School of Engineering and Applied Science (SEAS), Ahmedabad University

Name: _____ Roll no.: _____

BTech: Mid Semester Examination: Winter 2024
MEC300 Control Engineering Theory and Applications
Marks: 20 Date: 24 February 2024 Time: 2 hours

Obtained Marks:

Q1 = /06	Q2 = /03	Q3 = /05	Q4 = /06	Total = /20

Instructions:

1. **There are four questions. All questions are compulsory.**
2. **Write answers in the space provided in this paper only.**
3. **Write important steps and answers in this paper.**
4. **Only this paper will be considered for evaluation. Don't write elsewhere.**
5. **Figures to the right indicate full marks; all acronyms carry their usual meaning.**
7. **Assume suitable data wherever necessary and specify it clearly in your answers.**
8. **Table of Laplace transforms is given on the last page for your reference.**

Answer the following four questions

Q-1: Evaluate. First state if the information is true/false; then explain why. (06 marks)

(1a): The impedance value of a spring is equal to its spring constant, while the impedance value of a mass is not equal to its mass value. (02 marks)

Answer:

(1b): A system has a transfer function whose pole is at $s = (-1)$. When unit impulse input is applied, the order of denominator of the system response in the Laplace domain is one. However, when input is a unit ramp, the order of the denominator of the system response in the Laplace domain is three. (02 marks)

Answer:

1c): A system **S1** has a pole at $s = (-4.0)$ and another system **S2** has a pole at $s = (-4.4)$. Therefore, system **S2** is slower than system **S1**. (02 marks)

Q-2: Write the equation of motion for the system shown in **Figure 1**. The values of masses, spring constants and damping constants are given. Consider the given values when you write down the equation of motion. (03 marks)

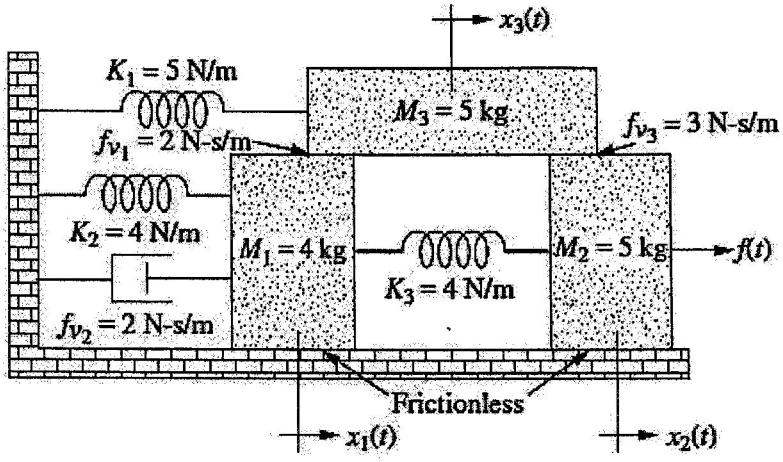


Figure 1: Translational system for Q-2

Answer:

Q-3: Find transfer function

$$G(s) = \frac{\theta_2(s)}{T(s)}$$

for the rotational system shown in **Figure 2**. The values of inertia, spring constants, and damping coefficients are given. Please consider the given values when you derive the transfer function.

(05 marks)

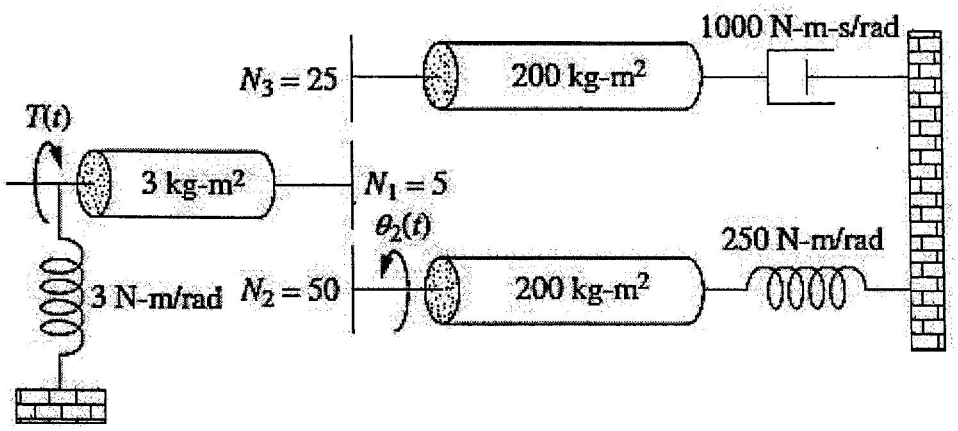
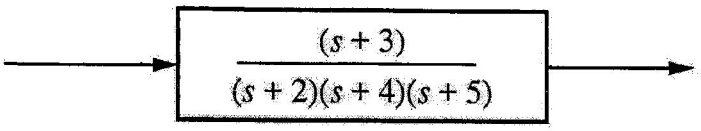


Figure 2: Rotational system for Q-3

Answer:

Continue answer of **Q-3:**

Q-4: Find the response of a system with the transfer function given below, when a unit step input is applied. Write the system response in the time domain. Comment on each term of the system response if it belongs to forced response or natural response with an explanation.



(06 marks)

Answer:

Table of Laplace Transform

$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$	$f(t)=\mathcal{L}^{-1}\{F(s)\}$	$F(s)=\mathcal{L}\{f(t)\}$
1. 1	$\frac{1}{s}$	2. e^{at}	$\frac{1}{s-a}$
3. $t^n,\ n=1,2,3,\ldots$	$\frac{n!}{s^{n+1}}$	4. $t^p,\ p>-1$	$\frac{\Gamma(p+1)}{s^{p+1}}$
5. $\sqrt{t}$	$\frac{\sqrt{\pi}}{2s^{\frac{3}{2}}}$	6. $t^{n-\frac{1}{2}},\ n=1,2,3,\ldots$	$\frac{1\cdot3\cdot5\cdots(2n-1)\sqrt{\pi}}{2^n s^{n+\frac{1}{2}}}$
7. $\sin(at)$	$\frac{a}{s^2+a^2}$	8. $\cos(at)$	$\frac{s}{s^2+a^2}$
9. $t\sin(at)$	$\frac{2as}{(s^2+a^2)^2}$	10. $t\cos(at)$	$\frac{s^2-a^2}{(s^2+a^2)^2}$
11. $\sin(at)-at\cos(at)$	$\frac{2a^3}{(s^2+a^2)^2}$	12. $\sin(at)+at\cos(at)$	$\frac{2as^2}{(s^2+a^2)^2}$
13. $\cos(at)-at\sin(at)$	$\frac{s(s^2-a^2)}{(s^2+a^2)^2}$	14. $\cos(at)+at\sin(at)$	$\frac{s(s^2+3a^2)}{(s^2+a^2)^2}$
15. $\sin(at+b)$	$\frac{s\sin(b)+a\cos(b)}{s^2+a^2}$	16. $\cos(at+b)$	$\frac{s\cos(b)-a\sin(b)}{s^2+a^2}$
17. $\sinh(at)$	$\frac{a}{s^2-a^2}$	18. $\cosh(at)$	$\frac{s}{s^2-a^2}$
19. $e^{at}\sin(bt)$	$\frac{b}{(s-a)^2+b^2}$	20. $e^{at}\cos(bt)$	$\frac{s-a}{(s-a)^2+b^2}$
21. $e^{at}\sinh(bt)$	$\frac{b}{(s-a)^2-b^2}$	22. $e^{at}\cosh(bt)$	$\frac{s-a}{(s-a)^2-b^2}$
23. $t^n e^{at},\ n=1,2,3,\ldots$	$\frac{n!}{(s-a)^{n+1}}$	24. $f(ct)$	$\frac{1}{c}F\left(\frac{s}{c}\right)$
25. $u_c(t)=u(t-c)$	$\frac{e^{-cs}}{s}$	26. $\delta(t-c)$	e^{-cs}
27. $u_c(t)f(t-c)$	$e^{-cs}F(s)$	28. $u_c(t)g(t)$	$e^{-cs}\mathcal{L}\{g(t+c)\}$
29. $e^{ct}f(t)$	$F(s-c)$	30. $t^n f(t),\ n=1,2,3,\ldots$	$(-1)^n F^{(n)}(s)$
31. $\frac{1}{t}f(t)$	$\int_s^\infty F(u)\,du$	32. $\int_0^t f(v)\,dv$	$\frac{F(s)}{s}$
33. $\int_0^t f(t-\tau)g(\tau)\,d\tau$	$F(s)G(s)$	34. $f(t+T)=f(t)$	$\frac{\int_0^T e^{-st}f(t)\,dt}{1-e^{-sT}}$
35. $f'(t)$	$sF(s)-f(0)$	36. $f''(t)$	$s^2F(s)-sf(0)-f'(0)$
37. $f^{(n)}(t)$	$s^nF(s)-s^{n-1}f(0)-s^{n-2}f'(0)\cdots-sf^{(n-2)}(0)-f^{(n-1)}(0)$		