Roll No. | | | | | | | | | | | |  Total No. of Pages : 03

Total No. of Questions : 09

B.Tech.(ME) (2011 Onwards)  (Sem.–7,8)

# MECHANICAL VIBRATIONS

Subject Code : BTME-803

Paper ID : [A3064]

Time : 3 Hrs.  Max. Marks : 60

INSTRUCTIONS TO CANDIDATES :

1. SECTION-A is COMPULSORY consisting of TEN questions carrying TWO marks each.
2. SECTION-B contains FIVE questions carrying FIVE marks each and students have to attempt any FOUR questions.
3. SECTION-C contains THREE questions carrying TEN marks each and students have to attempt any TWO questions.



## SECTION-A

Q1 **Write briefly :**

a) If the motion of a particle is represented by $x = A \sin(\omega t) + B \sin(2\omega t)$; determine its velocity at time, $t = 2s$, given: $A = 4$mm, $B = 2$mm and $\omega = 5$ rad/s.

b) Calculate the number of samples ($2k$) that will be recorded per cycle of the fifth harmonic of a 1 kHz periodic signal by a 1 MHz data recorder.

c) Given $V_1 = 4e^{j0}$ and $V_2 = 2e^{j\frac{3\pi}{2}}$; determine analytically the phase-angle $\beta$ of the resultant, $V_R$ with the first vector $V_1$

d) Determine damped natural frequency, $\omega_d$ for a system having mass, $m = 1000$kg, static deflection, $\Delta = 98$mm and damping coefficient, $c = 10^4$ N/m/s. Take g = 9.8 m/s$^2$

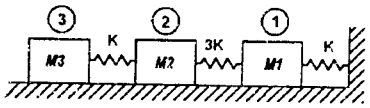
e) Determine the minimum and maximum values for periodic function $f(t) = e^{\sin(\omega t)}$ and without solving, comment whether the constant term $a_0$ in Fourier analysis of this function would be a negative, zero or positive quantity.

f) The damped natural frequency ($\omega_d$) of a system is 86.6Hz, while the maximum amplitude occurs at an exciting frequency ($\omega_p$) of 70.7 Hz. Find the damping factor ($\zeta$) and the undamped natural frequency ($\omega_n$).

g) State the design criteria for acceleration measuring instruments.

h) Applying Euler's theorem to the complex representation of vector $V = 1e^{j\frac{\pi}{2}}$ where $j = \sqrt{-1}$, show that $j^j$ is real.

i) Neglecting friction and inertia forces, determine all nine (flexibility) influence coefficients for the system shown in figure.



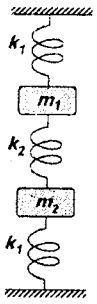

j) Determine the estimate for lowest natural frequency of a 3 DoF system by Dunkerley's method, if its component frequencies are 10. 14 and 20 Hz.

## SECTION-B

Q2 If two harmonic motions $x_1$ and $x_2$ of equal amplitude $X$ and frequencies $\omega_1$ and $\omega_2$ respectively are added, show that their resultant displacement $x$ is in the form of product of a higher and a lower frequency motion.

Q3 Determine the mass $M$ to be placed at the end of the reeds of a Fraham's tachometer so as to get a frequency of 50 rad/s; Given : Length of reed, $L$ = 50mm; width, $w$ = 6mm; thickness, $t$ = 0.5mm; and $E = 19.6 \times 10^{10}$ N/m$^2$.

Q4 For the *2DoF* spring-mass system shown in figure is constrained at both ends. The two springs on sides are identical with a stiffness of $k_1$ = 2000 N m, while the middle spring has a stiffness of $k_2$ = 3000 N/m, $m_1 = m_2$ = 20kg. Determine the two natural frequencies of the system.



Q5 A shaft $AE$ of 50mm diameter and length, $L = 6$m carries three discs at locations $B$, $C$ and $D$ of 1kg each, mounted at a distance of $L_i = 2$, 3 and 4 m from the left end. Find the lowest frequency of vibration by Dunkerley's method. Given, $E = 1.96\times10^{11}$ N/m$^2$, deflection, $y_i = \dfrac{(m_i g)\, L_i^2 (L - L_i)^2}{3EIL}$ for simply supported shaft.

Q6 Starting with the expression for strain energy $u$ during free longitudinal vibrations of a bar of length $L$ and uniform cross-section, determine the normal functions for the boundary conditions as one end fixed and the other end free.

## SECTION-C

Q7 Using analytical method, determine the harmonics of the saw-tooth wave function given by $f(t) = 3t$ for $0 < t < 2$

Q8 A beam having $L = 0.42$m, $I = 1\times10^{-6}$m$^4$ and $E = 1.96\times10^{11}$N/m$^2$ is supporting two masses, $m_1 = 40$kg and $m_2 = 20$kg at distances of 0.16 and 0.24m from left end.

Determine the lowest natural frequency of the system by Rayleigh's method.

Q9 A torque $T_0$ applied at the midpoint of a uniform circular shaft of length $L$ twists it by an angle $\theta_0$ radians. Solve for the resulting motion of the shaft if this torque is released suddenly.