

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.*

*Answer should be brief and to-the-point and be supple-
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may result in loss of marks.*

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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
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- (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
- $$i = 0.45 \sqrt[3]{D} + 0.001 D,$$
- where D is the geometric mean of diameter step. Fundamental deviation for shaft, $f = -5.5 D^{0.41}$. 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 0.7 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/mm². 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.

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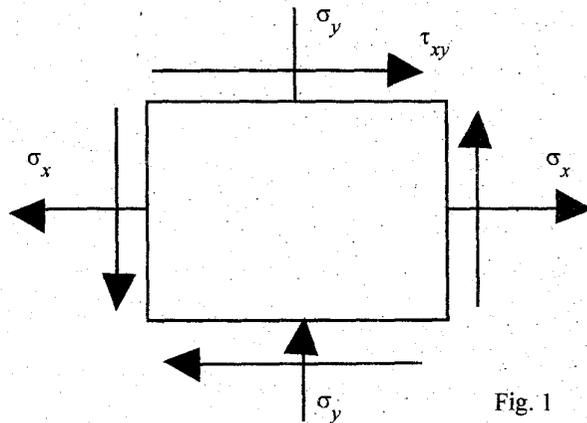
Group A

1. (a) Explain the following cycles with reference to ma-
chine 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 dimen-
sions $b = 25$ 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 $b = 25 \text{ mm}$ and $t = 10 \text{ mm}$. 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 $\sigma_x = 200 \text{ MPa}$, $\sigma_y = -300 \text{ MPa}$, and $\tau_{xy} = 100 \text{ MPa}$ 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

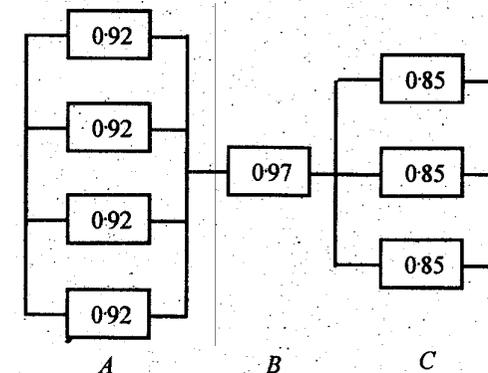


4. (a) Explain the basic principle of 'Monte Carlo method' used in simulation of design. 4
- (b) What are the different criteria for selection of materials? 4

- (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



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 $\rho = 7800$ kg/m³, $\nu = 0.3$ 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

	<i>Machine A</i>	<i>Machine B</i>
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_t).
- (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.

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

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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 follo-
wing 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/mm², 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/m² ; $\tau = 55$ MN/m² 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/mm². 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/mm²
 Factor of safety = 1.5
 Endurance limit in shear = 300 N/mm²
 Density of spring wire = 7850 kg/m³

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 $(\delta_{cr} / L_0) = 0.45$; $G = 81370 \text{ N/mm}^2$. 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. $E_p = E_g = 210 \text{ GPa}$. 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.
(d) nominal diameter of the threads.

- (vii) Springs used in sofa sets are
- (a) conical.
 - (b) flat spiral.
 - (c) helical.
 - (d) upholstery.
- (viii) Residual compressive stresses in parts subjected to cyclic loading
- (a) increase the endurance limit.
 - (b) decrease the endurance limit.
 - (c) have no effect on the endurance limit.
 - (d) unpredictable.
- (ix) Which one of the following is the *correct* statement :
- (a) The contact in case of spur gears is a line.
 - (b) The contact in case of spur gears is a point.
 - (c) The noise in helical gears is more as compared to spur gears.
 - (d) The contact in case of helical gears remains a line throughout.
- (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.
-

- (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

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(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/mm², find the maximum safe air pressure. 6

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- (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/mm². 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/mm²
 Factor of safety = 1.5
 Endurance limit in shear = 300 N/mm²
 Density of spring wire = 7850 kg/m³

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 $(\delta_{cr} / L_0) = 0.45$; $G = 81370 \text{ N/mm}^2$. 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. $E_p = E_g = 210 \text{ GPa}$. 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

$$n = 60 \text{ rev/sec}$$

$$W = 7 \text{ kN}$$

$$\text{Viscosity} = 6 \text{ Pa-s}$$

$$\text{Clearance} = 0.1 \text{ mm}$$

$$\text{Diameter} = 100 \text{ mm}$$

$$\text{Length} = 150 \text{ mm}$$

$$\text{Oil temperature} = 80 \text{ }^\circ\text{C}$$

$$\text{Altitude angle} = 60^\circ$$

$$C_L = 1.8$$

$$H_{mm} = 0.04 \text{ mm}$$

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.
- (d) nominal diameter of the threads.

- (vii) Springs used in sofa sets are
- (a) conical.
 - (b) flat spiral.
 - (c) helical.
 - (d) upholstery.
- (viii) Residual compressive stresses in parts subjected to cyclic loading
- (a) increase the endurance limit.
 - (b) decrease the endurance limit.
 - (c) have no effect on the endurance limit.
 - (d) unpredictable.
- (ix) Which one of the following is the *correct* statement :
- (a) The contact in case of spur gears is a line.
 - (b) The contact in case of spur gears is a point.
 - (c) The noise in helical gears is more as compared to spur gears.
 - (d) The contact in case of helical gears remains a line throughout.
- (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.
-

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 supple-
mented 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

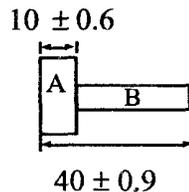


Fig. 1

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

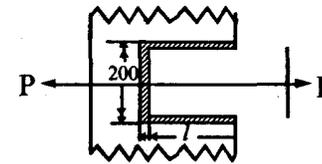


Fig. 2

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

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

- (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 component 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 diameter 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.