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.

Question Nos. 1 and 5 are compulsory and out of the remaining, THREE questions 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 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.
Q. 1(a) A rod AB 6 m long is held against sliding by a string AD. The rod weighs 10 kN. Determine the tension in the string AD assuming that all surfaces are smooth.

![Diagram of rod AB held by string AD](image)

Q. 1(b) The global stiffness matrix of a structure contains rigid body displacements. Describe how to modify it to account for nodes having zero displacements. Give two approaches.

Q. 1(c) 

![Diagram of beam with supports](image)

El = Constant

\[ I = 200 \times 10^{-6} \text{ m}^4 \]

E = 200 GPa

Q. 1(d) A steel plate of thickness 3 mm is subjected to an initial uniform temperature distribution of 30°C. The plate is then heated uniformly to 50°C. Determine the thermal strain in the plate.

![Diagram of plate with thermal strain](image)
The ground water movement at a site takes place through a soil zone comprised of 3 m thick sand with coefficient of permeability 0.01 cm/s (in both directions) overlain by 1 m thick fine gravel with coefficient of permeability 0.1 cm/s (in both directions). Determine the coefficient of permeabilities applicable for horizontal and vertical ground water movements through the layer.

Q. 1(e) प्रवाण अवरथन के प्रवेश पर, वेग $v$, प्रवेश से चूर्णण ाइप तक त्रिभुजीय दूरी $r$ के वर्ग के प्रतीतित विचारित होता है। $1.5$ m की त्रिभुजीय दूरी पर वेग $0.8$ ms$^{-1}$ पाया जाता है। धारा-रेखाओं को त्रिभुजीय मान कर, प्रवेश से $0.5$ m और $1.25$ m की दूरियों पर प्रवाह के त्वरण का परिकलन कीजिए।

At the entry of the pump intake the velocity $v$ varies inversely as the square of the radial distance $r$ from inlet to suction pipe. The velocity is found to be $0.8$ ms$^{-1}$ at a radial distance of $1.5$ m. Compute the acceleration of flow at radial distances of $0.5$ m and at $1.25$ m, from the inlet assuming the stream-lines to be radial.

Q. 2(a) तीन भिन्न बारो पिट्स/साइट्स (Borrow pits/sites) से अर्थात्क फिल के लिये मिट्टी उपलब्ध थी। कम्पैक्टेड धीरति में अर्थात्क $1.0 \times 10^5$ m$^3$ था और उसका वायुवत रेखियों $0.75$ था। इन-सिट्स (In-situ) वायुवत रेखियों व मूलय (सामान्य व परिवहन लागत) तीनों साइट्स के लिये नीचे दिया गया है।

<table>
<thead>
<tr>
<th>Borrow site</th>
<th>Void ratio</th>
<th>Total cost per cubic meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>Rs. 200</td>
</tr>
<tr>
<td>2</td>
<td>1.15</td>
<td>Rs. 180</td>
</tr>
<tr>
<td>3</td>
<td>1.25</td>
<td>Rs. 175</td>
</tr>
</tbody>
</table>

उपरोक्त अर्थात्क कार्य के लिये सबसे ज्यादा किफायती साइट ज्ञात करें।

Material for an earthfill was available from three different borrow pits/sites. In the compacted state the fill measured $1.0 \times 10^5$ m$^3$ at a void ratio of $0.75$. The corresponding in-situ void ratio and cost (cost of material and transportation) of the material for three sites are as follows:

<table>
<thead>
<tr>
<th>Borrow site</th>
<th>Void ratio</th>
<th>Total cost per cubic meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>Rs. 200</td>
</tr>
<tr>
<td>2</td>
<td>1.15</td>
<td>Rs. 180</td>
</tr>
<tr>
<td>3</td>
<td>1.25</td>
<td>Rs. 175</td>
</tr>
</tbody>
</table>

Determine the most economical site for the above earthfill work.
Q. 2(b) Two wheels, placed at a distance of 2.5 m apart, with a load of 200 kN on each of them, are moving on a simply supported girder (I-section) of span 6.0 m. The top and bottom flanges of the I-section are of 200 x 200 mm and the size of web plate is 800 x 6 mm.

If the allowable bending compressive, bending tensile and average shear stresses are 110 MPa, 165 MPa and 100 MPa respectively, check the adequacy of the section against bending and shear stresses, self weight of the girder may be neglected.

Q. 2(c) In order to predict lift and drag forces on a scale model of an aircraft during a section of operational envelope, involves sea level flight at 100 ms\(^{-1}\), where the speed of sound may be taken as 340 ms\(^{-1}\).

It is proposed to utilise cryogenic wind tunnel with Nitrogen at 5 atmosphere of pressure and a temperature of -90°C (\(\rho = 7.7 \text{ kg m}^{-3}\), \(\nu = 1.2 \times 10^{-5} \text{ Ns}\)) for nitrogen). The speed of sound in nitrogen at this temperature is 295 ms\(^{-1}\). Determine the wind tunnel flow velocity, the scale of model to ensure full dynamic similarity and, the ratio of forces acting on the model and prototype.
Q. 3(a)

Determine the slope at A, vertical deflections at B and mid span using the moment-area theorem. Take $EI = \text{Const.}$.

Q. 3(b)

Design a section of wall of a water tank on uncracked basis to resist a pull of 60 kN and a bending moment of 7.5 kNm/m width producing tension on the water face. Use M 30 concrete and Fe 415 grade steel.

Effective cover = 30 mm
Permissible stress in direct tension in concrete = 1.5 MPa
Permissible stress in bending tension in concrete = 2 MPa
Modular ratio = 9

Q. 3(c)

The pipes in the diagram are given as follows. The pipes are characteristics of:

<table>
<thead>
<tr>
<th>Pipe</th>
<th>D (mm)</th>
<th>L (m)</th>
<th>$f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>150</td>
<td>600</td>
<td>0.020</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>480</td>
<td>0.032</td>
</tr>
<tr>
<td>C</td>
<td>200</td>
<td>1200</td>
<td>0.024</td>
</tr>
</tbody>
</table>

The first pipes are for inelastic force. The analysis of the pipes is done as follows.
Three pipes are connected as shown in figure. The characteristics of pipe are as follows:

<table>
<thead>
<tr>
<th>Pipe</th>
<th>D (mm)</th>
<th>L (m)</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>150</td>
<td>600</td>
<td>0.020</td>
</tr>
<tr>
<td>B</td>
<td>100</td>
<td>480</td>
<td>0.032</td>
</tr>
<tr>
<td>C</td>
<td>200</td>
<td>1200</td>
<td>0.024</td>
</tr>
</tbody>
</table>

Determine the flow rate in each pipe. Minor losses may be neglected.

Q. 4(a) 压力降率变化（压力降率变化）是？压力降率变化的步骤是怎样的？

What is the preconsolidation pressure? Describe a method to determine the preconsolidation pressure.

Q. 4(b) 软粘土地层中，抽样时进行静摩擦试验。剪切面为155 N·m。直径100 mm，长度150 mm。软粘土的抗剪强度（Cu）是多少？剪切过程中，直径100 mm，长度150 mm的剪切面与软粘土的摩擦是如何的？

An in-situ vane shear test was conducted at the bottom of a borehole in a soft clayey soil. A torque of 155 N·m was required to shear the soil. The vane was 100 mm diameter and 150 mm long. What was the undrained shear strength, Cu of the soil? Derive the relevant expression relating to torque vane dimension, and undrained shear strength of the soil.

Q. 4(c) 一个卡穆特罗斯特拉普试验装置在飞机上，飞行高度达到19 kN/m²，试验角度为30°，飞行高度为30°。如何使用该卡穆特罗斯特拉普进行试验？飞行高度达到19 kN/m²，试验角度为30°，飞行高度为30°。M 30螺栓的卡紧力为Fe 500螺纹的试验使用情况是怎样的？

Q. 4(c) 一个卡穆特罗斯特拉普试验装置在飞机上，飞行高度达到19 kN/m²，试验角度为30°，飞行高度为30°。如何使用该卡穆特罗斯特拉普进行试验？飞行高度达到19 kN/m²，试验角度为30°，飞行高度为30°。M 30螺栓的卡紧力为Fe 500螺纹的试验使用情况是怎样的？
A counterfort retaining wall is shown in figure in plan and sectional elevation. It retains dry earth having a density of 19 kN/m³ and angle of repose of 30°. Design a counterfort in flexure only using the limit state design. Take M 30 grade of concrete and Fe 500 grade steel.

**SECTION—B**

Determine the diameter of the vertical pipe needed for a flow of a liquid of kinematic viscosity $1.95 \times 10^{-3} \text{ m}^2\text{s}^{-1}$ at a Reynolds number of 1500. The constant pressure is maintained throughout its length.
Q. 5(a) (ii) ज्वारीय बैंसल के लिये प्रोटोटाइप उपयोग किया जाता है:
चैनल की लम्बाई = 18 km, निर्माण = 250 m³s⁻¹
गहराई = 2.5 m, बैंसल की चौड़ाई = 50 m
चैनल का माइल उच्चांक क्रेट 1 : 50 व क्षेत्रीय क्रेट 1 : 500 पर बनाया गया है।
ज्वारीय अवधि 12 घंटे है।
चैनल माइल में औसत वेग (m/sec) और ज्वारीय अवधि सात करें।

Prototype data of Tidal Channel are as follows:
Length of channel = 18 km, Discharge = 250 m³s⁻¹
Depth = 2.5 m, Width of the channel = 50 m
Model is built with a vertical scale of 1 : 50 and a horizontal scale of 1 : 500
Tidal period is 12 hours

Compute the average velocity in ms⁻¹ and tidal period in the model.

Q. 5(b)
एक कण वर्टिकल लाइन में एससोलेशन को त 3√v में चल रहा है। t = 2 sec पर, इसका डिस्टेंस में 8 m और वेग 6 m/sec है। समय t = 4 sec पर इसका विनियमन, वेग और त्वरण निकालें।
a = त्वरण तथा v = वेग।

A particle moves on a vertical line with an acceleration \( a = 3\sqrt{v} \). At \( t = 2 \) sec, its displacement is 8 m and velocity is 6 m/s. Determine its displacement, velocity and acceleration at time \( t = 4 \) sec. \( a = \) acceleration and \( v = \) velocity.

Q. 5(c)
एक क्षेत्रीय पैट्रोल जो 12 m लम्बा है, दोनों फिंगरों पर फिंगर में 50 kNm वक्कलवा व 75 kNm एंटीवक्कलवा 5 m व 9 m कभ्या।
वां लिए सिरे, से 'शीफ्ट' पर कार्य कर रहा है।

A horizontal shaft 12 m in length is fixed at its ends. When viewed from its left end, axial couples of 50 kNm clockwise and 75 kNm counterclockwise act at 5 m and 9 m from the left end respectively.

Determine the end fixing couples and the position where the shaft suffers no angular twist.

Q. 5(d)
एक अंतिम नैसर्गिक प्रवाहण (स्लोप) जिसकी प्रवाहण कोण 15° है (स्लोप क्रिच्छिक से नाम गया है) में सेंचुरेक्ट यूनिट भर 18 kN/m² व प्रभावी एंटीव इंटरनल क्रिच्छिक \( \phi = 35° \) है। बाट करें प्रवाहण की विलक्त को रोकने का फॅक्टर साफ 'शीफ्टी' जब -(i) प्रवाहण पूर्ण रूप से सीपेज रहित घुश्चिया या निम्नमात्र हो, (ii) जब स्लोप के सतह पर और इसके समांतर सीपेज हो रहा हो।
An infinite natural slope with angle of slope 15° (inclination measured from horizontal) has a saturated unit weight of 18 kN/m³ and an effective angle of internal friction, \( \phi = 35° \). Determine the factor of safety against failure of the slope (i) when the slope is completely dry or submerged but without seepage, (ii) when seepage occurs at and parallel to the surface of the slope.

5(e) Fe 410 ग्रेड स्टील की दो प्लेटें जिनकी साइज 300 × 10 mm और 280 × 10 mm है को वेल्डेड लैप ज्वाइंट से जोड़ा गया है जैसा चित्र में दिखाया गया है।

फील्ड वेल्ड इस्तेमाल करते हुये, वेल्डेड लैप ज्वाइंट की डिजाइन करें जिससे प्लेट की टेंसाइल स्ट्रेन्ज्ड सेफ हो।

इस्ट्रेन्ज्ड आफ मटरियल = 250 MPa

\( \gamma_{mo} = 1.1 \)

फील्ड वेल्ड की आधिक फ़ीन्टर आफ सेफटी = 1.5

Design a welded lap joint to join two plates of size 300 × 10 mm and 280 × 10 mm in Fe 410 grade steel to mobilise the tensile strength of the plates using field weld.

Yield strength of material = 250 MPa

\( \gamma_{mo} = 1.1 \)

Partial safety factor for field weld = 1.5
A beam has a cross-section shown in figure. It is subjected to a vertical shear force of 10 kN at a given section. Determine the shear stress distribution on the section.

Q. 6(b) (i)
A booster pump is installed in the pipeline between two reservoirs. If the energy added by the pump is 20 m, determine the flow rate in the pipeline in m$^3$s$^{-1}$.

Length of the pipeline = 1500 m
Coefficient of friction = 0.02
Diameter of the pipeline = 300 mm

WSEL of A = 200 m  WSEL of B = 185 m
Q. 6(b) (ii) Compute the shear stress acting on the river bed for the data given:

Discharge = 5000 m$^3$/s$^{-1}$, River bed slope = 1 : 2500

Depth of flow = 4.50 m

Assume the river to be wide.

Q. 6(b) (iii) A hydraulic jump has an energy loss of 9.0 m and the downstream Froude number is 0.12.

Determine the initial depth and the discharge intensity.

Q. 6(c) (i) State the Abram's law on water-cement ratio.

(ii) Name the various grades of ordinary Portland cement.

(iii) Define characteristic strength of reinforcing steel.

(iv) State any five applications of prestressed concrete.

Q. 7(a) (i) For the sluice gate shown in Figure, if $C_v = 0.98$ and $C_c = 0.62$, what is the height of the opening? Given $V_1 = 2.006$ m$^3$/s, $g = 9.81$ ms$^{-2}$. Also determine the flow per unit width.

![Diagram of sluice gate](image-url)
Q. 7(a) (ii) एक समतली वाहिका (ट्रेंच्वाल्ड चैनल) जिसकी तली की चौड़ाई 20 m व साइड स्लोप 1(V) : 2(H) है, में कूचनक सफ़ेद की गहराई 1.5 m है। तली का स्लोप 1 × 10⁻⁴ है।

मैनिंग कुश्ता (राकेतेस) कोण्डिटियन = 0.2 है। अनुव्रत्त में (डाउनस्ट्रोम) केंद्रोल पानी की सतह की 3 m ऊँचा कर रहा है। प्रोफाइल का वर्गीकरण करें।

The uniform flow depth is 1.5 m in a trapezoidal channel of bottom width of 20 m with a side slope of 1(V) : 2(H). The bed slope is 1 × 10⁻⁴. Manning roughness coefficient is 0.2. The downstream control raises the water surface by 3 m. Classify the profile.

Q. 7(a) (iii) एक आयताकार चैनल के लिए निम्नलिखित डाटा दिया गया है:

- चौड़ाई = 9 m, n = 0.017, S₀ = 1 : 4000
- D/S गहराई = 6.80 m, U/S गहराई = 3.6865 m, दिल्लाइ = 48.748 m³s⁻¹
- सिग्ल स्टेप विधि का प्रयोग करते हुए, प्रोफाइल की लम्बाई निकालिये।

Following data are given for a rectangular channel:

- Width = 9 m, n = 0.017, S₀ = 1 : 4000
- D/S depth is 6.80 m, U/S depth is 3.6865 m
- Discharge 48.748 m³s⁻¹.

Using single step method compute the length of profile.

Q. 7(b) 9 घरण पाइल्स के पूप को एक कल मृदा में गहरी तेवर में प्रवेशित किया गया है। प्रत्येक पाइल्स का व्यास 0.4 m है। इब्नेडेड लम्बाई (गहराई) 12 m है व पाइल्स के बीच सेंटर टू सेंटर दूरी 1.2 m है। मृदा का संस्थान (कोडिशन) c = 50 kN/m², इकाई भार γ = 18 kN/m³. जात कीजिये कि (i) नुक्सा गुणक = 3.0 का इस्तेमाल करते हुए ब्लाक केमिस्ट्री (पाइल्स का) (ii) पूप केमिस्ट्री पाइल्स की अलग-अलग विफलता पर आधारित, (iii) पाइल्स के पूप के डिजाइन केमिस्ट्री (मानिए संस्थान गुणक अध्ययन फैक्टर α = 0.8)

A pile group consists of nine friction piles driven into a deep layer of clay soil. The diameter of each pile is 0.4 m, the embedded length is 12 m and center to center spacing of the piles is 1.2 m. The soil has cohesion, c = 50 kN/m², unit weight, γ = 18 kN/m³. Determine (i) the block capacity of the pile group using a factor of safety = 3.0, (ii) group capacity based on individual pile failure criterion and (iii) design capacity of the pile group. (Assume adhesion factor α = 0.8)
Q. 7(c) A radial flow turbine has the following dimensions:

Outer periphery radius \( r_1 = 0.5 \) m

Inner periphery radius \( r_2 = 0.3 \) m

The angle made by the relative velocity at the inlet is \( (\beta_1) = 80^\circ \).

The width of the flow passage between the two sides of the turbine is 0.25 m.

The flow of 4 m\(^3\)s\(^{-1}\) goes through the turbine when the speed is 300 rpm.

Find the blade angle \( \beta_2 \) such that water exit radially.

Find the torque exerted by the water in the turbine and the power thus developed.

Find the head utilised by the runner and the power resulting therefrom.

Assume no shock at the entrance and blades are of negligible thickness.

Q. 8(a) In the process of energy conversion, a turbine is designed to operate between two states.

Given: \( H = 5 \) m, \( \phi = 30^\circ \), \( C = 0 \), \( \beta = 90^\circ \), \( h_w = 2.0 \) m, \( \gamma_{sat} = 18 \) kN/m\(^3\), \( \gamma_{bulk} = 17 \) kN/m\(^3\) (above water table), \( q = 250 \) kN/m\(^2\).
For the earth retaining structure shown in the figure, determine the total active thrust on the wall, and the point of application of the thrust above the base of the wall. Given $H = 5 \text{ m}$, $\phi = 30^\circ$, $C = 0$, $\beta = 90^\circ$, $h_w = 2.0 \text{ m}$, $\gamma_{\text{sat}} = 18 \text{ kN/m}^3$, $\gamma_{\text{bulk}} = 17 \text{ kN/m}^3$ (above water table), $q = 250 \text{ kN/m}^2$.

For the truss shown in fig. draw the influence lines for force in members $U_3L_3$, $U_3L_2$ and $L_2L_3$. The load moves on the bottom chord.
A bracket connection shown in figure, consists of a joist cutting welded to the flange of a column by shop fillet welds 8 mm on flanges and 6 mm on the web. Determine the safe service load ‘W’, the bracket can support at a distance of 200 mm from the face of the column if the steel grade is Fe 410.

Partial factor of safety on shop weld = 1.25

Yield strength of steel = 250 MPa