MAE 2381: EXPERIMENTAL METHODS AND MEASUREMENTS

Fall 2006

MIDTERM EXAMINATION

November 1 2006

INSTRUCTIONS

- This is a closed-book/closed-notes examination. All formulas, constants and fluid properties will be given to you.
- This quiz is conducted in accordance with University rules regarding academic honesty.
- There is only one correct answer per question/problem. Two points for each correct answer. The total score is 50.
- You have FIFTY MINUTES.
- This booklet consists of nine (9) pages.

INSTRUCTOR
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Response of 1\textsuperscript{st} order system to a step excitation

Frequency response of 1\textsuperscript{st} order system

Frequency response of 2\textsuperscript{nd} order system
For each problem, mark the correct answer or most appropriate in the corresponding box

1. In general, a linear instrument is one which can be expressed by only one of the following equations,

   a. \( y = A \sin \omega t \)
   
   b. \( y = ax + b \)
   
   c. \( y = A \log x^b \)
   
   d. \( y = Ae^{bx} \)
   
   e. \( y = ax^2 + bx + c \)

   between the steady input \( x \) and the steady output \( y \), where the coefficients \( A, a, b, \) etc. are constants.

2. In general there are six major functions in a data acquisition chain, consisting of:

   a. Sensing, wiring, noise reduction, digitizing, transmission, presentation, and storage and playback
   
   b. Calibration, conversion, filtering, digitizing, transmission, presentation, and storage and playback
   
   c. Sensing, multiplexing, conversion, transmission, presentation, and storage and feedback
   
   d. Sensing, conversion, manipulation, transmission, presentation, and storage and playback
   
   e. None of the above

3. A single dynamic signal will typically possess the following information:

   a. Amplitude and complexity
   
   b. Magnitude and frequency
   
   c. Magnitude and phase
   
   d. Magnitude and instrument characteristics
   
   e. Hysteresis and damping

4. A zero-order instrument is one

   a. Which must be zeroed or nulled before a reading can be taken
   
   b. Which has a built-in calibrator
   
   c. Which requires a high-speed digitizer
   
   d. Which cannot be used to measure forces
   
   e. Which theoretically has an instant response
5. One of the following is NOT a reason for performing engineering experiments
   a. Discover basic phenomena.
   b. Determine pricing strategies.
   c. Product improvement.
   d. Calibrate computer models.
   e. Obtaining technical performance data on a new product.

6. The sensitivity of an instrument is
   a. Solely a zero-order property
   b. Solely a first-order property
   c. Solely a second-order property
   d. The slope of the output to the input
   e. None of the above

7. One of the following is NOT a valid purpose of signal conditioners
   a. Amplification
   b. Filtering
   c. Conversion of signal from one electrical form to another
   d. Compare the amplitude against a threshold
   e. Linearize a nonlinear signal

8. For a digital data acquisition system, filtering serves to
   a. Amplify the signal and to increase bandwidth
   b. Convert the raw signals into a voltage and to improve the signal quality
   c. Improve signal-to-noise ratio and to linearize the data
   d. Improve data resolution and prevent or minimize aliasing
   e. Improve the signal-to-noise ratio and to prevent or minimize aliasing
9. Suppose we are interested only in the fluctuations in a signal. The process of subtracting the mean level to allow the fluctuations to be more clearly observed is known as
   a. Fourier transforms
   b. Filtering
   c. Amplification
   d. DC offset
   e. Digitization

10. One of the following is **NOT** a purpose of calibration
   a. Determine the resolution of an instrument
   b. Determine the accuracy of an instrument
   c. Comparison of an instrument with a primary standard
   d. Comparison of an instrument with a secondary standard
   e. Comparison of an instrument with a known input source

11. One of the following is not considered a technique for reducing or eliminating electromagnetic interference
   a. Use of coaxial cable
   b. Use of anti-aliasing filters
   c. Use of shielding
   d. Use of twisted pairs
   e. Putting a radio frequency choke inline

12. One of the following sets of parameters is required for modeling a first-order dynamic system
   a. phase lag and amplitude ratio
   b. time constant and amplitude ratio
   c. time constant and sensitivity
   d. dynamic range and sensitivity
   e. dynamic range and signal-to-noise ratio

13. Consider a first-order system with a time constant of 5 s subjected to a sinusoidal excitation of 2 rad/s. The ratio of the steady-state response to the ideal response is approximately
   a. 0
   b. 0.1
   c. 0.707
   d. 0.9
   e. 1
14. When a first-order instrument is subjected to a high-frequency excitation, it will
   a. not respond at all
   b. respond with a larger amplitude than if the excitation was at lower frequency
   c. respond with a smaller amplitude than if the excitation was at lower frequency
   d. respond at a higher frequency
   e. respond at a lower frequency

15. Consider a first-order instrument. Since a step excitation is physically impossible, it can be achieved by applying
   a. A sinusoidal excitation at frequencies such that \( \omega \tau \gg 1 \)
   b. A damped excitation where the damping coefficient is larger than 1
   c. A sudden, fixed amplitude excitation where the rise time is much shorter than the time constant
   d. An exponentially rising excitation
   e. A random, white noise

16. The time constant of a first-order measurement system is known to be 2 s. If the device is used to measure an oscillating signal with an angular frequency of 5 rad/s, the phase lag is approximately
   a. 0°
   b. 5.7°
   c. 45°
   d. 84°
   e. 90°

17. The time constant of a first-order system is defined as the time it takes for the system to reach
   a. 0.5
   b. 0.632
   c. 0.707
   d. 0.9
   e. 1 of the final state when subjected to a step excitation.
18. For an instrument described as a first-order system, the phase lag is typically expressed in angular form. The phase lag is actually
   a. A time delay
   b. An amplitude attenuation
   c. An analog response
   d. Noise in the system
   e. A nonlinear effect

19. One of the following sets of parameters is required for modeling a second-order dynamic system
   a. Exponential rise time, phase lag and amplitude ratio
   b. Damping ratio, sensitivity and natural frequency
   c. Dynamic range, sensitivity and natural frequency
   d. Time constant, amplitude ratio and sensitivity
   e. Phase shift, hysteresis and saturation

20. When subjected to a step input, a second-order dynamic system that has a damping ratio of larger than one will undergo
   a. An exponential rise
   b. An exponentially damped oscillation
   c. An exponentially increasing oscillation
   d. A logarithmically damped oscillation
   e. An amplified oscillation

21. Manufacturers of instruments that exhibit second-order behavior usually like to have damping ratios of 0.6 – 0.7 because the instrument
   a. Is easier to manufacture
   b. Is stable against noise and fluctuations in environmental conditions
   c. Is able to reach the final state quickly despite a small overshoot
   d. Does not depend on external amplification
   e. Can be easily calibrated using a step excitation
   a.
22. The rise time of a second-order system may be reduced by
   a. Raising its sensitivity
   b. Reducing its “mass equivalent”
   c. Reducing the damping ratio (or damping coefficient)
   d. Amplifying its response
   e. Tuning the system to resonate

23. Manufacturers of instruments with a second-order response would typically want their instruments to operate within
   a. the dean zone
   b. the transmission band
   c. the rise time
   d. the hysteresis band
   e. the settling time

24. Excessive amplification can cause
   a. Unnecessary noise
   b. Beating
   c. Phase shift
   d. Oscillations
   e. Signal saturation

25. A set of reusable earplugs from Home Depot has a rating of 21 dB. Given that dB measures power ratios according to the formula $10 \log_{10} \frac{Power_{without\ protection}}{Power_{with\ protection}}$. What is the attenuation in sound power afforded by the earplugs? Choose the value closest to your calculation.
   a. 1/13
   b. 1/26
   c. 1/125
   d. 1/250
   e. 1/1000