6.s02: EECS II - From A Medical Perspective

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1. (a) Analytical expression for DT signal $x_1[n]$

$x_1[n] = \cos(\omega n)$

$\cos(16\omega) = 1$
$16\omega = 2\pi$
$\omega = \frac{\pi}{8}$

$x_1[n] = \cos\left(\frac{\pi}{8}n\right)$

(b) Sampling Frequency (Hz)

$\omega = 2\pi f$
$f = \frac{\omega}{2\pi} = \frac{\frac{\pi}{8}}{2\pi} = \frac{1}{16}$

(c) Analytical form of CT signal that corresponds to $x_1[n]$

$x(t) = \cos(\omega nTs) = \cos(\omega T)$

$x(16) = \cos(\omega(16)(5)) = 1$
$\omega(16)(5) = 2\pi$
$\Omega = \frac{\pi}{40}$

$x(t) = \cos\left(\frac{\pi}{40}T\right)$

(d) Analytical form of CT signal with sampling frequency decreased by 2

T is doubled
$\omega(16)(5 \times 2) = 2\pi$
$\Omega = \frac{\pi}{80}$

$x(t) = \cos\left(\frac{\pi}{80}T\right)$

1. (a) Minimum interval between heartbeats, in samples, determined by minimum distance between peaks: `213 samples/beat`

   (b) Sampling Rate

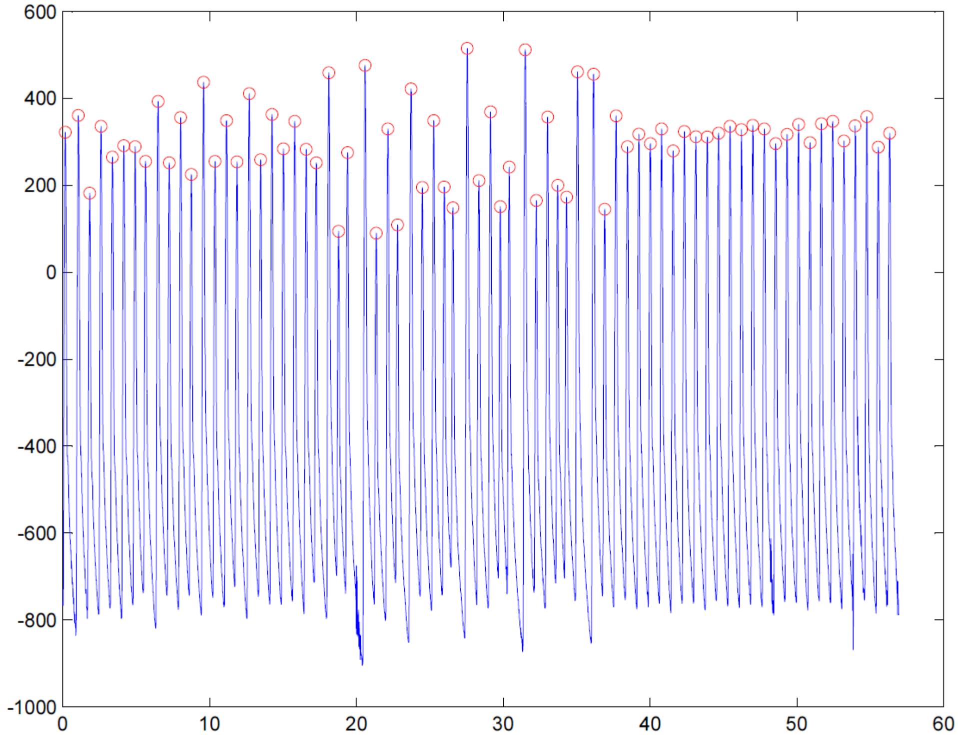
   $$\frac{\texttt{101.483 beat}}{\texttt{1 }\cancel{\texttt{min}}} \cdot \frac{\texttt{1 }\cancel{\texttt{min}}}{\texttt{60 sec}} = \texttt{1.694 beats/sec}$$

   $$\frac{\texttt{1.691 }\cancel{\texttt{beat}}}{\texttt{1 sec}} \cdot \frac{\texttt{213 sample}}{\texttt{1 }\cancel{\texttt{beat}}} \approx \texttt{360 sample/sec}$$

   (c) Total Beats

   $$\texttt{20500 }\cancel{\texttt{sample}} \cdot \frac{\texttt{1 beat}}{\texttt{213 }\cancel{\texttt{sample}}} = \texttt{96.24 beats}$$

   (d) x-axis: `Time (sec)`
   y-axis: `ABP (mmHg)`



3. (a) $I(1) = -\frac{2nFADC_0}{L} e^{\frac{-\pi^2 Dt}{4L^2}}$

$I(2) = -\frac{2nFADC_0}{L} e^{\frac{-9\pi^2 Dt}{4L^2}}$

$$\frac{I(2)}{I(1)} = \frac{-\frac{2nFADC_0}{L} e^{\frac{-9\pi^2 Dt}{4L^2}}}{-\frac{2nFADC_0}{L} e^{\frac{-\pi^2 Dt}{4L^2}}} = e^{\frac{-8\pi^2 Dt}{4L^2}}$$

(b) $0.01 = e^{\frac{-8\pi^2 Dt}{4L^2}}$

$t = -\ln\left(0.01 \frac{4L^2}{8\pi^2 D}\right)$

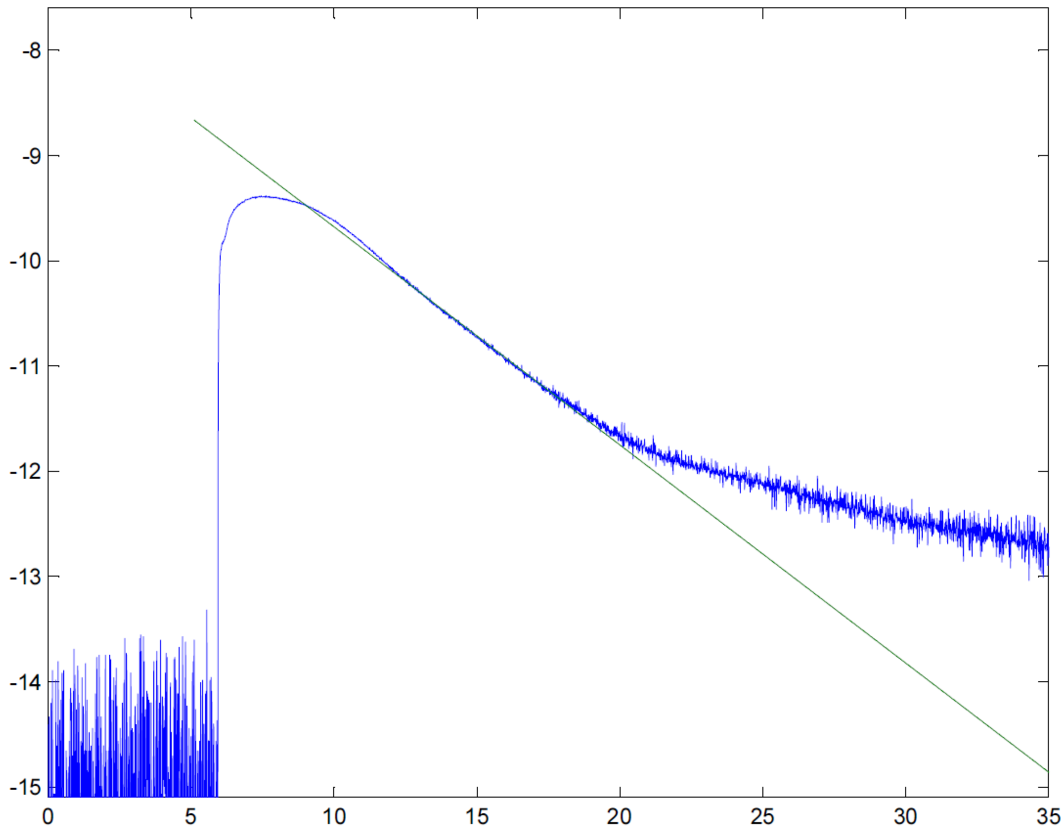
(c) $t = -\ln\left(0.01 \frac{4(50\times10^{-6})^2}{8\pi^2(6\times10^{-10})}\right) = 6.16$

(d) Estimate of current for $t > T_{0.01}$

$I_{bar}(t) = -\frac{2nFADC_0}{L} e^{\frac{-\pi^2 Dt}{4L^2}}$

4. (a) $C_0 = \frac{1 \text{ mol}}{180.16 \cancel{\text{g}}} \cdot \frac{1 \cancel{\text{g}}}{1000 \cancel{\text{mg}}} \cdot \frac{320 \cancel{\text{mg}}}{1 \cancel{\text{dL}}} \cdot \frac{10 \cancel{\text{dL}}}{1 \text{ L}} = 0.0178 \text{ mol/L}$

(b) x-axis: `Time (sec)`
y-axis: `Log Current (amp)`
Δ: 5.1 second delay
D: $2.1 \times 10^{-10}\ m^2/s$



(c) $T_2 = 24.42$ seconds
Found by iterating through time for $t > 10$ (this is approximately when we enter the exponential portion of the graph) and searching for the first time t at which the difference between the actual data and the line of best fit is greater than 1.