Name:_____

ID No.:___xxx-xx-_____

MAE 2381: EXPERIMENTAL METHODS AND MEASUREMENTS

Fall 2005

MIDTERM EXAMINATION

November 2, 2005

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 eight (8) pages.

INSTRUCTOR

For instructor only

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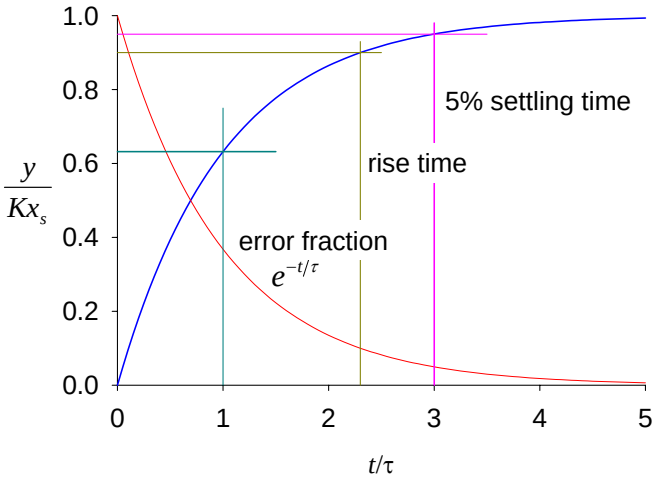
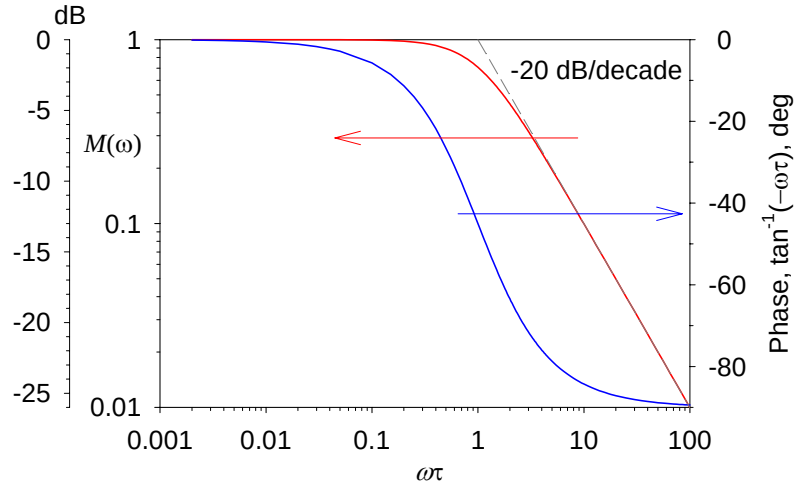
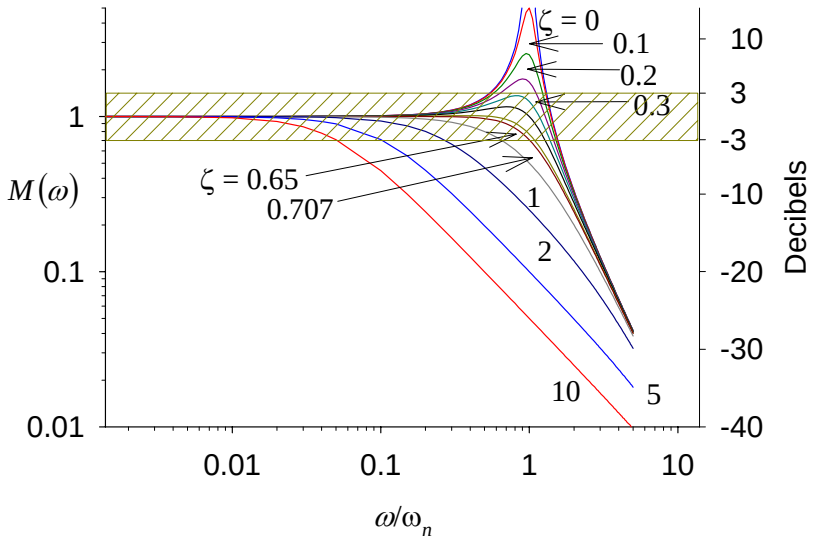


Response of 1st order system to a step excitation



Frequency response of 1st order system



Frequency response of 2nd order system

For each problem, mark the correct answer or most appropriate in the corresponding box

1. In general, a test plan requires the following steps,

   a. A parameter design plan, a system and tolerance design plan and preliminary testing
   b. A parameter design plan, a system and tolerance design plan and analytical modeling
   c. Exploratory testing, literature search and a field survey
   d. Literature search, prototyping and preliminary testing
   e. A parameter design plan, a system and tolerance design plan and a data reduction design plan

a	b	c	d	e
				■

2. In digital data acquisition, cold junction compensation of thermocouples refers to a technique to reference the thermocouple output voltage to the

   a. Ice point of water
   b. Boiling point of water
   c. Standard temperature (20 ^{o}C)
   d. Absolute zero
   e. None of the above

a	b	c	d	e
■				

3. An instrument's accuracy can be determined by

   a. Consulting the manufacturer's specifications
   b. Computer modeling
   c. Assuming a second-order dynamic response
   d. Calibrating the instrument against a (primary or secondary) standard
   e. An uncertainty analysis

a	b	c	d	e
			■	

4. A 16-bit digitizer can resolve 16 count in

   a. 14
   b. 1400
   c. 4096
   d. 16384
   e. 65536

a	b	c	d	e
				■

5. 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
			■	

6. 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
				■

7. The deviation of an instrument reading from a *known* value is the

   a. Error
   b. Drift
   c. Hysteresis
   d. Resonance
   e. Phase lag

a	b	c	d	e
■				

8. For digital data acquisition, the problem of aliasing can be removed or eliminated from a signal with a bandwith of $0 < f \le f_{max}$ by

a	b	c	d	e
	■			

   a. Sampling at a rate of at least $f_s = f_{max}$ and filtering at a cutoff of just over f_{max}
   b. Sampling at a rate of at least $f_s = 2 f_{max}$ and filtering at a cutoff of just over f_{max}
   c. Sampling at a rate of at least $f_s = f_{max}$ and filtering at a cutoff of just over $2 f_{max}$
   d. Sampling at a rate of at least $f_s = 2 f_{max}$ and filtering at a cutoff of just over $2 f_{max}$
   e. Using a system with a time constant of at least $1/f_{max}$

9. When acquiring data from multiple channels, time skew (time delay or phase shift) occurs if the data acquisition system is

a	b	c	d	e
				■

a. Is heavily damped
b. Does not have proper shielding
c. Does not have enough bandwidth
d. Has insufficient bit resolution
e. Multiplexed

10. One of the following is **NOT** a valid purpose of signal conditioners

a	b	c	d	e
			■	

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

11. One of the following is not considered a technique for reducing or eliminating electromagnetic interference

a	b	c	d	e
	■			

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	b	c	d	e
		■		

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. In comparing the dynamic output of a zero-order and a first-order system with the same gain,

a	b	c	d	e
■				

a. The first-order output amplitude is always attenuated compared to the zero-order
b. There is no difference in phase between the two systems
c. One cannot compare the outputs at all
d. The first-order system is too sluggish
e. The signal-to-noise ratio for the first-order system will be higher than the zero-order

14. The static calibration of an instrument yields an equation $y = mx + c$ between the input and output x and y respectively. The parameters m and c correspond to

a	b	c	d	e
	■			

a. the damping and sensitivity respectively

b. the sensitivity and offset respectively

c. the gain and adjustment respectively

d. the constant and fluctuating component respectively

e. the time constant and sensitivity respectively

15. When an instrument, described as a first-order system, is subjected to a step input, the transient response is

a	b	c	d	e
	■			

a. Always sinusoidal

b. Always exponential

c. Sometimes sinusoidal depending on the time constant

d. Sometimes exponential depending on the time constant

e. An exponentially damped sinusoid

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	b	c	d	e
			■	

a. 0^o

b. 5.7^o

c. 45^o

d. 84^o

e. 90^o

17. A first-order instrument initially at state (1) reaches a final state (2). The time required to reach the midpoint between these two states is

a	b	c	d	e
	■			

a. 0.5τ

b. 0.693τ

c. 0.632τ

d. 0.707τ

e. τ

where τ is the time constant.

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 less than one will undergo

a. A resonating motion
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. Consider a second-order system subjected to a harmonic excitation

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = F_o \cos \omega t$$

a	b	c	d	e
■				

The m, c and k coefficients are usually associated with

a. A mass, damper and spring respectively
b. A moment and two constants
c. A mass, a deflection and resonance
d. A mass, a strobe and a time delay
e. None of the above

22. 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
	■			

23. Manufacturers of instruments with a second-order response would typically want their instruments to operate within an amplitude band of

a. ±10 %
b. ±3 %
c. ±36.8 %
d. ±10 dB
e. ±3 dB

a	b	c	d	e
				■

24. One of the following is **NOT** usually considered a function of signal conditioners

a. Amplification to boost the signal strength to match digitizer range
b. Convert the signal from one electrical type to another
c. Filtering to improve signal-to-noise ratio
d. Linearize the signal (if needed)
e. Multiplex signals from different sources

a	b	c	d	e
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25. The signal-to-noise ratio in dB is given by $20\log_{10} SNR$. If the average noise amplitude of a signal is 0.1% of the average signal amplitude, this is equal to

a. 20 dB
b. 40 dB
c. 60 dB
d. 100 dB
e. 141 dB

a	b	c	d	e
		■		