Engineering Services Exam (ESE) is one of the most coveted exams written by engineering students aspiring for reputed posts in the various departments of the Government of India. ESE is conducted by the Union Public Services Commission (UPSC), and therefore the standards to clear this exam too are very high. To clear the ESE, a candidate needs to clear three stages – ESE Prelims, ESE Mains and Personality Test.

It is not mere hard work that helps a student succeed in an examination like ESE that witnesses lakhs of aspirants competing neck to neck to move one step closer to their dream job. It is hard work along with smart work that allows an ESE aspirant to fulfil his dream.

After detailed interaction with students preparing for ESE, IES Master has come up with this book which is a one-stop solution for engineering students aspiring to crack this most prestigious engineering exam. The book includes previous years’ solved conventional questions segregated subject-wise along with detailed explanation. This book will also help ESE aspirants get an idea about the pattern and weightage of questions asked in ESE.

IES Master feels immense pride in bringing out this book with utmost care to build upon the exam preparedness of a student up to the UPSC standards. The credit for flawless preparation of this book goes to the entire team of IES Master Publication. Teachers, students, and professional engineers are welcome to share their suggestions to make this book more valuable.

MR. KANCHAN KUMAR THAKUR
DIRECTOR—IES MASTER
IES MASTER
Institute for Engineers (IES/GATE/PSUs)

ESE 2020
Prelims Online Test Series

GS & Engineering Aptitude (Paper-I)
Engineering Discipline Technical (Paper-II)

- Thoroughly researched test papers
- Adheres to real exam layout
- Matches level of UPSC exam
- In-depth clarity to entire syllabus
- Track & monitor your performance
- Comprehensive analytical feedback

Test Series starts 20th April

Call 97118 53908, 80100 09955
Register Now

60 Tests
1. STRENGTH OF MATERIALS 01 – 202
2. STRUCTURE ANALYSIS 203 – 406
3. STRUCTURAL DYNAMICS 407 – 409
4. STEEL STRUCTURE 410 – 532
5. RCC AND PRESTRESSED CONCRETE 533 – 690
6. PERT CPM 691 – 767
7. BUILDING MATERIAL 768 – 864
**SYLLABUS**

- Basics of strength of materials, Types of stresses and strains, Bending moments and shear force, concept of bending and shear stresses;

**CONTENTS**

<table>
<thead>
<tr>
<th>Chapter No.</th>
<th>Topic</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Strength of Materials</td>
<td>02 – 23</td>
</tr>
<tr>
<td>2.</td>
<td>Shear Force and Bending Moment</td>
<td>24 – 81</td>
</tr>
<tr>
<td>3.</td>
<td>Deflection of Beam</td>
<td>82 – 107</td>
</tr>
<tr>
<td>4.</td>
<td>Transformation of Stress and Strain</td>
<td>108 – 137</td>
</tr>
<tr>
<td>5.</td>
<td>Combined Stress</td>
<td>138 – 156</td>
</tr>
<tr>
<td>6.</td>
<td>Bending Stress in Beam</td>
<td>157 – 170</td>
</tr>
<tr>
<td>7.</td>
<td>Shear Stress in Beams</td>
<td>171 – 177</td>
</tr>
<tr>
<td>8.</td>
<td>Torsion of Circular shaft</td>
<td>178 – 197</td>
</tr>
<tr>
<td>9.</td>
<td>Columns</td>
<td>198 – 198</td>
</tr>
<tr>
<td>10.</td>
<td>Thick and Thin Cylinder/Sphere</td>
<td>199 – 199</td>
</tr>
<tr>
<td>11.</td>
<td>Moment of Inertia</td>
<td>200 – 202</td>
</tr>
</tbody>
</table>
Q-1: A cylindrical piece of steel 80 mm dia and 120 mm long is subjected to an axial compressive force of 50,000 kg. Calculate the change in the volume of the piece if bulk modulus = \(1.7 \times 10^6\) kg/cm\(^2\) and Poisons' ratio = 0.3.

[10 Marks, ESE-1997]

Sol:

Given:

Axial compressive load = 50,000 kg

Bulk modulus (k) = \(1.7 \times 10^6\) kg/cm\(^2\)

Poisson's ratio (\(\mu\)) = 0.3

Determine:

We know that

\[
\frac{\Delta V}{V} = \varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z
\]

\[
\varepsilon_x = \frac{\sigma_x}{E} - \frac{\mu (\sigma_y)}{E} - \frac{\mu (\sigma_z)}{E}
\]

\[
\varepsilon_y = \frac{\sigma_y}{E} - \frac{\mu (\sigma_z)}{E} - \frac{\mu (\sigma_x)}{E}
\]

\[
\varepsilon_z = \frac{\sigma_z}{E} - \frac{\mu (\sigma_x)}{E} - \frac{\mu (\sigma_y)}{E}
\]

In our case,

\(\sigma_y = 0\); \(\sigma_z = 0\)

\[
\sigma_x = \frac{-50000 \text{ kg}}{\frac{\pi}{4} (8)^2 \text{ cm}^2} = -995.2 \text{ kg/cm}^2 \quad \{\text{(-ve) because its compressive}\}
\]

Also, we know,

\[E = 3k (1 - 2\mu) = 3 \times 1.7 \times 10^6 \times (1 - 2\times 0.3) = 2.04 \times 10^6 \text{ kg/cm}^2\]

\[
\Rightarrow \varepsilon_x = \frac{\sigma_x}{E} = \frac{-995.2}{2.04 \times 10^6} = -4.878 \times 10^{-4} \quad \{\text{(–) because comp.}\}
\]

\[
\varepsilon_y = \frac{-\mu \sigma_x}{E} = 0.3 \times 4.878 \times 10^{-4} = 1.4635 \times 10^{-4}
\]

\[
\varepsilon_z = \frac{-\mu \sigma_y}{E} = 1.4635 \times 10^{-4}
\]

\[
\Rightarrow \varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z = -1.951 \times 10^{-4}
\]
\[
\frac{\Delta V}{V} = -1.951 \times 10^{-4}
\]
\[
\Delta V = -1.951 \times 10^{-4} \times \frac{\pi}{4} (8)^2 \times 12 \text{ cm}^3 = -0.1176 \text{ cm}^3
\]

Change in vol. is (−)ve

\[
\Rightarrow \text{There is volume reduction of 0.1176 cm}^3
\]

Q-2: A steel rod, circular in cross-section, tapers from 30 mm diameter to 15 mm diameter over a length of 600 mm. Find how much its length will increase under a pull of 20 kN if Young’s modulus of elasticity = 200 kN/mm². Derive the formula used.

[15 Marks, ESE-1998]

Sol:

For deriving the expression of elongation for tapered beam, we assume a tapered beam of

Length = L, Small end Dia = D₁, Larger end dia = D₂

\[
D_x = D_1 + \left(\frac{D_2 - D_1}{L}\right)x,
\]

where Dₙ is Dia at any distance x from smaller end

i.e., \( D_x = D_1 + kx \), where \( k = \left(\frac{D_2 - D_1}{L}\right) \)

Change in the length of element of length dx = d(ΔL)

\[
d(\Delta L) = \frac{Pdx}{AE}
\]

So net elongation

\[
\int d(\Delta L) = \int_0^L \frac{Pdx}{AE} = \int_0^L \frac{Pdx}{\frac{\pi}{4} (D_1 + kx)^2 E}
\]

\[
\Rightarrow \Delta L = \int_0^L 4Pdx \left(\frac{1}{\pi (D_1 + kx)^2 E} \right) = \frac{4P}{\pi E} \left[ \frac{1}{k(D_1 + kx)} \right]_0^L
\]

\[
\Rightarrow \Delta L = \frac{4PL}{\pi ED_1D_2}
\]

Values given, \( P = 20 \text{ kN} = 20 \times 10^3 \text{ N} \)

\( D_1 = 15 \text{ mm}, \quad D_2 = 30 \text{ mm}, \quad L = 600 \text{ mm}, \quad E = 200 \text{ kN/mm}^2 = 200 \times 10^3 \text{ N/mm}^2 \)

\[
\Rightarrow \Delta L = \frac{4 \times 20 \times 10^3 \times 600}{\pi \times 15 \times 30 \times 200 \times 10^3} = 0.1697 \text{ mm}
\]
Q-3: **Draw the diagram of normal forces, stresses and displacements along the length of the stepped bar ABC shown in figure.**

Cross-sectional area over AB = 100 mm$^2$; and area over BC = 200 mm$^2$; modulus of elasticity = 200 kN/mm$^2$

[10 Marks, ESE-1998]

**Sol:**

Given:

\[ A_{AB} = 100 \text{ mm}^2, \quad A_{BC} = 200\text{mm}^2, \quad E = 200 \text{ kN/mm}^2 \]

Draw

Diagram of normal forces normal stresses & displacement → along the length

- **FBD for AB and BC,**

- **Normal force diagram**

  Normal force diagram will be constant equal to 50 kN (tension)

  ![Normal Force Diagram](image)

- **Normal stress diagram**

  Stress, \( \sigma_{AB} = \left( \frac{50 \times 1000}{100} \right) = 500 \text{ N/mm}^2 \)

  \[ \sigma_{BC} = \frac{50 \times 1000}{200} = 250 \text{ N/mm}^2 \]

  The normal stress diagram have discontinuity at interface as shown below

  ![Normal stress Diagram](image)
Pocket the Knowledge

As a maverick ESE/GATE platform, we embark upon being your learning partner, in your pursuit of excellence.

True to the likings of engineering students, here, information comes crisp, compact and exact, accompanied by myriad of illustrations that one’s eyes can feast upon, and brain to exercise and hone its capabilities. We believe that illustrations speak louder than words; and figurines communicate faster than complex wordy pages.

As your eyeballs roll through the app, concepts on all topics – from Material Science to Currents, right from the ESE and GATE toppers - shall come alive before you.

In the swarm of devices based on touch-based, smart technology, IES Master App literally manifests its belief that a right ‘touch’ can change one’s world.

Features

- Daily updates
- Timely notifications
- On the fly bookmark of important notes and questions
- Practice questions on all topics
- Study materials - in the form of notes, quizzes and videos

Also visit @
iesmaster.org | iesmasterpublications.com

Like us on Facebook
Follow us on Twitter
Watch us on YouTube

IES MASTER PUBLICATION
F-126 (Lower Basement), Katwaria Sarai, New Delhi-110016
Phone: 011 26522064, Mobile: 971185 3908
E-mail: info.publications@iesmaster.org, info@iesmaster.org
Web: iesmasterpublications.com

Price: ₹ 850.00