

III B.Tech II Semester Supplementary Examinations, Apr/May 2008
DYNAMICS OF MACHINES

(Common to Mechanical Engineering, Mechatronics, Production
 Engineering and Automobile Engineering)

Time: 3 hours

Max Marks: 80

Answer any FIVE Questions
All Questions carry equal marks

1. In the figure 1 given below the slider crank mechanism, the forces F_1 and F_2 are known. Determine the torque that may be applied on the crank shaft to maintain equilibrium. [16]

$F_1 = 100\text{kgf}$, $F_2 = 80\text{ kgf}$, $Ab = 36\text{ cm}$, $OA = 9\text{cm}$, $AS = 16\text{cm}$ $\angle AOB = 45^\circ$.

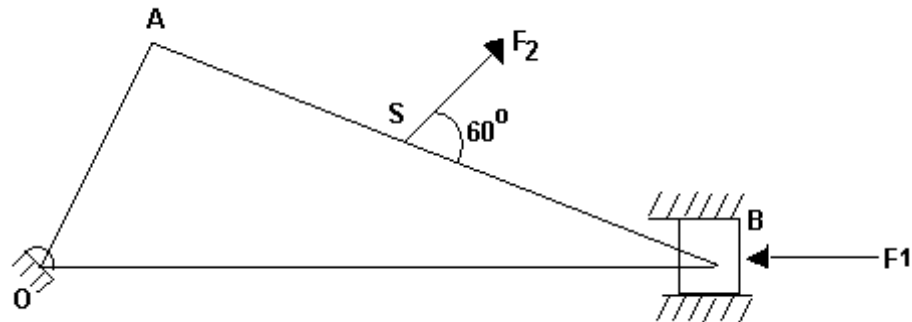


Figure 1

2. The connecting rod for an internal combustion engine has a length between centers of 230 mm and a total mass of 1.475 kg. Its center of gravity is 165 mm from the small end, and its radius of gyration about the center of gravity is 95.5 mm the mass of the piston and the gudgeon pin is 20 kg. The stroke is 140 mm and the cylinder bore is 100 mm.
 Determine the magnitude and direction of the resultant force acting on the crank pin, when the crank angle is 30° after inner dead centre, speed is 1600 r.p.m. If the effective gas pressure on the piston is 17.5 bar. [16]
3. In a block brake the angle of lap of the block is 90° . The maximum intensity of pressure on brake lining should not exceed not exceed 80 N/cm^2 . The brake drum is of 500 mm diameter. The coefficient of friction between the rim and lining is 0.35. The width of block is 120 mm. Find
 (a) the vertical force required to be applied at the middle of the block and
 (b) the resultant horizontal force acting on the block. [16]
4. (a) Define "Friction". Explain with examples, whether friction is friend or foe to human.
 (b) Derive an expression for the horizontal force 'F', necessary to move a load 'w' up a plane, which is inclined at an angle 'a' to the horizontal. [8+8]

5. (a) Derive an expression for the height of Proell governor.
 (b) Calculate the minimum speed of a Proell governor, which has equal arms each 200mm and are pivoted on the axis of rotation. The mass of each ball is 4kg and the central mass on the sleeve is 20kg. The extension arms of the lower links are each 60mm long and parallel to the axis when the minimum radius of the ball is 100mm. [8+8]
6. To balance the rotor in the following figure6 it is decided to use the planes containing m_2 and m_4 as the left and right planes respectively. Determine the correcting masses and their locations with respect to m_2 and m_4 for a perfect dynamic balance with no reactions at the bearings. [16]

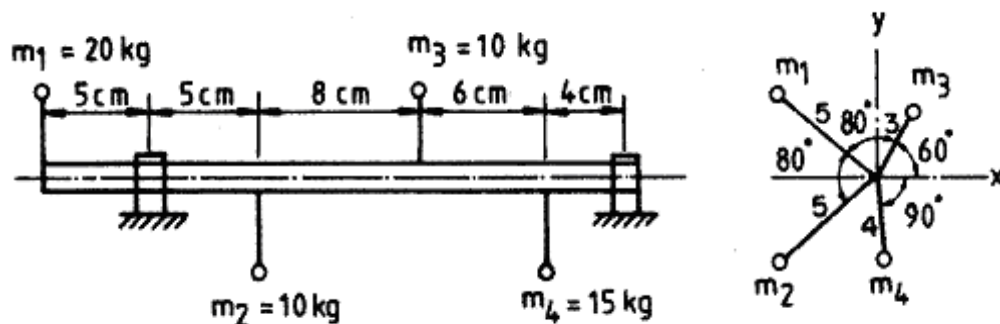


Figure 6

7. Two cylinder uncoupled locomotive with cranks at 90° has reciprocating mass and rotating mass for cylinder as 350 kg and 300 kg respectively. Crank radius is 30 cm and the pitch of cylinders 0.6 m. The balance masses are placed at radius of 0.6 m in the planes of driving wheels 1.5 m part. If the diameter of driving wheel is 1.98 m and the engine runs at 50 kmph. Find
- The magnitude and angular position of the balancing masses when all the rotating and the two third of the reciprocating masses are to be balanced.
 - Swaying couple
 - The maximum and minimum pressure on the rails, if the pressure due to dead load on each wheel is 40,000 N.
 - The maximum speed at which the wheels don't lift from the rails. [16]
8. (a) Derive an equation for the transverse vibration of a uniformly loaded shaft.
 (b) A rigid massless bar of length L is hinged at its end and carries a spring K_2 with mass at its right end. The bar is also supported by a spring K_1 at a distance from the left hinge. Determine the natural frequency of the bar. [8+8]

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1. A horizontal, single cylinder, single acting, otto cycle gas engine has a bore of 300 mm and a stroke of 500 mm. The engine runs at 180 rpm. The ratio of compression is 5.5. the maximum explosion pressure is 3.2 N/mm² gauge and expansion follows the law $p.V^{1.3} = \text{constant}$. If the mass of the piston is 150 kg and the connecting rod is 1.25 m long, calculate the turning moment on the crankshaft when the crank has turned through 60° from the inner dead centre. The atmospheric pressure is 0.1 N/mm². [16]
2. A horizontal steam engine 20 cm diameter by 40 cm stroke, connecting rod 100 cm makes 160 r.p.m. The mass of the reciprocating parts is 50 kg. When the crank has turned through an angle of 30 degrees, the steam pressure is 4.5 bar.
 - (a) Calculate the turning moment on crank shaft.
 - (b) If the mean resistance torque is 30 N-m and the mass of flywheel is 50 kg and the radius of gyration 70 cm Calculate the acceleration of the flywheel. [16]
3.
 - (a) Derive expression for total braking torque about fulcrum in differential band brake, when brake drum is rotating in clockwise direction.
 - (b) A band brake of drum diameter 400 mm provides a braking torque of 2 kNm. One end of the band is attached to a pin 100 mm from the fulcrum of the lever and the other end to another pin 20 mm from the fulcrum and on the other side of it where operating force is also acting. Find the operating force required at the end of the lever 600 mm long for the two directions of rotation of the drum. [8+8]
4.
 - (a) 20 kW is transmitted at 1000 r.p.m by a cone clutch having average friction diameter of 250 mm and semi-cone angle of 12°. Determine the axial force for engagement and the width of the friction face. Assume average pressure intensity is 0.7 bar and $\mu=0.3$.
 - (b) Determine the axial force required to engage a cone clutch transmitting 25 kW of power at 600 r.p.m. Average friction diameter of the cone is 400 mm, semi cone angle is 12° and coefficient of friction 0.25. Also find the width of the friction cone. [8+8]
5. A spring loaded governor of a Hartnell type has arms of equal length. When the sleeve is in the mid-position, the masses rotate in a circle of diameter 150mm (the ball arms are vertical in the mid-position). Neglecting friction, the equilibrium

speed for this position is 360 rpm, the maximum sleeve movement is 30mm and the maximum variation of speed taking account of friction is $\pm 6\%$ of the mid-position speed. The mass of the sleeve is 5kg and friction may be considered equivalent to 35N at the sleeve.

Assume that the power of the governor is sufficient to overcome the friction by 1% change of speed either way at mid position. Neglecting obliquity effect of arms, determine:

- (a) The value of each rotating mass
- (b) The spring stiffness in N/mm and
- (c) The initial compression of the spring. [16]

6. In a four cylinder petrol engine equally spaced, the cranks numbered from the front end are 1,2,3 and 4. The cranks 1 and 4 are in phase and 180° ahead of cranks 2 and 3. The reciprocating mass of each cylinder is 1 kg. The cranks are 50mm radius and the connecting rod 200mm long.

What are the resultant unbalanced forces and couples, primary and secondary, when viewed from the front. Take the reference plane midway between cylinders 2 and 3. [16]

7. An air compressor has four vertical cylinders 1,2,3 and 4 inline and the driving cranks at 90° intervals reach their upper most positions in this order. The cranks are of 150mm radius, the connecting rods 500mm long and the cylinder centre line 400mm apart. The mass of the reciprocating parts of each cylinder is 22.5kg and the speed of rotation is 400r.p.m. Show that there are no out-of-balance primary or secondary forces and determine the corresponding couples, indicating the positions of No. 1 crank for maximum values. The central plane of the machine may be taken as reference plane. [16]

8. The measurements on a mechanical vibration system show that the mass is 10 kg and the springs can be combined to give an equivalent spring of stiffness 5.5 kg/cm. If the vibrating system have a dashpot attached which exerts a force of 0.05 kg when the mass has a velocity of 10 mm/sec.. Find

- (a) critical damping coefficient
- (b) damping factor
- (c) logarithmic decrement and
- (d) ratio of two consecutive amplitudes. [16]

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1. (a) Explain the gyroscopic effect of pitching and rolling of a ship in the sea water. [6]
- (b) A ship is pitching through a total angle of 15° , the oscillation may be taken as simple harmonic and the complete period is 32 sec. The turbine rotor weighs 6 tones, its radius of gyration is 45 cm and it is rotating at 2400 rpm. Calculate the maximum value of gyroscopic couple set up by the rotor. ,If the rotation of the rotor is clockwise looking from left, in which direction will the bow tend to turn while falling?
What is the maximum angular acceleration to which the ship is subjected while pitching? [10]
2. A three cylinder single acting engine has its cranks set equally at 120° and it runs at 600 rpm. The torque crank angle diagram for each cylinder is a triangle for the power with maximum torque 8 mkg at 60° after dead center of the corresponding crank. The crank on the return stroke is sensibly zero. Determine in figure1:{As shown in the Figure2}
- (a) The horsepower developed.
- (b) Coefficient of fluctuation of speed of the wheel used is 10kg and has a radius of gyration of 8 cm.
- (c) Coefficient of fluctuation of energy.
- (d) The max angular acceleration of the flywheel. [16]

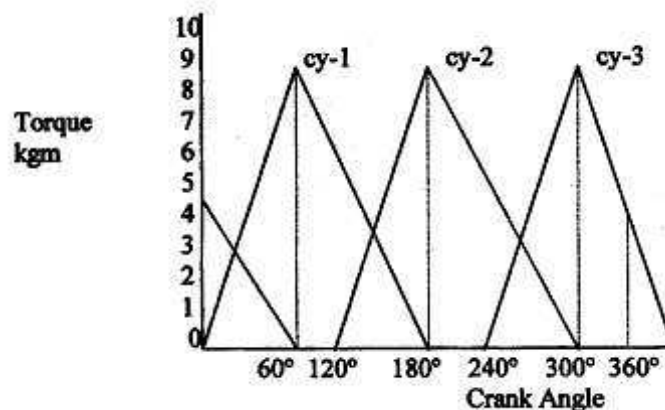


Figure 2

3. A band and block brake, having 14 blocks each of which subtends an angle of 15° at the centre, is applied to a drum of 1 m effective diameter. The drum and flywheel mounted on the same shaft of mass 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
- (a) maximum braking torque,
 - (b) angular retardation of the drum and
 - (c) time taken by the system to come to rest from the rated speed of 360 r.p.m. [16]
4. (a) Derive an expression for the efficiency of screw jack
- i. considering collar friction and
 - ii. neglecting collar friction.
- (b) Derive an equation for the friction moment of a collar thrust bearing. [10+6]
5. (a) Derive an expression for the height of Proell governor.
- (b) Calculate the minimum speed of a Proell governor, which has equal arms each 200mm and are pivoted on the axis of rotation. The mass of each ball is 4kg and the central mass on the sleeve is 20kg. The extension arms of the lower links are each 60mm long and parallel to the axis when the minimum radius of the ball is 100mm. [8+8]
6. 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 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 300° from the inner dead centre, find the magnitude of the unbalanced force due to the balancing mass. [16]
7. A four cylinder inline marine oil engine has cranks at angular displacement of 90° . The outer cranks are 3m apart and inner cranks are 1.2 m apart. The inner cranks are placed symmetrically between the outer cranks. The length of each crank is 450mm. If the engine runs at 90r.p.m. and the mass of reciprocating parts for each cylinder is 900 kg. Find the firing order of the cylinders for the best primary balancing force of reciprocating masses. Determine the maximum unbalanced primary couple for the best arrangement. [16]
8. (a) Explain briefly the phenomenon of the whirling of shafts.
- (b) A steel shaft 6 cm diameter and 50 cm long fixed at one end carries a flywheel of mass 100 kg and radius of gyration 30 cm at its free end. Find the frequency of free longitudinal and transverse vibration. [6+8]

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1. The turbine rotor of a ship has a mass of 20 tones and a radius of gyration of 0.75m. Its speed is 2000 rpm. The ship pitches 6° above and below the horizontal position. One complete oscillation takes 18 seconds and the motion is simple harmonic. Determine.
 - (a) The maximum couple tending to shear the holding down bolts of the turbine
 - (b) The maximum angular 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 clockwise when looking from rear. [16]
2. The turning moment requirement of a machine is represented by the equation $T = (1000 + 500 \sin 2\theta - 300 \cos 2\theta)$ N-m. Where θ is the angle turned by the crankshaft of the machine. If the supply torque is constant, determine:
 - (a) The moment of inertia by the flywheel. The total fluctuation of speed is not to exceed one percent of the mean speed of 300 rpm.
 - (b) Angular acceleration of the flywheel when the crankshaft has turned through 45° from the beginning of the cycle.
 - (c) The power required to drive the machine. [16]
3.
 - (a) Classify dynamometers. And explain function of one transmission type dynamometer.
 - (b) A simple band brake is operated by a lever of length 500 mm. The brake drum has a diameter of 500 mm and the brake band embraces $\frac{5}{8}$ th of the circumference. One end of the band is attached to the fulcrum of the lever while the other end is attached to a pin on the lever 100 mm from the fulcrum,. If the effort applied to the end of the lever is 2 kN and the coefficient of friction is 0.25, find the maximum braking torque on the drum. [6+10]
4.
 - (a) Define "Friction". Explain with examples, whether friction is friend or foe to human.
 - (b) Derive an expression for the horizontal force 'F', necessary to move a load 'w' up a plane, which is inclined at an angle 'a' to the horizontal. [8+8]
5.
 - (a) Derive an expression for the height of Proell governor.

- (b) Calculate the minimum speed of a Proell governor, which has equal arms each 200mm and are pivoted on the axis of rotation. The mass of each ball is 4kg and the central mass on the sleeve is 20kg. The extension arms of the lower links are each 60mm long and parallel to the axis when the minimum radius of the ball is 100mm. [8+8]
6. A single cylinder engine runs at 250r.p.m. and has stroke of 180mm.. The reciprocating part has a mass of 120 kg and revolving parts are equivalent to mass of 70 kg at a radius of 90 mm. A mass is placed opposite to the crank at a radius of 150 mm to balance the whole of the revolving mass and $\frac{2}{3}$ of the reciprocating mass. Determine the magnitude of the balancing mass and the resultant residual unbalance force when crank has turned 300 from the inner dead centre, neglect the obliquity of the connecting rod. [16]
7. A three cylinder radial engine driven by a common crank has the cylinders spaced at 120° . The stroke is 100 mm, length of the connecting rod 200 mm and the reciprocating mass per cylinder 1.5 kg. Calculate the primary and secondary forces at crank shaft speed of 1500 r.p.m. [16]
8. (a) What is meant by vibration isolation? Explain.
- (b) Large guns are designed so that on firing, the barrel recoils against a spring. At the end of the recoil, a dashpot is engaged that allows the barrel to return to its initial position in the minimum time without oscillation. Determine the proper spring constant and the dashpot damping co-efficient for a barrel of mass 800 kg, if the initial recoil velocity at the instant of firing is 25 m/sec. and recoil distance is 1.5 m. [6+10]

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