भारतीय वन सेवा परीक्षा 2011
Indian Forest Services Examination

2051

D-VSF-L-ZRA

MECHANICAL ENGINEERING

Paper I

Time Allowed : Three Hours | *Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt Questions No. 1 and 5 which are compulsory, and any THREE of the remaining questions, selecting at least ONE question from each Section.

All questions carry equal marks.

Marks carried by parts of a question are indicated against each.

Answers must be written in ENGLISH only.

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

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

SECTION A

1. Attempt any ***four*** of the following :

   (a) Discuss how single cylinder 4-stroke reciprocating engine is balanced. *10*

(b) A circular rod has 5 cm diameter for a length of 0·6 m, 8 cm diameter for a length of 1·8 m and 3 cm diameter for a length of 0·25 m. A disc of mass moment of inertia 15 kg m^2 is suspended with the help of this rod such that the disc is in horizontal plane. Neglecting inertia effect of the rod, find natural frequency of torsional oscillation in Hz. Assume $G = 0{\cdot}8 \times 10^{11}$ Pa. *10*

(c) Compare the bending strengths of three beams of same material, same weight and same depth if one of them has solid rectangular area of 6×20 cm^2. The second beam is a hollow rectangular section having a wall thickness of 2 cm. The third beam has I-section of equal flanges having web and flange thickness equal to 2 cm. *10*

(d) The load on a rod consists of an axial pull of 10 kN along with a transverse shear force of 5 kN. Determine the diameter of the rod by using the following theories of failure :

(i) Strain energy theory

(ii) Shear strain energy theory

Elastic limit in tension is 270 N/mm^2 and a factor of safety of 3 is to be used.

Poisson's ratio = 0·3. *10*

(e) Explain (i) bainite, (ii) martensite. Show with a figure, the variation of hardness of martensite with %C. Discuss polycarbonate, its properties and applications. Complete the table below for surface hardening process. *10*

Process	Temp °C	Case depth (mm)	Case hardness HRC	Main use
Cyaniding	—	—	—	—

2. (a) The total sleeve movement in a Hartnell type of governor is 3 cm. At mid position of sleeve, the sleeve arm which is 6 cm long, is horizontal. The length of ball arm is also 6 cm. The speed at the lowest position is 430 rpm. If the spring stiffness is 50 N/cm, find the speed in rpm at the top position of the sleeve. At midspan the ball rotates at 10 cm radius. The mass of the ball is 1·3 kg. *10*

(b) An epicyclic gear train consists of a sun gear, a stationary internal gear and three identical planet gears which are carried on a star-shaped planet carrier. The sun gear, internal gear and planet carrier have common axis. The speed of the planet carrier is one-fifth of the speed of the sun gear in the same sense. If minimum number of teeth on any gear is limited to 18, determine the number of teeth on each gear. Determine the torque to keep the internal gear stationary, if input torque at sun gear is 100 Nm. *10*

(c) A machine is vibrating with an amplitude of 0·04 mm at 500 cpm. An instrument weighing 20 kg is mounted on the four isolators on the machine. Each isolator has stiffness 314 N/cm and damping factor of 392 N sec/m. Determine

(i) amplitude of vibration of instrument, and

(ii) dynamic load on each isolator. *20*

3. (a) Two planes AB and AC make an angle of 50° at point A. Plane AB is subjected to tensile stress 3 kN/cm^2 and shear stress 3 kN/cm^2 from B towards A. Plane AC is subjected to a normal stress of unknown magnitude and a shear stress of magnitude 2 kN/cm^2 from C towards A. Determine

(i) normal stress on plane AC, and

(ii) principal stresses. *15*

(b) Design a suitable helical spring for a balance which is used to measure 0 to 100 kg over a scale of 80 mm. The spring is to be enclosed in a casing of 25 mm diameter. Approximate number of turns is 30. Also calculate the maximum shear stress induced. $G = 0{\cdot}85 \times 10^7$ N/cm^2. *10*

(c) A steel sleeve is pressed onto a solid steel shaft which has 5 cm diameter. The radial pressure between shaft and sleeve is 1800 N/cm^2 and hoop stress at the inner surface of the sleeve is 4500 N/cm^2. If an axial compressive load of 50 kN is applied to the shaft, determine change in radial pressure at the interface of shaft and sleeve. Assume $\mu = 0{\cdot}3$. *15*

4. (a) Prove that the packing fraction for F.C.C. structure is 0·74. Draw the phase diagram of Pb-Sn alloy and from this diagram draw cooling curve for eutectic alloy. How many atoms per mm^2 are there on the (100) planes of lead (Pb radius = 0·1750 nm) ? What is deformation by twinning ? *20*

(b) Describe the following heat treatment processes :

(i) Full annealing

(ii) Process annealing

Mention some advantages of thermosets and write at least four types of such material. What are the special properties of PTFE ? What are the materials used to make porcelain ? Write some important applications of oxide ceramics. *20*

SECTION B

5. Attempt any ***four*** of the following :

(a) What are the disadvantages of abrasive jet machining ? Write some of its applications. Write the advantages, limitations and applications of electron beam machining. What is the safety problem connected with EBM ? *10*

(b) Discuss with figure the various steps required for friction welding, mentioning at least two methods of control. What is meant by low hydrogen electrode ? What is the maximum output current that can be drawn at 100% duty cycle from a welding power source rated at 600 A at 60% duty cycle. *10*

(c) In NC machine, what is the purpose of the parity check ? What is the function of Data Processing Unit (DPU) and Control Loop Unit (CLU) of MCU. How is Feed Rate Number (FRN) expressed ? What is indirect feedback ? *10*

(d) Prepare a flow diagram for writing the computer programme in FORTRAN for Pulse MIG welding process. *10*

(e) In a four-month period, the best rainfall forecast is derived by using 40% of the rainfall for the most recent month; 30% of two months ago; 20% of three months ago; and 10% of four months ago; if the actual rainfall was as follows :

Month 1	Month 2	Month 3	Month 4
100	90	105	95

What is the rainfall forecast for Month 5 ? *10*

6. (a) What are the functions of jig ? Draw a jig to machine four holes in a plate. What are two reasons for not having drill bushings actually touching the workpiece ? What is a duplex fixture ? *10*

(b) What is meant by interchangeable manufacture ? Laser light has unique advantages for inspection. What are they ? Define the terms 'roughness height', 'waviness width' and 'lay' in connection with surface irregularities. *10*

(c) Discuss deep-hole drilling keeping in mind speed and feed, mentioning the technique of applying coolant. What is the main difference betwen rose reamer and chucking reamer ? Write in short about shell reamer. *10*

(d) Write four advantages of high velocity forming process. What advantages does press forging have over drop forging ? Why are pure metals more easily cold worked than alloys ? Compare metal spinning with press work. *10*

7. (a) National Bank is considering opening a drive-in window for serving the tourists at a forest entry gate. Management estimates that tourists will arrive for banking service at the rate of 15 per hour. The teller whom it is considering to staff the window can service customers at the rate of one every three minutes. Assuming Poisson arrivals and exponential service, compute : *25*

(i) The average utilization of the teller.

(ii) Average number in the waiting line.

(iii) Average number in the system.

(iv) Average waiting time in line.

(v) Average waiting time in the system.

(b) Specify the output and the cost objectives of the following organizations : *15*

(i) A Forest Service Regional Office.

(ii) A Summer Camp for children.

For each of the organizations listed above, develop an organization chart.

8. (a) The daily demand for a forest product is normally distributed with a mean of 60 and a standard deviation of 7. The source of supply is reliable and maintains a constant lead time of six days. If the cost of placing the order is ₹ 10 and annual holding costs are ₹ 0·50 per unit, compute the order quantity and reorder point to satisfy 95% of the customers. Given that 95% corresponds to 1·645 standard deviation. *20*

(b) The plating process for metal desk equipment painted by dipping can produce defective parts either because of too thick or too thin a plating or because of defective appearance, which shows up in surface defects. A record of twenty samples follows; construct a suitable control chart and plot the twenty samples. Is the process in control ? *20*

Item No.	No. of defects per unit
1	19
2	16
3	23
4	11
5	15
6	12
7	17
8	11
9	20
10	15
11	13
12	10
13	22
14	5
15	23
16	22
17	14
18	6
19	13
20	6