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TEST BOOKLET NO-25005

PAPER -II

Time Allowed: 3:00 hrs

Maximum Marks: 300

MECHANICAL ENGINEERING

INSTRUCTIONS TO CANDIDATES

Read the instructions carefully before answering the questions: -

1. This Test Booklet consists of 20 (twenty) pages and has 75 (seventy five) **items (questions).**
2. IMMEDIATELY AFTER THE COMMENCEMENT OF THE EXAMINATION, YOU SHOULD CHECK THAT THIS BOOKLET ***DOES NOT*** HAVE ANY UNPRINTED OR TORN OR MISSING PAGES OR ITEMS ETC. IF SO, GET IT REPLACED BY A COMPLETE TEST BOOKLET.
3. **Please note that it is the candidate's responsibility to fill in the Roll Number and other required details carefully and without any omission or discrepancy at the appropriate places in the OMR Answer Sheet and the Separate Answer Booklet. Any omission/discrepancy will render the OMR Answer Sheet and the Separate Answer Booklet liable for rejection.**
4. Do not write anything else on the OMR Answer Sheet except the required information. Before you proceed to mark in the OMR Answer Sheet, please ensure that you have filled in the required particulars as per given instructions.
5. Use **only Black Ball Point Pen** to fill the OMR Answer Sheet.
6. This Test Booklet is divided into 4 (four) parts – **Part – I, Part - II , Part – III** and Part IV
7. All four parts are **Compulsory**.
8. **Part-I consists of Multiple Choice-based Questions.** The answers to these questions have to be marked in the **OMR Answer Sheet** provided to you.
9. **Part - II ,Part – III and Part IV consists of Conventional Questions.** The answers to these questions have to be written in the **Separate Answer Booklet** provided to you.
10. In Part-I, each item (question) comprises of 04 (four) responses (answers). You are required to select the response which you want to mark on the OMR Answer Sheet. In case you feel that there is more than one correct response, mark the response which you consider the best. In any case, choose ***ONLY ONE*** response for each item.
11. After you have completed filling in all your responses on the OMR Answer Sheet and the Answer Booklet(s) and the examination has concluded, you should hand over to the Invigilator ***only the OMR Answer Sheet and the Answer Booklet(s)***. You are permitted to take the Test Booklet with you.
12. **Penalty for wrong answers in Multiple Choice-based Questions:**
    THERE WIL BE **PENALTY** FOR WRONG ANSWERS MARKED BY A CANDIDATE.
    (i) There are four alternatives for the answer to every question. For each question for which a wrong answer has been given by the candidate, **one-third** of the marks assigned to the question will be deducted as penalty.
    (ii) If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to the question.
    (iii) If a question is left blank. i.e., no answer is given by the candidate, there will be **no penalty** for that question.

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PART – I

MULTIPLE CHOICE BASED QUESTIONS

Instructions for Questions 1 to 50:

- Choose the correct answer for the following questions
- Each question carries 3 marks (50 x 3 = 150 marks)

1. A shaft with a circular cross-section is subjected to pure twisting moment. The ratio of the maximum shear stress to the largest principal stress is

   A. 2.0

   B. 1.0

   C. 0.5

   D. 0

2. A thin cylindrical pressure vessel with closed-ends is subjected to internal pressure. The ratio of circumferential (hoop) stress to the longitudinal stress is

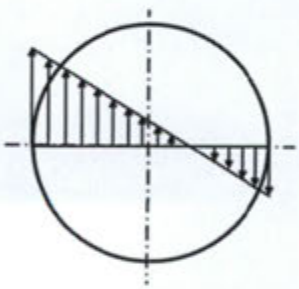
   A. 0.25

   B. 0.50

   C. 1.0

   D. 2.0

3. Shear stress distribution on the cross-section of the coil wire in a helical compression spring is shown in the figure. This shear stress distribution represents



   A. Direct shear stress in coil wire cross-section

   B. Combined direct shear and torsional shear stress in the coil wire cross-section

   C. Combined direct shear and torsional shear stress along with the effect of stress concentration at inside edge of the coil wire cross-section

   D. Torsional shear stress in the coil wire cross-section

4. If the wire diameter of a compressive helical spring is increased by 2%, the change in spring stiffness (in %).

   A. 2.84

   B. 4.50

   C. 10.90

   D. 8.24

5. The spring constant of a helical compression spring DOES NOT depend on

   A. Coil diameter

   B. Material strength

   C. Number of active turns

   D. Wire diameter

6. A grinding ratio of 200 implies that the

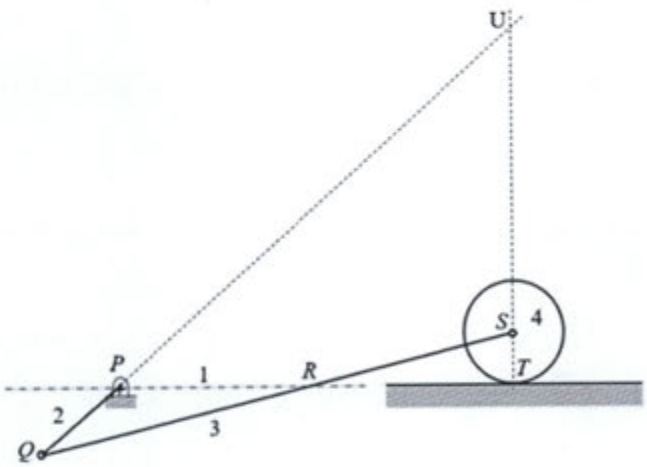
   A. Grinding wheel wears 200 times the volume of the material removed.

   B. Grinding wheel wear 0.005 times the volume of the material removed

   C. Aspect ratio of abrasive particles used in the grinding wheel is 200

   D. Ratio of volume of abrasive particles to that of grinding wheel is 200

7. Consider the mechanism shown in the figure. There is rolling contact without slip between the disc and ground.



Select the correct statement about instantaneous centers in the mechanism.

   A. Only points P, Q, and S are instantaneous centers of mechanism

   B. Only points P, Q, S and T are instantaneous centers of mechanism

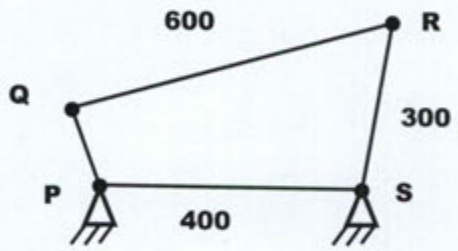
   C. Only points P, Q, R, S, and U are instantaneous centers of mechanism

   D. All points P, Q, R, S, T and U are instantaneous centers of mechanism

8. The number of qualitatively distinct kinematic inversions possible for a Grashof chain with four revolute pairs is

   A. 1
   B. 2
   C. 3
   D. 4

9. A four bar mechanism is shown below



   For the mechanism to be a crank-rocker mechanism, the length of the link PQ can be

   A. 80 mm
   B. 200 mm
   C. 300 mm
   D. 350 mm

10. A square threaded screw is used to lift a load W by applying a force F. Efficiency of square threaded screw is expressed as

    A. The ratio of work done by W per revolution to work done by F per revolution
    B. W/F
    C. F/W
    D. The ratio of work done by F per revolution to work done by W per revolution

11. For a ball bearing the fatigue life in millions of revolutions is given by $L = \left(\frac{C}{P}\right)^n$, where P is the constant applied load and C is the basic dynamic load rating. Which of the following statement is TRUE.

    A. n = 3, assuming that the inner race is fixed and outer race is revolving
    B. n = 1/3, assuming that the inner race is fixed and outer race is revolving
    C. n = 3, assuming that the outer race is fixed and inner race is revolving
    D. n = 1/3, assuming that the outer race is fixed and inner race is revolving

12. A heat engine extracts heat (Q_H)from a thermal reservoir at a temperature of 1000K and rejects heat (Q_L) to a thermal reservoir at a temperature of 100K, while producing work (W). Which one of the combinations of (Q_H, Q_L, W) given is allowed?

A. Q_H =2000J, Q_L =500J, W=1000J
B. Q_H =2000J, Q_L =750J, W=1250J
C. Q_H =6000J, Q_L =500J, W=5500J
D. Q_H =6000J, Q_L =600J, W=5500J

13. Which of the following statement is FALSE?

A. For an ideal gas, the enthalpy is independent of pressure.
B. For a real gas going through an adiabatic reversible process, the process equation is given by $PV^{\gamma} = Constant$, where P is the pressure, V is the volume and γ is the ratio of the specific heats of the gas at constant pressure and constant volume.
C. For an ideal gas undergoing a reversible polytropic process $PV^{1.5} = Constant$, the equation connecting the pressure, volume and temperature of the gas at any point along the process is $\frac{P}{R} = \frac{M\,T}{V}$., where R is the gas constant and m is the mass of the gas.
D. Any real gas behaves as an ideal gas at sufficiently low pressure and high temperature.

14. For a simple compressible system, v, s, p and T are specific volume, specific entropy, pressure and temperature, respectively. As per Maxwell's relations, $\left(\frac{\partial v}{\partial s}\right)_p$ is equal to

A. $\left(\frac{\partial s}{\partial T}\right)_p$
B. $\left(\frac{\partial p}{\partial v}\right)_T$
C. $-\left(\frac{\partial T}{\partial v}\right)_P$
D. $\left(\frac{\partial T}{\partial p}\right)_s$

15. A mass m of a perfect gas at pressure P_1 and volume V_1 undergoes an isothermal process. The final pressure is P_2 and volume is V_2. The work done on the system is considered positive. If R is the gas constant and T is the temperature, then the work done in the process is

A. $P_1V_1 ln\left(\frac{V_2}{V_1}\right)$
B. $-P_1V_1 ln\left(\frac{P_1}{P_2}\right)$
C. RT $ln\left(\frac{V_2}{V_1}\right)$
D. −m RT $ln\left(\frac{P_2}{P_1}\right)$

16. For an air-standard Diesel cycle,

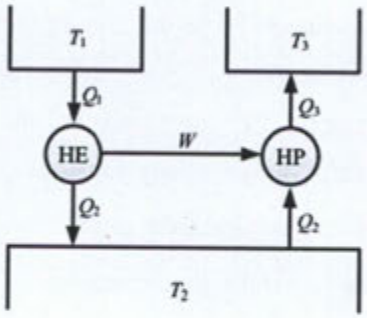
A. Heat addition is at constant volume and heat rejection is at constant pressure

B. Heat addition is at constant pressure and heat rejection is at constant pressure

C. Heat addition is at constant pressure and heat rejection is at constant volume

D. Heat addition is at constant volume and heat rejection is at constant volume

17. The figure shows a heat engine (HE) working between two reservoirs. The amount of heat (Q_2) rejected by the heat engine is drawn by a heat pump (HP). The heat pump receives the entire work output (W) of the heat engine. If temperatures, $T_1>T_3>T_2$, then the relation between the efficiency (η) of the heat engine and the coefficient of performance (COP) of the heat pump is



A. COP=η

B. COP=1+η

C. COP=η^{-1}

D. COP=$\eta^{-1}-1$

18. Which one of the following pairs of equations describes an irreversible heat engine?

A. $\oint \delta Q > 0 \; and \; \oint \frac{\delta Q}{T} < 0$

B. $\oint \delta Q < 0 \; and \; \oint \frac{\delta Q}{T} < 0$

C. $\oint \delta Q > 0 \; and \; \oint \frac{\delta Q}{T} > 0$

D. $\oint \delta Q < 0 \; and \; \oint \frac{\delta Q}{T} > 0$

19. An air-standard Diesel cycle consists of the following processes:

1-2: Air is compressed isentropically.

2-3: Heat is added at constant pressure.

3-4: Air expands isentropically to the original volume.

4-1: Heat is rejected at constant volume.

If γ and T denote the specific heat ratio and temperature, respectively, the efficiency of the cycle is

A. $1-\frac{T_4-T_1}{T_3-T_2}$

B. $1-\frac{T_4-T_1}{\gamma(T_3-T_2)}$

C. $1-\frac{\gamma(T_4-T_1)}{T_3-T_2}$

D. $1-\frac{T_4-T_1}{(\gamma-1)(T_3-T_2)}$

20. For the same values of peak pressure, peak temperature and heat rejection, the correct order of efficiencies for Otto, Dual and Diesel cycles is

A. ηOtto > ηDual > ηDiesel

B. ηDiesel > ηDual > ηOtto

C. ηDual > ηDiesel > ηOtto

D. ηDiesel > ηOtto > ηDual

21. For a spark ignition engine, the equivalence ratio (ϕ) of mixture entering the combustion chamber has values

A. $\phi < 1$ for idling and $\phi > 1$ for peak power conditions

B. $\phi > 1$ for both idling and peak power conditions

C. $\phi > 1$ for idling and $\phi < 1$ for peak power conditions

D. $\phi < 1$ for both idling and peak power conditions

22. The most suitable electrode materials for joining low alloy steel using Gas Metal Arc Welding (GMAW) process is

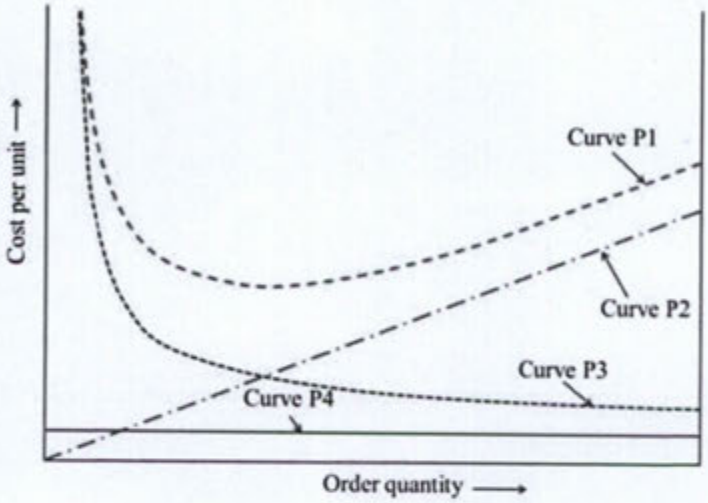
A. Copper

B. Cadmium

C. Low alloy steel

D. Tungsten

23. With reference to the Economic Order Quantity (EOQ) model, which one of the options given is correct?



A. Curve P1: Total cost, Curve P2: Holding cost, Curve P3: Setup cost, and Curve P4: Production cost.
B. Curve P1: Holding cost, Curve P2: Setup cost, Curve P3: Production cost, and Curve P4: Total cost.
C. Curve P1: Production cost, Curve P2: Holding cost, Curve P3: Total cost, and Curve P4: Setup cost.
D. Curve P1: Total cost, Curve P2: Production cost, Curve P3: Holding cost, and Curve P4: Setup cost.

24. Which one of the following is NOT a form of inventory?

A. Raw materials
B. Work-in-process materials
C. Finished goods
D. CNC Milling Machines

25. In Material Requirement Planning, if the inventory holding cost is very high and the setup cost is zero, which one of the following lot sizing approaches should be used?

A. Economic Order Quantity
B. Lot-for-Lot
C. Fixed Period Quantity, for 2 periods
D. Base Stock Level

26. A project consists of five activities (A, B, C, D and E). The duration of each activity follows beta distribution. The three time estimates (in weeks) of each activity and immediate predecessor(s) are listed in the table. The expected time of the project completion in weeks (in integer).

Activity	Time estimates (in weeks)			Immediate predecessor(s)
	Optimistic time	Most likely time	Pessimistic time	
A	4	5	6	None
B	1	3	5	*A*
C	1	2	3	*A*
D	2	4	6	*C*
E	3	4	5	*B, D*

A. 10

B. 12

C. 15

D. 17

27. Feed rate in slab milling operation is equal to

A. Rotation per minutes (RPM)

B. Product of RPM and number of teeth in cutter

C. Product of RPM, feed per tooth and number of teeth in cutter

D. Product of RPM, feed per tooth and number of teeth in contact

28. In the Critical Path Method (CPM), the cost-time slope of an activity is given by

A. $\frac{Crash\ Cost}{Crash\ Time - Normal\ Time}$

B. $\frac{Crash\ Cost - Normal\ Cost}{Normal\ Time - Crash\ Time}$

C. $\frac{Normal\ Cost}{Crash\ Time - Normal\ Time}$

D. $\frac{Crash\ Cost - Normal\ Cost}{Crash\ Time}$

29. The phases present in pearlite are

A. Austenite and ferrite

B. Cementite and austenite

C. Ferrite and cementite

D. Martensite and ferrite

30. Which one of the following methods is not effective in improving the fatigue strength of a circular mild steel (MS) shaft

A. Enhancing surface finish
B. Shot peening of the shaft
C. Increasing relative humidity
D. Reducing relative humidity

31. Which of the following heat treatment processes is not used for surface hardening of steels?

A. Carburizing
B. Cyaniding
C. Annealing
D. Carbonitriding

32. The Cast Iron which possesses all the carbon in the combined form as cementite is known as

A. Grey Cast Iron
B. Spheroidal Cast Iron
C. Malleable Cast Iron
D. White Cast Iron

33. Which one of the following statements about a phase diagram is INCORRECT?

A. It indicates the temperature at which different phases start to melt
B. Relative amount of different phases can be found under given equilibrium conditions
C. It gives information on transformation rates
D. Solid solubility limits are depicted by it

34. Match The Following

Heat Treatment Process		Effect	
P.	Tempering	1.	Strengthening
Q.	Quenching	2.	Toughening
R.	Annealing	3.	Hardening
S.	Normalizing	4.	Softening

A. P-2, Q-3, R-4, S-1
B. P-1, Q-1, R-3, S-2
C. P-3, Q-3, R-1, S-3
D. P-4, Q-3, R-2, S-1

35. Hardenability of steel is a measure of

A. The ability to harden when it is cold worked
B. The maximum hardness that can be obtained when it is austenitized and then quenched
C. The depth to which required hardening is obtained when it is austenitized and then quenched
D. The ability to retain its hardness when it is heated to elevated temperatures

36. Two surfaces P and Q are to be joined together. In which of the given joining operation(s), there is no melting of the two surfaces P and Q for creating the joint?

A. Arc welding
B. Brazing
C. Friction welding
D. Spot welding

37. Two plates, each of 6 mm thickness, are to be butt-welded. Consider the following processes and select the correct sequence in increasing order of size of the heat affected zone

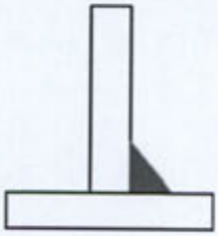
1-Arc welding
2-MIG welding
3-Laser beam welding
4-Submerged arc welding

A. 1-4-2-3
B. 3-4-2-1
C. 4-3-2-1
D. 3-2-4-1

38. Which one of the following welding methods provides the highest heat flux (W/mm^2)?

A. Oxy-acetylene gas welding
B. Tungsten inert gas welding
C. Plasma arc welding
D. Laser beam welding

39. The type of weld represented by the shaded region in the figure is

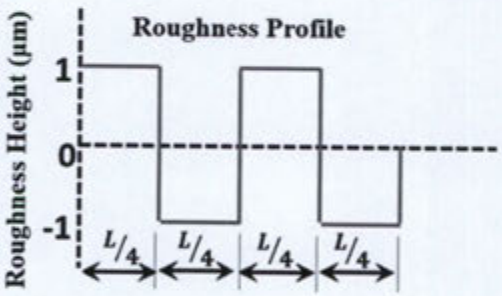


A. Groove
B. Spot
C. Fillet
D. Plug

40. In an arc welding process, welding speed is doubled. Assuming all other process parameters to be constant, the cross-sectional area of the weld bead will

A. Increase by 25%
B. Increase by 50%
C. Reduce by 25%
D. Reduce by 50%

41. Consider the surface roughness profile as shown in the figure.



The center line average roughness (Ra in µm) of the measured length (L) is

A. 0
B. 1
C. 2
D. 4

42. The figure below shows a symbolic representation of the surface texture in a perpendicular lay orientation with indicative values (I through VI) marking the various specifications whose definitions are listed below.

P: Maximum Waviness Height (mm);

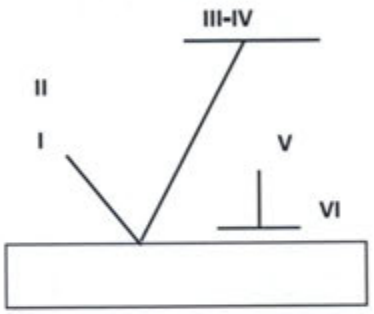
Q: Maximum Roughness Height (mm);

R: Minimum Roughness Height (mm);

S: Maximum Waviness Width (mm);

T: Maximum Roughness Width (mm);

U: Roughness Width (mm);



The correct match between the specifications and the symbols (I to VI) is:

A. I-R, II-Q, III-P, IV-S, V-U, VI-T

B. I-R, II-P, III-U, IV-S, V-T, VI-Q

C. I-U, II-S, III-Q, IV-T, V-R, VI-P

D. I-Q, II-U, III-R, IV-T, V-S, VI-P

43. The most common limit gauge used for inspecting the hole diameter is

A. Snap gauge

B. Ring gauge

C. Plug gauge

D. Master gauge

44. A cutting tool provides a tool life of 60 minutes while machining with the cutting speed of 60 m/min. When the same tool is used for machining the same material, it provides a tool life of 10 minutes for a cutting speed of 100 m/min. If the cutting speed is changed to 80 m/min for the same tool and work material combination, the tool life (in minutes) computed using Taylor's tool life model is (round off to the nearest integer).

A. 22

B. 25

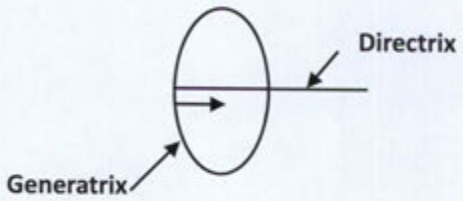
C. 8

D. 16

45. The correct sequence of machining operations to be performed to finish a large diameter through hole is

A. Drilling, boring, reaming
B. Boring, drilling, reaming
C. Drilling, reaming, boring
D. Boring, reaming, drilling

46. In a machining operation, if a cutting tool traces the workpiece such that the directrix is perpendicular to the plane of the generatrix as shown in figure, the surface generated is



A. Plane
B. Cylindrical
C. Spherical
D. Surface of revolution

47. In a turning process using orthogonal tool geometry, a chip length of 100 mm is obtained for an uncut chip length of 250 mm. The cutting conditions are cutting speed = 30 m/min. rake angle=20^0. The shear plane angle (in degrees) is (round off to the nearest integer).

A. 20
B. 23
C. 26
D. 18

48. The base of a brass bracket needs rough grinding. For this purpose, the most suitable grinding wheel grade specification is

A. C30Q12V
B. A50G8V
C. C90J4B
D. A30D12V

49. Which one of the following statements is TRUE?

A. The 'GO' gage controls the upper limit of a hole
B. The 'NO' gage controls the lower limit of a shaft
C. The 'GO' gage controls the lower limit of a hole
D. The 'NO GO' gage controls the lower limit of a hole

50. Which of the bearings given below SHOULD NOT be subjected to a thrust load?

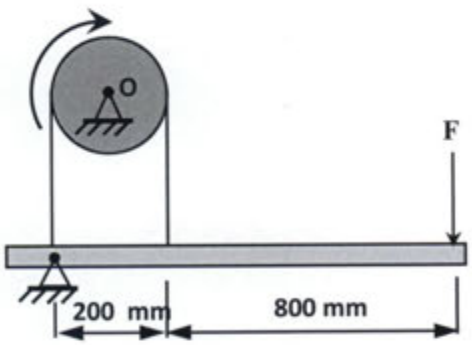
A. Deep groove ball bearing
B. Angular contact ball bearing
C. Cylindrical (straight) roller bearing
D. Single row tapered roller bearing

PART – II

SHORT ANSWER TYPE QUESTIONS

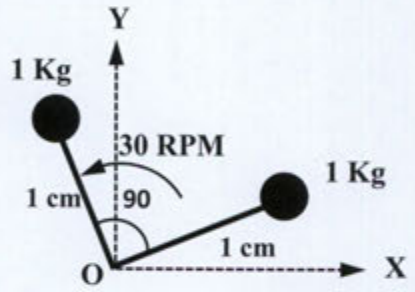
(Answer any 10 out of 13 questions) 10x 5 marks each = 50 marks

51. Write the modified Taylor's tool life equation. Explain the effect of machining process parameter on the tool life.
52. Calculate the height (in mm) for a 125 mm sine bar to measure a taper of 27°32′ on a flat work piece.
53. A band brake shown in the figure has a coefficient of friction of 0.3. The band can take a maximum force of 1.5 KN. Calculate the maximum braking force (F) that can be safely applied.



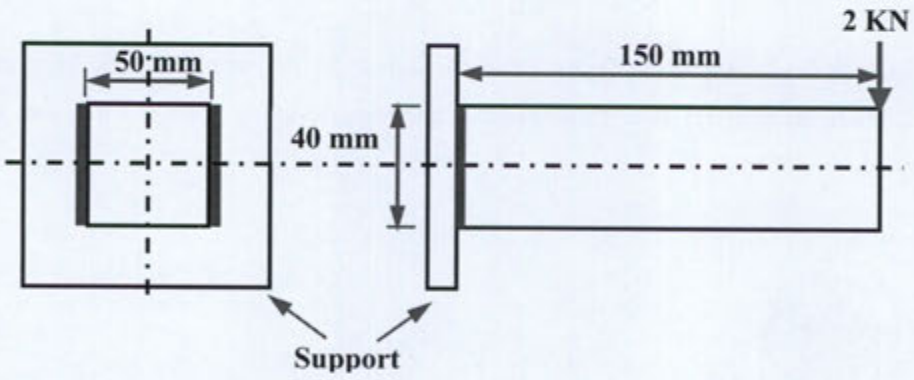
54. A self-aligning ball bearing has a basic dynamic load rating (C_{10} for 10^6 revolutions) of 35 kN. If the equivalent radial load on the bearing is 45 kN, calculate the excepted life.

55. A rigid body in the X-Y plane consists of two point masses (1 kg each) attached to the ends of two massless rods, each of 1 cm length, as shown in the figure. It rotates at 30 RPM counter-clockwise about the Z-axis passing through point O. A point mass of 22 kg, attached to one end of a third massless rod, is used for balancing the body by attaching the free end of the rod to point O. Calculate the length of the third rod.



56. Two helical tensile springs of the same material and also having identical mean coil diameter and weight, have wire diameters d and d/2. Calculate the ratio of their stiffness

57. A cantilever beam of rectangular cross-section is welded to a support by means of two fillet welds as shown in figure. A vertical load of 2 kN acts at free end of the beam. Considering that the allowable shear stress in weld is 60 N/mm^2, calculate the minimum size (leg) of the weld required.



58. A furnace can supply heat steadily at 1200 K at a rate of 24000 kJ/min. Calculate the maximum amount of power (in kW) that can by using the heat supplied by the furnace in an environment at 300 K.

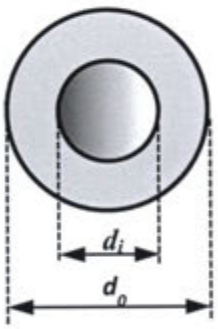
59. Briefly explain hydroelectric energy and geothermal energy.
60. A local tyre distributor expects to sell approximately 9600 steel belted radial tyres next year. Annual carrying cost is Rs. 16 per tyre and ordering cost is Rs. 75. Calculate the economic order quantity of the tyres
61. Differentiate between up milling and down milling operation.
62. What is wheel truing and wheel dressing in context of grinding wheel?
63. Write down the function of flux in welding

PART- III

LONG ANSWER TYPE QUESTIONS

(Answer any 5 out of 8 questions) 5 x 10 marks each = 50 marks

64. A shaft of length L is made of two materials, one in the inner core and the other in the outer rim, and the two are perfectly joined together (no slip at the interface) along the entire length of the shaft. The diameter of the inner core is d_i and the external diameter of the rim is d_0, as shown in the figure. The modulus of rigidity of the core and rim materials are G_i and G_0, respectively. It is given that $d_0 = 2d_i$ and $G_i = 3G_0$. When the shaft is twisted by application of a torque along the shaft axis, the maximum shear stress developed in the outer rim and the inner core turn out to be τ_0 and τ_i, respectively. All the deformations are in the elastic range and stress strain relations are linear. Calculate the ratio $\frac{\tau_i}{\tau_0}$.



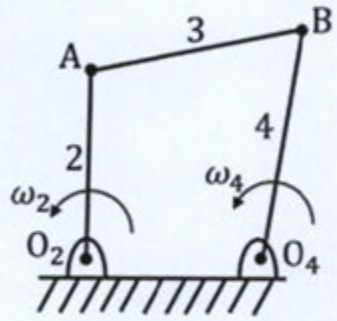
Shaft cross-section

65. A four bar mechanism is shown in the figure. The link numbers are mentioned near the links. Input link 2 is rotating anticlockwise with a constant angular speed ω_2. Length of different links are:

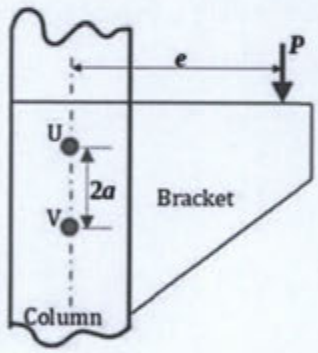
$O_2O_4=O_2A=L$,

$AB=O_4B=\sqrt{2}\,L$.

The magnitude of the angular speed of the output link 4 is ω_4 at the instant when link 2 makes an angle of 90° with O_2O_4 as shown. Calculate the ratio $\frac{\omega_4}{\omega_2}$ round off to two decimal places.



66. A bracket is attached to a vertical column by means of two identical rivets U and V separated by a distance of 2a=100mm, as shown in the figure. The permissible shear stress of the rivet material is 50MPa. If a load P=10kN is applied at an eccentricity $e=3\sqrt{7}\,a$, calculate the minimum cross-sectional area of each of the rivets to avoid failure.



67. Explain the mechanism of chip formation. Explain the conditions that results in the formation of

    A. Continuous chips without built up edge
    B. Continuous chips with built up edge
    C. Discontinuous chips

68. Explain the specification system of a grinding wheel. Discuss the significance of different parameters such as abrasive type, grit size, bond type, grade, and structure in the selection and performance of a grinding wheel.

69. Define sensitiveness of governor. What is hunting in context to a governor?

70. Explain the below heat treatment process in detail. How does they affect the microstructure and mechanical properties of steel?
    A. Annealing
    B. Normalizing
    C. Hardening (Quenching)
    D. Tempering
    E. Case Hardening (Surface Hardening)

71. Discuss the application of straight polarity and reverse polarity in arc welding. Calculate the melting efficiency in case of arc welding of steel with a potential 25 V and current 180 amp. The travel speed is 4 mm/sec and cross section area of the joint is 16 mm^2. Heat required to melt steel may taken as 12 Joule/mm^3 and heat transfer efficiency as 0.80.

PART- IV

ESSAY TYPE QUESTIONS

(Answer any 2 out of 4 questions) 2 x 25 marks each = 50 marks

72. Explain the classification of bearings based on their design and application. Discuss the advantages and disadvantages of each type. Explain the importance of lubrication in bearings. What are the different types of lubricants used in bearing systems?
73. Explain the working principle, construction, and applications of a Watt Governor. Discuss how it regulates the speed of an engine. Derive the expression for the equilibrium speed of a Watt Governor and explain the effect of load variations on its performance. Also, compare its sensitivity and stability with other types of centrifugal governors.
74. Describe all the inversions of a slider crank mechanism.
75. Explain the physics of arc initiation in arc welding. Discuss the different factors that influence arc initiation in welding, including voltage, electrode material, polarity, and environmental conditions. Why is arc initiation difficult in plasma arc welding? Why is plasma arc welding is called as plasma arc welding despite the fact that plasma is present in all other arc welding process?

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