

**Department : Mechanical Engineering**

**Year & Semester : III & V**

**Sub Code & Sub Name : 23MEC311T & Dynamics of Machinery**

**Unit-I**

<b>S.No</b>	<b>Part-A Questions</b>
1.	Write a short note on gyroscope.
2.	What do you understand by gyroscopic couple ? Derive a formula for its magnitude.
3.	Explain the application of gyroscopic principles to aircrafts.
4.	Describe the gyroscopic effect on sea going vessels.
5.	Define steering ,pitching and rolling.
6.	Discuss briefly the various types of friction experienced by a body.
7.	State the laws of (i) Static friction ; (ii) Dynamic friction ;
8.	State the laws of (i) Solid friction ; (ii) Fluid friction.
9.	Explain the following : (i) Limiting friction, (ii) Angle of friction
10.	Explain the following: (i)Pitch (ii) lead
11.	Differentiate between pivot and collar bearing
12.	What is meant by the expression 'friction circle'?
13.	What is limiting angle of friction?
14.	What is angle of Repose?
15.	What is over hauling and self locking screws?

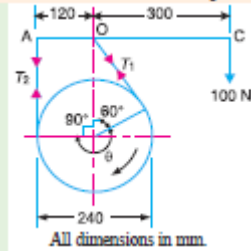
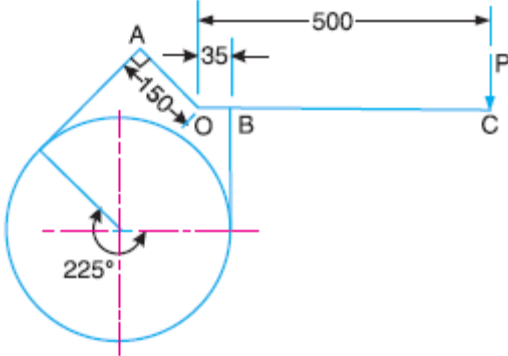
<b>S.No</b>	<b>Part-B Questions</b>
1.	A uniform disc of diameter 300 mm and of mass 5 kg is mounted on one end of an arm of length 600 mm. The other end of the arm is free to rotate in a universal bearing. If the disc rotates about the arm with a speed of 300 r.p.m. clockwise, looking from the front, with what speed will it precess about the vertical axis?
2.	An aeroplane makes a complete half circle of 50 metres radius, towards left, when flying at 200 km per hr. The rotary engine and the propeller of the plane has a mass of 400 kg and a radius of gyration of 0.3 m. The engine rotates at 2400 r.p.m. clockwise when viewed from the rear. Find the gyroscopic couple on the aircraft and state its effect on it.
3.	The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 r.p.m. clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship: 1. when the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h. 2. when the ship is pitching in a simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 40 seconds and the total angular displacement between the two extreme positions of pitching is 12 degrees.
4.	A four wheeled motor car of mass 2000 kg has a wheel base 2.5 m, track width 1.5 m and height of centre of gravity 500 mm above the ground level and lies at 1 metre from the front axle. Each wheel has an effective diameter of 0.8 m and a moment of inertia of 0.8 kg-m <sup>2</sup> . The drive shaft, engine flywheel and transmission are rotating at 4 times the speed of road wheel, in a clockwise direction when viewed from the front, and is equivalent to a mass of 75 kg having a radius of gyration of 100 mm. If the car is taking a right turn of 60 m radius at 60 km/h, find the load on each wheel.
5.	Find the angle of inclination with respect to the vertical of a two wheeler negotiating a turn. Given : combined mass of the vehicle with its rider 250 kg ; moment of inertia of the engine flywheel 0.3 kg-m <sup>2</sup> ; moment of inertia of each road wheel 1 kg-m <sup>2</sup> ; speed of engine flywheel 5 times that of road wheels and in the same direction ; height of centre of gravity of rider with vehicle 0.6 m ; two wheeler speed 90 km/h ; wheel radius 300 mm ; radius of turn 50 m.

6.	An effort of 1500 N is required to just move a certain body up an inclined plane of angle $12^\circ$ , force acting parallel to the plane. If the angle of inclination is increased to $15^\circ$ , then the effort required is 1720 N. Find the weight of the body and the coefficient of friction.
7.	A conical pivot supports a load of 20 kN, the cone angle is $120^\circ$ and the intensity of normal pressure is not to exceed $0.3 \text{ N/mm}^2$ . The external diameter is twice the internal diameter. Find the outer and inner radii of the bearing surface. If the shaft rotates at 200 r.p.m. and the coefficient of friction is 0.1, find the power absorbed in friction. Assume uniform pressure.
8.	Derive from first principles an expression for the friction moment of a conical pivot assuming (i) Uniform pressure, and (ii) Uniform wear.
9.	Derive from first principles an expression for the effort required to raise a load with a screw jack taking friction into consideration.
10.	The thrust of a propeller shaft in a marine engine is taken up by a number of collars integral with the shaft which is 300 mm in diameter. The thrust on the shaft is 200 kN and the speed is 75 r.p.m. Taking $\mu$ constant and equal to 0.05 and assuming intensity of pressure as uniform and equal to $0.3 \text{ N/mm}^2$ , find the external diameter of the collars and the number of collars required, if the power lost in friction is not to exceed 16 kW.

## Unit-II

S.No	Part-A Questions
1.	Explain different types of clutches.
2.	Differentiate between bearing and clutch.
3.	Sketch single plate clutch.
4.	Sketch multi plate clutch.
5.	Differentiate between single plate and cone clutch.
6.	Write down characteristics for brake lining.
7.	Describe the construction and operation of a prony brake or rope brake absorption dynamometer.
8.	Distinguish between brakes and dynamometers
9.	Discuss the various types of the brakes.
10.	What are the types of dynamometers?
11.	Differentiate between single shoe and band and block brake?
12.	Sketch neatly with belt transmission dynamometers?
13.	Differentiate between differential and simple band brake?
14.	Write down some materials value of coefficient of friction?
15.	Differentiate between single and double block brake?

S.No	Part-B Questions
1.	<p>A band brake acts on the 3/4th of circumference of a drum of 450 mm diameter which is keyed to the shaft. The band brake provides a braking torque of 225 N-m. One end of the band is attached to a fulcrum pin of the lever and the other end to a pin 100 mm from the fulcrum. If the operating force is applied at 500 mm from the fulcrum and the coefficient of friction is 0.25, find the operating force when the drum rotates in the <b>(a)</b> anticlockwise direction, and <b>(b)</b> clockwise direction.</p>
2.	<p>A single block brake, as shown in Fig. has the drum diameter 250 mm. The angle of contact is 90° and the coefficient of friction between the drum and the lining is 0.35. If the operating force of 650 N is applied at the end of the lever, determine the torque that may be transmitted by the block brake.</p> <div style="text-align: center;"> </div>
3.	<p>The simple band brake, as shown in Fig., is applied to a shaft carrying a flywheel of mass 400 kg. The radius of gyration of the flywheel is 450 mm and runs at 300 r.p.m. If the coefficient of friction is 0.2 and the brake drum diameter is 240 mm, find :</p> <ol style="list-style-type: none"> <li>1. the torque applied due to a hand load of 100 N,</li> <li>2. the number of turns of the wheel before it is brought to rest,</li> <li>and 3. the time required to bring it to rest, from the moment of the application of the brake.</li> </ol>

	
<p>4.</p>	<p>A differential band brake, as shown in Fig., has an angle of contact of <math>225^\circ</math>. The band has a compressed woven lining and bears against a cast iron drum of 350 mm diameter. The brake is to sustain a torque of 350 N-m and the coefficient of friction between the band and the drum is 0.3. Find : <b>1.</b> The necessary force (P) for the clockwise and anticlockwise rotation of the drum;</p>  <p style="text-align: center;">All dimensions in mm.</p>
<p>5.</p>	<p>Describe the construction and operation of a prony brake or rope brake absorption dynamometer.</p>
<p>6.</p>	<p>Describe with sketches one form of torsion dynamometer and explain with detail the calculations involved in finding the power transmitted.</p>
<p>7.</p>	<p>Describe with a neat sketch the working of a single plate friction clutch.</p>
<p>8.</p>	<p>A band and block brake, having 14 blocks each of which subtends an angle of <math>15^\circ</math> at the centre, is applied to a drum of 1 m effective diameter. The drum and flywheel mounted on the same shaft has a mass of 2000 kg and a combined radius of gyration of 500 mm. The two ends of the band are attached to pins on opposite sides of the brake lever at distances of 30 mm and 120 mm from the fulcrum. If a force of 200 N is applied at a distance of 750 mm from the fulcrum, find: <b>1.</b> maximum braking torque, <b>2.</b> angular retardation of the drum, and <b>3.</b> time taken by the system to come to rest from the rated speed of 360 r.p.m. The coefficient of friction between blocks and drum may be taken as 0.25.</p>

### Unit-III

S.No	Part-A Questions
1.	Define 'inertia force' and 'inertia torque'.
2.	What is the difference between piston effort, crank effort and crank-pin effort?
3.	How the velocity of the slider of a single slider crank chain determined analytically?
4.	How the acceleration of the slider of a single slider crank chain determined analytically?
5.	Explain Klien's construction for determining the velocity of the piston in a slider crank mechanism.
6.	Explain Klien's construction for determining the acceleration of the piston in a slider crank mechanism.
7.	Draw the turning moment diagram of a single cylinder double acting steam engine.
8.	What is the function of a flywheel?
9.	Define the term 'coefficient of fluctuation of energy' in the case of flywheels.
10.	Define the term 'coefficient of fluctuation of speed', in the case of flywheels.
11.	Explain the term 'fluctuation of energy' as applied to flywheels.
12.	Explain the term 'fluctuation of speed' as applied to flywheels.
13.	Differentiate between flywheel and governor.
14.	Draw the Turning Moment Diagram for a Four Stroke Cycle Internal Combustion Engine
15.	State D'Alembert's principle.

S.No	Part-B Questions
1.	A vertical petrol engine 100 mm diameter and 120 mm stroke has a connecting rod 250 mm long. The mass of the piston is 1.1 kg. The speed is 2000 r.p.m. On the expansion stroke with a crank 20° from top dead centre, the gas pressure is 700 kN/m <sup>2</sup> . Determine: <b>1.</b> Net force on the piston, <b>2.</b> Resultant load on the gudgeon pin, <b>3.</b> Thrust on the cylinder walls, and <b>4.</b> Speed above which, other things remaining same, the gudgeon pin load would be reversed in direction.
2.	The crank-pin circle radius of a horizontal engine is 300 mm. The mass of the reciprocating parts is 250 kg. When the crank has travelled 60° from I.D.C., the difference between the driving and the back pressures is 0.35 N/mm <sup>2</sup> . The connecting rod length between centres is 1.2 m and the cylinder bore is 0.5 m. If the engine runs at 250 r.p.m. and if the effect of piston rod diameter is neglected, calculate : <b>1.</b> pressure on slide bars, <b>2.</b> thrust in the connecting rod, <b>3.</b> tangential force on the crank-pin, and <b>4.</b> turning moment on the crank shaft.
3.	The crank and connecting rod of a steam engine are 0.3 m and 1.5 m in length. The crank rotates at 180 r.p.m. clockwise. Determine the velocity and acceleration of the piston when the crank is at 40 degrees from the inner dead centre position. Also determine the position of the crank for zero acceleration of the piston.
4.	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 inner dead centre. The crank shaft speed is 450 r.p.m. (clockwise). Using analytical method, determine: <b>1.</b> Velocity and acceleration of the slider, and <b>2.</b> Angular velocity and angular acceleration of the connecting rod.
5.	The turning moment diagram for a petrol engine is drawn to the following scales : Turning moment, 1 mm = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm <sup>2</sup> . The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m.
6.	A shaft fitted with a flywheel rotates at 250 r.p.m. and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 N-m to 3000 N-m uniformly during 1/2 revolution and remains constant for the following revolution. It then falls uniformly to 750 N-m during the next 1/2 revolution and remains constant for one revolution, the cycle being repeated thereafter. Determine the power required to drive the machine and percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is 500 kg with radius of gyration of 600 mm.
7.	The turning moment diagram for a four stroke gas engine may be assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows :Suction stroke = $0.45 \times 10^{-3} \text{ m}^2$ ;

	Compression stroke = $1.7 \times 10^{-3}$ m <sup>2</sup> ; Expansion stroke = $6.8 \times 10^{-3}$ m <sup>2</sup> ; Exhaust stroke = $0.65 \times 10^{-3}$ m <sup>2</sup> . Each m <sup>2</sup> of area represents 3 MN-m of energy. Assuming the resisting torque to be uniform, find the mass of the rim of a flywheel required to keep the speed between 202 and 198 r.p.m. The mean radius of the rim is 1.2 m.
8.	The turning moment curve for an engine is represented by the equation, $T = (20\,000 + 9500 \sin 2\theta - 5700 \cos 2\theta)$ N-m, where $\theta$ is the angle moved by the crank from inner dead centre. If the resisting torque is constant, find: <b>1.</b> Power developed by the engine ; <b>2.</b> Moment of inertia of flywheel in kg-m <sup>2</sup> , if the total fluctuation of speed is not exceed 1% of mean speed which is 180 r.p.m; and <b>3.</b> Angular acceleration of the flywheel when the crank has turned through $45^\circ$ from inner dead centre.
9.	The turning moment diagram for a multi-cylinder engine has been drawn to a scale of 1 mm to 500 N-m torque and 1 mm to $6^\circ$ of crank displacement. The intercepted areas between output torque curve and mean resistance line taken in order from one end, in sq. mm are - 30, + 410, - 280, + 320, - 330, + 250, - 360, + 280, - 260 sq. mm, when the engine is running at 800 r.p.m. The engine has a stroke of 300 mm and the fluctuation of speed is not to exceed $\pm 2\%$ of the mean speed. Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of the safe centrifugal stress of 7 MPa. The material density may be assumed as 7200 kg/m <sup>3</sup> . The width of the rim is to be 5 times the thickness.
10.	A machine punching 38 mm holes in 32 mm thick plate requires 7 N-m of energy per sq. mm of sheared area, and punches one hole in every 10 seconds. Calculate the power of the motor required. The mean speed of the flywheel is 25 metres per second. The punch has a stroke of 100 mm. Find the mass of the flywheel required, if the total fluctuation of speed is not to exceed 3% of the mean speed. Assume that the motor supplies energy to the machine at uniform rate.

## Unit-IV

S.No	Part-A Questions
1.	Why is balancing of rotating parts necessary for high speed engines ?
2.	Explain clearly the term 'static balancing'.
3.	Explain clearly the term 'dynamic balancing'.
4.	Define variation of Tractive force.
5.	What are the balancing of locomotives?
6.	Sketch neatly with inside cylinder locomotives.
7.	Sketch neatly with outside cylinder locomotives.
8.	What is Swaying Couple?
9.	What is Hammer Blow?
10.	What are in-line engines?
11.	Write the different types of balancing?
12.	Write the condition for complete balancing?
13.	Why rotating masses are to be dynamically balanced?
14.	List the effects of partial balancing of locomotives.
15.	Why radial engines are preferred?

S.No	Part-B Questions
1.	Four masses $m_1$ , $m_2$ , $m_3$ and $m_4$ are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are $45^\circ$ , $75^\circ$ and $135^\circ$ . Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m.
2.	A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B $45^\circ$ , B to C $70^\circ$ and C to D $120^\circ$ . The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions.
3.	A, B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150 mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the mass of B, C and D are 10 kg, 5 kg, and 4 kg respectively. Find the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance
4.	A shaft carries four masses in parallel planes A, B, C and D in this order along its length. The masses at B and C are 18 kg and 12.5 kg respectively, and each has an eccentricity of 60 mm. The masses at A and D have an eccentricity of 80 mm. The angle between the masses at B and C is $100^\circ$ and that between the masses at B and A is $190^\circ$ , both being measured in the same direction. The axial distance between the planes A and B is 100 mm and that between B and C is 200 mm. If the shaft is in complete dynamic balance, determine : <b>1.</b> The magnitude of the masses at A and D ; <b>2.</b> the distance between planes A and D ; and <b>3.</b> the angular position of the mass at D.
5.	Four masses A, B, C and D are attached to a shaft and revolve in the same plane. The masses are 12 kg, 10 kg, 18 kg and 15 kg respectively and their radii of rotations are 40 mm, 50 mm, 60 mm and 30 mm. The angular position of the masses B, C and D are $60^\circ$ , $135^\circ$ and $270^\circ$ from the mass A. Find the magnitude and position of the balancing mass at a radius of 100 mm.
6.	A rotating shaft carries four masses A, B, C and D which are radially attached to it. The mass centres are 30 mm, 38 mm, 40 mm and 35 mm respectively from the axis of rotation. The masses A, C and D are 7.5 kg, 5 kg and 4 kg respectively. The axial distances between the planes of rotation of A and B is 400 mm and between B and C is 500 mm. The masses A and C are at right angles to each other. Find for a complete balance, <b>1.</b> the angles between the masses B and D from mass A, <b>2.</b> the axial distance between the planes of rotation of C and D, <b>3.</b> the magnitude of mass B.

7.	An inside cylinder locomotive has its cylinder centre lines 0.7 m apart and has a stroke of 0.6 m. The rotating masses per cylinder are equivalent to 150 kg at the crank pin, and the reciprocating masses per cylinder to 180 kg. The wheel centre lines are 1.5 m apart. The cranks are at right angles. The whole of the rotating and $\frac{2}{3}$ of the reciprocating masses are to be balanced by masses placed at a radius of 0.6 m. Find the magnitude and direction of the balancing masses. Find the fluctuation in rail pressure under one wheel, variation of tractive effort and the magnitude of swaying couple at a crank speed of 300 r.p.m.
8.	The three cranks of a three cylinder locomotive are all on the same axle and are set at $120^\circ$ . The pitch of the cylinders is 1 metre and the stroke of each piston is 0.6 m. The reciprocating masses are 300 kg for inside cylinder and 260 kg for each outside cylinder and the planes of rotation of the balance masses are 0.8 m from the inside crank. If 40% of the reciprocating parts are to be balanced, find : <b>1.</b> the magnitude and the position of the balancing masses required at a radius of 0.6 m ; and <b>2.</b> the hammer blow per wheel when the axle makes 6 r.p.s.
9.	The following data refer to two cylinder locomotive with cranks at $90^\circ$ : Reciprocating mass per cylinder = 300 kg ; Crank radius = 0.3 m ; Driving wheel diameter = 1.8 m ; Distance between cylinder centre lines = 0.65 m ; Distance between the driving wheel central planes = 1.55 m. Determine : <b>1.</b> the fraction of the reciprocating masses to be balanced, if the hammer blow is not to exceed 46 kN at 96.5 km. p.h. ; <b>2.</b> the variation in tractive effort ; and <b>3.</b> the maximum swaying couple.
10.	A single cylinder horizontal engine runs at 120 r.p.m. The length of stroke is 400 mm. The mass of the revolving parts assumed concentrated at the crank pin is 100 kg and mass of the reciprocating parts is 150 kg. Determine the magnitude of the balancing mass required to be placed opposite to the crank at a radius of 150mm which is equivalent to all the revolving and $\frac{2}{3}$ rd of the reciprocating masses. If the crank turns $30^\circ$ from the inner dead centre, find the magnitude of the unbalanced force due to the balancing mass.

## Unit-V

S.No	Part-A Questions
1.	What is the function of a governor ? How does it differ from that of a flywheel ?
2.	Define and explain the following terms relating to governors : 1. Stability, 2. Sensitiveness
3.	Define and explain the following terms relating to governors: 1. Isochronism, 2. Hunting.
4.	What are the effects of friction and of adding a central weight to the sleeve of a Watt governor?
5.	State the different types of governors.
6.	Explain the term height of the governor.
7.	What is the difference between centrifugal and inertia type governors ?
8.	What is stability of a governor?
9.	What are the causes and effects of vibrations ?
10.	Define, in short, free vibrations.
11.	Define, in short, forced vibrations.
12.	Define, in short, damped vibrations.
13.	Explain the terms 'under damping
14.	Explain the term 'Logarithmic decrement
15.	Explain the term 'whirling speed

S.No	Part-B Questions
1.	In a Porter governor, the upper and lower arms are each 250 mm long and are pivoted on the axis of rotation. The mass of each rotating ball is 3 kg and the mass of the sleeve is 20 kg. The sleeve is in its lowest position when the arms are inclined at $30^\circ$ to the governor axis. The lift of the sleeve is 36 mm. Find the force of friction at the sleeve, if the speed at the moment it rises from the lowest position is equal to the speed at the moment it falls from the highest position. Also, find the range of speed of the governor.
2.	A Proell governor has arms of 300 mm length. The upper arms are hinged on the axis of rotation, whereas the lower arms are pivoted at a distance of 35 mm from the axis of rotation. The extension of lower arms to which the balls are attached are 100 mm long. The mass of each ball is 8 kg and the mass on the sleeve is 60 kg. At the minimum radius of rotation of 200 mm, the extensions are parallel to the governor axis. Determine the equilibrium speed of the governor for the given configuration. What will be the equilibrium speed for the maximum radius of 250 mm?
3.	A Proell governor has arms of 300 mm length. The upper arms are hinged on the axis of rotation, whereas the lower arms are pivoted at a distance of 35 mm from the axis of rotation. The extension of lower arms to which the balls are attached are 100 mm long. The mass of each ball is 8 kg and the mass on the sleeve is 60 kg. At the minimum radius of rotation of 200 mm, the extensions are parallel to the governor axis. Determine the equilibrium speed of the governor for the given configuration. What will be the equilibrium speed for the maximum radius of 250 mm?
4.	A Porter governor has all four arms 200 mm long. The upper arms are pivoted on the axis of rotation and the lower arms are attached to a sleeve at a distance of 25 mm from the axis. Each ball has a mass of 2kg and the mass of the load on the sleeve is 20 kg. If the radius of rotation of the balls at a speed of 250 r.p.m. is 100 mm, find the speed of the governor after the sleeve has lifted 50 mm. Also determine the effort and power of the governor.
5.	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/m <sup>2</sup> . Determine the frequency of longitudinal and transverse vibrations of the shaft.
6.	A shaft of length 0.75 m, supported freely at the ends, is carrying a body of mass 90 kg at 0.25 m from one end. Find the natural frequency of transverse vibration. Assume $E = 200 \text{ GN/m}^2$ and shaft diameter = 50 mm.
7.	A flywheel is mounted on a vertical shaft as shown in Fig. 23.8. The both ends of the shaft are fixed and its diameter is 50 mm. The flywheel has a mass of 500 kg. Find the natural frequencies of longitudinal and transverse vibrations. Take $E = 200 \text{ GN/m}^2$ .

8.	Derive the expression for natural frequency of free transverse vibrations for a shaft subjected to a number of point loads.
9.	A shaft 50 mm diameter and 3 metres long is simply supported at the ends and carries three loads of 1000 N, 1500 N and 750 N at 1 m, 2 m and 2.5 m from the left support. The Young's modulus for shaft material is 200 GN/m <sup>2</sup> . Find the frequency of transverse vibration.