Physics BSc of FNS BME
4. semester

MECHANICS 2 (2 credits)
lecturer: Attila Virosztek

1. **Basics of special relativity theory**
   Galilei transformation, Galilei's and Einstein's principle of relativity, event, interval, simultaneity, proper time, time dilation.

2. **Minkowski space**
   Contravariant and covariant four-vectors, metric tensor, requirements with respect to Lorentz transformation, dependence of the Lorentz matrix on the relative velocity of the inertial frames, Lorentz contraction, rapidity, addition of velocities.

3. **Relativistic dynamics**
   Four-velocity, rest mass, four-momentum, relativistic equation of motion, energy-momentum four-vector, particle with zero rest mass, four-force.

4. **Relativistic particle in electromagnetic field**
   Lorentz force, electromagnetic tensor, equation of motion, four-potential, Lagrangian and Hamiltonian of a relativistic particle in electromagnetic field.

5. **Lagrange formalism of elastic medium**
   Lagrange equation of motion for deformable solids, Hooke's law, kinetic energy, potential energy of volume and surface forces, Lagrangian density as a function of displacement field, elastic energy density of isotropic material.

6. **Dynamics of elastic medium**
   Hamilton's principle, Euler-Lagrange equation, its equivalence with the Lagrange equation of motion, equation of motion for the displacement field in isotropic and anisotropic materials, elastic waves in the isotropic and anisotropic case.

7. **Hamilton formalism of field theories**
   Canonical momentum density, Hamiltonian density, energy balance, energy current density, equation of continuity, energy conservation.

8. **Relativistic field theories**
   Lagrangian density and action of a real scalar field, equation of motion, energy-momentum four-tensor and its equation of continuity, Lorentz invariant Lagrangian density, Klein-Gordon equation, time-, and space-like blocks of the energy-momentum four-tensor.

9. **Symmetries in the Lagrange formalism**
   Consequences of the invariance with respect to temporal and spatial translation and rotation, conservation laws, general coordinate transformations, invariance of the Lagrangian with respect to point-transformations, Noether theorem.

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10. **Conserved quantities in the Hamilton formalism**
    Time dependence of physical quantities, properties of Poisson brackets, Poisson theorem, notable Poisson brackets, generators of transformations, symmetry transformations and conserved quantities.

11. **Canonical transformations**
    Mapping the phase space onto itself, definition of the canonical transformation, it's necessary and sufficient condition, it's properties, derivative matrix of the transformation, symplectic structure.

12. **Generating functions**
    Modified Hamilton's principle and Hamilton equations, introduction of the generating function, it's types and relation to the canonical transformation, old and new coordinates, momenta and Hamiltonian.

13. **Hamilton-Jacobi equation**
    The action as a function of coordinates and time, it's use as a type II generating function, conservative system and abbreviated action, separation of variables, the abbreviated action as a type II generating function, action-angle variables.

14. **Integrable systems**
    Independent constants of motion, definition of integrability in the sense of Liouville, choice of basis in the explorable subspace of the phase space, the appropriate canonical transformation, invariant torus, closed and open phase space trajectories.

15. **Chaotic behavior of dynamical systems**
    The driven damped harmonic oscillator and the attractor of it's motion, dependence on initial conditions, the driven damped pendulum as a nonlinear problem, period doubling, Poincare section, bifurcation diagram, strange attractor, sensitivity to initial conditions, Liapunov exponent.