Question Paper Specific Instructions

Please read each of the following instructions carefully before attempting questions:

There are EIGHT questions divided in TWO SECTIONS and printed both in HINDI and in ENGLISH.

Candidate has to attempt FIVE questions in all.

Questions no. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each section.

The number of marks carried by a question / part is indicated against it.

Answers must be written in the medium authorized in the Admission Certificate which must be stated clearly on the cover of this Question-cum-Answer (QCA) Booklet in the space provided. No marks will be given for answers written in a medium other than the authorized one.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Diagrams/Figures, wherever required, shall be drawn in the space provided for answering the question itself.

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

Attempts of questions shall be counted in sequential 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.
Q1. (a) A car starts from rest with an acceleration of 6 m/s² which decreases linearly with time to zero in 10 seconds after which the car continues at a constant speed. Determine the time required for the car to travel 400 m from start.

(b) A tower stands on a ball. If the ball is 80 m high and the tower is 40 m wide and 30 m long, find the forces acting on the ball.
A tower guy wire is anchored by means of a bolt at A. If the magnitude of the tension in the wire is 2500 N, determine the components of the force acting on the bolt in the x, y and z directions.

A five-bar chain is shown in the figure. Prove that it is an unconstrained chain.
(ii) चित्र में दर्शाई गई शृंखला, शुद्धतिक शृंखला नहीं है, सिद्ध कीजिए।

Show that the chain shown in the figure is not a kinematic chain.

(d) कठोरीयता पद को परिभाषित कीजिए। कौन-से कारक कठोरीयता को प्रभावित करते हैं?
Define the term hardenability. Which factors affect hardenability?

(e) एक शाफ्ट की क्रांतिक पृष्ठी चाल निर्धारित कीजिए जिसका व्यास 25 mm एवं लम्बाई 0.8 m है, और जो मध्य विस्तृति पर 1 kg त्रिकोण के साथ सिरों पर शुद्धाल्पमि है। शाफ्ट पदार्थ का घनत्व 50 g/cm$^3$ तथा यूंग्स मार्क्स 2 x $10^6$ bar है।

Determine the whirling speed of a shaft 25 mm diameter and 0.8 m long with a mass of 1 kg placed at mid span, simply supported at ends. The density of the shaft material is 50 g/cm$^3$ and Young's modulus is $2 \times 10^6$ bar.
At a certain point in a piece of elastic material, there are normal tensile stresses of magnitude 120 MN/m$^2$, 60 MN/m$^2$ acting orthogonally to each other. In addition, there is a shearing stress of 80 MN/m$^2$ acting normal to the normal stresses.

Determine:

(i) the magnitude and direction of the principal stresses
(ii) the magnitude and direction of the maximum shearing stress
(iii) the normal and shearing stress on a plane inclined at 30° to the direction of 120 MN/m$^2$ stress
(b) (i) Pinion के दौरान की संख्या एवं चाल निर्धारित कीजिए जहाँ 10 mm प्रमाणक के 60 दौरान बाल्क चालित गियर पद्धता 300 rpm पर घूमता है। दो स्पर्ग गियरों का वेगानुपात $\frac{1}{4}$ है। अन्तराल रेखीय वेग की भी गणना कीजिए।

Determine the number of teeth and the speed of the pinion where the driven gear wheel has 60 teeth of 10 mm module and rotates at 300 rpm. The two spur gears have a velocity ratio of $\frac{1}{4}$. Also compute the pitch line velocity.

(ii) लगभग 600 mm दूरी पर स्थित दो पृथक समान्तर शाफ्टों को स्पर्ग गियरों द्वारा संबंधित किया जाना है। एक शाफ्ट को 360 rpm एवं दूसरे को 120 rpm पर घूमता है। गियरों की अभिकल्पना कीजिए यदि वृताच्य अन्तराल 25 mm है।

Two parallel shafts, about 600 mm apart, are to be connected by spur gears. One shaft is to run at 360 rpm and the other at 120 rpm. Design the gears, if the circular pitch is to be 25 mm.

(c) x-अक्ष के सापेक्ष स्थापित क्षेत्र के जड़त्व आधूर्ण का निर्धारण कीजिए।

Determine the moment of inertia of the shaded area with respect to the x-axis.
3. (a) The bar is supported at both ends and externally and internally. Hence, both the ends and the middle of the bar are considered to be fixed. Determine the maximum values of shear force and bending moment along with their respective locations.

(b) The arm of a Porter governor is 300 mm long. The upper arms are pivoted on the axis of rotation. The lower arms are attached to a sleeve at a distance of 40 mm from the axis of rotation. The mass of the load on the sleeve is 70 kg and the mass of each ball is 10 kg. Determine the equilibrium speed when the radius of rotation of the balls is 200 mm. If the friction is equivalent to a load of 20 N at the sleeve, what will be the range of speed for this position?
Q4. (a) A 90 cm long, 20 cm internal diameter having thickness of metal as 8 mm is filled with fluid at atmospheric pressure. If an additional 20 cm$^3$ of fluid is pumped into the cylinder, find

(i) the pressure exerted by the fluid on the cylinder.

(ii) the hoop stress induced.

Given:

Young’s modulus = $2 \times 10^5$ N/mm$^2$

Poisson’s ratio = 0.3

A cylindrical shell 90 cm long, 20 cm internal diameter having thickness of metal as 8 mm is filled with fluid at atmospheric pressure. If an additional 20 cm$^3$ of fluid is pumped into the cylinder, find

(i) the pressure exerted by the fluid on the cylinder.

(ii) the hoop stress induced.

Given:

Young’s modulus = $2 \times 10^5$ N/mm$^2$

Poisson’s ratio = 0.3
A rotor is completely balanced when masses of 2 kg and 1.2 kg are added temporarily in planes A and D each at 200 mm radius as shown in the figure. The balanced mass in the plane A is along the x-axis whereas in the plane D, it is at 120 mm radius. Determine the magnitudes and the directions of the masses B and C.
(c) नैनो परिसर (नैनो रेंज) में बिमाओं की संख्या के आधार पर नैनो-पदार्थों का वर्गीकरण कीजिए। नैनो-संरचना वाले पदार्थों के प्रक्रमण के दो मुलभूत उपाय क्या हैं?

Classify the nano-materials depending on the number of dimensions in the nano range. What are the two basic approaches for processing of nano-structural materials?
Q5. (a) What do you understand by the term ‘flash’ in a forging? Explain with the help of a sketch.

(b) A hole and shaft have a basic size of 25 mm and are to have a clearance fit with maximum clearance of 0.02 mm and a minimum clearance of 0.01 mm. The hole tolerance is to be 1.5 times the shaft tolerance. Determine limits for both hole and shaft
(i) using a hole basis system.
(ii) using a shaft basis system.

(c) The life of a plain milling cutter of diameter 75 mm was found to decrease from 50 minutes to 30 minutes due to increase in speed of the cutter from 200 to 260 rpm while milling a cast iron plate at given feed and depth of cut. How much would be the life of that cutter if the speed is 120 rpm keeping other parameters unchanged?

(d) Enlist various types of plant layouts. Compare product layout and process layout.
(e) एक कंपनी किसी वस्तु को स्थानीय बाजार में बेचने की योजना बनाती है। ये वस्तुएं ₹5 पर इस शर्त पर खरीदी गई हैं कि सभी बिना बिकी वाली वस्तुएं वापस होंगी। जगह का किराया ₹2,000 है। वस्तुएं ₹9 की दर पर बेची जाएँगी।

आवश्यक रूप से बेची जाने वाली वस्तुओं की संख्या ज्ञात कीजिए यदि

(i) चाढ़ा पूरा करना हो।
(ii) ₹400 लाभ लेना हो।
(iii) यदि कंपनी 750 वस्तुओं को बेचती है, तो सुरक्षा छाता एवं लाभ की गणना कीजिए।

A company plans to sell an article at a local market. The articles are purchased at ₹5 on the condition that all unsold articles shall be returned. The rent of the space is ₹2,000. The articles will be sold at ₹9.

Determine the number of articles which must be sold

(i) To break-even.
(ii) To earn ₹400 as profit.
(iii) If the company sells 750 articles, calculate margin of safety and profit.

Q6. (a) निम्नलिखित ज्यामिति के औजार द्वारा एक धातु की छड़ का शुद्ध लाभमिक खराबत (टर्निंग) के दौरान पाया गया कि स्पर्श-रेखीय घटक एवं कर्ण बल के अंतर्गत घटक के परिमाण क्रमशः 600 N तथा 200 N हैं।

आन्तर कोण = 0°
लाभमिक नति = 0°
मुख्य कर्ण धार कोण (ऐज ऐंगिल) = 90°
छीतल लघुक्षण (रिडक्शन) गुणांक = 1.732

उपयुक्त स्थिति के लिए मॅर्चेट के वृत्त आरेख का उपयोग करते हुए, अपरापर बल तथा घर्षण बल के परिमाण की गणना कीजिए।

During pure orthogonal turning of a metal rod by a tool of the following geometry it was noted that the magnitudes of the tangential component and the axial component of the cutting force are 600 N and 200 N respectively.

Inclination angle = 0°
Orthogonal rake = 0°
Principal cutting edge angle = 90°
Chip reduction coefficient = 1.732

Using Merchant’s circle diagram, determine the magnitudes of the shear force and the frictional force for the above condition.
(b) A test centre provided a test centre to conduct a test which took 120 minutes. The test was conducted in two batches.

<table>
<thead>
<tr>
<th>Description</th>
<th>Centre Lathe</th>
<th>Turret Lathe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>30 minutes</td>
<td>120 minutes</td>
</tr>
<tr>
<td><strong>Total Time</strong></td>
<td>10 minutes</td>
<td>5 minutes</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>₹200</td>
<td>₹500</td>
</tr>
<tr>
<td><strong>Labour Cost</strong></td>
<td>₹2</td>
<td>₹2</td>
</tr>
<tr>
<td><strong>Depreciation</strong></td>
<td>₹10</td>
<td>₹20</td>
</tr>
</tbody>
</table>

Assessment of the test costs is shown in the table above. The cost of assessment is calculated based on the time taken and the labour cost.

(i) What is the break-even point (BEP) for this test?

(ii) Which machine is better suited for this test?

(iii) If the quantity required is 800 nos/year, which of the machines do you propose?

A component can be manufactured either on a centre lathe or on a turret lathe. The cost and time information to process a component is given below:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Centre Lathe</th>
<th>Turret Lathe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Set-up time</strong></td>
<td>30 minutes</td>
<td>120 minutes</td>
</tr>
<tr>
<td><strong>Processing time</strong></td>
<td>10 minutes</td>
<td>5 minutes</td>
</tr>
<tr>
<td><strong>Tooling-up cost</strong></td>
<td>₹200</td>
<td>₹500</td>
</tr>
<tr>
<td><strong>Labour cost/hr</strong></td>
<td>₹2</td>
<td>₹2</td>
</tr>
<tr>
<td><strong>Depreciation and other costs per hour</strong></td>
<td>₹10</td>
<td>₹20</td>
</tr>
</tbody>
</table>

The tooling-up cost is to be recovered within a year and there are no repeat orders. The requirements are to be met in two lots.

(i) Calculate the quantity at which both alternatives result in equal cost. (BEP)

(ii) Give the decision rule regarding the choice of lathes.

(iii) If the quantity required is 800 nos/year, which of the machines do you propose?
(c) Explain the process of metal transfer in gas metal arc welding process with neat sketches.

Q7. (a) The sales for a critical component manufactured by a company are given below. Forecast the demand for the components for the next three years using regression method:

<table>
<thead>
<tr>
<th>Year (in thousands)</th>
<th>Sales ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>30</td>
</tr>
<tr>
<td>1987</td>
<td>33</td>
</tr>
<tr>
<td>1988</td>
<td>37</td>
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<tr>
<td>1989</td>
<td>39</td>
</tr>
<tr>
<td>1990</td>
<td>42</td>
</tr>
<tr>
<td>1991</td>
<td>46</td>
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<tr>
<td>1992</td>
<td>48</td>
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<tr>
<td>1993</td>
<td>50</td>
</tr>
<tr>
<td>1994</td>
<td>55</td>
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<tr>
<td>1995</td>
<td>58</td>
</tr>
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<table>
<thead>
<tr>
<th>Years</th>
<th>Sales ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986</td>
<td>30</td>
</tr>
<tr>
<td>1987</td>
<td>33</td>
</tr>
<tr>
<td>1988</td>
<td>37</td>
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<td>1989</td>
<td>39</td>
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<td>1990</td>
<td>42</td>
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<tr>
<td>1991</td>
<td>46</td>
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<tr>
<td>1992</td>
<td>48</td>
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<td>50</td>
</tr>
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<td>1994</td>
<td>55</td>
</tr>
<tr>
<td>1995</td>
<td>58</td>
</tr>
</tbody>
</table>
A steel wire is drawn from an initial diameter of 12.7 mm to a final diameter of 10.2 mm at a speed of 90 m/min. The half-cone angle of the die is 6° and the coefficient of friction at the job-die interface is 0.1. A tensile test on the original steel specimen gives a tensile yield stress of 207 N/mm². A similar specimen shows a tensile yield stress of 414 N/mm² at a strain of 0.5. Assuming a linear stress-strain relationship for the material, determine the drawing power and the maximum possible reduction with the same die. No back tension is applied.

Enlist the basic elements of JIT and explain Kanban card in brief.

The annual demand for a component is 2500 boxes. The company procures the item from a supplier at the rate of ₹ 750 per box. The company estimates the cost of carrying inventory to be 18% per unit per annum and the cost of ordering as ₹ 1,080 per order. The company works for 250 days in a year. How should the company design an inventory control system for this component? What will be the overall cost of the plan?
(b) WC plates' contribution in the machinery process in the machine with a change in material. If the material is changed from copper to stainless steel, determine the percentage change in the machining time for a USM (Ultrasonic Machining) operation cutting WC plates when the tool material is changed from copper to stainless steel.

(c) अल्पसंचालन निर्माण (लीन मेन्यूफैक्चरिंग) के लाभ एवं परिसीमाएँ क्या हैं? अल्पसंचालन निर्माण तकनीक को अपनाने में आने वाली कठिनाइयों की चर्चा कीजिए।

What are the advantages and limitations of lean manufacturing? Discuss the difficulties in adopting lean technique.