1.5-2009

B-JGT-J-NFA

MECHANICAL ENGINEERING

Paper I

Time Allowed : Three Hours	Maximum Marks : 200

INSTRUCTIONS

Candidates should attempt questions 1 and 5 which are compulsory, and any THREE of the remaining questions selecting at least ONE question from each Section.

If any data is considered insufficient, assume suitable values and indicate the same clearly.

All questions carry equal marks.

Marks carried by each sub-part of the question is indicated at the end of the sub-part.

Answers must be written in ENGLISH only.

Unless otherwise indicated, symbols & notations have their usual meanings.

SECTION A

1. Answer any *four* of the following :

    (a) What are the various types of dislocations ? Explain any two of them with the help of sketches. What is interstitial free steel and where is it used ? *10*

(b) (i) Show that the cycloidal or the involute shape for profiles of wheel teeth satisfy the fundamental condition for the transmission of uniform motion.

(ii) What are the principal advantages of the involute shape over cycloidal shape of gear tooth ? 10

(c) Two rigid bodies 'A' and 'B' turn about fixed parallel axes and 'A' drives 'B' by direct contact. Show that the ratio of angular velocity of B to that of A can only be constant, if contact surfaces are so shaped that the normal at the point of contact intersects the line of centres at a fixed point. 10

(d) What is deep drawing process for sheet metal forming ? Explain the function of a blank holder. What is drawing ratio and how is the drawing ratio increased ? 10

(e) Construct Shear Force and Bending Moment diagrams for a beam as shown in Figure 1. The loading is shown in the diagram. 10
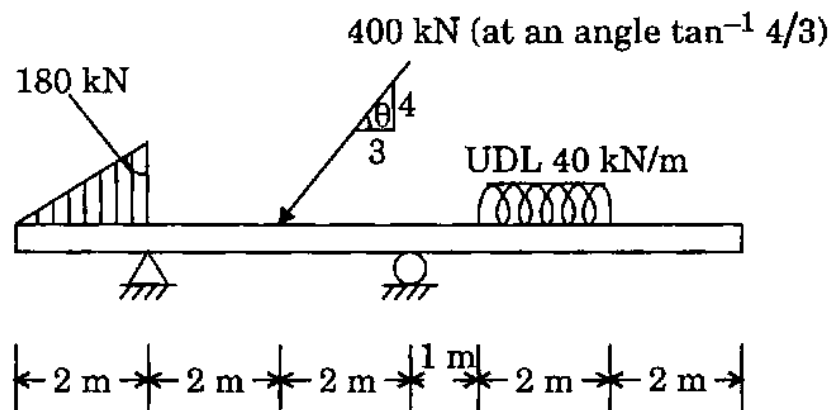
400 kN (at an angle $\tan^{-1} 4/3$)

180 kN

UDL 40 kN/m

├─ 2 m ─┤├─ 2 m ─┤├─ 2 m ─┤├1 m├├─ 2 m ─┤├─ 2 m ─┤

Figure 1 (not to scale)

2. (a) In a compound helical spring the inner spring is arranged within and concentric with the outer one but is 15 mm shorter. The outer spring has 12 coils of mean diameter 30 mm and the diameter of wire is 3 mm. Find the stiffness of the inner spring if an axial load of 120 N causes the outer one to compress 25 mm. If the vertical clearance between the two springs is to be 2 mm, find the diameter of the wire of the inner spring when it has 8 coils. Take G = 80 GPa for both springs. *15*

(b) In a two-dimensional stress system, normal stresses of 30 MPa and 100 MPa act on two mutually perpendicular planes in conjunction with a shear stress of 40 MPa. The stress intensity, judged by the distortion energy, is excessive. As it was found impossible to reduce the applied stresses, the severity of the distortion energy condition was reduced by increasing the normal stress of 30 MPa to have higher value, S. Find the value of S at which the distortion energy is minimum. *15*

(c) A straight bar of alloy 1 m long and 12 mm × 6 mm in section is loaded as a column till it buckles. Assuming Euler formula for pinned-ends to apply, estimate the maximum central deflection before the material attains its yield point, at 260 MPa. E = 80 GN/m^2. *10*

3. (a) A 40 mm diameter shaft 2·5 m long has a mass of 1 kg/metre length. It is simply supported at the ends and carries three masses 90 kg, 140 kg and 60 kg at a distance of 1·7 m, 1·0 m, and 0·5 m respectively from right support.

Taking $E = 200$ GN/m^2, find the frequency of transverse vibrations. *15*

(b) A revolving mass of a scooter engine crank is 2 kg at a radius of 10 cm. Determine the magnitude of balance mass at a radius of 100 mm in two planes 10 cm apart. One of the planes is at a distance of 5 cm from the plane of the crank. These planes are

(i) on same side of crank

(ii) on opposite sides of crank. *15*

(c) How do the following parameters affect the pressure angle in a cam follower combination ?

(i) Steepness of displacement diagram

(ii) Base circle radius

(iii) Follower displacement

Justify your answer. *10*

4. (a) "Composite material is a generic term." Explain this statement. Explain also the terms 'law of mixtures', 'wetting', and 'debonding' as applied to composite materials. What are the main constituents of a grinding wheel ? *20*

(b) Distinguish between grain boundary movement during cooling and heating and grain distortion during metal deformation during extrusion. Give two products/examples where there are no grain boundaries and what properties are enhanced as a result of absence of grain boundaries.   *20*

SECTION B

5. Answer any *four* of the following :

(a) What are 'G' codes and 'M' codes ?

To make a 175 mm dia hole in a mild steel plate of thickness 5 mm, with the surface finish of the finished hole to have a value of 20 microns, choose suitable machine tools to carry out this operation. Give the process plan.　　　　*10*

(b) Two plates of aluminium and stainless steel are to be welded back to back to create a single plate of thickness equal to the sum of the thicknesses of the two plates. Suggest the suitable process and explain it in brief.　　　　*10*

(c) What is the common composition of the electrolyte used in ECM process ? What is the wear on the electrode for making a 5 mm dia 50 mm deep blind hole in a plate of stainless steel by ECM ? What will be the tool wear, if instead of ECM, we use EDM process ?　　　　*10*

(d) How does Value Engineering differ from Value Analysis ? Define 'value'. Explain the different types of values with the help of suitable examples.　　　　*10*

(e) Define Material Requirement Planning (MRP). What are its objectives ? Explain the following terms associated with MRP :
　　　Dependent demand
　　　Lot size
　　　Time phasing
　　　Gross requirements
　　　Net requirements　　　　*10*

6. (a) With the help of Taylor's tool life equation, determine the shape of the curve between velocity of cutting and life of the tool. Assume an HSS tool and mild steel as work material. *10*

(b) Where do you use gauges instead of micrometers for the control of dimensions of machined parts ? Set gauges for the shaft of size 100 ± 1 mm and a bush with a hole size of 100 ± 1 mm. Can these gauges be used if the tolerances are changed to ± 1·2 mm ? *10*

(c) Casting is a process which gives the products with isotropic properties. Justify why the castings are subjected to the forging process, and the resulting change in some properties of the product. Name these properties and give examples of forgings where these properties are absolutely essential. *20*

7. (a) What is sales forecasting ? Explain why a sales forecast is required.

The past data about the load on a machine centre is as follows :

Month	Load in machine-hours
1	585
2	611
3	656
4	748
5	863
6	914
7	964

(i)   Compute the forecast of the load on the centre in the 8th month, using a five month moving average.

(ii) Compute a weighted three month moving average for the 8th month, where the weights are 0·5 for the latest month, 0·3 and 0·2 for the other months, respectively.   *10*

(b)   A project consists of 7 jobs. Jobs A and F can be started and completed independently. Jobs B and C can start only after job A has been completed. Jobs D, E and G can start only after jobs B, (C and D), and (E and F) are completed, respectively. Time estimates of all the jobs are given in the following table :

Job	Time Estimates (Days)		
	Optimistic	Pessimistic	Most likely
A	3	7	5
B	7	11	9
C	4	18	14
D	4	12	8
E	4	8	6
F	5	19	12
G	2	6	4

Draw the network and determine the critical path, and its expected duration (T_e). What is the probability of completing the project in T_e days ? Also, determine the total and free slacks of all the jobs.   *15*

(c) What is a line balancing problem ?

Explain the following terms related with line balancing :

Minimum rational work element

Total work content

Workstation process time

Cycle time

Precedence diagram

Balance delay   *15*

8. (a) Draw a flow chart to find the diameter of a solid steel shaft, using 'C' language, to transmit a given power at a specified speed. The ultimate tensile strength of steel and factor of safety are also given.   *15*

(b) What is a transportation problem ?

Solve the following assignment problem, in which the figures in the matrix represent unit cost of production of each component. What is the minimum cost ?   *15*

Component

		1	2	3	4	5
	A	11	17	8	16	20
	B	9	7	12	6	15
Machine	C	13	16	15	12	16
	D	21	24	17	28	26
	E	14	10	12	11	15

(c) Why and how is a queue formed ?

A store employs one cashier at its counter. On an average 10 customers arrive in 5 minutes while the cashier can serve 12 customers in the same time. Assuming Poisson distribution for arrival and exponential distribution for service rate, find the average number of units in the system, the average length of the waiting line, expected time a customer spends in the system, expected time a customer spends in the queue. *10*