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	68 / 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 mass 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/K)	8.314	Universal gas constant, R (J/mol/K)
Постоянная Больцмана, k (Дж/K)	$1.381 \cdot 10^{-23}$	Boltzmann constant, k (J/K)
Постоянная Стефана-Больцмана, σ ($Вт/м^2/K^4$)	$5.670 \cdot 10^{-8}$	Stefan-Boltzmann constant, σ ($W/m^2/K^4$)
Константа смещения Вина, b (м·K)	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)
Длина сидерического года, T (сут)	365.25636	Sidereal year length, T (days)
Длина аномалистического года, T (сут)	365.259636	Anomalistic year length, T (days)
Период обращения узлов лунной орбиты (лет)	-18.6	Nodal period of lunar orbit (years)
Стандартная атмосфера (Па)	101 325	Standard atmosphere (Pa)
Ослабление видимого света слоем 1 атмосферы (минимально)	19%, 0.23^m	Visible light extinction by the terrestrial atmosphere in zenith (minimum)
Высота однородной атмосферы (м)	7991	Height of homogeneous atmosphere (m)
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
Момент инерции сферы	$I = {}^2/_3\, MR^2$	Moment of inertia of sphere
Объём шара	$V = {}^4/_3\, \pi R^3$	Volume of a 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

Элементы орбит и физические характеристики планет, некоторых карликовых планет, Солнца и Луны

Parameters of orbits and physical characteristics of planets, some dwarf planets, Sun and Moon

Небесное тело, планета	Среднее расстояние от центрального 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 *tropical years*	in *days*	*e*	*km*	10^{24} *kg*	*g/cm*^{3}	*m/s*^{2}		
Солнце Sun	$1{,}6\cdot10^9$	$2{,}5\cdot10^{11}$	$2{,}2\cdot10^8$	$8\cdot10^{10}$		1392000	1989000	1,409		$-26{,}8^m$	
Меркурий Mercury	0,387	57,9	0,241	87,969	0 ,206	4 879	0,3302	5,43	3,70	$-2{,}2^m$	0,06
Венера Venus	0,723	108,2	0,615	224,701	0,007	12 104	4,8690	5,24	8,87	$-4{,}7^m$	0,78
Земля Earth	1,000	149,6	1,000	365,256	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
Марс Mars	1,524	227,9	1,880	686,980	0,093	6 794	0,6419	3,94	3,71	$-2{,}0^m$	0,15
Церера Ceres	2,77	414	4,60	1 681	0,077	963	0,0009	2,16	0,27	$6{,}7^m$	0,09
Юпитер Jupiter	5,204	778,6	11,862	4 332,59	0,048	142 984	1899,8	1,33	24,86	$-2{,}7^m$	0,66
Сатурн Saturn	9,584	1433,7	29,458	10 759,20	0,054	120 536	568,50	0,70	10,41	$0{,}7^m$	0,68
Уран Uranus	19,191	2871,0	84,015	30 685,93	0,046	51 118	86,625	1,30	8,44	$5{,}5^m$	0,74
Нептун Neptune	30,071	4498,6	164,778	60 187,64	0,008	49 532	102,78	1,76	11,20	$7{,}8^m$	0,58
Плутон Pluto	39,482	5906,4	248,09	90 613	0,249	2 374	0,0130	1,86	0,61	$15{,}1^m$	0,6
Макемаке Makemake	45,436	5906,4	306,28	111 867	0,163	1 502	0,003	1,70	0,40		0,77
Эрида Eris	67,668	10210	557	203 500	0,441	2 326	0,0167	2,52	0,68		0,90

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

Данные о некоторых звёздах

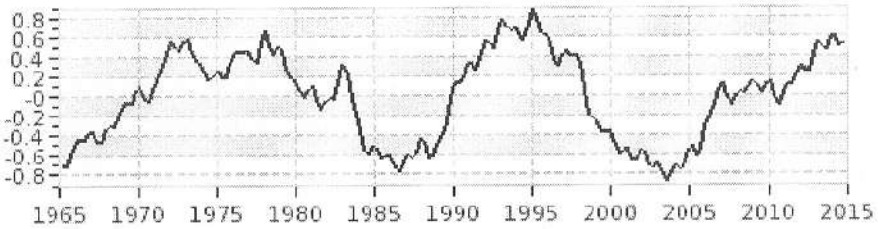
Data of some stars

			R.A.	*DEC*	*Расстояние Distance*	*Зв.вел. Mag.*	*Температура Temperature*	*Масса Mass*
Солнце	Sun	⊙	$0^h - 24^h$	-23°26' – +23°26'	1 au	$-26^m.74$	5777 K	$1\,M_\odot$
Бетельгейзе	Betelgeuse	α Ori	$05^h\ 55^m\ 10^s$	07° 24' 25"	197 pc	$0^m.5$	3590 K	$11.6\,M_\odot$
Альфа Центавра	Alpha Centauri	α Cen	$14^h\ 39^m\ 36^s$	-60° 50' 07"	1.33 pc	$-0^m.01$ $1^m.33$	5810 K 5260 K	$1.11\,M_\odot$ $0.93\,M_\odot$

Theoretical round. Problems to solve

1. **Satellite of Mars.** There is a project to launch an artificial satellite in an orbit around Mars with equipment for solar eclipse observations, similar to what we see from the Earth. Mars itself would be the object occulting the Sun. Estimate, whether it is possible, and what could be the orbital period of the satellite. Clearly explain your solution with a drawing.

2. **Length of Day.** Due to influence of the Moon the Earth's rotation is gradually slowing down, increasing the length of day by 16 milliseconds in every millennium. However, apart from this there is a considerable variation of this duration with the periods from one year to several hundred years. In the given figure, the so-called "subdecadal" length of day variations during last 50 years is along horizontal axis and deviation in milliseconds is along vertical axis. According to one of the theories, the only reason for these variations is fluctuations in sea level. In frames of this model find, for which value the sea level would rise (Δh = +...) or fall (Δh = –...) from 1995 to 2003.



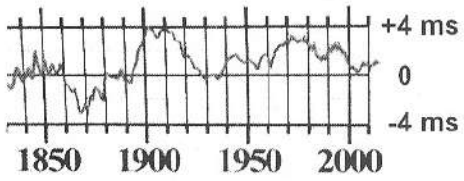
Problems 3, 4, 5 – see page 2.

Задачи 3, 4, 5 – см. стр. 2.

Theoretical round. Problems to solve

1. **Dyson sphere.** There is a fantastic hypothesis that Betelgeuse is not a red supergiant, but an artificial construction, Dyson sphere, made by a super-high-temperature civilization around their star. Naturally, the radius of the constructed sphere was the same as the previous orbital radius of their former planet. Estimate the orbital period of their former planet.

2. **Length of Day.** Due to influence of the Moon the Earth's rotation is gradually slowing down, increasing the length of day by 16 milliseconds in every thousand years. However, apart from this, considerable variations of this duration with the periods from one year to several hundred years exist. In the given figure, length of day shifts including the so-called "subdecadal" variations from year 1830 to 2014 is along horizontal axis and deviation in milliseconds is along vertical axis. According to one of the theories, the only reason for these variations is fluctuations of sea level. In frames of this model find, how the sea level was changing during this period. Draw an indicative plot of these changes (on the horizontal axis – years, on the vertical one – changes of sea level in a reasonable scale).



Problems 3, 4, 5 – see page 2.

Задачи 3, 4, 5 – см. стр. 2.

Theoretical round. Problems to solve.

Common introduction for problems 3 and 4. Heaven omen. On June 22, 813 A.D, after 15 days of standing opposite to each other, Bulgarian Khan Krum defeated the Byzantine army of Emperor Michael I Rhangabe near Adrianople (currently Edirne, Turkey) and took over the city. After this victory, the Bulgarian army marched on to Constantinople and besieged the capital of the Byzantine Empire. It is possible that the outcome of the battle was affected by superstitious generals. Fear of astronomical events is described in the Byzantine chronicles: "When the two armies, Bulgarian in north-west and Greek in south-east, converged, a terrible celestial omen was the gaze of warriors: two comets, bright as moons, separated from one another". Some historians of astronomy believe that it is one of the first descriptions of a cometary nucleus fragmentation. However, there are also other options.

3. **Heaven omen. Two comets.** Imagine two comets, moving one by one strictly on the same trajectory. Supposing orbital period of the comets is exactly 3 years, let us assume that they come in opposition for an observer on the Earth during the aphelion passage of their orbit (reaching the middle of asteroid belt), but their apparent positions in this position are so close to each other, that the comets merge into one visible point for the naked eye. At what maximum angular distance from each other the comets can be observed at the time of perihelion passage? (At this angular distance, perhaps two comets were seen in June 813 A.D).

4. **Heaven omen. Moon and comet.** Even more surprising, but nonetheless, a possible explanation for this phenomenon may be the end of the occultation of a bright comet by the Moon in thin crescent phase. Then the warriors can see how the comet comes out from behind the illuminated part of the Moon and two crescents break up in the sky. In this case:
   4.1. At what time of day could this phenomenon have been observed?
   4.2. In what constellation could this phenomenon have been observed?
   4.3. For which of the two armies the omen has given more fright? Why?
   4.4. Include an artistic picture with an image of warriors before the battle. Necessary sizes or angular sizes should be pointed out in the picture.
   4.5. Calculate (or explain what data is missing for the calculation), in which of the 15 days of standing armies before the battle, could this phenomenon have been observed.

5. **Search for asteroids.** It is possible to register an asteroid from the main asteroid belt down to a size of 2.5 km by a modern medium-size telescope. What size of the objects of the Kuiper belt can be registered by the same telescope with the same methods? You should remember all necessary properties and data of asteroids of the main belt and Kuiper belt by heart.