Indian Forest Service Examination-2012

D-GT-M-NFA

MECHANICAL ENGINEERING

Paper I

Time Allowed : Three Hours	*Maximum Marks : 200*

INSTRUCTIONS

Candidates should attempt Question Nos. 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.

Important Note : ***All parts and sub-parts of a question must be attempted contiguously. That is, candidates must finish attempting all the parts/sub-parts of each question they are answering in the answer-book before moving on to the next question.***

Pages left blank must be clearly struck out. Answers that follow any pages left blank may not be given credit.

(Contd.)

Section – A

1. (a) A disc of mass 5 kg is mounted at the mid-span of a simply supported horizontal shaft having a span of 0·5 m and diameter 10 mm. Modulus of elasticity of the shaft material is 2×10^5 N/mm^2. The centre of gravity of the disc is displaced by 2·5 mm from its geometric centre while fitting on the shaft. The equivalent viscous damping for the system may be taken as 50 N.s/m. The shaft rotates at 740 rpm. Determine

   (i) maximum stress on the shaft during its rotation and

   (ii) power required to drive the shaft freely. 10

   (b) Discuss the turning moment diagram of a single cylinder 4-stroke engine.

   A 4-stroke engine develops 18·5 kW at 250 rpm. The turning moment diagram of this engine may be assumed rectangular for the expansion stroke and compression stroke. The turning moment for expansion stroke is 2·8 times that of the compression stroke. Assume the energy consumed in other strokes in the cycle to be zero. Assuming constant load, determine the moment of inertia of the flywheel required to keep the speed between 247 rpm and 253 rpm. 10

(c) What do you understand by a rotating disc of uniform strength ?

A turbine disc is required to have a uniform stress of 150 MPa at a speed of 3200 rpm. The disc is to be of 30 mm thick at the centre. What will be its thickness at a radius of 40 mm ?

Assume density of disc material = 7800 kg/m^3. 10

(d) (i) Show how columns will buckle under axial load with four different end conditions. 4

(ii) Calculate the concentration of vacancies in copper at room temperature of 25°C. Assume that 20,000 cal. are required to produce a mol of vacancies in copper. The gas constant is 1·987 cal/mol.K. 6

2. (a) In a vertical double-acting steam engine running at 360 rpm, the cylinder diameter is 0·3 m, piston rod diameter is 40 mm and length of connecting rod is 0·7 m. When the crank has moved 120° from top dead centre, the pressure of steam at the covered end is 0·35 N/mm^2 and that at the crank end is 0·03 N/mm^2. If the weight of the reciprocating parts is 500 N and length of stroke is 300 mm, find :

(i) piston effort,

(ii) force on connecting rod, and

(iii) turning moment on the crank shaft for the given crank position. 10

(b) Two shafts *A* and *D* are co-axial. They are geared together through an intermediate parallel shaft carrying gears *B* and *C* which mesh with the gears on *A* and *D* respectively. Gears *A* and *B* have a module of 4 mm and *C* and *D* have a module of 9 mm. The number of teeth on any wheel is to be not less than 15 and the speed of *D* is to be about, but not greater than 1/12 the speed of *A* and the ratio of each reduction is the same. Find

(i) suitable number of teeth for all the gears,

(ii) actual reduction of speed and

(iii) actual configuration of the system with a dimensional sketch. 10

(c) Discuss how the function of a governor differs from that of the flywheel. Prepare the list of the following according to usage into the three groups :

(i) only flywheel, (ii) only governor, and

(iii) both flywheel and governor.

Stationary I. C. engine, automotive I. C. engine, gas turbine, steam turbine and hydraulic turbine.

The arms of a Hartnell governor are of equal length. At mid-span of the sleeve, the ball arm is vertical and the radius at which the ball rotates is 8·25 cm when the equilibrium speed neglecting the friction, is 450 rpm. On changing the speed by 1%, the governor is able to overcome friction at this position. The friction force is 30 N at the sleeve and has constant value. The sleeve moves ±1·6 cm from the mean position. The minimum speed of the governor is 428 rpm. The mass of the sleeve is 3·5 kg. Determine the magnitude of the rotating masses of ball and initial compression of the spring. 15

(d) Discuss how multicylinder in-line I. C. engines are balanced to minimise unbalance, if any.

Investigate the state of primary and secondary balancing of a 4-stroke cycle, 4-cylinder in-line engine with the following firing orders :

(i) 1-2-3-4, and

(ii) 1-2-4-3.

Give your comments. 5

3. (a) Compare the weights of equal lengths of hollow and solid shaft to transmit a given torque for the same maximum shear stress if the inside diameter is $\frac{2}{3}$ of the outside diameter. 10

(b) On a simply supported beam (10 m span) a concentrated load (10 kN) and a moment of 40 kN act at a section 7 m from one of the ends. Draw the shear force and bending moment diagrams. Indicate the points of contraflexure if any. 10

(c) How will you distinguish between a thin-walled and a thick walled pressure vessel ?

What advantage you obtain by wire winding a thin cylinder ?

What largest internal pressure can be applied to a cylindrical tank 1·8 metre in diameter and 14 mm wall thickness if the ultimate tensile strength of steel used is 467 MPa and a factor of safety of 7 is desired ? 10

(d) At a section in a beam the tensile stress due to bending is 50 N/mm^2 and there is a shear stress of 20 N/mm^2.

Determine from first principles the magnitude and direction of the principal stresses and calculate the maximum shear stress. 10

4. (a) What are superalloys ? Give their classifications and typical applications. 10

(b) Explain the characteristics of sintered ceramics. What do you mean by porosity in polycrystalline ceramic ?

Silicon carbide particles are compacted and fired at a high temperature to produce a strong ceramic. The specific gravity of silicon carbide is 3·2 gm/cm^3. The ceramic component was weighed in dry, after soaking in water, and after suspended in water. These values are 360 gm, 385 gm and 224 gm respectively. Calculate apparent porosity and true porosity. 15

(c) What do you mean by stainless steels ? Explain three types of stainless steels. 15

Section – B

5. (a) Discuss in brief, consideration of 'Green Design' and 'Design For Manufacture' approach in manufacturing. 10

(b) Briefly discuss the various stages involved in the process of product development. 10

(c) Define and distinguish between the following characteristics of measuring instruments :

Accuracy, drift, rule of 10, resolution, and sensitivity. 10

(d) Given the number of hours worked and the hourly wage rate, obtain a flow chart to compute the gross salary and net pay of the employee, assuming the tax deduction to be at the rate of 10% of the employee's gross salary if it is less than ₹ 15,000 and at the rate of 20% otherwise. 10

6. (a) How the EDM and ECM processes affect the fatigue strength of machined components ? Explain. 10

(b) What is a manufacturing cell ? Why it is developed ? How the product flow lines may be designed in a manufacturing cell ? 10

(c) Explain the mechanism of flank wear of a cutting tool. Plot a flank wear rate curve and indicate the region of tool failure. 10

(d) An orthogonal machining operation is being carried out under the following conditions :

depth of cut = 0·1 mm,

chip thickness = 0·2 mm,

width of cut = 5 mm,

rake angle = 10°.

The force components along and normal to the direction of cutting velocity are 500 N and 200 N respectively. Determine

(i) the coefficient of friction between the tool and chip, and

(ii) ultimate shear stress of the workpiece material. 10

7. (a) Discuss Tresca and Von Mises yield criterion for metal forming operations. Also derive tensile and shear yield stress relationships for their approaches. Which of these criterion is more realistic ? Why ? 10

(b) Discuss the underlying principles involved in designing a good clamping system for jigs and fixtures. 10

(c) A domestic appliance distributor needs to estimate the demand for a certain item on a quarterly basis. This information is important for his annual planning exercise. Data on the demand for the particular item in the last two years is given in the following table :

Data on demand in eight quarters		
Quarter		*Demand*
Year 1	Q1	80
	Q2	90
	Q3	65
	Q4	110
Year 2	Q1	60
	Q2	80
	Q3	80
	Q4	100

Extract the Trend component of the time series data and use it for predicting the future demand of the item. 20

8. (a) Discuss the difference between operation charts, activity charts and flow process charts. 10

(b) During production a lens manufacturing unit has been examining a lens for scratches. If, in inspectors opinion, there are too many scratches, the lens is "bad" and rejected. Otherwise it is accepted. Using the data given in the following table, construct a Control chart for last month's inspected lenses. Sample size is 100.

Table of data	
Sample No.	*Units rejected*
1	10
2	9
3	8
4	11
5	7
6	12
7	7
8	10
9	13
10	12
11	13
12	14

20

(c) Solve graphically the L.P.P.

Maximize $Z = 3X_1 + X_2$

subject to restrictions $-2X_1 + X_2 \leq 1$

$X_1 \leq 2$

$X_1 + X_2 \leq 3$

$X_1, X_2 \geq 0$

10