02.05.2017 **Final Semester Exam - Modern Physics - PH2817** **90 min** **50 Marks**

1. A 20-year-old political prisoner is exiled to travel space for 35 Earth years. By a strange twist of fate, his daughter is born the very day that he leaves to serve his sentence. How fast would he need to travel so that, when he arrives back on Earth, he's the same age as his daughter? **5** Marks

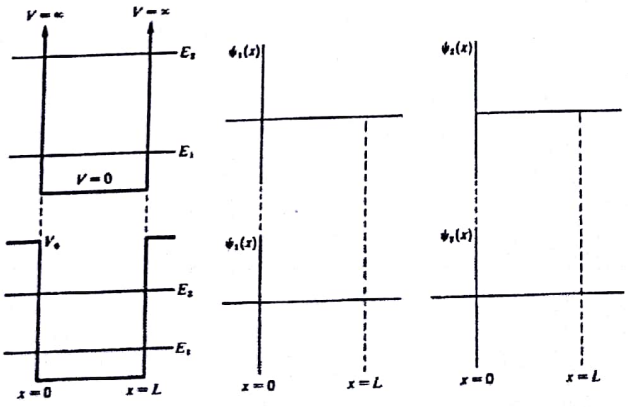
2. Muons are elementary particles with a (proper) lifetime of 2.2 μs. They are produced with very high speeds in the upper atmosphere when cosmic rays (high- energy particles from space) collide with air molecules. Take the height L of the atmosphere to be 100 km in the in the reference frame of the Earth. (a) What is the minimum speed that enables the muons to survive the journey to the surface of the Earth? (b) In the reference frame of the muon, what is the apparent thickness of the Earth's atmosphere? **10** Marks

3. Consider an ideal blackbody at TIncreasing the temperature by a factor of 2 does what to the frequency of the peak emission? Show all of steps. (**5** Marks)

4. Explain the difference between phase and group velocities for a wave packet. (5 Marks)

5. Consider a particle in a box (a.k.a. the infinite square well). Calculate the probability that a particle, in the ground state, will be found in the middle half of the well (i.e. L/4, 3L/4) **10 Marks**

6. Graphically compare the 1st and 2nd bound state of the infinite and finite square well by carefully sketching their wave functions in the space provided. **10** Marks



7. What is the physical meaning of the normalization condition? **5** Marks