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# MAE 2381: EXPERIMENTAL METHODS AND MEASUREMENTS

Fall 2006

## MIDTERM EXAMINATION

November 1 2006

**ANSWERS**

### **INSTRUCTIONS**

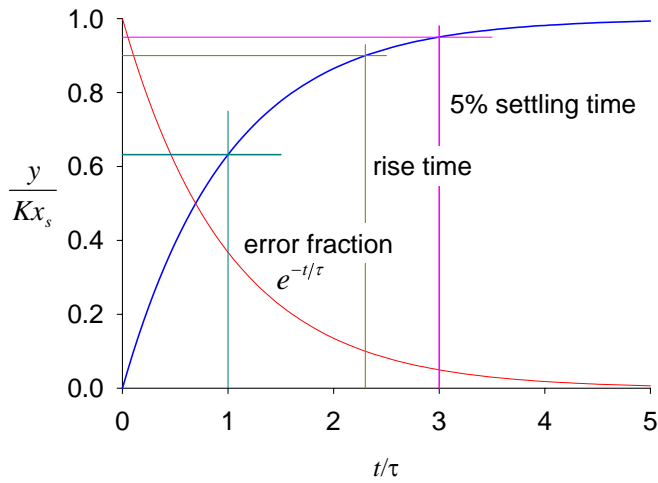
- This is a closed-book/closed-notes examination. All formulas, constants and fluid properties will be given to you.
- This quiz is conducted in accordance with University rules regarding academic honesty.
- There is only one correct answer per question/problem. Two points for each correct answer. The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

# **INSTRUCTOR**

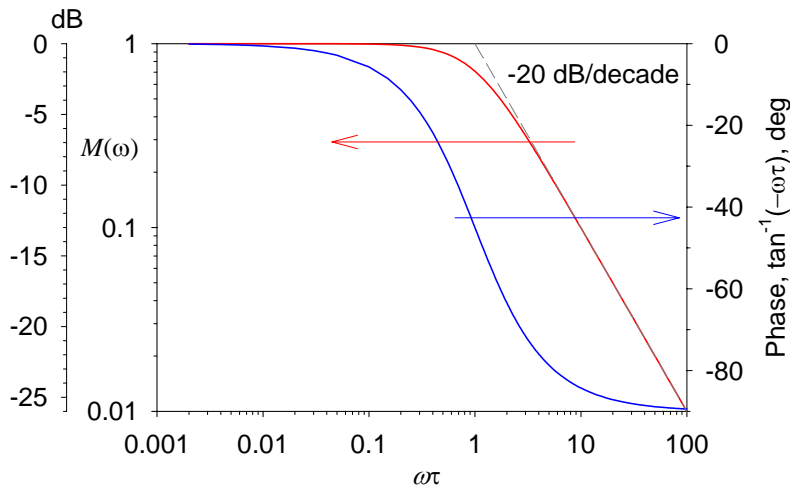
For instructor only

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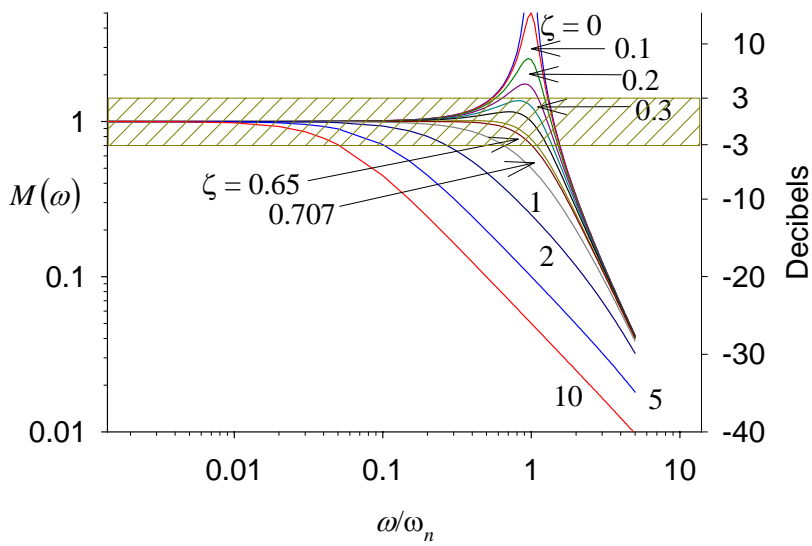
ANSWERS



**Response of 1<sup>st</sup> order system to a step excitation**



**Frequency response of 1<sup>st</sup> order system**



**Frequency response of 2<sup>nd</sup> 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.  $y = ax^2 + bx + c$

a	b	c	d	e

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

a	b	c	d	e

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

A	b	c	d	e

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

a	b	c	d	e

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.

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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.  $0^\circ$
- b.  $5.7^\circ$
- c.  $45^\circ$
- d.  $84^\circ$
- e.  $90^\circ$

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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

a	b	c	d	e

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	b	c	d	e

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
- b.

a	b	c	d	e

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

a	b	c	d	e

24. Excessive amplification can cause

- a. Unnecessary noise
- b. Beating
- c. Phase shift
- d. Oscillations
- e. Signal saturation

a	b	c	d	e

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

a	b	c	d	e