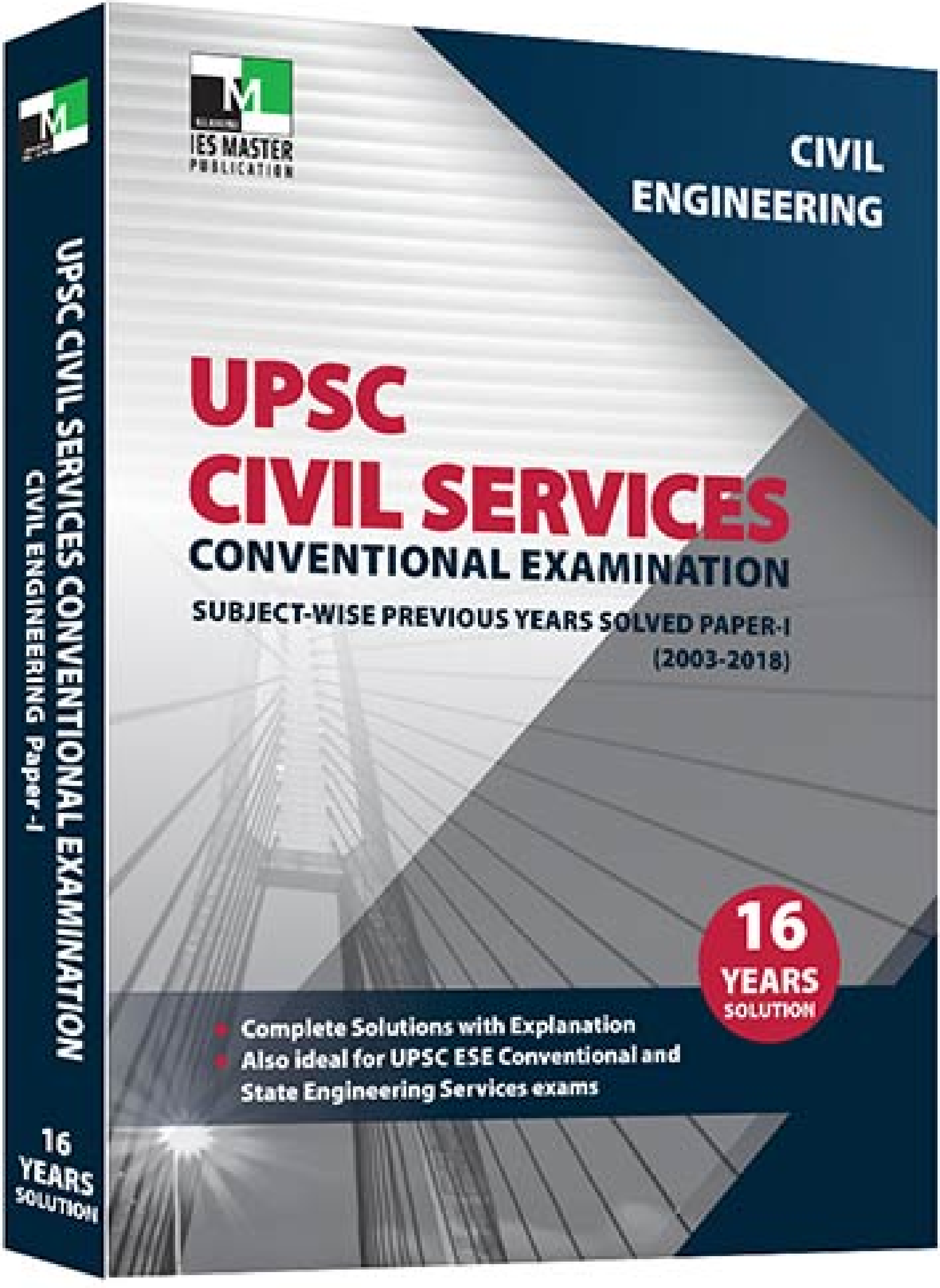
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# CIVIL SERVICES

CONVENTIONAL EXAMINATION

# CIVIL ENGINEERING

## SUBJECTWISE PREVIOUS YEARS SOLVED PAPER-I

2003–2018

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# PREFACE

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.

Civil Services Mains is a subjective exam, which demands good writing skill as well as core knowledge of the subject. Engineering students need to be familiar with the difficulty level as well as the demand of such an exam. A close and detailed scrutiny of the previous years' question papers of Civil Services Mains Examination by the Research & Development team at IES Master reveals the techniques that need to be deployed in handling the Mains exam of Civil Services.

Civil Engineering as an optional subject can do wonders in CSE. It is one stream that touches upon maximum knowledge area, given the vastness of the syllabus. It is this vastness and wilderness of applied knowledge that gives a decisive edge to the engineers in becoming top administrative officers.

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.

As you delve into the details of this branch, and confront individual subjects, numerous manifestations pile up block by block. With this final raft foundation, you can build upon absolute command over the required subjects. This book also allows you to practice freely on your own as the detailed solutions guide you step by step, whenever the need arises.

Backed by the trust inspired by the mark of 'IES Master', you can safely rely on this book.

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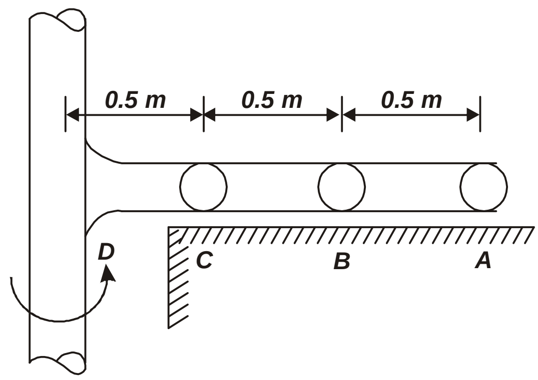
# CONTENT

# UNIT-1 ENGINEERING MECHANICS

## SYLLABUS

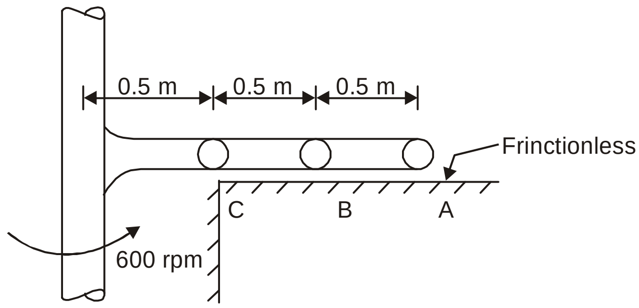
***Engineering mechanics:*** *Units and Dimensions, SI Units, Vectors, Concept of Force, Concept of particle and rigid body. Concurrent, Non- Concurrent and parallel forces in a plane, moment of force free body diagram, conditions of equilibrium, Principle of virtual work, equivalent force system. First and Second Moment of area, Mass moment of Inertia. Static Friction. Kinematics and Kinetics: Kinematics in cartesian Co-ordinates, motion under uniform and non-uniform acceleration, motion under gravity. Kinetics of particle : Momentum and Energy principles, collision of elastic bodies, rotation of rigid bodies.*

***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?***




***[12 Marks CSE–2004]***

**Sol:** Given a light Rod ABCD




Mass of A = Mass of B = Mass of C = 5 kg

Span on the horizontal plane

$$\omega = 600 \text{ rpm} = \frac{2\pi \times 600}{60} = 20\pi \text{ rad/s}$$

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

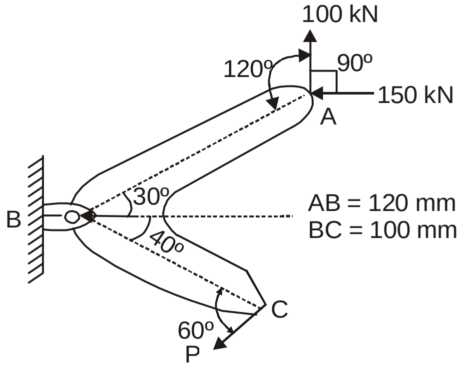
$$F_A = m_A \omega^2 R = 5 \times [20\pi]^2 \times 1.5$$

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

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

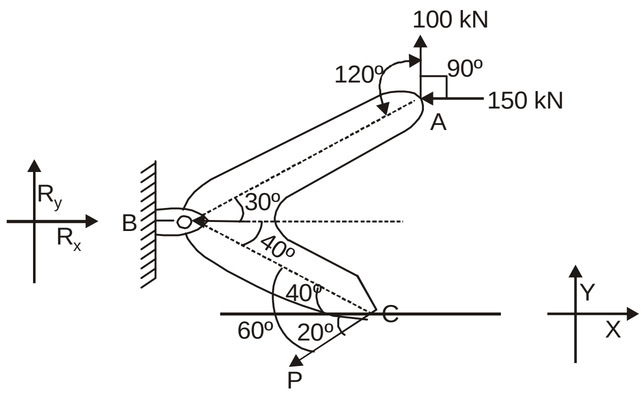
$$F = 59217.63 \text{ N} \simeq 59.22 \text{ kN}$$

***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.***




***[12 Marks CSE–2005]***

**Sol:**




For equillibrium

$$\Sigma F_x = 0$$

$$-150 - P\cos 20^\circ + R_x = 0 \qquad \text{...(i)}$$

$$AB = 120 \text{ cm}$$

$$BC = 100 \text{ cm}$$

$$\Sigma F_y = 0$$

$$+100 + R_Y - P\sin 20^\circ = 0 \qquad \text{...(ii)}$$

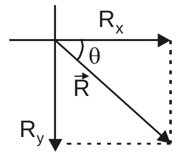
$$\Sigma M_B = 0$$

$\Rightarrow$ $-100 \times [AB\cos 30^\circ] - 150 \times [AB\sin 30^\circ] + P\cos 20^\circ [BC\sin 40^\circ] + P\sin 20^\circ [BC\cos 40^\circ] = 0$

Put $AB = 120$ mm

$$BC = 100 \text{ mm}$$

$\Rightarrow$ we got $P = +\ 223.92$ kN




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

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

$$\tan\theta = \frac{R_y}{R_x} = \frac{23.41}{360.41} \Rightarrow \quad \theta = 3^o 43' \text{ clockwise from x axis}$$

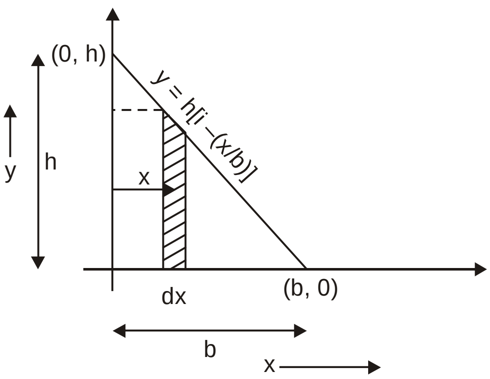
**Q.3:** ***Determine product of inertia of right-angled triangle with respect to x- and y-axes.***

***[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

$$I_{xy} = \int \bar{x}\,\bar{y}\,dA$$

$$\bar{x}_{strip} = x$$

$$\bar{y}_{strip} = \frac{y}{2}$$

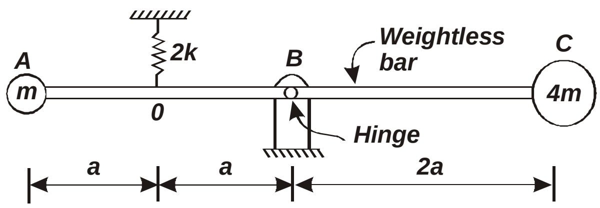
$$dA = ydx$$

$$I_{xy} = \int x\left[\frac{y}{2}\right] y\,dx = \int_0^b \frac{xy^2}{2} dx = \int_0^b \frac{x}{2}\left(h\left(1-\frac{x}{b}\right)\right)^2 dx$$

$$= \frac{h^2}{2}\int_0^b \left[x + \frac{x^3}{b} - \frac{2x^2}{b}\right] dx = \frac{h^2}{2}\left(\frac{b^2}{2} + \frac{b^4}{4b^2} - \frac{2b^3}{3b}\right)$$

$$= \frac{h^2b^2}{2}\left[\frac{1}{2} + \frac{1}{4} - \frac{2}{3}\right] = \frac{h^2b^2}{24} \quad \textbf{[Ans.]}$$

**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' Alemberts 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.

$$\sum_i (F_i - m_i a_i)\ .\ \delta r_i = 0$$

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

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