Vibrations Test 4

Number of Questions 25 **Time:60 min.**

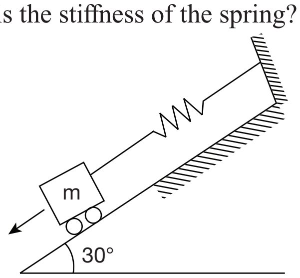
Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. A suspension system of mass 60 kg consists of a leaf spring of stiffness 3.9 kN/m and a damper of damping coefficient 400 N.s/m. Damping factor and damped natural frequency respectively are:
(A) 0.4134 and 1.1685 Hz
(B) 0.4134 and 7.3422 Hz
(C) 0.1258 and 1.1685 Hz
(D) 0.1258 and 7.3422 Hz

2. A shaft loaded at centre has a deflection of δ, the natural frequency of the vibration is
(A) $0.4985\sqrt{\delta}$ (B) 0.4985. δ Hz
(C) $\dfrac{0.4985}{\sqrt{\delta}}$ (D) $\dfrac{0.4985}{\delta}$ Hz

3. An oscillating system is defined by the acceleration $\ddot{x} = -200\ e^{2it}$, where $i = \sqrt{-1}$. What is the frequency of oscillation?
(A) $\dfrac{2}{\pi}$ Hz (B) $\dfrac{1}{\pi}$ Hz
(C) 2π Hz (D) π Hz

4. The static deflection of the spring connected to a mass of 10 kg lying on an inclined plane of inclination 30° is 2 mm. What is the stiffness of the spring?

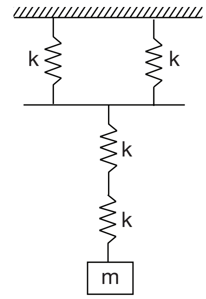


(A) 24.525 N/m (B) 24.525 N/mm
(C) 24.525 kN/mm (D) 24.525 kN/cm

5. A light shaft is having three discs of different masses attached at different positions on the shaft. How many critical speeds does the system posses?
(A) 2 (B) 1
(C) 3 (D) 4

6. A shaft supported by bearings, with a central rotor of mass 2 kg has a natural frequency of 300 rad/s. If the amplitude of steady state vibrations is 0.03 mm then the dynamic load on the bearings is
(A) 5.4 N (B) 540 N
(C) 5400 N (D) 54 N

7. A spring of stiffness 200 N/m is cut into four equal parts and arranged as shown. What is the resulting stiffness of the system?



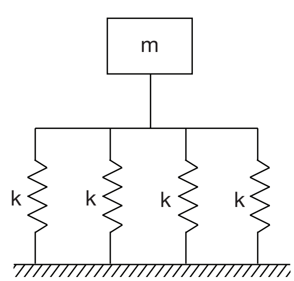
(A) 320 N/m (B) 80 N/m
(C) 20 N/m (D) 480 N/m

8. The magnification factor of a spring-mass-damper system is found to be 15 at resonance. What is the damping ratio of the system?
(A) 0.0667 (B) 0.0334
(C) 0.0167 (D) 0.0116

9. In spring mass damper system with mass, stiffness and damping coefficient as *m*, *k* and *c* respectively, what is the ratio of damped time period to natural time period of oscillation?
(A) $\dfrac{2\sqrt{\text{km}}}{\sqrt{2\text{km}-c^2}}$ (B) $\dfrac{4\sqrt{\text{km}}}{\sqrt{4\text{km}-c^2}}$
(C) $\dfrac{2\sqrt{\text{km}}}{\sqrt{4\text{km}-c^2}}$ (D) $\dfrac{\sqrt{\text{km}}}{\sqrt{\text{km}-c^2}}$

10. A spring-mass-damper system has a damping factor of 1.5. What is the transmissibility when the system is at resonance?
(A) 0.781 (B) 2.1808
(C) 1 (D) 1.054

11. Consider a car of mass 1200 kg with a ground clearance of 390 mm supported by four springs of equal stiffness of 9 kN/m as shown. What will be the deflection at static condition?



(A) 390 mm (B) 327 mm
(C) 300 mm (D) 332 mm

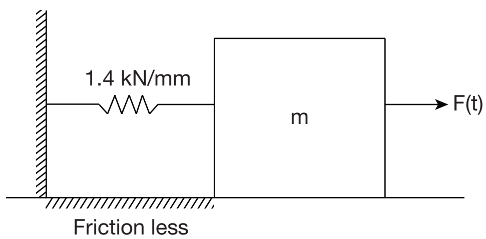
12. A shaft has a whirling speed of 20 rad/s while carrying a load at the centre. If the stiffness of the shaft is 40 N/mm what is the amount of load acting on it?

(A) 490.5 N (B) 9.81 N
(C) 981 N (D) 0.981 N

13. The amplitude reduction over 4 cycles of a viscous damped system is found to be 9.4. What is the viscous damping factor of the system?
(A) 0.089 (B) 0.079
(C) 0.069 (D) 0.0089

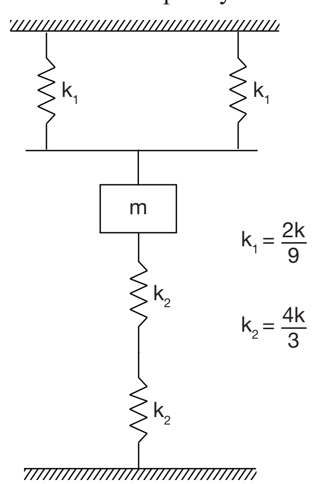
14. An elastic shaft of 100 cm long has two rotors *A* and *B* connected at its ends, of diameters 80 cm and 40 cm respectively. The masses of the rotors are 2 kg(*A*) and 3 kg(*B*). What is the distance *x* from rotor *B* at which the node of torsional vibration occurs?
(A) 27.273 cm (B) 77.273 cm
(C) 72.727 cm (D) 22.727 cm

15. A mass is acted upon by a force $F(t) = 20\ \mathrm{Cos}(60t)$ as shown. If the stiffness of the spring is 1.4 kN/mm and the amplitude of the motion is 30 mm what is the value of the mass?



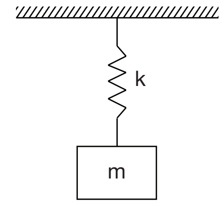
(A) 611.2 gms (B) 388.7 gms
(C) 222.3 gms (D) 776.8 gms

16. A mass of 40 kg is connected as shown with $k = 9$ N/mm. What is the natural frequency of the system in Hz.



(A) $\frac{1}{2\pi}$ (B) $\frac{1}{6\pi}$
(C) $\frac{1}{8\pi}$ (D) $\frac{1}{4\pi}$

17. A spring-mass system of stiffness 20 N/mm and mass of 120 kg is as shown. Natural frequency of the system decreases when



(A) $m = 100$ kg and $k = 20$ N/mm
(B) $m = 100$ kg and $k = 25$ N/mm
(C) $m = 100$ kg and $k = 15$ N/mm
(D) $m = 100$ kg and $k = 50$ N/mm

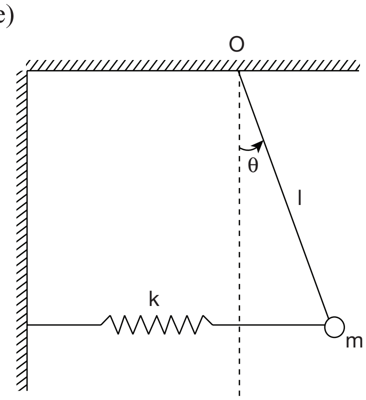
18. A body subjected to two simultaneous harmonic motions given by $10\ \mathrm{Sin}(30t)$ and $20\ \mathrm{Sin}(30t + 125)$ has the resultant motion as $X\ \mathrm{Sin}(\omega t + \beta)$. What is the angle β?
(A) –25.56° (B) –115.56°
(C) 16.727° (D) 73.274°

19. The displacement of a slider in a slider-crank mechanism is given by $x = 12\ \mathrm{Cos}(6\ \pi t) + \frac{5}{2}\ \mathrm{Cos}(24\ \pi t)$ mm.

What is the acceleration of the slider at $t = \frac{1}{6}$ s?
(A) $1.872\ \pi^2$ m/s² (B) $1872\ \pi^2$ m/s²
(C) $-1.008\ \pi^2$ m/s² (D) $-1008\ \pi^2$ m/s²

20. Two shafts *P* and *Q* under torsional vibration, have diameters 40 cm and 80 cm respectively. If the shafts are made of same material with the lengths of *P* and *Q* as 150 cm and 70 cm respectively what is the ratio of their stiffness $(k_t)_P/(k_t)_Q$?
(A) 0.0291 (B) 0.970
(C) 0.343 (D) 0.657

21. A concentrated mass of 20 kg is attached to one end of a light, stiff rod of length 2 m. A spring of stiffness 5 N/m is connected to the mass and the other end of the rod is pivoted. What is the angular acceleration of the system when the rod is displaced anticlockwise by an angle of $\frac{\pi}{20}$ radians. (Consider anticlockwise rotation is positive)



(A) 0.7735 rad/s² (B) 54.27 rad/s²
(C) –0.7735 rad/s² (D) –54.27 rad/s²

22. A spring-mass system of mass 50 kg and stiffness 12.5 N/m has the initial conditions: displacement and velocity are 4 mm and zero at $t = 0$. What is the displacement of mass from the mean position at $t = 0.5$ seconds?

(A) 3.999 mm (B) 0.174 mm
(C) 0.989 mm (D) 3.876 mm

23. A rotor of 14 kg is mounted midway on a shaft of negligible mass with diameter 2 cm which is supported by bearings at the ends. The eccentricity of the centre of gravity of the disc is 0.003 m from the geometric centre. What is the amplitude of steady state vibrations when the system rotates at 500 rpm and the distance between the bearings is 60 cm? ($E = 200$ GPa)

(A) 1.488 m (B) 1.488 m
(C) 0.370 m (D) 0.370 mm

24. A single degree of freedom system is defined as $5\ddot{x}+3\dot{x}+10x=20\,\text{Sin}(4\pi t)$. The amplitude and the angle between displacement and the force vectors are 4 mm and 30° respectively. What is the amount of damping force produced in the system when t = 0.5?

(A) 0.1707 N (B) –0.149 N
(C) 0.1306 N (D) 0.1500 N

25. What is the logarithmic decrement of a system with equation of motion is $3\ddot{x}+7\dot{x}+5x=0$.

(A) 2.11 (B) 13.261
(C) 4.221 (D) 6.630

Answer Keys

1. A	**2.** C	**3.** B	**4.** B	**5.** C	**6.** A	**7.** A	**8.** B	**9.** C	**10.** D
11. B	**12.** C	**13.** A	**14.** C	**15.** B	**16.** D	**17.** C	**18.** A	**19.** C	**20.** A
21. C	**22.** D	**23.** D	**24.** C	**25.** B					

Hints and Explanations

1. $k = 3.9$ kN/m, $c = 400$ N.s/m, $m = 60$ kg

ξ = damping factor $= \dfrac{c}{2\sqrt{k.m}} = \dfrac{400}{2\sqrt{3900\times 60}}$

$\therefore \quad \xi = 0.4134$

$$\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{3900}{60}} = 8.0622 \text{ rad/s}$$

$$\therefore \omega_d = \omega_n\sqrt{1-\xi^2} = 7.3422 \text{ rad/s}$$

$\therefore \quad f_d = \dfrac{1}{2\pi}\,\omega_d = 1.1685$ Hz Choice (A)

2. $\omega_n = \sqrt{\dfrac{g}{\delta}} = \sqrt{\dfrac{9.81}{\delta}} = \dfrac{3.132}{\sqrt{\delta}}$ rad/s

$\therefore \quad f_n = \dfrac{1}{2\pi}\omega_n = \dfrac{0.4985}{\sqrt{\delta}}$ Hz Choice (C)

3. $x = re^{i\omega t} \Rightarrow \ddot{x} = -\omega^2 r\, e^{i\omega t}$

$-\omega^2 r = -200$ and $2it = i\omega t \Rightarrow \omega = 2$

$\therefore \quad r = 50$

$\therefore$ frequency is $f = \dfrac{\omega}{2\pi} = \dfrac{2}{2\pi} = \dfrac{1}{\pi}$ Hz Choice (B)

4. In the equilibrium position

$k\,\delta_{St} = mg$ Sin30

here, $m = 10$ kg, $\delta_{St} = 2 \times 10^{-3}$ m

$\therefore \quad k = \dfrac{10\times 9.81\times \text{Sin}\,30}{2\times 10^{-3}} = 24525$ N/m

$k = 24.525$ N/mm Choice (B)

5. A shaft having more than one disc will have as many critical speeds as the number of discs. Choice (C)

6. $m = 2$ kg, $\omega_n = 300$ rad/s

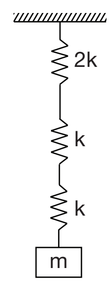
$$\omega_n = \sqrt{\frac{k}{m}} \Rightarrow k = m.\omega_n^2 = 2\times 300^2 = 180 \text{ kN/m}$$

$\therefore$ Dynamic load on the bearings $= R_d = k.r$

$r = 0.03$ mm $= 3 \times 10^{-5}$ m

$\therefore \quad R_d = 180 \times 10^3 \times 3 \times 10^{-5} = 5.4$ N Choice (A)

7. The resulting stiffness of the given configuration is



$$\frac{1}{k_e} = \frac{1}{2k} + \frac{1}{k} + \frac{1}{k}$$

$$\frac{1}{k_e} = \frac{5}{2k}$$

$$\Rightarrow k_e = \frac{2}{5}k = 0.4k$$

Where, $k = 4 \times 200$ N/m $= 800$ N/m

$\therefore \quad k_e = 0.4 \times 800 = 320$ N/m Choice (A)

8. $MF = \dfrac{1}{\sqrt{\left[1-\left(\dfrac{\omega}{\omega_n}\right)^2\right]^2+\left(2\zeta\dfrac{\omega}{\omega_n}\right)^2}}$

at resonance $\omega = \omega_n$

$MF = \dfrac{1}{2\zeta} = 15$

$\Rightarrow \quad \zeta = \dfrac{1}{2\times 15} = 0.0334$ Choice (B)

9. Damped time period,

$T_d = \dfrac{2\pi}{\omega_d}, \omega_d = \omega\sqrt{1-\zeta^2}$

$\therefore T_d = \dfrac{2\pi}{\omega\sqrt{1-\zeta^2}}$

Natural time period,

$T = \dfrac{2\pi}{\omega}$

$\dfrac{T_d}{T} = \dfrac{1}{\sqrt{1-\zeta^2}} = \dfrac{C_c}{\sqrt{C_c^2 - C^2}} = \dfrac{2\sqrt{\text{km}}}{\sqrt{4\text{km} - c^2}}$ Choice (C)

10. $\zeta = 1.5$

$T_r = \dfrac{\sqrt{1+\left(2\zeta\dfrac{\omega}{\omega_n}\right)^2}}{\sqrt{\left[1-\left(\dfrac{\omega}{\omega_n}\right)^2\right]^2+\left(2\zeta\dfrac{\omega}{\omega_n}\right)^2}}$

When resonance occurs, $\dfrac{\omega}{\omega_n} = 1$

$\Rightarrow T_r = \dfrac{\sqrt{1+4\zeta^2}}{2\zeta} = \dfrac{\sqrt{1+\left(4\times 1.5^2\right)}}{2\times 1.5} = 1.054$ Choice (D)

11. $\omega_n = \sqrt{\dfrac{k}{m}}$

Where $k = 9 \times 4 = 36$ kN/m, $m = 1200$ kg

$\therefore \quad \omega_n = \sqrt{\dfrac{36000}{1200}} = \sqrt{30}$ rad/s

But $\omega_n = \sqrt{\dfrac{g}{\delta}}$

$\Rightarrow \quad 30 = \dfrac{g}{\delta}$

$\Rightarrow \quad \delta = 0.327$ m

$\Rightarrow \quad 327$ mm

Choice (B)

12. $\omega_n = 20$ rad/$s = \sqrt{\dfrac{g}{\delta}}$, $k = 40$ N/mm $= 40 \times 10^3$ N/m

$\Rightarrow \quad \delta = \dfrac{9.81}{20^2} = 24.525$ mm

But, $\delta = \dfrac{W}{k}$

$\Rightarrow \quad 24.525 \times 10^{-3} = \dfrac{W}{40\times 10^3}$

$\Rightarrow \quad W = 981$ N

Choice (C)

13. $\dfrac{x_1}{x_2} = (9.4)^{1/4}$

Logarithmic decrement

$\delta = \ln(9.4)^{1/4}$

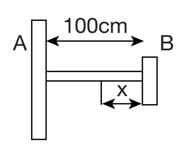
$\Rightarrow \quad \delta = 0.5602$

But, $\delta = \dfrac{2\pi\xi}{\sqrt{1-\xi^2}}$, ξ = damping factor

$\therefore \quad 7.9486 \times 10^{-3} = \dfrac{\xi^2}{1-\xi^2}$

$\Rightarrow \quad \xi = 0.089$ Choice (A)

14.



$d_A = 80$ cm, $d_B = 40$ cm

$I_A L_A = I_B L_B$

$\therefore \quad m_A r_A^2 \times (100 - x) = m_B r_B^2 \times x$

$m_A = 2$ kg, $m_B = 3$ kg

$\therefore \quad 2 \times 40^2 \times (100 - x) = 3 \times 20^2 \times x$

$\therefore \quad \dfrac{100 - x}{x} = \dfrac{3}{8}$

$\therefore \quad x = \dfrac{100\times 8}{11} = 72.7273$ cm Choice (C)

15. $F(t) = 20\,\text{Cos}(60t) = F_o\,\text{Cos}(\omega t)$

$\Rightarrow \quad F_o = 20\,N$, $\omega = 60$ rad/sec

As there is no damper, $c = 0$

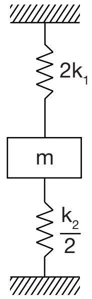
$\therefore \quad x = \dfrac{F_o}{\sqrt{\left(s - m\omega^2\right)^2 - (c\omega)^2}}$

$\therefore \quad x = \dfrac{F_o}{s - m\omega^2}, s = 1400$ N/mm

$\therefore \quad 30 = \dfrac{20}{1400 - m.60^2}$

$\Rightarrow \quad m = 0.3887$ kg $= 388.7$ gms Choice (B)

16. The system is equivalent to



$\therefore$ The equivalent stiffness of the system is

$= 2k_1 + \frac{k_2}{2}$

$k_{eq} = \left(2\times\frac{2}{9}k\right)+\left(\frac{1}{2}\times\frac{4}{3}k\right)=\left(\frac{4}{9}+\frac{2}{3}\right)k=\frac{10}{9}k=\frac{10}{9}\times 9$

$k_{eq} = 10$ N/mm

$\therefore$ Natural frequency of the system

$\omega_n = \sqrt{\frac{k_{eq}}{m}} = \sqrt{\frac{10}{40}} = \frac{1}{2}$ rad/s

$\therefore$ $f_n = \frac{1}{2\pi}\omega_n = \frac{1}{4\pi}$ Hz Choice (D)

17. $\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{20\times 10^3}{120}} = \sqrt{\frac{1000}{6}} = \sqrt{0.1667\times 10^3}$ rad/s

for $m = 100$ kg and $k = 15$ N/m

$\omega_n = \sqrt{\frac{15\times 10^3}{100}} = \sqrt{0.15\times 10^3}$ rad/s Choice (C)

18. $X\sin(\omega t + \beta) = 10\sin(30t) + 20\sin(30t + 125)$

Now expanding both sides

$X\cos\beta = 10 + 20\,\text{Cos}125$

$X\sin\beta = 20\,\text{Sin}125$

$\therefore$ $\text{Tan}\,\beta = \left(\frac{20\,\text{Sin}125}{10+20\cos125}\right) = -0.4784$

$\Rightarrow$ $\beta = -0.4462$ rad $= -25.56^{\circ}$ Choice (A)

19. $x = 12\cos(6\,\pi t) + \frac{5}{2}(\cos 24\pi t)$

$\dot{x} = -12.6\,\pi.\sin(6\pi t) - \frac{5}{2}.24\,\pi.\sin(24\,\pi t)$

$\ddot{x} = -12.(6\,\pi)^2.\cos(6\,\pi t) - \frac{5}{2}.(24\,\pi)^2.\cos(24\,\pi t)$

at $t = \frac{1}{6}$

$\ddot{x} = \pi^2[-12.6^2.\text{Cos}\,\pi - \frac{5}{2}.24^2.\text{Cos}4\,\pi]$

$= \pi^2[432 - 1440]$

$\ddot{x} = -1008\,\pi^2$ mm/s^2 $= -1.008\,\pi^2$m/s^2 Choice (C)

20. $\frac{T}{J} = \frac{G\theta}{L}$

$\frac{T}{\theta} = \frac{GJ}{L}$

$k_t = \frac{T}{\theta} = \frac{GJ}{L}$

$\Rightarrow$ $k_t \propto \frac{J}{L}$

$\therefore \frac{(k_t)_P}{(k_t)_Q} = \left(\frac{J}{L}\right)_P \Big/ \left(\frac{J}{L}\right)_Q$

$\left(\frac{J}{L}\right)_P = \frac{\frac{\pi}{32}d_P^4}{L_P} = \frac{\pi}{32}\times\frac{40^4}{150} = \frac{1600}{3}\pi$

$\left(\frac{J}{L}\right)_Q = \frac{\pi}{32}\times\frac{d_Q^4}{L_Q} = \frac{\pi}{32}\times\frac{80^4}{70} = \frac{128000}{7}\pi$

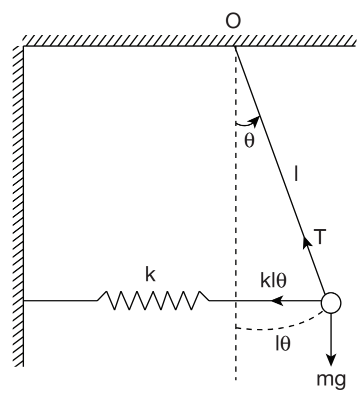
$\therefore \frac{(k_t)_P}{(k_t)_Q} = \frac{1600}{3}\times\frac{7}{128000} = \frac{7}{240} = 0.02916$

Choice (A)

21. θ is anticlockwise, taking moments around pivot O.

$\therefore$ $J\ddot{\theta} = -mg.(l\,\theta) - kl\,\theta(\theta)$

As the mass is concentrated and the rod is light $J = ml^2$



$\therefore$ $ml^2\,\ddot{\theta} = (-mg - k\,\theta)l\,\theta$

$\therefore \ddot{\theta} = -\frac{(mg + k\theta)l\theta}{ml^2}$

When $\theta = \pi/20$

$\Rightarrow$ $\ddot{\theta} = \frac{-\left(20\times 9.81 + 5\times\frac{\pi}{20}\right)\times\frac{\pi}{20}}{20\times 2}$

$\therefore$ $\ddot{\theta} = -0.7735$ rad/s^2 Choice (C)

22. $m = 50$ kg, $k = 12.5$ N/m

$\Rightarrow$ $\omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{12.5}{50}} = \sqrt{\frac{1}{4}} = \frac{1}{2}$ rad/s

Consider the standard solution for the differential equation

$\ddot{x} + \omega_n x = 0$ as $x = A \text{ Sin}\omega_n t + B \text{ Cos}\omega_n t$

$\therefore$ at $t = 0$

$4 = A \text{ Sin}0 + B \text{ Cos}0$

$\Rightarrow$ $B = 4$

$\dot{x} = A\omega_n \text{Cos}\omega_n t - B\omega_n.\text{Sin}\omega_n t$

at $t = 0$

$0 = A\omega_n \text{ Cos } 0 - B\omega_n \text{ Sin}0$

$\Rightarrow$ $A = 0$

$\therefore$ $x = 4 \text{ Cos}\omega_n t = 4 \text{ Cos}t/2$

at $t = 0.5$

$$x = 4 \times \text{Cos}\left(\frac{0.5}{2}\right) = 4 \times 0.969 = 3.876 \text{ mm}$$

Choice (D)

23. Taking the shaft as a simply supported shaft with centre load of 4 kg

$$\omega_n = \sqrt{\frac{g}{\delta}}$$

$$\delta = \frac{mgL^3}{48EI} = \frac{14 \times 9.81 \times 0.6^3}{48 \times 200 \times 10^9 \times \left(\frac{\pi}{64} \times 0.02^4\right)} = 0.3934 \text{ mm}$$

$$\Rightarrow \quad \omega_n = \sqrt{\frac{g}{\delta}} = 157.90 \text{ rad/s}$$

The shaft is rotating at 500 rpm

$$\therefore \omega = \frac{2\pi N}{60} = \frac{\pi \times 500}{30} = 52.36 \text{ rad/s}$$

$\therefore$ The amplitude of vibrations is

$$r = \frac{\left(\frac{\omega}{\omega_n}\right)^2 .e}{1 - \left(\frac{\omega}{\omega_n}\right)^2} = \frac{\left(\frac{52.36}{157.9}\right)^2 \times 0.003}{1 - \left(\frac{52.36}{157.9}\right)^2}$$

$$\therefore \quad r = \frac{0.3316^2 \times 0.003}{1 - 0.3316^2}$$

$r = 3.7 \times 10^{-4}$ m $= 0.370$ mm Choice (D)

24. $5\ddot{x} + 3\ddot{x} + 10x = 20 \text{ Sin}(4\pi t)$ $\rightarrow$ (1)

$m\ddot{x} + c\dot{x} + kx = F_o \text{ Sin}(\omega t)$

$\therefore$ $m = 5$ kg, $c = 3$ Ns/m, $k = 10$ N/m

$F_o = 20$ N, $\omega = 4\pi$ rad/s

Taking the solution as

$x = X \text{ Sin}(\omega t - \phi)$

where, $X = 4 \times 10^{-3}$ m and $\phi = 30^o = \frac{\pi}{6}$ rad

$\Rightarrow \dot{x} = X\omega \text{ Cos}(\omega t - \phi)$ $\rightarrow$ (2)

$\ddot{x} = -X\omega^2 \text{ Sin}(\omega t - \phi)$ $\rightarrow$ (3)

Substituting (2) and (3) in equation (1)

$-5X\omega^2 \text{ Sin}(\omega t - \phi) + 3X\omega \text{ Cos}(\omega t - \phi) + 10X \text{ Sin}(\omega t + \phi) = 20 \text{ Sin}(4\pi t)$

The damping force $= 3X\omega \text{ Cos}(\omega t - \phi)$

$= 3 \times 4 \times 10^{-3} \times 4\pi \times \text{Cos}(4\pi t - \pi/6)$

When $t = 0.5$

Damping force $= 0.1508 \times \text{Cos}(2\pi - \pi/6)$

$= 0.1306$ N Choice (C)

25. $3\ddot{x} + 7\dot{x} + 5x = 0$

$m = 3$kg, $C = 7$ Ns/m, $k = 5$ N/m

$\therefore$ $C_c = 2\sqrt{km} = 2\sqrt{5 \times 3} = 2\sqrt{15}$ Ns/m

C = 7 Ns/m

$$\text{damping factor } \zeta = \frac{C}{C_c} = \frac{2\sqrt{15}}{7} = 0.9037$$

Logarithmic decrement $= \delta$

$$= \frac{2\pi\zeta}{\sqrt{1-\zeta^2}} = \frac{2\pi \times 0.9037}{\sqrt{1 - 0.9037^2}}$$

$\Rightarrow$ $\delta = 13.261$ Choice (B)