Крым, Симеиз 1 – 9. X. 2004 Simeiz, Crimea

Задачи теоретического тура

Theoretical round. Problems to solve

язык / language	English

Group α

1. **Distance between galaxies.** In the cluster of galaxies in the constellation of Virgo the density of galaxies is 30 per cubic megaparsec. Estimate the average distance between the galaxies in this cluster.

2. **Comet.** During an observation of a solar eclipse the observers discovered a comet bodies in the constellation of Aries near the solar corona. Further research have shown that at the detection time the comet was in the aphelion of its orbit (distance from the Sun A = 8.85 a.u.), and in perihelion the distance from the Sun is equal to P = 1.63 a.u. Will the comet be visible to any observer on the Earth during its nearest transit of perihelion? In what constellation will it be? The answer has to be explained by necessary formulae and numerical calculations. (Note: the answer «Да-Yes» or «Нет-No» has to be written in English or Russian.)

3. **Occultation.** Venus makes a central occultation of a star at the time of maximum elongation. Please find the duration of the occultation. The orbits of Venus and Earth may be considered as circular ones.

4. **Moon.** Yesterday during the observation round you saw the moon. Sometimes there were no clouds. Imagine that at the same time the moon was observed by school children on mountain Koshka (which means "cat" in Russian) (branch of the Crimean Astrophysical Observatory). The objective diameter of the telescope-refractor used is D = 8 cm and its focal length is F = 304.8 cm. There was a photographic plate in the focal plane of the objective. Draw in actual size the image (with the main details), which appeared on the photographic plate after it had been developed. The direction "top" in your picture should coincide with the direction "top" on the photographic plate. All calculations necessary for the correct solution should be shown.

5. **Cats in space.** Exactly 47 years ago, on October 4, 1957, the first artificial satellite of the Earth, "Sputnik I", was launched. Soon after animals went to space. At first there were Russian dogs, then American monkeys... And the French government planned to send cats into space, and not simply one or two cats, but a whole crew of 5 cats! You can see the squad of French cat astronauts (five members of the main crew and one doubler (reserved astronaut)) on the photo. In one of the experiments the cats were illuminated by a strong floodlight located on the Eiffel tower and the data were analyzed. The experiments with the doubler located 10 km from Eiffel tower, have shown, that each of its eyes when hit by this floodlight sparkles as a star of 7^m (while observed from Eiffel tower).

   Calculate approximately the visible stellar magnitude of the total constellation of the eyes of the crew, if the satellite flies above Paris at an altitude of 250 km.

   Estimate roughly from what maximum distance the members of the main crew could determine that the light of the eyes of the cat-doubler is not simply a single star but a binary star?

   Consider all the crew members and doubler to be identical to each another. The height of the Eiffel tower is h = 300 m.

6. **Eclipse.** For the reconstruction of historical events, dates and places of the past solar eclipses are often calculated. However, the rotation of the Earth continually slows down and solar eclipses take place not there, where they should be in agreement with calculations on a model with constant rotation of the Earth with the present angular rate. In what century did such an eclipse take place in Paris ($\lambda = 0°$, $\varphi = 45°$) instead of Crimea ($\lambda = 34°$, $\varphi = 45°$)? The length of a day increases by 0.0016 seconds per 100 years due to that rotation of the Earth slows down.

Data from the "Table of planetary data" may be used for the solving of every problem.
And the White Bear and Penguin are waiting for you on the practical round.

Крым, Симеиз 1 – 9. X. 2004 Simeiz, Crimea

Задачи теоретического тура

Theoretical round. Problems to solve

язык / language	English

Group β

1. **Distance between galaxies.** There are about 100 galaxies in the cluster of galaxies in the constellation of Virgo. The region in our sky covered by this cluster is about 6×6°. The distance to the cluster is equal to 15 Mpc. Estimate the average distance between the galaxies in this cluster.

2-3. **Cometary bodies.** During an observation of a solar eclipse the observers discovered two cometary bodies in the constellation of Aries near the solar corona at an angular distance of $\alpha = 9''$ from each other. Further researches have shown that these two bodies are moving along exactly the same path, at the detection time they were in the aphelion of their orbit (distance from the Sun A = 8.85 a.u.), and in perihelion the distance from the Sun is equal to P = 1.63 a.u.

2. Will these bodies be visible to any observer on the Earth during their nearest transit of perihelion? In what constellation will they be? The answer has to be explained by necessary formulae and numerical calculations. (Note: answer «Да-Yes» or «Нет-No» has to be written in English or Russian.)

3. What will thus be (or would thus be) the angular distance β between them as seen from the Earth?

4. **Moon.** Yesterday during the observation round you saw the moon. Sometimes there were no clouds. Imagine that at the same time the moon was observed by school children on mountain Koshka (which means "cat" in Russian) (branch of the Crimean Astrophysical Observatory). The objective diameter of the telescope-refractor used is D = 8 cm and its focal length is F = 304.8 cm. There was a photographic plate in the focal plane of the objective. Draw in actual size the image (with the main details), which appeared on the photographic plate after it had been developed. The direction "top" in your picture should coincide with the direction "top" on the photographic plate. All calculations necessary for the correct solution should be shown.

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   Calculate approximately the visible stellar magnitude of the total constellation of the eyes of the crew, if the satellite flies above Paris at an altitude of 250 km.

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   Consider all the crew members and doubler to be identical to each another. The height of the Eiffel tower is h = 300 m.

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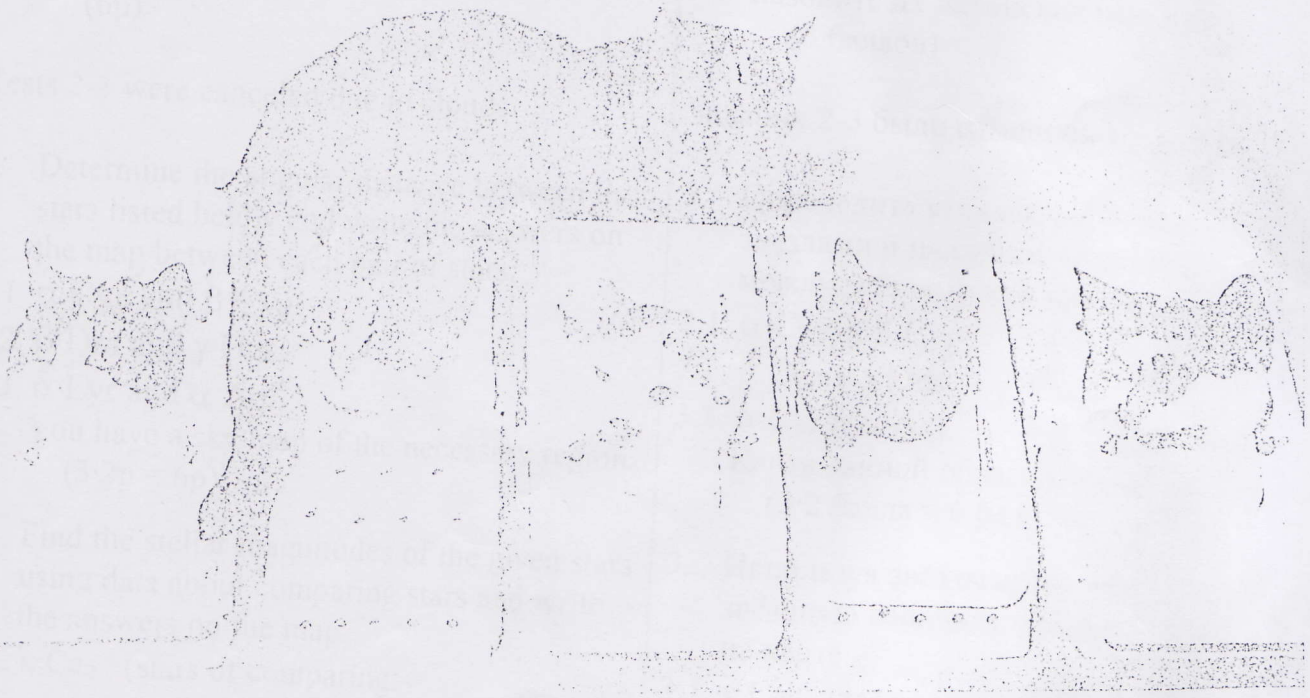
Data from the "Table of planetary data" may be used for the solving of every problem.
And the White Bear and Penguin are waiting for you in the practical round.

Элементы орбит. Физические характеристики некоторых планет, Луны и Солнца

Parameters of orbits. Physical characteristics of some planets, Moon and Sun

Небесное тело, планета	Среднее расстояние от центр. тела		Сидерический период обращения		Эксцентриситет,	Экваториальн. диаметр	Масса	Средняя плотность	Ускор. своб. пад. у пов.	Макс. блеск, вид. с Земли **)	Альбедо
	в *астр. ед.*	в *млн. км*	в тропич. годах	в средних сутках	*e*	*км*	10^{24} *кг*	$г/см^3$	$м/с^2$		
Body, planet	Average distance to central body		Sidereal (or analogous) period		Eccentricity	Equat. diameter	Mass	Av. density	Grav. acceler. at surf.	Max. magn. from Earth **)	Albedo
	in *astr. units*	in *mln. km*	in troph. years	in days	*e*	*km*	10^{24} *kg*	g/cm^3	m/s^2		
Солнце Sun	$1{,}6 \cdot 10^9$	$2{,}5 \cdot 10^{11}$	$2{,}2 \cdot 10^8$	$8 \cdot 10^{10}$		1392000	1989000	1,409		$-26{,}8^m$	
Меркурий Mercury	0,387	57,9	0,241	87,97	0,206	4 879	0,3302	5,43	3,70	$-2{,}2^m$	0,06
Венера Venus	0,723	108,2	0,615	224,70	0,007	12 104	4,8690	5,24	8,87	$-4{,}7^m$	0,78
Земля Earth	1,000	149,6	1,000	365,26	0,017	12 756	5,9742	5,515	9,81		0,36
Луна Moon	0,00257	0,38440	0,0748	27,3217	0,055	3 475	0,0735	3,34	1,62	$-12{,}7^m$	0,07

**) Для внешних планет и Луны – в среднем противостоянии.
**) For outer planets and Moon – in mean opposition.



Фотография. Коты на тренировке к космическому полёту, планировавшемуся французским правительством в 1973 году. Смоделированы условия пребывания в тесных скафандрах.

Photo. Cats train for space travel planned by the French government in 1973. The enclosures are meant to simulate spacesuit confinement.

Крым, Симеиз 1 – 9. X. 2004 Simeiz, Crimea

Тезисы решений задач теоретического тура

Theoretical round. Sketches for solutions

язык / language	English

α1. **Distance between galaxies.** The volume for 1 galaxy in the cluster is 1/30 of a cubic megaparsec. The reference linear size of this volume of space is $(1/30)^{1/3} = 0{,}322$ megaparsecs. It is also the average distance between galaxies. However, the precision up to three and even up to two significant figures here is inappropriate. The correct answers: "about 0,3 megaparsecs" or "about 1/3 megaparsecs".

β1. **Distance between galaxies.** Note at first, that the precision up to three and even up to two significant figures here is inappropriate, therefore the calculations will be yielded to within two significant figures, and in the answer one figure is pertinent only. The linear size of the cluster is approximately equal to 1.5 Mpc (6° is about 1/10 radian. Accordingly the linear size is approximately 10 times less than the distance to the cluster). Thus, the volume for these 100 galaxies is equal to $1.5^3 \approx 3.4$ cubic megaparsecs. So the volume for 1 galaxy in the cluster is equal to 0.034 cubic megaparsecs. The reference linear size of this volume of space is $(0.034)^{1/3} \approx 0.32$ megaparsecs. It is also the average distance between galaxies. Since only one significant digit is appropriate, the correct answers are: "about 0,3 megaparsecs" or "about 1/3 megaparsecs".

α2. **Comet.** See solution for β2.

β2. **Cometary bodies.** The major semi-axis of the orbit of the cometary bodies is $a = (A+P)/2 = 5.24$ a.u. It means, according to Kepler's Third Law, that they make a full revolution around the Sun during $T = T_0 \cdot (a/a_0)^{3/2} = 12$ years. Thus, they will be in perihelion $t = T/2 = T_0 \cdot (a/a_0)^{3/2} / 2 = 6$ years later. Therefore, the Earth at this moment will be at the same point, as during the discovery, and the bodies – at a point opposite in ecliptic longitude. As during the discovery the bodies were in cojunction with the Sun (or very close to this position), in the perihelion they will be in opposition and so they can be observed. Answer: **Да-Yes**. They will be in constellation opposite to Aries, that is in Libra.

β3. **Cometary bodies.** That the bodies are moving along the same path means, that one of them exactly repeats the positions of the other through some constant period of time. Accordingly, the distance L between them is proportional to their speed. According to Kepler's Second Law for the positions of aphelion and perihelion $V_A \cdot A = V_P \cdot P$. Accordingly

$$L_A \cdot A = L_P \cdot P.$$

The angular distances as seen from the Earth:

$$\alpha = L_A / (A+1) \text{ (conjunction)},$$
$$\beta = L_P / (P-1) \text{ (opposition)}.$$

Thus:

$$\beta = L_P / (P-1) = L_A \cdot (A/P) / (P-1) = \alpha \cdot (A/P) \cdot (A+1) / (P-1) \approx 85\,\alpha \approx 12'.7.$$

α3. **Occultation.** At the time of Venus's maximum elongation the angular velocity of its sky motion is equal to the angular velocity of the Sun motion by the ecliptic:

$$\omega = (2\pi/T) = 0.986°/\text{day}.$$

The distance l between Venus and Earth at the time of maximum elongation can be calculated using Pythagoras' theorem since the angle (Sun – Venus – Earth) is equal to 90°.

$$l = (r_2^2 - r_1^2)^{1/2} = 103.4 \text{ mill. km}.$$

Here r_1 and r_2 are the radii of Venus and the Earth orbits, respectively. Let's denote Venus radius by r, then its angular diameter from this distance will be equal to

$$d = 2r/l = 1.17 \cdot 10^{-4} = 24.1''.$$

The duration of the central occultation will be

$$t = d/\omega = rT/\pi(r_2^2 - r_1^2)^{1/2} = 9.8 \text{ minutes}.$$

Note: numerical values for the orbit radii of Earth and Venus, radius of Venus should be taken from the Solar System data.

4. **Moon.** A reversed image of the waning moon in the age of approximately 19 days will be on the photographic plate after the development. Just this image should be in the solution (with the main parts of the surface of the moon). There is a negative image on the photographic plate. so the light parts of the surface of the moon have to be drawn dark. As it is required to draw

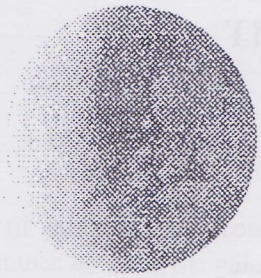
focal plane at the distance of 3048 mm from the lens and the distance between the points is the diameter of the image in the focal plane of the objective. So from the drawn triangle we have:

$$d = \beta \cdot F,$$

but β should be in radians (that is, non-dimensional values):

$$d = 31' \cdot \pi / (180 \cdot 60)' \cdot 3048 \text{ mm} \approx \mathbf{27.5 \text{ mm}}.$$

The figure should be approximately such as:



5. **Cats in space.** The light from the floodlight reflected from the cat's eyes reaches an observer. The flow of light from the floodlight falling in the cat's eye is inversely proportional to the square of the distance from the floodlight to the cat ($\sim R^{-2}$), the flow of light from the cat's eye to the observer is also inversely proportional to the square of the distance to it ($\sim R^{-2}$). Thus, the flow of light returning to the observer after reflection at the cat's eyes, is proportional to R^{-4}. Taking into account that the constellation "the crew of the cats" consists of 10 eyes, and the "laboratory experiment" is conducted with one eye, we receive a difference in flows:

$$I_C/I_O = 10 \cdot (10/250)^{-4} = 10/25^4 = 10^{-3} \cdot 2.5^{-4}.$$

In stellar magnitudes it is

$$3 \cdot 2^m.5 + 4 \cdot 1^m = 11^m.5.$$

Thus, visible from the Eiffel tower the total stellar magnitude of the crew eyes is

$$7^m + 11^m.5 = 18^m.5.$$

Roughly the distance between the cats' eyes is equal to 5 cm, and resolving power of the eyes maybe twice better than human one, 30 ". The distance from which 5 cm are visible as 30" is equal to

$$0{,}05 \text{ m} \times 206265 / 30 \approx 350 \text{ m}.$$

The cats-astronauts quite can see a binary star of eyes of the doubler from such a distance. The right answer for the estimation is: from 200 to 500 meters.

6. **Eclipse.** The mechanical analogy for the process is a race of two trains. One of them moves with a constant velocity (moving without deceleration, hypothetical Earth), and the second one – with the constant acceleration "**a**" (as the real Earth). If the trains came to one point with identical speeds, and the acceleration of the second train is equal "**a**", in the past (time **t** ago) the distance between them was $S = at^2/2$. The analog of S in our case is $\Delta\lambda = 360° - 34° = 326°$ or $34/360 = 0.906$ revolutions of the planet. (In the opposite case $\Delta\lambda = 34°$ or $34/360 = 0.094$ revolutions of the planet.) If S will be used in connection with revolutions of the planet (i.e. in days), and time is given in years, $a = 0.0016 \text{ sec} / (\text{day} \cdot 100 \text{ years})$ should be in units day/yrs^2. Evidently for this purpose it is required to divide it by the number of seconds in a day and to multiply with the number of days in one year:

$$a = 0.0016 \text{ sec} / (1 \text{ day} \cdot 100 \text{ yrs}) = (1.6 \cdot 10^{-3} \cdot 365.24)/(100 \cdot 86400) \text{ day/yrs}^2 = 6.76 \cdot 10^{-8} \text{ day/yrs}^2.$$

Now we easily find the time, for which the difference 0.906 revolutions will be accumulated:

$$t = (2S/a)^{1/2} = (0.189 \text{ day} / 6.76 \cdot 10^{-8} \text{ day/yrs}^2)^{1/2} \approx 5180 \text{ years, the 32-th century B.C.}$$

(For the case $\Delta\lambda = 34°$ $t = (2S/a)^{1/2} = (0.189 \text{ day} / 6.76 \cdot 10^{-8} \text{ day/yrs}^2)^{1/2} \approx 1670$ years, the fourth century.)

Answer: in the 32-th century B.C. (in the fourth century).

Another way of middle part of the solution. If S will be used in degrees (i.e. in units of 1/360 revolution of the planet = 1/360 day), and time is given in years, $a = 0.0016 \text{ sec} / (\text{day} \cdot 100 \text{ years})$ should be in units degree/yrs^2. Evidently for this purpose it is required to divide it by the number of seconds for one degree of the Earth rotation and to multiply with the number of days in one year:

$$a = 0.0016 \text{ sec} / (1 \text{ day} \cdot 100 \text{ yrs}) = (1.6 \cdot 10^{-3} \cdot 365.24)/(100 \cdot 240) \text{ °/yrs}^2 = 2.43 \cdot 10^{-5} \text{ °/yrs}^2.$$

Now we easily find the time, for which the difference 326° will be accumulated:

$$t = (2S/a)^{1/2} = (652 \text{ °} / 2.43 \cdot 10^{-5} \text{ °/yrs}^2)^{1/2} \approx 5180 \text{ years.}$$

(For the case $\Delta\lambda = 34°$ $t = (2S/a)^{1/2} = (68 \text{ °} / 2.43 \cdot 10^{-5} \text{ °/yrs}^2)^{1/2} \approx 1670$ years.)

Задачи практического тура

Practical round. Problems to solve

язык / language	English

Group α

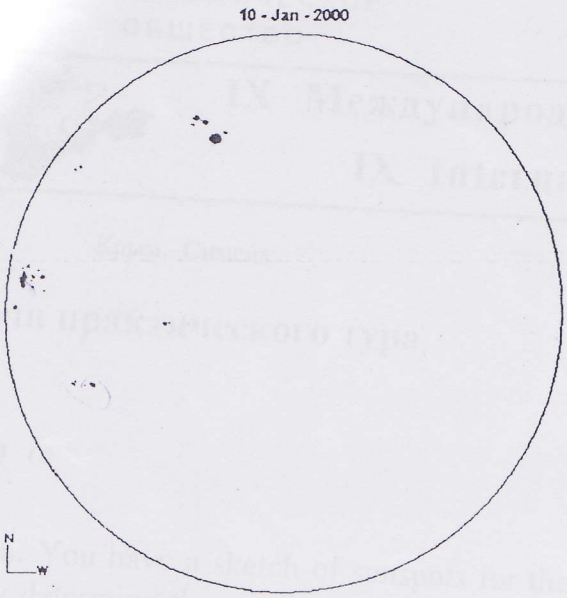
7. **Sun.** You have a sketch of sunspots for the days from January 10 to January 24, 2000. For each day determine the number of sunspots **f** and the number of groups of sunspots **g**, visible on this day on the solar disc. Using these data define Wolf's number and put the results into the table:

№	Date	Julian date	Number of		Wolf's number **W**
			spots **f**	groups **g**	
1.					
..					
..					

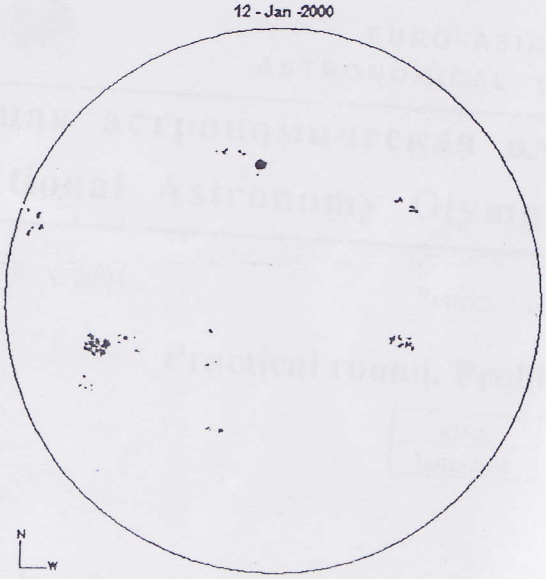
Using the obtained results plot a graph of relation of Wolf's number as a function of date.
Note: Julian date for today is 2453285. 6-th of October 2004

8. **Sunrise.** The White Bear and Penguin (whom was already met in the texts of the VII and VIII International Astronomy Olympiads) decided to meet each other. For this purpose they arrived to Crimea a few days before the IX Olympiad and they decided to observe sunrise at the day of the autumnal equinox. «I shall go to the Eastern point of Crimea and see the sunrise before others», – the Penguin has said. «No, I shall see the sunrise earlier, because I'll climb to the highest mountain in Crimea – Roman-Kosh», – the Bear parried. Who is right? On how many minutes or seconds earlier will he see the sunrise? Make a table with all data, which you have found or recollected and used in solving the problem. The solution has to include a picture with an image of the Bear on the mountain Roman-Kosh and the Penguin at the coast of the Kerch channel; the necessary linear or angular sizes should be in the picture. Assume that the Earth is spherical. Recollect for yourself the necessary information about the White Bear and the Penguin.
A map of Crimea is attached.
(Note: the answer «**Медведь / Bear**» or «**Пингвин / Penguin**» has to be written in English or Russian.)

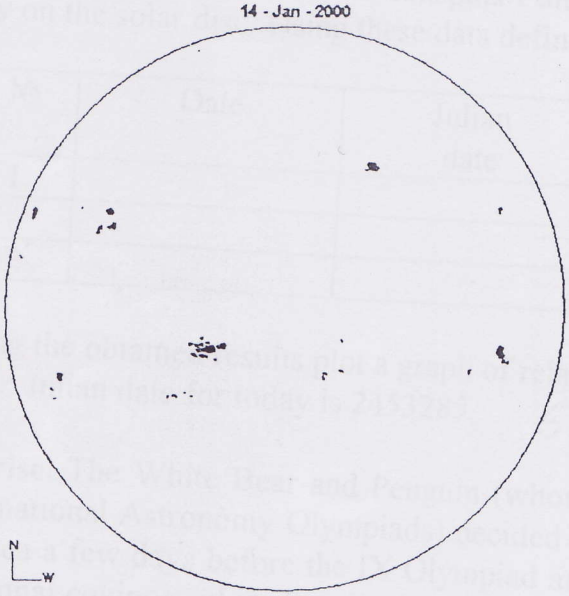
10 - Jan - 2000



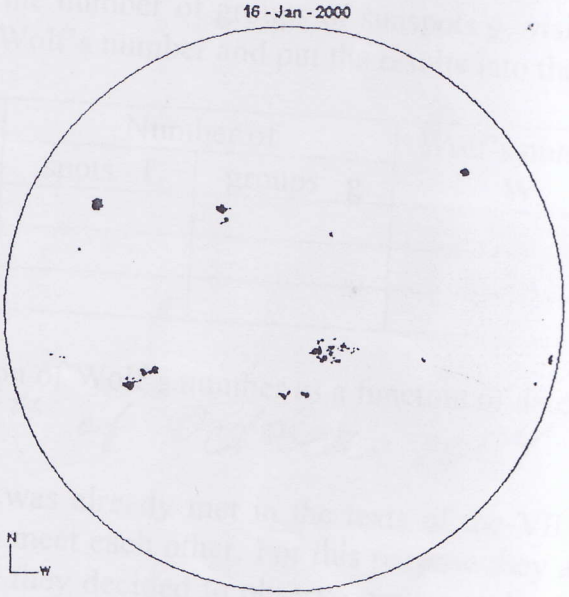
12 - Jan -2000



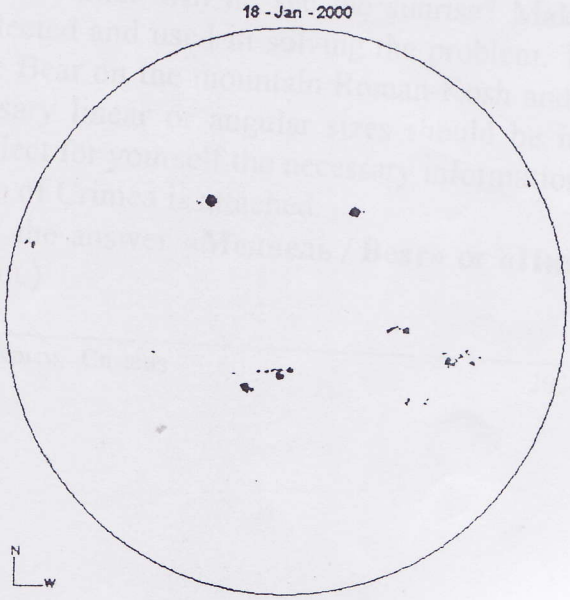
14 - Jan - 2000



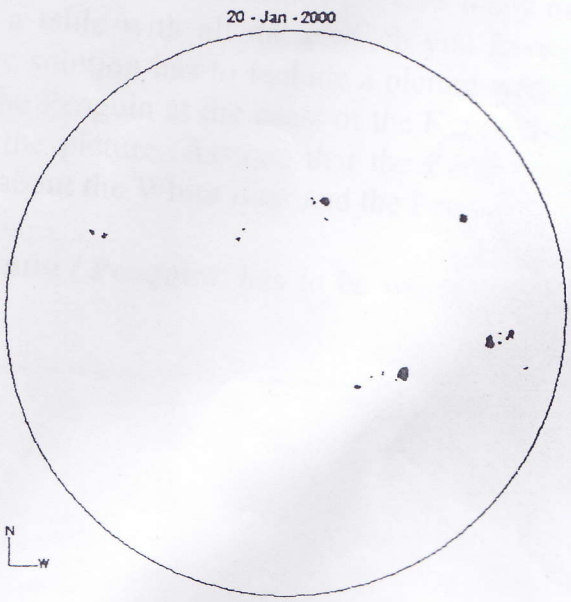
16 - Jan - 2000

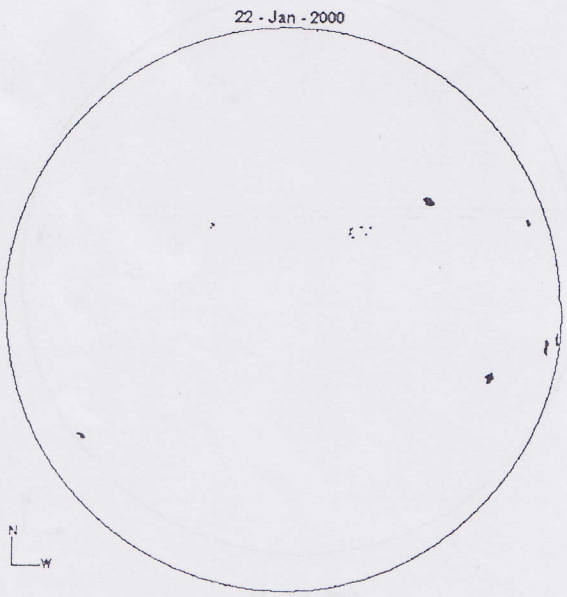


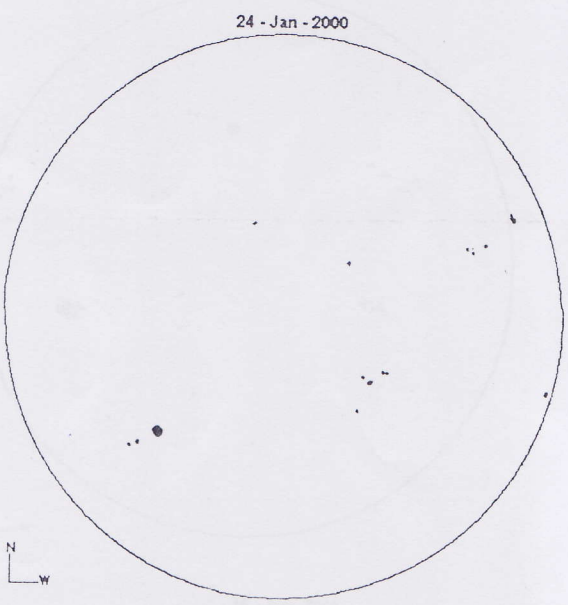
18 - Jan - 2000

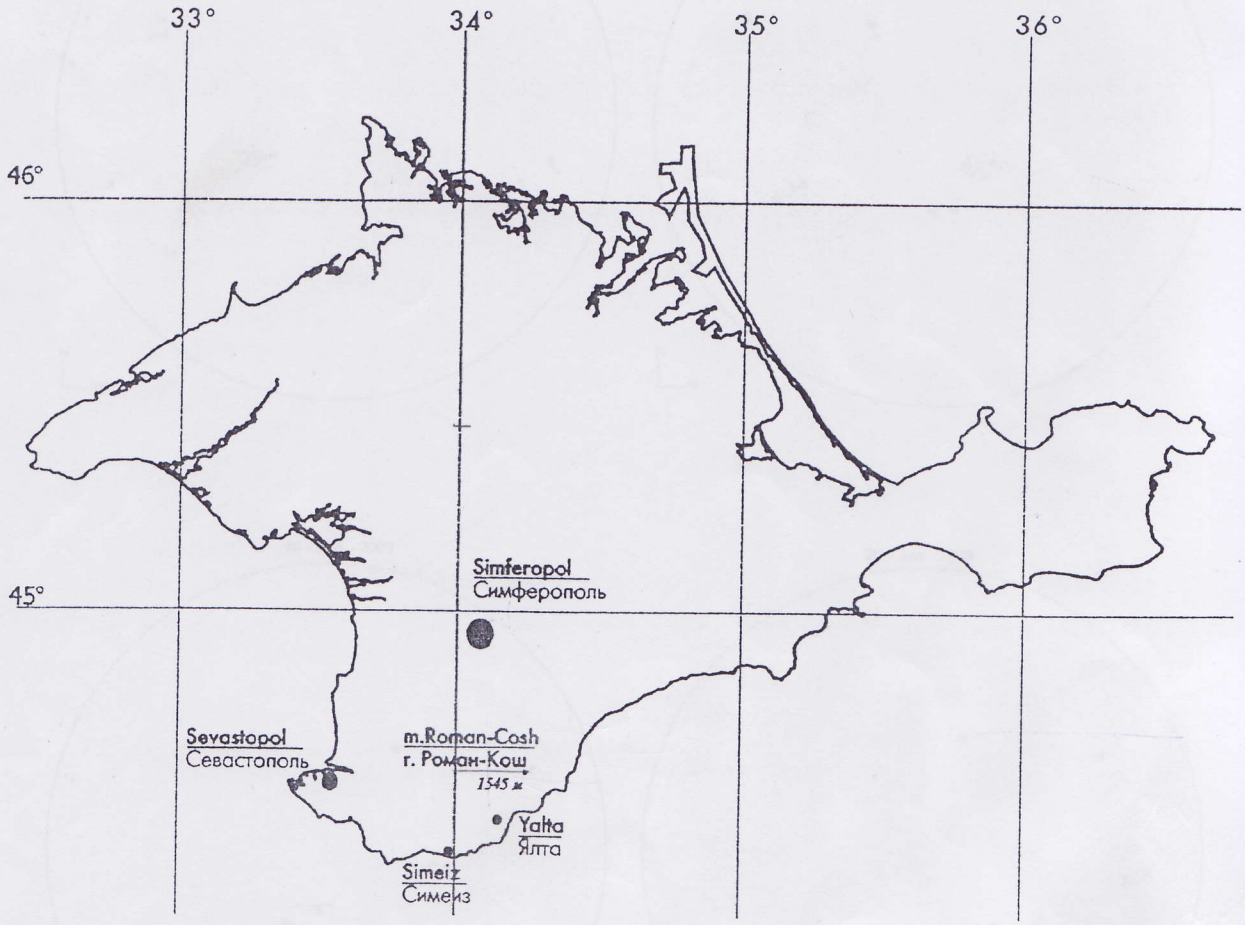


20 - Jan - 2000




22 - Jan - 2000
N
W


24 - Jan - 2000
N
W


33°
34°
35°
36°
46°
45°
Simferopol
Симферополь
Sevastopol
Севастополь
m.Roman-Cosh
г. Роман-Кош
1545 м
Yalta
Ялта
Simeiz
Симеиз

Тезисы решений задач практического тура
Practical round. Sketches for solutions

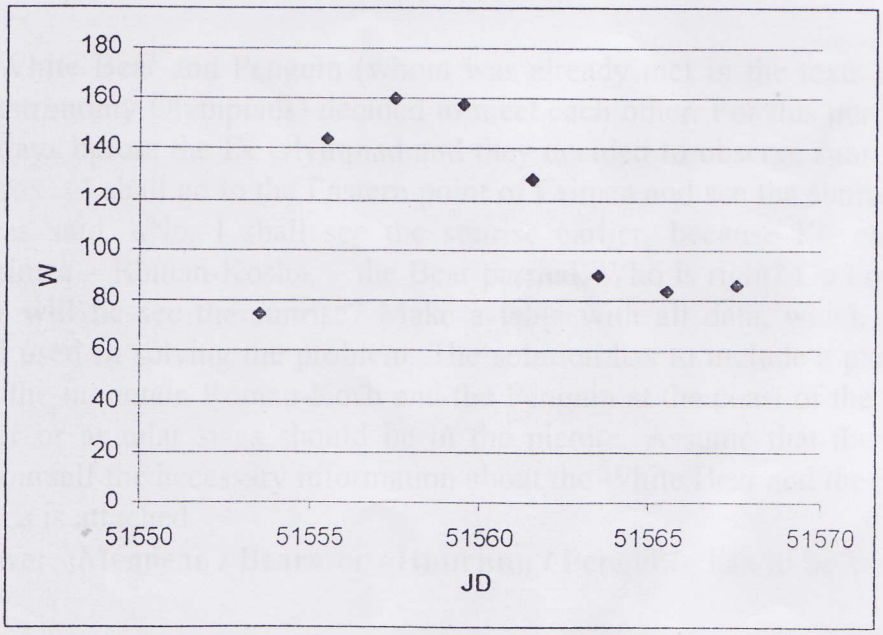
язык language	***English***
язык language	***Русский***

Group α

7. Sun. Солнце.

$W = k \cdot (10g + f)$ $k = 1$

№	Date	Julian date	Number of		Wolf's number
			spots **f**	groups **g**	**W**
№	Дата	Юлианская дата	Число		Число Вольфа
			пятен **f**	групп **g**	**W**
1	10.01.2000	2451554	25	5	75
2	12.01.2000	2451556	54	9	144
3	14.01.2000	2451558	40	12	160
4	16.01.2000	2451560	48	11	158
5	18.01.2000	2451562	38	9	128
6	20.01.2000	2451564	20	7	90
7	22.01.2000	2451566	14	7	84
8	24.01.2000	2451568	16	7	86



Задачи практического тура

Practical round. Problems to solve

язык / language	English

Group β

7. **Stars.** Attached is a table with some data about bright stars in our sky.

7.1. Using these data calculate for each star: the absolute stellar magnitude (**M**) and the projection of the distance from the Sun on the plane of the galactic equator (**R**). Fill the results into the table:

	Name of the star	Absolute stellar magnitude	Projection on the plane of the galactic equator of the distance from the Sun to the star (in light years)
№	Star	**M**	**R**
1			
..			
..			

Arrange the stars in the table in order of decreasing absolute stellar magnitude.

7.2. For the stars with **R** not larger than 50 light years draw in your copybook positions of the nearest stars in projection to a plane of galactic equator **in scale 1 cm – 10 light years**. The sizes of the circles have to be **M** dependent (see fig under the table given). **0°** direction of galactic longitude has to be horizontally to the right. Mark the stars with the numbers given in the table of **conditions for the problem**.

8. **Sunrise.** The White Bear and Penguin (whom was already met in the texts of the VII and VIII International Astronomy Olympiads) decided to meet each other. For this purpose they arrived to Crimea a few days before the IX Olympiad and they decided to observe sunrise at the day of the autumnal equinox. «I shall go to the Eastern point of Crimea and see the sunrise before others», – the Penguin has said. «No, I shall see the sunrise earlier, because I'll climb to the highest mountain in Crimea – Roman-Kosh», – the Bear parried. Who is right? On how many minutes or seconds earlier will he see the sunrise? Make a table with all data, which you have found or recollected and used in solving the problem. The solution has to include a picture with an image of the Bear on the mountain Roman-Kosh and the Penguin at the coast of the Kerch channel; the necessary linear or angular sizes should be in the picture. Assume that the Earth is spherical. Recollect for yourself the necessary information about the White Bear and the Penguin.
A map of Crimea is attached.
(Note: the answer «**Медведь / Bear**» or «**Пингвин / Penguin**» has to be written in English or Russian.)

Крым, Симеиз 1 – 9. X. 2004 Simeiz, Crimea

Practical round. Table for problem 7 to solve
Таблица к задаче 7 практического тура

язык / language	
	English
язык / language	
	Русский

Group β

	Name of the star	Parallax (arcsec.)	Visible stellar magnitude	Galactic longitude (degrees)	Galactic latitude (degrees)
	Название звезды	Параллакс (угл.сек.)	Видимая звёздная величина	Галактическая долгота (градусы)	Галактическая широта (градусы)
№	Star	P	m	l	b
1	α CMa	0.376	-1.46	227	-9
2	α Car	0.018	-0.72	261	-25
3	α Cen	0.751	-0,27	316	+1
4	α Boo	0.009	-0.04	15	+69
5	α Lyr	0.123	+0.03	67	+19
6	α Aur	0.073	+0.08	163	+5
7	β Ori	0.003	+0.12	209	-25
8	α CMi	0.288	+0.38	214	+13
9	α Eri	0.032	+0.46	291	-59
10	α Ori	0.005	+0.50	200	-9
11	β Cen	0.016	+0.61	312	+1
12	α Aql	0.198	+0.77	48	-9
13	α Tau	0.048	+0.85	181	-20
14	α Cru	0.008	+0.87	300	0
15	α Sco	0.019	+0.96	352	+15
16	α Vir	0.021	+0.98	316	+51
17	B Gem	0.093	+1.14	192	+23
18	α PsA	0.144	+1.16	20	-65
19	α Cyg	0.004	+1.25	84	+2
20	β Cru	0.007	+1.25	302	+3
21	α Leo	0.039	+1.35	226	+49

1^m -1^m -3^m

Тезисы решений задач практического тура
Practical round. Sketches for solutions

язык / language	*English*
язык / language	*Русский*

Group β

7. Stars. Звёзды.

7.1.

	Name of the star	Absolute stellar magnitude	Projection on the plane of the galactic equator of the distance from the Sun to the star (in light years)
	Название звезды	Абсолютная звёздная величина	Проекция расстояния от Солнца на плоскость галактического экватора (световых лет)
№	Star	M	R (two digits – две значащие цифры)
1	β Ori	-7,49	980
3	α Ori	-6,01	640
3	α Cyg	-5,74	810
4	α Boo	-5,26	130
5	α Cru	-4,61	410
6	β Cru	-4,52	470
7	α Car	-4,44	149
8	β Cen	-3,37	204
9	α Sco	-2,65	166
10	α Vir	-2,41	98
11	α Eri	-2,01	52
12	α Tau	-0,74	64
13	α Leo	-0,69	55
14	α Aur	-0,60	44
15	α Lyr	0,47	25
16	β Gem	0,98	32
17	α CMa	1,41	8,3
18	α PsA	1,95	9,6
19	α Aql	2,25	16,3
20	α CMi	2,68	11,0
21	α Cen	4,10	4,3

7.2. See figure. См. чертёж.

IX Международная астрономическая олимпиада
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Тезисы решений задач практического тура
Practical round. Sketches for solutions

язык / language	English

Groups α β

8. **Sunrise.** Following is the text in Russian, the solution should be easily understand from the formulae.

Восход. Действительно, рассуждения каждого из животных логичны. Примем за начало отсчёта тот момент времени, в который произошёл бы восход Солнца в точке с координатами вершины горы Роман-Кош на уровне моря.

Данные, использованные при решении задачи:

Радиус Земли	$R = 6371$ км
Высота самой высокой горы Крыма (Роман-Кош)	$h_{RK} = 1545$ м
Долгота самой высокой горы Крыма (Роман-Кош), по карте IAO-04	$\lambda_0 = 34°21'$ в.д.
Широта самой высокой горы Крыма (Роман-Кош), по карте IAO-04	$\varphi_B = 44°36'$ с.ш.
Долгота самой восточной точки Крыма (мыс Фонарь на берегу Керченского пролива), по карте IAO-04	$\lambda_P = 36°40'$ в.д.
Широта самой восточной точки Крыма (мыс Фонарь на берегу Керченского пролива), по карте IAO-04	$\varphi_P = 45°26'$ с.ш.
Угловая скорость суточного синодического вращения Земли	$\omega = 1° / 4$ мин
Высота уровня глаз Медведя над уровнем поверхности, на которой он стоит	$h_B = 2$ м
Высота уровня глаз Пингвина над уровнем поверхности, на которой он стоит	$h_P = 1$ м

Поскольку дело происходит в день осеннего равноденствия, линия терминатора проходит по меридиану и моменты восхода солнца не зависят от широты местности. Таким образом, поскольку Пингвин находится на $\Delta\lambda_P = 2°19'$ восточнее по долготе, чем наблюдатель «Роман-Кош на уровне моря», он увидит восход раньше на время

$$t_P = \Delta\lambda_P / \omega,$$

где $\omega = 1° / 4$ мин – угловая скорость суточного синодического вращения Земли.

$$t_P \approx 9^{м}16^{с}.$$

Медведь же решил воспользоваться эффектом понижения физического горизонта, забравшись на гору Роман-Кош, высота которой согласно карте равна 1545 м. Понижение физического горизонта можно вычислить по формуле

$$\Delta\alpha = \arccos(R/(R+h)) \approx ((R+h)^2 - R^2)^{1/2}/R \approx (2h/R)^{1/2} \text{ (в радианах)},$$

размерами Медведя ($h \approx h_{RK}$) Медведя для горе Роман-Кош $h = 1545$ м и понижение горизонта составляет около

$$\Delta\alpha_B \approx (2 \cdot 1545 \text{ м} / 6371000 \text{ м})^{1/2} \approx 0{,}022 \text{ рад} = 1°16'.$$

(Даже если учесть размеры Медведя, вставшего на задние лапы на горе Роман-Кош, $h = h_{RK} + h_B = 1547$ м, понижение горизонта всё равно составляет около 1°16'

$$\Delta\alpha_B \approx (2 \cdot 1547 \text{ м} / 6371000 \text{ м})^{1/2} \approx 0{,}022 \text{ рад} = 1°16').$$

Таким образом, в тот момент, когда Медведь увидит восход, для наблюдателя «Роман-Кош на уровне моря» Солнце ещё в 1°16' ниже. На широте около $\varphi_B = 44°36'$ для достижения точки восхода Солнце должно пройти по небу путь в $\beta_B = \Delta\alpha_B / \cos\varphi_B \approx 1°46'$. Время, за которое Солнце пройдёт этот путь, равно

$$t_B = \Delta\alpha_B / (\cos\varphi_B \cdot \omega),$$

$$t_B \approx 7^{м}04^{с}.$$

Таким образом, Пингвин увидит рассвет раньше Медведя на время

$$t_P - t_B = (\Delta\lambda_P - \Delta\alpha_B/\cos\varphi) / \omega \approx 2^{м}12^{с}.$$

Рефракция на ответ не влияет, так как одинаково приближает восход как Пингвину, так и Медведю.

Answer-Ответ: **Пингвин-Penguin**, на 2 минуты 12 секунд раньше.

Справедливости ради, вычислим эффект от понижения горизонта для Пингвина высотой 1 м:

$$\Delta\alpha_P \approx (2 \cdot 1 \text{ м} / 6371000 \text{ м})^{1/2} \approx 5{,}6 \cdot 10^{-4} \text{ рад} \approx 1{,}9'.$$

Таким образом, аналогично рассуждениям с Медведем, на широте $\varphi_P = 45°26'$,

$$\beta_P = \Delta\alpha_P / \cos\varphi_P \approx 2{,}7'.$$

Время, за которое Солнце пройдёт этот путь, равно

$$t_{P1} = \Delta\alpha_P / (\cos\varphi_P \cdot \omega),$$

$$t_{P1} \approx 11^{с}.$$

В этом случае получаем, что Пингвин увидит рассвет раньше Медведя на время

$$t_P + t_{P1} - t_B = (\Delta\lambda_P + \Delta\alpha_P/\cos\varphi_P - \Delta\alpha_B/\cos\varphi) / \omega \approx 2^{м}47^{с}.$$

и answer-ответ: **Пингвин-Penguin**, 2 минуты 23 секунды раньше.

Задачи практического тура

Practical round. Problems to solve

язык / language	Русский

Group α

7. **Солнце.** Перед Вами зарисовки солнечных пятен за период с 10 по 24 января 2000 года. Для каждого дня определите число пятен **f** и число групп пятен **g**, видимых в этот день на солнечном диске. По этим данным определите число Вольфа и занесите все полученные данные в таблицу:

№	Дата	Юлианская дата	Число		Число Вольфа **W**
			пятен **f**	групп **g**	
1.					
..					
..					

По полученным результатам постройте график зависимости числа Вольфа от даты. Юлианская дата для сегодняшнего дня – 2453285.

8. **Восход.** Белый Медведь и Пингвин (те, что уже встречались в условиях VII и VIII Международных астрономических олимпиад) решили встретиться друг с другом. Для этого они приехали в Крым за несколько дней до IX Олимпиады и решили пронаблюдать восход Солнца в день осеннего равноденствия. «Я поеду на самую восточную точку Крыма и увижу восход раньше всего», – сказал Пингвин. «Нет, я раньше увижу восход, потому что заберусь на самую высокую гору в Крыму – Роман-Кош», – парировал Медведь. Кто из них прав? На сколько минут или секунд раньше он увидит восход? Выпишите в таблицу все данные, которые Вы нашли или вспомнили и использовали при решении задачи. Решение сопроводите рисунком с Медведем на горе Роман-Кош и Пингвином на берегу Керченского пролива, на рисунке должны быть указаны необходимые линейные или угловые размеры. Форму Земли считать сферической. Необходимые сведения о Белом Медведе и Пингвине вспомните сами.
В Вашем распоряжении карта Крыма.
(Примечание: ответ «**Медведь / Bear**» или «**Пингвин / Penguin**» должен быть написан по-русски или по-английски.)

Задачи практического тура — Practical round. Problems to solve

язык / language	Русский

Group β

7. **Звёзды.** Вам дана таблица с некоторыми характеристиками ряда ярких звёзд нашего неба (прилагается).

7.1. Исходя из данных таблицы, вычислите для каждой звезды: абсолютную звёздную величину (**M**) и проекцию расстояния от Солнца на плоскость галактического экватора (**R**). Постройте для них таблицу с данными:

	Название звезды	**Абсолютная звёздная величина**	**Проекция расстояния от Солнца на плоскость галактического экватора (световых лет)**
№	**Star**	**M**	**R**
1			
..			
..			

Звёзды расположите в порядке убывания абсолютной звёздной величины.

7.2. Для звёзд с **R** не более 50 световых лет, в масштабе **в 1 см – 10 световых лет**, изобразите в тетради расположение ближайших звёзд в проекции на плоскость галактического экватора. Размеры кружков – в соответствии с **M** (см. рисунок под таблицей, прилагаемой к условию). Направление **0°** галактической долготы направьте по горизонтали вправо. Обозначьте звёзды номерами из **данной в условии** таблицы.

8. **Восход.** Белый Медведь и Пингвин (те, что уже встречались в условиях VII и VIII Международных астрономических олимпиад) решили встретиться друг с другом. Для этого они приехали в Крым за несколько дней до IX Олимпиады и решили понаблюдать восход Солнца в день осеннего равноденствия. «Я поеду на самую восточную точку Крыма и увижу восход раньше всего», – сказал Пингвин. «Нет, я раньше увижу восход, потому что заберусь на самую высокую гору в Крыму», – парировал Медведь. Кто из них прав? На сколько минут или секунд раньше он увидит восход? Выпишите в таблицу все данные, которые Вы нашли или вспомнили и использовали при решении задачи. Решение сопроводите рисунком с Медведем на горе Роман-Кош и Пингвином на берегу Керченского пролива, на рисунке должны быть указаны необходимые линейные или угловые размеры. Форму Земли считать сферической. Необходимые сведения о Белом Медведе и Пингвине вспомните сами.
В Вашем распоряжении карта Крыма.
(Примечание: ответ «**Медведь / Bear**» или «**Пингвин / Penguin**» должен быть написан по-русски или по-английски.)

IX International Astronomy Olympiad
IX Международная астрономическая олимпиада

Simeiz, Crimea — 1 – 9. X. 2004 — Крым, Симеиз

Observational round. Problems

Задачи наблюдательного тура

язык / language	English
язык / language	русский

Groups α, β

English	Русский
1.1. The latitude of the region where the Olympiad is taking place is 45° North. Contour by your hand the circumpolar region of the sky. 1.2. Indicate (by hand) the circumpolar constellations and say their Latin names. (6p)	1.1. Зная, что широта местности, где проводится Олимпиада, равна 45° с.ш., очертите рукой незаходящую область неба. 1.2. Укажите незаходящие созвездия и назовите их латинские названия. (6 баллов)
Tests 2-3 were canceled due to clouds	Задания 2-3 были отменены из-за облачности.
2. Determine the angular distance between the stars listed below and write the answers on the map between each pair of stars: 2.1. α Cyg and β Cyg. 2.2. β Dra and γ Dra. 2.3. α Lyr and α Aql. You have a sky map of the necessary region. (3·2p = 6p)	2. Определите угловые расстояние между звёздами и напишите ответ на карте между звёздами каждой пары: 2.1. α Cyg и β Cyg. 22° 2.2. β Dra и γ Dra. 1° 3.3. α Lyr и α Aql. 34° Карта данной области неба прилагается. (3·2 балла = 6 баллов)
3. Find the stellar magnitudes of the given stars using data about comparing stars and write the answers on the map. 3.1. κ Cas (stars of comparing: φ Cas = $5{,}0^m$ and β Cas = $2{,}3^m$). 3.2. δ Cyg (α Cyg = $1{,}3^m$ and φ Cyg = $4{,}7^m$). 3.3. π Her (α Lyr = 0^m and φ Her = $4{,}2^m$). 3.4. β Cep (α Cas = $2{,}2^m$ and μ Cep = $4{,}1^m$). You have a sky map of the necessary region. (4·2p = 8p)	3. Используя звёзды сравнения, определите звёздную величину звёзд и напишите их на карте. 3.1. κ Cas (звёзды сравнения: 4^m17 φ Cas = $5{,}0^m$ и β Cas = $2{,}3^m$). 3.2. δ Cyg (α Cyg = $1{,}3^m$ и φ Cyg = $4{,}7^m$). 2.9 3.3. π Her (α Lyr = 0^m и φ Her = $4{,}2^m$). 3.14^m 3.4. β Cep (α Cas = $2{,}2^m$ и μ Cep = $4{,}1^m$). 3.19^m Карта данной области неба прилагается. (4·2 балла = 8 баллов)