

# Midterm Exam - Problems 2 & 3

**Due** Thursday by 12:30pm    **Points** 70    **Submitting** a file upload    **File Types** pdf  
**Available** after Jun 17 at 11am

Complete Problems 2 and 3 below. You must show your steps to obtain full credit. Submit all your solutions in a single PDF file. You may start any time after the exam starts. **You must submit your PDF file before the end of the exam.**

**This is an open-book exam. You may consult your textbook, notes, lecture videos, and the instructor's notes. You may also use MATLAB and/or calculators in the exam. You must work alone, and must not solicit/receive help from or provide help to anyone. Searching the Internet for help and chatting/texting/communicating with your fellow students are not allowed.**

**Problem 2.** (36%) Consider the signal  $s(t) = 2 \cos(9000\pi t - \frac{\pi}{2}) \cos(4000\pi t)$ .

(a) (10%) Express  $s(t)$  as a sum of two real-valued sinusoids. Determine the fundamental period  $T_0$  of  $s(t)$ .

(b) (10%) Determine all the Fourier series coefficient  $\{a_k\}_{k=-\infty}^{\infty}$  of  $s(t)$ . Draw the spectrum of  $s(t)$ .

Consider the following piece of MATLAB code that attempts to implement  $s(t)$ :

```
tt = 0:1/8000:2;
```

```
s1 = cos(9000*pi*tt-pi/2);
```

```
s2 = 2*cos(4000*pi*tt);
```

```
ss = s1.*s2;
```

(c) (8%) Give a math expression for  $s[n]$  in the form of a sum of two real-valued discrete-time sinusoids. Express your answer such that the normalized radian frequencies of the sinusoidal components of  $s[n]$  are within the range from 0 to  $\pi$ .

(d) (8%) Consider that  $s[n]$  is reconstructed using the MATLAB command `soundsc(ss,4000)`.

Assuming the MATLAB command implements perfect D/A (or D/C) conversion, give an expression for the reconstructed continuous-time signal  $\tilde{s}(t)$ . Also determine for how long (in seconds) the sound will play.

**Problem 3.** (34%) Consider the following piece of MATLAB code that implements a cascaded system consisting of two FIR filters whose impulse responses are stored in the vectors `h1` and `h2`. You may adopt our standard convention that the first element of any signal vector contains the value of the signal at discrete time  $n = 0$ .

```
h1 = [1.0, -0.5];
```

```
h2 = [2, 0, -1];
```

```
tt = 0: 1/1000: 1;
```

```
dd = zeros(1, length(tt));
```

```
dd(10) = 3;
```

```
dd(11) = -2;
```

```
xx = 2*cos(2*pi*600*tt - pi/3);
```

```
yy = filter(conv(h1,h2), 1, xx);
```

(a) (9%) Determine the impulse response  $h[n]$  of the cascaded system.

(b) (5%) Determine the frequency response  $H(e^{j\hat{\omega}})$  of the cascaded system.

(c) (13%) Ignoring any transient effects, give an equation for the discrete-time output signal (called it  $y[n]$ ) that the vector `yy` contains.

(d) (7%) Repeat (c) if the following line is inserted between the second last and last lines in the code above:

```
xx = xx + dd;
```