UNIVERSITY OF CALIFORNIA AT BERKELEY

DEPARTMENT OF MECHANICAL ENGINEERING

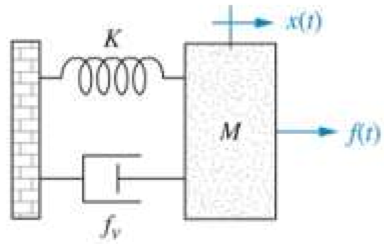
ME132 DYNAMICS SYSTEMS AND FEEDBACK

FINAL SUMMER 2019

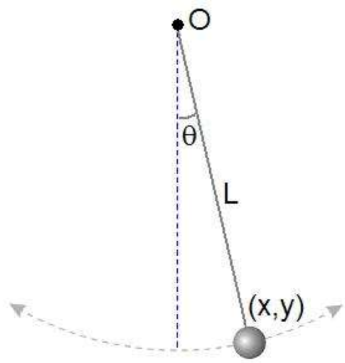
YOUR NAME:

PROBLEM	1	2	3	4	5	TOTAL
MAX GRADE	20	15	40	30	15	120
YOUR GRADE						

1. (20) a) (5) Derive the transfer function for the system below for x(s)/f(s).



b) (5) Evaluate the final value of X(t) to an initial condition of X_o



c) (5) Derive the transfer function $\frac{\theta(s)}{\theta_0}$ for the pendulum above, where θ_0 is a non-zero initial angle of the pendulum.

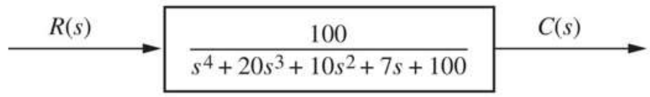
d) (5) Under what conditions are the transfer functions in (a) and (c) equivalent.

2. (15) Please represent each system in State-Space:

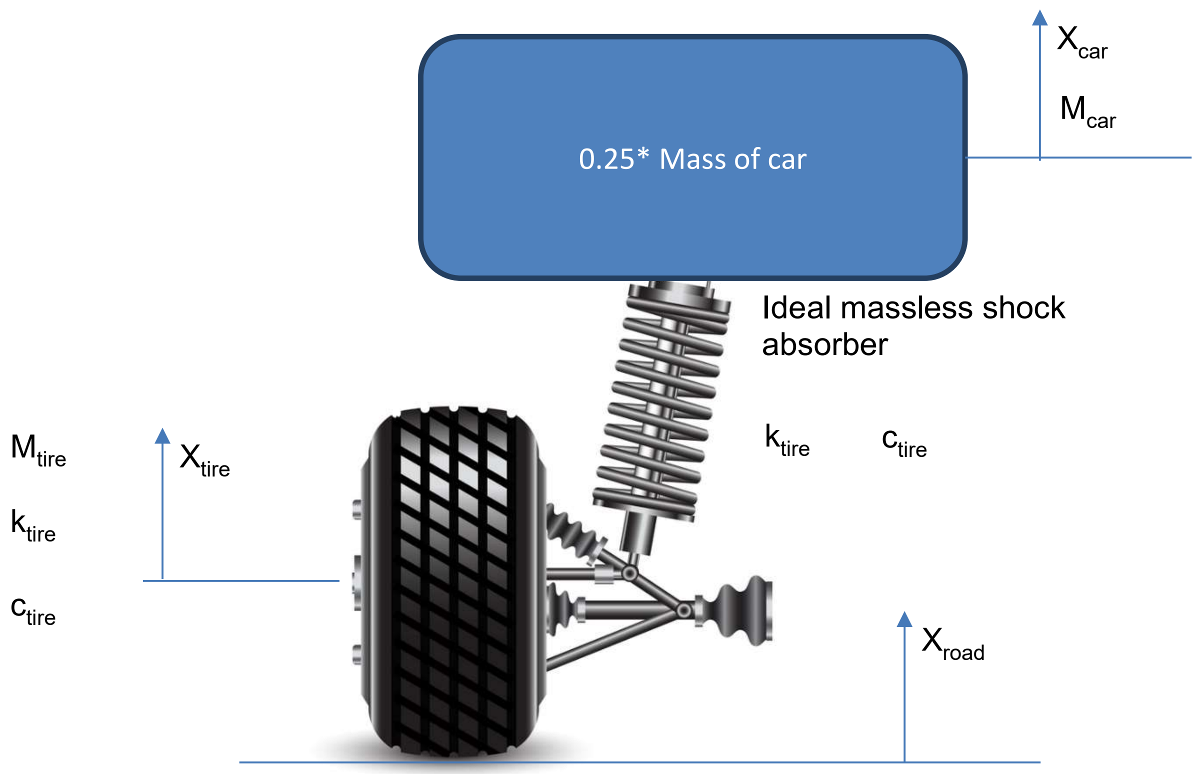
a. (5) $u(t) = a\,\ddot{y}\,(t) - b\,\dot{y}(t) + cy(t)$

b. (5) $\ddot{y}^2(t) + 2\ddot{y}(t)y(t) + y^2(t) = \big(2u(t)\big)(\ddot{y}(t) + y(t)\,)$ for $u(t) = \sin\omega t$.

c. (5)



3. (40) a) (15) Consider the diagram shown below. Find the State Space representation where the input is X_{road}. Assume the shock absorber to be perfectly vertical and all forces are in line with the center of gravity of each mass.



b) (5) Assuming the mass of the car is infinite, reduce the model to a 2^{nd} order system. Derive the State Space model for the new 2^{nd} order system

c) (10) You are now in charge of designing the next generation electronic suspension system, eliminating the shock absorber. Being able to measure the vertical position of the wheel relative to the car mass, and its velocity. Show you can achieve the role of the shock absorber using PD control and a force actuator. (Assume the mass of the car is infinite)

d) (5) Design a controller to have a damping of $\xi = 0.707$ and a settling time of 5 seconds.

e) (5) What is the percent overshoot for your design? And would you buy the car?

4. (30)
    a. (10) Develop the linear model of a just a simple pendulum (vertically down) of length L and mass M with an ideal linear torsional spring K at the pivot joint of the pendulum.

b. (5) Draw the root locus of the system for K. (You may assume unity for all other parameters)

c. (5) Describe the stability of the system in terms of the value K

d. (5) Draw the block diagram of the system in terms of L.

e. (5) Draw the root locus of the system for the pendulum as you vary L. (Again, you may assume unity for all parameters)

5. (15) Given the following transfer function:

$$\frac{C(s)}{R(s)} = \frac{(s+a)(s^2+bs+c)}{(s+d)(s+e)(s^2+fs+g)}$$

a. (5) Under what condition(s) will the transfer function always respond as a 1st order system

b. (5) Under what condition can you consider the system to response approximately as a 1st order system

c. (5) Under what condition will the response of the system to R(s) be always k*R(s) , k being an arbitrary non-zero constant scaling factor, as t -> ∞ while maintaining the same order of magnitude of the original transfer function.