# MAE334 - Introduction to Instrumentation and Computers 

Midterm Examination

October 24, 2007

- USE A \#2 Pencil
- Closed Book and Notes
- No Calculators


1. Fill in your name on side 2 of the scoring sheet (Last name first!)
2. Fill in your 8-digit person number on your scoring sheet.
3. Fill in circle 1 under GRADE OR EDUCATION on your scoring sheet. This is your test number! You will receive a ZERO if you do not indicate your test number.

- For each question, choose THE BEST ANSWER and mark the corresponding answer on the
 scoring sheet.

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 $24+2 \times 12=36$ 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, $\tau$, 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 $\mathrm{S}_{\mathrm{xy}}$.
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 $\mathrm{M}(\omega)=0.707$, 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, $y(x)=A+B e^{-x / C}$, 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, $\tau$, 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, $Q=H\left(T_{\text {calorimeter }}-T_{\text {lab }}\right)$
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 ( $\mathrm{T}_{4}=\mathrm{T}_{3} \neq \mathrm{T}_{2} \neq \mathrm{T}_{1}$ )?
a. $\left(\mathrm{T}_{1}-\mathrm{T}_{2}\right)$
b. $\left(T_{1}-T_{2}\right)-T_{3}$
c. $\left(T_{1}-T_{3}\right)+\left(T_{2}-T_{4}\right)$
d. None of the above
21. For a normal distribution of $x_{i}$ about some sample mean value, $x_{i}=\bar{x} \pm C I$, the confidence or precision interval is expressed as:
a. $\pm t_{\nu, P} S_{x}(P \%)$
b. $\pm t_{v, P} S_{\bar{x}}(P \%)$
c. $\pm t_{v, P} S_{y x}(P \%)$
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, $\sum_{i=1}^{N}\left(y_{i}-y_{c i}\right)$, the sum of the differences between the calibration data, $y_{i}$, and the calibration curve, $y_{c i}$,
a. True
b. False
25. The ADC used in the lab would output what binary value corresponding to -7?

26. As used in this class the confidence interval of a linear fit $y=a_{0}+a_{1} x \pm C I$ 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, $\omega_{\mathrm{d}}$, of an under damped second order sensor like the one plotted in Figure 2 in terms of natural frequency, $\omega_{\mathrm{n}}$, and the damping ratio, $\zeta$.
29. An analog to digital converter (ADC) quantization step size is defined in terms of the input range, $E_{F S R}$, Gain and the number of ADC bits, $M$, with the equation:
30. What is the equation used to determine the output/input signal magnitude, $\mathrm{M}(\omega)$, in terms of the time constant, $\tau$, and the input frequency $\omega$ :

