INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

MID SPRING SEMESTER EXAMINATION, 2016-2017

SUBJECT-DYNAMICS OF MACHINES (ME22004 & ME 30606) TIME-2 HOURS FULLMARKS-60

ANSWER ALL QUESTIONS. THE QUESTION PAPER CONSISTS OF TWO PAGES. WRITE YOUR ASSUMPTIONS, IF ANY.

NOTATIONS HAVE USUAL MEANINGS. ASSUME DATA IF NECESSARY.

Q1) Determine the undamped natural frequency of small oscillations of the system shown in Figure 1. The uniform disc of mass m has two springs attached as indicated. Assume that the disc rolls without slipping. USE THE RALEIGH METHOD.

(5 MARKS)

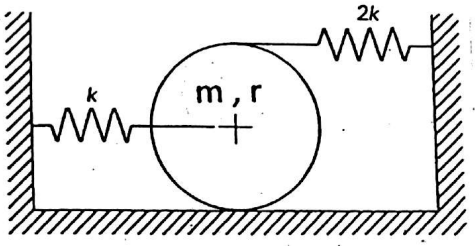

FIG.1

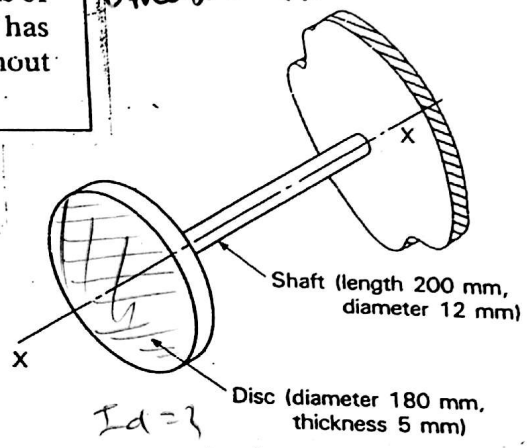

FIG.2

Q2) One end of a solid steel shaft is fixed and a uniform steel disc is attached at its centre to the other end of the shaft. Dimensions of the shaft and disc are shown in Figure 2. The modulus of rigidity G for steel is 8×10^{10} Pa and the density of steel is 7.8×10^3 kg/m^3.

Determine the natural frequency of torsional oscillations of the system.

(8 MARKS)

Q3) The disc of a torsional pendulum has a moment of inertia of 0.6 kg m^2 and is immersed in a viscous fluid. The disc is suspended on a brass shaft which has a diameter of 9.0 mm and length of 400 mm. When the pendulum is oscillating the amplitudes that are observed on the same side of the mid-position for three successive cycles are 14.4°, 1.2° and 0.1°.

Take modulus of rigidity G to be 34.5 GN/m^2 for brass.

Determine:

(a) the logarithmic decrement,
(b) the damping ratio,
(c) the undamped circular natural frequency,
(d) the damped circular natural frequency,
(e) the damping torque at unit angular velocity.

(10 MARKS)

(SEE FIG.3)

(PTO)

Q4) Figure 4 shows a rigid link BCD which can pivot about the axis through C and has a moment of inertia about this axis of 0.25 kg m^2. The spring AB has a stiffness of 700 N/m and the damper DE has a rate of 60 N per m/s; both spring and damper may be assumed to be massless.

The forced displacement *y* of end A of the spring is sinusoidal with a circular frequency of 10 rad/s and an amplitude of 1 cm.

Find the amplitude of angular displacement, assuming this to be small, of the steady-state forced oscillation of link BCD.

(10 MARKS)

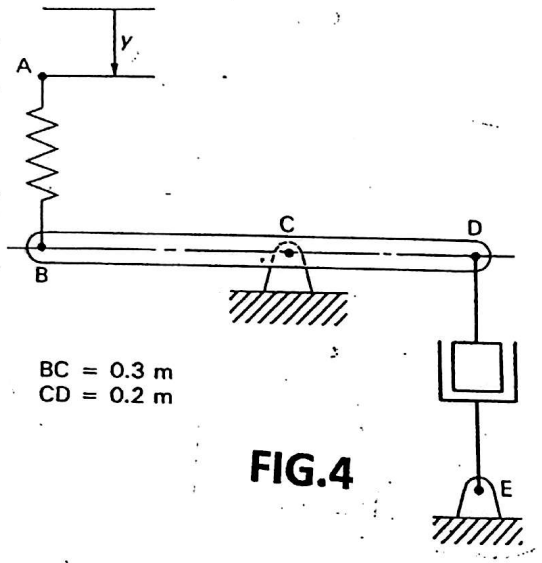

FIG.4

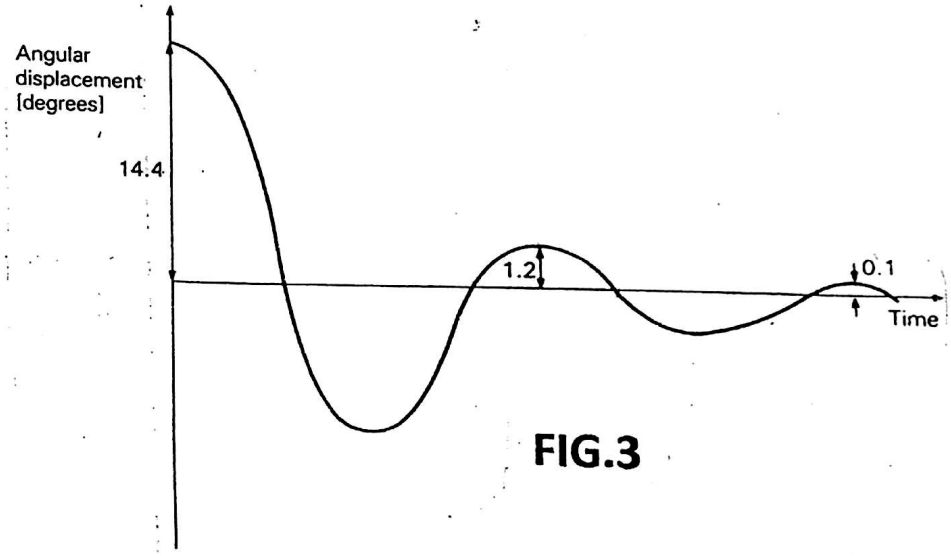

FIG.3

Q5) A body of mass 5.5 kg is hung on a spring of stiffness 1000 N/m. It is pulled down 50 mm below the position of static equilibrium and released so that it executes vertical vibrations. There is a viscous damping force acting on the body of 40 N when the velocity is 1 m/s.

(a) Determine the differential equation of the motion and obtain the expression for the displacement of the body as a function of time.

(b) Calculate the distance the body moves from the instant of release until it is momentarily at rest at the highest point of its travel, and the time that has elapsed when it reaches that position.

(c) Calculate the time that elapses for the body to pass through the equilibrium position for the first time after release.

(20 MARKS)

Q6) A body of mass 100 kg is suspended by a spring of stiffness 30 kN/m and a dashpot of damping constant 1000 N s/m. Vibration is excited by a harmonic force of amplitude 80 N and frequency 3 Hz.

Calculate the amplitude of the displacement for the vibration and the phase angle between the displacement and the excitation force.

(7 MARKS)