АСТРОНОМИЧЕСКОЕ ОБЩЕСТВО | EURO-ASIAN ASTRONOMICAL SOCIETY

XVII Международная астрономическая олимпиада
XVII International Astronomy Olympiad

Корея, Кванджу 16 – 24. X. 2012 Gwangju, Korea

Round	Theo	
Group	α	β
язык / language	English	

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**» has to be written in English or Russian.

αβ-1. Transit of Venus. Recently, on June 6, 2012 an infrequent astronomical phenomenon, transit of Venus across the solar disc took place. The next transit of Venus will take place only in 2117. Calculate the date of that transit. (Answer without calculations will be not considered even as a part of solution.)

αβ-2. Transit of Pseudovenus. Recently, on June 6, 2012 an infrequent astronomical phenomenon, transit of Venus across the solar disc took place. Suppose somebody did not understand the phenomenon and ascribed it not to transit of real Venus but of some moon, which we name Pseudovenus, rotating around the Earth by circular orbit. Find the radius of orbit of Pseudovenus and diameter of this sky body. Effects appears due to axial rotating of the Earth should be not taken into account.

αβ-3. Old persons star. There is ancient legend in Korea that says, if you managed to see the "Old person star" thrice, you are lucky person and will live a long life. The "Old person star", now known as Canopus, was seen brighter and better in past times, but even now sometimes one can see this star in Korea. Estimate approximately what visible stellar magnitude may have Canopus by its observing from the southern coast of Jeju island (Korea) in the most favorable conditions. The territory of the island is located at latitudes between 33°12' N and 33°34' N and longitudes between 126°09' E and 126°57' E. Take from the tables and recollect for yourself the necessary additional information.

α-4. Stars on Mars. As you know, last year the Polar Bear (whom was already met in the texts of many International Astronomy Olympiads) arrived to Mars for astronomical observations. Nowadays his friend Penguin also made fascinating journey to Mars. At the same instant of time the Bear and the Penguin observe stars in zenith, and see Canopus and Sirius respectively. Estimate roughly, what is the distance (measured by Martian surface) between the animals? At what height above horizon does the Bear observe Sirius? The solution has to include a picture with an image of the Bear and the Penguin on Mars. Necessary sizes or angular sizes should be in the picture. Recollect for yourself the necessary information about the Polar Bear and Penguin.

β-4. Altair. Estimate density of the star Altair.

α-5. Venus and Earth. At what maximum distance from the own (Venus) ecliptic the Earth can be visible at the sky from Venus (actually, from a point outside Venus atmosphere)? Orbits of the planets may be considered circular.

β-5. Venus and Earth. At what maximum distance from the own (Venus) ecliptic the Earth can be visible at the sky from Venus (actually, from a point ouside Venus atmosphere)? Orbits of the planets may be considered circular.

Estimate stellar magnitude of Earth in this situation.

α-6. **Parallaxes.** In our part of the galaxy the mean distance between the stars is about 6 light years. Assume that an interferometer can measure parallaxes with an error of ±0,001 arc second. How many stars of our Galaxy could have their parallax determined by this interferometer?

β-6. **Remote galaxy.** Astronomers have discovered a distant galaxy that in Earth's sky at first glance looks like ε Eridani, the same in colour, but 1000 times less in intensity. It appears, however, that this galaxy is composed only of the stars similar to the Sun in physical characteristics. Find the number of stars in the galaxy.

Элементы орбит.
Физические характеристики некоторых планет, Луны, Солнца и Эриды

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

Небесное тело, планета / Body, planet	Среднее расстояние от центрального тела / Average distance to central body		Сидерический (или аналогичный) период обращения / Sidereal period (or analogous)		Наклон орбиты / Orbital inclination	Эксцентриситет / Eccentricity	Экваториальн. диаметр / Equat. diameter	Масса / Mass	Средняя плотность / Av. density	Ускор. своб. пад. у пов. / Grav. accelr. at surf.	Наклон оси / Axial tilt	Макс. блеск, вид. с Земли **) / Max. magn. From Earth **)	Альбедо / Albedo
	в *астр. ед.* / in *astr. units*	в *млн. км* / in *10^6 km*	в тропич. годах / in tropical years	в средних сутках / in days	*i*	*e*	*км* / *km*	*10^{24} кг* / *10^{24} kg*	*г/см³* / *g/cm^3*	*м/с²* / *m/s^2*			
Солнце Sun	$1{,}6\cdot10^9$	$2{,}5\cdot10^{11}$	$2{,}2\cdot10^8$	$8\cdot10^{10}$			1392000	1989000	1,409			$-26{,}74^m$	
Меркурий Mercury	0,387	57,9	0,241	87,969	7,00°	0,206	4 879	0,3302	5,43	3,70	0,01°		0,06
Венера Venus	0,723	108,2	0,615	224,7007	3,40	0,007	12 104	4,8690	5,24	8,87	177,36		0,78
Земля Earth	1,000	149,6	1,000	365,2564	0,00	0,017	12 756	5,9742	5,515	9,81	23,44		0,36
Луна Moon	0,00257	0,38440	0,0748	27,3217	5,15	0,055	3 475	0,0735	3,34	1,62	6,7	$-12{,}7^m$	0,07
Марс Mars	1,524	227,9	1,880	686,98	1,85	0,093	6 794	0,6419	3,94	3,71	25,19	$-2{,}0^m$	0,15
Юпитер Jupiter	5,204	778,6	11,862	4 332,59	1,30	0,048	142 984	1899,8	1,33	24,86	3,13	$-2{,}7^m$	0,66
Сатурн Saturn	9,584	1433,7	29,458	10 759,20	2,48	0,054	120 536	568,50	0,70	10,41	26,73	$0{,}7^m$	0,68
Эрида Eris	68,05			205 029	43,82	0,435	2 326	0,0167	2,52	0,7			0,96

**) Для Луны – в среднем противостоянии.
**) For Moon – in mean opposition.

Некоторые константы и формулы
Some constants and formulae

Скорость света в вакууме, c (м/с)	299 792 458	Speed of light in vacuum, c (m/s)
Гравитационная постоянная, G ($Н \cdot м^2/кг^2$)	$6.674 \cdot 10^{-11}$	Constant of gravitation, G ($N \cdot m^2/kg^2$)
Солнечная постоянная, A ($Вт/м^2$)	1367	Solar constant, A (W/m^2)
Параметр Хаббла, H_0 (км/с/МПк) — среднее значение / диапазон значений	71 / 50-100	mean value / diapason of values — Hubble parameter, H_0 (km/s/Mpc)
Постоянная Планка, h (Дж·с)	$6.626 \cdot 10^{-34}$	Plank constant, h (J·s)
Заряд электрона, e (Кл)	$1.602 \cdot 10^{-19}$	Charge of electron, e (C)
Масса электрона, m_e (кг)	$9.109 \cdot 10^{-31}$	Mass of electron, m_e (kg)
Соотношение масс протона и электрона	1836.15	Proton-to-electron ratio
Постоянная Фарадея, F (Кл/моль)	96 485	Faraday constant, F (C/mol)
Магнитная постоянная, μ_0 (Гн/м)	$1.257 \cdot 10^{-6}$	Magnetic constant, μ_0 (H/m)
Универсальная газовая постоянная, R (Дж/моль/К)	8.314	Universal gas constant, R (J/mol/K)
Постоянная Больцмана, k (Дж/К)	$1.381 \cdot 10^{-23}$	Boltzmann constant, k (J/K)
Постоянная Стефана-Больцмана, σ ($Вт/м^2/К^4$)	$5.670 \cdot 10^{-8}$	Stefan-Boltzmann constant, σ ($W/m^2/K^4$)
Константа смещения Вина, b (м·К)	0.002897	Wien's displacement constant, b (m·K)
Лабораторная длина волны Hα (Å)	6562.81	Laboratory wavelength of Hα (Å)
Длина тропического года, T (сут)	365.242199	Tropical year length, T (days)
Стандартная атмосфера (Па)	101 325	Standard atmosphere (Pa)
Ослабление видимого света земной атмосферой в зените (минимально)	19%, 0.23^m	Visible light extinction by the terrestrial atmosphere in zenith (minimum)
Показатель преломления воды при 20°C, n	1.334	Refractive index of water for 20°C, n
Момент инерции шара	$I = {}^2/_5 MR^2$	Moment of inertia of a solid ball
Площадь сферы	$S = 4\pi R^2$	Area of sphere
π	3.14159265	π
e	2.71828183	e
Золотое сечение, φ	1.61803399	Golden ratio, φ

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Round **Theo**
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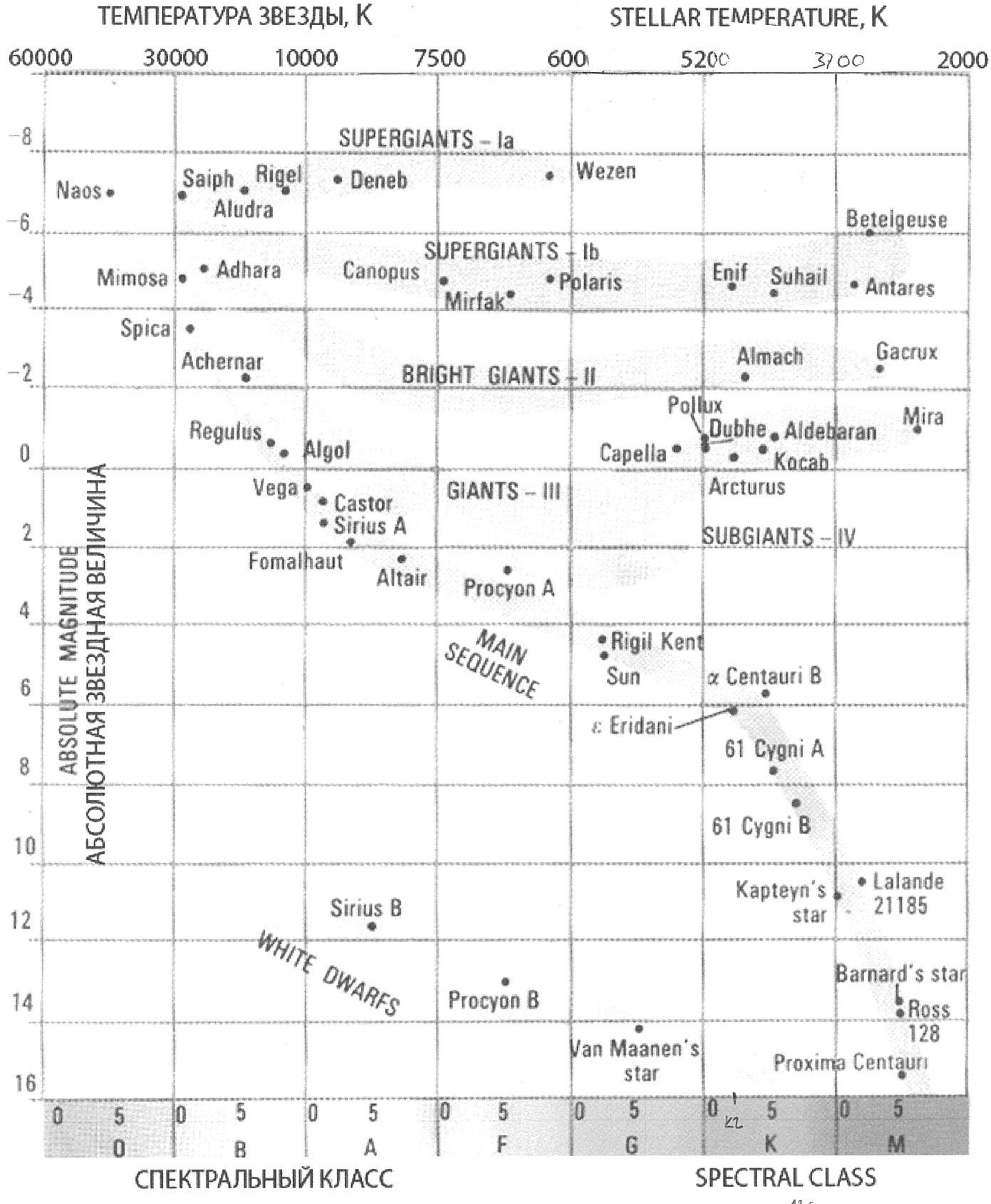
Данные о некоторых звёздах
Data of some stars

			RA	DEC	*p*	m	SC	масса mass
Солнце	Sun	Θ	$0^h - 360^h$	-23°26' +23°26'	8".794	$-26^m.74$	G2	1 M_Θ
Альдебаран	Aldebaran	α Tau	$04^h\ 35^m\ 55^s$	16° 30' 33"	0".048	$0^m.85^v$	K5	2.5 M_Θ
Альтаир	Altair	α Aql	$19^h\ 50^m\ 47^s$	08° 52' 06"	0".195	$0^m.77$	A7	1.7 M_Θ
Антарес	Antares	α Sco	$16^h\ 29^m\ 24^s$	-26° 25' 55"	0".006	$0^m.96$	M1+B4	22.4 M_Θ
Арктур	Arcturus	α Boo	$14^h\ 15^m\ 40^s$	19° 10' 57"	0".089	$-0^m.04^v$	K1	1.1 M_Θ
Ахернар	Achernar	α Eri	$01^h\ 37^m\ 43^s$	-57° 14' 12"	0".026	$0^m.46$	B3	
зв.Барнарда	Barnard's star	Oph	$17^h\ 57^m\ 48^s$	04° 41' 36"	0".545	$9^m.54$	M4	
Бетельгейзе	Betelgeuse	α Ori	$05^h\ 55^m\ 10^s$	07° 24' 25"	0".005	$0^m.5^v$	M1	
Вега	Vega	α Lyr	$18^h\ 36^m\ 56^s$	38° 47' 01"	0".129	$0^m.03$	A0	
Денеб	Deneb	α Cyg	$20^h\ 41^m\ 26^s$	45° 16' 49"	0".002	$1^m.25$	A2	
Канопус	Canopus	α Car	$06^h\ 23^m\ 57^s$	-52° 41' 45"	0".010	$-0^m.72$	F0	
Капелла	Capella	α Aur	$05^h\ 16^m\ 41^s$	45° 59' 53"	0".073	$0^m.08$	G5+G0	
Полярная	Polaris	α UMi	$02^h\ 31^m\ 49^s$	89° 15' 51"	0".0076	$1^m.97^v$	F7	
Процион	Procyon	α CMi	$07^h\ 39^m\ 18^s$	05° 13' 30"	0".288	$0^m.38$	F5	
Ригель	Rigel	β Ori	$05^h\ 14^m\ 32^s$	-08° 12' 06"	0".013	$0^m.12$	B8	
Сириус	Sirius	α CMa	$06^h\ 45^m\ 09^s$	-16° 42' 58"	0".375	$-1^m.46$	A1	
Спика	Spica	α Vir	$13^h\ 25^m\ 12^s$	-11° 09' 41"	0".023	$0^m.98$	B1	
Альфа Центавра	Alpha Centauri	α Cen	$14^h\ 39^m\ 36^s$	-60° 50' 07"	0".751	$-0^m.01$ $1^m.33$	G2 K1	2.0 M_Θ
Бета Центавра	Beta Centauri	β Cen	$14^h\ 03^m\ 49^s$	-60° 22' 23"	0".009	$0^m.61$	B1	21 M_Θ
Эпсилон Эридана	Epsilon Eridani	ε Eri	$03^h\ 32^m\ 56^s$	-09° 27' 30"	0".311	$3^m.74$	K2	0.82 M_Θ

Диаграмма Герцшпрунга-Рассела Hertzsprung-Russell diagram



For translation only. **Practical round. Problem _7_ to solve**

Note. If you find somewhere in the problems an impossible situation, write in English «**impossible situation**».

7. **Fireball.** A fireball was observed at 3 different observing sites I, II, III. The position of the observing sites, the altitude and azimuth of start and end points are given in Table 1. Azimuth is measured eastward from the North direction, and altitude is given in degrees above the horizon. Following the steps below, find true trajectory and location of fallen debris of the fireball.

Table 1. Observational Data for a Fireball

	observing position		starting point (**A**)		end point (**B**)	
	longitude	latitude	azimuth	altitude	azimuth	altitude
I	127.3°E	+35.7°	17°	35°	77°	10°
II	128.5°E	+37.0°	235°	-	139°	-
III	128.5°E	+35.4°	325°	-	48°	-

7.1. You are provided by a cross-section paper. Mark the 3 observing positions (I, II, III) and draw a projected trajectory of the fireball.
7.2. Calculate the longitude and latitude of start (λ_A, φ_A) and end (λ_B, φ_B) points of the fireball and total length **L** of the trajectory projected on the earth surface.
7.3. Find the heights of starting point $\mathbf{h_A}$ and end point $\mathbf{h_B}$.
7.4. Where can you find a meteorite, if it survives passage through the atmosphere and hit the ground? Calculate the longitude and latitude (λ_C, φ_C) of the location where the meteorite hits the ground.

Finally, redraw the table below to your answer-book and fill the empty cells with you results.

point	longitude λ	latitude φ	L (km)	h_A (km)	h_B (km)	You may find the meteorite at longitude λ	You may find the meteorite at latitude φ
A							
B							

For translation only. **Practical round. Problem _8_ to solve**

Note. If you find somewhere in the problems an impossible situation, write in English «**impossible situation**».

8. Moon. The Korean Astronomy and Space Science Institute (KASI) publishes the Korean Astronomical Almanac every year. The table that shows the Korean local time of Moon culmination is extracted from the Korean Astronomical Almanac of 2012. (See separate sheet, and you may fill the empty cells by necessary content.)

Date	Culmination of Moon		Date	Culmination of Moon		Date	Culmination of Moon	
Mar 2			April 1			May 1		

Also you are provided by a Geed-Sheet to plot graphs.

8.1. Find the date in April 2012 when the Moon is closest to the Earth.
8.2. Find the date in March 2012 when the Moon is remotest from the Earth.
8.3. The Geed-Sheet (a) shows the eccentric orbit of the Moon, where the earth is located at the center. Mark the positions of the Moon by **x** on April 19 and April 23 (with labels A19 and A23).
8.4. Calculate the ratio of the apparent angular sizes of the Moon (α_{Moon}) and the Sun (α_{Sun}) on July 1.
8.5. Draw on the Geed-Sheet the geostationary orbit around the Earth in the given scale.

For translation only. **Practical round. Problem _8_ to solve**

Note. If you find somewhere in the problems an impossible situation, write in English «**impossible situation**».

8. **Clusters.** Using the moving cluster method, the Hyades cluster is known to be 45 pc away. This open cluster is important as a standard candle, because we can use it to determine the distances of other clusters. However, the interstellar medium absorbs light making a star appear fainter and redder, which is called the interstellar extinction A_V and reddening $E_{(B-V)}$, both measured in stellar magnitudes. The true distance modulus can be computed using the relation

$$m - M = 5 \log \mathbf{d} - 5 + A_V.$$

The empirical relation between A_V and $E_{(B-V)}$ is

$$A_V = 3 \cdot E_{(B-V)}.$$

In Tables I and II, you are provided with photometric data of the two open clusters, Hyades and NGC 2682.

8.1. Find Make the colour-magnitude diagrams of the Hyades cluster and NGC 2682 using the provided Grid Sheet (A). In the diagrams, draw the main sequence line of each cluster.
8.2. Plot the colour-colour diagrams of the Hyades cluster and NGC 2682 using the provided Grid Sheet (B).
8.3. Assuming that the interstellar reddening of Hyades cluster is negligible, derive the interstellar reddening, $E_{(B-V)}$ of NGC 2682.
8.4. Determine the distance to NGC 2682.
8.5. Find the absolute magnitude and colour index (B-V) of the main sequence turn-off star in each cluster, approximately.
8.6. Which cluster is older? (Write in English «**Hyades**» or «**NGC 2682**».)

Round **Obs**

Group α β

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Code of participant

Вопросы наблюдательного тура. Чистое небо

Observational round. Questions. Clean sky

Русский	English
В Вашем распоряжении **фонарик**	You are provided with a **light**
9. Покажите экзаменатору направление на следующие объекты. **9.1.** Полярную звезду, **9.2.** Эклиптику (проведите рукой вдоль линии эклиптики). **10.** Расположите NGC 869 и NGC 884 в поле зрения телескопа. После нахождения объектов покажите их экзаменатору. **10.2.** Оцените часовой угол этих объектов (с точностью ± 10 градусов). Ответ в градусах: **11.** Расположите M15 в поле зрения телескопа. Карта прилагается. После нахождения объекта покажите его экзаменатору. **12.** Приблизительно оцените зенитное расстояние Меркурия. Ответ:	**9.** Point the direction of the following objects (show it to examiner): **9.1.** the Polaris, **9.2.** the Ecliptic (draw the line following the ecliptic). **10.** Place NGC 869 and NGC 884 in the field of view of the telescope. After identifying the objects, show them to the examiner. **10.2.** Estimate the current hour angle of them (to ± 10 degree accuracy). Answer in degrees: **11.** Place M15 in the field of view of the telescope. The finding chart is given. After identifying the object, show it to the examiner. **12.** Estimate the approximate zenith distance of Mercury. Answer:
Максимальное время выполнения задания – **17 минут**.	The maximum total time for all tasks is **17 minutes**.