UPSC CIVIL SERVICES
CONVENTIONAL EXAMINATION
SUBJECT-WISE PREVIOUS YEARS SOLVED PAPER-I
(2003-2018)

- Complete Solutions with Explanation
- Also ideal for UPSC ESE Conventional and State Engineering Services exams

16 YEARS SOLUTION
CIVIL ENGINEERING
SUBJECTWISE PREVIOUS YEARS
SOLVED PAPER-I
2003-2018
Civil Services Examination (CSE) and Engineering Services Examination (ESE) are two of the most sought after exams in India. The entrance exams for these highly esteemed services are conducted by the Union Public Services Commission (UPSC) every year.

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This book captures and decodes technical questions of CSE from 2003 to 2018. It is this depth in time that gives students the ability to gauze the direction, and the construct of an engineer required to be a top bureaucrat.

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Q.1: Three 5 kg masses attached to a light rod ABCD are spun on a frictionless horizontal plane at 600 rpm (10 Hz) about a pinion. What is the maximum force induced in the rod due to spinning?

Sol: Given a light Rod ABCD

Span on the horizontal plane
\[ \omega = 600 \text{ rpm} = \frac{2\pi \times 600}{60} = 20\pi \text{ rad/s} \]

Force acting on the rod (F) = centrifugal force due to \( m_A, m_B, m_C \)

\[ F_A = m_A \omega^2 R = 5 \times [20\pi]^2 \times 1.5 \]

\[ F = m_A \times 1.5 \times \omega^2 + m_B \times 1.0 \times \omega^2 + m_C \times 0.5 \times \omega^2 \]

\[ F = 5 \times (20\pi)^2 \times [1.5 + 1 + 0.5] \]

\[ F = 59217.63 \text{ N} = 59.22 \text{ kN} \]

**Q.2:** A component of a machine is subjected to a system of coplanar forces shown in the figure. Neglecting friction, determine the magnitude of force \( P \) to keep the component in equilibrium. Also determine the magnitude and direction of the reaction at the hinge at B.

\[ \begin{align*}
AB &= 120 \text{ mm} \\
BC &= 100 \text{ mm}
\end{align*} \]

**Sol:**

For equilibrium

\[ \Sigma F_x = 0 \]

\[ -150 - P\cos20^\circ + R_x = 0 \]

\[ AB = 120 \text{ cm} \]

\[ \Sigma F_y = 0 \]

\[ +100 + R_y - P\sin20^\circ = 0 \]

\[ \Sigma M_B = 0 \]

\[ -100 \times [AB\cos30^\circ] - 150 \times [AB\sin30^\circ] + P\cos20^\circ [BC\sin40^\circ] + P\sin20^\circ [BC\cos40^\circ] = 0 \]

Put \( AB = 120 \text{ mm} \)
BC = 100 mm
⇒ we got
P = + 223.92 kN

From eqn (i) and (ii), we got,

\[ R_x = 360.41 \text{ kN} \quad R_y = -23.41 \text{ kN} \]

\[ \tan \theta = \frac{R_y}{R_x} = \frac{23.41}{360.41} \Rightarrow \theta = 3°43' \text{ clockwise from x axis} \]

Q.3: **Determine product of inertia of right-angled triangle with respect to x- and y-axes.**

[20 Marks CSE–2005]

Sol:

\[ I_{xy} = \int x y \, dA \]

\[ y = h \left( 1 - \frac{x}{b} \right) \]

Taking a strip element of dx thickness at distance

\[ I_{xy} = \int x y \, dA \]

\[ \bar{x}_{\text{strip}} = x \]

\[ \bar{y}_{\text{strip}} = \frac{y}{2} \]

\[ dA = y \, dx \]

\[ I_{xy} = \int x \left[ \frac{y}{2} \right] y \, dx = \int_0^b \frac{b x y^2}{2} \, dx = \frac{b}{2} \left[ \frac{1}{2} \left( \frac{b^2}{2} \right) \right] \left[ \frac{1}{4} - 2 \frac{3}{2} \right] = \frac{h^2 b^2}{24} \quad [\text{Ans.}] \]

Q.4: **State the D’Alembert’s principle. Use the principle to determine the natural frequency of a machine component shown in the figure.**

[12 Marks CSE–2005]

Sol: **D’Alembert’s principle:** The principle states that the sum of the differences between the forces acting on a system of mass particles and the time derivatives of the momentum of the system itself along any virtual displacement consistent with the constraints of system, is zero.

\[ \sum_i (F_i - m_i a_i) \cdot \delta x_i = 0 \]

where \( F_i = \) Total applied force (excluding constraint force) on \( i^{th} \) particle.
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