

ES360 Exam 2

Practice Exam

Permitted Materials:

You are permitted and **expected** to use the following to take this exam:

- Your calculator
- Your notes and text book

You may not use printed versions of the course solutions!

**Exchanging or sharing of any material
during the actual exam is prohibited.**

The SIMULINK Section (page 10):

A portion of this exam requires the use of SIMULINK.

Half the class will work on the SIMULINK section during the first 45 minutes of the exam. The other half of the class will complete the SIMULINK portion during the second 45 minutes of the exam. If you finish the SIMULINK portion early you may continue working on the rest of the exam.

SHOW ALL WORK. For short answer and calculating problems show all appropriate work and clearly indicate your answer by drawing a box around it. Partial credit may be awarded at the instructor's discretion, but only if you have shown your work.

This exam is 10 pages long (including this cover sheet and SIMULINK Section). Ensure you have all 10 pages.

Comments on the Practice Exam:

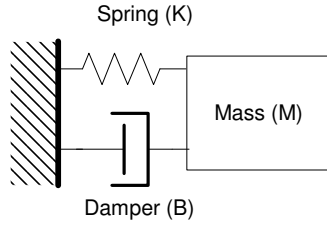
This practice exam shows the types questions on Exam 2. On the actual exam, there may be more or less of any particular question type.

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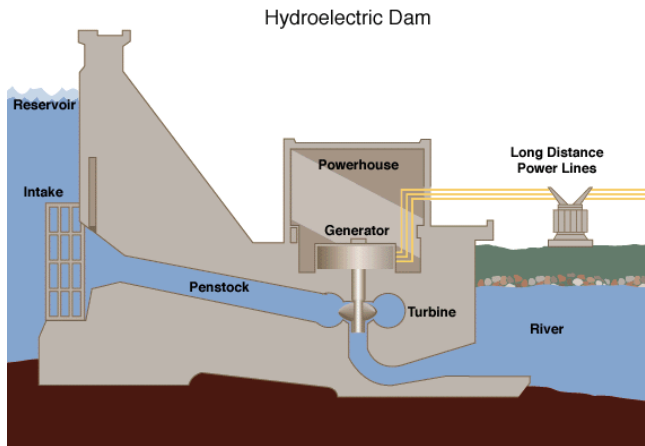
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In the systems pictured below label the kinetic and potential energy storage elements and the dissipative elements. Additionally label any devices which convert energy from one domain to another (Translational to Thermal, electric to rotational, etc.).

1)



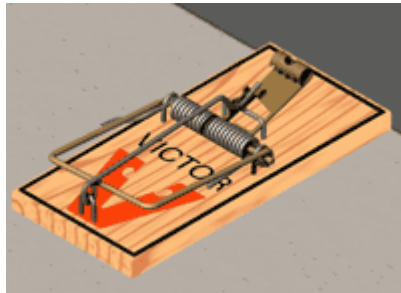
2)



3)



4)



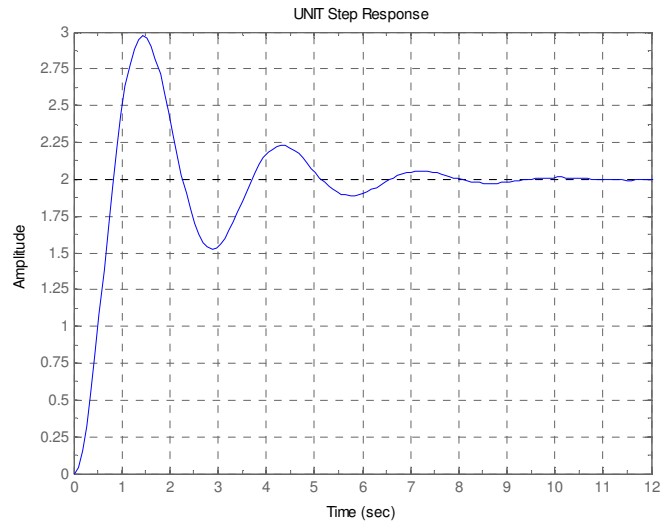
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5) For the unit step applied to the transfer function $G(s) = \frac{14}{s^2 + 5s + 28}$ find the following:

Characteristic Equation	
Roots of the Characteristic Equation	
System Response Type: (Over Damped, Critically Damped, Under Damped, Unstable)	
ω_n	
$\zeta\omega_n$	
ζ	
ω_d	
T_s	
T_p	
%OS	
DC Gain	

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6) A unit step applied to a system generates the following response. Use the plot to find the values for: ω_d , T_s , T_p , %OS, and DC Gain.



7) Find the second order transfer function of which gives the response depicted in question 6. The transfer function should have the form:

$$G(s) = \frac{d}{s^2 + b \cdot s + c}$$

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8) Read the following description. Decide if it describes a system with no feedback, negative feedback or positive feedback.

The cruise control of a car continually monitors the vehicles speed. As the vehicle's speed rises above the set point the cruise control closes the throttle to slow the vehicle. As the vehicle's speed slows below the set point, the cruise control opens the throttle to speed the vehicle up.

Circle One:

No Feedback	Negative Feedback	Positive Feedback
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9) Read the following description. Decide if it describes a system with no feedback, negative feedback or positive feedback.

Sometimes one can hear “feedback” in a public address system. This happens when the microphone is placed in front of the speaker. The microphone detects some amount of noise from the speaker. The system amplifies this noise and the speaker plays it louder. The microphone amplifies this new noise level.

Circle One:

No Feedback	Negative Feedback	Positive Feedback
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10) For the transfer function $G(S) = \frac{1/M}{s^2 + \frac{B}{M}s + \frac{K}{M}}$. How does increasing the **friction** (B)

of the system effect, Tp, Ts, damping ratio, and %OS. Show your work.

Tp	Ts	ζ	%OS
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11) Summarize the key points of lessons 6 and 8 in the table below. Use no more than three sentences per lesson. You should write in complete sentences.

6	
8	

12) In the PID controller, which gain term only effects the transient response? Why?

13) In the PID controller, when does the derivative term provide a large correction to the error signal?

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14) Implement a **PID** controller to control the output of a system with the transfer function

$$G(s) = \frac{6}{s+2}.$$

- a) Sketch a block diagram of the system.
- b) Simplify the block diagram to find the closed loop transfer function of the system. Leave the gain terms as variables.

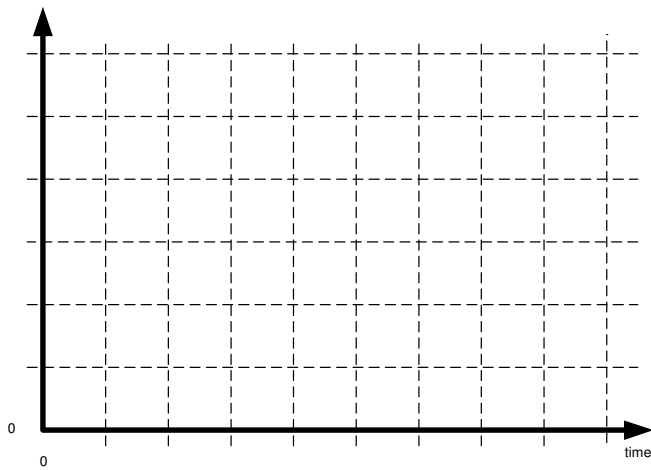
CLTF(s)=

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c) For gain values of $K_P = 20$ and $K_I = 5$ and $K_D = 10$ calculate.

Characteristic Equation	
Roots of the Characteristic Equation	
System Response Type: (Over Damped, Critically Damped, Under Damped, Unstable)	
ω_n	
$\zeta\omega_n$	
ζ	
ω_d	
T_s	
T_p	
%OS	
DC Gain	

15) Plot the unit step response for $G(s) = \frac{64}{s + 32}$.



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16) The rotational motion of windmill can be modeled by a first order transfer function.



a) Write a first order transfer function which related the windmill speed to the applied torque.

$G(s) =$

b) For a given torque applied by the blades, which variable in the transfer function determines the systems steady state speed? Why?

c) Which parameter will change the most as the blades of the windmill get longer? How does making the blades of the windmill longer change the amount of time it takes the windmill to reach its steady state speed? Use the transfer function to explain.

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SIMULINK

Question Version: Practice Name: _____ Section: _____

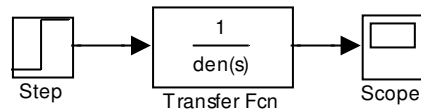
Directions:

- You will have no more than 45 minutes to complete this portion of the exam.
- You may not ask another student for help during the exam.
- You may use your notes and the MATLAB help handout.
- Any printed plots/diagrams must have your name and section number **typed** on the plot. (no hand written names and section numbers).
- I will collect the plots from the printer.

Part 1:

Build the SIMULINK model below to find the open loop step response for the transfer $G(s)$ to a unit step.

$$G(s) = \frac{1}{s^4 + 10s^3 + 30s^2 + 2s + 1}$$



Ensure the following:

- The step occurs at time 0 (the default is for it to occur at time 1).
- The stop time of the simulation is **200** seconds.
- MATLAB is set to send plots to the printer as “always send as black and white”.

a) From the plot of the response determine the following:

Ts =	Tp =	%OS =	DC Gain =
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Part 2:

Implement **position feedback** in this system.

a) Find the grain value (to the nearest integer) which makes the system **marginally stable**.

K _P =

b) Print the block diagram, ensure the following:

- Your name and section number is typed on the on the diagram. Double click on any blank portion of the diagram to start typing an annotation.
- The transfer function blocks and gain blocks are big enough so that the actual transfer function and gain values are displayed.

c) Print a plot of the response.

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Solutions:

1-4) See Lesson 3b

5)

Characteristic Equation	$s^2 + 5s + 28 = 0$	ω_d	4.66
Roots of the Characteristic Equation	$s = -0.25 \pm 4.66i$	Ts	1.6 sec
System Response Type: (Over Damped, Critically Damped, Under Damped, Unstable)	Under Damped	Tp	0.67 sec
ω_n	$\sqrt{28}$	%OS	14.5%
$\zeta\omega_n$	2.5	DC Gain	0.5
ζ	0.47		

6) $\omega_d = \frac{2\pi}{2.88} = 2.18$, Ts = 8, Tp = 1.5, %OS = 48%, DC gain = 2

7) This answer will vary based on the results of question 6. For the numbers listed above

$$G(s) = \frac{10}{s^2 + s + 5}$$

8-9) See Lesson 6

10) Tp↑ Ts↓ ζ↑ %OS↓

11) See Lessons 6 and 8

12) See Lessons 9 or 10

13) See Lesson 9

14 a) See Figure 10 and Question 7a of Lesson 9

14 b) $CLTF(s) = \frac{6K_D s^2 + 6K_P s + 6K_I}{(6K_D + 1) \cdot s^2 + (6K_P + 2) \cdot s + 6K_I}$

14 c)

Characteristic Equation	$61s^2 + 122s + 30 = 0$ $s^2 + 2s + 0.49 = 0$	ω_d	0
Roots of the Characteristic Equation	$s = -0.29$ and -1.71	Ts	13.8 sec
System Response Type: (Over Damped, Critically Damped, Under Damped, Unstable)	Over Damped	Tp	∞
ω_n	$\sqrt{0.49} = 0.701$	%OS	0%
$\zeta\omega_n$	1	DC Gain	1
ζ	1.43		

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15) See Lesson 11a. The settling time is 0.125 seconds and the DC gain is 2.

16)

a) $G(s) = \frac{\omega(s)}{\tau(s)} = \frac{\frac{1}{J}}{s + \frac{B}{J}}$

b) The amount of friction (b) will determine the system's steady state speed because the DC gain of this transfer function is $\frac{1}{B}$. The $\frac{1}{J}$ terms cancel out.

c) As the blades of the windmill get longer the rotational inertia (J) of the system will go up. Inertia is a function of mass and distances from the axis of rotation. As the inertia increases the system will take longer to reach its steady state value because the settling time is given by $T_s = \frac{4 \cdot J}{B}$.

SIMULINK Solutions:

Part 1)

$T_s = 128$, $T_p = 17$, $\%OS = 61\%$, DC gain = 1

Part 2)

$K_p = 5$

