

Instructions:

- Place your name on all of your pages.
- Staple your pages with this **signed sheet on top** for full credit.
- Be clear and neat in your work. Any illegible work will not be graded.
- Answer in full sentences and paragraphs when required..

Pay attention to the point distribution. Also, not adhering to directions can cost points and any suspicion of cheating could result in a zero on the whole exam.

Page	Pts	Score
1	18	
2	17	
3	16	
4	8	
5	16	
6	10	
Total	85	

Have a good break!

You are to obey the honor code. There is to be no sharing of results, or getting answers from any other human being. If you have questions, you may consult Dr. Herman.

Sign the following:

I have not discussed this exam with anyone other than Dr. Herman. This is entirely my own work.

Name _____ Date _____

NOTE!

This cover page has to be signed and attached to the front of your solutions.

This is due no later than Dec 3rd.

I. (10 Pts) Who's Who?

Match the following names to the descriptions. (Enter the letter.)

A. Penzias	D. Pebbles	G. Eddington	J. Thomson
B. Wheeler	E. Slipher	H. Hubble	K. Kaluza
C. Planck	F. Randall	I. Rubin	L. Michell

- a. He confirmed the bending of light in 1919. _____
- b. Person who originally called black holes dark stars. _____
- c. She worked on anti-deSitter warping. _____
- d. She pioneered studies on galaxy rotation rates. _____
- e. Measured nebulae speeds using Doppler shift. _____
- f. Coined the term wormhole. _____
- g. He extended general relativity to five dimensions. _____
- h. He found that the universe was expanding. _____
- i. Nobel prize for discoveries in physical cosmology. _____
- j. A co-discoverer of CMBR. _____

II. (8 pts) Flatland:

- a. Why is it hard to recognize another person in Flatland?

- b. How do the shapes reflect social status?

- c. How does a Flatlander perceive of a person from Sphereland?

- d. How would you perceive a 5 dimensional Bulk Being?

III. (10 Pts) Terms from the Course

Find the best match and place the letter in the space provided.

A. Dark Energy	B. Doppler Effect	C. Bulk	D. Dark Matter
E. Lepton	F. Homogeneous	G. Isotropic	H. Spectrograph
I. Brane	J. Vulcan	K. Mercury	L. Quark
M. Cassini	N. Voyager	O. Time Dilation	P. Accretion disk

- a. What was probe was forced to crash into Saturn? _____
- b. A planet hypothesized to exist in the 1800s. _____
- c. The universe looks the same in any direction. _____
- d. What is used to detect composition of stars? _____
- e. What did Zwicky introduce to cosmology? _____
- f. Region where protons, electrons, and quarks live. _____
- g. What space probe has left the solar system? _____
- h. What is the cause of the accelerated expansion of the universe? _____
- i. La Verrier studied the motion of what planet? _____
- j. An electron is what fundamental particle in physics? _____

IV. (7 Pts) Numbers

- a. How old is the universe? _____
- b. How many galaxies are there? _____
- c. What are the current percentages of
 - i. Dark Energy _____
 - ii. Cold Dark Matter _____
 - iii. Radiation _____
- d. What is the radius of Gargantua? _____
- e. How big is a massive black hole? _____

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- V. **(16 pts) Short Answers: Be as specific as possible**
- a. Describe all of the anomalies in the movie.

 - b. How do massive black holes form?

 - c. What distinguishes a naked singularity from others?

 - d. How would you describe the Bulk to a lay person?

 - e. What was Einstein's greatest blunder?

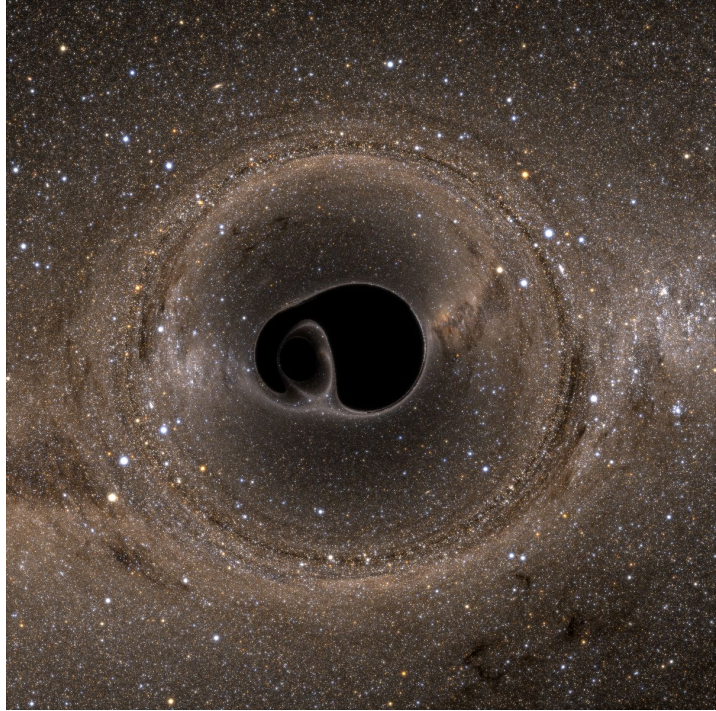
 - f. What was Einstein's "happiest thought?"

 - g. What is a hologram and how is this idea used to describe black holes?

 - h. You can draw a triangle in Flatland and a 4-pointed pyramid in Sphereland. What would the generalization look like in four dimensions or five dimensions?

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- VI. (8 pts) **Black Hole Image** Describe what you see in this picture. Make sure to discuss things like Einstein rings, black hole shadows, gravitational lensing, possible multiple images, etc. Describe the physics behind what you see and point out specifics in the image supporting your claims.



IX. **(10 Pts)** Short Essays II. –Write coherent essays on each topic, listing at least five important facts.

a. What was the importance of gravity in the movie?

b. Time is presented as one of many dimensions. Present an argument as to why you think time is, or is not, a dimension.