Reg.No.

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
A Constituent Institution of Manipal University

VII SEMESTER B.TECH. (AERONAUTICAL/AUTOMOBILE ENGINEERING)

END SEMESTER EXAMINATIONS, NOV/DEC 2018

SUBJECT: THEORY OF VIBRATIONS [AAE -4101]

REVISED CREDIT SYSTEM

(20/11/2018)

Time: 3 Hours MAX. MARKS: 50

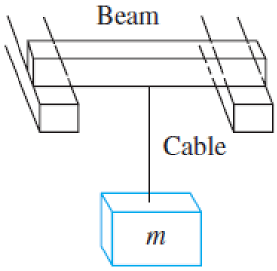
Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Graph sheets may be used

1A. A harmonic function is given by $x(t) = X\cos(120t+\theta)$ mm. Determine the constants of the equation if the initial conditions are $x(0) = 3$ mm and $\dot{x}(0) = 1$ mm/s. **(03)**

1B. An assembly plant uses a hoist to raise and maneuver large objects. The hoist shown in figure 1 is a winch attached to a beam that can move along a track. Determine the natural frequency of the system when the hoist is used to raise a 800-kg machine part at a cable length of 9 m. **(05)**

Beam: $L = 3.1$ m
$E = 200 \times 10^9$ N/m^2
$I = 3.5 \times 10^{-4}$ m^4
Cable: $E = 200 \times 10^9$ N/m^2
$r = 10$ cm
$L = 9$ m



1C. Derive the expression to find the natural frequency of the torsional pendulum **(02)**

2A. A damped spring-mass system has a mass of 15 kg, stiffness coefficient of 1500 N/m and damping coefficient of 450 Ns/m. Plot the displacement of the mass v/s time for 2 cycles. **(04)**

2B. A racing car is modeled as single degree of freedom damped system in the vertical direction. The road profile is assumed to be sinusoidal. The distance between peak and the trough is 0.2 m and the distance between the peaks is 70m. The natural frequency of the system is 2 Hz and the damping ratio is 0.15. Determine the amplitude of vibration of the racing car at 120 km/hour and the most unfavorable speed for the racing car if the speed of the car varies. **(04)**

2C. Derive the equations of motion of a system with a small rotating unbalance of m_o kg. **(02)**

3A. Show that energy dissipated per cycle at resonance in the case of forced vibrations with viscous damping is $(E.D)_{res}/cycle = 2\pi\xi kX^2$ **(03)**

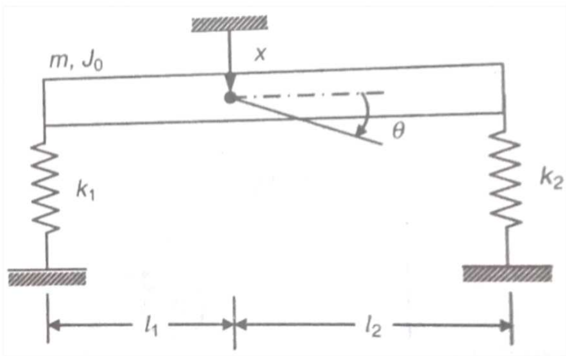
3B. Briefly explain how the phase plots with respect to forced vibrations are useful in designing a vibrometer. **(03)**

3C. It is required to find the damping ratio of a new type of rubber material synthesized in a lab to be used for engine mounts. A forced vibration experiment is conducted, and the results are listed in the table 1 and the graph of transmissibility ratio v/s frequency is also shown in page 3. Determine the natural frequency and the damping ratio of the rubber material. **(04)**

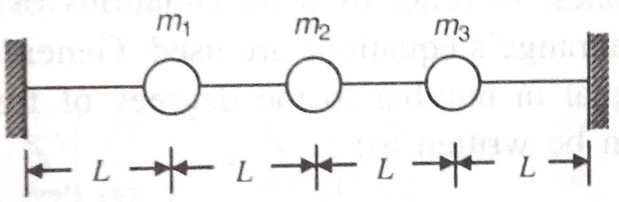
Table 1

Frequency (Hz)	Transmissibility ratio	Frequency (Hz)	Transmissibility ratio
60	1.20	171	18.24
80	1.36	172	20.10
90	1.49	173	21.44
100	1.58	174	21.90
110	1.79	178	15.05
120	2.12	179	12.14
140	2.41	180	10.15
150	3.89	200	2.53
160	6.44	225	2.25
165	10.08	250	1.12
168	12.63	270	0.92
169	14.31	300	0.63
170	16.04	325	0.51

4A. A machine of mass 1500 kg and a mass moment of inertia of 400 kg-m^2 is supported on elastic supports as shown. The stiffness of the supports is k_1=3000 N/m and k_2=2000 N/m and the supports are located from the center of gravity at l_1=0.4 m and l_2= 0.5m. Determine the natural frequencies and the mode shapes. **(05)**

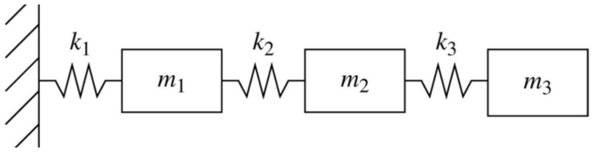


4B. Determine the flexibility influence of coefficients of the following system. Assume the tension to be uniform throughout the length of the string. **(03)**



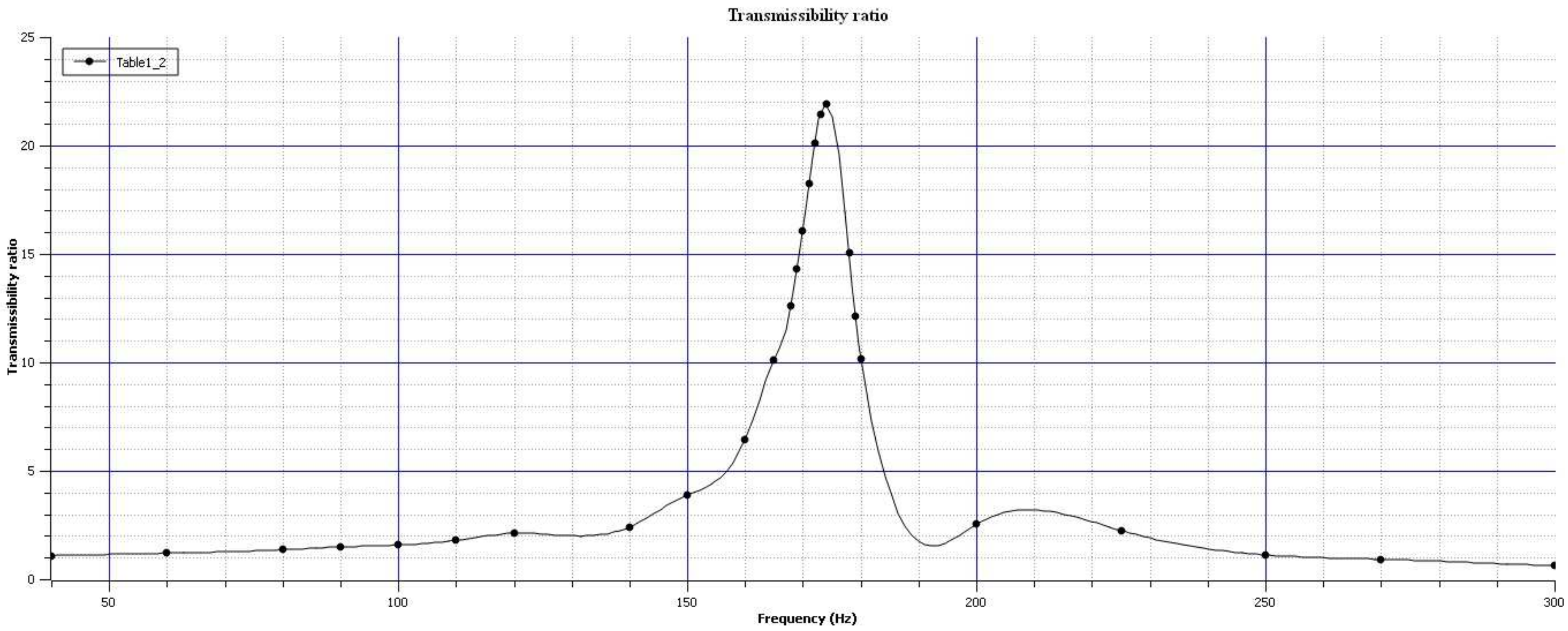
4C. Explain the Stodola method of determining the first natural frequency of a multi degree system. **(02)**

5A. For the system shown below, obtain the principal modes of vibration. It is given that $k_1=k$, $3k_2=2k_3=6k$, $m1=m$,$3m_2=2m_3=6m$. **(06)**



5B. Determine the first natural frequency of the system in question 5A by making use of Rayleigh's method and find the percentage error. **(03)**

5C. What are the assumptions to find the governing equation of longitudinal vibrations of a bar using continuous system approach? **(01)**


Transmissibility ratio
Table1_2
Transmissibility ratio
Frequency (Hz)
0
5
10
15
20
25
50
100
150
200
250
300