Several tasks for postgraduate students

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1) An observer holds in hands a magnetometer an electrometer, and an amperemeter. Initially, the magnetometer indicates the magnetic field **B**. The electrometer indicates the electric field **E** = 0. The amperemeter indicates the electric current **j**. What will be the indications of the devices after the observer starts moving with the velocity **v**? Write the Ohm's low.
2) A plane wave propagates along a uniform magnetic field with the phase velocity v_{ph}. The wave electric field is perpendicular to the ambient magnetic field and rotates with the frequency equal to the Larmor frequency of a charged particle. At the initial moment the particle is at rest. Prove that the particle velocity can not exceed 2 v_{ph}.
3) Which electric currents provide the frozen-in condition in the case when magnetic field lines envelop a non-conductive body surrounded by cold plasma?
4) Describe the behavior of a magnetic field tube filled with hot plasma:
   a) in a uniform magnetic field with straight field lines;
   b) in a non-uniform magnetic field with straight field lines;
   c) in a dipolar magnetic field with closed field lines;
   d) in the magnetotail lobe with open field lines.
   The tube is surrounded by vacuum.
5) Find plasma pressure distribution along a magnetic field tube, provided the pitch-angle distribution in the point of the minimum magnetic field is isotropic for large pitch-angles ($\alpha > \alpha_0$, $\alpha < \pi - \alpha_0$) and equal to zero for small pitch-angles ($\alpha < \alpha_0$, $\alpha > \pi - \alpha_0$).
6) Find the equivalent ionospheric current systems in the following cases:
   a) a vertical linear current flows into the horizontally uniform ionosphere;
   b) a vertical linear current flows into the plane ionosphere divided by a straight line into two semi-infinite parts of different uniform conductivities; (first consider the case of zero Hall conductivity, then of non-zero Hall conductivity).
   c) a three-dimensional current loop consisting of two vertical linear currents closed by a horizontal linear segment;
   d) a three-dimensional current system consisting of a uniform horizontal current flowing in a circle area (with no currents outside the circle) and vertical currents flowing on the sides of the cylinder based on the circle.
7) Describe the electric current system generated when a uniformly conducting disk oriented perpendicular to the magnetic field moves in magnetized plasma across the magnetic field.
8) Calculate the reflection coefficient of a hydromagnetic Alfvén wave in the following cases:
   a) the wave falls onto a sharp boundary of two homogeneous media, the boundary being oriented perpendicularly to the magnetic field;
   b) the wave falls onto a thin ionosphere with the horizontally uniform height-integrated Pedersen conductivity; the magnetic field being vertical; there is a vacuum below the ionosphere.
9) Calculate the contribution of the inner currents into the *Dst* index, providing the Earth contains a perfectly conducting layer having a form of a concentric sphere of radius r_i.
10) Of what form must be an electron for there were no electromagnetic wave radiation in its rotation around the atomic nucleus?