

Sl. No.

B-JGT-K-NFA

311

**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.

**Section—A**

- 1. (a) In reference to balancing of reciprocating masses, define what is 'Hammer Blow'.

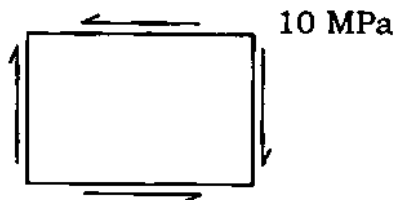
If a balancing mass  $B$  is kept at a radius  $b$  in order to balance the reciprocating parts only, what is the magnitude of the Hammer Blow? What is the effect of

Hammer Blow on rail wheels? Give the expression for the permissible angular speed so that the wheels will not lift from the rails. 10

(b) A thick-walled steel cylinder having an inside diameter of 150 mm is to be subjected to an internal pressure of  $40 \text{ N/mm}^2$ . Find to the nearest mm the outside diameter required, if the hoop stress in the cylinder wall is not to exceed  $125 \text{ N/mm}^2$ . 10

(c) Distinguish between radial follower and offset follower in reference to path of motion of a flat-faced follower-cam mechanism. Draw neat sketches for each of the two. 5

(d) An infinitesimal element of a body subjected to plane stress is found to have the state of stress as shown below :



Draw Mohr's circle for the above state of stress. What is this state of stress called? 5

(e) What is coordination number? Explain with an example. 5

(f) What is 'polymorphism'? What changes may take place during polymorphic change? 5

2. (a) (i) Define the phenomenon of interference in mating gears. What is the method of prevention of this?

(ii) A rack and pinion drive has the following data :

Pinion : 20 numbers of involute teeth, 120 mm pitch circle diameter and addendum of 6.25 mm

Rack : Addendum of 6.25 mm

What is the least pressure angle which can be used to avoid interference? With this pressure angle, find the minimum number of teeth in contact at a time. 5+15

(b) Show the controlling force vs. radius of rotation graphs for (i) Porter governor and (ii) Spring-controlled governors, and discuss the stability considerations. 10

(c) A machine part of mass 2 kg vibrates in a viscous medium. Determine the damping coefficient when a harmonic exciting force of 20 N results in a resonant amplitude of 12 mm with a period of 0.2 second. If the system is excited by a harmonic force of frequency 4 Hz, what will be the percentage increase in the amplitude of vibration when damper is removed as compared to that with damping? 10

3. (a) A beam of I-section 300 mm depth with flanges 150 mm wide and 20 mm thick, and web 12 mm thick is simply supported over a span of 10 m. If the maximum permissible bending stress is 75 MPa, what concentrated load can be carried at a distance of 3 m from one of the supports? 20
- (b) Determine the ratio of the maximum shear stress in the hollow shaft to that in the solid shaft for the following data : The two shafts are constructed of the same material and have the same length, and same outside radius  $r$ . The inside radius of the hollow shaft is  $0.6r$ . Assume that both shafts are subjected to the same torque. 10
- (c) Draw the Bending Moment and Shear Force Diagrams for a simply supported beam of span  $l$  and a uniformly distributed load of intensity  $w$ /unit length acting over the entire length of the span of the beam. 5
- (d) An axial tensile load of 100 kN is applied to a steel rod of 38 mm diameter and 500 mm long. Calculate the change in volume of the rod, if  $E = 200$  GPa and  $\nu = 0.26$ . 5
4. (a) What is the purpose of 'annealing' and 'tempering' steel? Explain with the help of T-T-T diagram or other diagrams the cycles and the resultant properties in steel. 20

- (b) The following data are available in case of a V-belt drive connecting two shafts 1 m apart to transmit 75 kW at 1200 r.p.m. of driver pulley :

Effective diameter of driver pulley  
= 300 mm

Effective diameter of driven pulley  
= 900 mm

Coefficient of friction between belt  
and pulley = 0.25

Density of belt material = 1100 kg/m<sup>3</sup>

Angle of groove = 40°

Area of belt section = 400 mm<sup>2</sup>

Permissible stress in belt = 2.46 MPa

(i) How many belts are needed?

(ii) Can the driven pulley be flat?  
Justify your answer.

10

- (c) A simply supported beam of span  $L$  and rectangular cross-section ( $b \times h$ ) is loaded by uniformly distributed load of  $w$  N/unit length. If  $\sigma_{\max}$  is the maximum bending stress and  $A$  is the cross-sectional area, then show that the elastic strain energy due to bending of the beam will be given by

$$\left( \frac{\sigma_{\max}^2}{2E} \right) \left( \frac{8}{45} \times \text{volume of the beam} \right)$$

Sketch the beam.

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## Section—B

5. (a) How do you define the cutting angles of a single-point tool in (i) International (LMN) and (ii) American ( $x, y, z$ ) system? Show them in the form of diagrams. 10
- (b) Which probability distribution is usually associated with PERT and why? Plot this distribution and indicate on it the relevant parameters of PERT. Which other distribution do you think may be appropriate for the purpose? 10
- (c) (i) Why does the tool wear during cutting? Enumerate the possible mechanism of tool wear.
- (ii) A tool lasted for 45 min before regrind in a milling operation. The cutting speed was recommended to be increased by 50%, but it was found that now the regrind was needed after every 20 min on an average. Can you define Taylor's tool-life equation valid for this operation, assuming that there is no other change in the system? 5+5
- (d) Draw a flow chart to find the torque to be transmitted by a solid steel shaft at a specified speed. Maximum shear stress is to be limited to a specified value. Factor of safety, tensile strength of steel and other parameters can be assumed to be given. 10

6. (a) Define 'angle of nip' and 'angle of bite' during rolling operation. 20

(b) Calculate the neutral plane to roll 250 mm wide annealed copper strip from 2.5 mm to 2.0 mm thickness with 350 mm diameter steel rolls. Take  $\mu = 0.05$  and  $\sigma'_0 = 180$  MPa. 10

(c) (i) What instructions are necessary in typical part programming for NC or CNC machine tool?

(ii) Differentiate between G, M and T functions.

(iii) With an example, explain the difference between word address format and fixed sequential format of instructions. 10

7. (a) A manufacturer of plastic parts uses two machines *M-1* and *M-2* such that each part is processed first on machine *M-1* and then on *M-2*. The manufacturer has currently 6 orders / jobs on hand. The estimated processing times and due dates for these jobs are as given in the table below :

Job	Processing time (in days)		Due date from now
	M-1	M-2	
A	5	9	37
B	4	6	41
C	7	10	38
D	8	8	47
E	12	9	52
F	9	6	39

- (i) Determine the optimum sequence in which jobs can be processed to minimize make span.
- (ii) What is the value of make span time?
- (iii) What is the average job tardiness resulting from optimum sequence obtained earlier?
- (iv) Explain the methodology/algorithm used to get optimum sequence in (i). 10

(b) Majestik Furnitures produces a type of desk that has bill of materials as given in the table below. The desk is made by assembling two drawers, two handles (one for each drawer), one drawer frame, and two legs into a drawer module. Then two drawer modules, a desk-back and a desk-top are assembled into the final product (desk) :

Level	Item description	Quantity required	Make/Buy	Lead time (in weeks)
00	Desk		Make	1
01	Desk-top	1	Buy	2
01	Desk-back	1	Buy	1
01	Leg/drawer module	2	Make	1
02	Drawer frame	1	Buy	1
02	Desk-legs	2	Buy	1
02	Drawers	2	Buy	2
02	Handles	2	Buy	2



- (i) Construct the product structure tree for the product (desk).
- (ii) Construct a production time chart.
- (iii) For the following desk requirements, construct the material requirements plan for the desk and each of its components using lot-for-lot procurement assuming no initial inventories :

<i>Week</i>	1	2	3	4	5	6	7	8	9	10
<i>Requirement</i>	—	—	—	—	20	0	50	0	0	30

20

- (c) What is the difference between an  $\bar{X}$ -chart and an  $R$ -chart? Why are they used together? 5
  - (d) Briefly explain the following assumptions of linear programming models : 5
    - (i) Proportionality
    - (ii) Certainty
    - (iii) Additivity
    - (iv) Divisibility
- 8. (a)** Write a C program to get required inputs from an organization to help them in—
- (i) obtaining the break-even quantity for their product(s);

(ii) obtaining profit in rupees from the sale of a specified quantity of product(s), there could also be a loss;

(iii) obtaining total revenue figures at different quantities of sale of their product(s).

State the inputs that you would require. Draw a flow chart for the above program. Statements should accompany in your program to explain what is being done.

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(b) What is the standard of linear measurement? Differentiate between measurement and gauging with reference to the application and method of use.

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(c) Tourist vehicles arrive at the security check post at the entry of a wildlife park according to Poisson distribution with an average of 10 minutes between two successive vehicles. For security reasons, the time taken to complete the vehicle checking and issuing of vehicle pass is assumed to be exponentially distributed with mean of 9 vehicles per hour.

Determine—

(i) the average number of vehicles waiting for the security pass;

(ii) the average time spent by a vehicle in waiting before getting the entry pass;

(iii) the probability that a vehicle arriving at the security check post will have to wait.

State the assumptions made in solving the above problem.

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