

АСТРОНОМИЧЕСКОЕ
ОБЩЕСТВО

EURO-ASIAN
ASTRONOMICAL SOCIETY



IX Международная астрономическая олимпиада
IX International Astronomy Olympiad

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.

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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 other. 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 ($\lambda = 0^\circ$, $\varphi = 45^\circ$) instead of Crimea ($\lambda = 34^\circ$, $\varphi = 45^\circ$)? 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.



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Group β

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 $6 \times 6^\circ$. The distance to the cluster is equal to 15 Mpc. Estimate the average distance between the galaxies in this cluster.

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.

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.)

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

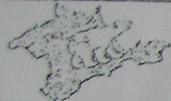
Moon. Yesterday during the observation round you saw the moon. Sometimes there were no clouds. Imagine that at the same time the moon was observed by school children on mountain Koshka (which means "cat" in Russian) branch of the Crimean Astrophysical Observatory). The objective diameter of the telescope-refractor 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

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And the White Bear and Penguin are waiting for you in the practical round

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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 в astr. ed.	в mln. km	Сидерический период обращения в трокоп. годах	в средних сутках	Экс- центри- ческ. ст.	Эквато- ральный диаметр km	Масса 10^{24} kg	Сред- няя плот- ность g/cm^3	Ускор. свои- чайш. упор m/s^2	Макс блеск вдл. с Земли m	Аль- бедо
Body, planet	Average distance to central body in astr. units	in mln. km	Sidereal (or analogous) period in tropoh. years	in days	Eccen- tricity	Equat. diameter km	Mass 10^{24} kg	Av den- sity g/cm^3	Grav acceler. at sur. m/s^2	Max. mag. from Earth m	Al- bedo
Солнце Sun	$1,6 \cdot 10^9$	$2,5 \cdot 10^{11}$	$2,2 \cdot 10^8$	$8 \cdot 10^{16}$		1322000	$198 \cdot 10^{27}$ kg	$1,409 \cdot 10^{-6}$		-26,8 ^m	
Меркурий Mercury	0,387	57,9	0,241	87,97	0,206	4879	0,3302	5,43	3,70	-2,2 ^m	0,06
Венера Venus	0,723	108,2	0,615	224,70	0,007	12104	4,8690	5,24	8,87	-4,7 ^m	0,78
Земля Earth	1,000	149,6	1,920	365,26	0,017	12756	5,9742	5,515	9,81		0,36
Луна Moon	0,00257	0,38440	0,0748	27,3217	0,055	3475	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.