Indian Forest Service Examinat.. -2013

A–JGPT–M–NFFO–A

MECHANICAL ENGINEERING

PAPER—I

(CONVENTIONAL)

Time Allowed : Three Hours	Maximum Marks : 200

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions

There are EIGHT questions in all out of which FIVE are to be attempted.

Question Nos. **1** and **5** are compulsory. Out of the remaining SIX questions, THREE are to be attempted selecting at least ONE question from each of the two Sections A and B.

Attempts of questions shall be counted in chronological order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

All questions carry equal marks. The number of marks carried by a question/part is indicated against it.

Answers must be written in ENGLISH only.

Unless otherwise mentioned, symbols and notations have their usual standard meanings.

Assume suitable data, if necessary and indicate the same clearly.

Neat sketches may be drawn, wherever required.

SECTION—A

1. Answer **all** of the following :

(a) The tooth profiles of both the gears used in a gear drive are—involute with 20° pressure angle, 12 mm module and 10 mm addendum. The pinion and the gear have 36 and 96 teeth respectively. Find the length of path of contact, arc of contact and the contact ratio. Show the path of contact with a sketch. 8

(b) The following data refer to a single-cylinder reciprocating engine :

Speed = 250 r.p.m.
Stroke = 300 mm
Mass of reciprocating parts = 50 kg
Mass of revolving parts at 150 mm radius = 38 kg

If two-thirds of reciprocating parts and all the revolving parts are to be balanced, find—

(i) the balance mass required at a radius of 410 mm;

(ii) the residual unbalance force when the crank has rotated 60° from inner dead centre. 8

(c) A cylindrical shaft, 80 mm in diameter, is subjected to a maximum bending moment of 2·5 kN-m and a twisting moment of 4·2 kN-m. Find the maximum principal stress developed in the shaft. If the yield stress of the shaft material is 380 MPa, determine the factor of safety of the shaft according to the maximum shearing stress theory of failure. 8

(d) A horizontal simply supported beam *AB*, 8 m long, carries a total uniformly distributed load of 300 kN. The beam is supported at *A* and at a point *C*, between *A* and *B*, where overhang *BC* is *x*. Determine the value of *x*, if the midpoint of the beam *AB* is to be a point of inflexion. 8

(e) Differentiate the characteristics of basic cubic and orthogonal crystal systems. Give at least three examples of each category of crystal system. 8

2. *(a)* In a quick-return motion of the crank and slotted lever type, the ratio of maximum velocities during return and forward motions is 2. If the length of stroke is 250 mm, find—

(i) the length of the slotted lever;

(ii) the ratio of times of cutting and return strokes;

(iii) the maximum cutting velocity per second if the crank rotates at 30 r.p.m. 10

(b) A punching machine carries out 5 holes per minute. Each hole of 32 mm diameter in 35 mm thick plate requires 10 N-m of energy/mm^2 of the sheared area. The punch has a stroke of 90 mm. Find the power of the motor required if the mean speed of the flywheel is 25 m/s. If the total fluctuation of speed is not to exceed 3% of the mean speed, determine the mass of the flywheel. 10

(c) A pulley of 150 mm effective diameter running at 1500 r.p.m. drives a follower of 750 mm diameter, the two shafts being parallel, 1 m apart. The belt has a mass of $0 \cdot 4$ kg/m and the maximum tension is to be 720 N. If $\mu = 0 \cdot 4$, estimate the maximum tension difference allowing for the inertia of the belt. If the belt has a cross-sectional area of 320 mm^2 and E for the material is 300 MPa, estimate the speed of the driven pulley at the maximum power condition and the power transmitted. Consider belt slip of $7 \cdot 5\%$. 20

3. (a) A steel tube, 24 mm external diameter and 18 mm internal diameter, encloses a copper rod 15 mm diameter to which it is rigidly joined at each end. If at a temperature of 30 °C there is no longitudinal stress, calculate the stresses in the rod and tube, when the temperature is raised to 200 °C. Given—

for steel :
$E_s = 210$ GPa
α_s = coefficient of thermal expansion
$= 11 \times 10^{-6}$/°C

for copper :
$E_c = 100$ GPa
$\alpha_c = 18 \times 10^{-6}$/°C 10

(b) A hollow cylindrical steel shaft is $1 \cdot 5$ m long and has inner and outer diameters equal to 40 mm and 60 mm respectively.

(i) What is the largest torque that can be applied to the shaft if the shearing stress is not to exceed 150 MPa?

(ii) What is the corresponding minimum value of the shearing stress in the shaft? 10

(c) The cylinder of a hydraulic ram has 160 mm internal diameter. Find the thickness required to withstand an internal pressure of 60 MPa, if the maximum tensile stress is limited to 90 MPa and the maximum shearing stress to 80 MPa. Use Lame's formula for thick cylinders under internal pressure. 20

4. (a) A thin cylindrical shell is 5 m long, has 200 mm internal diameter and has thickness of metal 10 mm. It is filled completely with a fluid at atmospheric pressure. If an additional 25000 mm^3 fluid is pumped in, find the pressure inside the shell and hoop stress developed. Find also the changes in diameter and length. Take $E = 200$ MPa and $\nu = 0 \cdot 3$. 10

(b) (i) What is normalizing?

(ii) Compare between normalizing and annealing of metals. 10

(c) Explain the following hardening processes used for medium carbon steel. State their advantages and disadvantages : 20

(i) Induction hardening

(ii) Flame hardening

SECTION—B

5. Answer **all** of the following :

(a) Explain the need for use of unconventional machining processes compared to the conventional ones. Name any five unconventional processes with one example of its application. Explain the basic principle of waterjet machining. 8

(b) In a metal cutting experiment, the tool life was found to vary with the cutting speed in the following manner :

Cutting speed, V (in m/min)	*Tool life, T* (in min)
100	120
130	50

Derive Taylor's tool life equation for this operation and estimate the tool life at a speed of 2·5 m/sec. Also estimate the cutting speed for a tool life of 80 min. 8

(c) Explain, with the help of sketches, the concepts of hole basis and shaft basis in terms of assembly fit specifications. Which of the two is preferred and why? 8

(d) An aluminium rod, 6·25 mm diameter, is drawn into a wire 5·60 mm diameter. Neglecting friction between the rod and the dies, determine the drawing stress and the reduction in area when the yield stress for aluminium is $35\ N/mm^2$. Also calculate the tangential stress at the exit. 8

(e) What is work sampling? A pilot study shows 30% ineffective time in a job order shop which has 10 general purpose machines. A work sampling study is planned. Compute the number of observations that are required to ensure an accuracy of 5% with 95% confidence level. 8

6. *(a)* The table below lists 12 work elements along with their number of predecessors and time duration in minutes. Design a suitable production line consisting of appropriate number of workstations assuming cycle time of 10 min. Also compute the line efficiency, balance delay and smoothness index :

Work element	1	2	3	4	5	6	7	8	9	10	11	12
No. of predecessors	0	1	2	1	2	5	6	7	6	6	7	11
Time of completion (in min)	5	3	4	3	6	5	2	6	1	4	4	7

Write the steps used in solution. 15

(b) A company manufactures two products A and B. The manufacturing and marketing data for the two products are given below :

Department	*Product A*	*Product B*	*Capacity*
Welding	2·0 man-hours	2·5 man-hours	1000 man-hours
Machines	3·0 man-hours	1·5 man-hours	1200 man-hours
Assembly	1·5 man-hours	4·0 man-hours	1200 man-hours
Profit	₹ 120/unit	₹ 100/unit	—

Find the product-mix to maximize profit, assuming that whatever is produced will be sold. 15

(c) A function $F(x)$ is defined as follows :

$$\begin{aligned} F(x) &= ax^3 - bx^2 + cx - d \quad \text{if} \quad x > 1 \\ &= 0 \quad \text{if} \quad x = 0 \\ &= -ax^3 + bx^2 - cx + d \quad \text{if} \quad x < 1 \end{aligned}$$

Write a FORTRAN program that reads the values of a, b, c, d, x and find the values of $F(x)$ in print. 10

7. (a) A company is engaged in the assembly of a wagon on a conveyor. 500 wagons are required per day. Production time available per day is 420 minutes. The other information is given in the table below regarding assembly steps and precedence relationships. Find the minimum number of workstations, balance delay and line efficiency : 15

Activity	*Time* (in sec)	*Activity that must precede*
A	45	—
B	11	*A*
C	09	*B*
D	50	—
E	15	*D*
F	12	*C*
G	12	*C*
H	12	*E*
I	12	*E*
J	08	*F, G, H, I*
K	09	—
Total	195	

(b) Classify the costs associated with the management of quality.

A company Balance Sheet shows the following expenditure on quality control. Group them in appropriate quality cost : 10

Sl. No.	*Item*	*Expenditure* (in lakhs of ₹)
1	Vendor quality assurance	20
2	Products returned from field	15
3	Warranty claims	04
4	Scrap	30
5	Field testing before commissioning	10
6	Rework	20
7	Receiving inspection	10
8	Downtime	10
9	Materials consumed during measurements	04
10	Quality training	10
11	Depreciation on equipment	25
	Total : 158	

(c) A manufacturing company requires special gears at the rate of 300 numbers per year. Each gear costs ₹ 380. The procurement cost and inventory carrying cost are estimated to be ₹ 300 and 20% respectively. If the supplier offers a discount of ₹ 20 per gear on an order of 200 gears or more, will it be advisable to avail the discount? What should be the order quantity? 15

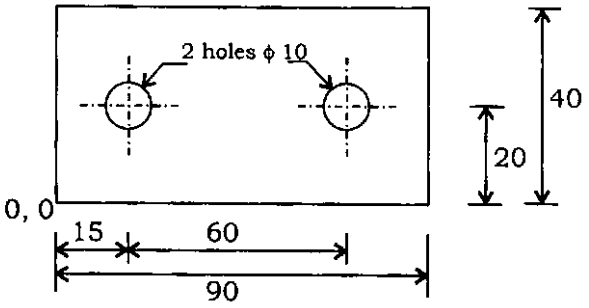
8. (a) (i) What is the difference between a jig and a fixture? Explain with the help of one example for each. 4

(ii) Explain the 3 : 2 : 1 principle of location. 8

(b) (i) Differentiate among the simple, compound and progressive dies. 6

(ii) A symmetrical cup of circular cross section with diameter 40 mm and height 60 mm with a corner radius of 2 mm is to be obtained in C20 steel of 0·6 mm thickness. Calculate the blank size for the drawn cup. Will it be possible to draw the cup in single step? 10

(c) Two holes are to be drilled with a 10 mm diameter drill on a job as shown below :



The drill rotates at 500 r.p.m. and feed rate is 200 mm/min. How do you code the information in—

(i) fixed block format;

(ii) TAB sequential format;

(iii) word address format? 12

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