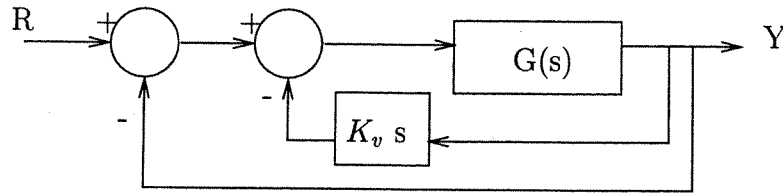


**National Exams - December 2003**  
**98-Elec-A2, Control**  
**3 hours duration**

**NOTES:**

1. If doubt exists as to interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
  2. Candidates may use one of two calculators, the Casio or Sharp approved models. This is a Closed Book examination. However, Candidates are permitted to bring a double-sided, 8.5 by 11 formula sheet.
  3. Any four questions constitutes a complete paper. Only the first four questions as they appear in your answer book will be marked.
  4. All questions are of equal value.
-



- (ii) To reduce the overshoot, velocity feedback is added, as shown in the diagram. Determine the gain  $K_v$  required to reduce the closed loop system response overshoot to a unit step input to 10%.
4. Consider the frequency response of a type-2 loop transfer function, shown on the following page:
- Find the gain and phase margin, and the corresponding cross-over frequencies.
  - Design and find the transfer function of a first-order lead or lag compensator to satisfy a phase margin  $> 40$  deg requirement.
5. The transfer function of a plant and sensor of a system are given by

$$G(s) = \frac{10}{s(s+1)}; H(s) = 0.5.$$

A PID controller is added to the system with transfer function

$$G_c(s) = \left( K_p + \frac{K_i}{s} + K_d s \right).$$

- Determine the gains  $K_p$ ,  $K_i$ , and  $K_d$  that provide the following performance characteristics of the closed loop system:
  - the fastest mode transient has time constant of 0.05 seconds,
  - the dominant modes have frequency of oscillation of 1.0 rad/sec., and time constant of 0.5 seconds.
- Find a dominant  $2^{nd}$  order model for the closed loop system.

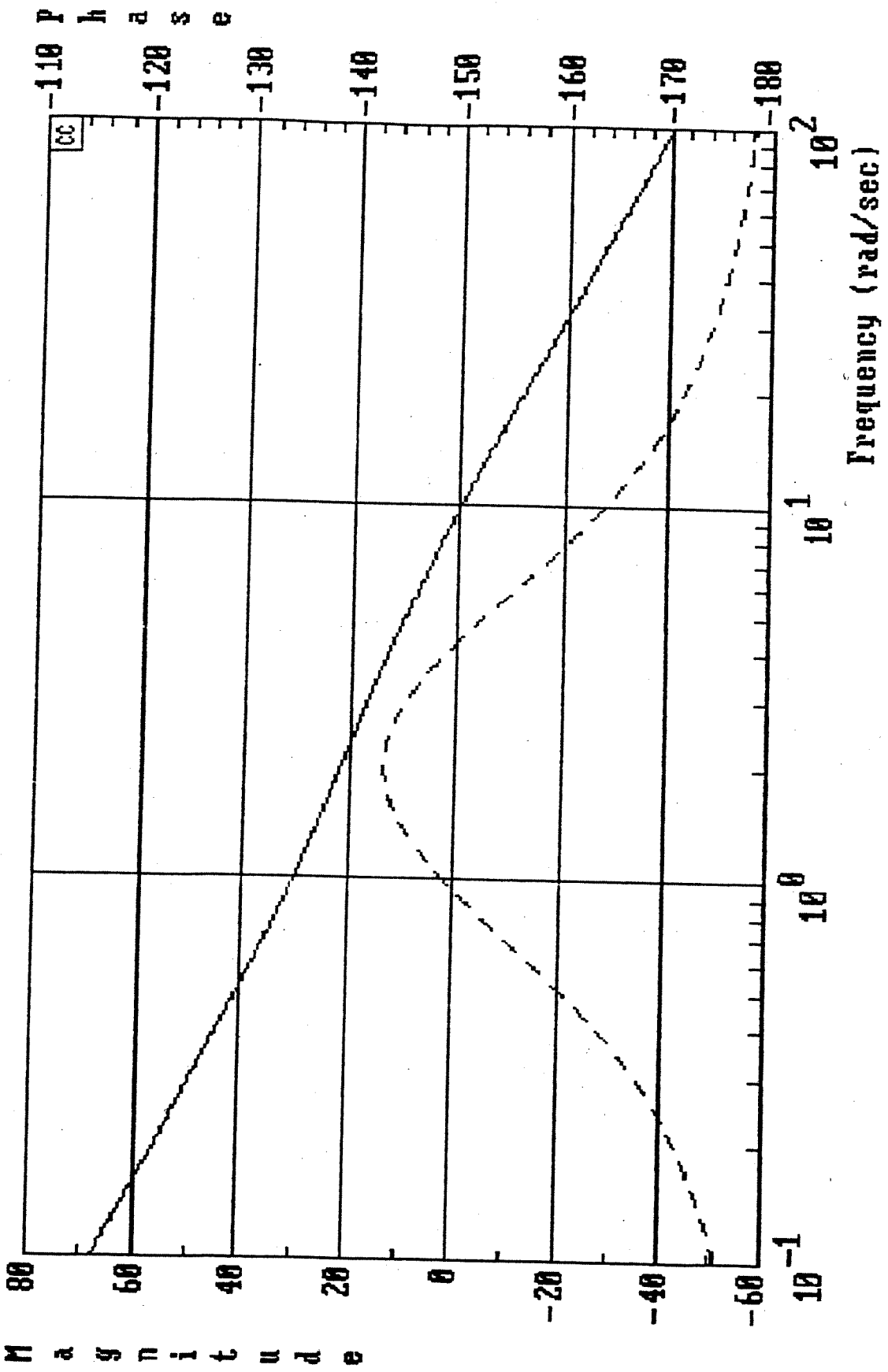


FIGURE FOR QUESTION 4