cos(100t + \frac{\pi}{2})$

- 1.6. (a) $x_1(t)$ is a periodic complex exponential.

$$x_1(t) = je^{j2\pi t} + je^{j4\pi t} + 1$$

The fundamental period of $x_1(t)$ is $\frac{1}{2} = \frac{1}{N}$.

- (b) $x_2(t)$ is a complex exponential multiplied by a decaying exponential. Therefore, $x_2(t)$ is not periodic.

- (c) $x_3(t)$ is a periodic signal.

$$x_3(t) = e^{j\pi t} + e^{j2\pi t}$$

$x_3(t)$ is a complex exponential with a fundamental period of $\frac{1}{2} = \frac{1}{N}$.

- (d) $x_4(t)$ is a periodic signal. The fundamental period is given by $N = \text{m.c.}(\frac{1}{2N_1}) = \text{m.c.}(\frac{1}{2})$. By choosing $m = 2$, we obtain the fundamental period to be 10.

- (e) $x_5(t)$ is not periodic. $x_5(t)$ is a complex exponential with $\omega_0 = 1/5$. We cannot find any integer m such that $m(\frac{1}{5})$ is also an integer. Therefore, $x_5(t)$ is not periodic.

- 1.7.

$$x(t) = 2\cos(20t + 1) - \sin(40t - 1)$$

Period of first term in RHS = $\frac{2\pi}{20} = \frac{1}{5}$

Period of second term in RHS = $\frac{2\pi}{40} = \frac{1}{10}$

Therefore, the overall signal is periodic with a period which is the least common multiple of the periods of the first and second terms. This is equal to 1.

- 1.8.

$$x(t) = 1 + e^{j\pi t} - e^{j2\pi t}$$

Period of the first term in the RHS = 1

Period of the second term in the RHS = $\text{m.c.}(\frac{1}{2N_1}) = 1$ (when $m = 2$)

Period of the third term in the RHS = $\text{m.c.}(\frac{1}{2N_2}) = 1$ (when $m = 1$)

Therefore, the overall signal $x(t)$ is periodic with a period which is the least common multiple of the periods of the three terms in $x(t)$. This is equal to 1.

- 1.9.

- (a) The signal $x(t)$ is as shown in Figure S1.12. $x(t)$ can be obtained by flipping $x_1(t)$ and then shifting the flipped signal by 3 to the right. Therefore, $x(t) = x_1(t-3)$. This implies that $M = -1$ and $n_0 = -3$.

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- (c) The signal $x(t)$ is flipped. The flipped signal will be zero for $t < -4$ and $t > 2$.
 (d) The signal $x(t)$ is flipped and the flipped signal is shifted by 2 to the right. This new signal will be zero for $t < -2$ and $t > 4$.
 (e) The signal $x(t)$ is flipped and the flipped signal is shifted by 2 to the left. This new signal will be zero for $t < -6$ and $t > 6$.

- 1.10.

- (a) $x(t) = 1$ is obtained by flipping $x_1(t)$ and shifting the flipped signal by 1 to the right. Therefore, $x(t) = 1$ will be zero for $t > 2$.
 (b) From (a), we know that $x(t) = 1$ is zero for $t > 2$. Similarly, $x(t) = 1$ is zero for $t < -1$. Therefore, $x(t) = 1$ will be zero for $t > -3$.
 (c) $x(t)$ is obtained by linearly compressing $x_1(t)$ by a factor of 3. Therefore, $x(t)$ will be zero for $t < 1$.
 (d) $x(t)$ is obtained by linearly stretching $x_1(t)$ by a factor of 3. Therefore, $x(t)$ will be zero for $t < 9$.

- 1.11.

- (a) $x_1(t)$ is not periodic because it is zero for $t < 0$.
 (b) $x_2(t) = 1$ for all t . Therefore, it is periodic with a fundamental period of 1.
 (c) $x_3(t)$ is as shown in the Figure S1.14.



Figure S1.14

Therefore, it is periodic with a fundamental period of 4.

- 1.12. (a)

$$f(x_1(t)) = \frac{1}{2}(\cos(t) + \cos(-t)) = \frac{1}{2}(\cos(t) + \cos(t)) = \cos(t)$$

Therefore, $f(x_1(t))$ is zero for $|t| > \pi$.

- (b) Since $x_2(t)$ is an odd signal, $f(x_2(t))$ is zero for all values of t .

- (c)

$$f(x_3(t)) = \frac{1}{2}(\cos(t) + \cos(-t)) = \frac{1}{2}(\frac{1}{2}e^{j\pi t} + \frac{1}{2}e^{-j\pi t}) = \frac{1}{4}(e^{j\pi t} + e^{-j\pi t}) = \frac{1}{2}\cos(\pi t)$$

Therefore, $f(x_3(t))$ is zero when $|t| \leq 3$ and when $|t| \rightarrow \infty$.

- (d)

$$f(x_4(t)) = \frac{1}{2}(\cos(t) + \cos(-t)) = \frac{1}{2}(e^{j\pi t} + e^{-j\pi t}) = \frac{1}{2}(e^{j\pi t} + e^{-j\pi t}) = \cos(\pi t)$$

Therefore, $f(x_4(t))$ is zero only when $|t| \rightarrow \infty$.

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Figure S1.13

- 1.13.

$$y(t) = \int_{-\infty}^{\infty} x(\tau) d\tau = \int_{-\infty}^{\infty} (A(\tau + 1) - B(\tau - 2)) d\tau = \begin{cases} 0, & t < -2 \\ 1, & -2 \leq t \leq 2 \\ 0, & t > 2 \end{cases}$$

Therefore,

$$E_{\text{avg}} = \int_{-\infty}^{\infty} y(t) dt = 4$$

- 1.14. The signal $x(t)$ and its derivative $y(t)$ are shown in Figure S1.14.



Figure S1.14

Therefore,

$$y(t) = 1 \sum_{n=-\infty}^{\infty} \delta(t - 2n) - 1 \sum_{n=-\infty}^{\infty} \delta(t - (2n + 1))$$

This implies that $A_1 = 1$, $A_2 = 0$, $A_3 = -1$, and $A_4 = 1$.

- 1.15. (a) The signal $x_2(t)$, which is the input to S_2 , is the same as $x_1(t)$. Therefore,

$$\begin{aligned} y_2(t) &= x_2(t-2) = \frac{1}{2}x_1(t-2) \\ &= \frac{1}{2}(x_1(t-2) + \frac{1}{2}x_1(t-4)) \\ &= \frac{1}{2}(x_1(t-2) + \frac{1}{4}x_1(t-4)) \\ &= \frac{1}{2}(x_1(t-2) + \frac{1}{4}x_1(t-4)) + \frac{1}{4}(x_1(t-4) + \frac{1}{4}x_1(t-6)) \\ &= \frac{1}{2}(x_1(t-2) + \frac{1}{4}x_1(t-4)) + \frac{1}{8}(x_1(t-4) + \frac{1}{4}x_1(t-6)) \end{aligned}$$

The input-output relationship for S is

$$y(t) = 2x(t-2) + 2x(t-4) + 2x(t-6)$$

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Signal And Systems Solution Manual

Robert A. Gabel, Richard A. Roberts



Signal And Systems Solution Manual:

Solutions Manual Naveed Akhtar Malik, Syed Hamid Nawab, 1983 **Solutions Manual for Signals and Systems**
Primer with Matlab Alexander D Poularikas, Poularikas Alexander D Staff, 2007-01-01 Solutions Manual for Signals and Systems Michael D. Adams, 2022 Signals and Linear Systems Robert A. Gabel, Richard A. Roberts, 1987-03 Analog and Digital Signals and Systems R. K. Rao Yarlagadda, 2010-08-05 This book presents a systematic comprehensive treatment of analog and discrete signal analysis and synthesis and an introduction to analog communication theory This evolved from my 40 years of teaching at Oklahoma State University OSU It is based on three courses Signal Analysis a second semester junior level course Active Filters a first semester senior level course and Digital signal processing a second semester senior level course I have taught these courses a number of times using this material along with existing texts The references for the books and journals over 160 references are listed in the bibliography section At the undergraduate level most signal analysis courses do not require probability theory Only a very small portion of this topic is included here I emphasized the basics in the book with simple mathematics and the sophistication is minimal Theorem proof type of material is not emphasized The book uses the following model 1 Learn basics 2 Check the work using benchmarks 3 Use software to see if the results are accurate The book provides detailed examples over 400 with applications A three number system is used consisting of chapter number section number example or problem number thus allowing the student to quickly identify the related material in the appropriate section of the book The book includes well over 400 homework problems Problem numbers are identified using the above three number system **Signals and Systems** Oktay Alkin, 2016-04-19 Drawing on the author's 25 years of teaching experience Signals and Systems A MATLAB Integrated Approach presents a novel and comprehensive approach to understanding signals and systems theory Many texts use MATLAB as a computational tool but Alkin's text employs MATLAB both computationally and pedagogically to provide interactive visual reinforcement **Signals and Systems** Leslie Balmer, 1997 This new edition of a successful text presents the subject of signals and systems in a step by step integrated manner The concepts are developed gradually with continual reference to the practical situations where they would be applicable Solutions Manual 0 13 803693 4 *Signals and Systems using MATLAB* Luis F. Chaparro, 2010-11-10 This new textbook in signals and systems provides a pedagogically rich approach to what can commonly be a mathematically dry subject With features like historical notes highlighted common mistakes and applications in controls communications and signal processing Chaparro helps students appreciate the usefulness of the techniques described in the book Each chapter contains a section with MATLAB applications Pedagogically rich introduction to signals and systems using historical notes pointing out common mistakes and relating concepts to realistic examples throughout to motivate learning the material Introduces both continuous and discrete systems early then studies each separately in more depth later Extensive set of worked examples and homework assignments with applications to controls communications and signal processing throughout Provides review of all the

background math necessary to study the subject MatLab applications in every chapter

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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

Ultra Wideband Signals and Systems in Communication Engineering M. Ghavami, Lachlan Michael, Ryuji Kohno, 2007-02-06 The thoroughly revised and updated second edition of *Ultra Wideband Signals and Systems in Communication Engineering* features new standards developments and applications It addresses not only recent developments in UWB communication systems but also related IEEE standards such as IEEE 802.15 wireless personal area network WPAN Examples and problems are included in each chapter to aid understanding Enhanced with new chapters and several sections including Standardization advanced topics in UWB Communications and more applications this

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