S'08 : 2 FN : MC 421 (1506)

DESIGN OF MECHANICAL SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

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Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Discuss various phases in the design of mechanical systems. 4

(*b*) What do you understand by creative and evolutionary design ? Explain with examples. 6

(*c*) A closed-ended cast iron cylinder of 200 mm inside diameter is to carry an internal pressure of 10 N/mm^2 with a permissible stress of 18 MPa. Determine the wall thickness. 10

2. (*a*) Make a systematic search of fresh design ideas using morphological analysis for a wall clock. 6

(*b*) Define standardisation, discuss its advantages in machine design. Give different types of standards used in design office. 6

(*c*) Calculate the tolerances, fundamental deviations and limits of sizes for the shaft designated as 40H8/f7. The grade of a tolerance for IT 8 is given by $25i$, where i is given as

$$i = 0{\cdot}45\sqrt[3]{D} + 0{\cdot}001\,D,$$

where D is the geometric mean of diameter step. Fundamental deviation for shaft, $f = -5{\cdot}5\,D^{0{\cdot}41}$. 8

3. (*a*) Describe briefly the information needed for designating the surface finish on drawing, giving a suitable example. 5

(*b*) What do you mean by factor of safety? List the important factors that influence the magnitude of factor of safety. 5

(*c*) The cylinder head of a steam engine is subjected to a steam pressure of $0{\cdot}7\ N/mm^2$. It is held in position by means of 12 bolts. A soft-copper gasket is used to make the joints leak-proof. The efficiency diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa. 10

4. (*a*) State *any three* advantages of brass as a material for machine parts. Give its applications. 4

(*b*) Distinguish clearly between cast iron, wrought iron and mild steel regarding their constituents and properties. 6

(*c*) How much length of a 10 mm fillet weld is required to weld the long side of an ISA angle $150 \times 75 \times 10$ to a steel plate with side welds only? A static load of 125 kN acts through the centre of gravity of the angle section which is 53·2 mm from the short side. The allowable load per mm of the weld length is 665 N. 10

Group B

5. (*a*) Define objective function and constraints in design with an example. 4

(*b*) Explain why there exist more than one solution to a design problem. Explain the concept of optimum design of machine elements and mechanical systems. 6

(*c*) A system consists of 200 elements having MTBF (Mean Time Between Failures) of 10,000 hours. What is reliability? Cumulative operating time is 10 hour. What is probability of failures? 10

6. (*a*) Explain the phenomenon of interference in involute gears. What are the conditions to be satisfied in order to avoid interference? 5

(*b*) Define formative or virtual number of teeth on a helical gear. Derive the expression used to obtain its value. 5

(*c*) A bronze spur pinion rotating at 600 rpm drives a cast iron spur gear at a transmission ratio of 4 : 1. The allowable static stresses for the bronze pinion and cast iron gears are 84 MPa and 105 MPa, respectively. The pinion has 16 standard 20° full depth involute teeth of module 8 mm. The face width of both the gears is 90 mm. Find the power that can be transmitted from the strength point of view. 10

7. (*a*) It is stated that the speed at which a belt or rope should be run to transmit maximum power is that at which the maximum allowable tension is three times the centrifugal tension in the belt or rope at that speed. Prove the statement. 8

(*b*) A helical compression spring made of oil tempered carbon steel is subjected to a load which varies from 400 N to 1000 N. The spring index is 6 and the design factor of safety is 1·25. If the yield stress in shear is 770 MPa and endurance stress in shear is 350 MPa, find

(*i*) size of the spring wire;

(*ii*) diameters of the spring;

(*iii*) number of turns of the spring; and

(*iv*) free length of the spring.

The compression of the spring at the maximum load is 30 mm. The modulus of rigidity for the spring material may be taken as 80 kN/mm^2. 12

8. (*a*) Discuss the function of a coupling. How does the working of a clamp coupling differ from that of a muff coupling? Explain. 6

(*b*) How do you express the life of a bearing? What is an average or median life? 4

(*c*) A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10,000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and a ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft. 10

Group C

9. (*A*) Fill in the blanks for the following: 1 × 10

(*i*) The module is the —— of diametral pitch.

(*ii*) The size of weld is —— the throat of weld in a butt welded joint.

(*iii*) Total number of fundamental deviations is —— according to ISI.

(*iv*) The —— coupling is designed as a hollow shaft.

(*v*) Screws used for power transmission should have —— efficiency.

(*vi*) The cast iron will be of —— colour, when the carbon in the cast iron is principally in the form of graphite.

(*vii*) In the design of a nut, the —— is the most important dimension.

(*viii*) In cycling loading in —— materials, the stress concentration is more serious.

(*ix*) On —— stress, the design of thin cylinder is based.

(*x*) The pitch diameter is the —— diameter of an external or internal screw thread.

(*B*) Choose most appropriate answer for the following: 1 × 10

(*i*) The product of the diametral pitch and circular pitch is equal to

(*a*) 1

(*b*) $1/\pi$

(*c*) π

(*d*) 2π

(*ii*) Involute profile is preferred to cycloidal because

(*a*) the profile is easy to cut

(*b*) only one curve is required to cut

(*c*) the rack has straight line and hence can be cut accurately

(*d*) None of the above

(*iii*) Due to slip of the belt, the velocity ratio of the belt drive

(*a*) decreases

(*b*) increases

(*c*) does not change

(*d*) None of the above

(*iv*) For maximum power, the velocity of the belt will be

(*a*) $\sqrt{T/m}$

(*b*) $\sqrt{T/2m}$

(*c*) $\sqrt{T/3m}$

(*d*) $\sqrt{T/4m}$

(*v*) When a helical compression spring is subjected to an axial compressive load, the stress induced in the wire is

(*a*) tensile stress.

(*b*) compressive.

(*c*) shear stress.

(*d*) bending stress.

(*vi*) Oldham coupling is used to connect two shafts

(*a*) which are perfectly aligned

(*b*) which have lateral misalignment

(*c*) which are not in exact alignment

(*d*) whose axes intersect at a small angle.

(*vii*) The size of a part, to which all limits of variations are determined, is called

(*a*) actual size.

(*b*) basic size.

(*c*) tolerance.

(*d*) zone of tolerance.

(*viii*) The size of the weld, in case of a transverse fillet welded joint, is equal to

(*a*) one-third of the throat of weld

(*b*) half of the throat of weld

(*c*) 1·414 times the throat of weld

(*d*) throat of weld

(*ix*) Gear box is used

(*a*) to produce torque.

(*b*) for speed reduction.

(*c*) to increase efficiency of the system.

(*d*) to obtain variable speeds.

W'08 : 7 AN : MC 407/PR 407 (1500)

DESIGN OF MACHINE ELEMENTS

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Design data book is not permitted to use.

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Group A

1. (*a*) Give a flow-chart indicating different stages of engineering design. Discuss the role of computers in designing of machine elements for strength. 8

(*b*) State the procedure adopted to integrate the functions of design and manufacturing giving importance to economic feasibility. 4

(*c*) An element in plane stress is subjected to stresses $\sigma_x = -50$ MPa, $\sigma_y = 10$ MPa, and $\tau_{xy} = \pm 40$ MPa.

Using Mohr's circle, determine the (*i*) stresses acting on an element rotated through an angle $\theta = 45°$; (*ii*) principal stresses; and (*iii*) maximum shear stress. Show all results on sketches of properly oriented elements. 8

2. (*a*) A machine member, 0·05 m diameter and 0·25 m effective length, is fixed at one end as a cantilever. The cantilever at the other end is subjected to a downward bending load of 2·75 kN and axial tensile load of 13·75 kN. Additionally, it is subjected at this end to a twisting moment of 250 N-m. Determine the maximum normal and shear stresses induced in the member. 10

(*b*) State the following theories of failure:

(*i*) Maximum shear stress theory, and

(*ii*) Maximum distortion energy theory.

Compare the two and state which one is more conservative. 4

(*c*) A thick cylinder is subjected to internal fluid pressure. Write the Lame's equations for radial and circumferential (hoop) stresses through the thickness of the cylinder. Show their variations across the thickness, indicating whether tensile or compressive. 6

3. (*a*) What is endurance strength of a material? Describe a standard test with a neat sketch for determining this material property. Draw the stress (*S*)-cycle (*N*) diagram, showing the endurance strength. 8

(*b*) Discuss the effect of following surface treatments on fatigue strength: 4

(*i*) Shot peening; and

(*ii*) Surface hardening by nitriding.

(*c*) A steel cantilever has a length of 30 cm and area of cross-section is 10 cm wide by 5 cm deep. If a factor of safety of 3 is applied to the variable stress component, determine the value of an end transverse load, *P*, so that fatigue failure will not occur for the following conditions. Consider the yield point criterion of failure for the steady stress component when

(*i*) *P* is completely reversed; and

(*ii*) *P* varies from zero to a maximum.

The material has the following properties:

Yield strength = σ_y = 420 MPa
Endurance strength = $\sigma_e = \pm 320$ MPa. 8

4. (*a*) (*i*) Derive the Euler's formula for the critical buckling load of a column pin-jointed at both ends. 6

(*ii*) Determine the ratio of the buckling strengths of a solid steel column to that of a hollow column of the same material and having the same cross-sectional area. The internal diameter of the hollow column is half of the external diameter. Both the columns are of the same length and are pinned at both ends. 8

(*b*) A square threaded bolt has a root diameter of 27·5 mm and pitch of 5 mm. It is tightened by screwing in a nut which has a mean diameter of bearing surface of 60 mm. Determine the force required at the end of spanner, which is 60 cm long when the load on the bolt is 10 kN. Assume coefficient of friction between nut and screw = 0·1 and that between nut and bearing surface = 0·15. 6

Group B

5. (*a*) A carriage, weighing 50 kN and moving at a speed of 2·5 km/h, is brought to rest by a buffer. The buffer consists of a number of springs made out of a wire of 22 mm diameter. Each spring is of mean diameter 10 cm and has 20 coils. Determine the number of springs required so that their compression in bringing the carriage to rest does not exceed 10 cm. The rigidity modulus of the spring material, G = 84 GPa. 10

(*b*) (*i*) Discuss the design steps involved in hydrodynamic journal bearing.

(*ii*) The load on the journal bearing is 150 kN due to turbine shaft of 300 mm diameter running at 1800 rpm. Determine the following: 10

(1) Length of bearing, if the allowable bearing pressure is 1·6 N/mm^2, and

(2) Amount of heat to be removed by the lubricant per minute, if the bearing temperature is 60°C and viscosity of the oil at 60°C is 0·2 N/m-s and bearing clearance is 0·25 mm. Take

$$\mu = 33/10^8\,(ZN/p)(d/c) + 0{\cdot}002.$$

6. (*a*) (*i*) Define module, circular pitch and diametral pitch of involute spur gears. Give the mutual relationship between them. 5

(*ii*) Describe, with good sketches, the working principle of following gear trains: 5

(1) Simple gear train

(2) Compound gear train

(3) Epicyclic gear train.

(*b*) In a spur gear drive, the driving bronze spur pinion rotates at 600 rpm. If drives a cast iron spur gear at a transmission ratio of 4:1. The allowable static stresses for the bronze pinion and cast iron gear are 84 MPa and 105 MPa, respectively. The pinion has 16 standard 20° full depth involute teeth of module 8 mm. The face width of both the gears is 90 mm. Find the power that can be transmitted from the standpoint of strength. Take velocity factor = $c_v' = 3/(3 + v)$ and tooth form factor = $y_p = 0{\cdot}154 - (0{\cdot}912/T_p)$. 10

7. (*a*) A hollow steel shaft, 20 cm internal and 30 cm external diameter, is to be replaced by a solid alloy shaft. If the polar modulus has the same value for both, calculate the diameter of the latter and the ratio of their rigidities. Take rigidity modulus of steel, G_s, equal to 2·4 times the G_a for the alloy. 10

(*b*) A cotter joint has to resist a tensile load of 60 kN between two steel rods. All parts of the joint are made of the same material with the following allowable stresses:

σ_t = allowable tensile strength = 60 MPa
σ_c = allowable compressive strength = 125 MPa
τ_s = allowable shear strength = 70 MPa

Find out (*i*) diameter of rods, (*ii*) diameter of enlarged end of rods, (*iii*) thickness of cotter, width of cotter, assume, if necessary, and (*iv*) sleeve dimensions. Draw a sectional view of the cotter joint. 10

8. (*a*) Design a single dry plate clutch to transmit 7·5 kW at 900 rpm. Find

(*i*) diameter of the shaft;

(*ii*) mean radius and face width of friction lining assuming the ratio of the mean radius to the face width as 4; and

(*iii*) outer and inner radius of the clutch plate.

Take the intensity of pressure on the clutch plate = 0·07 N/mm^2 and coefficient of friction = μ = 0·25. 10

(*b*) An impregnated belt, 10 mm × 250 mm, drives a pulley 100 cm in diameter at 340 rpm. The angle of contact on the smaller pulley is 120°. The stress in the tight side is 1000 kN/m^2. Determine the power transmitted by the belt drive. Density of the belt material is 0·98 g/cm^3. The coefficient of friction between the belt and the driving pulley is 0·35. Take the centrifugal tension into consideration for the design. 10

Group C

9. (*A*) Choose the *correct* answer for the following: 1 × 10

(*i*) A point in a loaded member is subjected to pure state of shear stress given by $\tau_{xy} = \pm$ 500 MPa. The principal stresses σ_1 and σ_2 are given by

(*a*) σ_1 = 500 MPa, σ_2 = -500 MPa

(*b*) $\sigma_1 = \sigma_2$ = 500 MPa

(*c*) $\sigma_1 = \sigma_2$ = -500 MPa

(*d*) σ_1 = 500 MPa, σ_2 = 0.

(*ii*) A ductile material has yield strength in tension given by σ_y. At a point of a loaded member, the principal stresses are given by σ_1, σ_2 and zero with $\sigma_1 > \sigma_2$. According to maximum shear stress theory,

(*a*) $(\sigma_1 - \sigma_2)/2 = \sigma_y$

(*b*) $(\sigma_2 - \sigma_1)/2 = \sigma_y$

(*c*) $\sigma_1 - \sigma_2 = \sigma_y$

(*d*) $\sigma_2 - \sigma_1 = \sigma_y$.

(*iii*) A thin tube under internal pressure p has the hoopstress given by (with r = inner dia and t = material thickness)

(*a*) $pr/2t$

(*b*) pr/t

(*c*) $pr/4t$

(*d*) $2pr/t$.

(*iv*) The curvature effect of a coil spring under compressive load is taken care of in the design by

(*a*) Tresca's criterion

(*b*) Soderberg's law

(*c*) Lewis form factor

(*d*) Wahl's stress factor.

(*v*) The stress concentration effect in fatigue design is taken by considering notch sensitivity effect. The machine part with an elliptical fillet has a static stress concentration factor K_t. The notch sensitivity is determined to be q. The fatigue stress concentration factor is given by

(*a*) $K_f = 1 + q(K_t - 1)$

(*b*) $K_f = 1 + q(K_t + 1)$

(*c*) $K_f = 1 + q(2K_t - 1)$

(*d*) $K_f = 1 + q(2K_t + 1)$.

(*vi*) In a journal bearing, the oil used has a absolute viscosity Z, the bearing pressure is p and the speed of the journal is N rpm. The bearing characteristic number is given by

(*a*) Z

(*b*) N

(*c*) p/ZN

(*d*) ZN/p.

(*vii*) For maximum power transmission in a flat belt drive, the centrifugal tension, T_C, in terms of maximum belt tension, is given by

(*a*) $T_C = T_1$

(*b*) $T_C = T_1/3$

(*c*) $T_C = 2T_1$

(*d*) $T_C = T_1/2$.

(*viii*) In a clutch, which has been used for quite sometime, the power transmitted is calculated on the basis of

(*a*) both uniform rate of pressure and wear

(*b*) uniform rate of pressure

(*c*) uniform rate of wear

(*d*) neither uniform rate of pressure nor uniform rate of wear.

(*ix*) A shaft is subjected to a maximum shear stress τ_{max}. The shaft has a diameter d. The maximum torque transmitted is

(*a*) $(\pi d^3/32)\,\tau_{max}$

(*b*) $(\pi d^3/64)\,\tau_{max}$

(*c*) $(\pi d^3/16)\,\tau_{max}$

(*d*) $(\pi d^3/8)\,\tau_{max}$.

(*x*) A column is hinged at both ends. The length is l and moment of intertia is I. The material has a Young's modulus E. The crippling load is given by

(*a*) $4\pi^2 EI/l^2$

(*b*) $2\pi^2 EI/l^2$

(*c*) $\pi^2 EI/l^2$

(*d*) $\pi^2 EI/2l^2$.

(*B*) Draw free-hand good sketches for the following: 5 x 2

(*i*) Woodruff key

(*ii*) Crane hook with trapezoidal cross-section

(*iii*) Shot peening method

(*iv*) Worm gear

(*v*) Cone clutch.

S'09 : 2 FN : MC 421 (1506)

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Group A

1. (*a*) Explain the following cycles with reference to machine design : (*i*) Product life-cycle, and (*ii*) Process development cycle. 4+4

(*b*) Explain the concept of CAD, CAM and CAE. 6

(*c*) Write a note on concurrent engineering. 6

2. (*a*) What are the steps of problem-solving methodology used in machine design ? 6

(*b*) A rectangular section beam of wood has the dimensions $b = 25$ mm and $d = 100$ mm. It is subjected to a pure bending moment of 200 N–m so as to produce compression of the inner fiber. Find the stresses

(*Turn Over*)

when the (*i*) beam is straight, (*ii*) beam is strengthened by putting two steel flitches placed at top and bottom symmetrically. The dimensions of steel plates are $b = 25$ mm and $t = 10$ mm. Take $E_s = 15\,E_w$, and (*iii*) centroidal axis of the beam has a radius of curvature of 100 mm. 4+4+6

3. (*a*) What is 'ergonomics'? How is the user-friendly design created? 8

(*b*) Define 'principal stresses' and principal planes'. 4

(*c*) The stresses at a point in a certain component are found as $\sigma_x = 200$ MPa, $\sigma_y = -300$ MPa, and $\tau_{xy} = 100$ MPa as shown in Fig. 1. Calculate the principal stresses, location of principal planes, maximum shear stress, and location of planes having maximum shear stress. 8

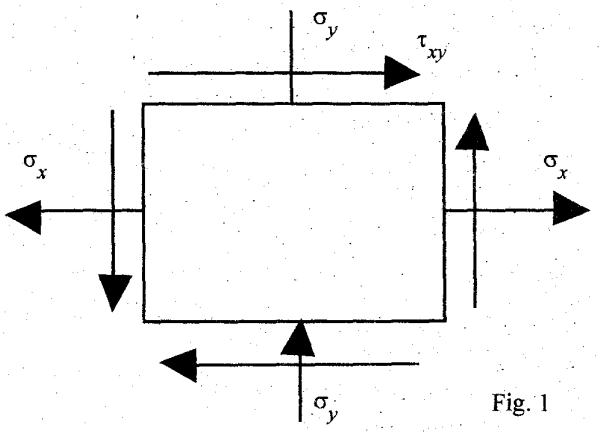

Fig. 1

4. (*a*) Explain the basic principle of 'Monte Carlo method' used in simulation of design. 4

(*b*) What are the different criteria for selection of materials? 4

(*c*) Explain the concept of 'value analysis' and 'value engineering'. 4

(*d*) Draw the stress-strain diagram for low carbon steel obtained in tension test. 4

(*e*) Explain the failure of 'ductile material' and 'brittle material' in tension test. 4

Group B

5. (*a*) Explain the term 'system reliability'. How is it evaluated? 4

(*b*) How are the optimization methods classified? What do you mean by 'optimization' in machine design? 6

(*c*) A complex engineering design can be described by a reliability block diagram as shown in Fig. 2. In sub-system *A*, two components must operate for the sub-system to function successfully. Subsystem *C* has true parallel reliability. Calculate the reliability of each sub-system and overall system reliability. 10

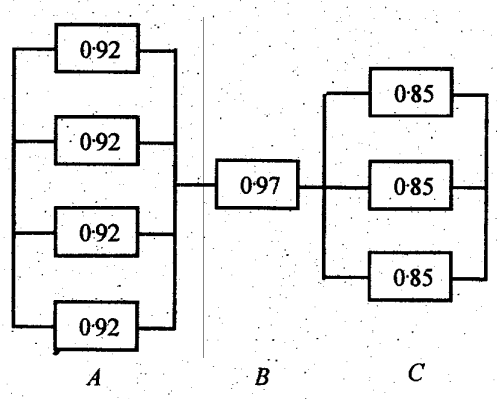

Fig. 2

6. (*a*) What is the difference between 'fatigue limit' and 'endurance limit'? 4

(*b*) What is S-N diagram and P-S-N diagram? How is the effect of mean stress taken into account? 6

(*c*) A shaft has to transmit 2 MW power at 1725 rpm. The maximum torque is 20% more than mean torque. The safety factor is 2·5. The shaft is hollow as outer diameter is twice the inner diameter. If maximum shear stress is 200 MPa, find the inner and outer diameter of the shaft and corresponding angle of twist/length. Take $G = 80$ GPa. If torque is fluctuating between 1·2 times mean torque to 0·8 times mean torque, find the corresponding diameters again. Take $\tau_e = 150$ MPa. 10

7. (*a*) What is the meaning of 'short bearing' and 'long bearing' and why? 4

(*b*) A flywheel of bore diameter 50 mm and outer diameter 600 mm is rotating at 3000 rpm. It is also shrunk on the shaft such that shrinkage pressure is 40 MPa. Calculate the maximum radial and hoop stresses, and plot their variations. Take $\varrho = 7800$ kg/m^3, $\nu = 0{\cdot}3$ and $E = 207$ GPa. Also, find the extension of bore. 16

8. (*a*) Two machines, each have a useful life of 5 years. If money is worth as 10%, which machine is more economical? 10

	Machine A	*Machine B*
Initial cost	25000·00	15000·00
Yearly maintenance cost	2000·00	4000·00
Rebuilding at the end of 3 years	—	3500·00
Salvage value	3000·00	—
Annual benefit from better quality	500·00	—

(*b*) What are the different pitches of gears. 4

(*c*) Explain the following terms with reference to gears : (*i*) Pressure angle, (*ii*) involute, and (*iii*) backlash. 3×2

Group C

9. Choose most appropriate answer for the following : 20×1

(*i*) The ratio of fatigue strength without notch to fatigue strength with notch is called

(*a*) stress concentration factor (k_t).

(*b*) fatigue strength reduction factor (k_f)

(*c*) notch sensitivity factor (q).

(*d*) stress Intensity Factor (K_I).

(*ii*) The energy required to fracture the specimen in impact test is called as

(*a*) impact toughness.

(*b*) toughness.

(*c*) resilience.

(*d*) modulus of resilience.

(*iii*) By decreasing carbon content in mild steel, yield point

(*a*) decreases.

(*b*) does not change.

(*c*) increases.

(*d*) is not observed.

(*iv*) In S-N diagram obtained from fatigue test, mean stress is

(*a*) maximum, positive.

(*b*) minimum, negative.

(*c*) zero.

(*d*) equal to yield stress.

(*v*) A closed coiled helical spring, subjected to axial load, has

(*a*) shear stress only.

(*b*) bending stress only.

(*c*) shear stress and bending stress.

(*d*) tensile stress only.

(*vi*) A disk-clutch has to be designed with disks made of cast iron. The coefficient of friction may be taken as

(*a*) 0·5 or more.

(*b*) 0·25 – 0·45.

(*c*) 0·15 – 0·25.

(*d*) 0·05 – 0·15.

(*vii*) M8 × 1·25 thread defines a thread with 8 mm diameter by 1·25 mm pitch having groove angle

(*a*) 90°

(*b*) 60°

(*c*) 30°

(*d*) 15°

(*viii*) Wahl factor in the design of spring takes care of

(*a*) effect of curvature and direct shear.

(*b*) effect of curvature only.

(*c*) effect of direct shear only.

(*d*) None of the above.

(*ix*) The ideal spring material should have

(*a*) less ultimate strength.

(*b*) low modulus of elasticity.

(*c*) lower yield point.

(*d*) less deformation.

(*x*) A shaft material is selected for

(*a*) minimizing deflection.

(*b*) low modulus of elasticity.

(*c*) low hardness value.

(*d*) All of the above.

(*xi*) The mostly used relationship in designing against fatigue is

(*a*) Goodman's line

(*b*) Geber's parabola

(*c*) Soderberg's line

(*d*) None of the above.

(*xii*) The failure in keys occurs

(*a*) shear only.

(*b*) bearing only.

(*c*) tensile only.

(*d*) both shear and bearing.

(*xiii*) A rotating motion can be converted into translation using

(*a*) helical gearing.

(*b*) bevel gearing.

(*c*) rack and pinion.

(*d*) worm and worm wheel.

(*xiv*) The materials used in manufacturing gears are

(*a*) cast iron.

(*b*) steels.

(*c*) bronzes.

(*d*) All of the above.

(*xv*) In bevel gearing, the predominant stress is

(*a*) bending stress

(*b*) shear stress

(*c*) tensile stress

(*d*) compressive stress

(*xvi*) Plywood is an example of

(*a*) isotropic material

(*b*) orthotropic material

(*c*) anisotropic material

(*d*) None of the above.

(*xvii*) Tool steel possesses

(*a*) high hardness.

(*b*) high wear resistance.

(*c*) good toughness.

(*d*) All of the above.

(*xviii*) In case of shear force and bending moment diagram, a point of contraflexure is that

(*a*) shear force is zero.

(*b*) shear forces change its sign.

(*c*) bending moment is zero.

(*d*) bending moment is maximum.

(*xix*) The usual value of slenderness ratio (l/k) for long columns is

(*a*) < 10

(*b*) > 10

(*c*) < 5

(*d*) > 5

(*xx*) Most effective theory of failure used in design is

(*a*) maximum stress theory.

(*b*) maximum shear-stress theory.

(*c*) von-Mises stress theory.

(*d*) distortion energy theory.

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Group A

1. (*a*) What do you mean by 'embodiment design' ? Explain various steps involved in this phase of design. 5

(*b*) Explain the Bureau of Indian Standards (BIS) method of designation of plain carbon steel with suitable examples. 5

(*c*) The central horizontal section of a hook is symmetrical trapezium 60 mm deep , the inner width being 60 mm and outer width being 30 mm. Estimate the extreme intensities of stress when the hook carries a load of 20 kN. The load line passes at 40 mm from the inside edge of the section and the centre of curvature lies in the load line. 10

2. (*a*) Explain, with suitable neat sketches, how the effect of stress-concentration can be reduced. 5

(*b*) What is the significance of theories of failure? What are common drawbacks of maximum shear stress theory as compared to the maximum distortion energy theory? 5

(*c*) When a motor is mounted on a beam, as shown in *Fig.* 1, it is observed that the end of the beam is subjected to a completely reversible load of 15 kN. The span of the beam is 1 m. The material of the beam is C35 cold rolled steel having ultimate strength $600\,N/mm^2$. The stress concentration factor at wall is 2·0. Determine cross-section of the beam. 10

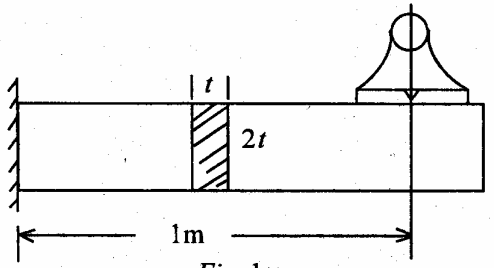

Fig. 1

3. (*a*) Two length of mild steel tie rods, having width 200 mm and thickness 12·5 mm, are to be connected by means of a butt joint with equal straps. Design the Lozenge joint, if the permissible stress in plates and rivets material are: $\sigma_t = 80\,N/mm^2$, $\tau = 50\,N/mm^2$ and $\sigma_{cr} = 150\,N/mm^2$. 10

(*b*) An air compressor of elective diameter 300 mm is subjected to air pressure of $1{\cdot}5\,N/mm^2$. The cylinder head is connected by means of 8 bolts having yield strength of $350\,N/mm^2$ and endurance limit of $240\,N/mm^2$. The bolts are tightened with an initial preload force of 1·5 times that of external force. A copper is used to make joint leak-proof. Assume stress concentration factor of 2·5 and factor of safety 2·0. Determine the required size of the bolt. 10

4. (*a*) Design a screw jack for lifting a load of 20 kN through a distance of 200 mm. Assume following data: 14

Screw material: Plain carbon steel with yield strength $350\,N/mm^2$

Nut material: Phosphur bronze having yield strength $120\,N/mm^2$

Factor of safety: 4

Friction coefficient, μ : 0·15

(*b*) Explain the following: 3 × 2

(*i*) What is limitation of single strap butt joint?

(*ii*) What is throat thickness of a fillet weld?

(*iii*) Why are welded joint preferred over riveted joint?

Group B

5. (*a*) Design a leaf spring for the rear axle of a tractor trolley. The load on the rear axle of the trolley is 10 kN. The span is 1200 mm and width of clamp is 100 mm. In all, 12 leaves are used out of which two are main leaves and the remaining graduated leaves. Assume that spring material is chrome-vanadium steel having ultimate strength $1500\,N/mm^2$ and endurance strength $600\,N/mm^2$. Factor of safety = 2·0. 12

(*b*) What is the importance of the adjustment of belt tension in a belt drive? 2

(*c*) How are V belt designated? 2

(*d*) Explain the theory of hydrodynamic lubrication as used in sliding bearing. 4

6. (*a*) Compare 14·5° and 20° pressure angle systems in gear drives. 4

(*b*) Explain the concept of virtual number of teeth for a helical gear. 4

(*c*) Design a pair of helical gears to transmit 30 kW power at a speed reduction ratio of 4 : 1. The input shaft rotates at 2000 rpm. Take helix and normal pressure angles equal to 25° and 20°, respectively. Both pinion and gear are made of steel having following property:

Part	Permissible Stress	BHN
Pinion	55 MPa	340
Gear	40 MPa	300

The number of teeth on pinion may be taken as 30. 12

7. (*a*) Draw the typical Raimondi & Boyd chart and explain its use in the design of sliding bearing. 5

(*b*) Design a clutch plate for the speed gear box of a lathe machine to transmit 15 kW at 1000 rpm. Due to space limitation the outer diameter is limited to 150 mm. Assume following data: Friction coefficient = 0·2 and bearing pressure = 0·3 - 0·7 N/mm^2. 10

(*c*) Explain why does a cone clutch transmits more power than a plate clutch? 5

8. (*a*) Design a pair of Kennedy key for transmitting 30 kW at 360 rpm. The shaft and key both are made of C50 steel having yield strength of 390 N/mm^2 and factor of safety of 3·0. 10

(*b*) Explain any *three* from the following: 3 + 3 + 4

(*i*) Use of gib type cotter joint

(*ii*) Mechanism of lock nut

(*iii*) Stress distribution in the wire of helical compression spring

(*iv*) Interference of gears.

Group C

9. Choose the *correct* answer for the following: 1 × 20

(*i*) Killed steels are those steels

(*a*) which are destroyed by burning

(*b*) which can be recycled

(*c*) in which carbon content is burnt

(*d*) which are deoxidized with silicon.

(*ii*) The depth of hardness of steel is increased by the addition of

(*a*) Nickel

(*b*) Chromium

(*c*) Tungsten

(*d*) Vanadium.

(*iii*) The equivalent length of column supported firmly at both ends is

(*a*) 2*l*

(*b*) *l*

(*c*) 0·5*l*

(*d*) 0·7*l*

(*iv*) The bending moment on a beam is maximum where shear force is

(*a*) zero

(*b*) minimum

(*c*) maximum

(*d*) equal.

(*v*) The commutative fatigue damage can be determined by

(*a*) soap film method

(*b*) Minor's rule

(*c*) Major's rule

(*d*) Goodman's method.

(*vi*) Acme threads are preferred to the square thread because

(*a*) their efficiency is high

(*b*) they can be manufactured easily

(*c*) of their higher coefficient of friction

(*d*) they can carry load in one direction.

(*vii*) Preloading of bolts

(*a*) improves the factor of safety

(*b*) reduces the factor of safety

(*c*) secure the part tightly

(*d*) prevent leakage.

(*viii*) If the thickness of boiler plate is 25 mm, the rivet diameter will be

(*a*) 15 mm

(*b*) 20 mm

(*c*) 25 mm

(*d*) 30 mm.

(*ix*) The allowable stress in compression springs for most of the material with increase in the size of wire will

(*a*) increase

(*b*) decrease

(*c*) remain same

(*d*) be unpredictable.

(*x*) To equalize the stress in leaf spring, the initial radius of curvature of full length leaves should be

(*a*) smaller than graduated leaves

(*b*) greater than graduated leaves

(*c*) equal and opposite to graduated leaves

(*d*) equal to graduated leaves.

(*xi*) In a flat belt drive, the maximum value of tension is

(*a*) T_c

(*b*) $2T_c$

(*c*) $3T_c$

(*d*) $4T_c$

where T_c is the centrifugal tension.

(*xii*) Interference is inherently absent in the following types of gear:

(*a*) Involute

(*b*) Cycloidal

(*c*) Stub

(*d*) Hypocycloidal.

(*xiii*) Diametral quotient of worm gear is defined as

(*a*) axial module/reference diameter

(*b*) pitch diameter/module

(*c*) module/pitch diameter

(*d*) pitch/pitch diameter.

(*xiv*) Which one of the following key is unusually strong in failure against shear and crushing?

(*a*) Rectangular

(*b*) Flat

(*c*) Square

(*d*) Kennedy.

(*xv*) The average value of the weakening effect of a keyway is to reduce the strength of the shaft in shear to

(*a*) 50 per cent

(*b*) 60 per cent

(*c*) 70 per cent

(*d*) 75 per cent.

(*xvi*) Which one of the following coupling provides kinematic flexibility?

(*a*) Pin type

(*b*) Oldham

(*c*) Split muff

(*d*) Flange.

(*xvii*) In block brake, the normal reaction and frictional force act at the mid-point of the block. This is true only if the angle is

(*a*) less than 45°

(*b*) less than 60°

(*c*) greater than 45°

(*d*) greater than 60°.

(*xviii*) Which one of the following bearing has a low starting friction?

(*a*) Ball bearing

(*b*) Roller bearing

(*c*) Journal bearing

(*d*) Taper roller bearing.

S'10 : 7 AN : MC 407/PR 407 (1500)

DESIGN OF MACHINE ELEMENTS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define the terms 'standards' and 'codes' in relation to machine design. What is the difference between them? 2 + 2 + 2

   (*b*) What are important considerations in machine design? Give a list of 10 important design considerations. 4

   (*c*) A specimen of stress 25 mm diameter with a gauge length of 200 mm, is tested to destruction. It has an

extension of 0·16 mm, under a load of 80 kN, and the load at elastic limit is 160 kN. The maximum load is 180 kN. The total extension at fracture is 56 mm and the diameter at neck is 18 mm. Find the

(*i*) stress at elastic limit;

(*ii*) Young's modulus;

(*iii*) percentage elongation;

(*iv*) percent reduction in area and

(*v*) ultimate tensile stress. 2 x 5

2. (*a*) Write the beam bending equation relating bending moment to moment of inertia, stress and modulus of elasticity. Explain its importance in machine design. 2 + 2

(*b*) Define principal stresses. What is their importance in machine design? 2 + 2

(*c*) Draw Mohr's circle for like stress and explain it completely. 8

(*d*) (*i*) What is understood by stability of columns? 1

(*ii*) What are long and short columns? 1

(*iii*) Define slenderness ratio in case of columns. 2

3. (*a*) Draw Goodman diagram, Soderberg line and Gerber parabola. Explain it briefly. 3 + 2

(*b*) Explain the term 'cumulative fatigue damage' and 'Miner's rule'. 3 + 2

(*c*) A cantilever beam of 40 C8 steel has two sections. The first part from the support is 150 mm and has a diameter of '1·5 *d*' while the second portion is 100 mm long and has a diameter '*d*'. The fillet radius at charge in section is 0·2 *d*. This cantilever is subjected to a transverse load varying from - 50 N to + 150 N at the free end. Determine the diameter '*d*' with the following values : $k_a = 0 \cdot 76$, $k_b = 0 \cdot 85$, reliability factor = 0·879 and $q = 0 \cdot 9$. $\sigma_4 = 600$ MPa for the steel and F.S. = 1·5.

For $r/d = 0 \cdot 2$ and $D/d = 1 \cdot 5$,

$k_\epsilon = 1 \cdot 35$

$k_f = 1 + q\,(k_\epsilon - 1) = 1 \cdot 315$

Use Goodman's equation. 10

4. (*a*) What is the difference between power screws and threaded fasteners from machine design point of view? Why are square/acme thread used in power screws while Vee threads are used in threaded fasteners'. 3 + 2

(*b*) A plate 100 mm wide and 10 mm thick is to be welded to another plate by means of double parallel fillets. The plates are subjected to a static load of 80 kN. Find the length of the weld, if the permissible shear stress in the weld does not exceed 55 MPa. 5

(*c*) (*i*) Draw the radial stress variation and tangential stress variation at a cross-section of a thick cylinder subjected to internal pressure only. 3

(*ii*) The inner diameter of a cylindrical tank for liquified gas is 250 mm. The gas pressure is limited to 15 MPa. The tank is made of plain carbon steel 10 C4 ($\sigma_{wt} = 340\ N/mm^2$ and $\mu = 0{\cdot}27$) and the factor of safety is 5. Determine the cylinder wall thickness. 7

Group B

5. (*a*) Write short notes on the following : 2 + 2

(*i*) Curvature effects in design of springs

(*ii*) Buckling of compression springs.

(*b*) A close-coiled helical spring is to have a stiffness of 900 N/m in compression, with a maximum load of 45 N and a maximum shearing stress of $120\ N/mm^2$. The 'solid' length of the spring (i.e. coils touching) is 45 mm. Find the wire diameter, mean coil diameter, and number of coils. $G = 40{,}000\ N/mm^2$. 10

(*c*) Differentiate between the following : 2 + 2 + 2

(*i*) Hydrostatic and hydrodynamic bearings

(*ii*) Thick film and thin film lubrication

(*iii*) Bearing characteristic number and bearing modulus.

6. (*a*) Select suitable ball bearing to carry a radial load of 10,000 N, and an axial load of 4000 N. The shaft rotates at 1000 rpm. Average life of 5000 hr is desired. Inner race rotates, the service factor is 1·5, $X = 0{\cdot}56$, $Y = 1{\cdot}2$. 10

(*b*) A solid shaft is transmitting 1 MW at 240 rpm. Determine the diameter of the shaft if the maximum torque transmitted exceeds the mean torque by 20 %. Take the maximum allowable shear stress as 60 MPa. 7

(*c*) Answer the following : 1 + 1 + 1

(*i*) Why is the cotter kept the weakest in a cotter joint ?

(*ii*) Why is the taper provided in a cotter ?

(*iii*) Why is the bush in knuckle joint made of brass ?

7. (*a*) Explain the following terms : 3 + 3

(*i*) Coupling, clutches and brakes

(*ii*) Uniform intensity of pressure and uniform rate of wear theories in clutches.

(*b*) (*i*) What are thermal considerations in brake design ? 2

(*ii*) What are the materials used for brake linings ? 2

(*c*) A solid cast iron disc, 1 m in diameter and 0·2 m thick, is used as a flywheel. It is rotating at 350 rpm. It is brought to rest in 1·5 sec by means of a brake. Calculate the (*i*) energy absorbed by the brake, and (*ii*) torque capacity of the brake. Take the mass density of cast iron as $7200\ kg/m^3$. 10

8. (*a*) (*i*) State and explain the law of gearing. 3

(*ii*) Explain the phenomenon of interference in gears. 3

(*b*) What are the advantages and disadvantages of Vee belt over flat belt drive? 4

(*c*) A pair of gears is to be designed for compact size. Power to be transmitted is 20 kW at 1450 rpm of pinion with a gear ratio of 4 : 1, tooth profile of 20° stub. Material for pinion is cast steel and for gear cast iron. Determine the module and necessary face width by using Lewis equation. Assume :

Addendum = module

σ for cast steel = 100 MPa

σ for cast iron = 70 MPa 10

Group C

9. Choose the *correct* answer for the following : 1 x 20

(*i*) Which one of the following is dimensionless ?

(*a*) Stress

(*b*) Strain

(*c*) Young's modulus

(*d*) deformation.

(*ii*) The most appropriate theory of failure for ductile materials is

(*a*) maximum strain theory

(*b*) maximum strain energy theory

(*c*) energy of distortion theory

(*d*) principal stress theory.

(*iii*) Endurance strength is found at

(*a*) 10^3 cycles of reversals

(*b*) 10^9 cycles of reversals

(*c*) 10^6 cycles of reversals

(*d*) 10^7 cycles of reversals.

(*iv*) A knuckle joint is preferred to a cotter joint

(*a*) where the cost is the criteria

(*b*) where relative motion between the rods is desirable

(*c*) where rods have different materials

(*d*) for rods of different diameters.

(*v*) It is advisable to use a rectangular key of width/ thickness ratio

(*a*) more than one

(*b*) less than one

(*c*) one

(*d*) None of the above.

(*vi*) The type of stress induced in a close coiled helical tension spring is

(*a*) tensile

(*b*) torsional shear

(*c*) compressive

(*d*) None of the above.

(*vii*) Bolts one rarely subjected to

(*a*) bending moment

(*b*) shear

(*c*) tension

(*d*) compression.

(*viii*) Acme threads are preferred over square threads for power screws because

(*a*) their efficiency is high

(*b*) they can be manufactured using dies

(*c*) they have higher coefficient of friction

(*d*) None of the above.

(*ix*) Ferodd is preferred for the friction lining due to
- (*a*) high heat resistance
- (*b*) high coefficient of friction
- (*c*) good heat dissipation
- (*d*) low wear.

(*x*) Assumption of uniform rate of wear is used for estimating capacity of clutch as
- (*a*) intensity of pressure is not uniform
- (*b*) rate of wear is uniform
- (*c*) intensity of pressure is uniform for new surfaces but as the surfaces do not wear uniformly after some use, the intensity of pressure does not remain uniform
- (*d*) it is safe.

(*xi*) Lewis equation in spun gears is applied
- (*a*) only to the pinion
- (*b*) only to the gear
- (*c*) the stronger of the pinion or gear
- (*d*) the weaker of the pinion or gear.

(*xii*) It is desirable to have angle of helix 15–30° in helical gears so that
- (*a*) axial thrust is limited and engagement is smooth
- (*b*) engagement is smooth and gradual
- (*c*) axial thrust is eliminated
- (*d*) None of the above.

(*xiii*) Mckee equation is useful for finding
- (*a*) Sommerfield number
- (*b*) viscosity of oil
- (*c*) minimum film thickness
- (*d*) power loss in friction.

(*xiv*) When the length of the journal is equal to the diameter of the journal, then the bearing is said to be
- (*a*) short bearing
- (*b*) long bearing
- (*c*) medium bearing
- (*d*) square bearing.

(*xv*) The piston pin bearings in heavy duty diesel engines are
- (*a*) needle roller bearings
- (*b*) tapered roller bearings
- (*c*) spherical roller bearings
- (*d*) cylindrical roller bearings.

(*xvi*) Worm gear drive is used for hoists because it is
- (*a*) very efficient
- (*b*) noiseless
- (*c*) self-locking
- (*d*) capable of taking large load.

(*xvii*) Bevel gears with shaft angles of 90° are termed as
- (*a*) zerol gears
- (*b*) angular bevel gears
- (*c*) mitre gears
- (*d*) hypoid gears.

(*xviii*) A pressure vessel is said to be a thin cylindrical shell if the ratio of the wall thickness of the shell to its diameter is
- (*a*) equal to 1/10
- (*b*) less than 1/10
- (*c*) more than 1/10
- (*d*) None of the above.

(*xix*) The pipes carrying fluid pressure varying from $5\,N/mm^2$ to $14\,N/mm^2$ should have

(*a*) square flanged joint

(*b*) circular flanged joint

(*c*) oval flanged joint

(*d*) spigot and socket joint.

(*xx*) According to Unwin's formula, the relation between diameter of rivet hole (d) and thickness of plate (t) is given by

(*a*) $d = t$

(*b*) $d = 1{\cdot}6\sqrt{t}$

(*c*) $d = 2t$

(*d*) $d = 6\,t$

when both d and t are in mm.

S'11 : 7 AN : MC 407 / PR 407 (1500)

DESIGN OF MACHINE ELEMENTS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A**, ANY TWO *from* **Group B** *and* ALL *from* **Group C**.

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define the terms 'stress' and 'strain' in relation to machine design. What is the relation between them? 1 + 1 + 2

(*b*) Write *any eight* important factors to be considered in the selection of materials for the machine members. 4

(*c*) Sketch and explain salient points of the stress-strain curve of mild steel specimen in tensile test. 2 + 4

(*d*) An aluminium bar of 60 mm diameter, when subjected to an axial tensile load 100 kN, elongates 0·2 mm in a gauge length of 300 mm and the diameter is decreased by 0·012 mm. Calculate the modulus of elasticity and the Poisson's ratio of the material. 6

2. (*a*) Write *any four* important mechanical properties of materials and define those properties. 2 + 4

(*b*) Differentiate between thick cylindrical shells and thin cylindrical shells. 2

(*c*) A thin cylindrical pressure vessel of 1·2 m diameter carries steam at a pressure of 1·75 N/mm^2. Find the minimum wall thickness, if the (*i*) longitudinal stress does not exceed 28 MPa; and (*ii*) circumferential stress does not exceed 42 MPa. 3 + 3

(*d*) (*i*) Define the term 'principal stress'. 3

(*ii*) Write the Euler's and Johnson's formulae used for the design of piston rod and connecting rod. 3

3. (*a*) Define the terms 'stress concentration factor', 'notch sensitivity' and 'fatigue'. 2 + 2 + 2

(*b*) Give examples of brittle and ductile materials and write their applications. 4

(*c*) A bolt is subjected to an axial pull of 12 kN together with a transverse shear force of 6 kN. Determine the diameter of the bolt according to (*i*) maximum normal stress theory, (*ii*) maximum shear stress theory, and (*iii*) maximum distortion energy theory. Given : 10

Elastic limit in tension = 300 N/mm^2
Factor of safety = 3
Poisson's ratio = 0·3

4. (*a*) Write about bolts of uniform strength and give examples of practical applications of such bolts. 2 + 2

(*b*) A steel rod is subjected to a reversed axial load of 180 kN. Find the diameter of the rod for a factor of safety of 2. Neglect column action. The material has an ultimate tensile strength of 1070 N/mm^2 and yield strength of 910 N/mm^2. The endurance limit in reversed bending may be assumed to be one-half of the ultimate tensile strength. Other correction factors may be taken as follows : 8

For axial loading = 0·7
For machined surface = 0·8
For size = 0·85
For stress concentration = 1·0.

(*c*) A double riveted lap joint with zig-zag riveting is to be designed for 13 mm thick plates. Assume $\sigma_t = 80$ MPa; $\tau = 60$ MPa and $\sigma_c = 120$ MPa. State how the joint will fail and find the efficiency of the joint. Here σ_t = permissible tensile stress, σ_c = permissible crushing stress, and τ = permissible shear stress. 8

Group B

5. (*a*) Define the following terms : 4 x 1

(*i*) Spring index

(*ii*) Spring stiffness

(*iii*) Solid length of the spring

(*iv*) Free length of the spring.

(*b*) A helical spring is made from a wire of 6 mm diameter and has outside diameter of 75 mm. If the permissible shear stress is 350 MPa and modulus of rigidity is 84 kN/mm^2, find the axial load which the spring can carry and the deflection per active turn. 10

(*c*) (*i*) State and explain the law of gearing. 3

(*ii*) What are the types of gear teeth used in design of gears for different applications? 3

6. (*a*) Define the term 'hydrodynamic lubrication'. 2

(*b*) Give two examples of applications for the following springs : 4 x 1

(*i*) Helical springs

(*ii*) Leaf springs

(*iii*) Torsional springs

(*iv*) Disc springs.

(*c*) A journal bearing of diameter 50 mm and length 100 mm is subjected to a bearing load of 7 kN. The speed of the journal is 900 rpm and coefficient of friction is 0·004. The temperature of lubricating oil is 75°C and room temperature is 35°C. Find the amount of artificial cooling required. Assume coefficient of heat dissipated as 0·00167 kJ/min/cm^2/°C. 10

(*d*) What is the main difference between key and cotter joint ? Write their applications. 2 + 2

7. (*a*) A bronze spur pinion rotating at 600 rpm drives a cast iron supergear at a transmission ratio of 4 : 1 ; the allowable static stresses for the bronze pinion and cast iron gear are 84 N/mm^2 and 105 N/mm^2, respectively. The pinion has 16 standard 20° full depth involute teeth of module 8 mm. The face width of each of the gears is 90 mm. Find the power that can be transmitted. 10

(*b*) The shaft of a machine is subjected to a maximum torque of 2100 N-m and a maximum bending moment of 4100 N-m. Determine the diameter of a solid shaft to withstand the above loads. Take the allowable shear stress in the material of the shaft as 45 MN/m^2 and the combined shear and fatigue factors in torsion as 1·5 and in bending as 2. Suppose a hollow shaft is to be designed for the same situation with inside diameter equal to 0·6 of outside diameter, what saving in material (in percentage) would have resulted ? 10

8. (*a*) Name the *two* theories applied for the design of friction clutches. 2

(*b*) In what ways the clutches are different from brakes ? 2

(*c*) A compressor, requiring 90 kW, is to run at about 250 rpm. The drive is by V-belts from an electric motor running at 750 rpm. The diameter of the pulley on the compressor shaft must not be greater than 1000 mm, while the centre distance between the pulleys is limited to 1750 mm. The belt speed should not exceed 1600 m/min. Determine the number of V-belts required to transmit the power, if each belt has

a cross-sectional area of 375 mm^2, density 1000 kg/m^3, and an allowable tensile stress of 2·5 N/mm^2. The groove angle of the pulley is 35°. The coefficient of friction between the belt and the pulley is 0·25. Also, calculate the length required for each belt. 10

(*d*) Describe, with the help of a neat sketch, the principle of operation of an internal expanding shoe brake. 3 + 3

Group C

9. Choose the *correct* answer for the following : 20 × 1

(*i*) The area under stress-strain curve per unit volume represents
- (*a*) material hardness.
- (*b*) breaking strength.
- (*c*) energy required to cause the failure.
- (*d*) None of the above.

(*ii*) Which one of the following is dimensionless ?
- (*a*) Deformation
- (*b*) Young's modulus
- (*c*) Stress
- (*d*) Strain.

(*iii*) The maximum value of stress concentration factor in an infinite plate of vary large width with a circular hole under uniaxial tension is
- (*a*) 2
- (*b*) 3
- (*c*) 4
- (*d*) 5

(*iv*) The maximum value of notch sensitivity can be
- (*a*) 0·5
- (*b*) 1
- (*c*) 1·5
- (*d*) 2

(*v*) An M8 screw indicates that the metric screw thread has
- (*a*) major diameter of 8 mm.
- (*b*) minor diameter of 8 mm.
- (*c*) pitch diameter of 8 mm.
- (*d*) root diameter of 8 mm.

(*vi*) If the pitch of square threads is 10 mm, then the depth of threads is
- (*a*) 2·5 mm
- (*b*) 5 mm
- (*c*) 10 mm
- (*d*) 20 mm

(*vii*) A shaft of diameter '*d*' mm is subjected to a torque '*T*' N-mm. Then the shear stress (N/mm^2) induced in a shaft is
- (*a*) $4\,T/\pi\,d^3$
- (*b*) $8\,T/\pi\,d^3$
- (*c*) $16\,T/\pi\,d^3$
- (*d*) $32\,T/\pi\,d^3$

(*viii*) According to Unwin's formula, the diameter of rivet is given by

(*a*) $\sqrt{5t}$

(*b*) $5\sqrt{t}$

(*c*) $\sqrt{6t}$

(*d*) $6\sqrt{t}$

where t is the thickness of the plate.

(*ix*) In a boiler shell if the diameter of rivet hole is 10 mm, then the margin shall be

(*a*) 10 mm

(*b*) 15 mm

(*c*) 20 mm

(*d*) 25 mm

(*x*) In a transverse fillet welded joint, the size of weld is equal to

(*a*) 0·5 × throat of weld

(*b*) throat of weld

(*c*) $\sqrt{2}$ × throat of weld

(*d*) 2 × throat of weld

(*xi*) Which one of the following types of spring is used in trucks?

(*a*) Spiral

(*b*) Helical

(*c*) Volute

(*d*) Leaf

 (*Continued*)

(*xii*) Which one of the following is antifriction bearing?

(*a*) Footstep bearing

(*b*) Collar bearing

(*c*) Ball bearing

(*d*) Slider bearing

(*xiii*) If 'W' is the load on a cylindrical journal of diameter (d), length (l), then bearing pressure is

(*a*) $2\ W/\pi d^2$

(*b*) $4\ W/\pi d^2 l$

(*c*) $W/\pi\ dl$

(*d*) W/dl

(*xiv*) The Lewis formula is used to calculate

(*a*) tensile stress in the gear teeth.

(*b*) impact stress.

(*c*) dynamic stress.

(*d*) bending stress.

(*xv*) The pressure angle of gear recommended by BIS is

(*a*) 12 - 1/2°

(*b*) 20°

(*c*) 22 - 1/2°

(*d*) 30°

(*xvi*) The suitable taper on the cotter is generally

(*a*) 1 : 8

(*b*) 1 : 16

(*c*) 1 : 24

(*d*) 1 : 32

 (*Turn Over*)

(*xvii*) The width of rectangular sunk key in terms of diameter '*d*' of shaft is

(*a*) *d*/4

(*b*) *d*/2

(*c*) *d*/8

(*d*) *d*/6

(*xviii*) Single plate clutches are used in

(*a*) scooter.

(*b*) three-wheelers.

(*c*) buses.

(*d*) mopeds.

(*xix*) The power transmitted by a cross belt as compared to a flat belt is

(*a*) less.

(*b*) more.

(*c*) equal.

(*d*) unpredictable.

(*xx*) In a belt drive, slip occurs on a smaller pulley due to

(*a*) more angle of contact.

(*b*) less angle of contact.

(*c*) less width of belt.

(*d*) more width of belt.

W'11:2 FN:MC 421 (1506)

DESIGN OF MECHANICAL SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Explain different phases in the design process, acknowledging many feedbacks and iterations with a suitable block diagram. 6

(*b*) What are different design considerations which influence the design of an element or the entire system ? 6

(*c*) What are alloy steels ? State the effect of the following elements in steel : 4 × 1

(*i*) Manganese

(*ii*) Silicon

(*iii*) Chromium

(*iv*) Nickel

(*d*) Write a note on the following casting materials : 2 + 2

(*i*) Alloy cast iron

(*ii*) Cast steel

2. (*a*) Find the shaft and hole limits for a medium drive fit 50H7/s6 IT7 grade $\Delta D = 0.025$ mm using a basic hole size of 50 mm. Fundamental deviation $\delta_f = 0.043$. 6

(*b*) In a railway wagon, the maximum load on a pair of wheels is 100 kN : one wheel takes 70 kN and the other 30 kN. The distance between the rails is 1.45 m and between the centres of the axle boxes is 1.90 m . Find the diameter of axle at the wheel. Safe stress is 77 MPa. 8

(*c*) A cylindrical compressed air drum is 2 m in diameter with plates 125 mm thick. The efficiencies of the longitudinal and circumferential joints are 85% and 45%, respectively. If the tensile stress in the plating is to be limited to 1000 N/mm^2, find the maximum safe air pressure. 6

3. (*a*) A stepped shaft, with the reduction ratio of 1.2, is to have a fillet radius of 10% of the smaller diameter. The material of the shaft has notch sensitivity factor of 0.925, a shear stress of 160 MPa at yield and a shear stress of 120 MPa at endurance limit. Determine the diameter of the shaft at the minimum cross-section to sustain a twisting moment of that fluctuates between 500 Nm and 800 Nm. Take $K_t = 1.33$; $C_v = 0.95$; $C_s = 0.85$ and $F_s = 2$. 10

(*b*) A cylindrical rough machined member made from C-50 steel of 50 mm is reduced to 30 mm diameter by a 5 mm fillet. It is subjected to light shock load producing a completely reversed stress in bending and the life is estimated to be 10 million cycles. Find the bending moment. Take $K_t = 1.5$; $F_s = 1.5$, endurance stress = 317 MPa and yield stress = 373 MPa. 10

4. (*a*) A plate, 80 mm wide and 15 mm thick is joined with another plate by a single transverse weld and a double parallel weld. Determine the length of the parallel fillet weld if the joint is subjected to both static and fatigue loading. Take $\sigma_t = 90$ MN/m^2 ; $\tau = 55$ MN/m^2 as the allowable stresses and stress concentration factor as 1.5 for transverse weld and 2.7 for parallel weld. 10

(*b*) A steam engine cylinder of effective diameter 300 mm is subjected to a steam pressure of 1.5 MPa. The cylinder head is connected by means of 8 bolts having yield strength of 330 MPa and endurance limit of 240 MPa. The bolts are tightened with an initial pre-load of 1.5 times that of steam load. A soft copper gasket is used to make the joint leak-proof. Assuming a stress concentration factor of 2.8 ; C for gasket 0.4 ; and a factor of safety as 2, find the size of the bolts required. 10

Group B

5. (*a*) Design a close coiled helical spring for an engine from the following data : 10

State of Valve	Length of Spring, mm	Spring Load, N
Open	40	400
Close	50	200

Maximum inside diameter of spring = 28 mm
Permissible shear stress in spring material = 400 MPA
Modulus of rigidity = 80 GPa

(*b*) A shaft of 1.5 m long is simply-supported on two bearings. It carries a flat belt pulley (B) of diameter 200 mm, weighing 200 N at a distance of 0.4 m from the left bearing and a flat belt pulley (A) of diameter 300 mm, weighing 300 N at a distance of 0.6 m from the right bearing. If the shaft is receiving 20 kW at pulley A and delivering the same power at pulley B, determine the diameter of the shaft, assuming coefficient of friction for belts to be 0.30 and shaft speed to be 450 rev/min. Safe shear stress for the shaft is 50 N/mm^2. 10

6. (*a*) A closed helical spring has the following data :

Mean coil diameter = 60 mm
Wire diameter = 12 mm
Active number of coils = 10
Free length = 200 mm
Yield strength in shear = 600 N/mm^2
Factor of safety = 1.5
Endurance limit in shear = 300 N/mm^2
Density of spring wire = 7850 kg/m^3

The spring is subjected to a load varying from F to 3F. Calculate the load this spring can take up, natural frequency, and buckling load. Take $(\delta_{cr} / L_0) = 0.45$; $G = 81370$ N/mm^2. 10

(*b*) It is desired to determine the proportions of a spur gear drive to transmit 8 kW from a shaft rotating at 1200 rev/min to a low speed shaft, with a reduction of 3:1. Assume that the teeth are 20 degree full depth involute, with 24 teeth on the pinion. The pinion is to be 40C8 normalized steel and gear of 30C8 normalized steel. Assume that the stalling torque is 130% of the rated torque. C for 20° full depth profile is 295 N/mm : 10

Material	Allowable Stress	HB	S_c	S_b
40C8 steel	568.8 N/mm^2	152	1.125	14.05
30C8 steel	490.3 N/mm^2	143	0.985	11.95

7. (*a*) Two steel bevel gears, both having a Brinell hardness of 250, connect shafts at 90 degrees. The teeth are 14.5 degree full depth and module is 5 mm. The number of teeth on the pinion and gear are 30 and 48. The face width is 38 mm. Determine the wear load. $E_p = E_g = 210$ GPa. 10

(*b*) The following data is given for a dry single plate clutch : Power = 18.65 kW ; speed = 1500 rev/min ; number of springs = 6 ; ratio of mean radius to radial width of friction faces = 4.5. Determine (*i*) mean radius and radial width of the friction faces ; (*ii*) dimensions of the clutch plate ; and (*iii*) dimension of the spring. 3 + 3 + 4

8. (*a*) Mention different types of rolling bearings. 8

(*b*) Analyse a full journal bearing operating under the following conditions: 12

n = 60 rev/sec
W = 7 kN
Viscosity = 6 Pa-s
Clearance = 0.1 mm
Diameter = 100 mm
Length = 150 mm
Oil temperature = 80 °C
Altitude angle = 60°
$C_L = 1.8$
$H_{min} = 0.04$ mm

Group C

9. Choose the *correct* answer for the following: 10×2

(*i*) As the diameter of spring wires increase, their tensile strength
- (*a*) increases.
- (*b*) remains constant.
- (*c*) decreases.
- (*d*) unpredictable.

(*ii*) A wood ruff key is generally used in the
- (*a*) machine tool industry.
- (*b*) automobile industry.
- (*c*) textile machinery.
- (*d*) hydraulic machinery.

(*iii*) Thermal conductivity of a material reflects its
- (*a*) chemical property.
- (*b*) physical property.
- (*c*) mechanical property.
- (*d*) dimensional property.

(*iv*) Which one of the following statement is true ?
- (*a*) Cast iron is very strong in tension but weak in compression.
- (*b*) Cast iron is very strong in compression but weak in tension.
- (*c*) Cast iron is very weak in tension and compression.
- (*d*) Cast iron is very strong in tension and compression.

(*v*) Angle of trapezoidal thread is
- (*a*) 30°
- (*b*) 45°
- (*c*) 55°
- (*d*) 65°

(*vi*) To reduce stress concentration in threads, one should make bolt shank diameter equal to the
- (*a*) pitch diameter of the threads.
- (*b*) major diameter of the threads.
- (*c*) minor diameter of the threads.
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(*vii*) Springs used in sofa sets are
(*a*) conical.
(*b*) flat spiral.
(*c*) helical.
(*d*) upholstery.

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(*a*) increase the endurance limit.
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(*a*) The contact in case of spur gears is a line.
(*b*) The contact in case of spur gears is a point.
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(*x*) A bearing in which hydrodynamic pressure is generated due to rotation of journal is called
(*a*) slider bearing.
(*b*) journal bearing.
(*c*) pivot bearing.
(*d*) hydrostatic bearing.

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S'12: 7AN: MC 407/PR 407 (1500)

DESIGN OF MACHINE ELEMENTS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) **Describe *seven* steps in design procedure. Show them in blocks with feedback loops.** **6**

(*b*) **What is tolerance ? Distinguish among three types of fits.** **6**

(*c*) **An excavator applies push pull forces on a short plain carbon steel rod of 20 mm diameter. During one min three forces of magnitude of 20,000 N, 16,000 N and 12,000 N are applied inducing stresses σ_1, σ_2 and σ_3. Fatigue tests at these three stresses performed on 9 specimens at each stress level, resulted in following mean life : $N_1 = 10^4$ cycles, $N_2 = 5 \times 10^4$ cycles and $N_3 = 1{\cdot}3 \times 10^5$ cycles. If machine works for 4 hr in a day, find after how many days the rod should be replaced.** **8**

(Turn Over)

2. (*a*) Compare stress and strain diagrams of mild steel and medium carbon steel. Show the yielding and define yield strength for mild steel. If yield point (yielding) does not appear on σ-ε diagram, how do you define yield strength or its equivalent ? 8

(*b*) It is understood that fatigue strength of material is much sensitive property in comparison with ultimate tensile strength. What are different factors that reduce the fatigue strength. Then how do you calculate the fatigue strength by taking all fatigue strength reduction factors for steel, if its ultimate tensile strength is known ? 8

(*c*) If K_t = stress concentration factor and K_f = fatigue strength reduction factor, then define match sensitivity index. If steel bar has $K_t = 1{\cdot}5$ and notch sensitivity index of 0·85, find K_f. 4

3. (*a*) State following theories of failure :

(*i*) Maximum normal stress

(*ii*) Maximum shearing stress.

A shaft of diameter *d* is subjected to a torque *T* and a bending moment *M*. Find expressions for equivalent bending moment and equivalent torque. 7

(*b*) Design circumferential lap joint for a boiler whose inner diameter is 1650 mm and steam pressure is 2 N/mm². Assume joint efficiency of 70%. Use the following data :

Ultimate tensile strength of plate = 450 N/mm²
Ultimate shear strength of plate and rivet = 350 N/mm²
Ultimate crushing strength for plate and rivet = 750 N/mm²

Take factor of safety of 5 on all ultimate strengths. Standard does not allow pitch in circumferential joint to be greater than $1{\cdot}3\,t + 41$. Calculate number of rivets, pitch, number of rows, and check for crushing. 9

(*c*) Sketch following joints in eccentric loading : 2 + 2

(*i*) Riveted joint with six rivets.

(*ii*) Welded joint with three fillets.

4. (*a*) Draw Mohr's circle and show how you read principal stresses, maximum shearing stress and stresses on any plane inclined at an angle θ with principal planes. Also, show direct stress on plane of maximum shear. Is this circle empirical or theoretical ? 6

(*b*) A broaching cutter is pulled through a job by an Acme threaded screw which rotates at 600 rpm. A collar of internal and external diameters respectively 60 mm and 90 mm supports the tensile force in the screw. The coefficient of friction for all contact surfaces is 0·15 and the Acme thread angle is 30°. The pitch of the Acme thread is 10 mm and the screw diameter is 55 mm. The machine consumes 0·37 kW of power. Calculate the axial force upon the tool. 9

(*c*) How do you find the outside and inside diameters of hollow piston pin in an IC engine ? Consider the pressure and bending. 5

Group B

5. (*a*) Define basic static load capacity and dynamic load capacity of a rolling contact bearing. Which is the capacity related to life of bearing ? 4

(*b*) Name three parts that make a cotter joint. Sketch these parts. 6

(*c*) How do you correlate permissible pressure with axial force in a plate clutch ? For transmitting 15 kW of power at 4000 rpm, a single plate clutch with both side effective is to be designed such that the outer diameter is 50% greater than the inner diameter. Calculate the size of the clutch in dry and lubricated condition. The plates are made in cast iron, μ in dry condition = 0·15, μ in running oil condition = 0·06. The permissible pressure between CI plates, $p = 0{\cdot}3$ N/mm² (dry condition) and in oil, $p = 0{\cdot}7$ N/mm². 10

6. (*a*) Write an expression for allowable bending stress in a gear tooth, if ultimate tensile strength is σ_u, total fatigue strength reduction factor is K_e, and factor of safety is u. 3

(*b*) What are the materials used to make flat belts ? Mention required properties and applications according to belt material. 7

(*c*) A V-belt drive transmits 7·45 kW of power at 1440 rpm. RPM of driven sheave is 480. Pitch diameters of driving and driven sheaves respectively are 150 mm and 450 mm. The power is obtained from an a.c. motor for which service factor is 1·1. The centre distance is restricted to 325 mm. Find the belt length and the type of belt section using following table :

Cross-sectional Areas of V-belt Sections

Belt section	*A*	*B*	*C*	*D*
Area, mm²	87.74	118.71	280	635.5

The permissible tensile stress in V-belt is 2·245 N/mm² and centrifugal force coefficient at the belt speed is 0·180 N/mm². 10

7. (*a*) Sketch an internally expanding shoe brake and define leading and trailing shoes. How can the two shoes be made leading and what advantage they offer ? 6

(*b*) In a cotter joint, the spigot is likely to fail either due to tension or crushing against cotter. The crushing strength is 60% more than tensile strength of spigot, σ_t. The diameter of spigot is d and the thickness of cotter is t. Write two expressions for tensile load capacity and crushing load capacity of cotter joint. Show that $d = \sqrt{6{\cdot}5P / \Pi\sigma_t}$, where P is the load carried by the joint. 8

(*c*) Write an expression for Sommerfeld number for a sliding contact bearing. What is the unit of this number ? Show the plate of $(r/c)f$ against Sommerfeld number for a full bearing ($\beta = 360^\circ$). Here r = radius of bearing, f = coefficient of friction and c = radial clearance. 6

8. (*a*) A pinion has 21 teeth and rotates at 1440 rpm to transmit 3 kW of power. The gear is made in fully hardened steel for which total fatigue strength reduction factor is 2·0 and factor of safety is 1·8. The design load factor which increases power to be transmitted is 1·5. Use face width to module ratio, $\Psi_m = 12$, ultimate tensile strength steel of gear = 600 N/mm². For involute teeth, pressure angle is 20° and form factor is given as

$$\gamma = 0{\cdot}154 - \frac{1{\cdot}23}{Z} + 3{\cdot}38\,Z^2$$

Calculate module, face width and pitch circle diameter. 10

(*b*) Petroff's analysis of a sliding contact bearing results in coefficient friction as function of bearing dimension and pressure in lubricant layer. Write this equation and plot coefficient of friction against $\mu N/p$. Discuss stable and unstable lubrication. 6

(*c*) What is a gasket ? What is the material of gasket ? Where are the gaskets used ? Give examples of five applications. 4

Group C

). Choose *correct* answer for the following : 20 × 1

(*i*) The surface finish or texture is measured in terms of

(*a*) shine, waviness and roughness.

(*b*) roughness, waviness and lay.

(*c*) lay, shine and roughness.

(*d*) waviness, shine and lay.

(*ii*) In boiler drum, two riveted joints (1) longitudinal, and (2) circumferential are made.

(*a*) (1) and (2) are butt joints.

(*b*) (1) is butt joint and (2) is lap joint.

(*c*) (1) is lap joint and (2) is butt joint.

(*d*) (1) and (2) are lap joints.

(*iii*) If d = diameter of the pin and D = diameter of the eye hole in knuckle joint, which combination of dimensions is correct ?

(*a*) $d = 30^{+0.042}_{+0.016}$ $D = 30^{+0.025}_{+0.000}$

(*b*) $d = 30^{+0.042}_{+0.026}$ $D = 30^{+0.030}_{+0.00}$

(*c*) $d = 30^{+0.042}_{+0.026}$ $D = 30^{+0.026}_{+0.00}$

(*d*) $d = 30^{+0.042}_{+0.026}$ $D = 30^{+0.050}_{+0.00}$

(*iv*) The caulking of plate edges in riveted joints helps improve

(*a*) shearing strength of the margin.

(*b*) shearing strength of the rivet.

(*c*) the pressure tightness of the joint.

(*d*) the tearing strength of plate.

(*v*) Which one of the following would not improve fatigue strength ?

(*a*) Shrink filting

(*b*) Shut peening

(*c*) Nitriding

(*d*) Grinding

(*vi*) Which one of the following alloying element improves fatigue strength of steel ?

(*a*) Nickel

(*b*) Chromium

(*c*) Tungsten

(*d*) Vanadium

(*vii*) Which one is not the correct expression of energy of a close coiled helical spring with mean diameter, D, wire diameter, d, length of wire, l, number of turns, n, axial force, p. No consideration of end conditions.

(*a*) $(1/2)\,P \times$ deflection

(*b*) $4\,P^2D^3\,n/Gd^4$

(*c*) $(\pi d^2 l)/16G \times (\text{shear stress})^2$

(*d*) $(4P^2D^2l)/\pi d^4G$

(*viii*) Each leaf of the leaf spring is loaded as a beam with simple supports

(*a*) equal overhangs and concentrated loads at ends.

(*b*) at ends and a concentrated at middle of length.

(*c*) and load varying from zero at middle to maximum at ends.

(*d*) load varying from zero at ends to maximum at centre.

(*ix*) In helical coiled springs, whether loaded in tension or compression, special end conditions are provided. In which case permissible stress is less than that in the body of the spring ?

(*a*) Compression spring with end squared and ground.

(*b*) Compression spring with plain ends.

(*c*) Tension spring with eye extended to centre.

(*d*) Tension spring with screw eye.

(*x*) A leaf spring is designed with permissible stress of 500 MPa and is required to have 10·7 leaves. The number of leaves is corrected to 11. The actual bending stress is

(*a*) 473.2 MPa

(*b*) 486.4 MPa

(*c*) 514 MPa

(*d*) 528.4 MPa

(*xi*) The normal force on friction surface is greater than axial force in case of

(*a*) single plate clutch with two effective sides.

(*b*) multiple plate clutch.

(*c*) cone clutch.

(*d*) clutch designed for uniform pressure.

(*xii*) In a band and block brake, each of n blocks subtends an angle θ at the centre. The coefficient of friction = μ. Lower tension in band = T_n. Higher tension = T_0. Which one of the following is correct :

(*a*) $T_0/T_n = (1 - \mu \tan \theta)/(1 + \mu \tan \theta)^n$

(*b*) $T_0/T_n = (1 - \mu \tan \theta)/(1 + \mu \tan \theta)^{1/n}$

(*c*) $T_0/T_n = (\mu - \mu^2 \tan \theta/1 + \tan \theta)^{1/n}$

(*d*) $T_0/T_n = (1 + \mu \tan \theta)/(1 - \mu \tan \theta)$

(*xiii*) Two rigid plates, having stiffness of k_1 and k_2, are compressed together with a bolt and nut and gasket of stiffness of k_g. The stiffness of combined plates and bolt is very nearly equal to

(*a*) $k_1 + k_2 + k_g$

(*b*) $k_g/k_1 + k_2$

(*c*) $k_1 + k_2$

(*d*) k_g

(*xiv*) A shaft of diameter d has a keyway of width w and depth $h/2$. The modulus of section of the section through which keyway passes is

(*a*) $\pi d^3/32$

(*b*) $\pi d^3/32 - wh/2\ (1/2 - h/4d)^2$

(*c*) $\pi d^3/32 - wh(d - h/2)^2/4d$

(*d*) $\pi d^3/32 - wh(\sqrt{d}/2 - h/4\sqrt{d})$

(*xv*) The maximum oil pressure in a journal bearing occurs

(*a*) under the load, i.e, along the load line.

(*b*) along the line of centres of bearing and journal.

(*c*) between the above two lines.

(*d*) None of the three above.

(*xvi*) Which statement is correct ?

(*a*) Fatigue cracks in rolling element of a rolling contact bearing initiate below the surface.

(*b*) All elements of rolling contact bearing are made of steel.

(*c*) Some sliding contact bearings are made of steel.

(*d*) Rolling elements in rolling contact bearing are always case hardened.

(*xvii*) In flat belt drive, the arms of pulley are designed as

(*a*) cantilever under bending moment equal to torque transmitted.

(*b*) strut under compression load equal to driving force.

(*c*) strut under compression force equal to tight side belt tension.

(*d*) strut under compression equal to slack side tension.

(*xviii*) In a multiple V-belt drive, it is preferable to use large number of small section belts rather than small number of large section belts. It is because

(*a*) large section belts are weaker.

(*b*) large section belts have higher weight per m.

(*c*) large section belt cannot sit as flat pulley.

(*d*) large section belts are not easily available.

(*xix*) Gears are ground after carburizing because

(*a*) grinding is easy on hardened surface.

(*b*) grinding reduces the hardness on the surface.

(*c*) carburizing causes teeth to swell, and grinding brings them back to designed size.

(*d*) grinding introduces residual compressive stresses on the surface.

(*xx*) A helical gear and straight tooth spur gear are designed to transmit same power with same driving speed and velocity ratio. Choose the *wrong* statement. Helical gears will

(*a*) have smaller pitch circle diameter.

(*b*) have smaller module.

(*c*) have teeth subjected to lesser bending stress.

(*d*) have smaller length of teeth.

W'12: 7AN: MC 407/PR 407 (1500)

DESIGN OF MACHINE ELEMENTS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Discuss the logical steps in the procedure of designing machine elements. 6

(*b*) Discuss the importance of safety, ecological and societal consideration in design. 6

(*c*) A shaft transmits 20 kW power and rotates at 500 rpm. The material of the shaft is 50 C4 (σ_{yt} = 460 N/mm^2) and the factor of safety is 2. Determine the diameter of shaft (*i*) on the basis of shear strength, and (*ii*) on the basis of its torsional rigidity, if the angle of twist permissible is 3° per metre length and modulus of rigidity of shaft material is 79300 N/mm^2. 8

2. (*a*) Discuss *any four* factors that govern selection of material while designing a machine component. 5

(*b*) Explain *any three* advantages of aluminium alloys as material for machine components. 3

(*c*) The hydraulic cylinder 400 mm bore operates at a maximum pressure of 5 N/mm^2. The piston rod is connected to the load and the cylinder to the frame through hinged joints. Design cylinder, piston rod, hinge pin and flat end cover. Take allowable tensile stress for cast steel cylinder and end cover is 80 MPa and for piston rod is 60 MPa. 12

3. (*a*) Explain stress concentration with the help of a neat sketch. How will you account for stress concentration in design ? 4

(*b*) What do you understand by transverse and parallel fillet welds ? Compare triangular and convex cross-sections of fillet welds. 4

(*c*) A boiler, with 2 m internal dia, is required to generate steam at a pressure of 1·75 MPa. Design a triple riveted double-strap longitudinal butt joint for the boiler shell. The straps are of unequal width. The pitch of rivets in outer row is to be twice of the pitch in the middle and inner rows and zig-zag riveting is recommended. The efficiency of the joint should be at least 80%. The permissible stresses for steel plate and rivets in tension, shear and compression are 80 N/mm^2, 60 N/mm^2 and 120 N/mm^2, respectively. Calculate the following : 6 × 2

(*i*) Thickness of the plate
(*ii*) Diameter of the rivets
(*iii*) Pitch of the rivets
(*iv*) Distance between the row of rivets
(*v*) Thickness of inner and outer edges.
(*vi*) Margin.

4. (*a*) What is Mohr's circle ? Describe three-dimensional Mohr's circle to determine the normal and shear stresses on a plane whose state of stress at a point is given. 6

(*b*) Explain Johnson's formula for columns. Describe the use of Johnson's formula and Euler's formula. 4

(*c*) A power screen, having double start threads of 25 mm nominal diameter and 5 mm pitch, is acted upon by an axial load of 10 kN. The outer and inner dia of screw collar are 50 mm and 20 mm, respectively. The coefficient of thread friction and collar friction may be assumed as 0·2 and 0·15, respectively. The screw rotates at 12 r.p.m. Assume uniform wear condition at the collar and allowable thread bearing pressure of 5·8 N/mm^2. Find the (*i*) torque required to rotate the screw, (*ii*) stress in the screw, and (*iii*) number of threads of nut engagement with screw. 10

Group B

5. (*a*) The extension springs are in considerably less use than compression springs. Why ? Discuss materials used for springs and give their properties. 5

(*b*) State the desirable properties of a good bearing material. What are babbits ? State *any two* advantages and disadvantages of babbits. 5

(*c*) A journal bearing, 60 mm in diameter and 90 mm long, runs at 450 rpm. The oil used for hydrodynamic lubrication has absolute viscosity of 0·06 kg/m.s. If the diametral clearance is 0·1 mm, find the safe load on the bearing. 10

6. (*a*) State the applications of the cotter joint. Explain various types of failure to be considered in designing a cotter joint. Write strength equation for each failure along with neat sketches. 7

(*b*) What is coupling ? State *two* important applications of the coupling. Distinguish between coupling and a clutch. 3

(*c*) A V-belt is driven on a flat pulley and a V-pulley. The drive transmits 20 kW from a 250 mm diameter V-pulley operating at 1800 rpm to a 900 mm diameter flat pulley. The centre distance is 1 m, the angle of groove 40° and $\mu = 0{\cdot}2$. If density of belt is 1110 kg/m^3 and allowable stress is 2·1 MPa for belt material, what will be the number of belts required, if C-size V-belts having 230 mm^2 cross-sectional areas are used. 10

7. (*a*) List important factors upon which the capacity of a brake depends. Describe, with the help of a neat sketch, the principle of operation of an internal expansion shoe brake. 6

(*b*) What are the materials used for lining of friction surfaces ? Why is it necessary to dissipate the heat generated when clutches operate ? 4

(*c*) Describe, with neat sketches, various types of pipe joints commonly used in engineering practice. Also, explain the procedure for design of an oval flanged pipe joint. 10

8. (*a*) Explain different causes of gear tooth failures and suggest possible remedies to avoid such failures. 5

(*b*) Write the expressions for static strength, limiting wear load and dynamic load for helical gears and explain various terms used therein. 5

(*c*) A speed reducer unit is to be designed for an input of 1·1 kW with a transmission ratio 27. The speed of the hardened steel worm is 1440 rpm. The worm wheel is made of phosphor bronze. The tooth form is to be 20° involute. 10

Group C

9. Answer the following : 10 × 2

(*i*) BIS codes for design.

(*ii*) Strain-strain curve for ductile material.

(*iii*) Difference between cast iron and steel on the basis of carbon content.

(*iv*) Mention two advantages and two disadvantages of plastics as a material for machine parts.

(*v*) Effect of surface hardening on fatigue life of components.

(*vi*) Petioff's equation for a sliding contact bearing.

(*vii*) How do you express life of a bearing ?

(*viii*) Virtual number of teeth on a helical gear.

(*ix*) Why is it necessary to dissipate the heat generated when clutches operate ?

(*x*) Distinguish between failure due to static load and fatigue failure.

S'13 : 2 FN : MC 421 (1506)

DESIGN OF MECHANICAL SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) Distinguish between the following terms using examples : (*i*) Design synthesis and design analysis, (*ii*) Sequential design and concurrent engineering, and (*iii*) Design by evolution and design by innovation. 3 × 5

(*b*) What are the basic traits of a good designer ? 5

2. (*a*) What do you understand by morphology of the design ? 5

(*b*) Explain the design process with the help of a flow diagram. 10

(*c*) Explain the weighted point method for selection of material for machine component. 5

3. (*a*) Explain the following terms with the help of examples : (*i*) Clearance fit, (*ii*) transition fit, and (*iii*) interference fit. 3 × 2

(*b*) The tolerance specified for diameter of shaft is 25.000 ± 0.025 mm. The shafts are machined on three different machines. It was observed from the sample of shafts that the diameters are normally distributed with a standard deviation of 0.015 mm for each of three machines. However, the mean diameter of shafts fabricated on three machines is found to be 24.99 mm, 25.00 mm and 25.01 mm, respectively. Determine the percentage of rejected shafts in each case and comment on the results. 8

(*c*) Differentiate between roughness and waviness. What is the effect of cut-off length on roughness? 3

(*d*) An assembly of two components, A and B, with an overall dimension of 40 ± 0.9 mm is shown in Fig. 1. The overall dimension as well as the dimensions of individual components are normally distributed, and natural tolerances are equal to design tolerances. Specify the dimensions for the component B along with its tolerance. 3

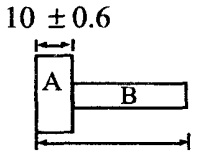

Fig. 1

4. (*a*) Sketch different types of ends used for pressure vessels and list their applications. 10

(*b*) A steel plate, 200 mm wide and 20 mm thick, is joined with another steel plate by means of single transverse double parallel fillet welds as shown in Fig. 2. The strength of the welded joint should be equal to the strength of the plates to be joined. The permissible tensile and shear stresses for the weld material are 100 MPa and 60 MPa, respectively. Find the length of each parallel fillet weld. Assume the tensile force acting on the plates as static. 10

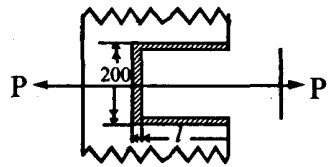

Fig. 2

Group B

5. (*a*) Formulate the following problem : Design a gear pinion pair for minimum weight which can transmit 5 kW power at 1000 rpm. The velocity ratio is 3. 10

(*b*) What is the Lagrange multiplier method and what is the significance of Lagrange multipliers ? 10

6. (*a*) Why is the probabilistic approach of the design preferred to deterministic approach ? What do you understand by the reliability ? Develop the generalized reliability model for mechanical design and use it to develop the expression for reliability, if the strength is normally distributed and stress is exponentially distributed. 14

(*b*) What do you understand by MTBF ? 6

7. (*a*) If T_i is the initial tension of the belt and m, the

mass of the unit length of the belt, then prove that the optimum velocity of the belt for maximum power transmission is given by

$$V = \sqrt{T_i / m}$$ 10

(*b*) Starting from Hertz equation, develop the expression for wear check in gear. 10

8. (*a*) Explain the difference between coupling and clutch with the help of neat sketches. 10

(*b*) A solid shaft of diameter *d* is used in power transmission. Due to modification of the existing transmission system, it is required to replace the solid shaft by a hollow shaft of the same material and equally strong in torsion. Further, the weight of the hollow shaft per meter length should be half of the solid shaft. Determine the outer diameter of the hollow shaft in terms of *d*. 10

Group C

9. Choose the *correct* answer for the following : 10 × 2

(*i*) In the need analysis stage of design, all information is

(*a*) reliable in nature.

(*b*) statistical.

(*c*) rational.

(*d*) dispensable.

(*ii*) Factor of safety does not ensure against

(*a*) uncertainties in the magnitude of external force acting on the component.

(*b*) variations in properties of the materials like yield strength or ultimate strength.

(*c*) variations in dimensions of the compo-nent due to imperfect workmanship.

(*d*) variations in price of the material used.

(*iii*) Mathematical models are required in the following phase of design process :

(*a*) Definition of the problem

(*b*) Recognition of the need

(*c*) Synthesis

(*d*) Analysis and optimization.

(*iv*) 1% manganese, 18% sulphur and 4% carbon alloy steel designated by BIS is as follows :

(*a*) 100 S18 C 40

(*b*) 40 C 10 S18

(*c*) 10 C 40 S18

(*d*) 10 S18 C 40

(*v*) RMS value of surface finish, R_g, is obtained from the following equation :

(*a*) $R_g = \frac{1}{L}\int_0^L |y|dx$

(*b*) $R_g = \left[\frac{1}{L}\int_0^L |y|dx\right]^{\frac{1}{2}}$

(*c*) $R_g = \frac{1}{L}\int_0^L y^2 dx$

(*d*) $R_g = \left[\frac{1}{L}\int_0^L y^2 dx\right]^{\frac{1}{2}}$

(*vi*) Pressure vessels used for boilers belong to the category of

(*a*) Class I

(*b*) Class II

(*c*) Class III

(*d*) Class IV

(*vii*) If T is the life length of the system, then reliability of a system at time t, say $R(t)$, is defined as

(*a*) $R(t) = P(T > t)$

(*b*) $R(t) = P(T < t)$

(*c*) $R(t) = P(T = t)$

(*d*) $R(t) = 1 - P(T > t)$

(*viii*) If design space is of n dimension, then the hyperplane has a dimension of

(*a*) $n - 1$

(*b*) n

(*c*) $n + 1$

(*d*) $n + 2$

(*ix*) In an involute pinion and gear system, the interference can be avoided by

(*a*) decreasing number of teeth in pinion.

(*b*) lowering the pressure angle.

(*c*) taking long and short addendum system.

(*d*) making the gears using from milling cutter.

(*x*) A solid steel shaft of drameter D shows a first critical speed of 1200 rpm. If the shaft were bored to make it hollow with an inside diameter (3/4) D, its critical speed would be

(*a*) 1050 rpm

(*b*) 1200 rpm

(*c*) 1350 rpm

(*d*) 1500 rpm.

W'13: 7AN: MC407/PR407 (1500)

DESIGN OF MACHINE ELEMENTS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What are preferred numbers ? How will you find the numbers belonging to R10 series ? State the advantages of preferred numbers. 3

(*b*) Discuss the factors which govern the selection of material for a machine component. 3

(*c*) What is meant by 'hole basis system' and 'shaft basis system' ? Which one is preferred and why ? 4

(*d*) A simply-supported beam has a concentrated point load at its centre. The load fluctuates from P to $4P$. The span of the beam is 500 mm and it is of circular cross-section with a diameter of 60 mm. The yield stress is

390 MPa and endurance limit is **260 MPa.** Surface correction factor is 0·85 and factor of safety is 1·5. Calculate the value of P that can be applied. **10**

2. (*a*) What do you understand by stress concentration ? Define and differentiate between form stress factor and stress concentration factor. 6

(*b*) What is the criteria of failure for (*i*) ductile material subjected to static load, (*ii*) brittle material subjected to static load, and (*iii*) ductile material subjected to varying load. 3 × 2

(*c*) The state of stress at a point in a body are σ_x = 81 MPa, σ_y = 21 MPa and $\hat{i}_{xy}$ = 84 MPa . The yield stress of material is 280 MPa. Find the factor of safety by (*i*) maximum shear stress theory, and (*ii*) distortion energy theory. 8

3. (*a*) Derive an equation for finding maximum stress in a long column subjected to eccentric loading. 5

(*b*) A carbon steel shaft with σ_u = 600 MPa, σ_y = 330 MPa is subjected to torsional load varying from 200 N-m to 400 N-m. Determine the diameter of the shaft required based on a factor of safety 2. Base the design on Soderberg's equation taking the design endurance shear stress to be 25% of σ_u. 10

(*c*) A machine component is subjected to bending stress which fluctuates between +300 MN/m² and –150 MN/m². Determine the value of the minimum ultimate strength according to (*a*) Goodman, and (*b*) Girber formula. Assume N = 2. 5

4. (*a*) What do you understand by Caulking and Fullering ? Explain. 2 + 2

(*b*) A 16 mm thick steel plate is welded to a vertical support by two fillet welds as shown in Fig. 1. Determine the size of the weld, if the permissible shear stress for the weld material is 75 MPa. 8

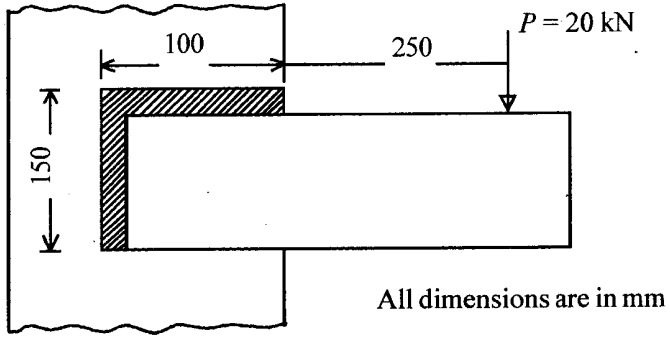

Fig. 1

(*c*) The jaws of a machine vice weigh 300 N and is slided by a two start Acme thread of 50 mm diameter and 8 mm pitch at the rate of 0·8 m/min. The end of the screw is carried on a thrust collar 30 mm inside diameter and 70 mm outside diameter. The coefficient of friction for threads is 0.1 and for the collar is 0·14. Determine the power required to drive the slide. 8

Group B

5. (*a*) Explain the term 'surge' as applied to cylindrical springs. What is its effect on the working of a spring ? How can this be avoided ? 5

(*b*) A spring is made from a wire of 1·25 mm diameter and 780 N/mm² as its yield strength. For a mean diameter

of 12·5 mm and 14 active coils of the spring, determine (*i*) static load corresponding to the yield point of the material and deflection corresponding to that; (*ii*) stiffness of the spring; and (*iii*) pitch of the wire so that solid stress will not exceed the yield point. Take $C = 0{\cdot}85 \times 10^5$ N/mm^2. 10

(*c*) How will you define the dynamic equivalent load for rolling contact bearings. Derive an equation for dynamic load rating for rolling contact bearings under variable load. 5

6. (*a*) Why is dynamic loading not a problem in worm gear ? Do you think that heat balance is an important aspect in the design of gears ? 4

(*b*) Determine the main dimensions and the capacity of a double block brake for the following conditions :

Weight of the hoist with its load	= 25 kN
Downward velocity	= 1·25 m/sec
Pitch diameter of hoist drum	= 1·20 m
Stopping distance for hoist	= 3 m

Neglect the kinetic energy of the drum. Assume suitable data, if necessary. 8

(c) Determine the safe power which can be transmitted by a pair of helical gears, 20-degree full depth; 25 degree helix, having a normal module of 5 mm. Both the gears are made of forged C-30 steel for which bending stress is 175 MPa and BHN is 150. It has a face width of 76·2 mm. The pinion speed is 2000 rev/min and has 20 teeth. The velocity ratio is to be 5 : 1. 8

7. (*a*) What do you understand by the lay of a rope ? In how many ways steel wire ropes are laid ? 4

(*b*) An 8 × 19 (9 × 9 × 1) steel wire rope is used to lift a load of 15 kN from a depth of 1000 m. The maximum speed of rope is 2·5 m/sec and the acceleration is 1·5 m/s^2 when starting under no slack condition. Determine the size of the rope required. Factor of safety for hoists can be assumed as 4·5. Modulus of elasticity = 68600 N/mm^2. Assume a wire diameter of 20 mm. 8

(*c*) The following particulars refer to a belt drive from a cast iron pulley mounted on a shaft :

Power required	= 25 kW
RPM of the shaft	= 250
Ratio of belt tension	= 3
Velocity of leather belt	= 800 m/min
Allowable belt tension	= 10 N/mm width
No. of arms with elliptical cross-section on the pulley	= 6

Select a suitable belt and design the (*i*) pulley, (*ii*) shaft, and (*iii*) key. Assume suitable stresses for shaft, key and pulley material. 8

8. (*a*) What is the necessity of a sealing device ? Discuss briefly various axial sealing devices. What points would you consider while selecting end-face seals ? 4

(*b*) What is a packing ? Discuss various types of packings used for reciprocating shaft. 4

(*c*) Design a muff coupling to connect two shaft transmitting 40 kW at 150 rev/min. The allowable shear and crushing stresses for the shaft and key, which are made of 50C8 steel are 37 N/mm^2 and 96·23 N/mm^2, respectively. The material for the muff is FG 150 cast iron with permissible shear strength of 17·3 N/mm^2. Assume that the maximum torque transmitted is 20 % greater than the mean torque. 12

Group C

9. Answer the following is brief : 10×2

(*i*) Tolerance and fit

(*ii*) Notch sensitivity

(*iii*) Ferro fluidic seals

(*iv*) Membrane stresses

(*v*) Flexible shaft

(*vi*) Self-energising and self-locking brakes

(*vii*) Stress concentration in a bolt

(*viii*) Design of compression and extension springs

(*ix*) Shot peening

(*x*) Condition for full film lubrication.

S'14:7AN:MC 407/PR 407 (1500)

DESIGN OF MACHINE ELEMENTS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a,b,etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What do you understand by safety, ecological and societal considerations in design ? Explain briefly. 5

(*b*) Discuss the significance of codes for design and design data handbooks. Discuss BIS codes commonly used in design. 5

(*c*) A cantilever member 0·1 m long having cross-section of 0·05 m × 0·25 m supports a load of 27·5 kN. What is the maximum shear stress and where does it occur ? 10

2. (*a*) Suggest suitable materials for the following components giving reasons for their choice : (*i*) Turbine blades, (*ii*) connecting rod, (*iii*) lathe bed, (*iv*) bearings and (*v*) springs. 5 × 1

(*b*) Define the following mechanical properties and their importance in mechanical engineering design : (*i*) Yield strength, (*ii*) ultimate stress, (*iii*) hardness, (*iv*) toughness and (*v*) resilience. 5 × 1

(*c*) A long straight tube, 76 mm internal diameter and 2·5 mm thick, is subjected to an internal pressure of 5·6 N/mm^2. Consider it as a thin cylinder. If the tube is subjected to a twisting moment of 70 N-m, elastic limit stress = 282 N/mm^2, determine the factor of safety by (*i*) maximum principal stress theory ; (*ii*) maximum shear stress theory ; and (*iii*) distortion energy theory. 3 + 3 + 4

3. (*a*) What do you understand by stress concentration ? Define and differentiate between form stress factor and stress concentration factor. 4

(*b*) What is meant by a column and end conditions of a column. Under what conditions the Euler's formula, Rankine formula, Rankine-Gordon formula and Johnson formula are applicable ? 6

(*c*) Two lengths of a mild steel tie rod (flat blate) 190 mm × 12 mm are to be connected together by means of a lap joint using only four rivets. Find the diameter of the rivets, when the rods are subjected to tensile loading. Indicate the arrangement of the rivets to give the strongest joint. The allowable stresses are f_t = 90·0 N/mm^2, f_s = 75·0 N/mm^2, f_c = 150·0 N/mm^2. 10

4. (*a*) Discuss bolts of uniform strength in detail. 5

(*b*) Describe the procedure for designing a lozenge joint. 5

(*c*) A screw press is to exert a force of 60 kN with an applied torsional moment of 550 Nm. The unsupported length of the screw is 0·45 m and a thrust bearing of hardened steel on CI is provided at the power end. The screw is to be made of steel having an ultimate strength of 530 MN/m^2 and a yield stress of 265 MN/m^2. The design stresses are to be 87·5 MN/m^2 in tension and compression 52·5 MN/m^2 in shear and 14 MN/m^2 in thread bearing. The nut is of CI and the permissible shear is 21 MN /m^2. Determine the dimension of the screw and nut. 10

Group B

5. (*a*) What are the requirements to be satisfied by a spring ? How can the surge in the springs be eliminated ? 4

(*b*) Distinguish between hydrodynamic bearings and hydrostatic bearings. 4

(*c*) Define bearing number and Sommerfield number. 4

(*d*) The thrust of 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 rpm. Taking μ constant and equal to 0·05 and assuming the bearing pressure as uniform and equal to 0·3 N/mm^2, find the (*i*) number of collars required ; (*ii*) power lost in friction ; and (*iii*) heat generated at the bearing (in kJ/mm). 3 + 3 + 2

6. (*a*) Explain different causes of gear tooth failures and suggest possible remedies to avoid such failures. 5

(*b*) Define formative or virtual number of teeth on a helical gear. Derive the expression used to obtain its value. 5

(*c*) Two shafts 0·30 m apart transmitting 18·75 kW are to be connected by a steel pinion meshing with a cast iron gear. The velocity ratio is to be 3 to 1 and the smaller gear is to run at 600 rpm. The ultimate strength of the material for gear is 168 MPa and factor of safety is 4. Design the arms for the gear and find the diameter of the gear shaft. 10

7. (*a*) Prove that a square key is equally strong in shear and crushing. 2

(*b*) Write equations showing the strength of the cotter joint for the most probable methods of failure. 8

(*c*) Design and draw an oval flanged pipe joint for a pipe having 50 mm bore. It is subjected to an internal fluid pressure of 7 N/mm^2. The maximum tensile stress in the pipe material is not to exceed 20 MPa and in the bolts 60 MPa. 10

8. (*a*) What are the important factors in brake design ? How its function differs from that of a clutch ? 5

(*b*) List and discuss briefly the factors that control the power transmission capacity of a belt. 5

(*c*) A multiple disc clutch, steel or bronze, is to transmit 4·5 kW at 750 rpm. The inner radius of the contact is 40 mm and outer radius of contact is 70 mm. The clutch operates in oil with an expected coefficient of friction of 0·1. The average allowable pressure is 0·35 N/mm^2. Find the (*i*) total number of steel and bronze discs ; (*ii*) actual axial force required ; (*iii*) actual average pressure ; and (*iv*) actual maximum pressure. 10

Group C

9. Answer the following in brief : 10 × 2

(*i*) Torsional rigidity and lateral rigidity

(*ii*) Difference between endurance limit and fatigue strength

(*iii*) Different types of cast iron

(*iv*) Surface hardening

(*v*) Petroff equation

(*vi*) Bearing characteristic number

(*vii*) Sketch sheave for a fibre rope

(*viii*) Efficiency of a riveted joint

(*ix*) Dynamic equivalent load for rolling contact bearing

(*x*) Applications of a bevel gear.