AST 2000 - Part 9
General relativity

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This abstract is abstract.

I. EXERCISE 1

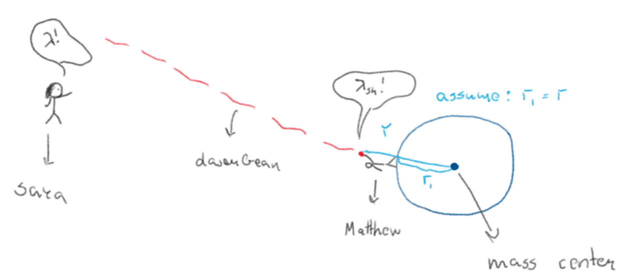
Introduction

We assume that the reader is familiar witht the situation. Here we will be attempting to find the the wavelenght which Sara observe from Matthews laser pen. We will be attemting to find out the difference between

Situation

A shell observer (Matthew) is located on shell with radius r from the center of mass. Matthew have gotten his new laser pain, and chooses to point the laser pen radially outwards from the center of mass. Matthew can observe this lasers wavelength with λ_{shell}.

We have another observer (Sara) who is far-away observer. Sara observer the laser beam from Matthews pen with wavelenght λ.



Method

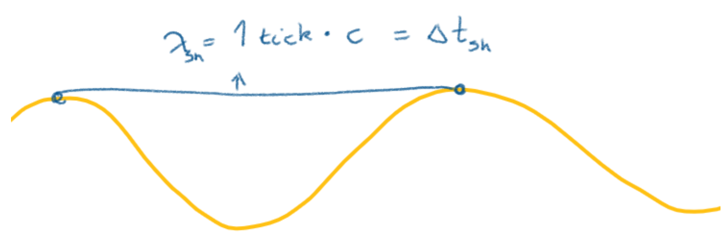
First we will be showing that the difference in time interval measured by the two observers is given by

$$\Delta t = \frac{\Delta t_{shell}}{\sqrt{1 - \frac{2M}{r}}}$$

In order to answer this we will be assuming that Matthew lives in local inertialsystem. And therefore he follows Lorentz geometry. If matthew is really really small, he then observers his world as a flat world, the curviture is so insignificant, that we can confidently assume that he lives on a flat world.

Sara however, is far away, and sees the planet as round, and she therefore has to use spherical Schwarzschildgeometry! We then will use invariance of spacetime distance, in order to find the expression above.

We have also gotten informed that in every tick on the clock of the observer, the peak of wave of the light beam passes.



We then know we can use same transformation principle of transforming wavelenght from one ref. system to another as for time. Then we are left to put in values in expression

$$\frac{\Delta\lambda}{\lambda_{shell}} = \frac{\lambda - \lambda_{shell}}{\lambda_{shell}}$$

We show full solution in special question section.

II. EXERCISE 2

Introduction

In this exercise we will be using maximums aging principle in order to show the law of conservation of angular momentum in general relativity. We will apply this by looking at a specific situation, a debris falling to the planet (explained in situation section).

The Situation

We have a space debris which falls towards a planet. This debris passes three points

$$(r_1, \phi_1)$$

$$(r_2, \phi_2)$$

$$(r_3, \phi_3)$$

at time t_1, t_2 and t_3
These three points are infinitesimal close to each other, we therefore define two points r_a and r_b, where r_a is inbetween (r_1, ϕ_1) and (r_2, ϕ_2), and r_b is inbetween (r_2, ϕ_2) and (r_3, ϕ_3). Figure below illustrates this situation visually.

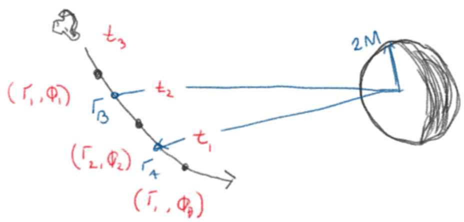


Figure 1. debris falling

method

III. EXERCISE 3

IV. EXERCISE 4

V. EXERCISE 5

VI. EXERCISE 6

VII. EXERCISE 7

ACKNOWLEDGMENTS

I would like thank myself for writing this beautiful document.

REFERENCES

- Reference 1
- Reference 2

Appendix A: Name of appendix

This will be the body of the appendix.

Appendix B: This is another appendix

Tada.

Note that this document is written in the two-column format. If you want to display a large equation, a large figure, or whatever, in one-column format, you can do this like so:

This text and this equation are both in one-column format. [1]

$$\frac{-\hbar^2}{2m}\nabla^2\Psi + V\Psi = i\hbar\frac{\partial}{\partial t}\Psi \tag{B1}$$

Note that the equation numbering (this: B1) follows the appendix as this text is technically inside Appendix B. If you want a detailed listing of (almost) every available math command, check: https://en.wikibooks.org/wiki/LaTeX/Mathematics.

And now we're back to two-column format. It's really easy to switch between the two. It's recommended to keep the two-column format, because it is easier to read, it's not very cluttered, etc. Pro Tip: You should also get used to working with REVTeX because it is really helpful in FYS2150.

One last thing, this is a code listing:

```
This will be displayed with a cool programming font!
```

You can add extra arguments using optional parameters:

```
This will be displayed with a cool programming font!
```

You can also list code from a file using `lstinputlisting`. If you're interested, check https://en.wikibooks.org/wiki/LaTeX/Source_Code_Listings.

This is a basic table:

Table I. This is a nice table

Hey	Hey	Hey
Hello	Hello	Hello
Bye	Bye	Bye

You can a detailed description of tables here: https://en.wikibooks.org/wiki/LaTeX/Tables.

This is a more advanced table:

Table II. Tabelleksempel

Partikkelindeks (i)	**Posisjon** (m)	**Hastighet** (m/s)
0	139.22	12.4
1	14.88	18.7
2	233.9	10.10
3	816.12	13.4

I'm not going to delve into Tikz in any level detail, but here's a quick picture:
If you want to know more, check: https://en.wikibooks.org/wiki/LaTeX/PGF/TikZ.

[1] This equation is actually from quantum mechanics. "It's called Schrödinger's Time-Dependent Wave Equation", named after the awesome Austrian physicist Erwin Rudolf Josef Alexander Schrödinger. Yep, the "Schrödinger's cat" guy. Pretty cool dude actually, check his wiki page: https://en.wikipedia.org/wiki/Erwin_Schrodinger. He was physics' no. 1 Ladies' man if there ever was one. Anyway, you will learn more about this equation in FYS2140. You can also find it printed on a glass wall in the UiO Physics Building (it really is that important).

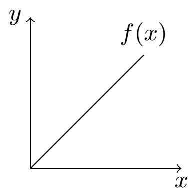


Figure 2. This is great caption