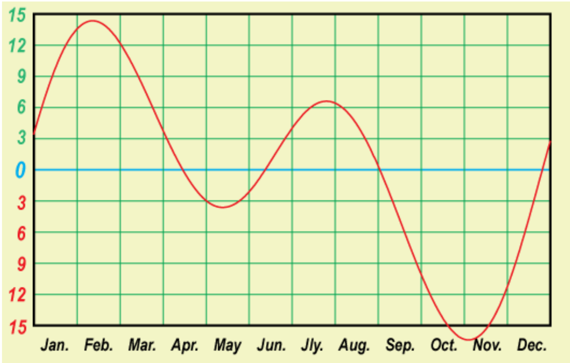
Some constants and formulae

Speed of light in vacuum, c	299 792 458 ms^{-1}
Constant of gravitation, G	6.674×10^{-11} $Nm^{-2}kg^{-2}$
Solar constant, A	1367 Wm^{-2}
Mean value, Hubble parameter	68
Diapason of values, H_0	50-100 $kms^{-1}Mpc^{-1}$
Plank constant, h	6.626×10^{-34}Js
Charge of electron, e	1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Proton-to-electron mass ratio	1836.15
Faraday constant, F	96 485 C/mol
Magnetic constant, μ_0	1.257×10^{-6} Hm^{-1}
Universal gas constant, R	8.314 $Jmol^{-1}K^{-1}$
Boltzmann constant, k	1.381×10^{-23} JK^{-1}
Stefan-Boltzmann constant, σ	5.67×10^{-8} $Wm^{-2}K^{-4}$
Wien's displacement constant, b	0.002897 mK
Laboratory wavelength oh Hα	6562.81 Å
Tropical year length, T	365.242199 days
Sidereal year length, T	365.25636 days
Anomalistic year length, T	365.259636 days
Nodal period of lunar orbit	-18.6 years
Standard atmosphere	101 325 Pa
Visible light extinction by the terrestrial atmosphere in zenith (minimum)	19%, 0.23m
Height of homogeneous atmosphere	7991 m
Refractive index of water at 20⁰C, n	1.334
Moment of inertia of a solid ball	$I = {}^{2}/_{5}\, MR^2$
Moment of inertia of sphere	$I = {}^{2}/_{3}\, MR^2$
Volume of a ball	$V = {}^{4}/_{3}\, \pi R^3$
Area of sphere	$A = 4\pi R^2$
π	3.14159265
e	2.71828183
Golden ratio,φ	1.61803399

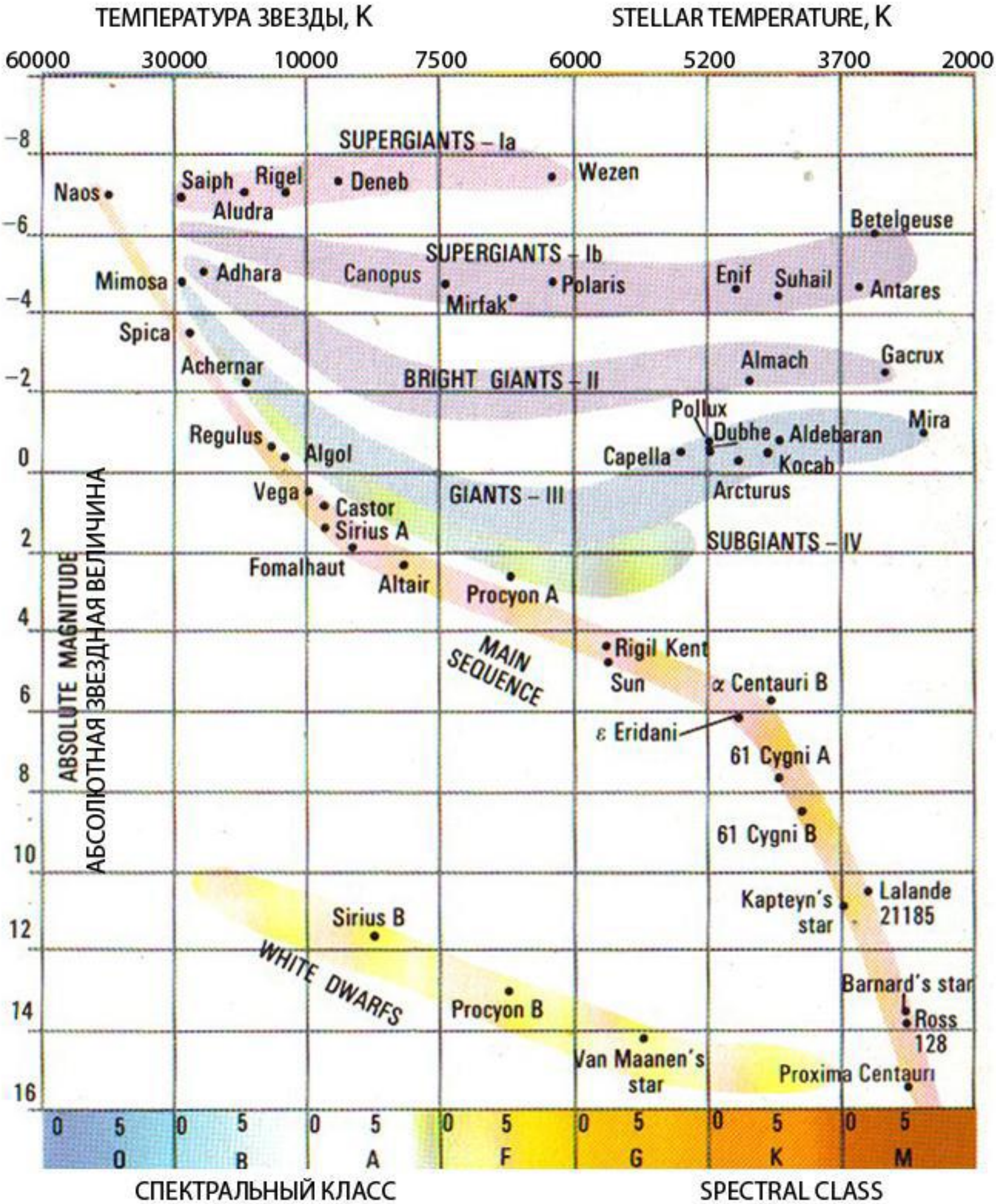
Parameters of orbits and physical characteristics of planets, Sun and Moon

Body, planet	Average distance to central body		Sidereal (or analogous) period		Eccentricity, e	Equat. Diameter **(km)**	Mass **(10^{24} kg)**	Av. Density **(g/cm^3)**	Grav. acc. at surface **(m/s^2)**	Max. mag. from Earth* (^{m})	Albedo
	A.U	**10^6 km**	**Tropical years**	**days**							
Sun	1.6×10^9	2.5×10^{11}	2.2×10^8	8×10^{10}		1392 000	1989 000	1.409		-26.8	
Mercury	0.387	57.9	0.241	87.969	0.206	4 879	0.3302	5.43	3.70	-2.2	0.06
Venus	0.723	108.2	0.651	224.701	0.007	12 104	4.8690	5.24	8.87	-4.7	0.78
Earth	1.000	149.6	1.000	365.256	0.017	12 756	5.9742	5.52	9.81		0.36
Moon	0.00257	0.3844	0.0748	27.3217	0.055	3 475	0.0735	3.34	1.62	-12.7	0.07
Mars	1.524	227.9	1.880	686.980	0.093	6 794	0.6419	3.94	3.71	-2.0	0.15
Jupiter	5.204	778.6	11.862	4 332.59	0.048	142 984	1899.8	1.33	24.86	-2.7	0.66
Saturn	9.584	1433.7	29.458	10 759.2	0.054	120 536	568.50	0.70	10.41	0.7	0.68
Uranus	19.191	2871.0	84.015	30 685.93	0.046	51 118	86.625	1.30	8.44	5.5	0.74
Neptune	30.071	4498.6	164.778	60 187.64	0.008	49 532	102.78	1.76	11.20	7.8	0.58

*for outer planets and Moon – in mean position



Equation of time



20 brightest stars in the sky

		RA	Dec	*p*	m	SC
Altair	α Aql	$19^h 50^m 47^s$	08° 52' 06"	0".195	$0^m.77$	A7
Capella	α Aur	$05^h 16^m 41^s$	45° 59' 53"	0".073	$0^m.08$	G5+G0
Arcturus	α Boo	$14^h 15^m 38^s$	19° 10' 57"	0".089	$-0^m.04$V	K1
Canopus	α Car	$06^h 23^m 57^s$	-52° 41' 45"	0".028	$-0^m.72$	F0
Toliman (Rigel Kent)	α Cen A B	$14^h 39^m 36^s$	-60° 50' 07"	0".747	$-0^m.01$ $1^m.33$	G2 K1
Hadar	β Cen	$14^h 03^m 49^s$	-60° 22' 23"	0".009	$0^m.61$	B1
Sirius	α CMa	$06^h 45^m 09^s$	-16° 42' 58"	0".375	$-1^m.46$	A1
Procyon	α CMi	$07^h 39^m 18^s$	05° 13' 30"	0".288	$0^m.38$	F5
Acrux	α Cru	$12^h 26^m 36^s$	-63° 05' 57"	0".010	$0^m.77$	B0
Becrux	β Cru	$12^h 47^m 43^s$	-59° 41' 20"	0".009	$1^m.30$	B0
Deneb	α Cyg	$20^h 41^m 26^s$	45° 16' 49"	0".002	$1^m.25$	A2
Achernar	α Eri	$01^h 37^m 43^s$	-57° 14' 12"	0".026	$0^m.46$	B3
Pollux	β Gem	$07^h 45^m 19^s$	28° 01' 35"	0".097	$1^m.14$	K0
Vega	α Lyr	$18^h 36^m 56^s$	38° 47' 01"	0".123	$0^m.03$	A0
Betelgeuse	α Ori	$05^h 55^m 10^s$	07° 24' 25"	0".005	$0^m.5$V	M2
Rigel	β Ori	$05^h 14^m 32^s$	-08° 12' 06"	0".013	$0^m.12$	B8
Fomalhaut	α PsA	22h 57m 39s	-29° 37' 20"	0".130	$1^m.16$	A3
Antares	α Sco	$16^h 29^m 24^s$	-26° 25' 55"	0".024	$0^m.96$	M1+B4
Aldebaran	α Tau	$04^h 35^m 55^s$	16° 30' 33"	0".048	$0^m.85$V	K5
Spica	α Vir	$13^h 25^m 12^s$	-11° 09' 41"	0".023	$0^m.98$	B1
			Some other stars			
Hamal	α Ari	$02^h 07^m 10^s$	23° 27' 45"	0".050	$2^m.01$	K2
Polaris	α UMi	$02^h 31^m 49^s$	89° 15' 51"	0".007	$1^m.97$V	F7
Kochab	β Umi	$14^h 50^m 42^s$	74° 09' 20"	0".025	$2^m.07$	K4
Proxima Centaruy	α Cen c	14h 29m 43s	-62° 40' 46"	0".769	$11^m.05$	M5.5

Greek Letters

Α	α	alpha	Ι	ί	iota	Ρ	ρ	rho
Β	β	beta	Κ	κ	kappa	Σ	ζ	sigma
Γ	γ	gamma	Λ	λ	lambda	Τ	η	tau
Δ	δ	delta	Μ	μ	mu	ϒ	υ	upsilon
Ε	ε	epsilon	Ν	ν	nu	Φ	θ	phi
Ζ	δ	zeta	Ξ	ξ	xi	Χ	χ	chi
Η	ε	eta	Ο	*ο*	omicron	Ψ	ψ	psi
Θ	ζ	theta	Π	π	pi	Ω	ω	omega

<u>THEORETICAL QUESTION</u>

1. Suppose a person is standing on the Moon surface. What can the person see in the Moon's sky more often – the Sun or the Earth? Explain.

2. In a problem on celestial mechanics we are asked to determine the orbital elements of a satellite orbiting the Earth. The orbital elements are the parameters required to uniquely identify the orbit of the satellite. Sketch a diagram and show in the diagram the following six orbital elements of the satellite around the Earth.
   a. Eccentricity (e)
   b. Semimajor axis (a)
   c. Inclination (i)
   d. Longitude of the ascending node (Ω)
   e. Argument of periapsis (ω)
   f. True anomaly (ν)

3. The highest-velocity stars an astronomer might observe in the Milky Way Galaxy have radial velocities of about 400 km per second. What change in wavelength would this cause in the Balmer-beta spectral line of hydrogen?
   (Note: The laboratory wavelength of Balmer-beta line of hydrogen is 486.1 nm)

4. The period-luminosity relationship for classical Cepheid variable stars is
   $$\log\left(\frac{L}{L_{sun}}\right) \approx 1.15 \cdot \log\left(\frac{P}{1\ day}\right) + 2.47$$
   Use this and the absolute visual magnitude of the Sun (+4.83) to derive a relation between the absolute visual magnitude M_V and period P of a Cepheid.

5. Usually we consider that there are about 6000 stars in the whole sky which are visible by our eyes. Estimate, how many visible stars are circumpolar from Penang (5.416° N, 100.333° E).
   (Note: formula for sphere's area calculation: $S = 4\pi R^2$.)

6. The Italian inventor Guglielmo Marconi made the first long distance radio broadcast from Europe to America in 1901. Some of the radio waves in this broadcast also has escaped into space. Since that time until today (2020), these radio waves have travelled in space for 119 years. In the solar neighborhood there are, on average, one star-system per 400 cubic light-years. How many star systems could have heard Marconi's radio broadcast?

7. Suppose that a total solar eclipse is seen by an observer from a place at the Earth's equator when the Sun is at zenith. Also, suppose that the shadow of the Moon moves along the Earth's equator. Calculate the speed of the Moon's shadow relative to the observer.

8. A binary star system has Star A and Star B with a brightness ratio of 2. The binary system is difficult to resolve and is observed from the Earth as one star of magnitude = 5. Find the apparent magnitudes of each of the two stars.

9. Estimate the number of solar neutrinos which should pass through a 1 m^2 area of the Earth's surface perpendicular to the Sun every second. (Use the fact that each fusion reaction in the Sun produces 26.8 MeV of energy and 2 neutrinos).

10. Describe the advantages and disadvantages of using reflecting telescopes as compared to refracting telescopes.