Computer technology in Science and Education

Course Contents:

The class presents acquaintance with modern computer technologies, their actual development directions in science and education. During the course the representation about position of information technologies in modern life is given. Finally different useful programs applied in scientific and educational activities are presented.

Subjects covered by the lectures are:

Section 1. Information Technologies in Education

Topic 1.1. Conception and Classification of Information Technologies

The conception of information (data) systems. Examples of data systems. Classification of data systems by architecture. Classification of information systems by data handling type. Classification of data systems by their application. Automated Information Systems (AIS), Information Retrieval Systems (IRS), Training Data Systems, Batch Control. Decision Support Systems (DSS): ERP, GIS, DocFlow, Business Modeller, Project Management, SCADA (Supervisory Control And Data Acquisition), DCS (Distributed Control Systems). Business Intelligence Tools.

Topic 1.2. Society Informatization and the Problems of Education

Concept of education in advance. Basic theses of education in advance and their role in the development of society informatization. Informatization of education as the fundamental contemporary problem. Up-to-date vision of education informatization purposes and problems; main ways of solving. Information alignment of education. Education informatization as a mean of increasing the educational process efficiency. Educational information science and technique, its main purposes, problems and trends.

Topic 1.2.1. Matlab 8.2 System in Science and Education (www.mathworks.com)

Topic 1.2.2. Technical Computing Software for Engineers

Maple (www.maplesoft.com). Mathematica (www.wolfram.com). Maxima - system for working with expressions (maxima.sourceforge.net). Expressions. Evaluation. Simplification. Built-in object types. Programming. Lists. Matrices. Sets. Defining a function. Solving an equation. Integrating and differentiating. Making a plot. Saving and loading a file.

Topic 1.3. The Internet as an Educational Resource

The concept of the Internet. The main subspaces and services of the Internet. Web2.0 and Web3.0. Educational system dataware. Information network development for the educational system.

Topic 1.4. The Academic Databases and Knowledge Bases

Learning Technology Systems Architecture – LTSA: learner; evaluation; learner records; system coach; learning resources; delivery. Examples: ADL (http://www.adlnet.org), AICC (http://www.aicc.org), ANSI IISP (http://www.ansi.org/iisp) etc.

Topic 1.5 Usage of Remote Educational Technologies in Educational Process

The concept of distance education. Distance education as a method of educational area expansion (http://www.ido.ru). Contemporary condition and perspectives of international distance education development. International Academy of Open Education (http://www.maoo.ru).

Topic 1.6 Methological and Methodological Aspects of Working Out the Electronic Educational Resources (OER)

Types of educational resources. The concept of the electronic educational resources. Multimedia technologies in education. Methodological problems of OER usage in educational process.

Section 2. Efficient Use of Current Information Technologies in Scientific Research

Topic 2.1. Review of Current Information Technologies

Definition of a computer. Configuration of a computer. Review of operation systems and platforms. Network information technologies. Databases.

Topic 2.1.1. Office Technologies

Microsoft Office (www.office.microsoft.com). Adobe Systems (www.adobe.com): Adobe Acrobat Reader Professional, Adobe Illustrator. Open Office (www.openoffice.org) – free software.

Topic 2.1.2. Document Preparation Systems

LATEX (www.latex-project.org) – a high-quality typesetting system; it includes features, designed for the production of technical and scientific documentation. The de facto standart for the communication and publication of scientific documents. Free software.

MIKTEX (www.miktex.org) – an up-to-date implementation of Tex/LaTex and related programs for Windows (all current variants).

Topic 2.1.3. Impact factor (IF)

Journal Impact Factor (http://globalimpactfactor.com/journals-list/). Calculation of IF. Use of IF. Scopus Journal Analyzer.

Topic 2.1.4. Electronic Libraries

Elsevier (www.elsevier.com). Web of Science (WOS http://www.isiknowledge.com/). Kluwer Online Journals (http://library.ucsc.edu/find/eresources/kluwer-online-journals). Springer (http://www.springer.com). SAGE Journals (http://online.sagepub.com/).

Topic 2.2. Methods of Mathematical Simulation and Modern Information Technologies

Basic points of mathematical simulation methods. Creation of an information model on the basis of a mathematical model. Calculus of approximations as the essential principle of solving current problems of deformable solid body mechanics (mechanics of liquid and gas). Finite-element method (FEM) and method of boundary elements as the example of contemporary calculus of approximations for mechanical problems.

Topic 2.3. Information Technologies as a Tool for Scientific Research

Dataware for scientific research. Three main components of the modeling process: physical model, mathematical model, computational model. Hierarchy of models, their interconnection and filling. Modeling process dataware. Computational experiment as a part of a computational model. Conformity of the computational model and the computing system. Methods of machine intelligence in scientific research. Scientific research visualization.

Topic 2.4. Applied Programs for Mechanical Problems

COSMOS, CFX, FLUENT, STAR-CD, LS-DYNA, ANSYS (www.ansys.com), ABAQUS (www.tesis.com.ru), FlowVision, MSC/NASTRAN (www.mscsoftware.ru), MSC/MARC, MAGMASOFT, SolidWorks (www.solidworks.com), ERTFEM, etc.

Topic 2.5. Knowledge Bases

Knowledge based systems architecture. Development of knowledge based systems. Knowledge management. Agent based systems. Connectionist models. Genetic algorithms. Soft computing systems. Knowledge-based multi-agent system accessing distributed database grid: an e-learning solution. Knowledge intensive learning: diet menu planner. Natural language interface: question answering system.

Learning Outcomes of the Course:

Through a deep understanding of the theory and the realization of a project, the student will be able to study a wide class of information technologies. In particular:

- He will have a deep understanding of modern technologies in science.
- He will be able to apply different computer technologies.
- He will be able to use the main educational resources that modern society can provide.

Topics for Reports:

Topic 1.1. Conception and Classification of Information Technologies

1. Classification of Automated Information Systems (AIS).
2. The automated workplaces. Types and sphere of usage.
3. Information retrieval.
4. Automated Information Retrieval Systems (AIRS). Types A, B, C. Examples. Main functions. Applicability. Differences.

Topic 1.4. The Academic Databases and Knowledge Bases

1. Learning Technology System Architecture (LTSA). Learner and environment interactions.
2. Ontologies, Expert systems.
3. Multiple role learning, Team learning.
4. European Union ARIADNE.

Topic 1.6 Methological and Methodological Aspects of Working out the Electronic Educational Resources (OER)

5. Open Educational Resources (OER): the value of reuse in higher education.
6. The importance of 'E' as well as 'O' in OER.
7. Discovering: How are resources found?
8. Discerning: How are resources chosen?
9. Designing: How are resources integrated into teaching?

Activities

Topic 2.1.2. Document Preparation Systems

1. Prepare the below-mentioned formulas in LaTex:
   a. $\sigma_{ij}^{S} = \sigma_{ij}^{*} + \overline{\sigma}_{ij}$, $f(\sigma_{ij}^{S}) < 0$
   b. $\int_0^T \{\int X_i \dot{u}_{i0} dv + \int_{Sp} p_i \dot{u}_{i0} dS\} dt > \int_0^T F(\dot{\varepsilon}_{ij0}^{"}) dv$
   c. $\sigma = \frac{\partial W}{\partial \varepsilon} = -\frac{\partial W}{\partial \varepsilon^{p}}$, $A = -\frac{\partial W}{\partial \alpha}$
   d. $W(\varepsilon - \varepsilon^{p}, \alpha) = \frac{1}{2}(\varepsilon - \varepsilon^{p} : L : (\varepsilon - \varepsilon^{p}) + \frac{1}{2}\alpha : Z : \alpha)$
   e. $\dot{\varepsilon}^{p} = \frac{\partial \varphi}{\partial \sigma}(\sigma, A)$, $\dot{\alpha} = \frac{\partial \phi}{\partial A}(\sigma, A)$.
   f. $\left(\sigma, A, \dot{\varepsilon}^{P}, \dot{\alpha}\right)(t) - (\sigma_{\infty}, A_{\infty}, \dot{\varepsilon}_{\infty}^{P}, \dot{\alpha}_{\infty})(t) \xrightarrow{t \to \infty} 0$
   g. $\int_0^T \dot{\varepsilon}_{\infty}^{P}(x,t) dt \neq 0$

h. $J(\varepsilon_0^P, \alpha_0) = \frac{1}{2}\int_V (\Delta\sigma(x) : L^{-1} : \Delta\sigma(x) + \Delta A(x) : Z^{-1} : \Delta A(x))dV$ where

$\Delta\sigma(x) = \sigma(x,T) - \sigma(x,0)$, $\Delta A(x) = A(x,T) - A(x,0)$

i. $\min_{(\varepsilon_0^P, \alpha_0) PA} J(\varepsilon_0^P, \alpha_0)$

2. Prepare a fragment of scientific text in LaTex.
3. Find a way to include pictures in a LaTex document.

Topic 2.3. Applied Programs for Mechanical Problems

Computational experiments in applied programs:

1. Consider a rectangular plate with a hole in 2D plane stress.
2. Static calculation of a console beam.
3. A 3D problem of the fixed beam bending.
4. The analysis of frequency response. The round plate rigidly anchored on a contour.

Topic 1.2.2. Technical Computing Software for Engineers

Solve the following systems of the differential equations using Maple, Mathematica or Maxima software.

1. $\begin{cases} \frac{dx}{dt} = -2x + 4y \\ \frac{dy}{dt} = -x + 3y \end{cases}$
2. Find partial solution of system $\begin{cases} x' = 2x - 5y + 3 \\ y' = 5x - 6y + 1 \end{cases}$, where x(0)=6; y(0)=5
3. $\begin{cases} \frac{dx}{dt} = -x - 5y \\ \frac{dy}{dt} = -7x - 3y \end{cases}$
4. $\begin{cases} \frac{dx}{dt} = 2x + y \\ \frac{dy}{dt} = 3y + t\exp(t) \end{cases}$
5. $\begin{cases} \frac{dx}{dt} = -y \\ \frac{dy}{dt} = x + \cos t \end{cases}$

Recommended or Required Readings:

1. Lvovsky S.M. Panel and imposition in system LATEX, 2003.
2. Lamport L. LATEX. A document Preparation System, User's Guide and Reference Manual. – Addison-Wesley, 1994.

3. Goossens M., Mittelbach F., Samarin A. The LATEX Companion. – Addison-Wesley, 1994.
4. Gratzer G. Math into TEX. A simple introduction to AMS-LATEX. – Birkhauser, 1993.
5. Gratzer G. First steps in LATEX. Birkhauser; Springer-Verlag, 1999.
6. Rao S. S. The Finite Element Method In Engineering. Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo: Elsevier, 2011. 727p.
7. Zienkiewicz O.C., Taylor R.L. The Finite Element Method for Solid and Structural Mechanics. Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney, Tokyo: Elsevier, 2005. 648p.
8. Segerlind L. J. Applied FiniteElement Analysis. Inc. New York/London/Sydney/Toronto: John Wiley and Sons, 1976. 393p.
9. Akerkar R. Knowledge-Bassed Systems. India:Priti Sajja – Sardar Patel University. 2010. 254 p.
10. SIMULIA Abaqus/CAE User`s Manual
11. SIMULIA Abaqus Example Problems Manual
12. Nushtaev D. V. Abaqus. The manual for beginners. The step by step instruction. TESIS, Moscow 2010, 78 p.
13. Professor Suvranu De. Abaqus Handout. Rensselaer Polytechnic Institute. Department of Mechanical, Aerospace and Nuclear Engineering. 61 p.
14. Rychkov S.P. Construction modeling in MSC visual NASTRAN for Windows. Moscow: NT Press. 2004. 552p