ESE 406 – Spring 2012 – *Practice* Midterm Exam – *Closed* Book & Notes

- Choose one best answer for each question by *circling the letter* (unless other instructions given)
- A correct answer is worth 2 points.
- No answer is worth 0 points.
- An incorrect answer is worth -1 point. Random guessing will lower your grade (on average).

==

1. Which of the following statements is NOT correct concerning the differential equation:

$$\frac{dy}{dt} + \sin(3y) = 2u$$

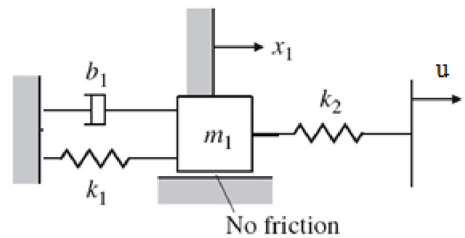
   A. It is a first-order differential equation.
   B. It is a non-linear differential equation.
   C. The Laplace transform of the equation with zero initial conditions is $sY(s) + \sin[3Y(s)] = 2U(s)$

2. Which of the following is NOT correct regarding the differential equation $\frac{dy}{dt} = -uy^2 + 4$?

   A. It is a first-order equation.
   B. It is a non-linear equation.
   C. It is readily solved with Laplace Transforms if the initial condition, $y(0)$, is known.
   D. If the constant control $u = 1$ is applied, one possible steady-state solution is $y = 2$.

3. For the system in the previous problem, what is the transfer function $H(s) = \frac{\Delta Y(s)}{\Delta U(s)}$ for small changes from the trim at $y_o = 1$?

   A. $H(s) = \frac{-1}{s+8}$
   B. $H(s) = \frac{4}{s-1}$
   C. $H(s) = \frac{8}{s+1}$
   D. None of the above.



4. The equation of motion for the system show above is:

   A. $m_1\ddot{x}_1 + b_1\dot{x}_1 + (k_1 + k_2)x_1 = (k_1 + k_2)u$
   B. $m_1\ddot{x}_1 + b_1\dot{x}_1 + (k_1 - k_2)x_1 = k_2 u$
   C. $m_1\ddot{x}_1 + b_1\dot{x}_1 + (k_1 + k_2)x_1 = k_2 u$
   D. None of the above.

5. The differential equation $\frac{d^2y}{dt^2} - y = 7u$. can be written in state-space form with $B = [0 \quad 7]^T$, $C = [1 \quad 0]$, $D = [0]$, and...

   A. $A = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$
   B. $A = \begin{bmatrix} -1 & 0 \\ 1 & 0 \end{bmatrix}$
   C. $A = \begin{bmatrix} 0 & 1 \\ -2 & 0 \end{bmatrix}$
   D. None of the above.

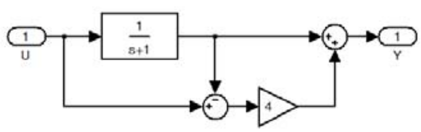
6. A system governed by the differential equation $\frac{dy}{dt} = u$. If $y(0) = 0$ and the system is subjected to the input $u(t) = \cos(2t)$, the response will be

   A. $y(t) = t + \sin(2t)$
   B. $y(t) = t + \sin(2t) - \cos(2t)$
   C. $y(t) = \frac{1}{2}\sin(2t)$
   D. None of the above.

7. Which of the following is NOT a true statement about the transfer function

$$G(s)=\frac{2s+36}{\left(s^2+18s+324\right)}$$

   A. The system corresponding to this transfer function is stable.
   B. The poles are complex with natural frequency $\omega_n = 18$ and damping ratio $\varsigma = 0.5$
   C. The zero is on the negative real axis at $z=-36$
   D. The steady-state (“DC”) gain of the system is $\frac{1}{9}$.

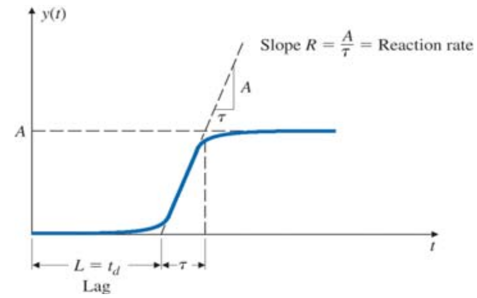


8. Which transfer function corresponds to the block diagram shown above?

   A. $G(s)=\frac{(s+4)}{(s+1)}$
   B. $G(s)=\frac{(4s+1)}{(s+4)}$
   C. $G(s)=\frac{(4s+1)}{(s+1)}$
   D. None of the above

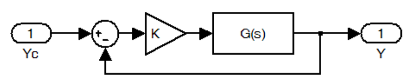
9. Which of the following statements is NOT correct concerning derivative feedback?

   A. It is usually used to improve damping.
   B. It has infinite gain at high frequency, which can result in noise rejection issues.
   C. It can only be used in conjunction with proportional and integral feedback (PID control).



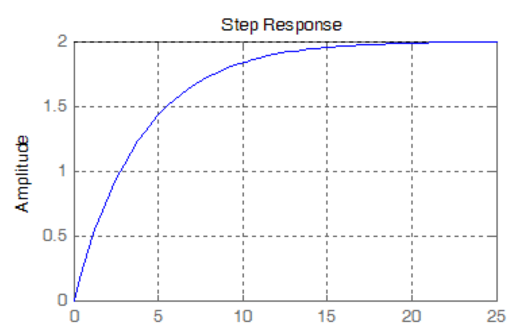
10. The figure shown above is associated with which of the following?

   A. Ziegler-Nichols PID tuning rules.
   B. Romney-Santorum PID tuning rules.
   C. The Laffer Curve.
   D. All of the above.



11. Which of the following statements is the correct transfer function for the block diagram shown above?

   A. $\frac{Y(s)}{Y_C(s)}=\frac{KG(s)}{1+KG(s)}$
   B. $\frac{Y(s)}{Y_C(s)}=KG(s)-1$
   C. $\frac{Y(s)}{Y_C(s)}=\frac{1}{KG(s)-1}$
   D. None of the above.



12. The time constant for the first-order step response shown above is approximately:

   A. 2 seconds
   B. 4 seconds
   C. 8 seconds
   D. 16 seconds

13. The transfer function corresponding to the differential equation

$$\frac{d^2y}{dt^2}+3\frac{dy}{dt}+2y=2\frac{du}{dt}+8u \ldots$$

   A. …has poles at +3 and +2 & zeros at +2 and +8.
   B. has poles at -3 and -2 & zeros at -2 and -8.
   C. has poles at -1 and -2 & a zero at -4.
   D. has poles at -1 and -2 & no zeros

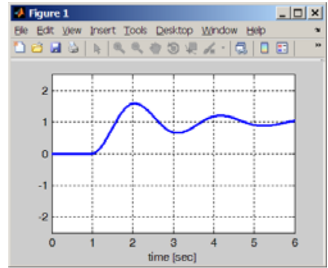
14. Which of the following is NOT true with respect to the transfer function $\frac{Y(s)}{U(s)}=\frac{K\tau s+1}{\tau s+1}$, with $\tau>0$?

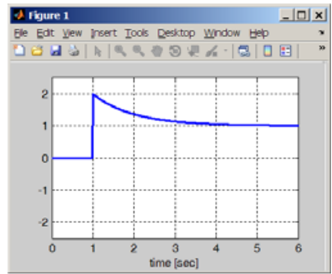
   A. It is a stable system.
   B. The corresponding differential equation is $\tau\frac{dy}{dt}+y=K\tau\frac{du}{dt}+u$.
   C. It is a lag compensator if $K>1$.
   D. It is a low-pass filter if $K=0$.

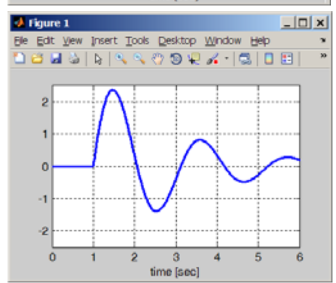
15. Which of the following is NOT true with respect to a time delay of T seconds in a control system?

   A. The exact Laplace transform of the delay is e^{-Ts}.
   B. A first-order Pade approximation of the delay is $\frac{-0.5Ts+1}{0.5Ts+1}$.
   C. A Pade approximation is useful because it represents delay using polynomial numerator and denominator.
   D. A unity-feedback closed-loop system including delay will be stable for arbitrarily large gain, provided the delay is less than the "Nyquist threshold".

For each of the following, fill in the blank with the letter of the unit step response (input @ t=1sec) that corresponds to the transfer function shown. Write "D" if the step response for the transfer function is not shown.

A. 

B. 

C. 

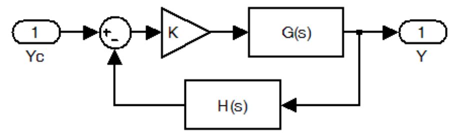
16. ______ $H(s)=\frac{2s+1}{s+1}$

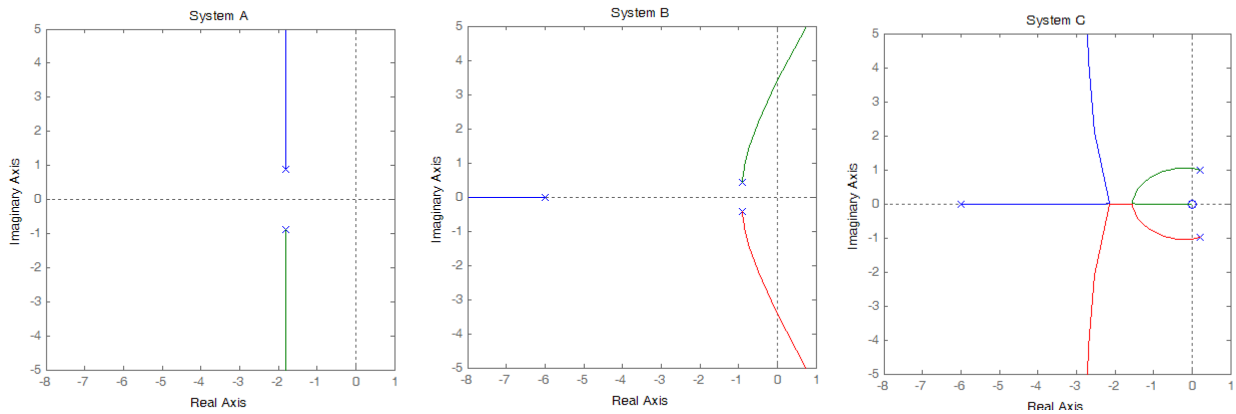
17. ______ $H(s)=\frac{9s}{s^2+s+9}$

18. ______ $H(s)=\frac{2s}{s+1}$

19. ______ $H(s)=\frac{9}{s^2+s+9}$

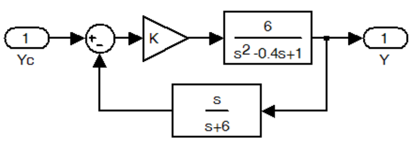
The following figures show the root loci for positive values of the gain K in systems which have block diagrams of the form shown at the right, but with different functions G(s) and H(s).





20. Which system is stable for all positive values of the gain, K?

    A. System A
    B. System B
    C. System C
    D. None of the above.



21. Which system could be the locus for K in the block diagram shown above?

    A. System A
    B. System B
    C. System C
    D. None of the above.

22. For system A, replacing the proportional gain, K, with what type of compensation would improve the damping ratio of the poles at large values of K?

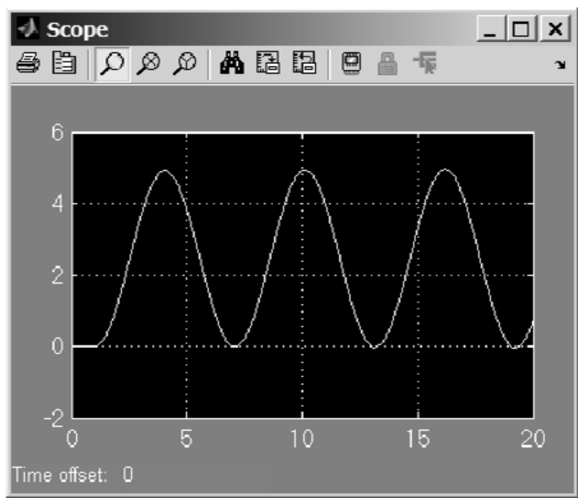
    A. PD Compensation
    B. PI Compensation
    C. A Low-Pass Filter.
    D. All of the above.

23. If the gain K is replaced with integral feedback, which system will be unstable for all positive values of the integral feedback gain?

    A. System A
    B. System B
    C. System C
    D. None of the above.

24. For which system is the closed-loop settling time approximately constant regardless of the gain?

    A. System A
    B. System B
    C. System C
    D. None of the above.



25. If the gain, K, were increased just to the point of neutral stability, which system could have the closed-loop unit step response (input at t=1 sec) shown above?

    A. System A
    B. System B
    C. System C
    D. None of the above.