CBCS SCHEME

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15ME52

Fifth Semester B.E. Degree Examination, Jan./Feb. 2023
Dynamics of Machinery

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. With neat sketches briefly discuss the equilibrium of three force and four force systems. **(04 Marks)**

b. With suitable sketches show the force conventions and force polygon for each link of a four-link mechanism. **(04 Marks)**

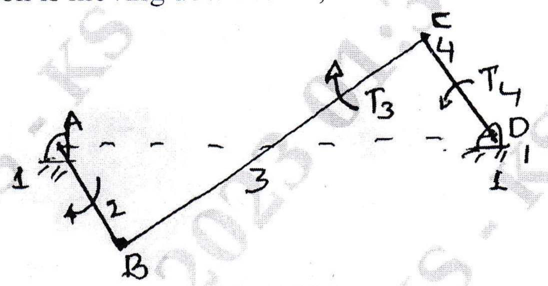
c. In four bar mechanism shown in Fig.Q1(c), the torque T_3 and T_4 have magnitudes of 50 Nm and 40 Nm respectively. For the static equilibrium of the mechanism, determine the required input torque T_2. **(08 Marks)**

OR

2 a. State the D'Alembert's principle. **(02 Marks)**

b. Define: (i) Inertia force (ii) Inertia torque **(02 Marks)**

c. The connecting rod of a vertical reciprocating engine is 2m long between centres and its mass is 250 kg. The mass centre is 800 mm from big end bearing. When suspended as a pendulum from the gudgeon pin axis, it makes 8 complete oscillations in 22 seconds. Calculate the radius of gyration of the rod about an axis through its mass centre. The crank is 400 mm long and rotates at 200 rpm. When the crank has turned through 40° from the TDC and the piston is moving downwards, find the inertia torque exerted on the crankshaft.



AB = 30 mm
BC = 74 mm
CD = 35 mm
AD = 70 mm

Fig.Q2(c) **(12 Marks)**

Module-2

3 a. A shaft carries four masses M_1, M_2, M_3 and M_4 attached to it. They all revolve in the same plane. The magnitude of the masses are 6, 5, 9 and 7.5 kg respectively. The C.G of the masses are located at a radial distance of 100, 125, 150 and 75 mm from the axis of the shaft. The angular positions of the masses are 60°, 135 ° and 270° from M_1. Determine the position and magnitude of mass M_5 at 250 mm radius to balance the system. **(08 Marks)**

b. A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 50 mm, 60 mm, 70 mm and 60 mm respectively. The 2nd, 3rd and 4th masses revolve in planes 80 mm, 160 mm and 280 mm respectively measured from the plane of the first mass and are angularly located at 60°, 135° and 270° respectively measured anticlockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, bolt located at 50 mm radii and revolving in planes mid way between those of 1st and 2nd masses and midway between those of 3rd and 4th masses. Determine the magnitudes of the masses and their respective angular positions. **(08 Marks)**

OR

4 A six cylinder two stroke single acting diesel engine with cylinder centre lines are spaced at 650 mm. In the end view the cranks are 60° apart and inorder 1-4-5-2-3-6. The stroke of each position is 400 mm and the crank to connecting rod ratio is 1:5. The mass of reciprocating part is 250 kg per cylinder and that of rotating part is 100 kg per crank. The engine rotates at 240 rpm. Determine the engine for out of balance primary and secondary forces and couples by analytically and graphically. **(16 Marks)**

Module-3

5 a. A porter governor has equal arms each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 kg and the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150 mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find the range of speed, sleeve lift, effort and power of the governor. **(08 Marks)**

b. In a Hartnell governor, the lengths of ball and sleeve arms of a ball crank lever are 120 mm and 100 mm respectively. The distance of the fulcrum of the bell crank lever from the governor axis is 140 mm. Each governor ball has a mass of 4 kg. The governor runs at a mean speed of 300 rpm with the ball arms vertical and sleeve arms horizontal. For an increase of speed of 4%, the sleeve moves 10 mm upwards. Neglecting friction, find:
(i) The minimum equilibrium speed if the total sleeve movement is limited to 20 mm
(ii) The spring stiffness
(iii) The sensitiveness of governor
(iv) The spring stiffness if the governor is to be isochronous at 300 rpm. **(08 Marks)**

OR

6 a. With neat sketches, explain the effect of gyroscopic couple on Aeroplane and Naval ship. **(08 Marks)**

b. A ship is propelled by a turbine rotor which has a mass of 5000 kg and a speed of 1200 rpm. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions:
(i) The ship sails at speed of 16 knots (1 knot = 1860 m/hr). It steers to the left in a curve having 60 m radius.
(ii) The ship pitches 6° above and 6° below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and periodic time is 20 seconds.
(iii) The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/sec, clockwise when viewed from stern. Determine also the maximum acceleration during pitching. Explain how the diversion of motion due to gyroscopic effect is determined in each case. **(08 Marks)**

Module-4

7 a. Define: (i) Periodic time (ii) Natural frequency (iii) Damping (iv) Resonance **(04 Marks)**

b. Derive an equation of motion for spring mass system by energy method. **(04 Marks)**

c. Determine the effect of the mass of the spring on the natural frequency of the spring mass system. **(08 Marks)**

OR

8 a. Add the following harmonic motions analytically and check the solution graphically:
$x_1 = 4\cos(\omega t + 10^\circ)$ and $x_2 = 6\sin(\omega t + 60^\circ)$ **(08 Marks)**

b. A circular cylinder of mass 4 kg and radius 150 mm is connected by a spring of stiffness 4000 N/m as shown in Fig.Q8(b). It is free to roll on horizontal rough surface without slipping, determine the natural frequency.

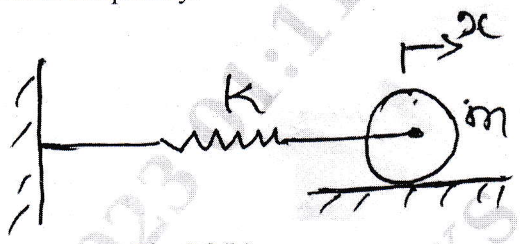


Fig.Q8(b) **(08 Marks)**

Module-5

9 a. Show the logarithmic decrement of successive amplitudes in a damped vibrating system. **(08 Marks)**

b. A vibrating system is defined by the following parameters: M = 3 kg, K = 100 N/m and C = 3 N-s/m. Determine:
(i) The damping factor
(ii) The natural frequency of damped vibration
(iii) Logarithmic decrement
(iv) The ratio of two consecutive amplitude
(v) The number of cycles after which the original amplitude is reduced to 20%. **(08 Marks)**

OR

10 a. Derive an expression for magnification factor or amplitude ratio for spring-mass system with viscous damping subjected to harmonic force. **(08 Marks)**

b. A machine of mass one tonne is acted upon by an external force of 2450 N at a frequency of 1500 rpm. To reduce the effects of vibration, isolator of rubber having a static deflection of 2 mm under the machine load and an estimated damping $\xi = 0.2$ are used. Determine:
(i) The force transmitted to the foundation
(ii) The amplitude of vibration of machine
(iii) The phase lag **(08 Marks)**

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CBCS SCHEME

USN 1KS16ME072

15ME53

Fifth Semester B.E. Degree Examination, Jan./Feb. 2023
Turbo Machine

Time: 3 hrs. Max. Marks: 80

Note: 1. *Answer any FIVE full questions, choosing ONE full question from each module.*
2. *Use of steam tables and Mollier chart is permitted.*

Module-1

1 a. Define a Turbo machine. Explain the functions of different parts of a Turbo machine. **(06 Marks)**

b. Indentify the following as power generating on power absorbing Turbo machine :
i) Centrifugal compressor ii) Steam Turbine iii) Air blower. **(03 Marks)**

c. Test on a turbine runner 1.25m in diameter of 30m head gave the following results :
Power developed = 736kW, Speed = 180rpm, discharge = 2.7m^3/s. Find the diameter, speed and discharge of a runner to operate at 45m head and give 1472kW at the same efficiency. What is the specific speed of both the turbines? **(07 Marks)**

OR

2 a. With h-s diagram, show that reheat factor in multi stage turbine is greater than unity. **(08 Marks)**

b. A 16-stage axial flow compressor is to have a pressure ratio of 6.3 and tests have shown that a stage efficiency of 89.5% can be obtained. The intake conditions are 288K and 1 bar. Find : i) Overall efficiency ii) Polytropic efficiency iii) Preheat factor. **(08 Marks)**

Module-2

3 a. An inward flow radial hydraulic turbine has a degree of reaction R and utilization factor E. The radial velocity is constant throughout. There is no velocity of whirl at outlet. Show that the nozzle angle is given by $\alpha_1 = \cot^{-1}\sqrt{\frac{1-R}{1-\epsilon}\epsilon}$. **(08 Marks)**

b. An inward flow reaction turbine has an inlet and outlet diameter as 1m and 0.5m respectively. The vanes are radial at inlet and the discharge is radial at outlet. The water enters the vanes at an angle of 10°. Assume the velocity of flow to be constant and equal to 3m/s. Find the following : i) Speed of the runner ii) Vane at outlet. **(08 Marks)**

OR

4 a. Draw the velocity triangles for an axial flow compressor and show that for an axial flow compressor having no axial thrust, the degree of reaction is given by $R = \frac{V_a}{2u}\left[\frac{\tan\beta_1 + \tan\beta_2}{\tan\beta_1 \cdot \tan\beta_2}\right]$. Where V_a = Axial velocity, β_1 and β_2 = Inlet and outlet blade angles with respect to tangential direction. **(08 Marks)**

b. Air flows into a stage of an axial flow compressor at 33°C and 1 bar pressure. The axial speed of air flow through the stage is 110m/s. The compressor is one of 50% reaction with symmetric inlet and outlet velocity triangles, the inlet blade angle being 30° and outlet angle 50° with respect to tangential direction. Compute the absolute velocity at the rotor inlet, the mean blade tip speed and the temperature rise of the air is passing through the stage. **(08 Marks)**

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-3

5 a. Derive the condition for maximum blade efficiency of a single stage impulse steam turbine. Further, show that $(\eta_b)_{max} = \cos^2\alpha_1$ for symmetrical blades with no friction in the blade channels where α_1 = Nozzle angle. **(08 Marks)**

b. A single stage impulse turbine rotor has a diameter of 1.2m running at 3000rpm. The nozzle angle is 18°. Blade speed ratio is 0.42. The ratio of relative velocity at outlet to relative velocity at inlet is 0.9. The outlet angle of the blade is 3° less than the inlet angle. Steam flow rate is 5Kg/s. Draw the velocity triangles and find :

i) Blade angles
ii) Tower developed
iii) Blade efficiency. **(08 Marks)**

OR

6 a. What do you mean by compounding of steam turbine? Explain with the help of a schematic diagram, a two row pressure compounded impulse turbine stage. **(06 Marks)**

b. Dry saturated steam at 10bar is supplied to a single rotor axial flow impulse turbine, the condenser pressure being 0.5 bar. The nozzle efficiency is 94% and the nozzle angle at rotor inlet is 18° to the wheel plane. The rotor blades are equiangular and move at a speed of 450m/s. If the blade velocity coefficient for the moving blades is 0.91, determine: i) Power output for a mass flow rate of 1Kg/s ii) Rotor efficiency iii) Stage efficiency. **(10 Marks)**

Module-4

7 a. Show that for a Pelton wheel, the maximum hydraulic efficiency is given by

$$(\eta_b)_{max} = \frac{1 + K\cos\beta_2}{2}.$$

Where K = blade velocity coefficient, β_2 = Blade angle at exit. **(08 Marks)**

b. A three jet Pelton wheel is required to generate 10,000 kW under a net head of 400m. The blade angle at outlet is 15° and the reduction in relative velocity over the buckets is 5%. If the overall efficiency is 80%, $C_\gamma = 0.98$ and speed ratio = 0.46, find :

i) Diameter of each jet
ii) total flow rate in m^3/s
iii) Tangential force exerted by a jet on the buckets. **(08 Marks)**

OR

8 a. Mention the functions of a Draft tube in a reaction hydraulic turbine using Bernoulli's equation, show that the pressure head at the inlet of the draft tube is less than the atmospheric pressure. **(06 Marks)**

b. Following data refers to an inward radial flow Francis turbine : Output = 15000kW, Speed = 300rpm, Net Head = 120m, Inner diameter of the runner = 0.6 × outer diameter of the runner, axial length of the blade at inlet = 0.1 × corresponding diameter, flow ratio = 0.15, hydraulic efficiency = 80%, overall efficiency = 85%, area blocked by the blade thickness = 5% of area of flow at inlet. Assume radial discharge at outlet and velocity of flow is constant throughout. Calculate :

i) Diameter of the runner at inlet and outlet
ii) Guide vane angle
iii) Moving vane angle at inlet and outlet. **(10 Marks)**

Module-5

9 a. Write a note on cavitations in centrifugal pumps. (04 Marks)

b. Derive an expression for the static pressure rise in the impeller of a centrifugal pump with velocity triangles. (06 Marks)

c. A centrifugal pump is running at 1500rpm. The outlet angle of the impeller is 45° and the velocity of flow at the outlet is 2.5m/s. The discharge through the pump is $0.2m^3/s$ when the pump is working against a head of 20m. If the manometric efficiency is 80%, draw the outlet velocity triangle and calculate :

i) The diameter of the impeller at the outlet

ii) Width of the impeller at outlet. (06 Marks)

OR

10 a. Explain the following with appropriate sketches :

i) surging ii) chocking iii) pre-rotation. (09 Marks)

b. An axial flow compressor has the following data :

Entry conditions = 1 bar and 20°C, Degree of reaction = 50%

Mean blade ring diameter = 36cm

rotational speed = 18000 rpm

blade height at entry = 6cm,

Blade angle at rotor exit = 65°

Axial velocity = 180m/s, mechanical efficiency = 0.967. Find :

i) Blade angle at rotor inlet

ii) Power required to drive the compressor. (07 Marks)

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CBCS SCHEME

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15ME54

Fifth Semester B.E. Degree Examination, Jan./Feb. 2023
Design of Machine Elements – I

Time: 3 hrs. Max. Marks: 80

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Any missing data may be suitably assumed.
3. Use of design data handbook is permitted.

Module-1

1 a. Discuss the factors which govern the selection of an appropriate material for a machine component. **(06 Marks)**

b. A shaft of 50 mm diameter is stepped down to 40 mm with a fillet radius of 5 mm and torque Mt. If the allowable shear stress is 50 N/mm^2, determine the power that can be transmitted at 1200 rpm. **(10 Marks)**

OR

2 a. Define stress concentration and show how stress concentration can be reduced for two examples with neat sketches. **(06 Marks)**

b. Determine the safe load that can be carried by a rectangular bar of cross section as shown in Fig.Q2(b) limiting the maximum stress to 130 MPa taking stress concentration into account.

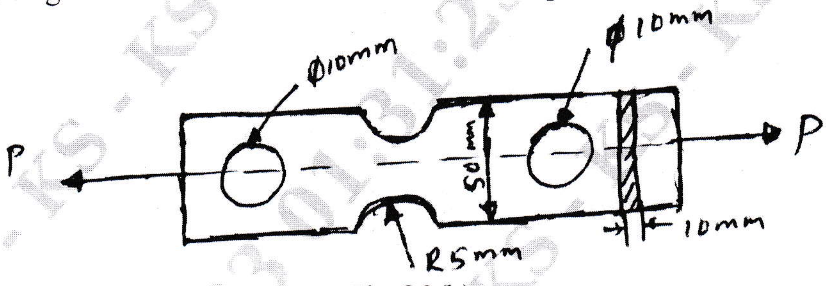

Fig.Q2(b) **(10 Marks)**

Module-2

3 a. Obtain an expression for impact stress induced in a member subjected to axial load. **(06 Marks)**

b. A mass of 15 kg falls from a height of 250 mm at the midpoint of a simply supported beam. It is made of steel, has a length of 1m between the supports. Cross section of the beam is 60 mm × 60 mm square. Determine maximum deflection and bending stress induced in the beam due to falling mss. **(10 Marks)**

OR

4 a. Obtain Soderberg's relation for a member subjected to fatigue loading. **(06 Marks)**

b. A steel connecting rod of rectangular bar cross section having depth twice that of width is subjected to a completely reversed axial load of 18 kN. The endurance stress is 300 MPa and yield stress is 420 MPa. Determine suitable cross-sectional dimensions of the connecting rod. Take size factor = 0.9, load factor = 0.7, surface factor = 0.85, stress concentration factor = 1.5, Notch sensitivity = 1, Factor of safety = 1.8. Neglect column effect. **(10 Marks)**

Module-3

5 A commercial steels shaft 1m long supported between bearings carries a pulley of diameter 600 mm weighing 1 kN located 400 mm to the right hand bearing and receives 25 KW at 1000 rpm by a horizontal belt drive. The power from the shaft is transmitted by a spur pinion of 20° pressure angle having pitch circle diameter 200 mm to a spur gear such that the tangential force on gear acts vertically upwards. The pinion is keyed to the shaft at a distance of 200 mm to the right of the left bearing. Taking the ratio of belt tensions as 3, determine the diameter of the shaft required. Use maximum shear stress theory. Take $\tau_d = 40$ N/mm^2. **(16 Marks)**

OR

6 a. It is required to design a cotter joint to connect two steel rods of equal diameter. Each rod is subjected to axial tensile force of 50 kN. Design the joint and specify main dimensions. Take permissible stresses for rods in tension = 67 N/mm^2, crushing = 134 N/mm^2 and for cotter in tension = 100 N/mm^2. **(08 Marks)**

b. Design a knuckle joint to connect two mild steel rods. The joint has to transmit a tensile load of 80 kN. Allowable stresses for the material may be taken as $\sigma_t = 80$ MPa, $\sigma_{cr} = 120$ MPa, $\tau = 40$ MPa. **(08 Marks)**

Module-4

7 a. A bracket attached to a vertical column by means of four identical rivets is subjected to an eccentric force of 25 kN as shown in Fig.Q7(a). Determine the diameter of rivets, if the permissible shear stress is 60 N/mm^2.

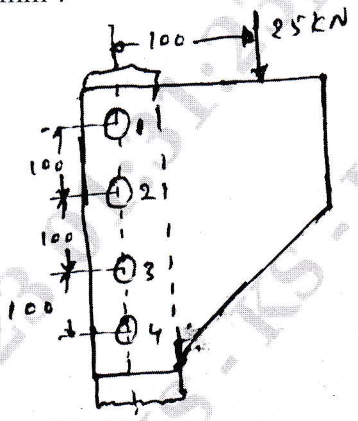

Fig.Q7(a) **(08 Marks)**

b. A bracket is supported by means of 4 rivets of same size as shown in Fig.Q7(b). Determine the diameter of rivet if the maximum stress is 140 N/mm^2.

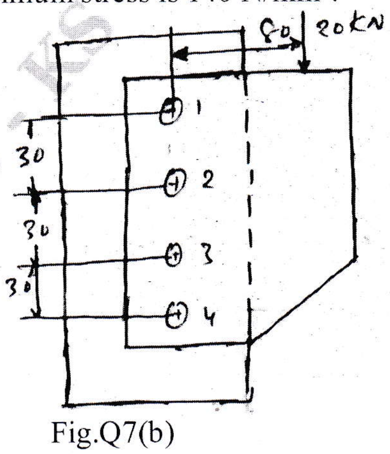

Fig.Q7(b) **(08 Marks)**

OR

8 a. A welded connections as shown in Fig.Q8(a) is subjected to an eccentric force of 60 kN in the plane of the welds. Determine the size of welds, if the permissible shear stress for the weld is 100 N/mm^2. Assume static conditions.

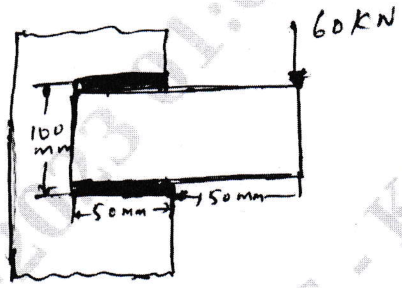

Fig.Q8(a) **(08 Marks)**

b. Determine the load carrying capacity of a welded joint as shown in Fig.Q8(b). The allowable shear stress for 10 mm weld used is 50 MPa.

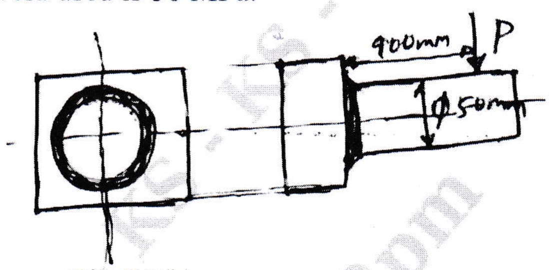

Fig.Q8(b) **(08 Marks)**

Module-5

9 a. Explain self locking and overhauling in power screws. **(06 Marks)**

b. A bracket is bolted as shown in Fig.Q9(b). All the bolts are of same size and are made of steel having allowable tensile stress of 90 MPa and allowable shear stress of 52 MPa. Determine the size of the bolts to be used.

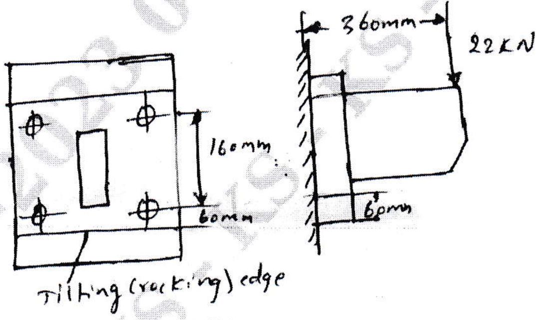

Fig.Q9(b) **(10 Marks)**

OR

10 a. Derive the expression for torque required to lift the load on square threaded screw. **(08 Marks)**

b. The square thread of screw jack with specification 80 × 16, with a double start is to raise a load of 100 kN. The mean collar diameter is 130 mm. The coefficient of friction for the threads and the collar are respectively 0.1 mm and 0.12. Determine:

(i) Torque required to raise the load
(ii) Efficiency of the screw
(iii) Whether self-locking exists? **(08 Marks)**

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