Astronomy 1142: Review Guide For Midterm

The midterm exam will be Wednesday, October 13, in class. The exam will consist of multiple choice questions and a short essay. It will take the whole class period.

You may bring one page (both sides) of *handwritten* notes, and a calculator.

There will be two Q&A review sessions, both optional, but likely to be very helpful. The first will be after class (4-5:15 pm) on Monday, October 11, *in our usual classroom.* The second will be in McPherson Lab, room 4054, from 5:30 pm - 6:45 pm, on Tuesday, October 12. I will run the first, and the course TA, John Bredall, will run the second. Both of these reviews are Q&A, so it's up to you to bring in questions, which can be on any aspect of the material, problem sets, etc. You will also benefit from hearing your classmates questions. We won't answer "will this be on the exam?" questions, but we'll try to give useful guidance to the importance of topics and levels of detail.

The topics for the midterm are the black hole overview (course introduction), Newton's theory of motion and gravity, Special Relativity, and General Relativity, up through what we cover in Monday's lecture.

You should review the lecture notes, the Prologue and Chapters 1 and 2, of Thorne's book, and the first two homework sets and their solutions. Be sure that you understand the basic principles of the homework solutions, even if you didn't get the problem right when you did the homework. Even if you take your own lecture notes, I highly recommend looking at the online lecture notes as well. Also, this would be a good time to *reread the syllabus* to remind yourself of the overall structure and goals of the course.

You should be familiar with the following equations: what principles they express, and how they can be used.

$$v_{\rm esc} = \sqrt{\frac{2GM}{R}}$$

$$d = vt = \frac{1}{2}at^2$$

$$F = ma$$

$$F = \frac{GMm}{r^2}$$

$$a = \frac{v^2}{r}$$

$$(P/1\,{\rm year})^2 = (r_p/1\,{\rm AU})^3$$

$$\frac{GM}{4\pi^2} = \frac{r^3}{P^2}$$

$$E = hc/\lambda$$

$$E = mc^2$$

$$t'/t = l'/l = \gamma, \qquad \gamma = 1\Big/\sqrt{1-\frac{v^2}{c^2}}$$

$$\lambda_o = \lambda_e \times \left(1+\frac{v}{c}\right) = \lambda_e \times \left(1+\frac{gl}{c^2}\right)$$

OVER $\longrightarrow$

You should know what Newton's laws of motion are. You should know what Kepler's laws are of planetary motion are and why they were important to the development of Newton's theory of gravity.

Names you should know: Newton, Einstein.

Pay attention to the relation between Einstein's theory of gravity and Newton's theory of gravity.

Most important of all: Pay attention to the *empirical* evidence that supports Newton's theory of gravity, Special Relativity. and General Relativity. For a reminder about the meaning of "empirical evidence," see the end of the lecture notes for Part 1.

Example Questions For A1142 Midterm

1. Isaac Newton
(a) invented calculus
(b) invented the reflecting telescope
(c) showed that white light is really a superposition of multiple colors
(d) discovered the inverse-square law of gravity
(e) all of the above

2. A hydroelectric dam produces electrical power that can be used to light and heat homes and businesses. What is the initial source of energy for a hydroelectric dam?
(a) Electrical energy stored in the water
(b) Chemical energy stored in the water
(c) Gravitational potential energy of the water
(d) $E = mc^2$ energy of the water

3. The distance from the earth to the moon is 384,000 km. You discover a new planet, which has a moon that orbits it (in a circular orbit) at a distance of 768,000 km, exactly twice the earth-moon distance. With repeated observations, you determine that the orbital period of the new planet's moon is one month, exactly the same as earth's moon. What is the mass of the planet?
(a) the same as the mass of the earth
(b) twice the mass of the earth
(c) four times the mass of the earth
(d) eight times the mass of the earth
(e) there is not enough information to infer the mass of the planet

4. Mr. Tompkins glances at his watch, and he realizes with horror that it is already 2:30 pm and he has a 3:00 pm meeting very far from his house. He leaps onto his bicycle and quickly accelerates up to 80 percent of the speed of light ($0.8c$). After pedaling furiously for 29 minutes, he brakes, hops off his bike, brushes his jacket off, and walks into the meeting just as his watch reads 3:00 pm. (Don't worry about the fact that he could have gone many times around the earth; pretend either that the earth is big or the speed of light is slow.) Is Mr. Tompkins
(a) About 12 minutes early for his meeting
(b) About 2 minutes early for his meeting
(c) Exactly on time for his meeting
(d) About 2 minutes late for his meeting
(e) About 20 minutes late for his meeting

5. Over the course of 10 years, you monitor a star near the center of the Milky Way and find that it orbits in a circle around the Milky Way's central black hole. Which of the following equations could you use to determine the mass of the black hole?

$$\text{(a) } E = mc^2, \quad \text{(b) } \frac{GM}{4\pi^2} = \frac{r^3}{P^2}, \quad \text{(c) } \gamma = 1/\sqrt{1 - \frac{v^2}{c^2}}, \quad \text{(d) KE} = \frac{1}{2}mv^2, \quad \text{(e) } R_{\rm Sch} = \frac{2GM}{c^2}\ .$$

Sample "essay" question: Einstein's theory of special relativity is based on two postulates, and it predicts many remarkable phenomena: time dilation, length contraction, conversion of mass to energy, increase of inertial mass at high speeds, and so forth. Describe three examples of *empirical* evidence that show Einstein's predictions are correct — i.e., that they describe our universe and are not just mathematical oddities. For each example, explain what the evidence is and why it is significant.