GUJARAT TECHNOLOGICAL UNIVERSITY

BE-5 SEMESTER – OLD PAPER – S22 TO S26 – QUESTION BANK

Subject Name & Code: Dynamics of Machinery - 3151911

Chapter 1: Dynamic Force Analysis of Mechanisms

Repeated Questions:

1. State and Explain D'Alembert's Principle:

- **Q.** State and explain D'Alembert's Principle. **(SUMMER 2022, 4 Marks; WINTER 2023, 3 Marks; SUMMER 2025, 3 Marks; SUMMER 2026, 3 Marks)**

2. Analytical Method for Slider-Crank Mechanism (Numerical):

- **Q.** In a slider crank mechanism, the length of the crank and connecting rod are 150 mm and 600 mm respectively. The crank position is 60° from IDC. The crank shaft speed is 450 rpm. Using analytical method, determine: (i) Velocity and acceleration of the slider, (ii) Angular velocity and angular acceleration of the connecting rod. **(SUMMER 2022, 7 Marks OR; SUMMER 2023, 7 Marks OR)**

3. Forces in IC Engine / Steam Engine Mechanism (Numerical):

- **Q.** Find (i) thrust on connecting rod, (ii) piston side thrust, (iii) torque acting on the crank shaft, (iv) load on main bearings when crank is at a given angle. (Variants exist for steam engines.) **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**

4. Inertia Force and Inertia Couple:

- **Q.** Define Inertia Force and Inertia Couple. **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks)**

Other Important Questions:

1. Dynamically Equivalent System:

- **Q.** Explain the Dynamical Equivalent System of two masses. **(SUMMER 2024, 4 Marks)**
- **Q.** What are the requirements of an equivalent dynamical system? **(WINTER 2022, 3 Marks)**

2. Inertia Torque Calculation (Numerical):

- **Q.** Determine the inertia torque on the crankshaft when the crank has turned 40° from IDC. (Data for reciprocating parts and connecting rod inertia is given.) **(SUMMER 2025, 7 Marks)**

3. Piston Effort and Force along the Connecting Rod:

- **Q.** Analyze forces like Piston effort and force acting along the connecting rod. **(SUMMER 2024, 7 Marks)**

4. Inertia Force in Slider-Crank Mechanism (Numerical):

- **Q.** Calculate the inertia force in a slider-crank mechanism given crank speed and dimensions. **(SUMMER 2026, 4 Marks)**

Chapter 2: Turning Moment Diagrams and Flywheels

Repeated Questions:

1. Flywheel Design for Multi-cylinder Engine (Numerical):

- **Q.** The turning moment diagram for a multi-cylinder engine is given (scale and areas provided). If the total fluctuation of speed is not to exceed ±x% of the mean, find the necessary mass of the flywheel of radius R. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; WINTER 2025, 7 Marks)**

2. Flywheel in Punching Press (Numerical):

- **Q.** A flywheel is attached to a punching press. Given max/min speed, energy per hole, punching time, etc., find (i) power required by the motor, and (ii) mass of the flywheel. **(WINTER 2023, 7 Marks OR; SUMMER 2025, 7 Marks)**

3. Draw and Explain Turning Moment Diagrams:

- **Q.** Draw the turning moment diagram for a four-stroke IC engine / multi-cylinder engine. **(SUMMER 2022, 4 Marks; WINTER 2023, 4 Marks)**

4. Define Key Terms:

- **Q.** Define: Coefficient of Fluctuation of Energy, Coefficient of Fluctuation of Speed, Maximum Fluctuation of Energy. **(WINTER 2022, 3 Marks; WINTER 2023, 3 Marks; WINTER 2025, 4 Marks)**

Other Important Questions:

1. Role of a Flywheel:

- **Q.** Explain the role of a flywheel. How does it differ from a governor? **(SUMMER 2025, 4 Marks)**

2. Single-cylinder Engine Flywheel (Numerical):

- **Q.** A single cylinder, four-stroke gas engine develops X kW at Y rpm. The work done during expansion is Z times the work during compression. If the total fluctuation of speed is not to exceed ±4%, find the moment of inertia of the flywheel. **(WINTER 2022, 7 Marks)**

3. Turning Moment Diagram – Single-cylinder vs Multi-cylinder:

- **Q.** Compare the characteristics of turning moment diagram for a single cylinder engine and multi-cylinder engine. **(SUMMER 2026, 4 Marks)**

4. Flywheel in Punching Presses (Theory):

- **Q.** Analyze the role of a flywheel in punching presses. **(SUMMER 2026, 4 Marks OR)**

Chapter 3: Balancing of Inertia Forces and Couples

Repeated Questions:

1. Balancing of Masses in Different Planes (Numerical):

- **Q.** X number of masses (with given mass, radius, angular position, and axial plane distances) are to be completely balanced by two masses in planes P and Q. Find the magnitude and angular position of the balancing masses. **(WINTER 2022, 7 Marks; SUMMER 2023, 7 Marks; WINTER 2023, 7 Marks; WINTER 2025, 7 Marks)**

2. Static and Dynamic Balancing:

- **Q.** Difference between Static and Dynamic Balancing. **(SUMMER 2022, 4 Marks; SUMMER 2024, 4 Marks; WINTER 2025, 3 Marks; SUMMER 2026, 3 Marks)**

3. Partial Balancing of Reciprocating Masses:

- **Q.** Explain why only a part of the unbalanced force due to reciprocating masses is balanced. **(SUMMER 2022, 4 Marks; WINTER 2022, 3 Marks)**

4. Balancing of Inline and V-Engines:

- **Q.** Explain the procedure of balancing of inline engines / V-engines. **(SUMMER 2022, 7 Marks; SUMMER 2023, 4 Marks; WINTER 2023, 4 Marks; SUMMER 2025, 7 Marks)**

5. Balancing of Multi-cylinder Inline Engine (Primary/Secondary Forces):

- **Q.** For an in-line four/six-cylinder engine, examine the engine for the balance of primary and secondary forces and couples. Find the maximum unbalanced forces and couples. **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**

6. Need and Effects of Balancing:

- **Q.** Explain the need for balancing and the effects of unbalancing. **(SUMMER 2022, 3 Marks; WINTER 2023, 3 Marks)**

Other Important Questions:

1. Balancing of Rotating Parts in High-Speed Systems:

- **Q.** "The balancing of rotating parts is crucial for high speed systems." Justify the statement. **(WINTER 2025, 4 Marks)**

2. Balancing of Reciprocating Masses (Theory):

- **Q.** Explain the concept of primary and secondary balancing in reciprocating engines. **(SUMMER 2026, 4 Marks)**
- **Q.** Explain the partial balancing of primary unbalanced forces in single cylinder reciprocating engine. **(SUMMER 2026, 4 Marks OR)**
- **Q.** Define imaginary crank using neat sketch with regard to the balancing of reciprocating secondary unbalanced forces. **(SUMMER 2026, 3 Marks OR)**

3. Partial Balancing in Locomotives (Theory):

- **Q.** Explain the effects of partial balancing in locomotives (Variation of Tractive Force, Swaying Couple). **(WINTER 2024, 4 Marks)**
- **Q.** Derive the equation for the following terms pertaining to locomotives: i) Tractive force ii) Swaying couple iii) Hammer blow. **(WINTER 2025, 7 Marks OR)**

4. Locomotive Balancing (Numerical):

- **Q.** For an inside cylinder locomotive, if X% of reciprocating masses are to be balanced, determine the magnitude and angular position of balanced masses in the plane of wheels. **(SUMMER 2025, 7 Marks)**
- **Q.** The following data refer to an outside cylinder uncoupled locomotive: Mass of rotating parts per cylinder = 350 kg, Mass of reciprocating parts per cylinder = 300 kg, Angle between cranks =

90°, Crank radius = 0.3 m, Cylinder centers = 1.8 m, Radius of balance masses = 0.8 m, Wheel centers = 1.5 m. If whole of the rotating and 2/3rd of the reciprocating parts is to be balanced in planes of the driving wheels, find (a) magnitude and angular positions of balance masses, (b) speed in km/h at which the wheel will lift off the rails when the load on each driving wheel is 30 kN, and the diameter of tread of driving wheels is 1.8 m. **(SUMMER 2026, 7 Marks)**

5. V-Engine Balancing (Numerical):

- **Q.** A twin cylinder V-engine has the cylinders set at an angle of 45°. The connecting rods are 30 cm long and the crank radius is 70 mm. The total rotating mass is equivalent to 3 kg at the crank radius and the reciprocating parts mass is 2 kg per line. A balance mass is fitted opposite to the crank equivalent to 2.5 kg at a radius of 10 cm. The engine speed is 2000 rpm. What is the value of the maximum resultant secondary force? **(SUMMER 2026, 7 Marks OR)**

Chapter 4: Gyroscope

Repeated Questions:

1. Gyroscopic Effect on a Naval Ship (Numerical):

- **Q.** The rotor of a turbine of a ship has a mass M, radius of gyration k, and speed N rpm. Determine the gyroscopic couple and its effect when: (a) The ship steers left/right on a curve of radius R at speed V. (b) The ship pitches with a simple harmonic motion (given period and angular displacement). (c) The ship rolls. **(WINTER 2022, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks; SUMMER 2025, 7 Marks; WINTER 2025, 7 Marks)**

2. Gyroscopic Couple:

- **Q.** What do you understand by a gyroscopic couple? Derive a formula for its magnitude. **(SUMMER 2022, 4 Marks; SUMMER 2023, 4 Marks)**

3. Gyroscopic Effect on an Aeroplane:

- **Q.** Explain the effect of the gyroscopic couple on an aircraft while taking a turn. (Often requires a sketch and stating the equation.) **(SUMMER 2022, 4 Marks; SUMMER 2025, 4 Marks)**

4. Active and Reactive Gyroscopic Couple:

- **Q.** Explain with a neat sketch: (i) Active Gyroscopic Couple (ii) Reactive Gyroscopic Couple. **(WINTER 2022, 4 Marks; WINTER 2023, 4 Marks)**

Other Important Questions:

1. Gyroscopic Effect on an Automobile / Four-Wheel Vehicle:

- **Q.** Explain the effect of the gyroscopic and centrifugal couple on the reaction of the four wheels of a vehicle negotiating a curve. **(SUMMER 2022, 7 Marks)**
- **Q.** A four-wheeled motor car takes a turn. Find the load on each wheel. (Involves considering both centrifugal and gyroscopic effects.) **(SUMMER 2023, 7 Marks)**

2. Gyroscope Terminology:

- **Q.** Define: i) Axis of spin ii) Plane of Precession iii) Axis of Gyroscopic Reaction iv) Plane of Gyroscopic Couple. Show each in an illustrative diagram. **(WINTER 2025, 3 Marks)**

3. Gyroscopic Effect on a Two-Wheeler:

- **Q.** Analyze the effect of gyroscopic couple on the stability of a two-wheeler during a turn. **(SUMMER 2026, 3 Marks)**

4. Gyroscopic Effect on an Aeroplane (Numerical):

- **Q.** An aeroplane makes a complete half circle of 60 m radius towards left when flying at 250 km/h. The rotary engine and the propeller of the plane have a mass of 450 kg with a radius of gyration of 300 mm. The engine runs at 2400 rpm clockwise when viewed from the rear. Find the gyroscopic effect on the aircraft. **(SUMMER 2026, 4 Marks)**

Chapter 5: Free and Damped Free Vibration / Torsional Vibration

Repeated Questions:

1. Damped Free Vibration Parameters (Numerical):

- **Q.** A damped system has a mass M. It is observed that it makes X oscillations in Y seconds. The amplitude reduces to Z of its initial value after W cycles. Determine: (i) Stiffness, (ii) Logarithmic Decrement, (iii) Damping Factor, (iv) Damping Coefficient. **(SUMMER 2022, 7 Marks; SUMMER 2024, 7 Marks; WINTER 2024, 7 Marks)**

2. Define Key Terms:

- **Q.** Define: Natural Frequency, Damping, Forced Vibration, Free Vibration, Resonance. **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; WINTER 2023, 3 Marks; SUMMER 2025, 3 Marks; WINTER 2025, 3 Marks)**

3. Logarithmic Decrement & Damping Factor from Successive Amplitudes (Numerical):

- **Q.** The successive amplitudes of vibrations are A1, A2, A3… Determine the logarithmic decrement and damping factor. **(WINTER 2022, 7 Marks; WINTER 2023, 7 Marks)**

4. Natural Frequency of Spring-Mass System (Numerical):

- **Q.** Find the natural frequency of the system shown in the figure. (Involves finding equivalent stiffness for combinations of springs.) [Diagram required – refer to the original question paper] **(WINTER 2022, 7 Marks; SUMMER 2023, 7 Marks; SUMMER 2025, 7 Marks OR)**

5. Types of Damping:

- **Q.** Compare the displacement-time curves for Underdamped, Overdamped, and Critically damped systems. **(WINTER 2022, 3 Marks; WINTER 2024, 4 Marks)**
- **Q.** List the types of damping and explain any one. / Explain the method of dry friction damping. **(WINTER 2023, 3 Marks; SUMMER 2025, 3 Marks; WINTER 2025, 4 Marks OR)**

6. Critically Damped System:

- **Q.** Derive equation for critically damped system. **(WINTER 2022, 4 Marks OR; SUMMER 2025, 4 Marks)**

Other Important Questions:

1. Torsional Vibration (Theory):

- **Q.** Derive an expression for the natural frequency of torsional vibration of a disc connected at the end of a shaft. **(WINTER 2023, 3 Marks)**

2. Torsional Vibration (Numerical):

- **Q.** Two rotors A and B are attached to a shaft. Find the position of the node and the natural frequency of torsional vibration. **(SUMMER 2022, 7 Marks)**
- **Q.** Analyze a three-rotor torsional vibration system and determine its natural frequencies. **(SUMMER 2026, 7 Marks)**
- **Q.** A motor drives a centrifugal pump through gearing. The speed of the pump is one-third of the speed of the motor. The diameter of pinion shaft is 40 mm and it is 300 mm long. The mass moment of inertia of motor is 400 kg·m². The gear shaft, on which impeller of centrifugal pump is mounted, has 60 mm diameter and is 600 mm long. The mass moment of inertia of the impeller is 1500 kg·m². Neglecting the inertia of gear and pinion, determine the natural frequency of torsional vibration. **(SUMMER 2026, 7 Marks OR)**

3. Logarithmic Decrement:

- **Q.** Define Logarithmic Decrement and derive expression of it with usual notations. **(WINTER 2025, 4 Marks)**
- **Q.** Explain logarithmic decrement and its use. **(SUMMER 2026, 3 Marks)**

4. Causes, Effects and Types of Vibration:

- **Q.** What are the causes and effects of vibrations? **(WINTER 2025, 3 Marks)**
- **Q.** Discuss briefly with neat sketches the longitudinal, transverse and torsion, free vibrations. **(WINTER 2025, 4 Marks)**

5. Longitudinal and Transverse Vibration of a Shaft (Numerical):

- **Q.** A cantilever shaft 50 mm diameter and 300 mm long has a disc of mass 100 kg at its free end. The Young's modulus for the shaft material is 200 GN/m². Determine the frequency of longitudinal and transverse vibrations of the shaft. **(WINTER 2025, 7 Marks)**

Chapter 6: Forced Vibration, Damping Response and Vibration Isolation

Repeated Questions:

1. Forced Vibration due to Rotating Unbalance (Numerical):

- **Q.** A machine of mass M is supported on springs of total stiffness K. It has a rotating unbalance force F at a speed of N rpm. If the damping factor is ζ, determine: (i) the amplitude of forced vibration, (ii) the transmissibility, and (iii) the force transmitted. **(WINTER 2022, 7 Marks; SUMMER 2023, 7 Marks; SUMMER 2025, 7 Marks)**

2. Force Transmissibility:

- **Q.** Draw the force transmissibility curve and explain the three regions of vibration control. **(WINTER 2023, 4 Marks; SUMMER 2025, 3 Marks)**

3. Vibration Isolation:

- **Q.** Explain vibration isolation in detail. / What is vibration isolation? List materials used. **(WINTER 2022, 3 Marks; WINTER 2023, 3 Marks; SUMMER 2025, 3 Marks; SUMMER 2026, 3 Marks OR)**

4. Analysis of a Vibrating System with Damping (Numerical):

- **Q.** A vibrating system is defined by m, k, and c. Determine: (i) Damping factor, (ii) Damped natural frequency, (iii) Logarithmic decrement, (iv) Ratio of two consecutive amplitudes. **(WINTER 2022, 7 Marks; SUMMER 2026, 7 Marks; SUMMER 2026, 7 Marks OR)**

5. Equation of Motion for Forced Damped Vibration:

- **Q.** Solve the equation of motion for a forced damped vibration by graphical method. / Illustrate all the forces graphically for forced damped vibration. **(SUMMER 2024, 3 Marks; WINTER 2024, 3 Marks)**

Other Important Questions:

1. Magnification Factor:

- **Q.** Explain the term Magnification Factor and obtain an expression for it. **(SUMMER 2022, 3 Marks)**
- **Q.** Define Magnification Factor and Frequency Ratio. **(WINTER 2025, 3 Marks OR)**

2. Forced Vibration of an Engine on a Chassis (Numerical):

- **Q.** A single cylinder vertical petrol engine of total mass 300 kg is mounted upon a steel chassis frame and causes a vertical static deflection of 2 mm. The reciprocating parts of the engine has a mass of 20 kg and move through a vertical stroke of 150 mm with simple harmonic motion. A dashpot is provided whose damping resistance is directly proportional to the velocity and amounts to 1.5 kN per meter per second. Examine the effect of forced vibration considering that the steady state of vibration is reached and determine the amplitude of forced vibrations, when the driving shaft of the engine rotates at 480 r.p.m, and the speed of the driving shaft at which resonance will occur. **(SUMMER 2026, 7 Marks)**

3. Effect of Damping on Forced Vibration:

- **Q.** Analyze the effect of damping on frequency forced vibrations under under-damped condition using graphical method. **(SUMMER 2026, 7 Marks OR)**

Chapter 7: Critical / Whirling Speed and Shaft Vibrations

Repeated Questions:

1. Critical / Whirling Speed of a Shaft:

- **Q.** Explain the whirling speed of a shaft. / Define critical or whirling speed of a shaft. **(WINTER 2023, 3 Marks; SUMMER 2024, 3 Marks)**
- **Q.** Derive the formula for the critical speed of a shaft carrying a single rotor without damping. **(WINTER 2023, 4 Marks; SUMMER 2025, 4 Marks)**

2. Critical Speed using Dunkerley's Method (Numerical):

- **Q.** A shaft of length L and diameter D, simply supported, carries multiple rotors. Find the critical speed of the shaft using Dunkerley's method. **(SUMMER 2024, 7 Marks; SUMMER 2025, 7 Marks)**

3. Shaft with Single Rotor (Numerical):

- **Q.** A rotor of mass M is mounted midway on a shaft of diameter D and length L. The CG is offset by e. If the rotor rotates at N rpm, find the amplitude of steady-state vibrations and the dynamic force transmitted to the bearings. Neglect damping. **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**

Other Important Questions:

1. Critical Speed considering Shaft Mass (Numerical):

- **Q.** A shaft of length L, supported at ends, carries two wheels. The shaft is hollow (given dimensions). Taking into account the mass of the shaft, find the lowest whirling speed. **(SUMMER 2024, 7 Marks OR)**

2. Whirling of Shafts (Theory):

- **Q.** Explain the term 'Half frequency whirl'. Derive the governing equation for the same. **(WINTER 2025, 7 Marks)**
- **Q.** With usual notations; Derive the equation to find the natural frequency of shaft carrying several loads undergoes transverse vibrations using Dunkerley's method. **(WINTER 2025, 7 Marks OR)**
- **Q.** Prove that the critical or whirling speed is the same as the natural frequency of transverse vibration with usual notations. **(WINTER 2025, 4 Marks)**

3. Critical Speed – Resonance, Damping and Safety:

- **Q.** Propose design modifications to prevent resonance in high-speed rotors. **(SUMMER 2026, 3 Marks)**
- **Q.** Propose safety considerations for operating near critical speed. **(SUMMER 2026, 3 Marks OR)**
- **Q.** Analyze the effect of damping on the critical speed of a horizontal shaft. **(SUMMER 2026, 4 Marks)**
- **Q.** Examine the effect of resonance in rotating shafts. **(SUMMER 2026, 4 Marks OR)**

4. Fundamental Frequency of a Shaft with Two Discs (Numerical):

- **Q.** A solid shaft of uniform diameter is supported by two short bearings as shown in Figure 1. The above shaft carries two discs having concentrated masses of 60 kg and 100 kg respectively. Determine the fundamental frequency of vibration if the moment of inertia of the shaft is 40×10^4 mm^4 and damping at the bearing is neglected. [Diagram required – refer to the original question paper] **(SUMMER 2026, 7 Marks)**

Chapter 8: Uncategorised Questions

Repeated Questions:

None identified.

Other Important Questions:

1. Statics (Lami's Theorem):

- **Q.** State Lami's theorem and give suitable example. **(WINTER 2025, 3 Marks)**

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