기 계 진 동 학 도전문제 (제2장)

출처 및 해답 [수업지정도서 (중앙도서관 5층 디지털미디어룸 내)]

[1] S. G. Kelly, Fundamentals of Mechanical Vibrations, 2nd ed., McGraw-Hill, 2000.
[2] L. Meirovitch, Fundamentals of Vibrations, McGraw-Hill, 2001.
[3] 이시복 등 8인 공역, 기계진동학, 제6판, 퍼스트북, 2019.
(원서 : S. S. Rao, Mechanical Vibrations, Prentice Hall, 2017.)

2.1 비감쇠계의 조화가진 [1] Ex. 3.1

Example 3.1 Assuming small displacements and using θ as the generalized coordinates, derive the differential equation governing the forced vibrations of the system of Fig. 3.5 using

(a) The free-body diagram method

(b) The equivalent-systems method

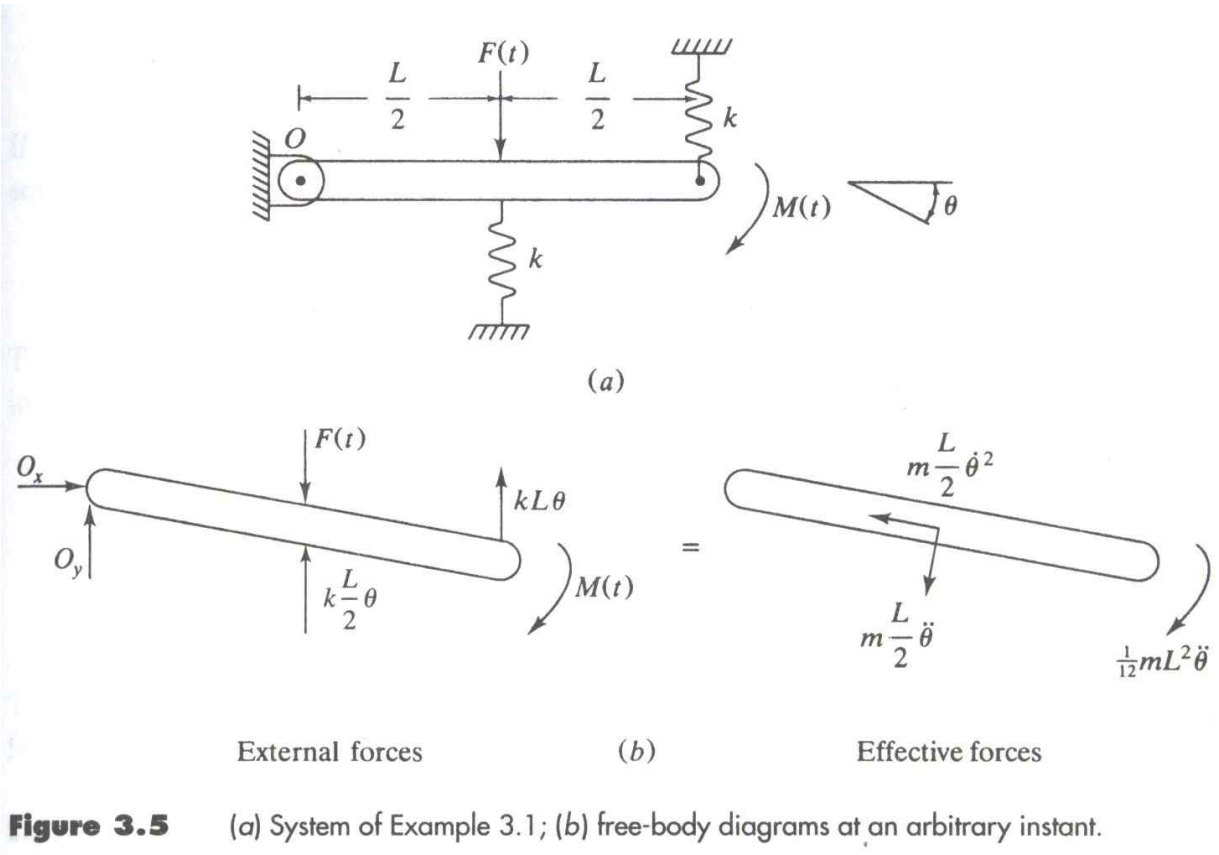

Figure 3.5 (a) System of Example 3.1; (b) free-body diagrams at an arbitrary instant.

Example 3.2 A moment, $M_O \sin\omega t$, is applied to the end of the bar of Fig. 3.13. Determine the maximum value of M_O such that the steady-state amplitude of angular oscillation does not exceed 10° if ω = 500 rpm, k = 7000 N/m, c = 650 N·s/m, L = 1.2 m, and the mass of the bar is 15 kg.

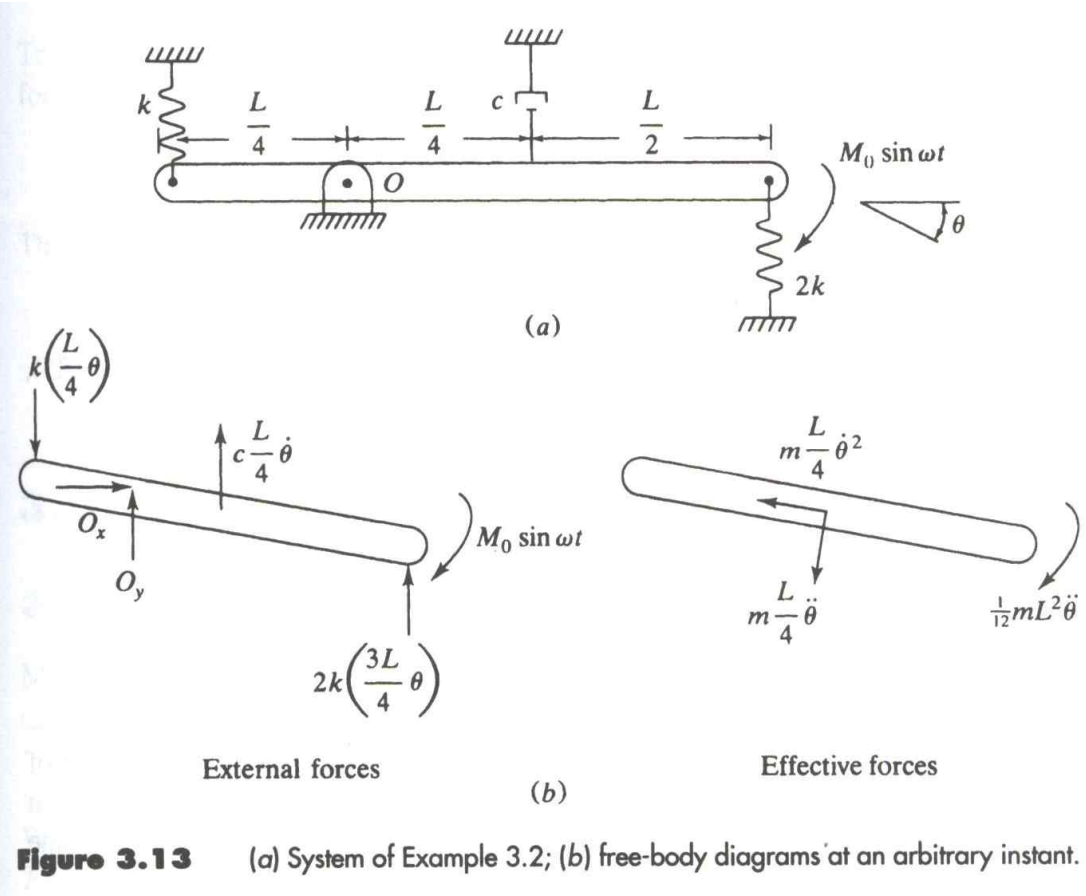

Figure 3.13 (a) System of Example 3.2; (b) free-body diagrams at an arbitrary instant.

Example 3.8 Scotch Yoke Mechanism

A Scotch yoke mechanism provides a harmonic base excitation for the mass-spring-dashpot system of Fig. 3.26. The crank arm is 80 mm long. The speed of rotation of the crank arm is varied and the resulting steady-state amplitude is recorded at each speed. The maximum recorded amplitude of the 14.73-kg block is 13 cm at 1000 rpm. Determine the spring stiffness.

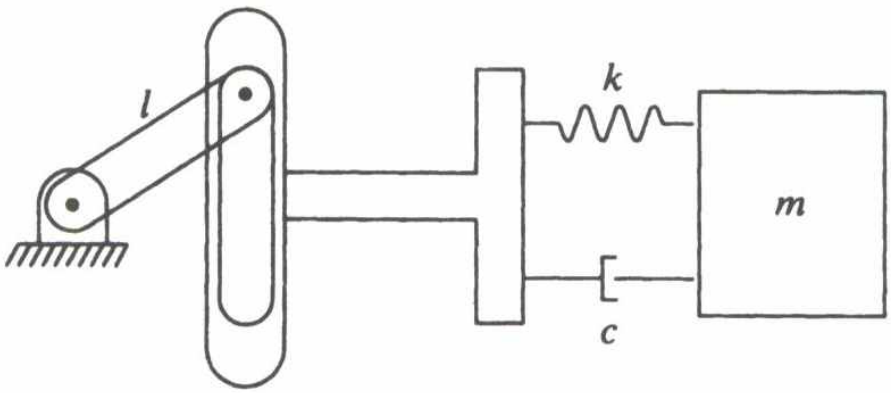

Figure 3.26 Scotch yoke mechanism produces simple harmonic motion and provides support excitation to mass-spring-dashpot system.

Example 3.8 Francis Water Turbine

The schematic diagram of a Francis water turbine is shown in Fig. 3.21 in which water flows from A into the blades B and down into the tail race C. The rotor has a mass of 250 kg and an unbalance ($m_0 e$) of 5 kg-mm. The radial clearance between the rotor and the stator is 5 mm. The turbine operates in the speed range 600 to 6000 rpm. The steel shaft carrying the rotor can be assumed to be clamped at the bearings. Determine the diameter of the shaft so that the rotor is always clear of the stator at all the operating speeds of the turbine. Assume damping to be negligible.

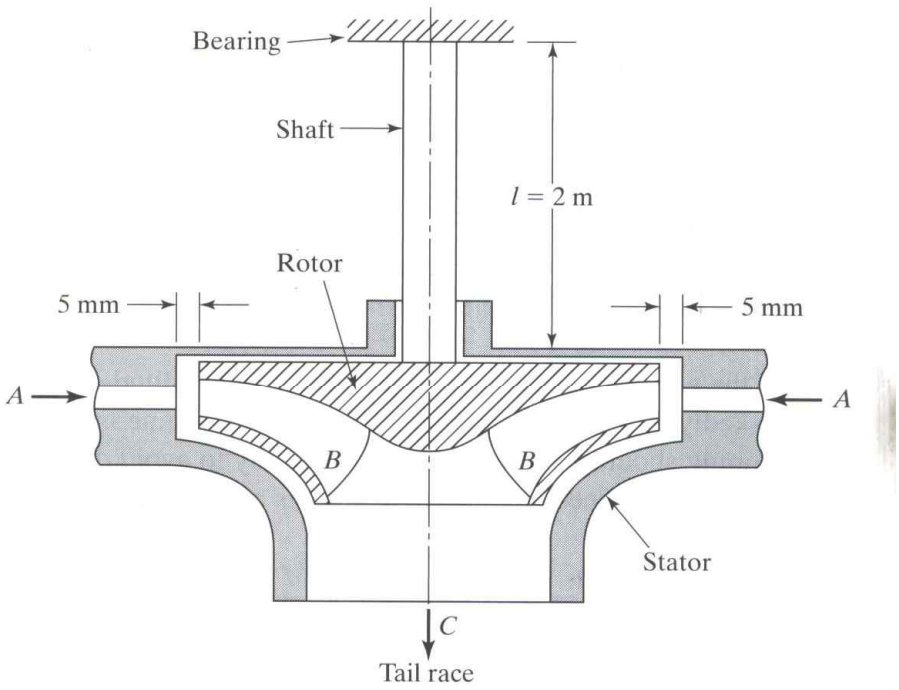

FIGURE 3. 21 Francis water turbine.

정 답

2.1 비감쇠계의 조화가진 [1] Example 3.1

$$m\frac{L^2}{3}\ddot{\theta} + \frac{5}{4}kL^2\theta = M(t) + \frac{L}{2}F(t)$$

2.2 감쇠계의 조화가진 [1] Example 3.2

$(M_O)_{\max} = 787$ N·m

2.4 바닥가진 [1] Example 3.8

$r = 0.89$ 일 때, $k = 2.04\times10^5$ N/m

2.5 회전불균형 [3] Example 3.8

$d = 127.0$ mm