Midterm Examination

October 24, 2007



The terms *lab 1, lab 2*, and *lab 3* refer to: Lab 1 Basics of A to D Conversion and Lab 2 Thermocouple, Static and Dynamic Calibration and Lab 3 Transient Thermal Behavior with Work and Heat Loss.

All multiple choice questions are worth 1 point.

All short answer questions are worth 2 points.

Total 24 + 2x12 = 36 points (Quizzes are worth 20 points)

- 1. The static sensitivity of the thermocouple calibrated in the second lab was constant (for both water and air use).
 - a. True
 - b. False
- 2. The time constant, τ , of the thermocouple used in the second lab was constant for both water and air use.
 - a. True
 - b. False
- 3. Impatience while doing the static calibration of the thermocouple in the second lab
 - a. would contribute to hysteresis error.
 - b. would exaggerate the bias error.
 - c. would minimize S_{xy} .
 - d. All of the above
 - e. None of the above
- 4. What portion of the repeated sampling of a static temperature signal are within one standard deviation of the true mean value?
 - a. 5%
 - b. 50%
 - c. 68%
 - d. 95%
- 5. A zero order sensor will attenuate and delay the output with respect to the input.
 - a. True
 - b. False
- 6. The frequency bandwidth of a first order instrument is defined as the frequency below which $M(\omega)=0.707$, or output/input power is -3 dB.
 - a. True
 - b. False
- 7. The most common dial pressure gauge contains a Bourdon Tube.
 - a. True
 - b. False
- 8. The variance is equal to the standard deviation of signal.
 - a. True
 - b. False
- 9. An exponential equation, $y(x) = A + Be^{-x/C}$, fit to a data set with 25 points has how many degrees of freedom?
 - a. 21
 - b. 22
 - c. 23
 - d. 24
- 10. A correlation coefficient, R, of 0.92, indicates a high quality fit to the data.
 - a. True
 - b. False



Figure 1. Magnitude Ratio, (output/input vs. frequency), of first order sensor like the thermocouple used in Lab 2.

- 11. The approximate time constant, τ , of the thermocouple response plotted in Figure 1 is:
 - a. 1/100 seconds
 - b. 1 seconds
 - c. 100 seconds
 - d. 10 seconds
 - e. 40 seconds
- 12. A very small, very sensitive thermocouple will reach a steady state value sooner for a small step input than a large step input.
 - a. True
 - b. False
- 13. An instrument's accuracy is a measure of the random fluctuations in output for repeated applications of the same input.
 - a. True
 - b. False
- 14. Which ADC setup would result in the best approximation of the mean value of the function: $y(t) = 3.2 + 4 \cos 2\pi t + 2 \sin 7\pi t$?
 - a. 1,000 samples at 2,000 samples/second
 - b. 1,000 samples at 1,000 samples/second
 - c. 1,000 samples at 10 samples/second
 - d. 5,000 samples at 10,000 samples/second
 - e. 5,000 samples at 5,000 samples/second



Figure 2. Pressure transducer time response to a step input function.

- 15. The settling time in seconds of the pressure transducer plotted in Figure 2 is approximately
 - a. 1
 - b. 2
 - c. 3
 - d. 4
 - e. 5
- 16. The ADC architecture normally associated with the fastest conversion rate is
 - a. Flash
 - b. Pipelined
 - c. Successive approximation
 - d. Sigma-delta
- 17. A 95 Hz sine wave sampled at 100 Hz will result in a sampled data set with what frequency
 - a. 95 Hz
 - b. 5 Hz
 - c. 45 Hz
 - d. 55 Hz
 - e. none of the above
- 18. Heat loss to the laboratory surroundings from the calorimeter used in lab 3 was modeled with the equation, $Q = H(T_{calorimeter} T_{lab})$
 - a. True b. False



Figure 3. Sample probability functions, p(x).

19. Which of the probability distribution functions in Figure 3 has the smallest standard deviation?



Figure 4. Example thermocouple connection configuration.

- 20. The thermocouple configuration in Figure 4 will measure what temperature if the junction is at constant temperature $(T_4 = T_3 \neq T_2 \neq T_1)$?
 - a. $(T_1 T_2)$
 - b. $(T_1 T_2) T_3$
 - C. $(T_1 T_3) + (T_2 T_4)$
 - d. None of the above
- 21. For a normal distribution of x_i about some sample mean value, $x_i = \bar{x} \pm CI$, the confidence or precision interval is expressed as:
 - a. $\pm t_{\nu,P}S_x$ (P%)
 - b. $\pm t_{\nu,P}S_{\bar{x}}$ (P%)
 - c. $\pm t_{v,P}S_{vx}$ (P%)
 - d. None of the above

22. Ambient temperature and barometric pressure are frequently extraneous variables.

a. True b. False

- 23. A temperature sensor with infinite input impedance would be a "null device".a. True b. False
- 24. Excel LINEST regression analysis minimizes, $\sum_{i=1}^{N} (y_i y_{ci})$, the sum of the differences between the calibration data, y_i , and the calibration curve, y_{ci} ,.
 - a. True
 - b. False

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25. The ADC used in the lab would output what binary value corresponding to -7?

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26. As used in this class the confidence interval of a linear fit $y = a_0 + a_1 x \pm CI$ is

- 27. What is the equation for the error function, $\Gamma(t)$, used in lab 2 to linearize the thermocouple response?
- 28. What is the equation used to calculate the damped or ringing frequency, ω_d , of an under damped second order sensor like the one plotted in Figure 2 in terms of natural frequency, ω_n , and the damping ratio, ζ .
- 29. An analog to digital converter (ADC) quantization step size is defined in terms of the input range, E_{FSR} , Gain and the number of ADC bits, *M*, with the equation:
- 30. What is the equation used to determine the output/input signal magnitude, $M(\omega)$, in terms of the time constant, τ , and the input frequency ω :