Exam Number: ________________

Department of Mechanical Engineering

Michigan State University

Ph.D. Qualifying Examination
January 2009
Dynamic Systems and Control

Open Book
Answer All Questions
All Questions Weighted Equally

Exam Prepared by

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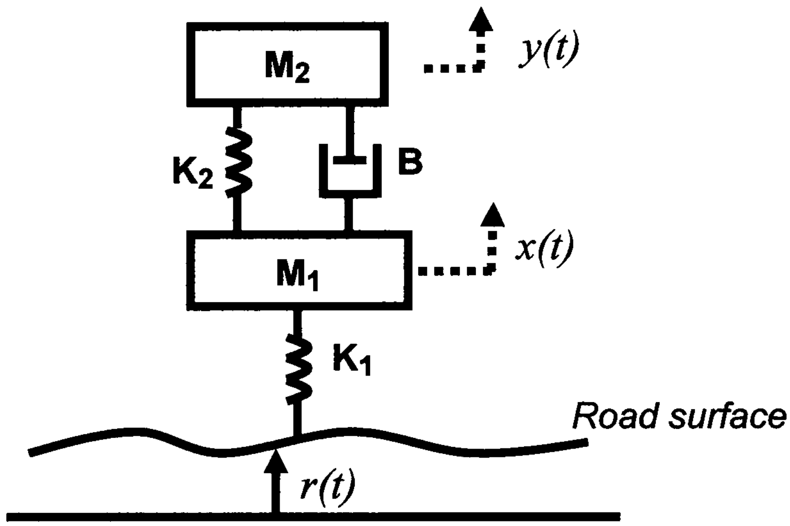
(revised 12-17-08)

1) Obtain the transfer function from *R(s)* to *Y(s)* where *R(s)* is the Laplace Transform of *r(t)* and *Y(s)* is the Laplace Transform of *y(t)*.



2) The dynamics of a system are governed by the ordinary differential equation

$$\ddot{y}(t) + 2y(t) + \dot{y}^2(t) + \sin(y(t)) = \sqrt{u(t)}$$

which may also be written in the form

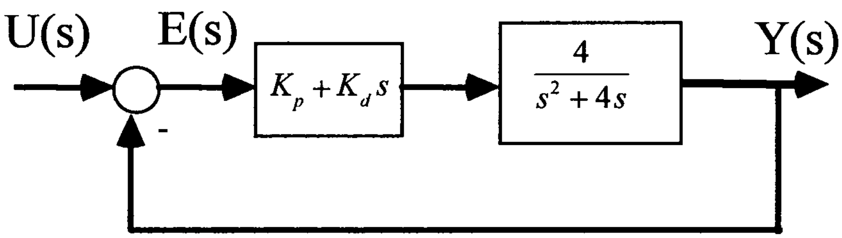
$$\ddot{y}(t) = f(u, y, \dot{y})$$

a) Let $v(t) = u(t) - u_0(t)$ and $x(t) = y(t) - y_0(t)$ and determine the linearized differential equation relating $v(t)$ to $x(t)$ for the equilibrium operating point at $y_0(t) = \pi/4$. Write the final solution in the box provided.

b) Determine the steady state response $x_{ss}(t)$ of the linearized system found above to the excitation $v(t) = 0.1$

$x_{ss}(t) =$

3) You are to design a Proportional + Derivative controller for the system shown below.



a) Determine the range of gains K_p and K_d that will lead to a stable closed-loop system.

$< K_d <$
$< K_p <$

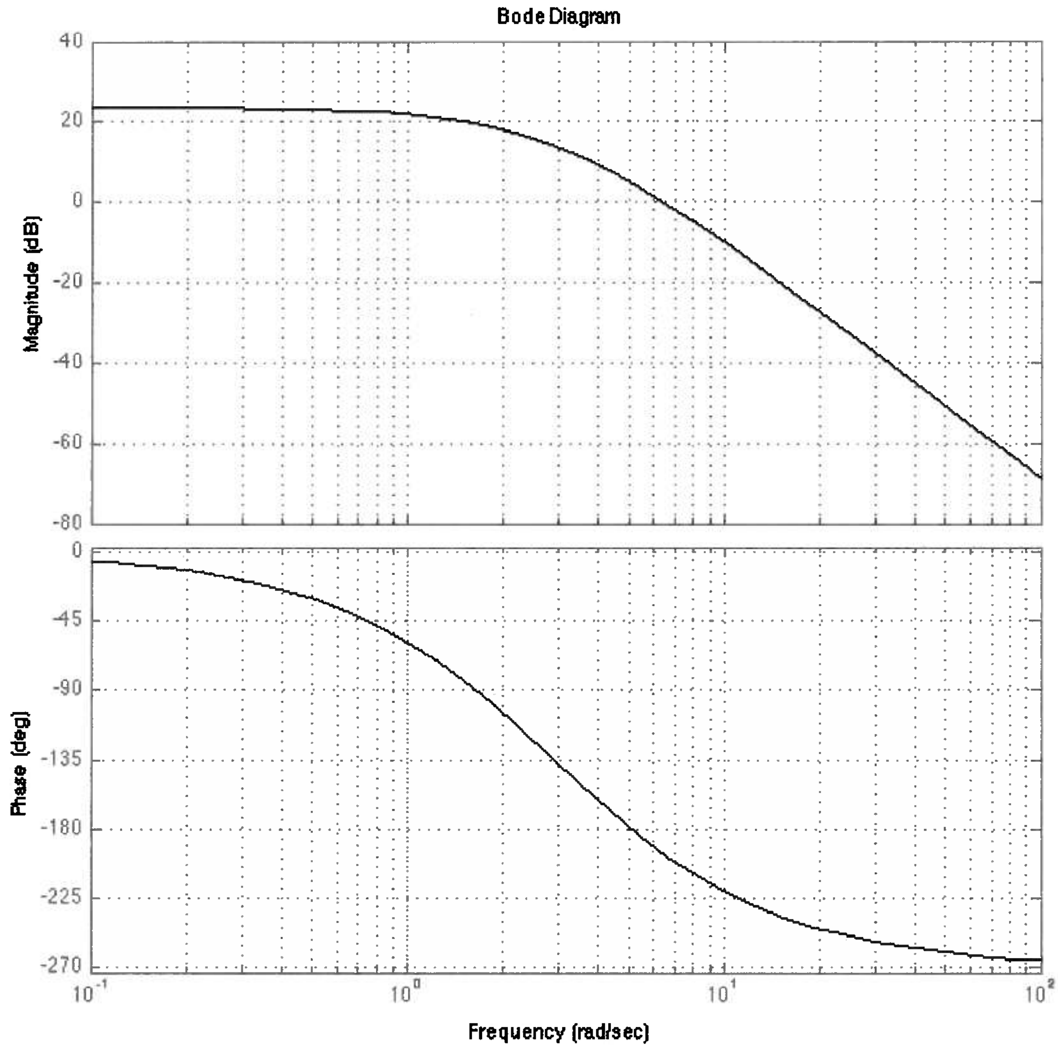
b) Determine the values of K_p and K_d that will result in the closed loop system having 70% critical damping and a natural frequency of 5 rad/sec.

$K_P =$
$K_d =$

c) At the gains you supplied in part b), what is the steady state error for a unit step input to this system?

$e_{ss} =$

4) Shown below is the Bode diagram of an uncompensated industrial process that is open-loop stable.



4a) Determine the "best" (widest bandwidth) Proportional feedback control system that will yield a phase margin of at least 80 degrees and a gain margin of at least 10 dB.

$K_p =$

b) If you were to augment the control designed in part A with either "integral" or "derivative" control action, which would you choose and why? Be specific, choose control action and show the analysis that justifies you choice.