

## PHY 490 GR-Black Hole Research Paper

The purpose of this paper is for you to explore in some depth a topic that was not covered in the class and that is intimately connected to general relativity or cosmology. You can pick a topic from the below list of topics. If you think of another topic, then you will need approval of your topic by the topic approval deadline.

To keep you on track there will be three phases to the project.

1. First you will submit a proposal. This will be a short description of the topic and what you plan to research. A cursory search of books in the library, papers in physics journals, and/or reliable internet sites will be required. Your proposal should reference these materials. Also, you should indicate why this topic appeals to you. **This is due March 30<sup>th</sup>.**
2. Upon approval, you will do more extensive research on the topic and will write a draft of your paper on the topic. This will be a serious look into the topic, explaining the topic, what you have learned, how it is connected to the class, etc. You should include appropriate equations typed using an equation editor, numbered and offset like you see in your textbooks. Appropriate figures with captions would be a plus. Also, a worked example, or two, would help to assess what you have learned. This is due **April 13<sup>th</sup>.**
3. For the last phase, you will be given an opportunity to make corrections to your paper and answer the instructor's questions, fix any formatting problems, incorporate answers to any questions you might have had on the first draft. The final draft will be due the **April 27<sup>th</sup>.**

You are to follow the

1. All work is to be typed in 10 or 12 pt format and double spaced.
2. Your name should be on all pages and the work should be titled in an appropriate way.
3. All pages should be stapled and NOT folded and on standard sized paper.
4. You are expected to write using good grammar and spelling. Your thoughts should be presented in full sentences and you are to group your thoughts into paragraphs.
5. Your facts should be correct and you should reference all work that is not your own. **You should use more than one source and at least one text and/or journal source from the library.** Do not simply cut and paste from the Internet!
6. All equations should be typed preferably with the Equation Editor, numbered, referenced as Equation (), off set from text, and punctuated as any part of a sentence. This should follow the style in your textbooks or articles.
7. Figures should not be too big and should be labeled (Fig. 1, etc) and have captions.
8. You should reference work that is not your own, use standard bibliographic style and citation. See a physics journal for examples.

### Possible Topics

1. GPS and General Relativity.
2. Wormhole metrics, traversable wormholes.
3. The Thermodynamics of Black Holes.
4. Gravitational Waves and the LIGO Project, recent detections.
5. Pulsars, Neutron Stars and Other Exotic Objects.
6. Einstein's Equation.
7. The Cosmological Constant, Dark Energy and/or Dark Matter.
8. Gravitational Lensing.
9. Black Holes, other types beyond Kerr and Schwarzschild.
10. General Relativity and Other Models of the Universe.
11. Alternative Models of Gravitation.
12. Physics of *Interstellar* (for those who did not take my class in Fall 2020).

### Possible Resources

- <http://arxiv.org/archive/gr-qc>
- [http://www.dmoz.org/Science/Physics/Relativity/Research\\_Groups/](http://www.dmoz.org/Science/Physics/Relativity/Research_Groups/)
- <http://www.personal.soton.ac.uk/dij/GR-Explorer/homepage.html>
- [Gravity In The Quantum World And The Cosmos](#)
- [Physics Today, American Journal of Physics](#)