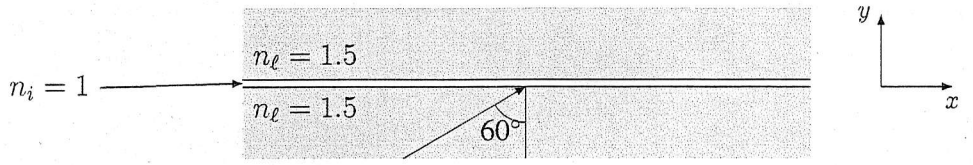
S-104.1320 Additional Course in Physics II Final exam May 20, 2011

Allowed material: writing implements, a graphical calculator and hand-written, at most A3-sized sheet of notes. Note sheet must be handed in, along with your exam solutions. You are not allowed to use any other material. There are some constants tabulated in last page of the exam. Justify the formulas you use in your answers and introduce the meaning of the symbols within these formulas. Solve each problem on separate page.

Try every problem. Good luck!

1. Define the following terms using at most about 30 words. Answering with only formulas will not yield full points. a) Fresnel coefficient b) electric polarization c) population inversion d) time dilatation e) proper length f) stimulated emission

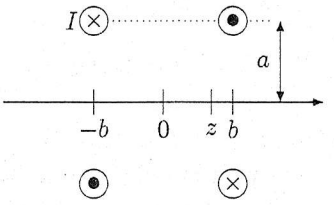
2. Figure below demonstrates two glass plates with a very narrow air gap in between them. A ray of light (vacuum wavelength 500 nm) is incident on the interface between the lower glass and air gap from the lower glass. The incidence angle is 60°.
   (a) Explain why in spite of the total internal reflection the beam of light continues its propagation also in the upper glass plate, provided that the air gap is very narrow. This phenomenon is called optical tunnelling or frustrated total internal reflection.
   (b) Determine the direction of propagation of the ray in the upper glass plate.



Problem 2

3. A particle's rest energy is mc^2. a) Determine the required speed for the particle momentum to be mc. b) Determine to particle's total energy in this case.

4. Magnetic resonance imaging (MRI) requires very uniform gradient of magnetic field. One possibility to realize this is by using two current loops with coinciding axes. The currents flow in the loop in opposite directions (cf. figure). Let the radii of the loops be a and their separation $2b$.



Problem 4

   (a) Determine the total magnetic flux density and its gradient due to the current loops at pois z on their common axis (cf. figure).
   (b) Find the separation of the current loops where the first and second derivatives of the total field's gradient vanish at origin $z = 0$. This configuration of coils is called the Maxwell coil.

Write CLEARLY in each paper your name, student number, degree programme, the code of the study module, and the date of the exam. Solve each problem on separate page.