

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  $e^{i(\theta+\phi)} = e^{i\theta}e^{i\phi}$ . Therefore,

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

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

$$\cos 2\phi + j \sin 2\phi = \cos^2 \phi - \sin^2 \phi + j 2 \cos \phi \sin \phi.$$

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

$$1 + j \sin^2 \phi = \cos^2 \phi.$$

Adding the two above equations and simplifying,

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

(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  $x_1 > x_2 > 0$  and  $-1 \leq \cos(\theta_1 - \theta_2) \leq 1$ ,

$$\begin{aligned} |z_1 - z_2|^2 &= |x_1 e^{j\theta_1} - x_2 e^{j\theta_2}|^2 \\ &= x_1^2 + x_2^2 - 2x_1x_2 \cos(\theta_1 - \theta_2) \\ &\geq x_1^2 + x_2^2 - 2x_1x_2 \cos(\theta_1 - \theta_2) \\ &\geq (x_1 - x_2)^2 \end{aligned}$$

and

$$|z_1| + |z_2|^2 = x_1^2 + x_2^2 + 2x_1x_2 \geq (x_1 + x_2)^2.$$

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,

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

(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

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

1.53. (a) The desired sum is

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

□

1.53. (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)  $(x_1 + x_2)^2 = x_1^2 + x_2^2 + 2x_1x_2 = x_1^2 + x_2^2 + 2x_1x_2 \cos(\theta_1 - \theta_2) = x_1^2 + x_2^2 + 2x_1x_2 \cos \theta$

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

$$\cos \theta = 0 \Rightarrow \cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2} = 0 \Rightarrow e^{j\theta} + e^{-j\theta} = 0 \Rightarrow e^{2j\theta} + 1 = 0 \Rightarrow e^{2j\theta} = -1 \Rightarrow 2\theta = \pi \Rightarrow \theta = \frac{\pi}{2}$$

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

$$\cos \theta = -|a| \Rightarrow \cos \theta = \frac{e^{j\theta} + e^{-j\theta}}{2} = -|a| \Rightarrow e^{j\theta} + e^{-j\theta} = -2|a| \Rightarrow e^{2j\theta} + 1 = -2|a| \Rightarrow e^{2j\theta} = -2|a| - 1 \Rightarrow 2\theta = \pi \Rightarrow \theta = \frac{\pi}{2}$$

(g) For  $\theta = 0$ ,

$$\left( \frac{a}{2} \right)^2 = \frac{a^2}{4} = \frac{a^2}{4} = \frac{a^2}{4} = \frac{a^2}{4}$$

(h) From (c), we get

$$N = \left( \frac{a}{2} \right)^2 = \frac{1}{4} \left[ \left( \frac{a}{2} \right)^2 + \left( \frac{a}{2} \right)^2 \right]$$

Using (d) in this, we get

$$N = \left( \frac{a}{2} \right)^2 = \frac{1}{4} \left[ \left( \frac{a}{2} \right)^2 + \left( \frac{a}{2} \right)^2 \right] = \frac{1}{4} \left[ \frac{a^2}{4} + \frac{a^2}{4} \right]$$

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

(b) Let  $x_1 = x_2 = a$  and  $\theta_1 = \theta_2 = \theta$ . Then,

$$\begin{aligned} |z_1 - z_2|^2 &= |a e^{j\theta} - a e^{j\theta}|^2 = 0 \\ |z_1 + z_2|^2 &= |2a e^{j\theta}|^2 = 4a^2 \end{aligned}$$

(c)  $|z_1| = |a e^{j\theta}| = a$  and  $|z_2| = |a e^{j\theta}| = a$

(d)  $|z_1 + z_2| = |2a e^{j\theta}| = 2a$  and  $|z_1 - z_2| = 0$

(e) Since  $a = a + j0$ ,  $|a| = \sqrt{a^2 + 0^2}$ . By the triangle inequality,

$$|a - (-a)| = |2a| \leq \sqrt{a^2 + 0^2} + \sqrt{a^2 + 0^2} = |a|$$

and

$$|2a + (-a)| = |a| \leq \sqrt{a^2 + 0^2} + \sqrt{a^2 + 0^2} = |a|$$

(f)  $|z_1 + z_2| = |2a| = 2|a|$  and  $|z_1 - z_2| = |0| = 0$

□

(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

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

(c) The desired sum is

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

(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

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

1.56. (a) The desired integral is

$$\int_0^{\infty} e^{-t} dt = \frac{e^{-t}}{-1} \Big|_0^{\infty} = 1$$

(b) The desired integral is

$$\int_0^{\infty} e^{-t} dt = \frac{e^{-t}}{-1} \Big|_0^{\infty} = -0 + 1 = 1$$

(c) The desired integral is

$$\int_0^{\infty} e^{-t} dt = \frac{e^{-t}}{-1} \Big|_0^{\infty} = -0 + 1 = 1$$

(d) The desired integral is

$$\int_0^{\infty} e^{-t} dt = \frac{e^{-t}}{-1} \Big|_0^{\infty} = -0 + 1 = 1$$

□

# Exercises Signals And Systems Oppenheim Solutions

**Victor M. Corman**



## **Exercises Signals And Systems Oppenheim Solutions:**

## **Exercises Signals And Systems Oppenheim Solutions** Book Review: Unveiling the Power of Words

In a global driven by information and connectivity, the energy of words has become more evident than ever. They have the capacity to inspire, provoke, and ignite change. Such could be the essence of the book **Exercises Signals And Systems Oppenheim Solutions**, a literary masterpiece that delves deep to the significance of words and their impact on our lives. Published by a renowned author, this captivating work takes readers on a transformative journey, unraveling the secrets and potential behind every word. In this review, we will explore the book is key themes, examine its writing style, and analyze its overall impact on readers.

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