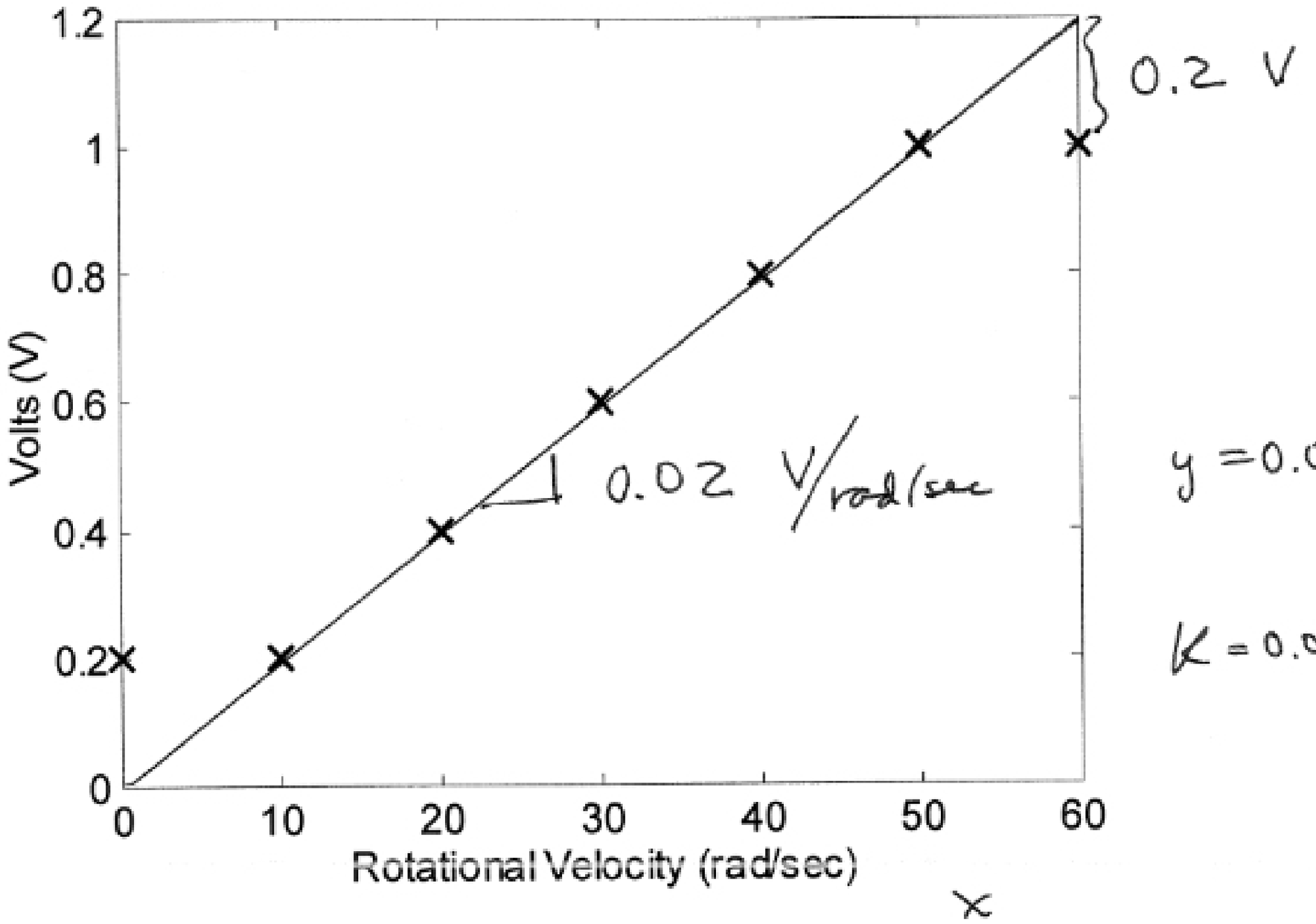
Problem #1 (30 points)

You have been asked to calibrate a tachometer, which generates a voltage proportional to rotational velocity. A set of data has been collected and is displayed in the following graph:



(a) What is the input range and span for this data set? (Remember units!)

input range : 0 to 60 rad/sec

span : 60 rad/sec

(b) What is the output range and span for this data set? (Remember units!)

output range : 0.2 to 1.0 V

span : 0.8 V

(c) If voltage is measured with a DMM that has a voltage step of 0.001 volts, what is the resolution of this tachometer?

$$\text{(input) resolution} = \frac{0.001\ V}{0.02\ V/r/s} = 0.05\ \text{rad/sec.}$$

(d) Determine the sensitivity and bias for the best-fit straight line through the data.

$$y = \underbrace{0.02}_{K} x + \underbrace{0}_{b}$$

$K = 0.02$ V/rad/sec , $b = 0$ V

(e) What is the maximum nonlinearity of the tachometer as % full scale deflection?

max NL = 0.2 V

fsd = 0.8 V

$$\text{max NL/\% fsd} = \frac{0.2}{0.8} = 25\%$$

(f) For what range of speeds would you recommend using this tachometer?

from 10 - 50 rad/sec.

Problem #2 (40 points)

A 10-bit analog-to-digital converter (ADC) measures voltages over the nominal range of ± 2.5 V.

(a) Determine the quantization ~~level~~ interval Q.

$$Q = \frac{+2.5 - (-2.5)\ V}{2^{10}} = 0.004883\ V$$

(b) Determine the true input range.

nominal range: $-R$ to $+R$

true range: $-R$ to $R - Q$

(c) Provide the possible range of voltages that would give an ADC code of 768.

$$V_{nom} = \text{code} \times Q - R = 1.25\ V$$

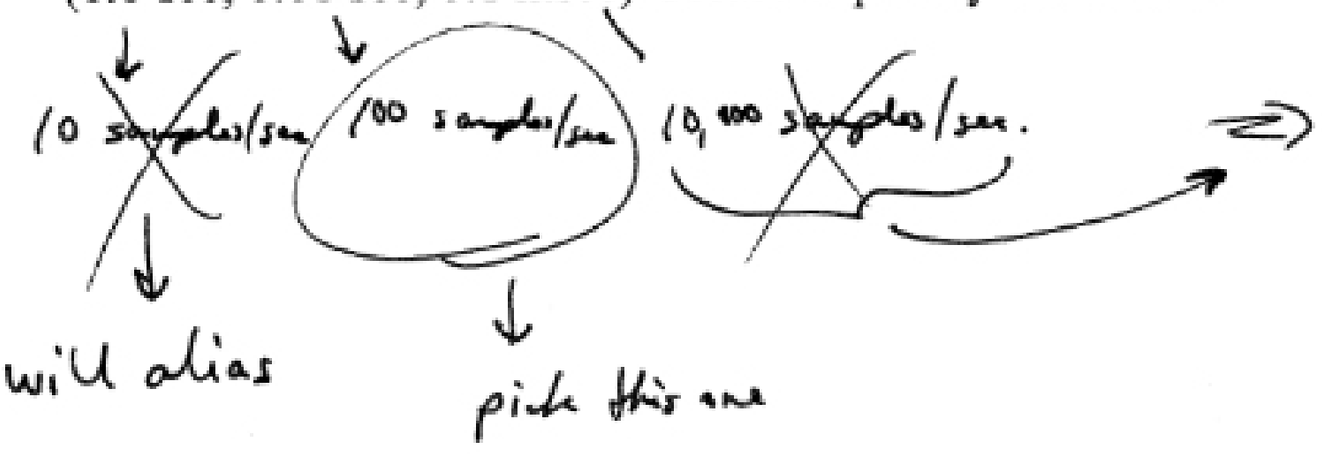
$$V_{ADC} = 1.25\ V \pm 0.00244\ V \quad (Q/2)$$

(d) If the aperture time for this ADC is 6 μsec., what is the highest frequency signal that can be sampled so that the error introduced by the aperture time is no larger than Q?

$$f \le \frac{1}{2^n \pi t_a} = \frac{1}{2^{10} \pi (6 \times 10^{-6}\ s)} = 51.8\ Hz$$

sampling theorem: >50 samples/sec

(e) If a sinusoidal input signal having a frequency of 25 Hz is to be sampled, and only a total of 100 samples can be stored, which ONE of the following sample periods would you recommend? (0.1 sec, 0.01 sec, 0.1 msec) Please explain your choice.



$\frac{1}{100}$ sec of data with 100 datapoints only 1/4 of period.

(f) If the 25 Hz signal from part (e) is sampled at a rate of 40 samples/sec, what is the apparent frequency of the sampled signal?

$$f_{app.} = |f_{act} - k f_s| < f_s/2 = 20\ Hz$$

$$|25 - k40| = 15\ Hz$$

for $k = 1$.