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TOPIC: FREQUENCY RESPONSE ANALYSIS
SUB: CONTROL SYSTEMS

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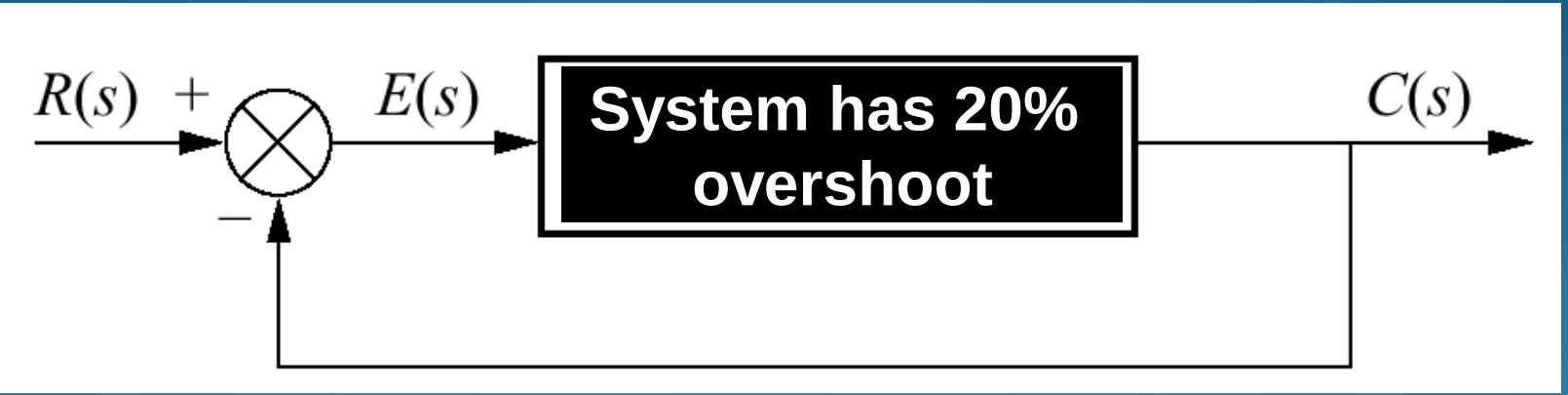


Design controller to decrease peak time to 2/3 and steady-state error to 0

expressions of sinusoidal signal

Starts from a sinusoidal signal, $A\cos(\omega t)+B\sin(\omega t)$ **, which can be rewritten as** $\sqrt{A^2+B^2}\cos\left[\omega t-\tan^{-1}(B/A)\right]$

- **Polar form (showing magnitude and phase shift):** $M_i\angle\phi_i$

$$M_i=\sqrt{A^2+B^2}$$

$$\phi_i=-\tan^{-1}(B/A)$$

- **Rectangular form** (complex number): $A - jB$

$$\cos(\omega t + \phi) = \cos(\omega t)\cos(\phi) - \sin(\omega t)\sin(\phi)$$

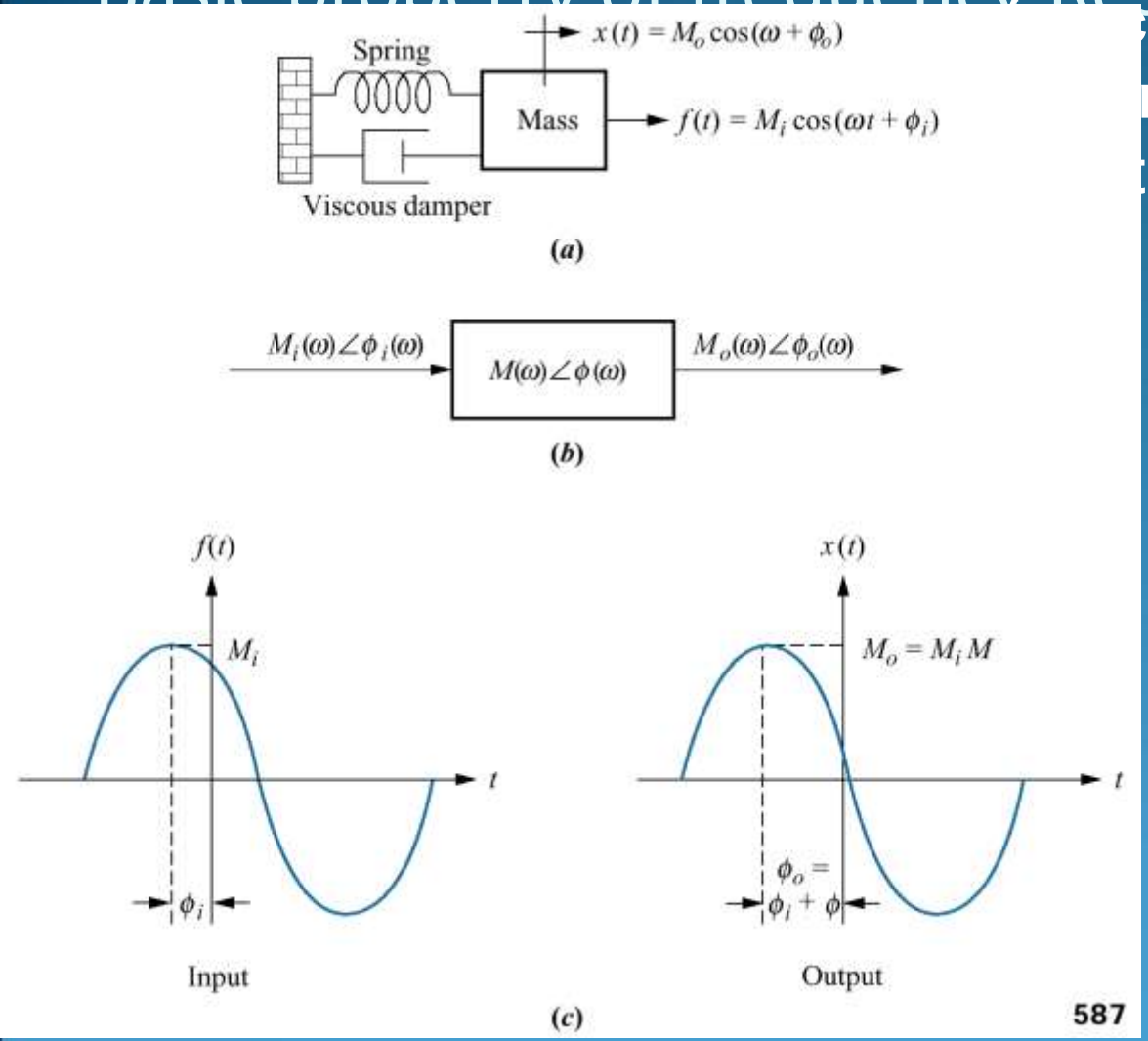
$$M_i \cos(\omega t + \phi_i) = \underbrace{M_i \cos(\phi_i)}_{A}\cos(\omega t) - \underbrace{M_i \sin(\phi_i)}_{B}\sin(\omega t)$$

- **Euler's formula** (exponential): $M_i e^{j\phi_i}$

Frequency response of system

- Magnitude response: $M(\omega)$
  - ratio of output mag. To input mag.
- Phase response: $\phi(\omega)$
  - difference in output phase angle and input phase angle
- Frequency response: $M(\omega)\angle\phi(\omega)$

Basic property of frequency Response



hanical system'

nput = force

tput = distance

Answer:

sinusoidal input gives sinusoidal output with same damped frequency shifted by , mag. expanded by

$M(\omega)$

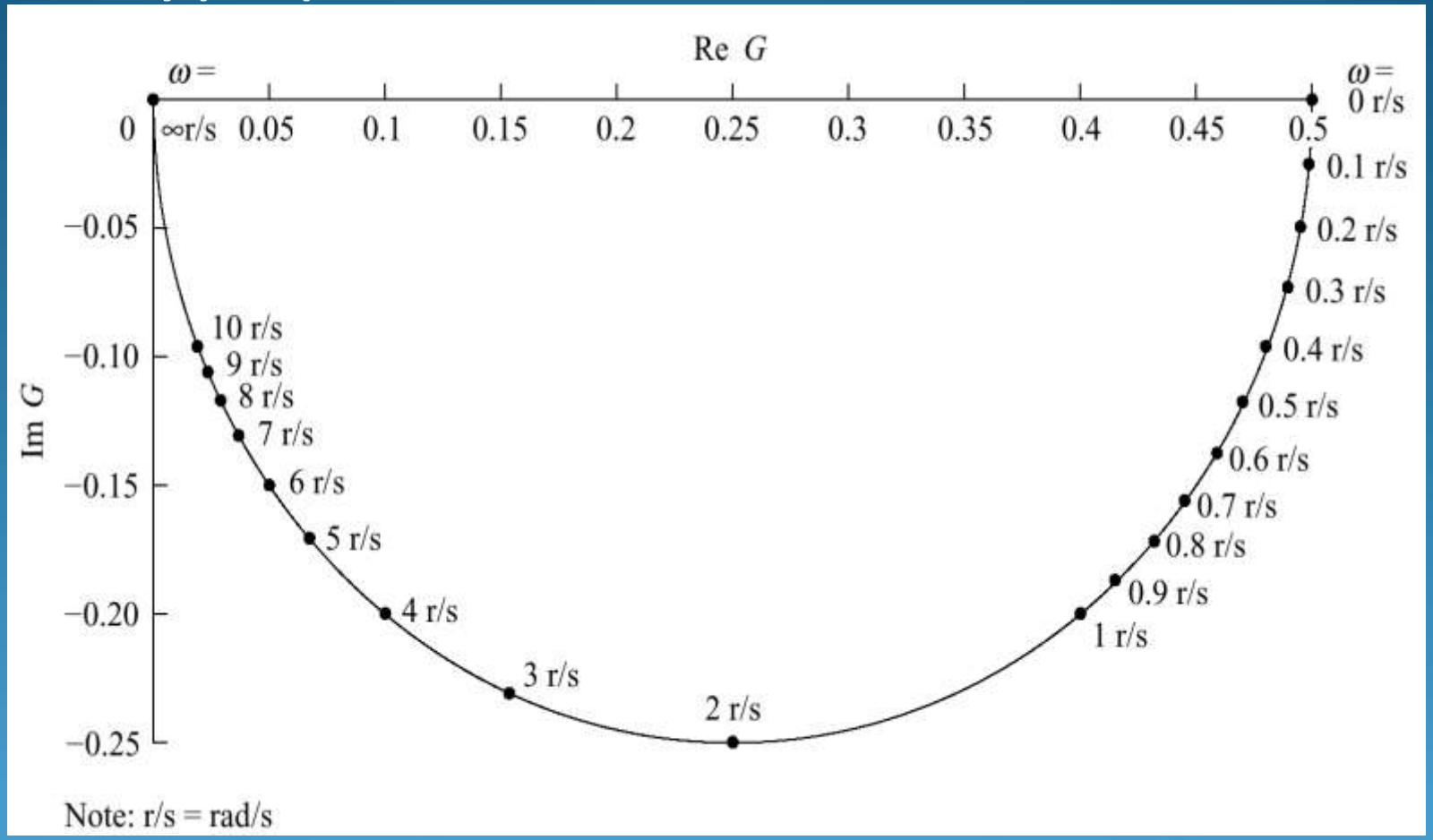
Types of frequency response plots

- **Polar plot (Nyquist plot):** real and imaginary part of open-loop system.
- **Bode plot**: magnitude and phase of open-loop system (begin with this one!!).

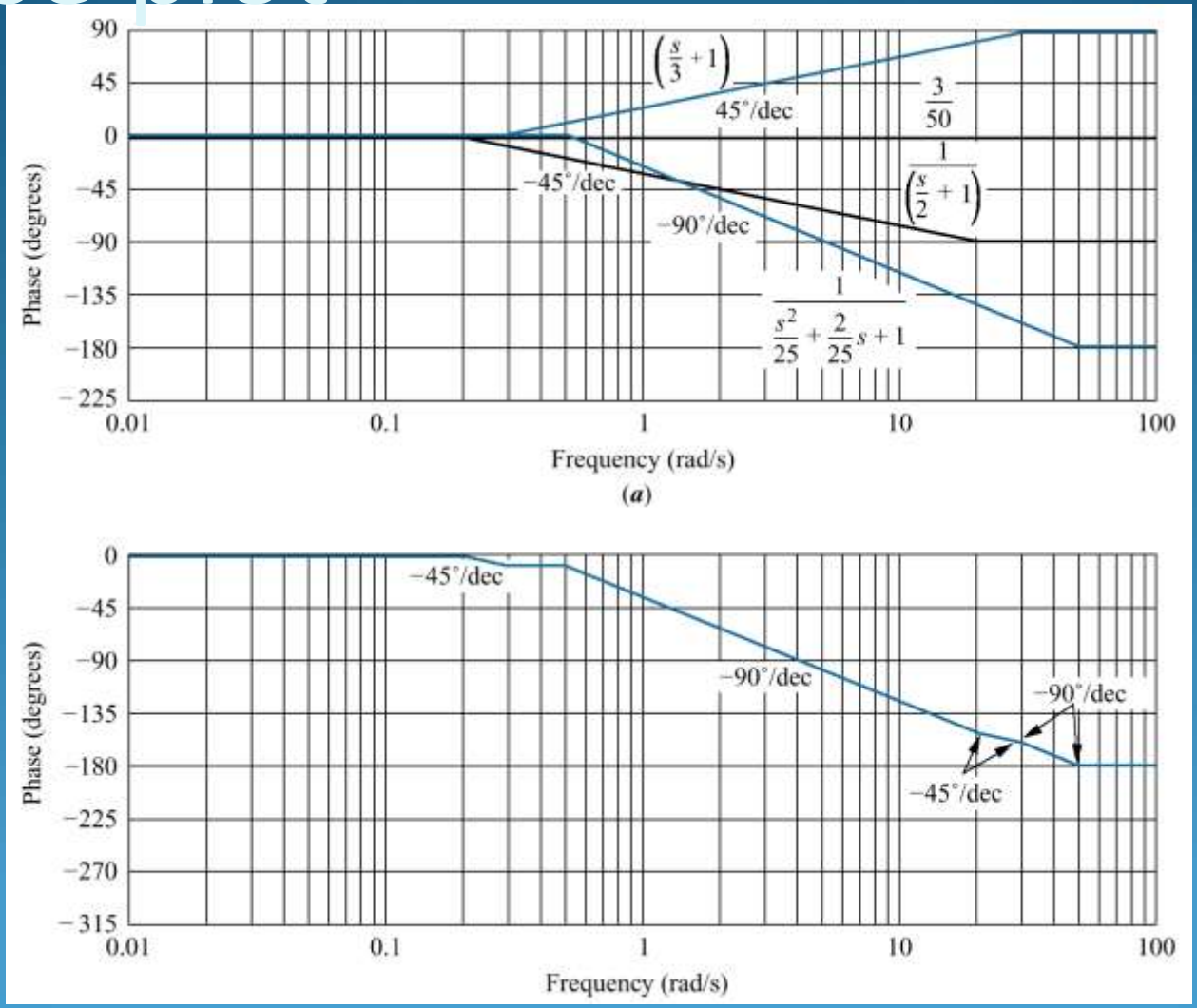
Polar plot of

$$G(s) = \frac{1}{(s+2)}$$

so called ‘Nyquist plot’



Phase plot


90
45
0
−45
−90
−135
−180
−225
Phase (degrees)
0.01
0.1
1
10
100
Frequency (rad/s)
$\left(\frac{s}{3}+1\right)$
45°/dec
$\frac{3}{50}$
$\frac{1}{\left(\frac{s}{2}+1\right)}$
−45°/dec
−90°/dec
$\frac{1}{\frac{s^2}{25}+\frac{2}{25}s+1}$
(a)
0
−45
−90
−135
−180
−225
−270
−315
Phase (degrees)
−45°/dec
−90°/dec
−90°/dec
−45°/dec
0.01
0.1
1
10
100
Frequency (rad/s)