General relativity: Questions for oral examination

The oral examination will take around 30 minutes, and will center around two of the questions below, randomly chosen. After you have presented your answers to your assigned questions, there will be some follow-up questions, and a discussion of related concepts. When passed, 40% of the final grade will come from the result of the oral examination.

1. Explain the equivalence principle, and use it to argue that gravity should be described as an expression of spacetime curvature, rather than as a force.

2. What is a geodesic? There are two definitions. State and explain both of them, in mathematical terms as well as in words.

3. Spacetime curvature is descibed by the Riemann tensor. Explain two different geometrical ways in which curvature shows up, and how these can be expressed by means of the Riemann tensor.

4. The causal structure of spacetimes can be visualized using Penrose diagrams. Explain what a Penrose diagram is in general, provide two examples of such diagrams, and explain what can be read off from them.

5. The predictions of General Relativity concerning properties of orbits around a star or a black hole differ in some respects from the Newtonian predictions. Explain in what ways, and compare the effective potentials of the two theories.

6. What experimental evidence is there for General Relativity? Imagine that you are trying to convince someone who doesn't believe in Einstein's theory, by describing how it does a better job in explaining experimental and observational data, compared to Newton's theory.

7. Write down the line element for a general Robertsson-Walker-cosmology. Explain the assumptions behind it. Discuss qualitatively what conclusions that can be drawn, when this line element is inserted into Einsteins equations for the case of a dust-filled universe.

8. Outline the correspondence between black hole physics and thermodynamics, by explaining what is meant by the first and the second law of black hole thermodynamics. These laws were formulated before Hawking's result that black holes radiate. How did this discovery affect these laws?