Enrolment No./Seat No_____

# GUJARAT TECHNOLOGICAL UNIVERSITY

**BE- SEMESTER–V (NEW) EXAMINATION – WINTER 2024**

**Subject Code:3151911 Date:17-12-2024**

**Subject Name:Dynamics of Machinery**

**Time:10:30 AM TO 01:00 PM Total Marks:70**

**Instructions:**

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

| | | | Marks |
|---|---|---|---|
| **Q.1** | **(a)** | What is the significance of inertia forces in reciprocating engines? | **03** |
| | **(b)** | Why is the correction couple applied while considering the inertia of the connecting rod of a reciprocating engine? | **04** |
| | **(c)** | In a vertical double-acting steam engine, the connecting rod is 4.5 times the crank. The weight 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 25 kN when the crank has turned through an angle of 120° from the top dead centre. Solve for thrust in the connecting rod, pressure on slide bars, and tangential force on the crank pin, thrust on the bearings, and turning moment on the crankshaft using the above information. | **07** |
| **Q.2** | **(a)** | Compare the effect of Primary and Secondary Unbalanced Forces of Reciprocating Masses. | **03** |
| | **(b)** | Explain the following terms using neat sketches and equations<br>1. Variation of Tractive Force<br>2. Swaying Couple | **04** |
| | **(c)** | A four-crank engine has two outer cranks set at 120° to each other, and their reciprocating masses are each 400 kg. The distance between the lanes of rotation of adjacent cranks are 450 mm, 750 mm, and 600 mm. If the engine is to be in complete primary balance, find the reciprocating mass and the relative angular position for each of the inner cranks. If the length of each crank is 300 mm, the length of each connecting rod is 1.2 m and the speed of rotation is 240 rpm., Calculate the maximum secondary unbalanced force. | **07** |
| | | **OR** | |
| | **(c)** | A shaft supported in bearings that are 1.6 m apart projects 400 mm beyond bearings at each end. It carries three pulleys one at each end and one at the centre of its length. The masses of the end pulleys are 40 kg and 22 kg and their centres of mass are 12 mm and 18 mm respectively from the shaft axes. The mass of the centre pulley is 38 kg and its centre of mass is 15 mm from the shaft axis. The pulleys are arranged in a manner that gives static balance. Calculate the (i) relative angular positions of the pulleys and (ii) dynamic forces developed on the bearings when the shaft rotates at 210 rpm. | **07** |

**Q.3** **(a)** Illustrate following terms in context to mechanical vibration **03**

1. Period of vibration
2. Cycle
3. Frequency

**(b)** Derive the expression for natural frequency of free longitudinal vibration through "Energy method". **04**

**(c)** The mass of a turbine rotor of a ship is 8000 kg and has a radius of gyration of 0.75 m. It rotates at 1800 rpm clockwise when viewed from the stern. Determine the gyroscopic effects in the following cases: (a) If the ship traveling at 100 km/h steers to the left along a curve of 80 m radius. (b) If the ship is pitching and the bow is descending with maximum velocity. The pitching is with simple harmonic motion with periodic time of 20 s and the total angular movement between extreme positions is 10°. (c) If the ship is rolling with an angular velocity of 0.03 rad/s clockwise when looking from stern. **07**

In each case, determine the direction in which the ship tends to move.

**OR**

**Q.3** **(a)** Explain following terms with neat sketches: **03**

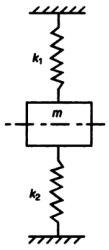
1. Longitudinal vibration
2. Lateral vibration
3. Torsional vibration

**(b)** Derive the expression for natural frequency of free longitudinal vibration through "Rayleigh's method" **04**

**(c)** A turbine rotor of a ship is of 2000 kg mass and has a radius of gyration of 0.8 m. Its speed is 2000 rpm. The ship pitches 5° above and below the mean position. A complete oscillation takes place in 20 s and the motion is simple harmonic. Calculate (a) the maximum couple tending to shear the holding down bolts of the turbine, (b) the maximum acceleration of the ship during pitching, and (c) the direction in which the bow will tend to turn while rising, if the rotation of the rotor is clock-wise, when looking from aft. **07**

**Q.4** **(a)** Discuss the effect of inertia of the shaft in longitudinal and transverse vibrations. **03**

**(b)** Evaluate the natural frequency of a vibratory system shown in figure. The mass of block is m and stiffness of springs are $k_1$ and $k_2$. **04**




**(c)** A spring-mass system consists of a spring of stiffness 350 N/m. The mass is 0.35 kg. The mass is displaced 20 mm beyond the equilibrium position and released. The damping coefficient is 14 Ns/m. Calculate (a) critical damping coefficient, (b) damped natural frequency, and (c) logarithmic decrement. **07**

**OR**

**Q.4** **(a)** Explain the term 'dynamic magnifier'. **03**

**(b)** A cylinder partially depressed slightly and released. Evaluate the natural frequency assuming that it stays upright all the time. Where x = displacement of the cylinder, A = cross sectional area of the cylinder, m = mass of the cylinder, ρ = specific gravity of the river water. **04**

**(c)** A vibrating system consists of a mass of 30 kg, a spring of stiffness 20 kN/m and a damper of damping factor 0.25. Calculate: **07**
(a) the critical damping coefficient
(b) the natural frequency of damped vibrations
(c) the logarithmic decrement, and
(d) the ratio of two successive amplitudes.

**Q.5** **(a)** Compare the displacement-time curves for following damping conditions. **03**
1. Under damped
2. Over damped
3. Critically damped

**(b)** Represent the expression for natural frequency of free transverse vibrations. **04**

**(c)** The rotor of a turbine of mass 15 kg is supported at the mid-span of a shaft of span 0.4 m. The rotor has an unbalance of 0.003 kg m. Determine the force exerted on the bearings at a speed of 6000 rpm. The diameter of steel shaft is 25 mm and E = 200 Gpa. **07**

**OR**

**Q.5** **(a)** Explain logarithmic decrement for free damped vibration **03**

**(b)** Illustrate all the forces graphically for forced damped vibration. **04**

**(c)** A circular disc having 10 kg mass in mounted at mid span of 25 mm diameter shaft supported by two bearings. Due to manufacturing inaccuracy, the mass centre is shifted by 0.025 mm away from the geometric centre of the disc of the span between two bearings is 500 mm and the shaft rotates at 4000 rpm, determine the amplitude of vibration and reactions on the bearings. Take modulus of elasticity $E = 2 \times 10^{11}$ N/mm$^2$ **07**

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