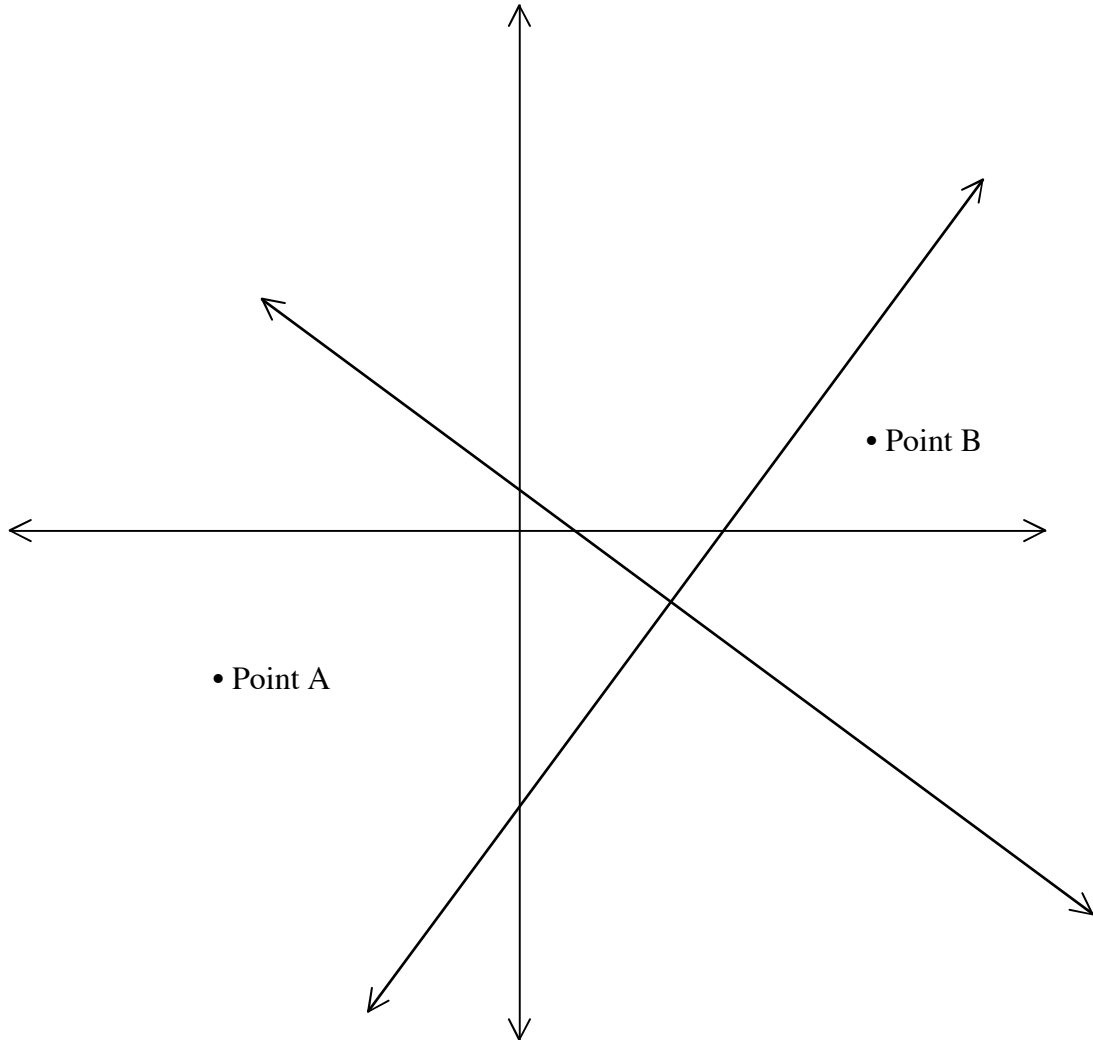


Modern Physics - Philosophy of the Natural World

# General Relativity Class Work

1. Einstein's **Special** Theory of Relativity states that what two situations are equivalent? How about his **General** Theory of Relativity?
2. In Special Relativity, which key variable controls the **degree** to which other interesting variables appear to be "distorted"? What are the three most interesting variables that appear to be distorted?
3. In Special Relativity, could an observer within the same reference frame as the "distorted" objects measure the amount of their distortion?
4. In General Relativity, could an observer within a non-inertial reference frame measure the **amount** of acceleration/gravity (number of g's) without looking outside this reference frame? If so, **carefully** describe an experiment they could do to measure the number of g's. If not, explain why they cannot determine the amount of acceleration/gravity without looking outside.
5. Suppose that you are inside a spaceship accelerating at 1g through deep space. Can you do more pushups, less pushups or the same number of pushups that you can do at your house on Earth?
6. What happens to the trajectory of a horizontally thrown ball (on Earth) if you increase the speed a little bit with each successive throw?
7. What happens to the trajectory of the same ball if you increase the strength of gravity a little bit before making each successive throw?
8. Give **two different** reasons why we don't notice the bending of light due to gravity here on Earth.
9. How would the trajectory of a baseball thrown horizontally near the surface of the Earth at the speed of light (assuming this were possible, of course) compare to the trajectory taken by light itself? Assume that there is no air resistance or other friction.
10. Suppose that a laser beam (on Earth) is shot horizontally so that it strikes a vertical mirror, reflects, and then strikes a second vertical mirror positioned behind the laser. (Don't worry about how the reflected beam gets past the laser.) Draw a simplified diagram showing the path that the beam will take as it reflects back and forth.

11. Use a ruler to measure the x and y coordinates of the two points below, with respect to the vertical and horizontal coordinate system:



12. Repeat this procedure, but this time use the coordinate system that's twisted a bit counter-clockwise.
13. Compute the distance between the points using the Pythagorean theorem and your x and y coordinates from **Question #1**, and then repeat this computation using your x and y coordinates from **Question #2**.
14. Use a ruler to directly measure the distance between the two points.
15. Draw a large triangle and then carefully use a protractor to measure each of the three angles. Compute the total of the three angles. If you had performed this exercise perfectly, what total **should** you have gotten?

16. As you move toward a massive object, what happens to the speed of your watch, according to an outside observer? How about when you move toward the center of a spinning disc?
17. Answer the same two questions in **Question #16**, but this time from **your own** perspective.
18. Explain how we on Earth can sometimes see the light emitted from a star that is directly behind some closer massive object that should completely obscure the star.
19. If you want to minimize distance on a direct flight from Pittsburg to Bangkok, which direction should you start flying, N, S, E, W, NE, NW, SE, or SW?
20. How does moving a meter stick from the basement of the Empire State Building to the observation deck on top affect the meter stick's length, according to an observer on the Moon?
21. What two seemingly unrelated phenomena did Isaac Newton unify as manifestations of a single force?
22. What aspect of Isaac Newton's theory of gravity did he leave completely unexplained?
23. Briefly describe Albert Einstein's answer to the question Newton left unanswered.
24. How long did Isaac Newton think it took the force of gravity to get from the Sun to the Earth? How about Albert Einstein? Note: the Earth is approximately  $1.5 \times 10^{11}$  meters away from the Sun.
25. Which two forces had James Clerk Maxwell already unified into a single force when Einstein began trying to unify the other known forces?