Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – V (NEW) EXAMINATION – WINTER 2015

Subject Code: 2152509 **Date:10/12/ 2015**

Subject Name: Machine Dynamics

Time:10:30am to 1:00pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Use drawing sheet/s for graphical solutions & answer books for analytical solutions.**

Q.1 **(a)** Following particular relate to a Wilson-Hartnell governor: **05**

Weight of each ball = 19.0 N; Minimum radius of ball rotation = 12.5 cm; Maximum radius = 17.5 cm; Minimum speed = 240 rpm; Maximum speed = 252 rpm; Length of ball arm of each bell crank lever = 15 cm; Length of sleeve arm of each bell crank lever = 10 cm; Combines stiffness of two ball springs = 1.96 N/cm. Find the equivalent stiffness of the auxiliary spring referred to the sleeve. Assume equal length of auxiliary spring lever arms on two sides of fulcrum.

(b) In a vertical double acting steam engine, the connecting rod is 4.5 times the crank. The mass of the reciprocating parts is 120 kg and the stroke of the piston is 440 mm. The engine runs at 250 rpm. If the net load on the piston due to steam pressure is 30 kN when the crank has turned through an angle of 120^0 from the top dead centre, determine the (i) thrust in the connecting rod (ii) pressure on slide bars (iii) tangential force on the crank pin (iv) thrust on the bearings (v) turning moment on the crank shaft. Solve the problem by analytical method. **09**

Q.2 **(a)** (i) State and explain D'Alembert's principle. **04**

(ii) What is meant by Equivalent offset inertia force? Explain.

(b) Following data refer to a two outside cylinder uncoupled locomotive: **10**

Reciprocating mass per cylinder = 300 kg; Revolving mass per cylinder = 250 kg; Distance between wheels = 1.5 m; Distance between cylinder centers = 1.8 m; Crank radius = 0.325 m; Radius for balancing mass = 0.76 m; Speed of locomotive = 54 kmph; Angle between two cranks = 90^0; Diameter of driving wheels = 1.825 m.

Find: (i) Magnitude & position of balancing mass required in the plane of driving wheels if whole of the revolving mass and $2/3^{rd}$ of the reciprocating masses are to be balanced (ii) Variation in tractive effort (iii) Swaying couple (iv) Hammer blow. Solve the problem by graphical method.

OR

(b) The following data refer to a shaft held in bearings at the ends: **10**

Length of shaft = 1.5 m; Shaft diameter = 20 mm; Mass of rotor at mid span = 18 kg; Eccentricity of rotor center of mass from shaft axis = 0.4 mm; Modulus of elasticity of shaft material = 200 GPa; Allowable stress in the shaft = 75 MPa. Find, neglecting mass of the shaft: (i) Whirling speed of shaft and (ii) Range of speed over which it is unsafe to run the shaft.

Q.3 **(a)** Following data refer to a four cylinder inline engine: **10**

Stroke = 600 mm; Speed of engine = 300 rpm; Reciprocating masses in the 1st & 4th cylinders = 200 kg; Reciprocating masses in the third cylinder = 250 kg; Distance between planes of 1st & 2nd cylinders = 0.4 m; Distance between planes of 2nd & 3rd cylinders = 0.5 m; Angle between masses in planes 1 & 3 is 90^0.

If the primary forces and couples are balanced completely, find: (i) Reciprocating mass in plane 2 & its position and (ii) Spacing between cylinders 3 & 4 & position of mass in plane 4. Solve the problem by graphical method.

(b) Explain the concept of over damping and under damping with the help of displacement-time diagrams for vibrating systems. **04**

OR

Q.3 **(a)** Following data refer to a 60^0 – V engine: **10**
Length of two connecting rods operating on a common crank pin = 200 mm; Stroke = 120 mm; Mass of reciprocating parts per cylinder = 1.12 kg; Engine speed = 2500 rpm. Find: (i) Maximum & minimum values of primary forces (ii) Maximum & minimum values of secondary forces. State the direction of forces and crank positions for maximum & minimum values. Solve the problem by analytical method.

(b) Define the following terms: (i) Transmissibility (ii) Resonance (iii) Critical damping (iv) Whirling speed of shaft **04**

Q.4 **(a)** A governor of the Hartnell type has equal ball of mass 3 kg set initially at a radius of 200 mm. The arms of the bell crank lever are 120 mm vertically and 150 mm horizontally. Find: (i) the initial compressive force on the spring, if the speed for an initial ball radius of 200 mm is 240 rpm and (ii) the stiffness of the spring required to permit a sleeve movement of 4 mm on a fluctuation of 7 per cent in the engine speed. **09**

(b) Explain the following terms for a governor : (i) Stability (ii) Isochronism (iii) Hunting (iv) Controlling force **05**

OR

Q.4 **(a)** A Proell governor has all the four arms of length 250 mm. The upper and lower ends of the arms are pivoted on the axis of rotation of the governor. The extension arms of the lower links are each 100 mm long and parallel to the axis when the radius of ball path is 150 mm. The mass of each ball is 4.5 kg and the central load on the sleeve is 353.2 N. Determine the equilibrium speed of the governor. **09**

(b) Explain with diagram the construction, working & application of a Pickering governor. **05**

Q.5 **(a)** A body of mass 200 kg is resting on a spring-dashpot system. The stiffness of the spring is 18 kN/m and the damping co-efficient of the dashpot is 250 N/m/sec. If the body is subjected to a periodic disturbing force of 1500 N and of frequency equal to 0.75 times the undamped natural frequency, find (i) the amplitude of forced vibration, (ii) dynamic magnification factor, (iii) force transmitted to the support & (iv) transmissibility. **09**

(b) Derive the equation of motion and hence find the natural frequency of vibration for the system shown in figure – 1. Consider the beam to be massless and rigid. Assume a = 0.5 m; L = 1.2 m; b = 0.4 m; m = 5 kg and k = 1500 N/m. **05**

OR

Q.5 **(a)** A steel shaft ABCD as shown in figure – 2, having 2.0 m length, has flywheels at its ends A & D. Flywheel A has mass of 750 kg and radius of gyration of 0.5 m. Flywheel D has mass of 1000 kg and radius of gyration of 0.75 m. The connecting shaft has a diameter of 60 mm for the portion AB which is 0.45 m long & has a diameter of 75 mm for the portion BC which is 0.8 m long and has a diameter 'd' for the portion CD which is 0.75 m long. Determine: **09**

(i) The diameter'd' of the portion 'CD' so that the node of the torsional vibration of the system lies at the center of the length 'BC'.

(ii)The natural frequency of the torsional vibration. Assume G = 0.8 x 10^5 MN/m^2.

(b) Find the lowest natural frequency of the system shown in figure – 3 by Rayleigh's method. The width and thickness of the beam is 50 mm and 25 mm respectively. Assume the beam to be mass less and E = 2.01x10^5 MPa. **05**

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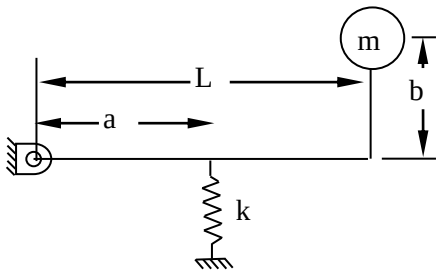

Figure – 1 [**Q.5 (b)**]

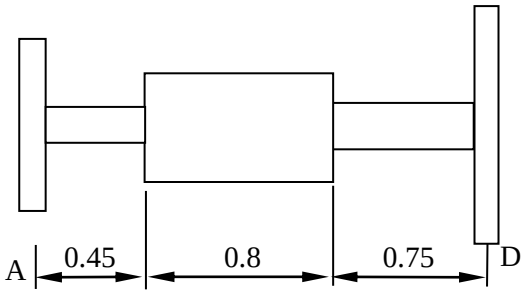

Figure – 2 [**OR Q.5 (a)**]

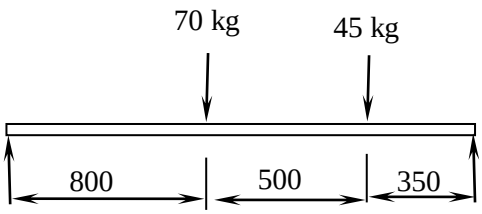

Figure – 3 [**OR Q.5 (b)**]