Theoretical round. Problems to solve

General note. Maybe not all problems have correct questions. Some questions (maybe the main question of the problem, maybe one of the subquestions) may make no real sense. In this case you have to write in your answer (in English or Russian): «**impossible situation – ситуация невозможна**». Of course, this answer has to be explained numerically or logically.

Data from the tables (Planetary data, stars, constants, etc.) may be used for solving every problem.

The answers «**Да-Yes**» or «**Нет-No**» have to be written in English or Russian.

1. **Star rise in Moletai.** An observer in Moletai recorded that a star culminated at 02:54 and set at 05:45 on September 8, 2013. Effects of irregularities of the horizon should not be taken into account.
   1.1. At what time will the star rise on September 9, 2013?
   1.2. In approximately which direction do you need to wait for the rising of the star? Choose one of the alternatives: N, NE, E, SE, S, SW, W, NW. Draw a picture with an explanation.

2. **Gliese 581 g.** This celestial body in the system of the star Gliese 581 is the most Earth-like planet found outside the Solar System, and the exoplanet with the greatest recognized potential for harboring albuminous based life.
   Estimate orbital period τ of Gliese 581 g. Consider the orbit to be circular.

3. **Observations from Gliese 581 g.**
   3.1. What is the apparent magnitude of our Sun and **3.2.** what is the approximate constellation in which our Sun will be seen when observed from the planet Gliese 581 g?

4. **XVIII century. Midday.** (Dubingiai is the nearest town to the accommodation place of XVIII IAO.).
   There were different systems of units of measurement in the history of science. This problem is to use historical (at present obsolete) units of measurement.
   4.1. Calculate the capacity of the solar energy that in the end of the XVIII century fell on the unit of area of the territory in the outskirts of Dubingiai at midday time:
   in winter, in spring, in autumn, and in summer.
   The answer must be given using only the «new» physical units, which were coming into operation in those days in this area: horse-powers per square verst.
   4.2. Estimate also the capacity of the solar energy incident on a local horse those times. The answer must also be expressed in physical units, which were coming into operation in those days. What can be surprising about the right answer?

5. **XXI century. Midday.** As is known, the Republic of Lithuania (see map) uses zone with winter time UT+02 and summer time UT+03. Calculate and draw a conclusion about the following:
   5.1. Are there any places in Lithuania, where today (September 8, 2013) the Sun will be exactly in the south at a time when the watches of residents will show just 12:00? (**«да-yes»** or **«нет-no»**).
   5.2. And in general, on the other days of the year, are there such places? (**«да-yes»** or **«нет-no»**). If "yes", then calculate in what dates, if "no", then justify it by calculations.

6. **Supernova remnant.** An X-ray image of supernova remnant (SNR) Cas A located at a distance of d = 3400 pc was obtained using Chandra Space Observatory. The negative of this image is shown in Fig. SNR. The boundaries of the SNR region are marked by a circle. The scale of the image is shown in the upper left corner of the figure. A dot located close to the center of the circle is the neutron star – the remaining core of the collapsed star. The rectangular marks outside the circle are given for the reference when determining the center of the circle.
   Assume that the amount of energy released in the supernova explosion was about $E_{SN} \approx 10^{46}$ J, 1% of which drives the expansion of the remnant. The average density of the matter in the SNR is $\rho \approx 10^{-21}$ kg/m^3.
   6.1. Estimate the age of the SNR Cas A.
   6.2. Calculate the average velocity of the motion of the neutron star from the center of the SNR.