1. (7 pts)

For the vehicle active suspension system with block diagram shown at right, find the transfer function from $D(s)$ to $Y(s)$, and then determine the values of constants $K_1$ and $K_2$ such that the vehicle does not bounce, i.e. $Y(s) = 0$, when it encounters a bump of $D(s)$ and the desired deflection $R(s) = 0$. 

![Block diagram of vehicle active suspension system]

- **Bump disturbance**
- **Vehicle dynamics**
- **Desired deflection**
- **Bounce of auto or deflection from horizontal**
2. (10 pts)
For the ball-suspension control system shown at right, the differential equation governing the mechanical dynamics is

\[ M \frac{d^2 y(t)}{dt^2} = Mg - K \frac{r^2(t)}{y(t)} \]

where \( M \), \( g \), and \( K \) are constants.

(a) Given that the voltage drop across the inductor is \( \frac{d}{dt} \left( \frac{L}{y(t)} \right) \), where \( L \) is a constant, what is the differential equation governing the electrical dynamics?

(b) Select a set of state variables, then write the \textit{nonlinear} state equations describing this system.
3. (8 pts) The Bode diagram below is of a dynamic system's loop transfer function \( L(s) = K L_0(s) \), with \( K = 10 \).

(i) What are the crossover frequencies and the gain margin and phase margin for this value of \( K \)?

(ii) Find the value of \( K \) to produce a gain margin of 10 dB, and sketch (and label) the resulting gain plot on the diagram.