9 Part 9: Making experiments with general relativity

In part 9 you will do a selection of the exercises in lecture notes 2C, 2D and 2E, but some with a twist:

1. Exercise 2C.1, your reporting should be on questions 1, 2, 3 and 5.

2. For exercise 2C.2, you will create the videos yourself. Here you need your partner. Read quickly through the exercise before reading on. Now you create the video for your partner:

   ```
   mySS.part2C_2(distance)
   ```

   where `distance` is a string being either `'far'` or `'close'`. Far or close here means observer far from or close to the black hole. You should agree with your partner who does which video. When running this method you will be prompted about your daily routine, i.e. when you wake up, eat breakfast etc and also about messages you want to send to your colleague in the other space whip when doing these tasks. An xml-video is then created which you should send to your partner. You will receive the video from the other reference system from your partner. Now you can do exercise 2C.2 using the video you received from your partner.

3. Do exercise 2C.3, here it is very important that you write clearly about the main principle and the main idea. Show that you understand.

4. You will create the videos for exercise 2C.5 youself:

   ```
   mySS.part2C_5(number_of_light_signals = 30)
   ```

   where the number of light signals can be in the range $[10, 100]$. This methodes automatically creates the xml for both frames. Decide with your partner who does which video. You send the video for one of the frames to your partner and vice versa. Note that for question 6, you must tell your partner which signals she/he should use as the colours you will see may differ from the ones in the standard-xmls. Now you should do exercise 2C.5 using the video you got from your partner.

5. Read through exercise 2C.7 without doing the exercise. Now design an exercise which may (or may not) be inspired by 2C.7 where two shell-observers at different shells (in a setting of your choice) where at least one shell observer has a constant velocity in the ϕ-direction. The exercise should aim at finding a time difference between the two shell clocks, you should adjust the numbers in the exercise such that there is a noticable time difference. Now exchange exercise with your partner and do the exercise which you are given.

6. For exercise 2C.8 you should again make a video for your partner:

   ```
   mySS.part2C_5(chosen_planet, theta = angle_position)
   ```

where chosen planet is the planet number where you have landed and `theta` is the position of the observer in the x-y plane: $\vec{r} = (R\cos\theta, R\sin\theta)$ where R is the radius of the planet. You may decide to use your friend's planet my specifying `friend_seed = seed`. As in part 8, you may also specify an `increase_height` parameter to get higher above the ground. In particular, make sure you are high enough to see the satellites through the atmosphere. After making the video, exchange with your partner and do exercise 2C.8

7. You should do exercise 2D.3. You only need to report on questions 5 - 7. Focus your reporting on showing understanding of the results.

8. Exercise 2E.2, again you are supposed to make your own video, make sure you use exactly the same parameters as when creating the corresponding video in 2C.5. In fact you are supposed to use the same method:

   ```
   mySS.part2C_5(number_of_light_signals = 30,
   consider_light_travel = True,
   filename1 = 'part2E_2_frame1.xml',
   filename2 = 'part2E_2_frame2.xml')
   ```

   where `consider_light_travel` makes the video include the light travel time (which you must do to create video for exercise 2E.2). Now exchange video with your partner and do exercise 2E.2

9. Do exercise 2E.4 but your reporting should focus on explaining the concept of effective potential and compare the shape of the effective potential for light with the effective potential for massive objects and explain why these behave differently in a gravitational field based on the shape of the potential.

10. Exercise 2E.7, question 1 and 2 only, focus your reporting on explaining the physics and geometry. Instead of the Sun, you should use the star in your solar system.

When writing your report for part 8 and 9, you should still not refer to exercise numbers, you should rather write the exercises as experiments performed where you need to explain the motivation for doing the experiment and what you expect to learn from the results. This helps you grasping and writing the meaning of each exercise instead of just answering questions one by one.