

Если выделить двумя бесконечно близкими поперечными сечениями элемент стержня длиной  $\delta x$ , то силы инерции, соответствующие вращению этого элемента, дадут нам моментъ равный

$$- \frac{J \gamma}{g} \frac{\partial^2 y}{\partial x \partial t^2} \delta x \dots \dots \dots (c)$$

При составлении дифференціального ур-ня для изогнутой оси стержня нужно принять во вниманіе не только непрерывно распределенную нагрузку, соответствующую силамъ инерции поступательнаго движенія, но и непрерывно распределенные моменты, опредѣляемые  $\phi$ -ой (c). Въ такомъ случаѣ вліяніе изгибающаго момента вдоль оси стержня представится такъ

$$\frac{\partial M}{\partial x} = Q - \frac{J \gamma}{g} \frac{\partial^2 y}{\partial x \partial t^2}$$

Здѣсь  $Q$  поперечная сила, получающаяся отъ силъ инерции поступательнаго движенія элементовъ стержня.

Вставляя найденное значеніе производной  $\frac{\partial M}{\partial x}$  въ дифференціальное ур-іе

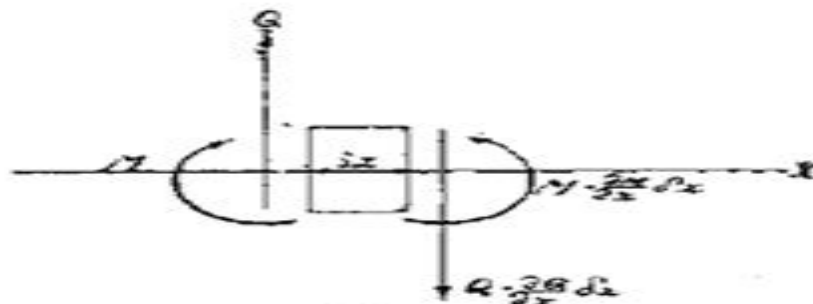
$$EJ \frac{\partial^2 y}{\partial x^2} = - \frac{\partial M}{\partial x},$$

получаемъ

$$EJ \frac{\partial^4 y}{\partial x^4} = - \frac{\gamma F}{g} \frac{\partial^2 y}{\partial t^2} + \frac{J \gamma}{g} \frac{\partial^4 y}{\partial x^2 \partial t^2} \dots \dots \dots (177)$$

Второй членъ въ правой части ур-ія представляетъ собой поправку, обусловленную поворотомъ поперечныхъ сеченій при колебаніяхъ.

Болѣе точное ур-іе мы получимъ, если примемъ во вниманіе не только вліяніе силъ инерции, соответствующихъ повороту сѣченій, но также и вліяніе касательныхъ напряженій на прогибъ стержня<sup>1)</sup>. Выделимъ изъ стержня двумя бесконечно близкими сѣченіями элементъ длиной  $\delta x$  и составимъ для него ур-іе движенія. Положеніе выделеннаго элемента опредѣлится по размѣщенію  $y$  его центра тяжести и угломъ поворота  $\phi$  относительно нейтральной линіи<sup>2)</sup>. Такъ какъ прогибъ



Черт. 76.

стержня обусловленъ не только относительнымъ поворотомъ поперечныхъ сѣченій, но также и движеньемъ ихъ одно относительно другого, то уголъ наклона кас-

<sup>1)</sup> Вліяніе касательныхъ напряженій на періодъ поперечныхъ колебаній стержня обыкновенно не принимается въ расчетъ, а между тѣмъ соответствующая ему поправка по своей величинѣ больше той, которая получается отъ поперечнаго сѣченія.

<sup>2)</sup> При составленіи ур-ія мы рассматриваемъ элементъ, какъ абсолютно твердое тѣло и пренебрегаемъ искривленіемъ поперечныхъ сѣченій, поэтому наша поправка лишь приближенно оцѣниваетъ вліяніе касательныхъ силъ. Нами совместно съ проф. П. Эренфестомъ получено также точное рѣшеніе задачи для колеса прямоугольнаго поперечнаго сѣченія. Это рѣшеніе, какъ и цитированное нами выше (стр. 184) рѣшеніе Рессламптона для круглаго цилиндра, показываютъ, что приведенное здѣсь приближенное рѣшеніе съ достаточной точностью учитываетъ вліяніе касательныхъ силъ.

# Elasticity Timoshenko Solution Manual

**Andreas Öchsner**



## **Elasticity Timoshenko Solution Manual:**

*Stretchable Electronics* Takao Someya, 2013-01-29 On a daily basis our requirements for technology become more innovative and creative and the field of electronics is helping to lead the way to more advanced appliances This book gathers and evaluates the materials designs models and technologies that enable the fabrication of fully elastic electronic devices that can tolerate high strain Written by some of the most outstanding scientists in the field it lays down the undisputed knowledge on how to make electronics withstand stretching This monograph provides a review of the specific applications that directly benefit from highly compliant electronics including transistors photonic devices and sensors In addition to stretchable devices the topic of ultraflexible electronics is treated highlighting its upcoming significance for the industrial scale production of electronic goods for the consumer Divided into four parts covering Theory Materials and Processes Circuit Boards Devices and Applications An unprecedented overview of this thriving area of research that nobody in the field or intending to enter it can afford to miss     Improved Numerical Methods for Solutions of a Beam's Axial, Torsion and Flexure Problems Zvi Friedman, 1997     *A Project-Based Introduction to Computational Statics* Andreas Öchsner, 2020-11-13 This book uses a novel concept to teach the finite element method applying it to solid mechanics This major conceptual shift takes away lengthy theoretical derivations in the face to face interactions with students and focuses on the summary of key equations and concepts and to practice these on well chosen example problems For this new 2nd edition many examples and design modifications have been added so that the learning by doing features of this book make it easier to understand the concepts and put them into practice The theoretical derivations are provided as additional reading and students must study and review the derivations in a self study approach The book provides the theoretical foundations to solve a comprehensive design project in tensile testing A classical clip on extensometer serves as the demonstrator on which to apply the provided concepts The major goal is to derive the calibration curve based on different approaches i e analytical mechanics and based on the finite element method and to consider further design questions such as technical drawings manufacturing and cost assessment Working with two concepts i e analytical and computational mechanics strengthens the vertical integration of knowledge and allows the student to compare and understand the different concepts as well as highlighting the essential need for benchmarking any numerical result     The Publishers' Trade List Annual ,1980     **Applied Mechanics Reviews** ,1955     *A Programmed Finite Difference Solution for Rotating Disks of Variable Thicknesses* Morris Reich, 1965

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