Solutions to exercises in part 2C

Exercise 2C.1

4. (a)

$$M_{\text{Sun},m} \approx 1485.18\, m$$

Thus

$$\frac{M_{\text{Sun},m}}{r_{\text{Sun}}} \approx 2.1354 \cdot 10^{-6}$$

(b)

$$\lambda \approx 500.001\, nm$$

The apparent color of the Sun will therefore not change.

(c)

$$\frac{M_{m,\text{Earth}}}{r_{\text{Earth}}} \approx 6.9608 \cdot 10^{-10}$$

(d)

$$\lambda_{\text{shell}} \approx 499.9999997\, nm$$

5.

$$r \approx 2.1689M$$

6.

$$\lambda_{\text{shell}} \approx 35.25 \cdot 10^{-9}\, m$$

This means that we would need a telescope that can observe ultraviolet/x-rays to look at the stars.

Exercise 2C.2

Numerical solutions can be found in the solutions folder for the xml-files.

Exercise 2C.4

1.

$$\left(1 - \frac{2M}{r}\right) \frac{dt}{d\tau} = 1,$$

Exercise 2C.5

Note: numerical solutions can be found in the solutions folder for the xml-files.

Exercise 2C.7

1. This deduction is done in detail in lecture note 2C (see GPS example).
2. $$\begin{aligned}\frac{M_m}{r} &\approx 6.961 \cdot 10^{-10} \\ v_{\text{plane}} &\approx 9.267 \cdot 10^{-7} \\ v_{\text{Earth}} &\approx 1.545 \cdot 10^{-6}\end{aligned}$$

   These values are so small that we can justify a Taylor expansion.
4. Over the the span of 50 years we find

   $$\Delta T \approx 1.0512 \cdot 10^{-3}\, s$$

   which is about $1\, ms$ extra.

Exercise 2C.8

Note: numerical solutions can be found in the solutions folder for the xml-files.