Fall 2022 ECE 317 Final Exam **Name:**___________________________

Mark your answers on your Scantron Form No 882-E. Submit this question paper along with your scantron. Use of calculators is not permitted.

1. A system has a single pole at the origin. Its impulse response will be:

   a. Constant   b. Ramp   c. Decaying exponential   d. Oscillatory

2. A system with zero initial conditions has the closed-loop transfer function

$$T(s) = \frac{s^2 + 4}{(s+1)(s+4)}$$

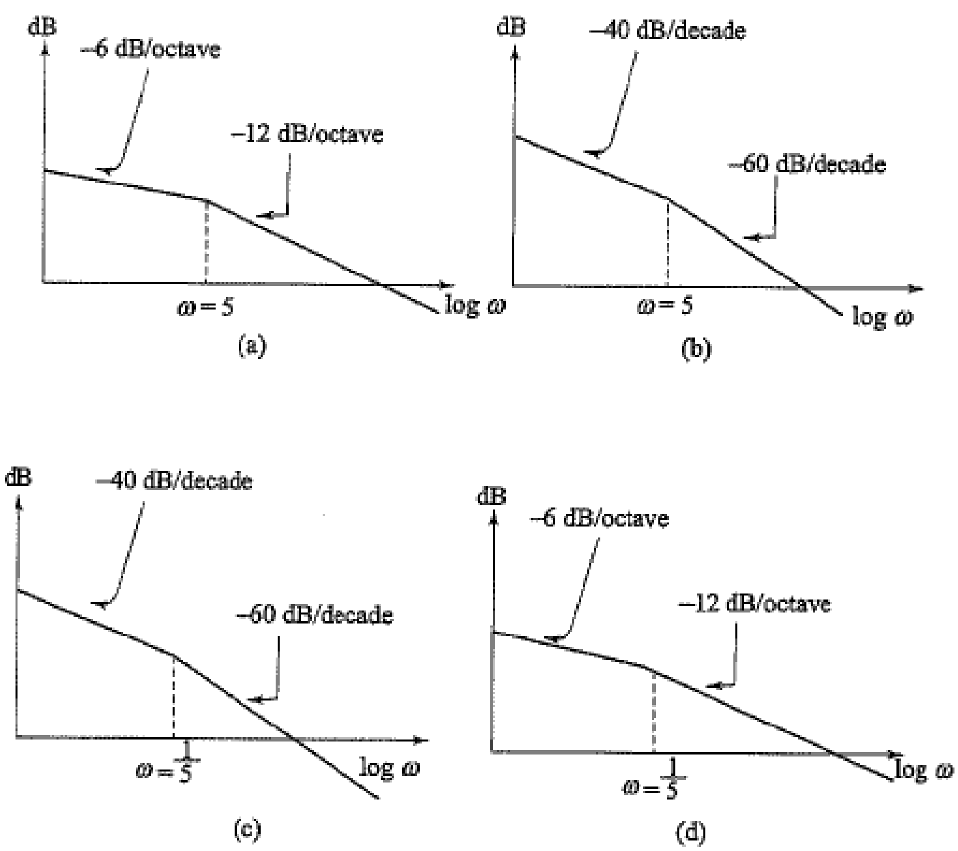
   The system output is zero at frequency:

   a. 0.5 rad/s   b. 1 rad/s   c. 2 rad/s   d. 4 rad/s

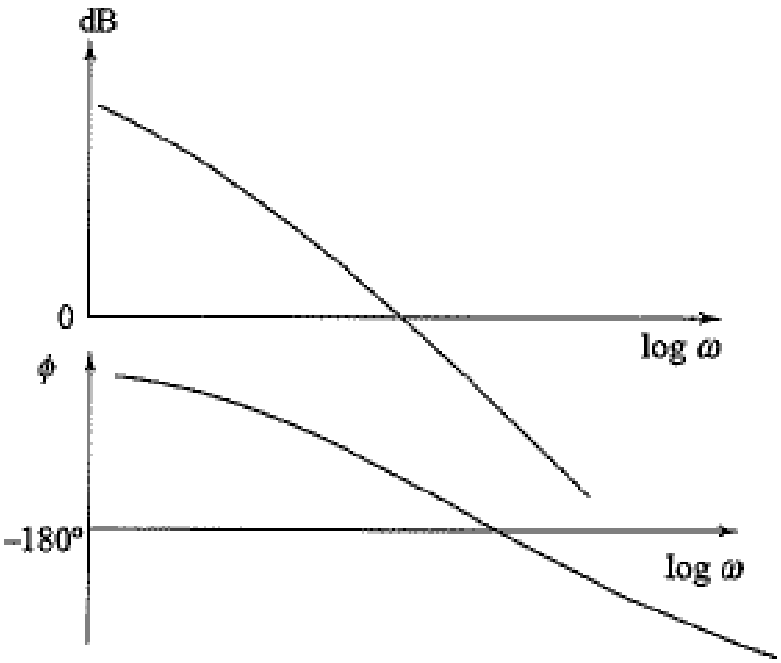
3. Which of the Bode asymptotic plots shown below is the correct plot for $G(s) = \frac{K}{s^2(s+5)}$?

   a. (a)   b. (b)   c. (c)   d. (d)

   (Hints: -6 dB/octave $\equiv -20$ dB/decade, and -12 dB/octave $\equiv -40$ dB/decade)



4. The figure below shows the Bode plot of the loop gain of a system. Which of the following statements is true concerning the system?



a. The gain and phase margins are both positive
b. The gain margin is negative but the phase margin is positive
c. The gain margin is positive but the phase margin is negative
d. The gain and phase margins are both negative

5. The feedback system whose loop gain Bode plot is shown in Question 4 is

a. stable
b. unstable

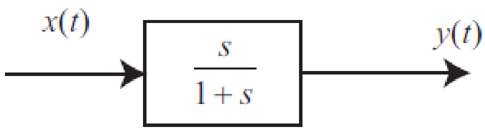
6. The response $c(t)$ of a system is described by the differential equation

$$\frac{d^2c(t)}{dt^2} + 4\frac{dc(t)}{dt} + 5c(t) = 0$$

The system response is

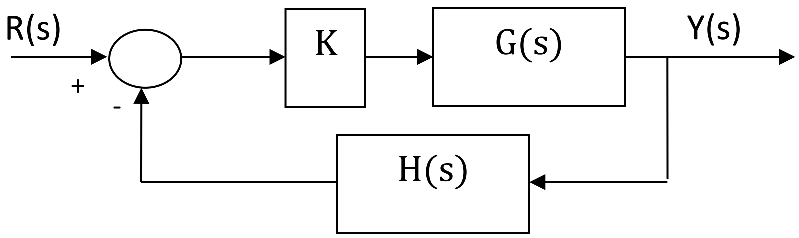
a. Undamped b. Underdamped c. Critically damped d. Overdamped

7. Consider the system shown below, where $x(t) = \sin t$.
   What will be the response $y(t)$ in the steady state?



a. $\sin(t - 45°)/\sqrt{2}$
b. $\sin(t + 45°)/\sqrt{2}$
c. $\sqrt{2}\sin(t + 45°)$
d. $\sin t - \cos t$

8. Referring to the figure below, the transfer function used for determining gain and phase margin from the Bode plot is:



a. $\frac{KG(s)}{1+KG(s)H(s)}$
b. $\mathrm{KG(s)}$
c. $1 + \mathrm{KG(s)H(s)}$
d. $\mathrm{G(s)H(s)}$
e. $\mathrm{KG(s)H(s)}$

9. To reduce the steady state error of a system the phase margin should be increased.
   a. TRUE
   b. FALSE

10. Increasing the loop bandwidth of a system decreases the rise time response to a step input.
    a. TRUE
    b. FALSE

11. Increasing the phase margin of a feedback system will reduce the overshoot in the step response.
    a. TRUE
    b. FALSE

12. It is desirable to increase the rate of drop of the loop gain for high frequencies far beyond the unity gain frequency.
    a. TRUE
    b. FALSE

13. Determine the system type number for a unity gain feedback system with closed loop transfer function, $M(s) = \frac{4}{s^2+3s+1}$.

a. 0
b. 1
c. 2
d. 3
e. 4

14. Determine the system type number for a feedback system with closed loop transfer function, $M(s) = \frac{4}{s^2+3s+1}$ (this system has a feedback gain, $H(s) = \frac{2}{3s+4}$).

a. 0
b. 1
c. 2
d. 3
e. 4

15. This and the following question refer to a feedback system with forward path gain, $G(s) = \frac{4}{s(s+2)}$, and feedback gain, $H(s) = 1/2$. The steady state error to a unit step is

a. 0
b. 2
c. 4
d. ∞

16. For the system of the previous question, the steady state error to a unit ramp is

a. 0
b. 0.5
c. 1
d. 2
e. ∞

Questions (17) to (21) consider the transfer function $T(s)$, given below. Using asymptotic straight-line approximations determine answers to following questions.
Hint: First sketch the Bode asymptotic magnitude plot before attempting to answer the questions.

$$T(s) = A\frac{1+\frac{s}{\omega_z}}{\left(\frac{s}{\omega_p}\right)^2+\left(\frac{s}{Q\omega_p}\right)+1},$$

where $A = 10$, $\omega_z = 100\ rad/s$, $\omega_p = 1{,}000\ rad/s$, $Q = 2$

17. For $\omega < \omega_z$, $|T(j\,\omega)|$ is given by:
    a. $\frac{10}{\omega}$
    b. 10
    c. 100
    d. $\frac{\omega}{10}$
    e. $\frac{\omega}{100}$

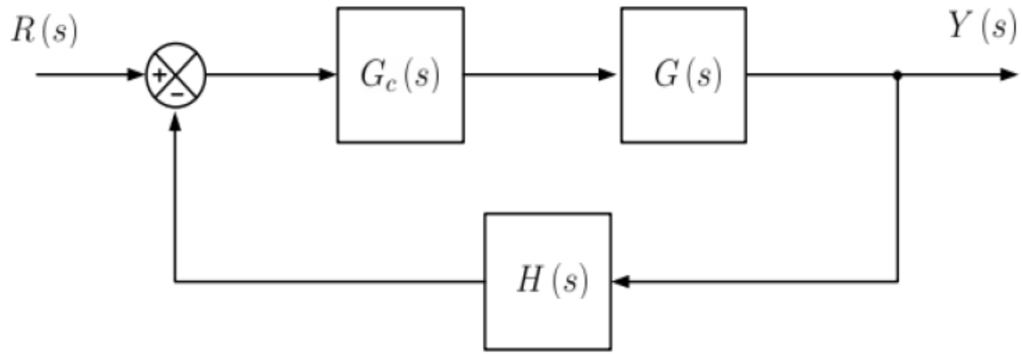
18. For $\omega_z < \omega < \omega_p$, $|T(j\,\omega)|$ is given by:
    a. $\frac{10}{\omega}$
    b. 10
    c. 100
    d. $\frac{\omega}{10}$
    e. $\frac{\omega}{100}$

19. For $\omega > \omega_p$, $|T(j\,\omega)|$ is given by:
    a. $\frac{1{,}000}{\omega}$
    b. $\frac{1{,}000}{\omega^2}$
    c. $\frac{100{,}000}{\omega}$
    d. $\frac{100{,}000}{\omega^2}$
    e. $\frac{10{,}000}{\omega^2}$

20. The frequency where the gain = 5 is
    a. 2,000 rad/s
    b. 20,000 rad/s
    c. 200,000 rad/s
    d. 500,000 rad/s
    e. 1,000,000 rad/s

21. The (absolute value of) the maximum magnitude over all frequencies is
    a. 100
    b. 200
    c. 400
    d. 800
    e. 1,000

Questions (22) to (29) consider the following system:



where the plant $G(s) = \frac{G_o}{1+\frac{s}{\omega_o}}$, where $G_o = 50,\ \omega_o = 200$ rad/s

and $H(s) = 1$. Transfer function $G_c(s)$ represents the compensator.

22. The uncompensated loop gain (i.e. when $G_c(s) = 1$) has a unity gain frequency closest to
    a. 200 rad/s
    b. 1 krad/s
    c. 5 krad/s
    d. 10 krad/s
    e. 20 krad/s

23. We would like to design a proportional compensator, such that $G_c(s) = K_p$, where gain K_p is to be determined. What should K_p be to achieve a unity gain bandwidth of 5 krad/s?

    a. $K_p = 0.25$
    b. $K_p = 0.50$
    c. $K_p = 0.75$
    d. $K_p = 1.00$
    e. $K_p = 1.25$

24. The phase margin achieved by the proportional compensator design of the previous question is closest to:

    a. 30°
    b. 50°
    c. 70°
    d. 90°
    e. 110°

25. The steady state error to a unit step for the proportional compensated system is closest to:

   a. 0
   b. 1/6
   c. 1/26
   d. 1/51
   e. ∞

26. We next consider the alternative design of an integral compensator, such that $G_c(s) = \frac{K_i}{s}$, where gain K_i is to be determined. What should K_i be to achieve a phase margin of 45°?
   Choose the closest answer.

   [Hint: in order to choose the correct answer from those given below it is necessary to account for the approximation inherent in the asymptotic Bode plots. Further hint: $-3\ dB$ => 0.7 .]

   a. 3
   b. 4
   c. 5
   d. 6
   e. 7

27. The system type number of the integral compensated system is

   a. -1
   b. 0
   c. 1
   d. 2
   e. ∞

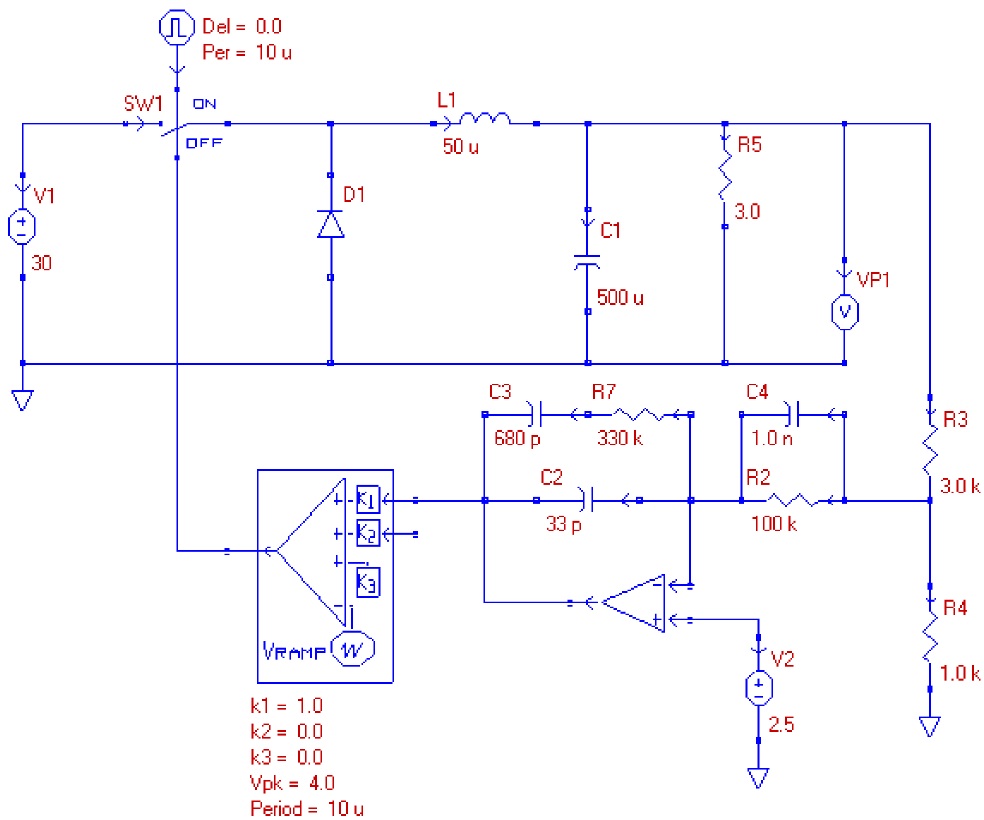
28. The steady state error of the integral compensated system to a unit step input is

   a. 0
   b. a constant $\neq 0$
   c. ∞

29. Comparing the two different compensator designs undertaken above, which will have the quicker response to a step input, as measured by the rise time.

   a. proportional compensated system
   b. integral compensated system

30. For the Buck converter circuit shown below, assuming a stable system, determine the steady state output voltage as seen across VP1.



a. 5 V
b. 10 V
c. 15 V
d. 20 V
e. 25 V