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# Solutions Manual for DSP First Second Edition

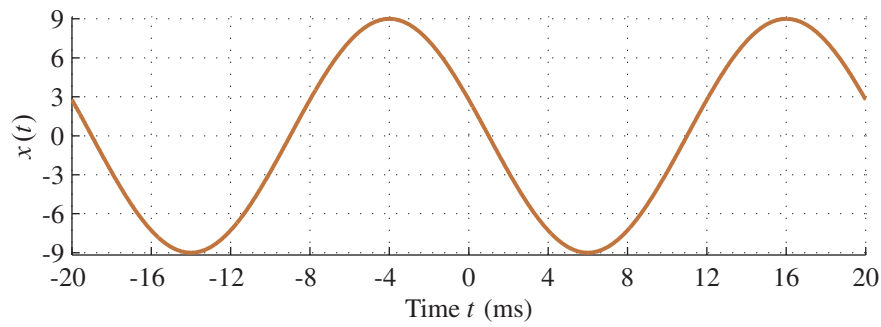
J.H. McClellan, R.W. Schafer, M.A. Yoder

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# Sinusoids

## 2-1 Problems

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## P-2.2

In the plot the period can be measured,  $T = 12.5 \text{ ms} \Rightarrow \omega_0 = 2\pi/(12.5 \times 10^{-3}) = 2\pi(80) \text{ rad.}$

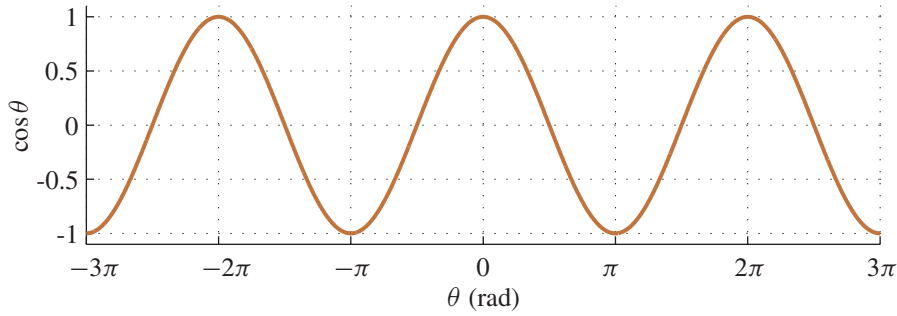
Positive peak closest to  $t = 0$  is at  $t_1 = 2.5 \text{ ms} \Rightarrow \varphi = -2\pi(2.5 \times 10^{-3})/(12.5 \times 10^{-3}) = 2\pi/5 = -0.4\pi \text{ rad.}$

Amplitude is  $A = 8$ .

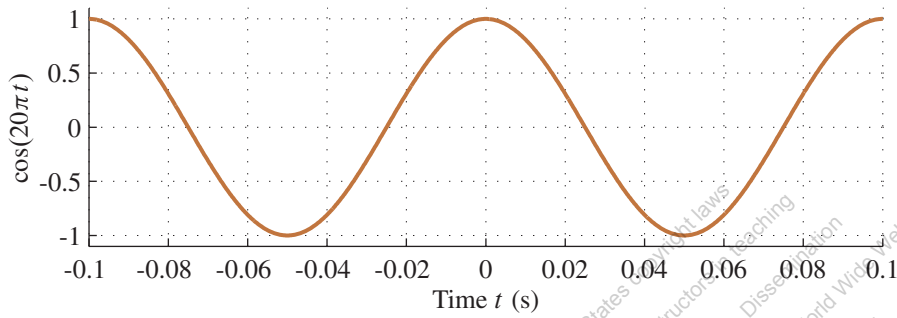
$$x(t) = 8 \cos(160\pi t - 0.4\pi)$$

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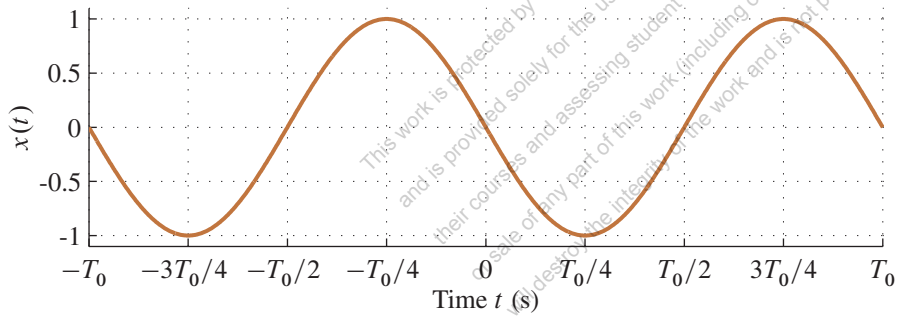
(a) Plot of  $\cos \theta$



(b) Plot of  $\cos(20\pi t)$



(c) Plot of  $\cos(2\pi/T_0 + \pi/2)$



$$\begin{aligned}
 e^{j\theta} &= 1 + j\theta + \frac{(j\theta)^2}{2!} + \frac{(j\theta)^3}{3!} + \frac{(j\theta)^4}{4!} + \frac{(j\theta)^5}{5!} + \dots \\
 &= 1 + j\theta - \frac{\theta^2}{2!} - j\frac{\theta^3}{3!} + \frac{\theta^4}{4!} + j\frac{\theta^5}{5!} + \dots \\
 &= \underbrace{\left(1 - \frac{\theta^2}{2!} + \frac{\theta^4}{4!} - \dots\right)}_{\cos \theta} + j \underbrace{\left(\theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} + \dots\right)}_{\sin \theta}
 \end{aligned}$$

Thus,  $e^{j\theta} = \cos \theta + j \sin \theta$

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(a) Real part of complex exponential is cosine.

$$\begin{aligned}\cos(\theta_1 + \theta_2) &= \Re \{e^{j(\theta_1 + \theta_2)}\} = \Re \{e^{j\theta_1} e^{j\theta_2}\} \\ &= \Re \{(\cos \theta_1 + j \sin \theta_1)(\cos \theta_2 + j \sin \theta_2)\} \\ &= \Re \{(\cos \theta_1 \cos \theta_2 - \sin \theta_1 \sin \theta_2) + j(\sin \theta_1 \cos \theta_2 + \cos \theta_1 \sin \theta_2)\}\end{aligned}$$

$$\cos(\theta_1 + \theta_2) = \cos \theta_1 \cos \theta_2 - \sin \theta_1 \sin \theta_2$$

(b) Change the sign of  $\theta_2$ .

$$\begin{aligned}\cos(\theta_1 - \theta_2) &= \Re \{e^{j(\theta_1 - \theta_2)}\} = \Re \{e^{j\theta_1} e^{-j\theta_2}\} \\ &= \Re \{(\cos \theta_1 + j \sin \theta_1)(\cos \theta_2 - j \sin \theta_2)\} \\ &= \Re \{(\cos \theta_1 \cos \theta_2 + \sin \theta_1 \sin \theta_2) + j(\sin \theta_1 \cos \theta_2 - \cos \theta_1 \sin \theta_2)\}\end{aligned}$$

$$\cos(\theta_1 - \theta_2) = \cos \theta_1 \cos \theta_2 + \sin \theta_1 \sin \theta_2$$

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

$$\begin{aligned} \left(\frac{3}{5} + j\frac{4}{5}\right)^n &= (e^{j0.927})^{100} = (e^{j0.295167\pi})^{100} \\ &= e^{j29.5167\pi} \\ &= e^{j1.5167\pi} \cancel{e^{j28\pi}} \overset{1}{\phantom{e^{j28\pi}}} \\ &= \cos(1.5167) + j \sin(1.5167) \\ &= 0.0525 - j0.9986 \end{aligned}$$

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## P-2.7

$$(a) 3e^{j\pi/3} + 4e^{-j\pi/6} = 5e^{j0.12} = 4.9641 + j0.5981$$

$$(b) (\sqrt{3} - j3)^{10} = (\sqrt{12}e^{-j\pi/3})^{10} = 248,832 \underbrace{e^{-j10\pi/3}}_{e^{+j2\pi/3}} = -124,416 + j215,494.83$$

$$(c) (\sqrt{3} - j3)^{-1} = (\sqrt{12}e^{-j\pi/3})^{-1} = (1/\sqrt{12})e^{+j\pi/3} = 0.2887e^{+j\pi/3} = 0.14434 + j0.25$$

$$(d) (\sqrt{3} - j3)^{1/3} = (\sqrt{12}e^{-j\pi/3}e^{j2\pi\ell})^{1/3} = ((12)^{1/6}e^{-j\pi/9}e^{j2\pi\ell/3}) \text{ for } \ell = 0, 1, 2.$$

There are 3 answers:

$$1.513e^{-j\pi/9} = 1.422 - j0.5175$$

$$1.513e^{-j7\pi/9} = -1.159 - j0.9726$$

$$1.513e^{-j13\pi/9} = 1.513e^{+j5\pi/9} = -0.2627 + j1.49$$

$$(e) \Re \{je^{-j\pi/3}\} = \Re \{e^{j\pi/2}e^{-j\pi/3}\} = \Re \{e^{j\pi/6}\} = \cos(\pi/6) = \sqrt{3}/2 = 0.866$$

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