System modeling and simulation(ME340)

Chapter 8. System Analysis in the Frequency domain

6.8 Frequency response examples

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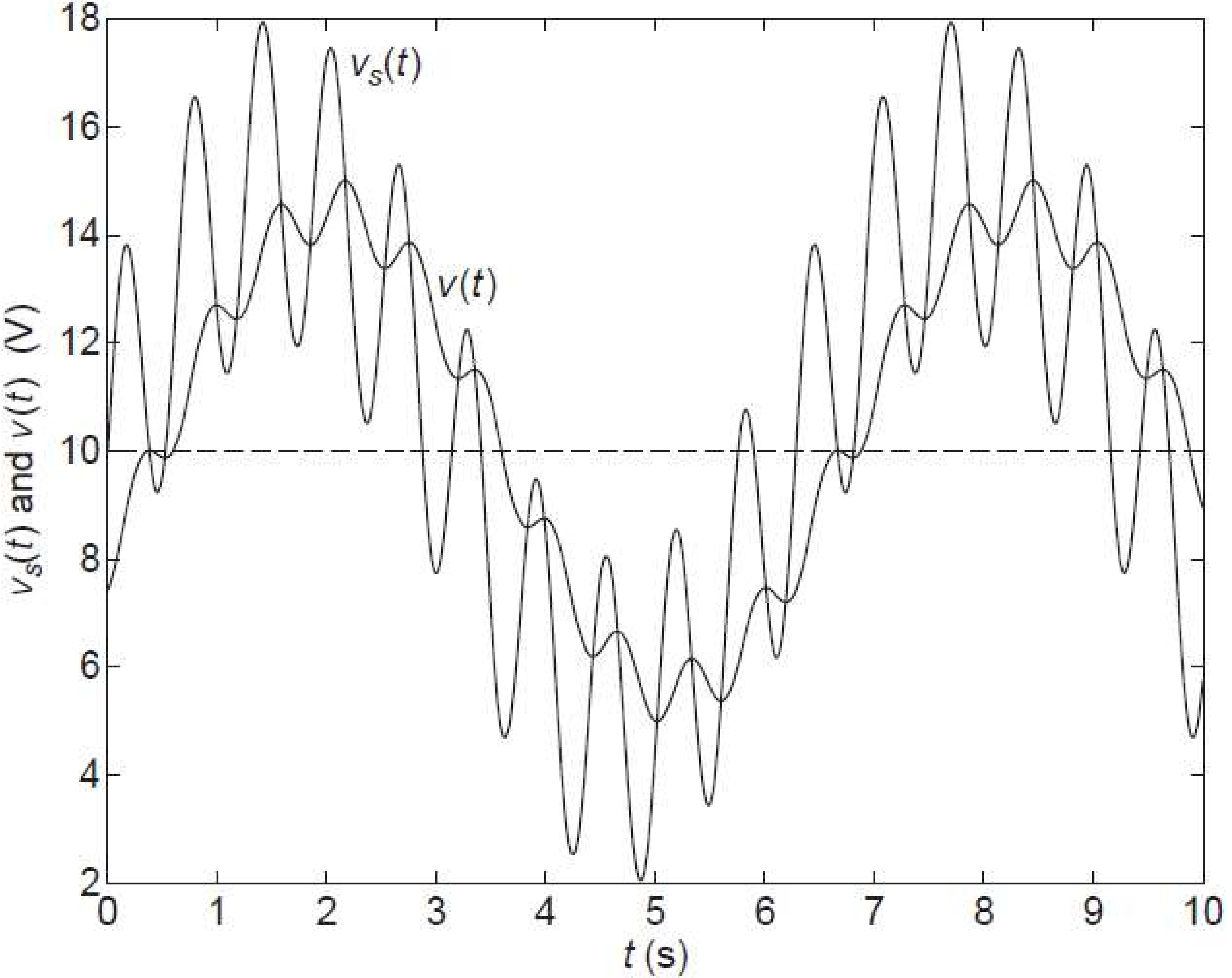
Superposition and forced response

- Consider the response: $RC\dot{v} + v = v_s$
- $v_s = 10 + 5sint + 3sin6t,\ \tau = RC = 0.5s$



$v_S(t)$
$v(t)$
$v_s(t)$ and $v(t)$ (V)
t (s)
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9
10

Response to general periodical inputs

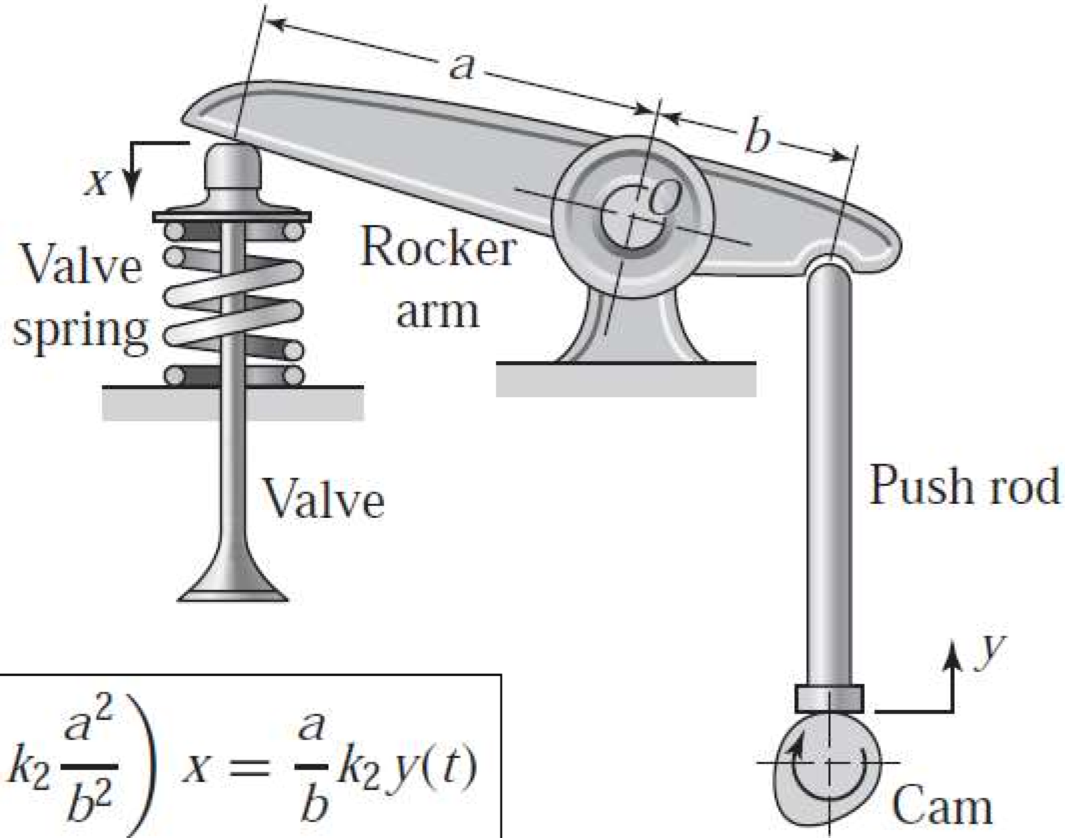
- For any periodical input, it can be expressed by sum of the Fourier series:

$$f(t) = \frac{a_0}{2} + a_1 \cos\left(\frac{\pi t}{p}\right) + a_2 \cos\left(\frac{2\pi t}{p}\right) + \cdots$$
$$+ \ b_1 \sin\left(\frac{\pi t}{p}\right) + b_2 \sin\left(\frac{2\pi t}{p}\right) + \cdots$$

- Similar treatment method as the previous example can be used. Superstition
- Is the infinite process? Bandwidth

A General example

- An engine valve train to control the air breath.



$$\frac{I_o}{a^2}\ddot{x} + c_e\dot{x} + \left(k_1 + k_2\frac{a^2}{b^2}\right)x = \frac{a}{b}k_2 y(t)$$

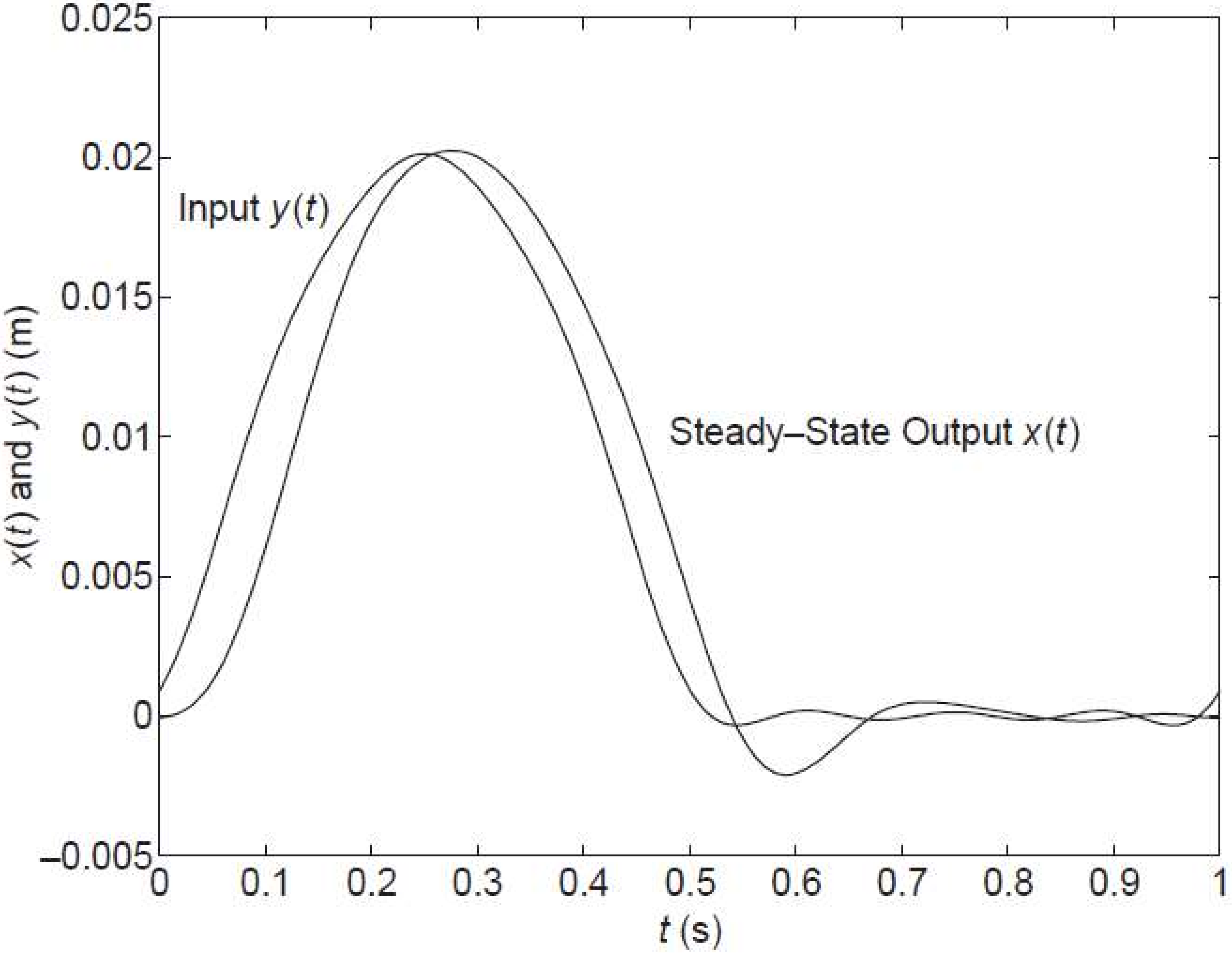
A general example

$$\ddot{x} + 20\dot{x} + 625x = 600\,y(t)$$

i	ω_i	A_i	M_i	B_i	ϕ_i
0	0	0.006366	0.96	0.006112	0
1	2π	0.01	1.001913	0.010019	−0.211411
2	4π	−0.004244	1.1312	−0.004801	−0.493642
3	8π	−0.000849	1.193557	−0.001013	−1.584035
4	12π	−0.000364	0.547162	−0.000199	−2.383436

$$x(t) = 0.006112 + 0.010019\sin(2\pi t - 0.211411)$$
$$- 0.004801\cos(4\pi t - 0.493642) - 0.001013\cos(8\pi t - 1.584035)$$
$$- 0.000199\cos(12\pi t - 2.383436)$$

Result analysis



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8.4 System identification from frequency response

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Why system identification?

- Sometimes, we don't know the transfer function, or its coefficient.
- Of course we can test the response at the different frequencies. Could we obtain the dynamic characteristic of the system?
- How? Identification method is useful.

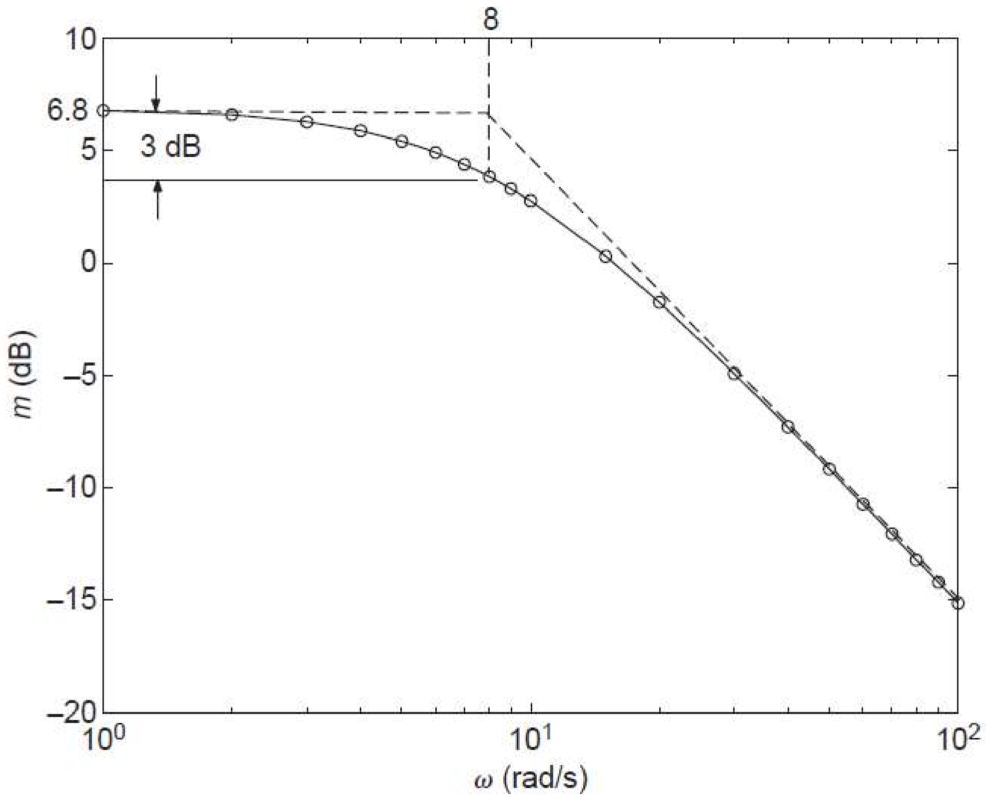
Test procedure

- A sinusoidal input is used.
- If a sinusoidal of adjustable frequency can be generated as input, then the system output amplitude and phase shift relative to the input can be measured for various input frequency.
- Easy for electric input or output or non-electronic input or output.
- Sweep through a range of frequency and plot the decibel and phase angle data.
- Easy to test even without interrupting the working.

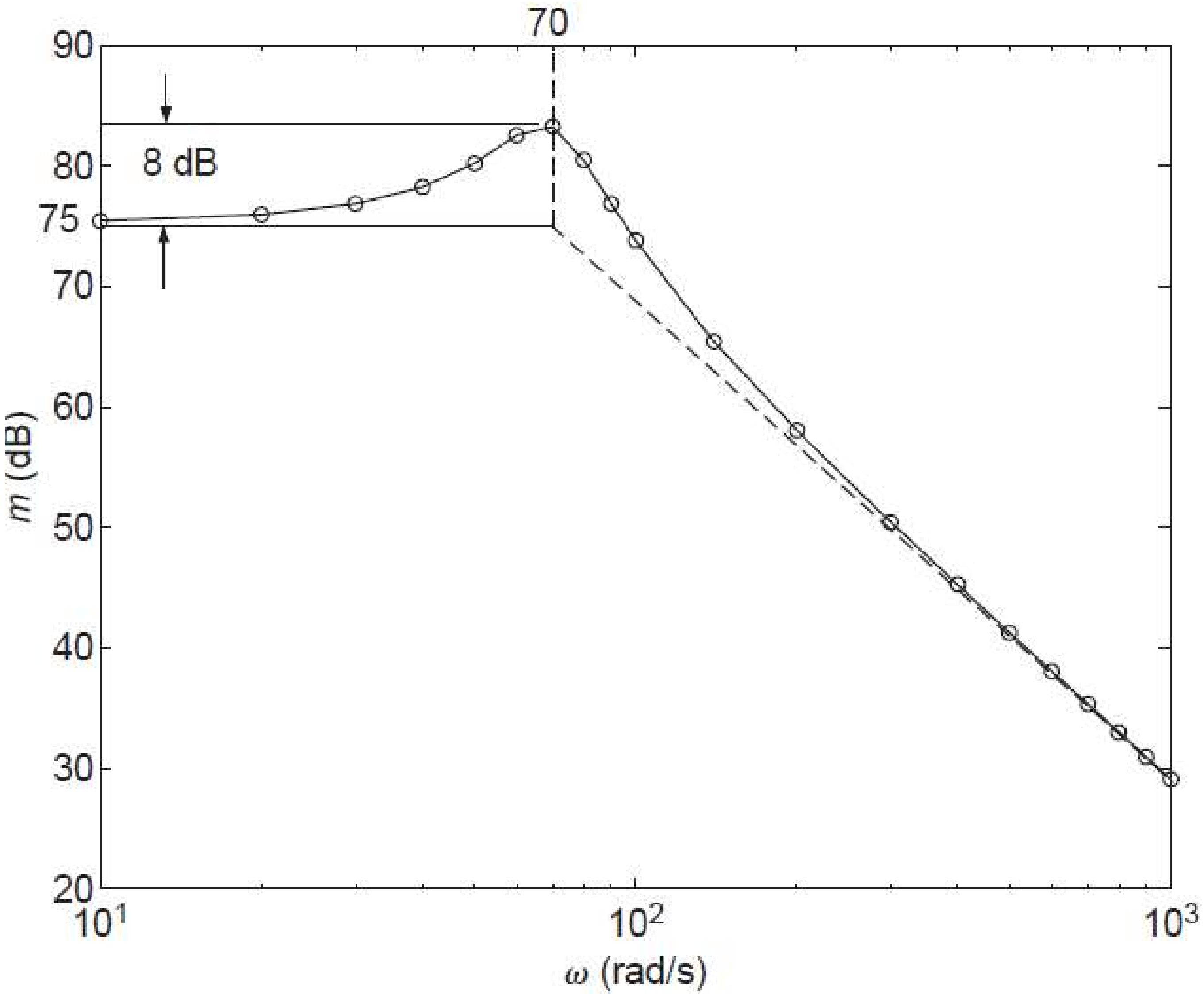
Identify the first-order system

- Determine the transfer function

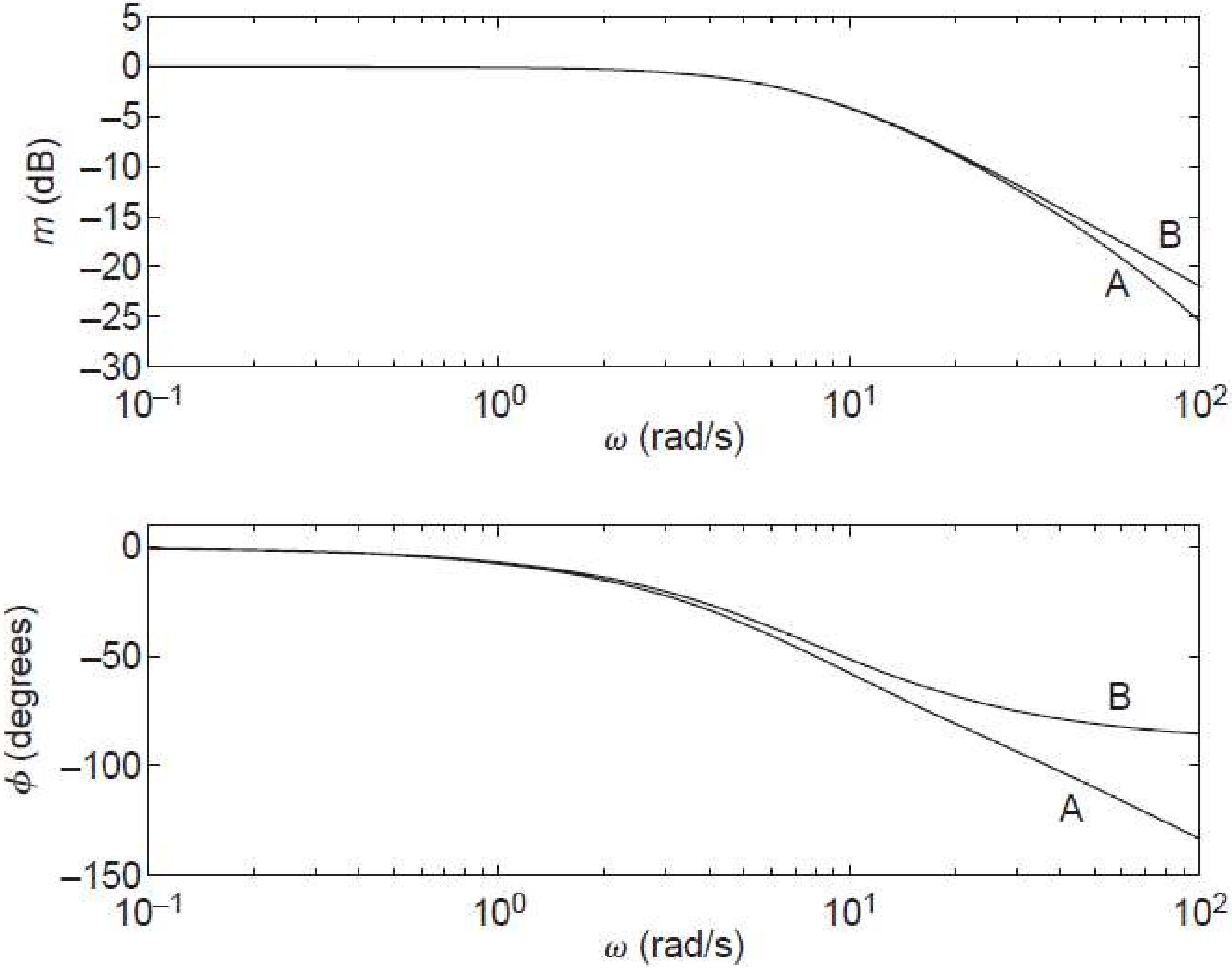
ω (rad/s)	$\lvert v_o \rvert$ (V)	$\lvert v_o \rvert/5$	$20\log(\lvert v_o \rvert/5)$
1	10.95	2.19	6.81
2	10.67	2.13	6.57
3	10.3	2.06	6.28
4	9.84	1.97	5.89
5	9.33	1.87	5.44
6	8.80	1.76	4.91
7	8.28	1.66	4.40
8	7.782	1.56	3.86
9	7.31	1.46	3.29
10	6.87	1.37	2.73
15	5.18	1.04	0.34
20	4.09	0.82	−1.72
30	2.83	0.57	−4.88
40	2.16	0.43	−7.33
50	1.74	0.35	−9.12
60	1.45	0.29	−10.75
70	1.25	0.25	−12.04
80	1.10	0.22	−13.15
90	0.97	0.19	−14.43
100	0.88	0.18	−14.89



Identify the second order system



Another example



Matlab case

- bode, bodemag, evalfr, freresp