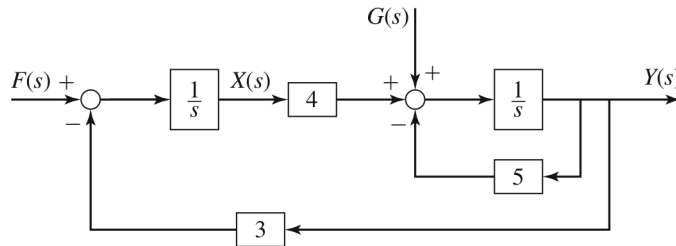


System Dynamics Exam 2

Fall 2013

The FE reference book, calculator, and 1 formula sheet may be used during this exam. Exam books provided. 10 points each.

- Find $\frac{Y(s)}{F(s)}$ and $\frac{X(s)}{G(s)}$ for the system shown below.



- Write the state space equation matrices A , B , C , and D for the following systems:

- $x_1 - 5u$ and x_2 are the outputs:

$$\begin{aligned}\dot{x}_1 &= -5x_1 + 3x_2 \\ \dot{x}_2 &= x_1 - 4x_2 + 5u\end{aligned}$$

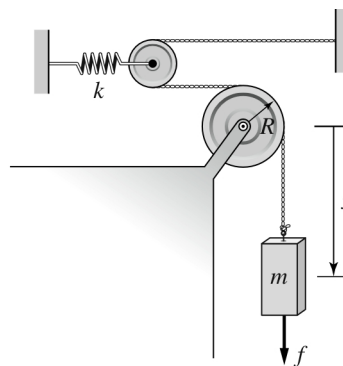
- \dot{y} is the output:

$$2\frac{d^3y}{dt^3} + 5\frac{d^2y}{dt^2} + 4\frac{dy}{dt} + 7y = f(t)$$

- $y(t)$ and $\dot{y}(t)$ are the outputs:

$$\frac{Y(s)}{F(s)} = \frac{6}{3s^3 + 63 + 10}$$

- Derive the governing equation or equations for the system shown below. Treat the pulleys as uniform disks. The mass of the top pulley is $\frac{1}{2}m$ and it has a radius of $R/2$. The mass of the second pulley is m (the same as the mass of the weight at the bottom). Of course, include the effect of gravity using g as the gravitational constant.



BONUS (2 points):

- For students not working for BWI only: What property of magneto-rheological fluids does BWI take advantage of in their suspension control products?
- For students working for BWI: What advantage does the dual coil system provide over the previous single coil system and why?

Table 2.2.1 Table of Laplace transform pairs.

$X(s)$	$x(t), t \geq 0$
1. 1	$\delta(t)$, unit impulse
2. $\frac{1}{s}$	$u_s(t)$, unit step
3. $\frac{c}{s}$	constant, c
4. $\frac{e^{-sD}}{s}$	$u_s(t - D)$, shifted unit step
5. $\frac{n!}{s^{n+1}}$	t^n
6. $\frac{1}{s + a}$	e^{-at}
7. $\frac{1}{(s + a)^n}$	$\frac{1}{(n - 1)!} t^{n-1} e^{-at}$
8. $\frac{b}{s^2 + b^2}$	$\sin bt$
9. $\frac{s}{s^2 + b^2}$	$\cos bt$
10. $\frac{b}{(s + a)^2 + b^2}$	$e^{-at} \sin bt$
11. $\frac{s + a}{(s + a)^2 + b^2}$	$e^{-at} \cos bt$
12. $\frac{a}{s(s + a)}$	$1 - e^{-at}$
13. $\frac{1}{(s + a)(s + b)}$	$\frac{1}{b - a} (e^{-at} - e^{-bt})$
14. $\frac{s + p}{(s + a)(s + b)}$	$\frac{1}{b - a} [(p - a)e^{-at} - (p - b)e^{-bt}]$
15. $\frac{1}{(s + a)(s + b)(s + c)}$	$\frac{e^{-at}}{(b - a)(c - a)} + \frac{e^{-bt}}{(c - b)(a - b)} + \frac{e^{-ct}}{(a - c)(b - c)}$
16. $\frac{s + p}{(s + a)(s + b)(s + c)}$	$\frac{(p - a)e^{-at}}{(b - a)(c - a)} + \frac{(p - b)e^{-bt}}{(c - b)(a - b)} + \frac{(p - c)e^{-ct}}{(a - c)(b - c)}$