S-104.1020 Physics II (AUT, BIO, EST,TLT) 1st midterm exam/renewal May 15, 2008

1. Two small metal balls with masses $m_1 = m_2 = 25 \cdot 10^{-5}$ kg are hanging from dielectric cords having a length of 0.5 m each and touching each other. The balls are charged with equal charges. Therefore, the balls repulse each other and move until the both cords form an angle of 45° with the vertical. How large is the charge of each ball?

2. An alpha particle (consists of two protons and two neutrons) having a kinetic energy of 5 MeV collides directly into the nucleus of a gold atom. Calculate how close to the nucleus the alpha particle is able to approach. The atomic number of gold is 79.

3. A capacitor of capacitance C is charged to a potential difference V_0. The terminals of the charged capacitor are then connected to those of an uncharged capacitor with capacitance $C/2$. Find a) the original charge of the system, b) the final potential difference across each capacitor, c) the final energy of the system, and d) the decrease in the energy of the system.

4. Ion with a mass of $2.344 \text{x} 10^{-26}$ kg and charge 1 e, is accelerated from rest with a potential difference of 800 V. The accelerated ion enters an area with a magnetic field with a flux density of $B = 0.520$ T.
   a) Calculate the radius of the path of the ion in the magnetic field.
   b) Additional electric field is applied to the same area. Calculate the strength and direction of the electric field needed for the ion to move along a straight line in the area.

5. The cross section of a long straight wire is circular (radius R). The current I carried by the wire has an inhomogeneous distribution. The current density as a function of the distance from the center axis (r) of the wire is $J = \alpha r$, where α is constant.
   a) Calculate α expressed with R and I.
   b) Calculate $B(r)$, when $r \leq R$ and when $r \geq R$, using Ampere's law.

Constants: mass $m = 9.11 \cdot 10^{-31}$ kg and charge $e = 1.60 \cdot 10^{-19}$ C of electron, mass of proton and neutron $m = 1{,}67 \cdot 10^{-27}$ kg, $c = 3.00 \cdot 10^{8}$ m/s, $\mu_0 = 4\pi \cdot 10^{-7}$ Tm/A, $\varepsilon_0 = 8.85 \cdot 10^{-12}$ F/m

Name, student number, degree programme (EST, TLT, AUT, ...), course code and the date on each examination paper.