III B.Tech II Semester Supplementary Examinations,
November/December 2005
DYNAMICS OF MACHINES
(Common to Mechanical Engineering, Mechatronics and Production Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

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1. Each road wheel of a motor cycle has a mass moment of inertia of 1.5 kg-m^2. The rotation parts of the engine of the motorcycle have a mass moment of inertia of 0.25 kg-m^2. The speed of the engine is 5 times the speed of the wheels and is in the same sense. The mass of the motor cycle is traveling at 50kmlh and its center of gravity is 0.6 m above the ground level.
   Find the angle of heel if the cycle with its rider is 250 kg and is taking a turn of m radius. The wheel diameter is 0.6m. [16]

2. (a) Derive the equation $K = \frac{e}{2E}$ where K=Coefficient of fluctuation of speed, explain maximum Fluctuation of energy and Kinetic energy.
   (b) Two Isosceles Triangles represent the turning moment diagram of an engine, the base of the two triangles being 0 to π and π to 2π the maximum torque being 1000 N-m. The engine runs at 500rpm. The fluctuation of speed is not to exceed $\pm$1.5%. Find the thickness of disc type flywheel required if diameter is 0.5m and density of material is 7.5 gm/cm^3. [6+10]

3. (a) Describe the construction and operation of a rope brake absorption dynamometer.
   (b) A lorry is moving on a level road at a sped of 36 kmph. Its centre of gravity lies at a distance of 0.6m from ground level. The wheel base is 204m and the distance of centre of gravity from the rear wheels is 0.9m. Find the distance travelled by the car before coming to rest when brakes are applied,
      i. to the rear wheels
      ii. to the front wheels &
      iii. to all the four wheels. The coefficient of friction between the tyres and the road surface is 0.45. [6+10]

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 12^0. Determine the axial force for engagement and the width of the friction face. Assume average pressure intensity is 0.7 bar and μ=0.3.
   (b) Determine the axial force required to engage a cone clutch tramitting 25 kW of power at 600 r.p.m. Average friction diameter of the cone is 400 mm, semi cone angle is 12^0 and coefficient of friction 0.25. Also find the width of the friction cone. [8+8]

5. The spring controlled governor of the Hartung type, the lengths of the horizontal and vertical arms of the bell crank levers are 100 mm and 80 mm respectively. The fulcrum of the bell crank lever is at a distance of 120 mm from the axis of the governor. The each revolving mass is 9 kg. The stiffness of the spring is 25 kN/m. If the length of each spring is 120 mm when the radius of rotation is 70 mm and the equilibrium speed is 360 r.p.m., find the free length of the spring. If the radius of rotation increases to 120 mm, what will be the corresponding percentage increase in speed? [16]

6. A four cylinder crank engine has the two outer cranks set at 120^o to each other, and their reciprocating masses are each 350kgs. The distances between the planes of rotation of adjacent cranks are 45, 75 and 60 cm. If the engine is to be in complete primary balance, find the reciprocating masses and the relative angular position for each of the inner cranks. If the length of each crank is 30cm, the length of each connecting rod is 120 cm, and the speed of rotation is 250 r.p.m., determine the maximum secondary unbalanced force. [16]

7. A three cylinder radial engine driven by a common crank has the cylinders spaced at 120^0. 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) Explain the term 'Damping factor'

   (b) A mass suspended from a helical spring vibrates is a viscous fluid medium whose resistance varies directly with the speed. It is observed that the frequency of damped vibration is 90 per minute and that the amplitude decreases to 20% of its initial value in one complete vibration. Find the frequency of the free undamped vibration of the system. [4+12]

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   Find the angle of heel if the cycle with its rider is 250 kg and is taking a turn of m radius. The wheel diameter is 0.6m. [16]

2. (a) Prove that the maximum fluctuation of 'E' is given by E=0.02ECs for a Fly-wheel where E=Mean kinetic energy of the flywheel and Cs=Total percentage fluctuation of speed.
   (b) The torque exerted on the crank shaft of a two stroke engine is given by the equation T=(14,500+2,300Sin2θ-1,900cos2θ)N-m where θ is the angle moved by the crank from I.D.C. If the resisting torque is constant find:
      i. The power of the engine, when the speed is 150rpm.
      ii. The moment of inertia of the flywheel if the speed variation is not to exceed $\pm$0.5% of the mean speed.
      iii. The angular acceleration of the flywheel when the crank has turned through 30^0 from the I.D.C. [6+10]

3. (a) A bicycle and rider of mass 100kg are travelling at the rate of 16kmph on a level road. A brake is applied to the rear wheel which is 0.9m in diameter and this is the only resistance acting. How far will the bicycle travel and how many turns will it make before it comes to rest. The pressure applied on the brake is l00N and coefficient of friction is 0.2.
   (b) Can a block brake become self locking? If so derive the condition for self locking. [8+8]

4. An effort of 3000N is required to just move a certain body up an in clined plane of angle 12^0, force acting parallel to the plane. If the angle of inclination is increased to 15^0 then the effort required is 3500N. Find the weight of the body and the coefficient of friction. [16]

5. (a) Derive an expression for the height of Pro ell 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 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. Explain terms

   (a) Variations in tractive effort

   (b) Swaying couple

   (c) Hammer blow as applied to locomotive balancing. [5+5+6]

   Derive expressions for these for two cylinder uncoupled locomotive balancing.

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, double acting steam engine has a stroke of 300mm and runs at 240 rpm. The cylinder diameter is 200 mm, connecting rod is 750 mm long and the mass of the reciprocating parts is 70 kg. The steam is admitted at 600 kN/m^2 for one-third of the stroke, after which expansion takes place according to the hyperbolic law p. V = constant. The exhaust pressure is 20 kN/m^2. Neglecting the effect of clearance and the diameter of the piston rod, find:
   (a) Thrust in the connecting rod, and
   (b) Effective turning moment on the crankshaft when the crank has turned through 120^0 from inner dead centre. [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 fly7wheel is 50 kg and the radius of gyration 70 cm Calculate the acceleration of the flywheel. [16]

3. (a) Describe with sketches one form of torsion dynamometer and explain in detail the calculations involved in finding the power transmitted.
   (b) In a vertical belt transmission dynamometer the diameter of the driving pulley rotating at 1500 r.p.m. is 80mm. The centre distance of the intermediate pulleys from the fulcrum is also 80mm each. The weighing pan on the lever is at a distance as 250mm. Find the power transmitted when a mass of 20 kg is required in the pan, including its own mass. [8+8]

4. (a) Derive an equation for efficiency of inclined plane when the body on is moving up the plane.
   (b) Intensity of pressure on a thrust bearing is not to exceed 400 kN/m^2. The external and internal diameters of the collar are 200 mm and 150 mm respectively. What should be the minimum number of collars for a total axial thrust of 40 kN on the bearing? If the shaft rotates at 600 r.p.m. and the coefficient of friction is 0.08, determine the frictional power loss for uniform pressure
   - [8+8]

5. In a spring-loaded Hartnell type of governor, the mass of each ball is 4kg and the lift of the sleeve is 40mm. The governor begins to float at 200rpm when the radius of the ball path is 90mm. The mean working speed of the governor is 16 times the range of speed when friction is neglected.
   The lengths of the ball and roller arms of the bell-crank lever are 100mm and 80mm respectively. The pivot centre and the axis of governor are l15mm apart. Determine the initial compression of the spring, taking into account the obliquity of arms.
   Assuming the friction at the sleeve to be equivalent to a force of l5N, determine the total alteration in speed before the sleeve begins to move from the mid-position. [16]

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 2/3rd 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 three cylinder radial engine driven by a common crank has the cylinders spaced at 120^0. 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) 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 steam engine running at 240 rpm has a bore of 300 mm and stroke 600mm. The connecting rod is 1.05m long and the mass of reciprocating parts is 60 kg. when the crank is 60^0 past its inner dead center, the steam pressure on the cover side of the piston is 1.125 N/mm^2 while that on the crank side is 0.125 N/mm^2. Neglecting the area of the piston rod, determine: 1. the force in the piston rod; and 2. the turning moment on the crankshaft. [16]

2. A single cylinder signle acting four stroke cycle gas engine develop 22 kW at 300rpm. The flywheel weighs 1000kg. Hoop stress developed is 5 MPa. Density of material of rim of flywheel is 8000kg/m^3. The speed variation on either side is 1% of mean speed. Determine ratio of work done during expansion and compression strokes.Work done in suction and exhaust stroke is negligible. - [16]

3. A band and block brake having 12 blocks, each of which subtends 16^0 at the centre, is applied to a rotating drum of 600 mm diameter. The blocks are 75 mm thick. The drum and the flywheel mounted on the same shaft have a mass of 2000 kg and have combined radius of gyration of 600 mm. The two. ends of the band are attached to pins on the opposite sides of the brake fulcrum at distances of 40mm and 150 mm from the fulcrum. If a force of 200 N is applied at a distance of 500 mm from the fulcrum, Calculate:
   (a) the maximum braking torque,
   (b) the angular retardation of the drum,
   (c) the time taken by the system to be stationary from the rated speed of 300 r.p.m. Take coefficient of friction is 0.3 [16]

4. (a) Differentiate between static friction and dynamic friction with suitable examples.
   (b) An effective diameter of the cone clutch is 75 mm. The semi-angle of the cone is 18^0. Find the torque required to produce slipping of the clutch if an axial force applied is 200 N. This clutch is employed to connect an electric motor running uniformly at 100 r.p.m with a flywheel which is initially stationary. The flywheel has a mass of 13.5 kg and its radius of gyration is 150 mm. Calculate the time required for the flywheel to attain full speed, and also the energy lost in the slipping of the clutch. Take coefficient of friction as 0.3 [6+10]

5. (a) Derive an expression for the height of Pro ell 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 2/3rd 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. 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 determined 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. (a) Derive an equation for the natural frequency of free transverse vibration of a shaft loaded with a number of concentrated loads, by energy method.
   (b) A shaft of 10 cm diameter and 100 cm long is fixed at one end and other end carries a flywheel of mass 80 kg. Taking young's modulus for the shaft material as 2 x 106 kg/cm^2, find the natural frequency of longitudinal and transverse vibration. [8+8]

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