기계진동학 연 습 문 제 정 답 (제1장) (2023. 3. 28.)

교 재 : D. J. Inman, Engineering Vibration, **4th** edition, Pearson, **2014**.

1.1절 <1.1> 생략 <1.2> 2.20 s <1.3> k = 8.17 kN/m

<1.4> 86.2±0.1 N/m <1.5> 생략 <1.6> 1.792 s

<1.7> $x(t)$ = 1.5 sin(2t+ 0.730) mm <1.8> $x(t)$ = cos2t mm

<1.9> x_0 = 1.364 mm, v_0 = -6.24 mm/s <1.10> 455 kN/m

<1.11> $m\ddot{x} + kx = 0$, $\omega_n = \sqrt{k/m}$ <1.12> A_v = 75.4 mm/s, A_a = 3,790 mm/s^2

<1.13> $A_1 = A\cos\phi$, $A_2 = A\sin\phi$ <1.14> $A_1 = v_0/\omega_n$, $A_2 = x_0$

<1.15> 생략 <1.16> (a) 0.0225 Hz (교재 답 오류) (b) 0.071 Hz <1.17> 생략

<1.18> (a) $\omega_n = \sqrt{(k_1+k_2)/m}$ (b) $\omega_n = \sqrt{(k_1+k_2+k_3)/m}$

<1.19> 생략 <1.20> 생략

<1.21> $\omega_n = \sqrt{(mg+kl)/ml}$ <1.22> 0.910 Hz <1.23> 0.248 m

<1.24> 0.773 rad/s <1.25> 1.268 mm <1.26> 교재 또는 노트 참조

1.2절 <1.27> 39.6 mm <1.28> 0.450 Hz <1.29> 9.25 N/m (교재 답 오류)

<1.30> $x(t)$ = 1.431 sin(3.00 t + 0.994) mm

<1.31> f_n = 0.225 Hz, $x(t)$ = (1.00 mm) cos(1.414 t)

<1.32> 44% 증가 <1.33> 8.97 s

<1.34> $x_{\text{rms}} = \frac{1}{\sqrt{2}}A$, $\dot{x}_{\text{rms}} = \frac{1}{\sqrt{2}}\omega_n A$, $\ddot{x}_{\text{rms}} = \frac{1}{\sqrt{2}}\omega_n^2 A$

<1.35> k = 5,610 N/m, ω_n = 33.5 rad/s

<1.36> (교재 오류 정정 → 승객 탑승전 질량 1,200 kg, 승객 탑승후 질량 1,500 kg),
진동수 변화 = -0.336 Hz, 속도진폭 변화 = -0.211 m/s, 가속도진폭 변화 = -8.00 m/s^2

<1.37> 생략 <1.38> A = 4.75 mm

<1.39> ω_n = 8.00 rad/s (f_n = 1.273 Hz) <1.40> ω_n = 20.0 rad/s (f_n = 3.18 Hz)

1.3절 <1.41> (a) underdamped (ζ = 0.01677 < 1),
(b) $x(t)$ = 0.01000 $e^{-0.1667t}$ sin(10.00 t + 1.554) m

<1.42> underdamped (ζ = 0.707 < 1)

<1.43> $x(t)$ = 1.293 $e^{-0.268t}$ - 0.0928 $e^{-3.72t}$ mm <1.44> $x(t) = e^{-t}\sin t$ mm

<1.45> 본문참조 <1.46> 본문참조

<1.47> $a_1 = \frac{1}{2}\left(x_0 - j\frac{v_0+\zeta\omega_n x_0}{\omega_d}\right)$, $a_2 = \frac{1}{2}\left(x_0 + j\frac{v_0+\zeta\omega_n x_0}{\omega_d}\right)$

<1.48> 본문참조 <1.49> 본문참조 <1.50> 본문참조 <1.51> 본문참조

<1.52> ζ = 0.259, ω_n = 2.83 rad/s, underdamped

<1.53> $x(t) = \sqrt{\frac{5+4\zeta}{4(1-\zeta^2)}}\,e^{-2\zeta t}\sin[2\sqrt{1-\zeta^2}\,t + \tan^{-1}\frac{2\sqrt{1-\zeta^2}}{1+2\zeta}]$ mm

<1.54> $x(t)$ = 1.005 x_0 $e^{-0.2t}$ sin(1.990 t + 1.471) =

<1.55> $x(t) = e^{-\frac{t}{2}}\left(\cos\frac{\sqrt{3}}{2}t + \frac{1}{\sqrt{3}}\sin\frac{\sqrt{3}}{2}t\right)$

<1.56> ω_n = 5.48 rad/s, ζ = 0.251, ω_d = 5.30 rad/s, oscillation.

<1.57> $\omega_n = \sqrt{\dfrac{k\,l^2}{J + m\,l^2}}$, $\omega_d = \sqrt{1-\zeta^2}\sqrt{\dfrac{k\,l^2}{J + m\,l^2}}$

<1.58> ω_n = 3.54 rad/s, ζ = 0.221, ω_d = 3.45 rad/s, underdamped, oscillation.

<1.59> $x(t) = 0.1251\ e^{-1.456t}\ \sin(4.95\ t + 1.284)$ m

<1.60> $x(t) = 6.52\ e^{-0.695t}\ \sin(3.08\ t - 1.170)$ mm <1.61> 생략

<1.62> $\ddot{x} + 2\,\zeta\omega_n\,\dot{x} + \omega_n{}^2\,x = 0$ 중력 영향 없음

<1.63> $m\,\ddot{x} + c\,\dot{x} + (k\cos^2\alpha)\,x = 0$ <1.64> 생략

1.4절 <1.65> $\omega_n = \sqrt{\dfrac{(3m+6m_T)\,g}{(2m+6m_T)\,l}}$ <1.66> 생략

<1.67> $\left(\dfrac{J}{r^2}+m\right)\ddot{x} + \left(k_2+\dfrac{k_1}{r^2}\right)x = 0$ <1.68> $\omega_n = \sqrt{-\dfrac{g}{l}+\dfrac{k}{m}}$

<1.69> $\omega_n = \sqrt{\dfrac{k l_1^2 + mg l_2}{m l_2^2}}$ <1.70> $\omega_n = \sqrt{\dfrac{g}{2(R-R_1)}}$

<1.71> $c_t = 0.01\ m\sqrt{g l^3}$ <1.72> $c = 0.016\sqrt{Jk}$ <1.73> ω_d = 0.645 rad/s

<1.74> $\omega_d = \sqrt{\dfrac{k}{m+\dfrac{J}{r^2}} - \dfrac{c^2}{4\left(m+\dfrac{J}{r^2}\right)^2}}$ <1.75> ζ = 0.0871, ω_d = 10.84 rad/s, -31.4%

<1.76> 생략 <1.77> 생략 <1.78> 생략 <1.79> 생략

<1.80> $\omega_n = 2\dfrac{a+r}{r}\sqrt{\dfrac{k}{3\,m}}$ <1.81> $\omega_n = \sqrt{\dfrac{-2(m_1+2m_2)g+kl}{(m_1+4\,m_2)l}}$

1.5절 <1.82> ω_n = 14,910 rad/s, f_n = 2,370 Hz

<1.83> 3.58 mm <1.84> $(\omega_n)_{longil}$ = 3,460 rad/s, (ω_n) = 1,073 rad/s

<1.85> A = 0.00269 m^2 <1.86> EI = 56,800 N·m^2 <1.87> 248 N/m

<1.88> 생략 <1.89> 생략 <1.90> 생략

<1.91> ω_n = 15.92 rad/s, ζ = 0.1884, underdamped system

<1.92> ω_d = 40.2 rad/s, ζ = 0.00124, underdamped system

<1.93> ω_n(al)/ω_n(st) = 0.581, 약 40% 감소

1.6절 (제4장과 함께 기재)

1.7절 <1.102> c = 36.7 kg/s <1.103> 생략 <1.104> 생략

<1.105> steel($G = 80\times10^9$ N/m^2)인 경우, d = 59.7 mm <1.106> n = 3.5 turns

<1.107> 생략

<1.108> A = 1 cm^2 인 경우, 플라스틱 L = 140 m, 고무 L = 0.7 m.
고무의 길이는 실제 가능.

<1.109> 생략 <1.110>

1.8절 <1.111> (a) $\dfrac{1}{3}ml\ddot{\theta} + \left(2\,kl - \dfrac{1}{2}m\,g\right)\theta = 0$, (b) stable when $2\,kl > \dfrac{1}{2}m\,g$

<1.112> 생략

<1.113> $\left(\dfrac{1}{3}m_1+m_2\right)l\ddot{\theta} + \left[\dfrac{1}{2}\,kl - \left(\dfrac{1}{2}m_1+m_2\right)g\right]\theta = 0$, stable when $\dfrac{1}{2}\,kl > \left(\dfrac{1}{2}m_1+m_2\right)g$