Bhagwan Mahavir College of Engineering and Technology, Surat
MECHANICAL DEPARTMENT
Sub: Theory of Machines (2151902)

Assignment 1-Gyroscope

Theory

1. What is gyroscopic couple? Explain the principle of gyroscopic action and determine the magnitude and direction of gyroscopic couple.
2. Explain gyroscopic couple and discuss its effect on an aero plane taking turns when viewed from rear.
3. Explain gyroscopic effect in case of naval ships with a diagram. Show the terminologies used to indicate sides, front and back of ship. Explain effect of steering, pitching and rolling, assuming ship moves left and right direction sequentially.
4. Explain the effect of the gyroscopic couple on the reaction of the four wheels of a vehicle negotiating a curve.
5. Derive an expression for angle of heel of a two wheeler taking turn.

Examples

1. The moment of inertia of an aero plane air screw is 20 kg.m^2 and the speed of rotation is 1250 rpm clockwise when viewed from the front. The speed of the flight is 200 km/hr. calculate the gyroscopic reaction of the air screw on the aeroplane when it makes a left hand turn on a path of 150 m radius. The turbine rotor of a ship has a mass of 2.2 tones and rotates at 1800 r.p.m. clockwise when viewed from the left. The radius of gyration of the rotor is 320mm. Determine the gyroscopic couple and its effect when (1) Ship turns right at a radius of 250 m. with a speed of 25 km/hr. (2) Ship pitches with the bow rising at an angular velocity of 0.8 rad/sec. (3) Ship rolls at an angular velocity of 0.1 rad/sec.

2. 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 rpm clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship: 1. when the ship is steering to 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.

3. The turbine of rotor of a ship has mass of 3000 kg. & radius of gyration of 0.4m, and clockwise speed of 2500 r.p.m. when looking from stern. Determine gyroscopic couple and its effect when (i) The ship steers to the left on curve of 100 m radius at a speed of 36km/hr. and (ii) When the ship is pitching in S.H.M., the bow falling with its maximum velocity. The period of pitching is 40 Sec.

4. A car is of total mass 2200 kg has the track width 1.5 m. Each wheel having an effective diameter 0.66 m and the mass moment of inertia 2.4 kg m2.The mass moment of inertia of rotating parts of the engine is 1.2 kg m2.Theengine axis is parallel to the rear axle and the crankshaft rotates in the same sense as the road wheels. The gear ratio of the engine to the rear wheel is 3.The center of mass of the car is 0.55 m above the road level. If the car is rounding a curve of 80 m radius at a speed of 100 km/h, determine the load distribution on the inner and outer wheels.

5. A two wheeler motor vehicle and its rider weight 225 kg and their combined center of gravity is 600 mm above the ground level, when the vehicle is upright. Each road wheel is of 600 mm diameter and has a moment of inertia of 1 kgm2. The rotating parts of the engine have a moment of inertia of 0.175 kg m^2. The engine rotates at 5.5 times the speed of the road wheels and in the same sense. Determine the angle of heel necessary, when the vehicle is rounding a curve of 30 m radius at a speed of 55 km/hr.

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Assignment 2-Friction Devices

Theory

1. Considering Uniform Pressure and wear theory derive the expression for total frictional torque in flat pivot bearing
2. Explain the single plate clutch in terms of elements, working and applications.
3. State different types of brakes .Explain Self Locking and Self Energizing brakes.
4. Explain Breaking Torque of an Internal Expanding Shoe Brake.
5. Explain disc Breaks.
6. Explain Epicyclic Train Dynamometer.

Examples

1 . single plate clutch with both sides effective is to transmit 75 kW at 900 rpm. The axial pressure is limited to 0.07 MPa. The coefficient of friction may be taken as 0.25. The ratio of face width to mean radius is 0.25. Determine the outer and inner radii of clutch plate.

2. multiplate clutch is used to transmit 5 KW power at 1440 rpm. The inner & outer diameters of contacting surfaces are 50 mm and 80 mm respectively. The coefficient of friction and the average allowable pressure intensity for the lining may be assumed as 0.1 and 350 KPa respectively. Determine

(i) Number of friction plates & pressure plates
(ii) Axial force required to transmit power
(iii) The actual average pressure
(iv) Actual maximum pressure intensity after wear.

3 . A brake as shown in Fig.1 is fitted with a C.I. brake shoe.

The braking torsional moment = 360 N.m
The drum diameter = 300 mm
The coefficient of friction = 0.3

Find (i) force P for counter clockwise rotation
(ii) force P for clockwise rotation
(iii) where must the pivot be placed to make the brake self locking with clockwise rotation?

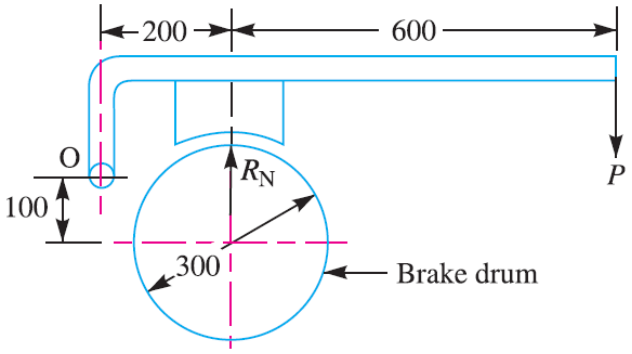

Fig 2

4 . A band brake shown in Fig. 3 below is used to balance a torque of 980 N-m at the drum shaft. The drum diameter is 400 mm (rotating in clockwise direction) and the allowable pressure between lining and drum is 0.5 MPa. The coefficient of friction is 0.25. Design the steel band, shaft, brake lever and fulcrum pin, if all these elements are made from steel having permissible tensile stress 70 MPa and shear stress 50 MPa.

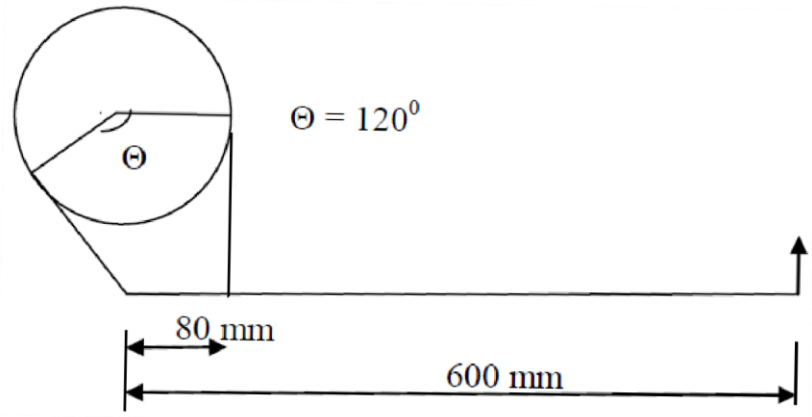

Fig. 3

5. In a belt transmission dynamometer, the driving pulley rotates at 300 rpm. The distance between the centre of the driving pulley and the dead mass is 800 mm. The diameter of each of the driving as well as the intermediate pulleys is equal to 360 mm. Find the value of the dead mass required to maintain the lever in a horizontal position when the power transmitted is 3 kW. Also, find its value when the belt just begins to slip on the driving pulley, μ being 0.25 and the maximum tension in the belt 1200 N.

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Assignment – 3 Flywheel

Theory

1. What are turning moment diagrams? What information can be avail from them?
2. Draw and explain to the point turning moment diagram of a 4-Strokesingle cylinder Engine.
3. Define the flywheel and state its importance. What are the functions of a flywheel? What are the types of flywheels?
4. Explain the terms: Coefficient of fluctuation of speed and Coefficient of fluctuation of energy.
5. Derive a relationship for the coefficient of fluctuation of speed in terms of maximum luctuation of energy and the kinetic energy of the flywheel at mean speed.
6. Explain in brief the working of flywheel in punching Press.

Examples

1. A flywheel, which is rotating at a maximum speed of 250 r.p.m. and is having radius of gyration as 0.5 m, is attached to a punching press. The press is driven by a constant torque electric motor and punches 750 holes per hour. Each punching operation requires 14000 N-m of energy and takes 1.8seconds. If the speed of the flywheel is not to fall below 225 r.p.m. Find: (i) power of the motor and (ii) mass of the flywheel.
2. The turning moment diagram for a multi cylinder engine has been to drawn to a scale of 1 mm to 500 N.m torque and 1 mm to 6° 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 RPM. The engine has a stroke of 300 mm and the fluctuation of speed is not to exceed 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 maybe assumed as 7200 Kg/m^3. The width of Rim is to be 5 times the thickness.
3. The turning moment diagram for a petrol engine is drawn to a vertical scale of 1mm = 5 N.m and a horizontal scale of 1 mm = 10. The turning moment repeats itself after every half revolution of engine. The areas above and below the mean torque line are 305, 710, 50, 350, 980 and 275 mm2. The rotating parts amount to a mass of 40 kg at a radius of gyration of 140 mm. Calculate the coefficient of fluctuation of speed if the speed of the engine is 1400 rpm.

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Assignment – 4 Governors

Theory

1. What is a function of a governor? How does it differ from that of a flywheel?
2. Define (i) Hunting (ii) Sensitiveness (iii) Sleeve lift and (iv) Isochronism (v) stability for governor.
3. Prove that a governor is stable if dF/dr> F/r, Where F is controlling force and r is corresponding radius of rotation.
4. Classify governors and prove for Watt governor, height of the governor h = 895/ N 2.where N is speed of rotation of sleeve.
5. Describe the function of a Proell governor with the help of a neat sketch. Establish a relation among various forces acting on the bent link.

Examples

1. A porter governor has equal arms 200mm long pivoted on the axis of rotation. The mass of each ball is 3 kg and the mass on the sleeve is15 kg. The ball path is 120 mm when the governor begins to lift and 160 mm at the maximum speed. Determine the range of speed. If the fraction at the sleeve is equivalent to a force of 10 N, find the coefficient of insensitiveness.
2. A porter governor has equal arms each 200 mm in length and pivoted on the axis of rotation. The mass of each ball is 5 kg and the mass of sleeve is 25 kg. The radius of governor is 100 mm when governor begins to lift. If the frictional increase of speed is 1%, then determine the governor effort and power.
3. A Hartnell governor having a central sleeve spring and two right angled bell crank lever operates between 290 r.p.m. and 310 r.p.m. for a sleeve lift of 15mm. The sleeve arms and the ball arms are 80 mm and 120 mm respectively. The levers are pivoted at 120 mm from the governor axis and mass of each ball is 2.5 kg. The ball arms are parallel to the governor axis at the lowest equilibrium speed. Determine stiffness of the spring.
4. The following data refers to a Hartnell governor. Length of horizontal arms of bell crank lever = 40 mm and Length of vertical arms of bell crank lever = 80 mm, Mass of each flying ball 1.2 kg. , The maximum radius of rotation = 100 mm, the minimum radius of rotation = 70 mm, the distance of fulcrum to axis of rotation = 75 mm, Minimum equilibrium speed = 400 rpm, Maximum equilibrium speed 5 % higher than minimum equilibrium speed. Neglecting obliquity of arms determine: (I) spring stiffness (ii) initial compression.

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Assignment – 5 Dynamic force analysis

Theory

1. What is gyroscopic couple? Explain the principle of gyroscopic action and determine the magnitude and direction of gyroscopic couple.
1. State and explain DAlembert's principle.
2. Draw and explain Klein's construction for determining the velocity and acceleration of the piston in a slider crank mechanism.
3. What is meant by dynamically equivalent system? State and prove conditions for it.
4. Explain dynamically equivalent two mass systems.
5. Explain with neat sketch Bi-filar and Tri-filar suspension.

Examples

1. The lengths of crank and the connecting rod of a horizontal reciprocating engine are 300 mm and 1.5 m respectively. The crank is rotating at 120 r.p.m. clockwise .The mass of the reciprocating parts of the engine is 290 kg where as the mass of the connecting rod is 250 kg. The C.G. of the connecting rod is 475 mm from the crank pin Centre and the radius of gyration of the connecting rod about an axis passing through the C.G. is 625 mm. Find the inertia torque on the crank shaft analytically, when $\theta = 40^0$.
2. In I.C .Engine Mechanism the Crank radius is 400 mm and Connecting rod is 950 mm long. The diameter of piston is 100 mm and net gas pressure acting on the piston is 15 MPa. Find (1) Thrust in connecting road (2) Piston side exhaust (3) Torque acting on Crankshaft (4) Radial force or load on main bearings when crank has made45° from TDC.
3. A horizontal gas engine running at 200 rpm has a bore of 200 mm and stroke of 400 mm. The connecting rod is 920 mm long and the reciprocating parts weigh20 kg. When the crank has turned through an angle of 300 from inner dead center, the gas pressure on the cover and the crank sides are 460 kN/m^2 and 70 kN/m^2 respectively. Diameter of piston rod is 50mm. Determine turning moment on the crank shaft, and (ii) thrust on the bearings.
4. A connecting rod is suspended from the point 25 mm above the small end Centre and 650 mm above its C.G. it takes 35 seconds for 20 oscillations. Find dynamically equivalent system of two masses when the mass is located at small end Centre. Mass of the connecting rod is 40 Kg.
5. The connecting rod of a reciprocating engine has a mass of 55 kg, distance between the bearing centers is 850 mm, diameter of small end bearing is 75mm, diameter of big end bearing is 100 mm, time of scillation when the connecting rod is suspended from the small end is 1.83 s and time of oscillation when it is suspended from the big end is 1.68 s. Determine:(i) the radius of gyration of the connecting rod about an axis passing through the mass centre and perpendicular to the plane of oscillation, (ii)the moment of inertia of the connecting rod about an axis passing through its mass centre and (iii) the dynamically equivalent system of the connecting rod comprising two masses, one at the small end bearing centre