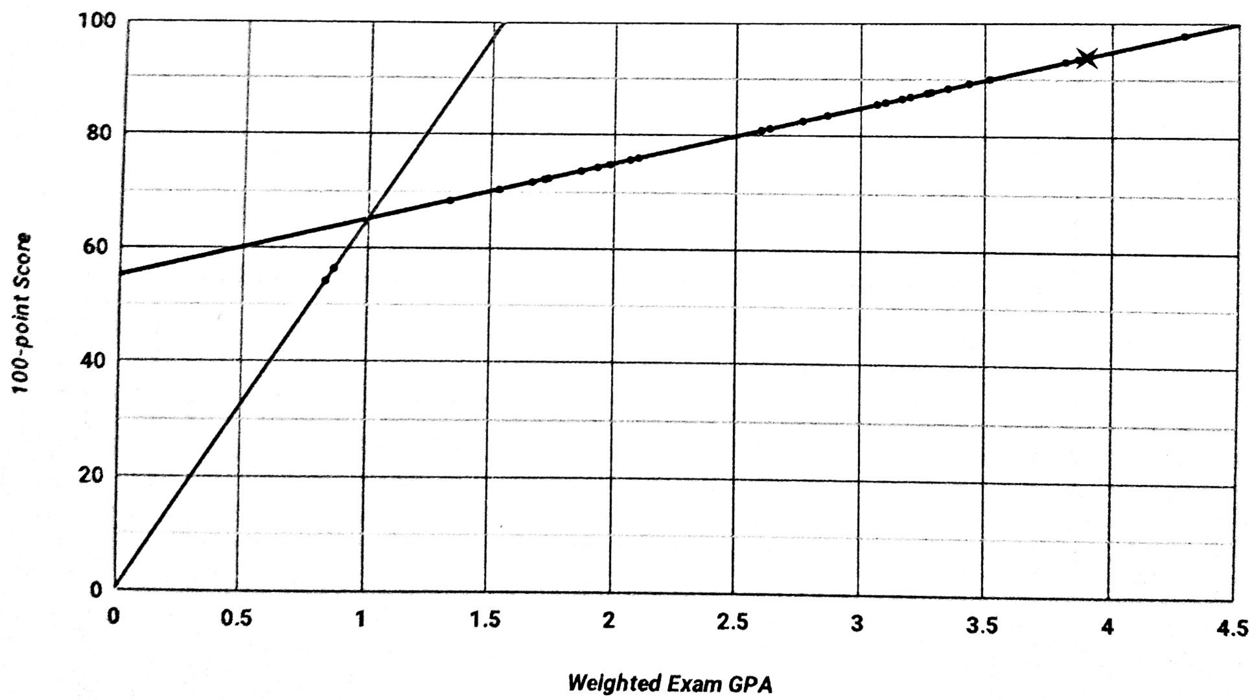
Goulette,Spencer J

	Problem Grade	Grade Points	Weight
Problem 1	A+	4.50	10%
Problem 2	A+	4.50	10%
Problem 3	A+	4.50	20%
Problem 4	A+	4.50	20%
Problem 5	B+	3.33	20%
Problem 6	B-	2.67	20%
Weighted Exam GPA:		**3.90**	

GPA > 1.0: Recorded 100-pt Score = 65.0+10.0(GPA-1.0)

GPA < 1.0: Recorded 100-pt Score = 65.0(GPA)

GPA to 100-point score mapping



Recorded 100-point max score:	**94.00**	**A**

(90/80/70/60 Scale)

Class Average GPA: 2.62

Class Average 100-pt score: 80.71

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	Score	Possible	Percent
Homework/Quiz	144.82	150	96.55%
Collected Notes	25.00	25	100.00%
Pretest	23.75	25	95.00%
Test 1	100.00	100	100.00%
Test 2	98.25	100	98.25%
Test 3	94.00	100	94.00%
Total (without final)	485.82	500	97.16%
Final Exam Points		100	
Total Course Possible Points:		600	

		Course Total Required	Final Exam Score Required
Minimum A-:	90%	540	54.2
Minimum B-:	80%	480	0.0
Minimum C-:	70%	420	0.0
Minimum D-:	60%	360	0.0

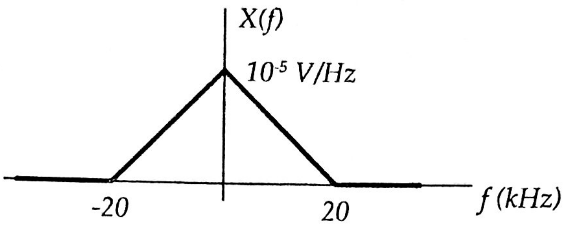
ECE-314 Test 3: Dec 4, 2018

2 Hours; Closed book;

Allowed calculator models: (a) Casio fx-115 models (b) HP33s and HP 35s (c) TI-30X and TI-36X models; Calculators not included in this list are not permitted.

Name : Spencer Canulelle

For problems 1 to 5, assume that the signal $x(t)$ has Fourier transform as illustrated below.



1. (10%) $x(t)$ can be seen to have bandwidth 20 kHz. What is the bandwidth of the signal $y(t) = x^2(t)$? (Justify your answer)

$y(t) = x^2(t)$

$Y(f) = X(f) * X(f)$ ✓

This will result in a bandwidth of 2 times that of $x(t)$, so the bandwidth will be 40kHz

$\boxed{B = 40\text{kHz}}$

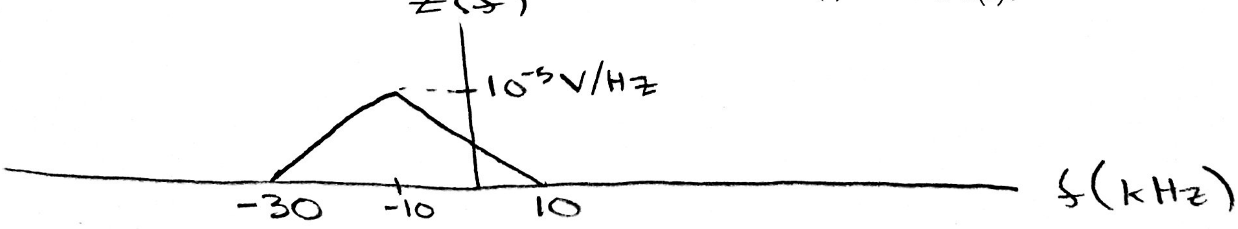
This can be checked by doing the convolution

$\int_{-\infty}^{\infty} X(\lambda) X(f-\lambda)\, d\lambda$

It'll be zero after 40kHz.

A+

2. (10%) Let $Z(f) = X(f + 10^4)$. Sketch and carefully label $Z(f)$. How is $z(t)$ related to $x(t)$?



$z(t)$ is similar to $x(t)$. $z(t)$ has a phase shift of $e^{-j2\pi 10^4 t}$, so $z(t) = x(t)\, e^{-j2\pi 10^4 t}$ ✓

?

$z(t) = \int_{-\infty}^{\infty} X(f+10^4)\, e^{j2\pi f t}\, df$

$u = f + 10^4$

$\int_{-\infty}^{\infty} X(u)\, e^{j2\pi(u-10^4)t}\, du$

$z(t) = x(t)\, e^{-j2\pi 10^4 t}$

A+ / A+

3. (20%) Define $v(t) = 10\,(x(t) + 3)\cos\left(2\pi(10^5)t\right) + 10x(t)$. Find $V(f)$ in terms of $X(f)$. Sketch and carefully label $V(f)$ assuming that $X(f)$ is as illustrated on the first page.

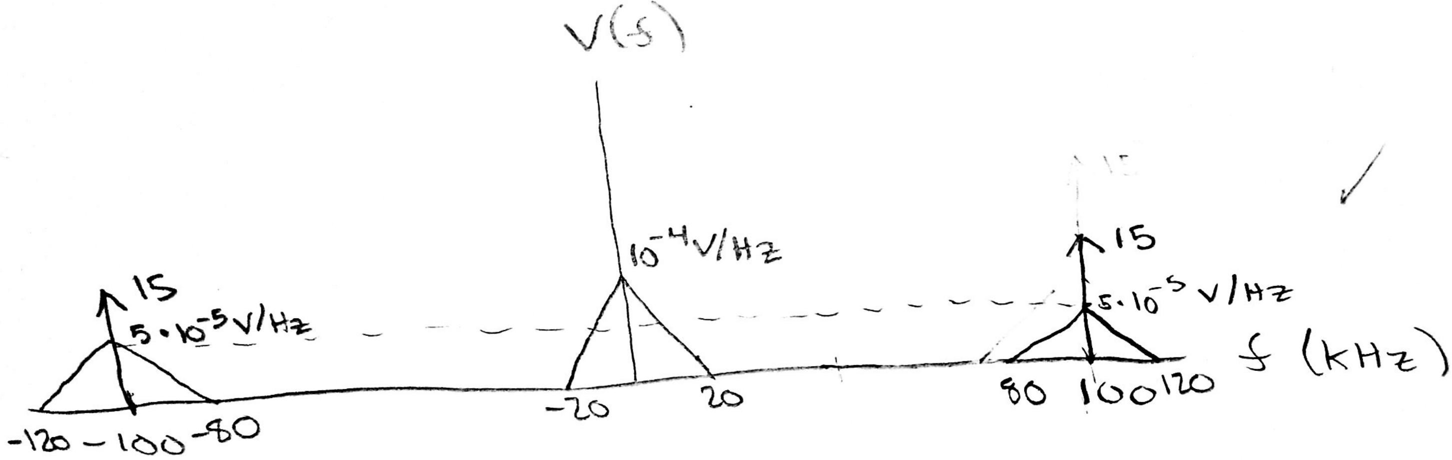
$$v(t) = 10(x(t)+3)\cos(2\pi(10^5)t) + 10x(t)$$

$$v(t) = 10x(t)\cos(2\pi(10^5)t) + 30\cos(2\pi(10^5)t) + 10x(t)$$

$$V(f) = 10X(f) * \mathcal{F}\{\cos(2\pi(10^5)t)\} + 30\,\mathcal{F}\{\cos(2\pi(10^5)t)\} + 10X(f)$$

$$V(f) = 10X(f) * \left(\tfrac{1}{2}\delta(f-10^5) + \tfrac{1}{2}\delta(f+10^5)\right) + 30\left(\tfrac{1}{2}\delta(f-10^5) + \tfrac{1}{2}\delta(f+10^5)\right) + 10X(f)$$

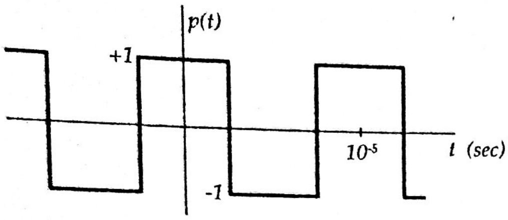
$$\boxed{V(f) = 5X(f-10^5) + 5X(f+10^5) + 15\delta(f+10^5) + 15\delta(f+10^5) + 10X(f)}$$



A+

4. (20%) Assume that $y(t) = x(t)p(t)$, where $p(t)$ is a 100 kHz 50% duty cycle square wave. The waveform $p(t)$ is illustrated below, and mathematical expressions for $p(t)$ (in terms of the rect() function, and using a Fourier series) are provided.

Find $Y(f)$ in terms of $X(f)$. Plot (and carefully label) your result, showing the interval -400 kHz $< f <$ 400 kHz (assuming that $X(f)$ is as shown on the first page).



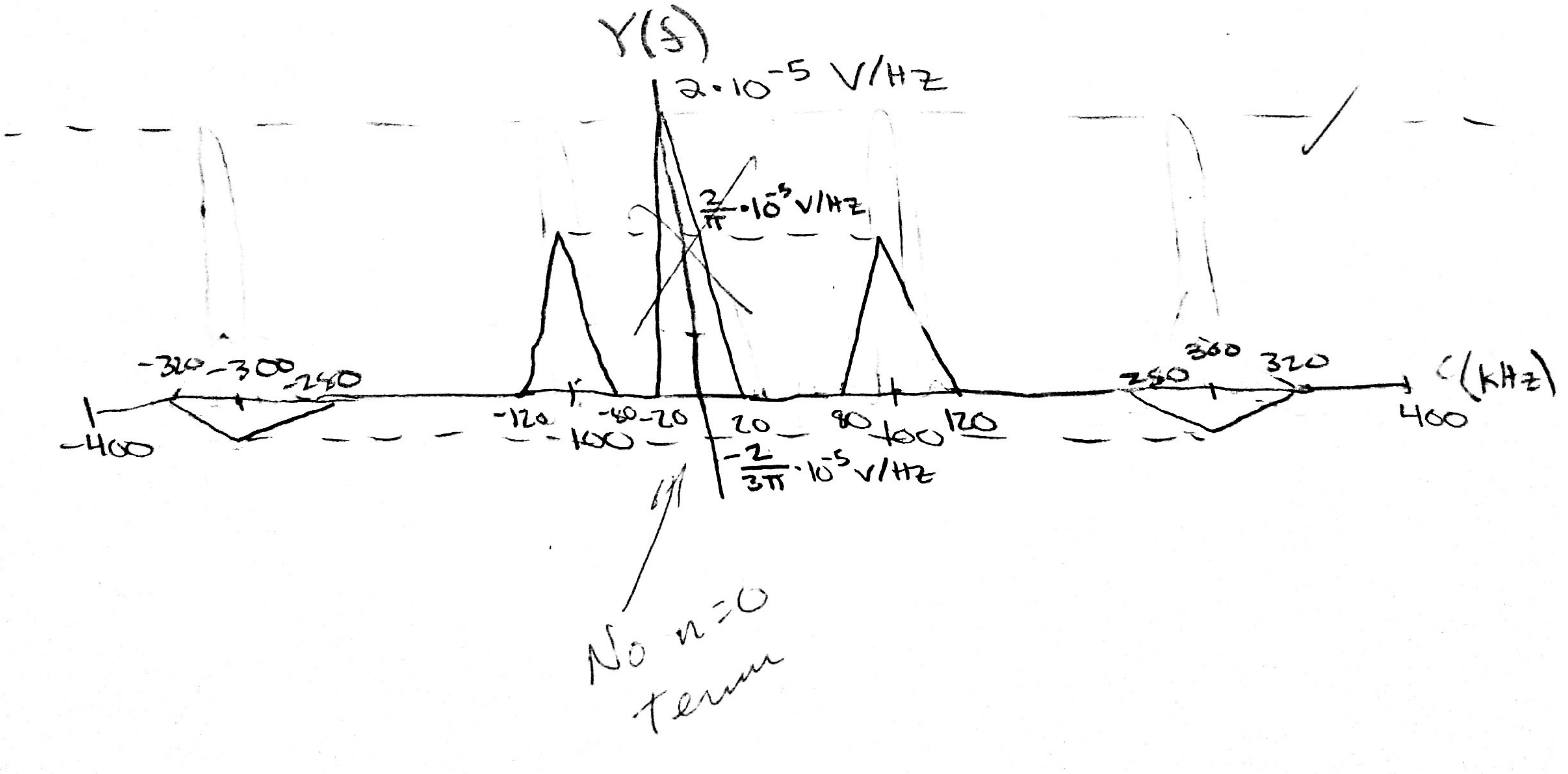
$$p(t) = -1 + \sum_{n=-\infty}^{\infty} 2\,\mathrm{rect}((2\times 10^5)t - 2n)$$

$$= \sum_{n \text{ odd}} 2\frac{\sin(\pi n/2)}{\pi n} e^{j2\pi n(10^5)t}$$

$Y(f) = X(f) * \mathcal{F}\{p(t)\}$ ✓

$Y(f) = X(f) * \left(\sum_{n \text{ odd}} 2\frac{\sin(\pi n/2)}{\pi n} \delta(f - n10^5) \right)$ ✓

$$\boxed{Y(f) = \sum_{n \text{ odd}} 2\frac{\sin(\pi n/2)}{\pi n} X(f - n10^5)}$$ ✓

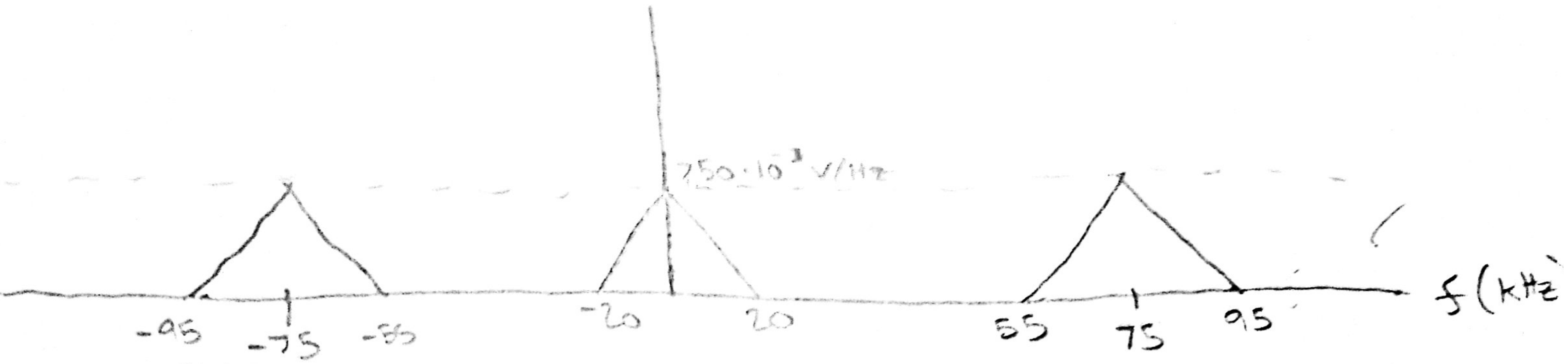


A+

5. (20%) Assume that $x(t)$ has been sampled using a sampling frequency of 75 kHz to form the ideal sampled waveform $\bar{x}(t)$.

(a) Draw and carefully label the spectrum of the ideal sampled waveform.

$f_s = 75kHz$

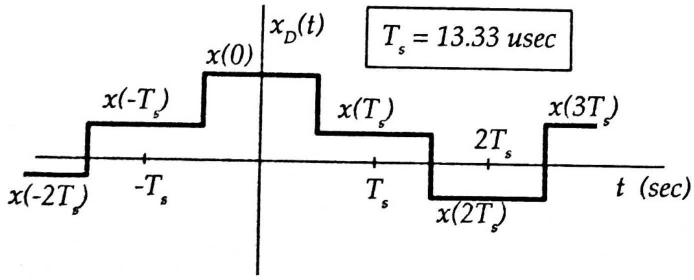


(b) A filter may be used to recover $x(t)$ from the ideal sampled waveform. Specify the required pass-band gain, pass-band edge, and stop-band edge for the filter. Separate the pass-band and stop-band edges as much as possible.

Pass-Band Gain: $1/75000$ Pass-Band Edge: 20kHz Stop-Band Edge: 55kHz

(c) Now assume that an ideal low-pass filter is driven by a "stare-step" DAC output $x_D(t)$ instead of using the ideal sampled waveform. (The ideal filter has bandwidth 35 kHz and gain 1.0.) The result will be that the recovery waveform at the filter output will have some high frequency attenuation. Predict the amount of attenuation (in decibels) of the signal at the band-edge ($f = 20$ kHz). The signal $x_D(t)$ is illustrated below.

$f_s = 75k$ Hz



X

35kHz bandwidth of the filter
gain 1.0

$$X_D(t) = \sum_{n=-\infty}^{\infty} x(nT_s)\, u\left(t - nT_s + \frac{T_s}{2}\right)$$

$$X_D(s) = \sum_{n=-\infty}^{\infty} x(nT_s) \frac{1}{s} e^{-s\left(nT_s + \frac{T_s}{2}\right)}$$

$$X_D(j2\pi 20k) = \sum_{n-\infty}^{\infty} x(nT_s) \frac{1}{j2\pi 20k} e^{-j2\pi 20k}$$

8+

6. (20%) A DC motor may be modeled as two coupled systems: a 1^{st}-order electrical model that includes the motor winding resistance and inductance, and a 2^{nd}-order mechanical model related to the damping coefficients, torque constants, and the load placed on the motor. The result is a third-order system. For a particular motor/load combination, the motor input voltage $v(t)$ is related to the motor shaft angle $\theta_m(t)$ by the system gain function

$$H_m(s) = \frac{\Theta_m(s)}{V(s)} = \frac{9.45 \times 10^4}{s\,(s^2 + 320s + 21300)}$$

(a) Is this a stable system? (Justify)

(b) For a constant 1-volt input ($v(t) = u(t)$), identify the functional forms that will be present in the motor shaft angle equations for $\theta_m(t)$. That is, find the functions $g_i(t)$ that will provided

$$\theta_m(t) = Ag_1(t) + Bg_2(t) + Cg_3(t) + \ldots$$

(No need to find the coefficients A, B, C, etc! Just provide all the functions $g_i(t)$ that you expect in your solution.

(c) For the constant 1-volt input of part 6b, we would hope that the motor will spin at a constant velocity (after other transients decay out). That is, we expect the output to include a component $\theta_m(t) = Vt$, were V is shaft velocity in radians/second. Find the final velocity for this motor.

a. No, one of the roots is zero, which isn't negative. There needs to be all negative roots to be stable.

b. $H_m(s) = \frac{\Theta_m(s)}{V(s)} = \frac{9.45 \cdot 10^4}{s(s^2+320s+21300)}$ (Don't need B if you have A)

$\Theta_m(s) = \frac{9.45 \cdot 10^4}{\cancel{s}^2(s^2+320s+21300)}$

$65.6 = \sqrt{4300}$

$\Theta_m(s) = \frac{A}{s} + \frac{Bs+C}{s^2} + \frac{Ds+E}{(s+160)^2 - 4300}$

$\Theta_m(t) = Au(t) + Bu(t) + Ctu(t) + Fe^{-160t}\sin(65.6t)u(t) + Ge^{-160t}\cos(65.6t)u(t)$

$\Theta_m(t) = Au(t) + (B+Ct)u(t) + Fe^{-160t}\sin(65.6t)u(t) + Ge^{-160t}\cos(65.6t)u(t)$

c. $\lim_{s \to 0} s\Theta_m(s) = \frac{9.45 \cdot 10^4}{(s^2+320s+21300)} = \frac{9.45 \cdot 10^4}{21300}$

$\boxed{4.44 \text{ rad/sec}}$

What happened to s^2?

These roots are real

B-