Ministry of science and higher education of the Russian Federation
Peter the Great St. Petersburg polytechnic university

Institute of Civil Engineering

APPROWED

Director of ICE

_____ G.L. Kozinets

«30» октября 2023 г.

PROGRAM

entrance test for applicants to themaster's degree program in the direction of training / educational program

08.04.01 «Civil engineering»

Code and name of the direction of training / educational program

Saint Petersburg
2023

ANNOTATION

The program contains a list of topics (questions) in the disciplines of the basic part of the professional cycle of the curriculum for the preparation of bachelors in the direction **08.04.01 "Civil engineering",** included in the content of tickets (test tasks) for the entrance examination for the magistracy.

The entrance test is assessed on a 100-point scale and consists of an interdisciplinary exam in the volume of requirements imposed by the state educational standards of the higher education for the level of preparation of a bachelor in a direction corresponding to the direction of a magistracy, conducted in person in writing or orally and online **(maximum score -100);**

The minimum number of points confirming the successful completion of the interdisciplinary exam is **50 points**.

Head of the educational program T.L. Simankina

Authors:

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The program was reviewed and recommended for publication in September by the Methodological Council of the Institute of Civil Engineering (Protocol No. 5 dated 26 september 2023).

1. DISCIPLINES INCLUDED IN THE PROGRAM OF INTERDISCIPLINARY EXAM

1.1. Engineering geodesy

1.2. Hydraulics

1.3. Strength of materials

1.4. Reinforced concrete and masonry structures

1.5. Structural mechanics

2. CONTENT OF EDUCATIONAL DISCIPLINES

2.1. Engineering geodesy

Applicable coordinate system; measurements of angles, distances and elevations; geodetic instruments; fundamentals of mathematical processing of measurement results; geodetic networks; topographic surveys; the main types of geodetic work in the design, construction and operation of structures.

Recommended reading list:

1. Alojz Kopačik, Ján Erdélyi, Peter Kyrinovič. Engineering Surveys for Industry. Publisher: Springer Cham, 2020. 213 p. (in English). ISBN978-3-030-48308-1. DOI: https://doi.org/10.1007/978-3-030-48309-8.
2. Joseph L. Awange,Erik W. Grafarend. Solving Algebraic Computational Problems in Geodesy and Geoinformatics. The Answer to Modern Challenges. PublisherSpringer Berlin, Heidelberg, 2005. 334 p. (in English). ISBN978-3-540-26862-8. DOI: https://doi.org/10.1007/b138214.

2.2 Hydraulics

Physical properties and models of fluids. The concept of a continuum medium. Forces acting on fluids, fluidity and viscosity of physical bodies. Compressibility, phase transitions, cavitation. Statics of fluids: hydrostatic pressure at a point, differential equation of equilibrium of a fluid volume (Euler's equations), relative rest of a fluid in presence of forces of inertia. The force of hydrostatic pressure on flat surfaces of arbitrary shape and flat rectangular surfaces, the force of hydrostatic pressure on cylindrical surfaces. Kinematics of fluids: methods for

describing the motion of a continuous medium, streamline, trajectory. Fundamentals of the dynamics of fluids: the law of conservation of mass, the law of conservation/change of momentum, the law of conservation/change of moment of momentum, the law of conservation/change of kinetic energy. Theoretical foundations for solving one-dimensional problems. Uniform and non-uniform motion, flow cross section, average speed. Continuity equation, Bernoulli equation for steady fluid flow in pipes, laminar and turbulent fluid flow, head and pressure loss in pipes (Darcy/Darcy-Weisbach friction factor, Chezy's formula), Moody chart (Colebrook equation), minor losses (loss/resistance coefficient, equivalent length) and the formula for minor losses for sudden expansion/enlargement. Steady-state fluid motion in pipelines, classification of pipelines (the notion of hydraulically long and short pipelines). Direct and inverse problems of pipeline calculation. Siphon pipeline, peculiarities of its calculation. Fluid outflow from holes and nozzles/orifices, conditions for normal operation of an orifice (vacuum in the orifice). Comparison of the hydraulic characteristics of different types of orifices.

Recommended reading list:

1. Anup Goel, Fluid Mechanics: Fundamentals and Applications. Vendors: Technical Publications. 2020ISBN: 9789333221726, 736 p. (in English).
2. Bansal R.K. A Textbook of Fluid Mechanics and Hydraulic Machines Paperback, Laxmi Publications, 2005. ISBN-10:8131808157, 1102 p. (in English).
3. Yunus A. Cengel, John Cimbala, Fluid Mechanics: Fundamentals and Applications. Fourth Edition. New York: McGraw Hill, 2018, ISBN: 978-1-259-696534-4, 1006 p. (in English).

2.3. Strength of materials

Basic concepts of strength of materials, external and internal forces, method of sections, deformations; tension and compression of bars; mechanical properties of materials, allowable stress, strength conditions; state stress; shear, torsion, determination of shear stresses and angles of twist; bending, determination of

normal stresses, geometric properties of an area, shear stresses during bending, determination of displacements in beams; combined loading, combined action of bending and tension or compression, combined action of torsion and bending; buckling of columns, stability of deformable systems, critical force, stability condition; dynamic problems, impact calculations, dynamic stresses and deformations, dynamic coefficient.

Recommended reading list:

1. Beer F.P., Johnston E. R., DeWolf J.T., Mazurek D.F. Mechanics of Materials. 8th edition. McGraw Hill, 2019, 896 p. ISBN-13: 978-1260113273 (in English).
2. Hibbeler R.C. Mechanics of Materials, 10th edition. Global Edition. Pearson, 2016. 896 p. ISBN-13: 978-0134319650 (in English).
3. Potter M.C. Schaum's Outline of Strength of Materials, 7th Edition, 2019, 304 p. ISBN: 9781260456547 (in English).

2.4. Reinforced concrete and masonry structures

Basic physical and mechanical properties of concrete and reinforcement; reinforced concrete; experimental theories of reinforced concrete resistance, the main provisions of methods for calculating strength, crack resistance and displacement of massive and rod reinforced concrete elements; the basics of resistance to dynamic loads, especially the calculation of massive structures of hydraulic structures; rolled concrete.

Recommended reading list:

1. Wight James K. Reinforced concrete: mechanics and design. 8th edition. Kindle Edition. Boston: Pearson, 2021. 1176 p. ISBN 978-1-292-10601-4 (in English).
2. Yining D., Xiliang N. Reinforced Concrete: Basic Theory and Standards. Springer Singapore. 2023. ISBN 978-981-19-2919-9 (in English).

2.5. Structural mechanics

Structural analysis of rod systems; Calculation of forces in statically determinate rod systems under fixed and moveable loads; basic theorems on linear deformable systems; definition of displacements; calculation of statically indeterminate systems by the methods of forces, displacements, mixed, combined; matrix method for calculating the displacements of rod systems: spatial systems; calculation of structures by the finite element method; calculation of structures by the ultimate equilibrium method; dynamic calculation of structures; stability of structures.

Recommended reading list:

1. Ghali A., Neville A.M. Structural Analysis. A Unified Classical and Matrix Approach. 7th edition. Taylor & Francis Group, 2017. 962 p. (in English).
2. Karnovsky I.A., Lebed O. Advanced methods of Structural Analysis. Strength, Stability, Vibration. Second Edition: Springer, 2021. 795 p. ISBN 978-3-030-44394-8 (in English).
3. Leet K.M., Uang C.M., Gilbert A.M. Fundamentals of Structural Analysis: McGraw-Hill (fifth Version), McGraw-Hill Education, 2018. 801 p. (in English).
4. Pataik S.N., Hopkins D.A. Strength of Materials. A Unified Theory: Elsevier, 2004. 750 p. ISBN 0-7506-7402-4 (in English).

3. EXAMPLE OF THE ENTRANCE TEST

Peter the Great St. Petersburg polytechnic university
Institute of Civil Engineering

УТВЕРЖДАЮ
Head of the educational program
_____ T.L. Simankina
«____» _____ _____ 20___ г.

ENTRANCE TEST
for applicants to the master's degree program
in the direction of training / educational program

08.04.01 «Civil Engineering»

Code and name of the direction of training / educational program

Unit 1. Engineering surveying

1. The difference in height between several points on the earth's surface is:
   - **difference of height**
   - relief
   - difference of topographic points
   - elevation

2. An acute angle measured from the north or south direction of the axial meridian or a line parallel to it, clockwise to the oriented line, is:
   - **grid bearing**
   - directional angle
   - magnetic azimuth
   - true bearing

3. Determine the direction of the line relative to another, taken as the original
   - determine its slope
   - **orient the line**
   - determine the direction
   - determine its position relative to the point

4. Common survey computation. According to the known coordinates x1 = 500 m and y1 = 500 m of point 1, directional angle a1-2 = 246 and distance d1-2 = 350 m, it is necessary to calculate the coordinates of point 2 (x2, y2):
   - x2 = 232.12, y2 = 424.52
   - **x2 = 357.64, y2 = 180.26**
   - x2 = 134.12, y2 = 352.41
   - x2 = 312.84 y2 = 171.33

5. Inverse survey computation. According to the known coordinates x1 = 321 m, Y1 = 186 m of point 1 and x2 = 320 m, Y2 = 144 m of point 2, it is required to calculate the distance between them d1-2 and the directional angle a1-2:

- d1-2= 123.302 м., a1-2= 141°17′46″
- d1-2= 518.912 м., a1-2= 278°56′14″
- **d1-2= 239.508 м., a1-2= 268°38′10″**
- d1-2= 324.812 м., a1-2= 23°07′39″

Unit 2. Hydraulics

6. Flow cross section is:
   - **a cross section of the flow perpendicular to the direction of flow**
   - a longitudinal section of the flow, perpendicular to the direction of flow
   - a cross section of the flow parallel to the direction of flow

7. Determine the force of hydrostatic pressure on the flat wall of a vessel of rectangular cross-section, if the depth of the liquid in the vessel is h=2 m, the width of the wall is b=1 m, and the density of the liquid is ρ=980 kg/m^3.
   - **19.2 kN**
   - 192 kN
   - 13.7 kN
   - 137 N

8. Head loss in pipes are calculated according to the formula:
   - $\boldsymbol{h_l=(\lambda L/D)\cdot v^2/(2g)}$
   - $h_l=\lambda\, v^2/(2g)$
   - $h_l=\zeta\lambda\, v^2/(2g)$
   - $h_l=\zeta\lambda L\,/(D)$

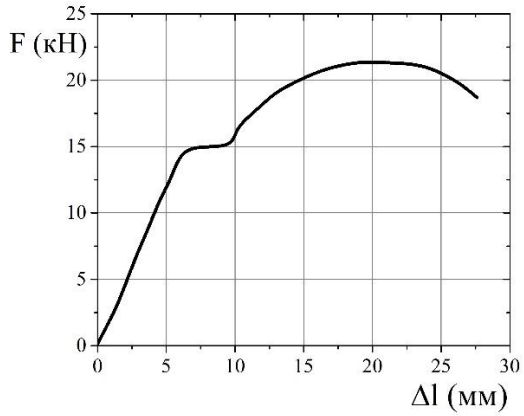
9. How many times will the fluid velocity in the pipe change at a constant flow rate if the diameter increases by 2.5 times?
   - It will decrease by 2.5 times
   - It will increase by 6.25 times
   - It will decrease by 5 times
   - **It will decrease by 6.25 times**

10. Find the flow rates Q_1 and Q_2 in parallel branches of a hydraulically long pipeline, if it is known that the flow rate in the pipeline is Q = 10 l/s, the resistance of the first branch is four times greater than the resistance of the second branch.
    - $Q_1 = Q_2 = 5{,}0$ l/s
    - $Q_1 = 7.0$ l/s, $Q_2 = 3{,}0$ l/s
    - **$Q_1 = 3.3$ l/s, $Q_2 = 6.7$ l/s**
    - $Q_1 = 6.7$ l/s, $Q_2 = 5.0$ l/s

Unit 3. Strength of materials

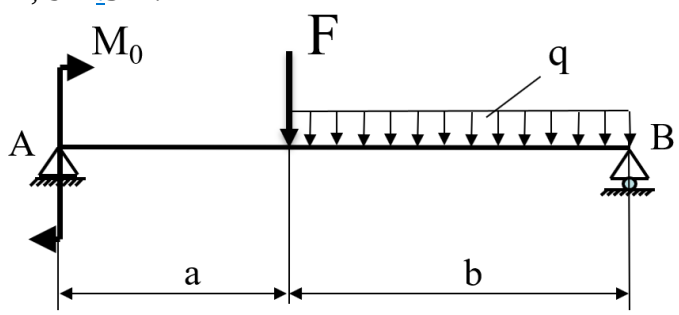
11. Plasticity is the property of a material to ……
    - return to original shape after removing the load
    - resist failure
    - **irreversibly change its size and shape when subjected to load**
    - resist the penetration of another solid body into it

12. Load-elongation curve for specimen having a cross-section of 150 mm^2 is given in the figure. Determine the yield stress.



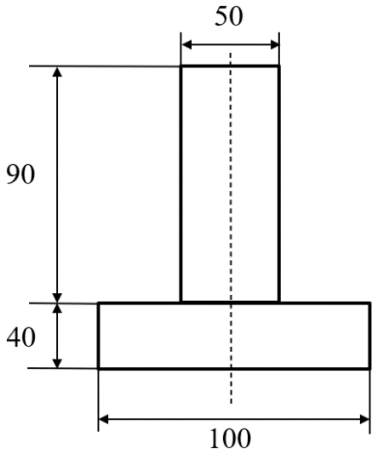
- 10 MPa
- 50 MPa
- **100 MPa**
- 150 MPa

13. Determine the maximum average bending moment, if M_0=5 kNm, F=20 kN, q=10 kN/m, a=1 m, b=1.5 m.



- 10.2 кNm
- **19.5 kNm**
- 32.6 kNm
- 45.9 kNm

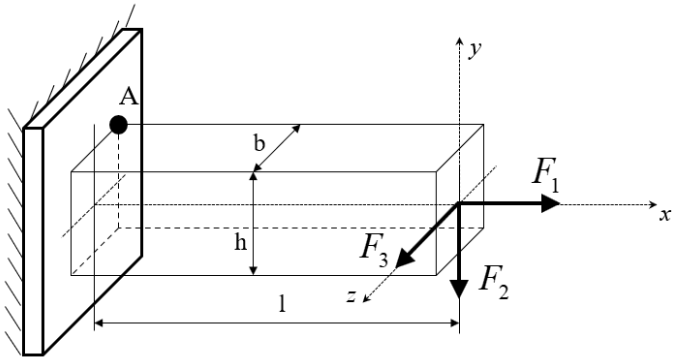
14. Determine the moment of inertia of the cross-sectional area of the T-beam shown in the figure.



- 824.6 cm^4
- **1251.8 cm^4**
- 2566.2 cm^4

- 3922.8 cm^4

15. The cantilevered rectangular bar (h=200 mm, b=100 mm) is subjected to the loading shown. F_1=100 kN, F_2=20 kN, and F_3=10 kN. l=1 m. Determine the normal stress at point A.

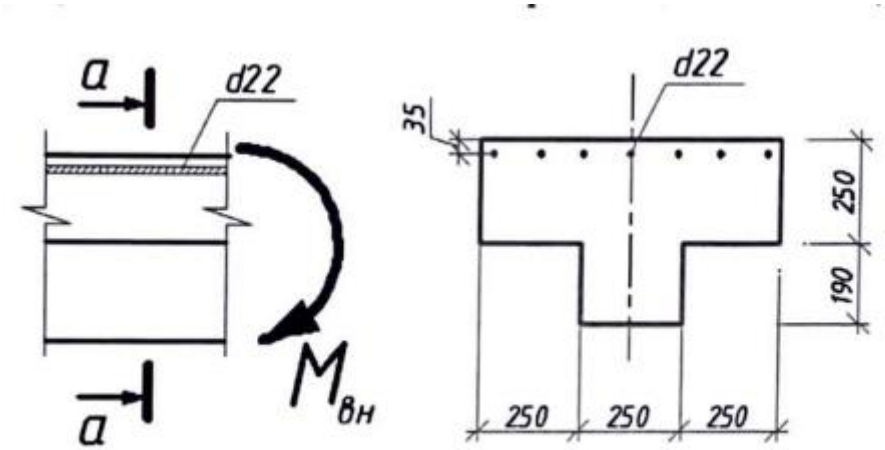


- 15 MPa
- 30 MPa
- **65 MPa**
- 125 MPa

Unit 4. Reinforced concrete and masonry structures

16. The tensile reinforcement of prestressed structures is made from:
- welded meshes
- welded frames
- embedded parts
- **separate rods**

17. What part of the reinforced concrete T-section is compressed in the limit state? The cross-section dimensions are indicated in mm. The calculated resistance of concrete to compression and reinforcement to tension, respectively, are R_b = 124 kgf/cm^2 and R_s = 3,650 kgf/cm^2.



- only the bottom part of the section wall
- only the top part of the section flange

- **the entire section wall and the bottom part of the section flange**
- the entire section flange and the top part of the section wall

18. Boundary relative height of the compressed zone of concrete approximately equals to :
    - $\xi_R = 5.2/(5+R_s/200)$
    - $\boldsymbol{\xi_R = 0.8/(1+R_b/700)}$
    - $\xi_R = 0.5R_s/(5+ \sin R_b/200)$
    - $\xi_R = 5.2R_s/(2+ \cos R_b/200)$

19. The minimum thickness of the concrete cover for the working reinforcement of the foundation base
    - 5 mm
    - 15 mm
    - 20 mm
    - **40 mm**

20. Dimensions of the beam cross section: b = 30 cm; h_0 = 55 cm; a` = 5 cm - the distance from the center of the compressed reinforcement to the compressed concrete face. Tensile reinforcement A_s = 40.22 cm^2 (R_s = 3,650 kgf/cm^2), compressed reinforcement A_s = 15.71 cm^2 (R_{sc} = 3,650 kgf/cm^2). Concrete of class B25 (R_b = 148 kgf/cm^2). The ultimate bending moment for the beam is approximately equal to:
    - 5,300 kgf*m
    - 16,300 kgf*m
    - **69,000 kgf*m**
    - 185,600 kgf*m

Unit 5. Structural mechanics

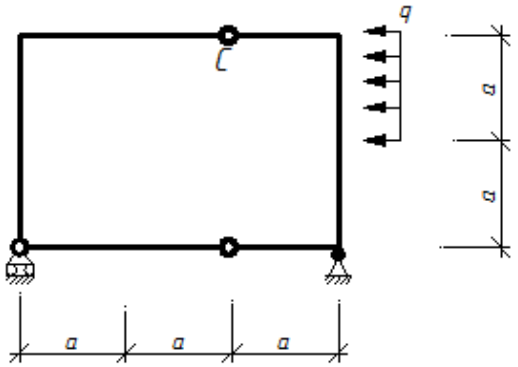
21. Determine the modulus of the inertial force that will act to the mass m= 47kg in 16 seconds after the start of the movement described by the equation:

    $$u(t) = 0.3e^{-0.125t}\cos(3\pi t + \frac{3\pi}{4})$$

    All measurements in the equation are in International System of Unit (SI).

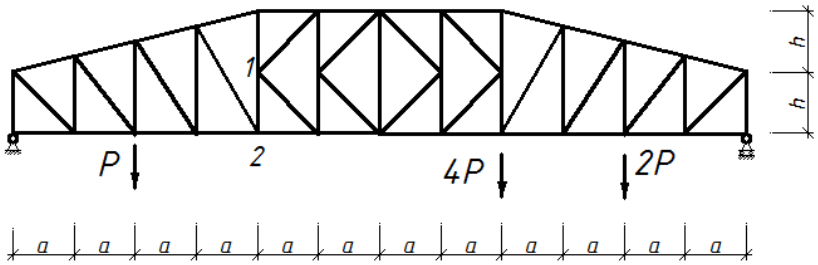
    Answer: 123 N

22. Determine the modulus of the ~~total~~ value of the forces in the hinge "C" at a load q = 70.7 kN/m, a = 4 m.



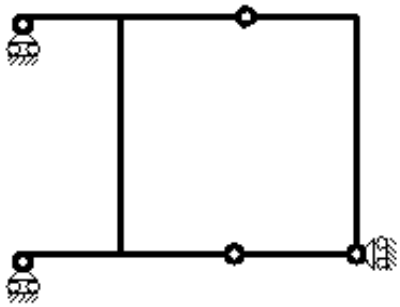
    Answer: 200 kN

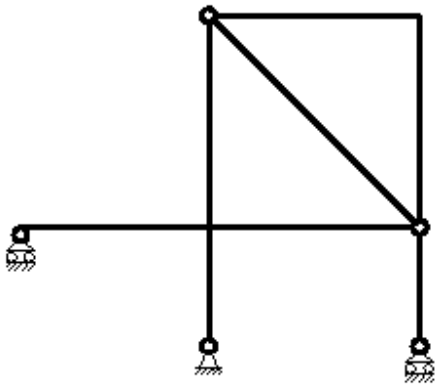
23. Determine the value of the normal force in the bar 1-2 of the truss, if it is known that a = 1.5 m, h = 2.5 m, P = 45 kN. Indicate your answer in kN and use +/-.



Answer: -22.5 kN

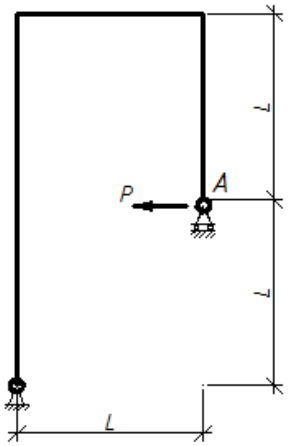
24. Indicate what type of frame drawn on the figures below:





- both are statically determinate frames
- both are statically indeterminate frames
- **both are geometrically unstable frames**
- one is statically determinate, the other is statically indeterminate frames
- one is statically determinate, the other is geometrically unstable frames
- one is statically indeterminate, the other is geometrically unstable frames

25. Determine the value of the horizontal displacement (mm) at point A of the frame, if it is known that P = 16 kN, L = 4 m, EI = 10,000 kN*m^2.



Answer: 546 mm