Today's goals

- **Last week**
  - Frequency response=G(jω)
  - Bode plots
- **Today**
  - Using Bode plots to determine stability
    - Gain margin
    - Phase margin
  - Using frequency response to determine transient characteristics
    - damping ratio / percent overshoot
    - bandwidth / response speed
    - steady-state error
  - Gain adjustment in the frequency domain

Gain and phase margins

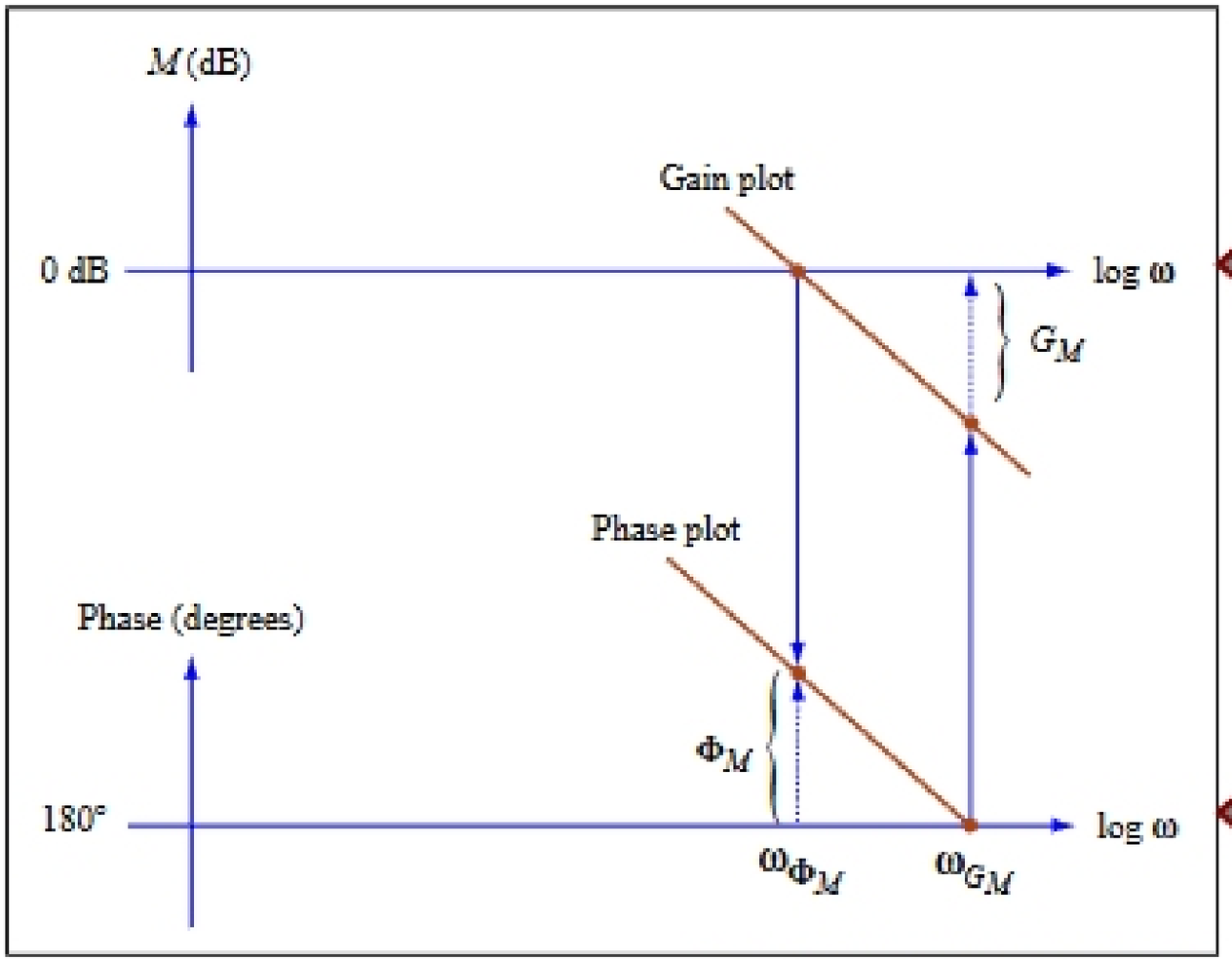


Figure by MIT OpenCourseWare.

Gain margin:
the difference (in dB) between 0dB and the system gain, computed at the frequency where the phase is 180°

Phase margin:
the difference (in °) between the system phase and 180°, computed at the frequency where the gain is 1 (i.e., 0dB)

A system is stable if the gain and phase margins are both positive

Figure 10.37

Example 1

Open–Loop Transfer Function

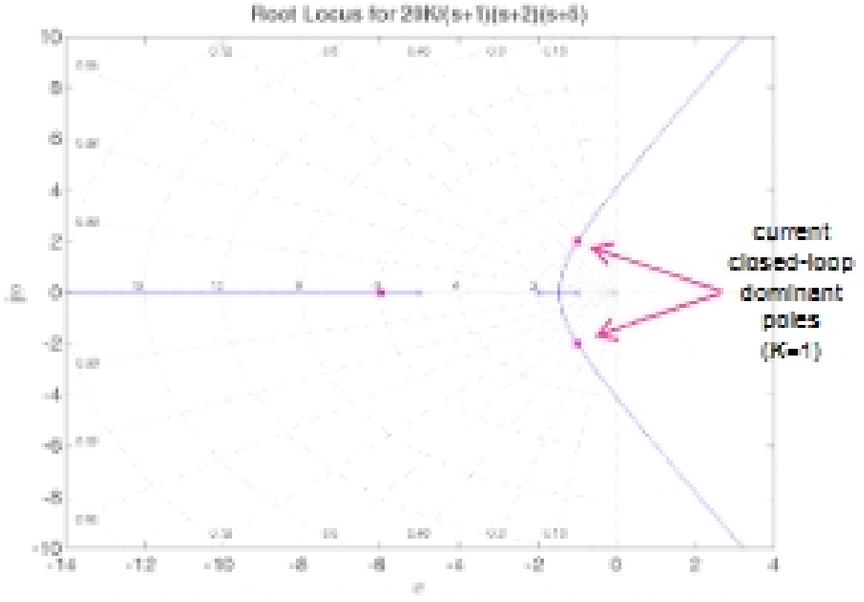
$$KG(s)H(s) = \frac{20K}{(s+1)(s+2)(s+5)}.$$

DC gain $= 20 = 20\log_{10}20(\text{dB}) \approx 6\text{dB}$

Break (cut–off) frequencies: 1, 2, 5 rad/sec.

Final gain slope: -60 dB/dec.

Total phase change: $-270°$.



Increasing the closed-loop gain by an amount equal to the G.M. (i.e., setting K=+G.M. dB or more) will destabilize the system