Scientific Computing Exam questions

Lectures 4 and 5
Exam questions
Nikolay Koshev

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Skolkovo Institute of Science and Technology

questions: Lec 4

- Give the definition of convolution. Explain its meaning in terms of point spread function. Provide real-world examples.
- Write the generalized form of an integral transform; describe its parts. Why do we use the integral transforms? What are we expecting of usage of them?
- Write the definition of the Fourier transform and inverse Fourier transform. Explain the differences of real domain and reciprocal (frequency) domain. Provide examples.
- What is the convolution theorem? Describe why, where and when this property is useful.
- Explain the pipeline of the spectral analysis with the Fourier transform. Which properties are meaningful in this context? Explain with examples.
- How do we use Fourier transform for calculation of correlation of two functions?
- How the derivatives of some function could be explained with its Fourier image? How can we apply this property to the differential equations? Explain with example.
- What is Parseval's theorem? When is it important?
- Why FT is that important? List all the applications of FFT you know. Provide at least two examples.
- Define the Radon transform. Describe the physical concept: how can we get the Radon transform?
- Describe the dependence of the quality of the Radon inversion on the number of projections.
- Explain the Fourier Slice Theorem. How the FST can be used for inversion of the Radon Transform?
- What is the Wavelet Transform? Give the definition and describe motivation.
- Write the definition of the STFT. Write its advantages and disadvantages. Provide at least one possible application.
- Describe step-by-step the idea of wavelet analysis. What is similar between the Fourier and continuous wavelet transforms?

Questions: Lec 5

- Describe four steps for computational solution of the scientific computing problem with usage of a mesh.
- Suppose the computational domain is covered with a uniform mesh. How can you approximate first and second derivatives of some function (defined in this domain) with FDM?
- Describe the "cross" template for approximation of second derivatives; write the approximation of the boundary value problem for the Poisson equation using this template. Analyze the obtained SLAE with respect to number of equations and variables.
- When should you use non-uniform meshes in FDM? When it is not reasonable to use them (in FDM)? What are disadvantages of this approach?
- Describe the procedure (steps) of reduction the problem for differential equation to SLAE using FDM.
- Describe general properties of FDM matrix, obtained using the Cross template.
- Why it is better to avoid usage of inverse matrices in real computations of Poisson equation with the Cross template?
- Explain the meaning of terms 'implicit scheme' and 'explicit scheme'. Which advantages and drawbacks has each of these schemes? Provide an example of implicit and explicit schemes for some differential equation.
- Compare FDM and FEM in terms of advantages and drawbacks of each method.
- Define the FEM approximation with basis functions. List necessary properties of the basis functions. Write the approximations or derivatives and integrals.
- What is the weak formulation? Describe with the example.
- Describe the procedure of reduction of the Poisson equation to the SLAE using FEM.
- List the properties of the matrix of SLAE, obtained using the FEM.