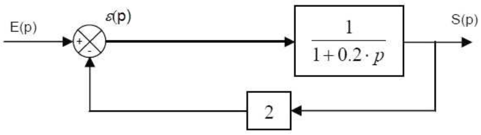
Representation and Analysis of Dynamical Systems

Test – 40min – without documentation

Marking scale: true:$+1$; false or no response: -0.5 : I don't know: 0

$u(t)$ is a unitary step input	1. The Laplace transform $U(s)$ of $u(t)$ is: ☐ $U(s) = 1$ ■ $U(s) = 1/s$ ☐ I do not know
The Laplace transform of a signal $u(t)$ is: $U(s) = \frac{2}{1+2s}$ Error: the solution is: $u(t) = \exp(-t/2)$	2. The final value (at $t = \infty$) of $u(t)$ is: ☐ $u(\infty) = 2$ ■ $u(\infty) = 0$ 3. Assuming $u(0) = 0$, $u(t)$ is: ☐ $u(t) = 2\exp(-t/2)$ ☐ $u(t) = 2\exp(t/2)$ ☐ $u(t) = 2\,(1 - \exp(-t/2))$ ☐ I don't know
Two signals $u(t)$ and $v(t)$ have respective Laplace transforms $U(s)$ and $V(s)$	4. $w(t) = u(t) + v(t)$ has Laplace transform $W(s) = U(s) + V(s)$ ■ Yes ☐ No 5. $w(t) = u(t) \times v(t)$ has Laplace transform $W(s) = U(s) \times V(s)$ ☐ Yes ■ No
Consider the transfer function of a system: $$H(s) = \frac{8}{2+5s}$$	6.The static gain of the system is 8: ☐ Yes ■ No ☐ I do not know 7.The system time constant is 5/2 ■ Yes ☐ No ☐ I do not know
The Laplace transform of differential equation $$6y''(t) + 3y'(t) + 2y(t) - \partial(t) = 0$$ with $\partial(t)$ unit impulse and initial conditions: $$y(0) = -1 \; and \; y'(0) = 2$$ is:	8. ☐ $Y(s) = \frac{1}{6s^2+3s-2}$ ☐ $Y(s) = \frac{6s-8}{6s^2+3s+2}$ ■ $Y(s) = \frac{10-6s}{6s^2+3s+2}$ ☐ I don't know

Consider the closed-loop system:



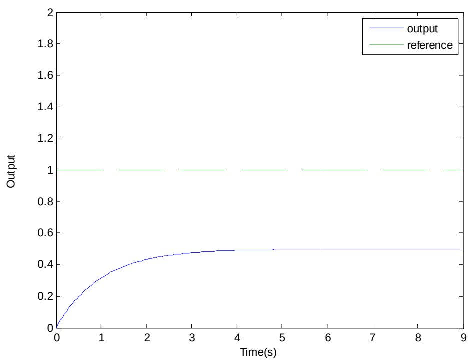
9. The transfer function of $\frac{S(s)}{E(s)}$ is:

- [ ] $\frac{2}{1+0.2s}$
- [ ] $\frac{1+0.2s}{3+0.2s}$
- [x] $\frac{1}{3+0.2s}$
- [ ] I do not know

10. The transfer function of $\frac{\varepsilon(s)}{E(s)}$ is:

- [ ] $\frac{2}{1+0.2s}$
- [x] $\frac{1+0.2s}{3+0.2s}$
- [ ] $\frac{1}{3+0.2s}$
- [ ] I do not know

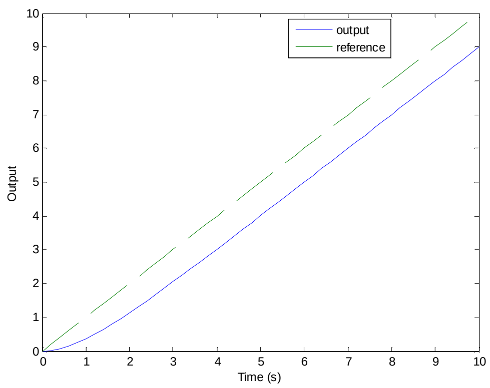
The following figure plots the step response of a system. (Broken line is the unitary step input, continuous line is the output)



11. The system has a gain:

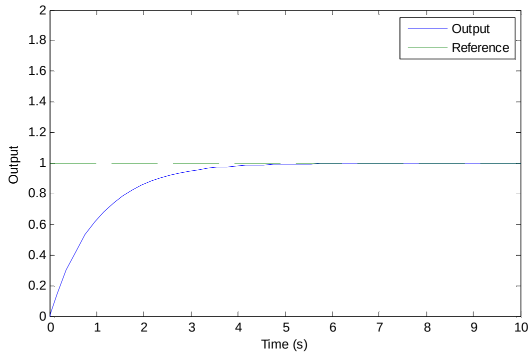
- [ ] equal to 1
- [x] inferior to 1
- [ ] superior to 1

The following figure plots the ramp response of a system. (Broken line is the ramp input, continuous line is the output)

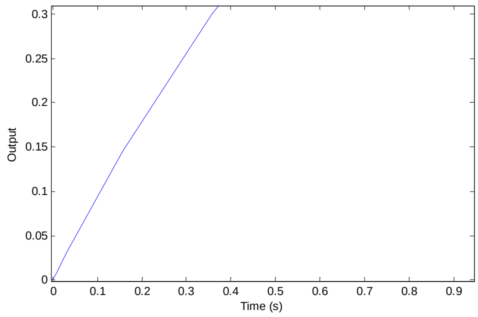


12. The system has a gain:

- [x] equal to 1
- [ ] inferior to 1
- [ ] superior to 1
- [ ] I do not know



Time response between 0 and 10s



Time response zoomed between 0s and 1s

13. The step response is the response of a first order system:

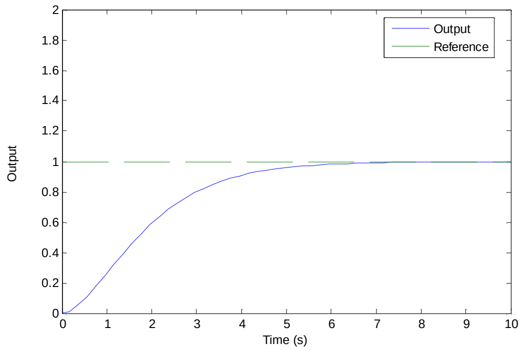
■ Yes
□ No
□ I do not know

14. The step response is the response of a second order system:

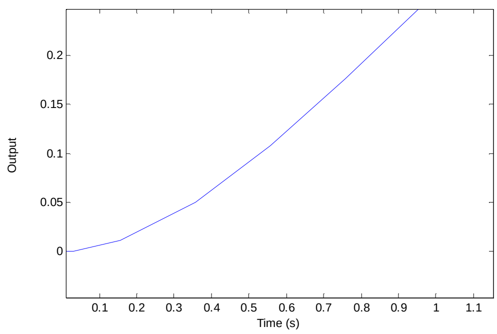
□ Yes
■ No
□ I do not know

15. (if your answer at question 14 is yes) the damping ratio is:

□ equal or superior to 1
□ inferior to 1
□ I do not know



Time response between 0 and 10s



Time response zoomed between 0 and 1s

16. The step response is the response of a first order system:

□ Yes
■ No
□ I do not know

17. The step response is the response of a second order system:

■ Yes
□ No
□ I do not know

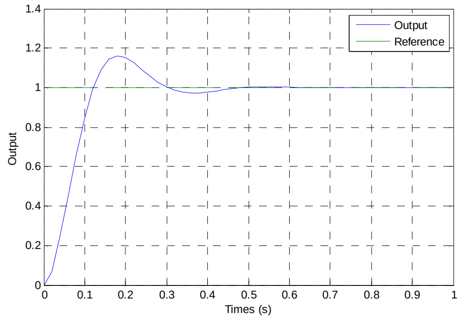
18. (if your answer at question 17 is yes) the damping ratio is:

■ equal or superior to 1
□ inferior to 1
□ I do not know

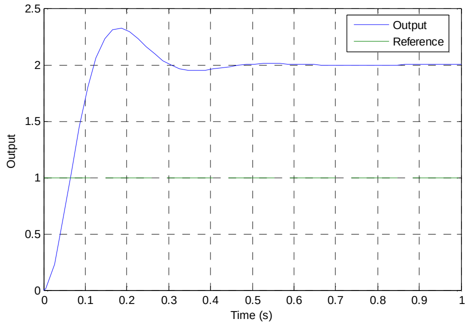
Consider the transfer function:

$$H(s) = \frac{800}{s^2 + 20s + 400}$$

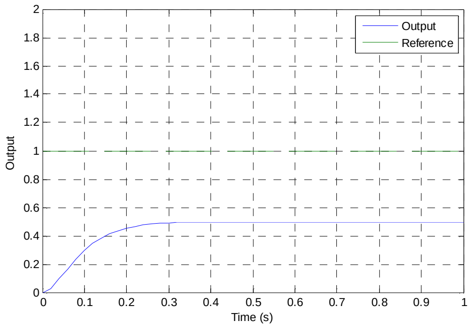
and the step responses below:



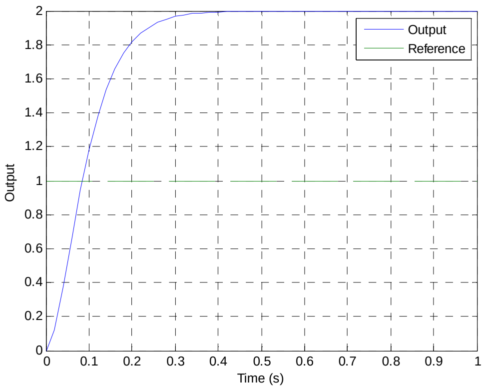
(A)



(B)



(C)



(D)

19. The step response corresponding to the transfer function is:

- [ ] A
- [x] B
- [ ] C
- [ ] D
- [ ] I do not know

Consider the transfer function of a system:

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

20. The system is stable

■ Yes
☐ No

Consider the transfer function of a system:

$$H(p) = \frac{1}{p^2 - p + 4}$$

21. The system is stable

☐ Yes
■ No

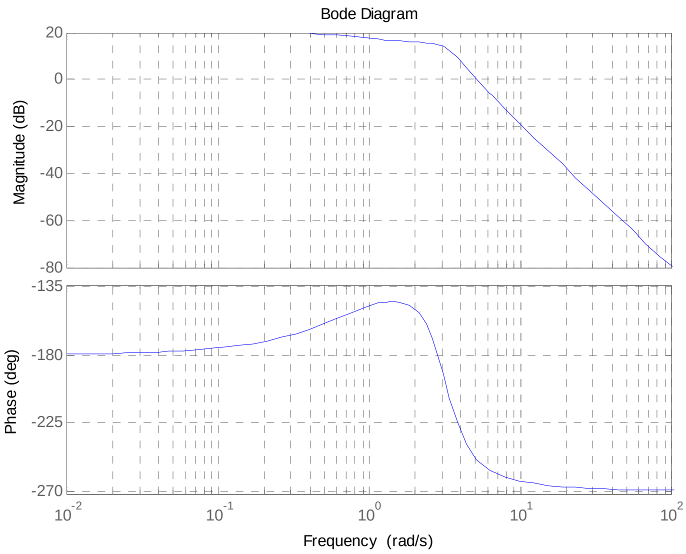
Consider the transfer function of a system:

$$H(p) = \frac{1}{(p-1)(p^2 + p + 4)}$$

22. The system is stable

☐ Yes
■ No

Consider the bode diagram of an open-loop system below:



23. This system in closed-loop with unitary feedback is stable:

☐ Yes
■ No
☐ I do not know

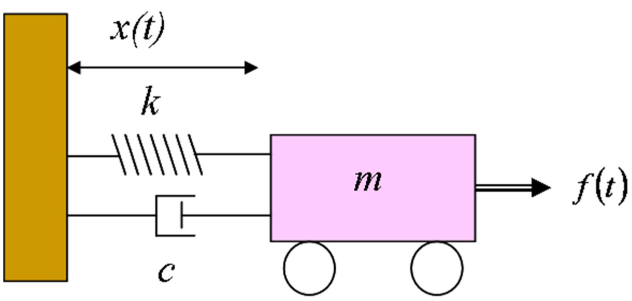
Static error:
the step response of the plant whose open loop transfer function is:

$$H(s) = \frac{100}{s^2 + 4s}$$

has a null closed loop static error.

24.

■ Yes
☐ No
☐ I do not know



25. The potential energy is

■ $E_p = \frac{1}{2}kx^2$

☐ $E_p = \frac{1}{2}m\dot{x}^2$

☐ $E_p = 0$

☐ I do not know

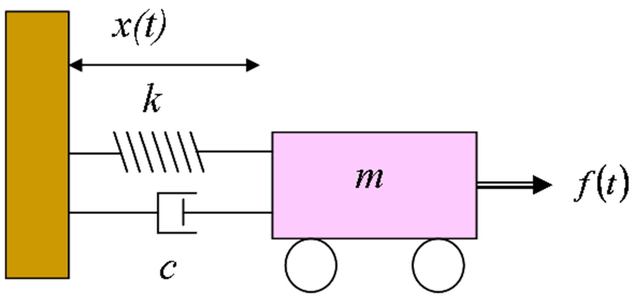
State Space representation

Consider the differential equation that characterizes a mechanical system with a mass *M*, a damper of constant *C* and a stiffness *K*:

$m\ddot{x} + c\dot{x} + kx = F$,

F being the force applied to the system.

The output of the system is the displacement x.



26. A possible representation of the mechanical system is:

☐

$$X = [x \quad \dot{x}]^t$$
$$\dot{X} = \begin{bmatrix} 0 & 1 \\ \frac{k}{m} & \frac{c}{m} \end{bmatrix} X + \begin{bmatrix} 0 \\ \frac{1}{m} \end{bmatrix} F$$
$$Y = [1 \quad 0]X$$

■

$$X = [x \quad \dot{x}]^t$$
$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -\frac{k}{m} & -\frac{c}{m} \end{bmatrix} X + \begin{bmatrix} 0 \\ \frac{1}{m} \end{bmatrix} F$$
$$Y = [1 \quad 0]X$$

☐

$$X = [x \quad \dot{x}]^t$$
$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -\frac{c}{m} & -\frac{k}{m} \end{bmatrix} X + \begin{bmatrix} 0 \\ \frac{1}{m} \end{bmatrix} F$$
$$Y = [1 \quad 0]X$$

☐ I do not know