Proceedings of the 4th IOAA

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Beijing 2010

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The fourth International Olympiad on Astronomy and Astrophysics

12th –21st September, 2010 Beijing, China

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Hosts

Chinese Astronomical Society
Beijing Planetarium

Co-organizers

National Astronomical Observatories, Chinese Academy of Sciences
Department of Astronomy, Beijing Normal University

Sponsors

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National Natural Science Foundation of China
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We would like to show our appreciation to people who have worked so hard to organize IOAA and other people and institutions whose contribution is significant. We thank Chairman of the organizer, LOC members, Staffs of the organizer, IOAA president, IOAA Secretary, Juries, Problems creators, Students guide and Sponsors. The 4th IOAA would not be so successful without you!

Content

The 4th IOAA

Participants / Leaders and Observers

The 4th IOAA Participants / Leaders and Observers

No.	Team Name	Position	Code	Name
1	**Bangladesh**	Team Leader #1	BA-T-1	Ronald Cruz
2	**Bangladesh**	Team Leader #2	BA-T-2	Moshurl Amin
3	**Bangladesh**	Observer #1	BA-O-1	Taif Hossain Rocky
4	**Bangladesh**	Student #1	BA-S-1	Md. Shahriar Rahim Siddiqui
5	**Bangladesh**	Student #2	BA-S-2	Syeda Lammim Ahad
6	**Bangladesh**	Student #3	BA-S-3	Nibirh Jawad
7	**Bangladesh**	Student #4	BA-S-4	Md. Tanveer Karim
8	**Bangladesh**	Student #5	BA-S-5	Pritom Mozumdar
9	**Belarus**	Student #1	BE-S-1	Svetlana Dedunovich
10	**Belarus**	Student #2	BE-S-2	Zakhar Plodunov
11	**Belarus**	Student #3	BE-S-3	Halina Aluf
12	**Belarus**	Student #4	BE-S-4	Hanna Fakanava
13	**Belarus**	Student #5	BE-S-5	Pavel Liavonenka
14	**Belarus**	Team Leader #1	BE-T-1	Alexander Poplavsky
15	**Belarus**	Team Leader #2	BE-T-2	Stanislaw Sekerzhitsky
16	**Bolivia**	Team Leader #1	BO-T-1	Mirko Raljevic

17	**Bolivia**	Student #1	BO-S-1	Gabriel Jaimes
18	**Bolivia**	Student #2	BO-S-2	Stefani Coco
19	**Bolivia**	Student #3	BO-S-3	Beymar Huchani
20	**Brazil**	Team Leader #1	BR-T-1	Thais Mothé Diniz
21	**Brazil**	Team Leader #2	BR-T-2	Felipe Augusto Cardoso Pereira
22	**Brazil**	Student #1	BR-S-1	Thiago Saksanian Hallak
23	**Brazil**	Student #2	BR-S-2	Tiago Lobato Gimenes
24	**Brazil**	Student #3	BR-S-3	Gustavo Haddad Francisco e Sampaio Braga
25	**Brazil**	Student #4	BR-S-4	Tábata Cláudia Amaral de Pontes
26	**Brazil**	Student #5	BR-S-5	Luiz Filipe Martins Ramos
27	**Cambodia**	Team Leader #1	CA-T-1	ING Heng
28	**Cambodia**	Team Leader #2	CA-T-2	SRIV Tharith
29	**Cambodia**	Observer #1	CA-O-1	CHEY Chan Oeurn
30	**Cambodia**	Student #1	CA-S-1	CHHAY Minea
31	**Cambodia**	Student #2	CA-S-2	EANG Mohethrith
32	**Cambodia**	Student #3	CA-S-3	KREM Sona
33	**Cambodia**	Student #4	CA-S-4	MENG Phal Kong
34	**Cambodia**	Student #5	CA-S-5	TOTH Gama

35	**China**	Team Leader #1	CN-T-1	Changxi Zhang
36	**China**	Student #1	CN-S-1	Bin Wu
37	**China**	Student #2	CN-S-2	Jianlin Su
38	**China**	Student #3	CN-S-3	Tengyu Cai
39	**China**	Student #4	CN-S-4	Chenyong Xu
40	**China**	Student #5	CN-S-5	Yonghao Xie
41	**China (Guest)**	Team Leader #1	CNG-T-1	Xia Guo
42	**China (Guest)**	Student #1	CNG-S-1	Runxuan Liu
43	**China (Guest)**	Student #2	CNG-S-2	Xinyu Gu
44	**China (Guest)**	Student #3	CNG-S-3	Zhuchang Zhan
45	**China (Guest)**	Student #4	CNG-S-4	Wenxuan Yu
46	**China (Guest)**	Student #5	CNG-S-5	Chenxing Dong
47	**Czech Republic**	Team Leader #1	CZ-T-1	Jan Kozusko
48	**Czech Republic**	Student #1	CZ-S-1	Stanislav Fort
49	**Greece**	Team Leader #1	GR-T-1	Loukas Zachilas
50	**Greece**	Team Leader #2	GR-T-2	John Seiradakis
51	**Greece**	Observer #1	GR-O-1	Maria Kontaxi
52	**Greece**	Student #1	GR-S-1	Orfefs Voutyras
53	**Greece**	Student #2	GR-S-2	Georgios Lioutas
54	**Greece**	Student #3	GR-S-3	Nikolaos Flemotomos

55	**Greece**	Student #4	GR-S-4	Despoina Pazouli
56	**Greece**	Student #5	GR-S-5	Stefanos Tyros
57	**India**	Team Leader #1	IN-T-1	Aniket Sule
58	**India**	Team Leader #2	IN-T-2	Pradip Dasgupta
59	**India**	Observer #1	IN-O-1	H. C. Pradhan
60	**India**	Student #1	IN-S-1	Aniruddha Bapat
61	**India**	Student #2	IN-S-2	Chirag Modi
62	**India**	Student #3	IN-S-3	Kottur Satwik
63	**India**	Student #4	IN-S-4	Nitesh Kumar Singh
64	**India**	Student #5	IN-S-5	Shantanu Agarwal
65	**Indonesia**	Team Leader #1	IO-T-1	Suryadi Siregar
66	**Indonesia**	Team Leader #2	IO-T-2	Ikbal Arifyanto
67	**Indonesia**	Observer #1	IO-O-1	Hari Sugiharto
68	**Indonesia**	Student #1	IO-S-1	Raymond Djajalaksana
69	**Indonesia**	Student #2	IO-S-2	Anas Maulidi Utama
70	**Indonesia**	Student #3	IO-S-3	Widya Ageng Setya Tutuko
71	**Indonesia**	Student #4	IO-S-4	Hans Triar Sutanto
72	**Indonesia**	Student #5	IO-S-5	Raditya Cahya
73	**Iran**	Team Leader #1	IR-T-1	Leila Ramezan

74	**Iran**	Team Leader #2	IR-T-2	Seyed Mohammad Sadegh Movahed
75	**Iran**	Observer #1	IR-O-1	Seyedamir Sadatmoosavi
76	**Iran**	Student #1	IR-S-1	Behrad Toghi
77	**Iran**	Student #2	IR-S-2	Ali Izadi Rad
78	**Iran**	Student #3	IR-S-3	Amir Reza Sedaghat
79	**Iran**	Student #4	IR-S-4	Ehsan Ebrahmian Arehjan
80	**Iran**	Student #5	IR-S-5	Mohammad Sadegh Riazi
81	**Iran (Guest)**	Team Leader #1	IRG-T-1	Kazem Kookaram
82	**Iran (Guest)**	Student #1	IRG-S-1	Seyed Fowad Motahari
83	**Iran (Guest)**	Student #2	IRG-S-2	Asma Karimi
84	**Iran (Guest)**	Student #3	IRG-S-3	Kamyar Aziz Zade Neshele
85	**Iran (Guest)**	Student #4	IRG-S-4	Nabil Ettehadi
86	**Iran (Guest)**	Student #5	IRG-S-5	Sina Fazel
87	**Kazakhstan**	Team Leader #1	KA-T-1	Baranovskaya Svetlana
88	**Kazakhstan**	Team Leader #2	KA-T-2	Filippov Roman
89	**Kazakhstan**	Observer #1	KA-O-1	Aigul Abzhaliyeva
90	**Kazakhstan**	Student #1	KA-S-1	Tursyn Yerbatyr
91	**Kazakhstan**	Student #2	KA-S-2	Maukenov Bexultan
92	**Kazakhstan**	Student #3	KA-S-3	Sagyndyk Ernur

93	**Kazakhstan**	Student #4	KA-S-4	Abdulla Bekzat
94	**Kazakhstan**	Student #5	KA-S-5	Sultangazin Adil
95	**Korean**	Team Leader #1	KO-T-1	Sang Gak Lee
96	**Korean**	Team Leader #2	KO-T-2	Inwoo Han
97	**Korean**	Observer #1	KO-O-1	In Sung Yim
98	**Korean**	Student #1	KO-S-1	Hyungyu Kong
99	**Korean**	Student #2	KO-S-2	Seo Jin Kim
100	**Korean**	Student #3	KO-S-3	Yunseo Jang
101	**Korean**	Student #4	KO-S-4	Seongbeom Heo
102	**Lithuania**	Team Leader #1	LI-T-1	Jokubas Sudzius
103	**Lithuania**	Team Leader #2	LI-T-2	Audrius Bridzius
104	**Lithuania**	Student #1	LI-S-1	Dainius Kilda
105	**Lithuania**	Student #2	LI-S-2	Povilas Milgevicius
106	**Lithuania**	Student #3	LI-S-3	Rimas Trumpa
107	**Lithuania**	Student #4	LI-S-4	Motiejus Valiunas
108	**Lithuania**	Student #5	LI-S-5	Arturas Zukovskij
109	**Philippine**	Team Leader #1	PH-T-1	Armando Cruz Lee
110	**Philippine**	Team Leader #2	PH-T-2	Erick Johnh. Marmol
111	**Philippine**	Student #1	PH-S-1	Kenneth Anthony Roquid
112	**Philippine**	Student #2	PH-S-2	Christopher Jan Landicho

113	**Philippine**	Student #3	PH-S-3	Gerico Arquiza Sy
114	**Philippine**	Student #4	PH-S-4	John Romel R. Flora
115	**Philippine**	Student #5	PH-S-5	Rigel Revillo Gomez
116	**Poland**	Team Leader #1	PO-T-1	Grzegorz Stachowski
117	**Poland**	Team Leader #2	PO-T-2	Waldemar Ogłoza
118	**Poland**	Student #1	PO-S-1	Damian Puchalski
119	**Poland**	Student #2	PO-S-2	Przemysław Mróz
120	**Poland**	Student #3	PO-S-3	Jakub Bartas
121	**Poland**	Student #4	PO-S-4	Maksymilian Sokołowski
122	**Poland**	Student #5	PO-S-5	Jakub Pająk
123	**Romania**	Team Leader #1	RO-T-1	Trocaru Sorin
124	**Romania**	Team Leader #2	RO-T-2	CRĂCIUN PETRU
125	**Romania**	Student #1	RO-S-1	Constantin Ana Maria
126	**Romania**	Student #2	RO-S-2	Pop Ana Roxana
127	**Romania**	Student #3	RO-S-3	MĂRGĂRINT VLAD DUMITRU
128	**Romania**	Student #4	RO-S-4	Oprescu Antonia Miruna
129	**Romania**	Student #5	RO-S-5	Kruk Sandor Iozset
130	**Russia**	Team Leader #1	RU-T-1	Eskin Boris
131	**Russia**	Team Leader #2	RU-T-2	Valery Nagnibeda
132	**Russia**	Student #1	RU-S-1	Krivoshein Sergey

133	**Russia**	Student #2	RU-S-2	Borukha Maria
134	**Russia**	Student #3	RU-S-3	Popkov Aleksandr
135	**Russia**	Student #4	RU-S-4	Apetyan Arina
136	**Serbia**	Team Leader #1	SE-T-1	Slobodan Ninkovic
137	**Serbia**	Team Leader #2	SE-T-2	Sonja Vidojevic
138	**Serbia**	Student #1	SE-S-1	Aleksandar Vasiljkovic
139	**Serbia**	Student #2	SE-S-2	Stefan Andjelkovic
140	**Serbia**	Student #3	SE-S-3	Filip Zivanovic
141	**Serbia**	Student #4	SE-S-4	Ognjen Markovic
142	**Serbia**	Student #5	SE-S-5	Milena Milosevic
143	**Slovakia**	Team Leader #1	SL-T-1	Ladislav Hric
144	**Slovakia**	Team Leader #2	SL-T-2	Mária Bartolomejová
145	**Slovakia**	Observer #1	SL-O-1	Marián Vidovenec
146	**Slovakia**	Observer #2	SL-O-2	Zdenka Baxova
147	**Slovakia**	Student #1	SL-S-1	Miroslav Jagelka
148	**Slovakia**	Student #2	SL-S-2	Peter Kosec
149	**Slovakia**	Student #3	SL-S-3	Jakub Dolinský
150	**Sri Lanka**	Team Leader #1	SR-T-1	Kalu Pathirennahelage Sarath Chandana Jayaratne
151	**Sri Lanka**	Team Leader #2	SR-T-2	Ranawaka Arachchige Sujith Saraj Gunasekera

152	**Sri Lanka**	Student #1	SR-S-1	Godagama Rajapakshage Danula Sochiruwan Godagama
153	**Sri Lanka**	Student #2	SR-S-2	Bannack Gedara Eranga Thilina Jayashantha
154	**Sri Lanka**	Student #3	SR-S-3	Dunumahage Sankha Lakshan Karunasekara
155	**Sri Lanka**	Student #4	SR-S-4	Hitihami Mudiyanselage Minura Sachinthana Dinith Kumara
156	**Sri Lanka**	Student #5	SR-S-5	Dhanasingham Birendra Kasun
157	**Thailand**	Team Leader #1	TH-T-1	Kulapant Pimsamarn
158	**Thailand**	Team Leader #2	TH-T-2	Sujint Wangsuya
159	**Thailand**	Observer #1	TH-O-1	Apiradee Wiroljana
160	**Thailand**	Student #1	TH-S-1	Patchara Wongsutthikoson
161	**Thailand**	Student #2	TH-S-2	Ekapob Kulchoakrungsun
162	**Thailand**	Student #3	TH-S-3	Yossathorn Tawabutr
163	**Thailand**	Student #4	TH-S-4	Krittanon Sirorattanakul
164	**Thailand**	Student #5	TH-S-5	Noppadol Punsuebsay
165	**Ukraine**	Team Leader #1	UK-T-1	Sulima Yevgen
166	**Ukraine**	Team Leader #2	UK-T-2	Reshetnyk Volodymyr

167	**Ukraine**	Observer #1	UK-O-1	Mykhailyk Kateryna
168	**Ukraine**	Student #1	UK-S-1	Dmytriyev Anton
169	**Ukraine**	Student #2	UK-S-2	Gorlatenko Oleg
170	**Ukraine**	Student #3	UK-S-3	Kandymov Emirali
171	**Ukraine**	Student #4	UK-S-4	Vasylenko Volodymyr

The 4th IOAA Programs

Programs

Timetable : Program in brief for 4th IOAA

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</table>

Timetable : Detailed arrangement

Sept. 12 For all participants

All day	Airport pickup, Registration
-9:00	breakfast
12:00-13:00	lunch
18:00-19:00	Welcome Dinner
19:15-20:00	Informal Meeting of all team leaders/observers

Sept. 13 For students

-8:30	Breakfast
9:00-10:30	Opening ceremony at Beijing Planetarium
10:30-11:00	Group photo
11:15-12:15	Lunch
12:30-15:00	Travel to the mountain villa in Miyun County
14:00-17:00	Sports activities
17:30-19:30	Dinner/team introduction

Sept. 13 For Team leaders/Observers

-8:30	Breakfast
9:00-10:30	Opening ceremony
10:30-11:00	Group photo
11:15-12:15	Lunch
14:30-15:00	Presentation by Greek team leader
15:00-17:30	IBM-1: General discussion on rules and statutes
18:00-19:00	Dinner
19:00-22:00	IBM-2: Discussion of theoretical problems

Sept. 14 For students

7:00-7:45	Breakfast
8;00-17:00	Visit to Observatories at Xinglong and Huairou, with lunch between visits
17:30-18:30	Dinner

Sept. 14 For Team leaders/Observers

-9:00	Breakfast
9:00-13:00	IBM-3: discussion on theoretical problems
13:00-14:00	Lunch

14:30-17:30	Translation of theoretical problems
18:00-19:00	Dinner
19:15-	Production/delivery of theoretical papers by LOC

Sept. 15 For students

7:00-7:45	Breakfast
8:00-13:00	Theoretical competition
13:00-14:00	Lunch
15:00-17:30	Climbing the Great Wall
18:00-19:00	Dinner

Sept. 15 For Team leaders/Observers

-9:00	Breakfast
9:00-13:00	IBM-4: discussion on data analysis problems
13:00-14:00	Lunch
14:00-17:30	Translation of data analysis problems
18:00-19:00	Dinner
19:15-22:00	IBM-5: discussion of observational and team competition problems
Production/delivery of data analysis papers (LOC)	

Sept. 16 For students

7:00-7:45	Breakfast
8:00-12:00	Data analysis competition
12:15-13:15	Lunch
14:30-16:30	Preparation for observation
16:30-17:30	Sports activities
18:00-19:00	Dinner
20:00-24:00	Observational Competition/or team competition

Sept. 16 For Team leaders/Observers

-9:00	Breakfast
9:00-13:00	Translation of observational + team competition problems
13:00-14:00	Lunch
14:00-	Free time
Production/delivery of observation/team competition papers (LOC)	
18:00-19:00	Dinner

Sept. 17 For students

7:00-7:45	Breakfast
8:00-17:00	Excursion in Miyun, activities with local students. With lunch between activities.
18:00-19:00	Dinner
20:00-24:00	Observational Competition (2nd try)/or team competition/with backup activity to be decided

Sept. 17 For Team leaders/Observers

-9:00	Breakfast
9:00-13:00	IBM-6: the next two hosts of IOAA, logo and other issues
13:00-14:00	Lunch
14:00-	Free time with optional visit to Great Wall
	Dinner

Sept. 18 For students

7:00-7:45	Breakfast
8:00-10:00	Travel to Beijing Planetarium
10:30-12:30	Observation(3rd try)/Activity at Beijing Planetarium

12:30-13:30	Lunch
13:45-17:00	Shopping
17:30-18:30	Dinner
19:00-21:00	Travel back to the mountain villa in Miyun

Sept. 18 For Team leaders/Observers

-9:00	Breakfast
9:00-13:30	Moderation I
13:30-14:30	Lunch
14:30-17:30	Moderation II
18:00-19:00	Dinner
19:30-22:00	IBM-7: Final medal distribution

Sept. 19 For All participants

For whole day	Visit to the Forbidden City/Ancient observatory/Beihai Park
	Breakfast
	Lunch
	Banquet

Sept. 20 For All participants

7:00-7:45	Breakfast
9:00-11:15	Lecture by NAOC astronomers at Miyun Children’s Palace
	Lunch
14:30-16:30	Closing ceremony
	Farewell Dinner

Sept. 21 For All participants

Team departure all day	
	Breakfast
	Lunch
	Dinner

The 4th IOAA Problems and Solutions

- Theoretical Competition
- Practical Competition: Data Analysis
- Observational Competition
- Team Competition
- Samples of Problems in Different Languages
- Samples of Solutions

The 4th IOAA
Theoretical Competition

Please read these instructions carefully:

1. Each student will receive problem sheets in English and/or in his/her native language.
2. The time available for answering theoretical problems is 5 hours. You will have 15 short problems (Theoretical Part 1, Problem 1 to 15), and 2 long problems (Theoretical Part 2, Problem 16 and 17).
3. Use only the pen that has been provided on your desk.
4. Begin answering each problem on a new page of the notebook. Write down the number of the problem at the beginning.
5. Write down your "country name" and your "student code" on the cover of the notebook.
6. The final answer in each question or part of it must be accompanied by units and the correct number of significant digits (use SI or appropriate units). At most 20% of the marks assigned for that part will be deducted for a correct answer without units and/or with incorrect significant digits.
7. At the end of the exam put all papers and the notebook inside the envelope and leave everything on your desk.
8. Please write down logically step by step with intermediate equations/calculations to get the final solution.

Short Problem

Note: 10 points for each problem

1) In a binary system, the apparent magnitude of the primary star is 1.0 and that of the secondary star is 2.0. Find the maximum combined magnitude of this system.

Solution:

Let F_1, F_2, and F_0 be the flux of the first, the second and the binary system, respectively.

$$\Delta m = -2.5\lg(F_1 / F_2)$$
$$(1-2) = -2.5\lg(F_1 / F_2)$$ 5

So, $F_1 / F_2 = 10^{1/2.5} = 10^{0.4}$

$$F_0 = F_1 + F_2 = F_1(1+10^{-0.4})$$ 3

The magnitude of the binary m is:

$$m - 1 = -2.5\lg(F_0 / F_1) = -2.5\lg(F_1(1+0.398)/F_1) = -0.36^m$$ 2

So, $m = 0.64^m$

2) If the escape velocity from a solar mass object's surface exceeds the speed of light, what would be its radius ?

Solution:

$$\sqrt{\frac{2GM_{object}}{R_{object}}} > c$$ 4

$$R_{object} < \frac{2GM_{object}}{c^2}$$ 2

$$R_{object} < \frac{2\times 6.6726\times 10^{-11}\times 1.9891\times 10^{30}}{(2.9979\times 10^{8})^{2}}$$

$$R < 2953.6m$$ 4

3) The observed redshift of a QSO is $z = 0.20$, estimate its distance. The Hubble constant is 72 km s^{-1} Mpc^{-1}.

Solution:

Recession velocity of the QSO is

$$\frac{v}{c} = \frac{(z+1)^2 - 1}{(z+1)^2 + 1} = 0.18$$ 4

According to the Hubble's law,

$$v = H_0 D$$ 2

The distance of the QSO is

$$D = v / H_0 = 0.18c / 72 = 750Mpc,$$ 4

Remarks： if the student calculate the distance using cosmological formula and arrive at the answer $D = 735\,Mpc$,assuming $\Omega_0 = 1.0$ will get the full mark.

4) A binary system is 10 pc away, the largest angular separation between the components is 7.0", the smallest is 1.0". Assume that the orbital period is 100 years, and that the orbital plane is perpendicular to the line of sight. If the semi-major axis of the orbit of one component corresponds to 3.0", that is a_1=3.0", estimate the mass of each component of the binary system, in terms of solar mass.

Solution:

The semi-major axis is

$a = 1/2 \times (7+1) \times 10 = 40\,AU$ 2

From Kepler's 3rd law,

$$M_1 + M_2 = \frac{a^3}{p^2} = \frac{(40)^3}{(100)^2} = 6.4 M_{sun}$$ 4

since $a_1 = 3'', a_2 = 1''$,then

$$\frac{m_1}{m_2} = \frac{a_2}{a_1}$$ 2

$m_1 = 1.6 M_{sun}, m_2 = 4.8 M_{sun}$ 2

5) If 0.8% of the initial total solar mass could be transformed into energy during the whole life of the

Sun, estimate the maximum possible life time for the Sun. Assume that the solar luminosity remains constant.

Solution:

The total mass of the Sun is

$$m \approx 1.99\times10^{30}\,kg$$

0.8% mass transform into energy:

$$E = mc^2 \approx 0.008\times2\times10^{30}\times(3\times10^8)^2 = 1.4\times10^{45}\,J$$ 5

Luminosity of the Sun is

$$L_{sun} = 3.96\times10^{26}\,W$$

Sun's life would at most be:

$$t = E/L_{sun} = 3.6\times10^{18}\,s \approx 10^{11}\,years$$ 5

6) A spacecraft landed on the surface of a spherical asteroid with negligible rotation, whose diameter is 2.2 km, and its average density is 2.2g/cm^3. Can the astronaut complete a circle along the equator of the asteroid on foot within 2.2 hours? Write your answer "YES" or "NO" on the answer sheet and explain why with formulae and numbers.

Solution:

The mass of the asteroid is

$$m_1 = \frac{4}{3}\pi r^3\rho = 1.23\times10^{13}\,kg$$ 2

Since $m_2 << m_1$, m_2 can be omitted,

Then $v = \sqrt{\frac{Gm_1}{r}} = 0.864 m/s$ 3

It is the first cosmological velocity of the asteroid.
If the velocity of the astronaut is greater then v, he will escape from the asteroid.

The astronaut must be at v_2 if he wants to complete a circle along the equator of the asteroid on foot within 2.2 hours, and

$$v_2 = \frac{2\pi \times (2200/2)m}{2.2 \times 3600s} = 0.873 m/s$$ 3

Obviously $v_2 > v$

So the answer should be "NO". 2

7) We are interested in finding habitable exoplanets. One way to achieve this is through the dimming of the star, when the exoplanet transits across the stellar disk and blocks a fraction of the light. Estimate the maximum luminosity ratio change for an Earth-like planet orbiting a star similar to the Sun.

Solution：

The flux change is proportional to the ratio of their surface areas, i.e.,

$$F_e / F_{sun} = (R_e / R_{sun})^2$$ 5

$$(R_e / R_{sun})^2 = 8.4\times10^{-5} \approx 10^{-4}$$ 5

Obviously this difference is extremely small.

8) The Galactic Center is believed to contain a super-massive black hole with a mass $M=4\times10^6\, M_\odot$. The astronomy community is trying to resolve its event horizon, which is a challenging task. For a non-rotating black hole, this is the Schwarzschild radius, $R_s = 3(M/M_\odot)$ km. Assume that we have an Earth-sized telescope (using Very Long Baseline Interferometry). What wavelengths should we adopt in order to resolve the event horizon of the black hole? The Sun is located at 8.5 kpc from the Galactic Center.

Solution:

Observationally, the diameter of the Galactic black hole at the distance of $L = 8.5 kpc$ has the angular size,

$$\theta_{BH} = 2R_s / L$$ 2

On the other hand, an Earth-sized telescope ($D = 2R_e$) has the resolution,

$$\theta_{tel} = 1.22\lambda/(2R_e)$$ 2

In order to resolve the black hole at Galactic center, we need to have $\theta_{BH} \geq \theta_{tel}$,which marginally we consider $\theta_{BH} = \theta_{tel}$

This leads to,

$$\lambda = 4R_e R_s / (1.22L) \qquad 4$$

Taking the values, we have

$$\lambda \approx 0.9mm \qquad 2$$

This means that we need to observe at least at near sub-mm frequencies, which is in radio or far-infrared band.

9) A star has a measured I-band magnitude of 22.0. How many photons per second are detected from this star by the Gemini Telescope(8m diameter)? Assume that the overall quantum efficiency is 40% and the filter passband is flat.

Filter	$\lambda_0(nm)$	$\Delta\lambda(nm)$	$F_{VEGA}(Wm^{-2}nm^{-1})$
I	8.00×10^2	24.0	8.30×10^{-12}

Solution:

The definition of the magnitude is:

$$m_I = -2.5\lg F_I + const$$

Where F_I is the flux received from the source. Using the data above, we can obtain the constant:

$$0.0 = -2.5\lg(0.83\times10^{11}) + const$$

Thus,

$$const = -27.7$$

$$m_I = -2.5\lg F_I - 27.7$$

$$F_I = 10^{\frac{m_I + 27.7}{-2.5}} = 1.3\times10^{-20} Wm^{-2}nm^{-1}$$ 4

For our star, at an effective wavelength $\lambda_0 = 800nm$

using this flux, the number of photons detected per unit wavelength per unit area is the flux divided by the energy of a photon with the effective wavelength:

$$N_I = \frac{1.3\times10^{-20}}{hc/\lambda_0} = 5.3\times10^{-2}\ photonss^{-1}m^{-2}nm^{-1}$$ 3

Thus the total number of photons detected from the star per second by the 8m Gemini telescope over the I band is

$$N_I(total) = (tel.collectingarea)\times QE\times Bandwidth\times N_I$$
$$= (\pi\times4^2)\times0.4\times24\times N_I$$ 3
$$= 26\, photons/s \approx 30\, photons/s$$

10) Assuming that the G-type main-sequence stars (such as the Sun) in the disc of the Milky Way obey a vertical exponential density profile with a scale height of 300pc, by what factor does the density of these stars change at 0.5 and 1.5kpc from the mid-plane relative to the density in the mid-plane?
Solution:

Since $h_z = 300pc$, we can substitute this into the vertical(exponential)disc equation:

$$n(0.5kpc) = n_0 \exp(-|500\ pc|/300\ pc) \approx 0.189\, n_0$$ 5

In other words, the density of G-type MS stars at 0.5kpc above the plane is just under 19% of its mid-plane value.

For $z = 1.5kpc$,this works out as 0.007 . 5

11) Mars arrived at its great opposition at UT $17^h 56^m$ Aug.28, 2003. The next great opposition of Mars will be in 2018, estimate the date of that opposition. The semi-major axis of the orbit of Mars is 1.524 AU.

Solution:

$$T_M = \sqrt{\frac{R_M^3}{R_E^3}} T_E = 1.881 years$$ 2

$$\frac{1}{T_s} = \frac{1}{T_E} - \frac{1}{T_M}$$

$$T_s = \frac{T_E \times T_M}{(T_M - T_E)} = \frac{1.881}{0.881} \times 365.25 = 779.8 days$$ 3

That means there is an opposite of the Mars about every 780 days.

If the next great opposite will be in 2018, then

$15 \times 365 + 4 = 5479\ days$

$5479 / 779.8 = 7.026$

It means that there will have been 7 opposites before Aug.28, 2018, 3

So the date for the great opposite should be

$5479 - 7 \times 779.8 = 20.4 days$, i.e.

20.4days before Aug.28,2018, 2

It is on Aug .7, 2018.

12) The difference in brightness between two main sequence stars in an open cluster is 2 magnitudes. Their effective temperatures are 6000K and 5000K respectively. Estimate the ratio of their radii.

Solution:

$$L_1 = 4\pi R_1^2 \sigma T_{\max}^4$$ 3

$$L_2 = 4\pi R_2^2 \sigma T_{\min}^4$$

$$\Delta m = -2.5\lg(L_{\min} / L_{\max}) = -5\lg(R_{\min} / R_{\max}) - 10\lg(T_{\min} / T_{\max})$$ 3

$$\lg(R_{\min} / R_{\max}) = -0.2\Delta m - 2\lg(T_{\min} / T_{\max}) = -0.24$$ 2

So,

$$R_{\min} / R_{\max} = 0.57$$ 2

13) Estimate the effective temperature of the photosphere of the Sun using the naked eye colour of the Sun.

Solution:

The Wien law is

$$\lambda_{\max} = \frac{0.29}{T}(cm)$$ 5

So the temperature is

$$T = \frac{0.29}{550\times10^{-9}} = 5272 \approx 5300K$$ 5

Or

$$T = \frac{0.29}{500\times10^{-9}} = 5800K$$

Note:5200~6000K all full mark

14) An observer observed a transit of Venus near the North Pole of the Earth. The transit path of Venus is shown in the picture below. A, B, C, D are all on the path of transit and marking the center of the Venus disk. At A and B, the center of Venus is superposed on the limb of the Sun disk; C corresponds to the first contact while D to the fourth contact, $\angle AOB = 90^\circ$, MN is parallel to AB. The first contact occured at 9:00 UT. Calculate the time of the fourth contact.

$$T_{venus} = 224.70 days, T_{earth} = 365.25 days, a_{venus} = 0.723AU \text{ , } r_{venus} = 0.949 r_{\oplus}$$

Solution:

Since the observer is at the pole, the affect of the earth's rotation on the transit could be neglected.

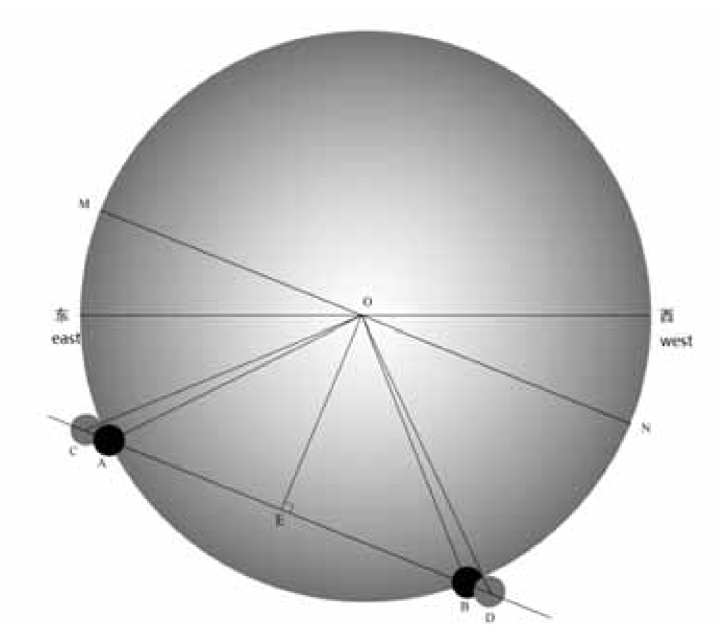
then the Sun's angle at the earth extends as $\theta_0 = \arcsin(\frac{2r_{sun}}{1AU}) \approx 32.0'$;

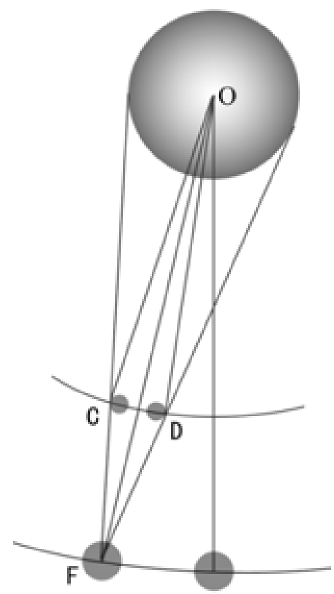
the angular velocity of the Venus around the Sun, respected to the earth is ω_1,

$$\omega_1 = \omega_{venus} - \omega_{earth} = \frac{2\pi}{T_{venus}} - \frac{2\pi}{T_{earth}} \approx 4.29 \times 10^{-4} ('/s)$$ 2

For the observer on earth, Venus moved θ during the whole transit ，
Let OE be perpendicular to AB,
OA=16 ' ∠AOB=90°, MN // AB，

So $OE = 11.3'$， $OC = \frac{d'_{venus}}{2} + \frac{r'_{sun}}{2}$， d'_{venus} is the angular size of Venus seen from Earth.





3

$$d'_{venus} = \frac{2\times0.949\times6378}{(1-0.723)\times1AU} \approx 1',$$

$OC \approx 16.5'$, $CD \approx 24.0'$,

$$CE = \sqrt{OC^2 - OE^2} \approx 12.0'$$

$$CD = 2CE = 24.0'$$

So, $\theta = \angle CFD = 24.0'$, 3

As shown on the picture,

$\theta' = \angle COD$ is the additional angle that Venus covered during the transit,

$$\frac{tg\frac{\theta}{2}}{tg\frac{\theta'}{2}} = \frac{0.723}{(1-0.723)}, \quad tg\frac{\theta}{2} = tg12', \theta' = 9.195';$$ 3

$t_{transit} = \frac{\theta'}{\omega_1} = \frac{9.195'}{4.29\times10^{-4}\,'/s} \times \cos\varepsilon$, that is $5^h56^m36^s$,

So the transit will finish at about 14^h57^m. 2

15) On average, the visual diameter of the Moon is slightly less than that of the Sun, so the frequency of annular solar eclipses is slightly higher than total solar eclipses. For an observer on the Earth, the

longest total solar eclipse duration is about 7.5 minutes, and the longest annular eclipse duration is about 12.5 minutes. Here, the longest duration is the time interval from the second contact to the third contact. Suppose we count the occurrences of both types of solar eclipses for a very long time, estimate the ratio of the occurrences of annular solar eclipses and total solar eclipses. Assume the orbit of the Earth to be circular and the eccentricity of the Moon's orbit is 0.0549. Count all hybrid eclipses as annular eclipses.

Solution

the semi-major axis of Moon's orbit is a; its eccentricity is e; T is the revolution period; apparent radius of the Moon is r; the distance between Earth and Moon is d; the angular radius of the Sun is $R_\circ$

When the Moon is at perigee, the total eclipse will be longest.

$$\omega_1=v_1/d_1,\ t_1=2\ (r_1-R)/\omega_1$$

Here, ωis the angular velocity of the moon, and v is its linear velocity; t2 is the during time of total solar eclipse; r1 is the angular radius of the Moon when it's at perigee.

When the Moon is at apogee, the annular eclipse will be longest.

$$\omega_2=v_2/d_2,\ t_2=2(R-r_2)/\omega_2$$

Since $v_2/v_1=d_1/d_2=(1-e)/(1+e)$,we get:

$$\frac{t_2}{t_1}=\frac{R-r_2}{r_1-R}\times\left(\frac{1+e}{1-e}\right)^2 \qquad (1) \qquad 3$$

Moon orbits the Earth in a ellipse. Its apparent size r varies with time. When r>R, if there occurred an center eclipse, it must be total solar eclipse. Otherwise when r<=R, the center eclipse must be annular.

We need to know that, in a whole moon period, what's the time fraction of r>R and r<=R. r ∝1/d.

But it's not possible to get d by solving the Kepler's equation. Since e is a small value, it would be reasonable to assume that d changes linearly with t. So, r also changes linearly with t. Let the moment when the Moon is at perigee be the starting time (t=0), in half a period, we get:

$$r = r_2 + kt = r_2 + \frac{2(r_1 - r_2)}{T} \cdot t, \quad 0 \le t < T/2$$

Here, $k = 2(r_1 - r_2)/T$=constant.

When r=R, we get a critical t :

$$t_R = \frac{R - r_2}{k} = \frac{(R - r_2)}{2(r_1 - r_2)} \cdot T \qquad (2)$$ 2

During a Moon period, if $t \in (t_R, T - t_R)$, then r>R, and the central eclipses occurred are total solar eclipses. The time interval from t_R to T -t_R is Δt_T=T-2t_R. If $t \in [0, t_R]$ & $t \in [T - t_R, T]$, then r≤R, and the central eclipses occurred are annular eclipses. The time interval is Δt_A=2t_R.

4

The probability of occurring central eclipse at any t is the same. Thus the counts ratio of annular eclipse and total eclipse is:

$$\frac{f_A}{f_T} = \frac{\Delta t_A}{\Delta t_T} = \frac{2t_R}{T - 2t_R} = \frac{R - r_2}{r_1 - R} = \frac{t_2}{t_1} \Big/ \left(\frac{1+e}{1-e}\right)^2 \approx \frac{4}{3}$$ 1

Long Problem

Note: 30 points for each problem

16) A spacecraft is launched from the Earth and it is quickly accelerated to its maximum velocity in the direction of the heliocentric orbit of the Earth, such that its orbit is a parabola with the Sun at its focus point, and grazes the Earth orbit. Take the orbit of the Earth and Mars as circles on the same plane, with radius of r_E=1AU and r_M=1.5AU, respectively. Make the following approximation: during most of the flight only the gravity from the Sun needs to be considered.

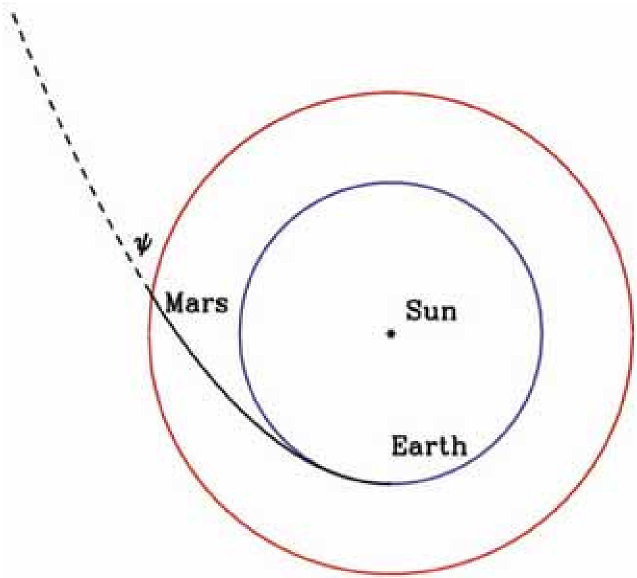


Figure 1:

The trajectory of the spacecraft (not in scale). The inner circle is the orbit of the Earth, the outer circle is the orbit of Mars.

Questions:

(a) What is the angle ψ between the path of the spacecraft and the orbit of the Mars (see Fig. 1) as it crosses the orbit of the Mars, without considering the gravity effect of the Mars?

(b) Suppose the Mars happens to be very close to the crossing point at the time of the crossing, from the point of view of an observer on Mars, what is the approaching velocity and direction of approach (with respect to the Sun) of the spacecraft before it is significantly affected by the gravity of the Mars?

Solution: (1) 10 points; (2) 20 points

(1) The orbit of the spacecraft is a parabola, this suggests that the (specific) energy with respect to the Sun is initially

$$\varepsilon = 1/2v_{\max}^2 + U(r_E) = 0$$ 2

and

$$v_{\max} = \sqrt{2U} = \sqrt{2k_{sun}/r_E}$$

The angular momentum is

$$l = r_E v_{\max} = \sqrt{2k_{sun} r_E}$$ 2

When the spacecraft cross the orbit of the Mars at 1.5 AU, its total velocity is

$$v = \sqrt{2U} = \sqrt{2k_{sun} r_M} = \sqrt{\frac{2}{3}} v_{\max}$$

This velocity can be decomposed into v_r and v_θ, using angular momentum decomposition,

$$r_M v_\theta = l = r_E v_{\max}$$ 2

So,

$$v_\theta = \frac{r_E}{r_M} v_{\max} = \frac{2}{3} v_{\max}$$ 2

Thus the angle is given by

$$\cos\psi = \frac{v_\theta}{v} = \sqrt{\frac{r_E}{r_M}} = \sqrt{\frac{2}{3}}$$

or

$$\psi = 35.26^\circ$$ 2

Note: students can arrived at the final answer with conservation of angular momentum and energy, full mark.

(2) The Mars would be moving on the circular orbit with a velocity

$$v_M \equiv \sqrt{\frac{k_{sun}}{r_M}} = \sqrt{\frac{2}{3}} v_E = 24.32 km/s$$ 3

from the point of view of an observer on Mars, the approaching spacecraft has a velocity of

$$\overrightarrow{v_{rel}} = \vec{v} - \vec{v}_M$$ 2

Now

$$\vec{v} = v\sin\psi\,\hat{r} + v_\theta\,\hat{\theta}$$ 2

with

$$\sin\psi = \sqrt{1-\cos^2\psi} = \frac{1}{\sqrt{3}}$$

So

$$\overrightarrow{v_{rel}} = v\sin\psi\,\hat{r} + (v_\theta - v_M)\,\hat{\theta}$$
$$= \frac{1}{\sqrt{3}}\sqrt{\frac{2k_{sun}}{r_M}}\,\hat{r} + \left(\frac{2}{3}\sqrt{\frac{2k_{sun}}{r_E}} - \sqrt{\frac{k_{sun}}{r_M}}\right)\hat{\theta}$$
$$= \sqrt{\frac{2k_{sun}}{3r_M}}\,\hat{r} + \left(\frac{2}{\sqrt{3}} - 1\right)\sqrt{\frac{k_{sun}}{r_M}}\,\hat{\theta} \qquad 8$$
$$= \sqrt{\frac{k_{sun}}{r_M}}(0.8165\,\hat{r} + 0.1547\,\hat{\theta})$$

The angle between the approaching spacecraft and Sun seen from Mars is:

$$\tan\theta = \frac{0.1547}{0.8165} = 0.1894 \qquad 3$$
$$\theta = 10.72^\circ$$

The approaching velocity is thus

$$v_{rel} = \sqrt{\frac{2}{3} + \left(\frac{2}{\sqrt{3}} - 1\right)^2}\sqrt{\frac{k_{sun}}{r_M}} = 20.21 km/s \qquad 2$$

17) The planet Taris is the home of the Korribian civilization. The Korribian species is a highly intelligent alien life form. They speak Korribianese language. The Korribianese-English dictionary is shown in Table 1; read it carefully! Korriban astronomers have been studying the heavens for thousands of years. Their knowledge can be summarized as follows:

★ Taris orbits its host star Sola in a circular orbit, at a distance of 1 Tarislength.

★ Taris orbits Sola in 1 Tarisyear.
★ The inclination of Taris's equator to its orbital plane is 3°.
★ There are exactly 10 Tarisdays in 1 Tarisyear.
★ Taris has two moons, named Endor and Extor. Both have circular orbits.
★ The sidereal orbital period of Endor (around Taris) is exactly 0.2 Tarisdays.
★ The sidereal orbital period of Extor (around Taris) is exactly 1.6 Tarisdays.
★ The distance between Taris and Endor is 1 Endorlength.
★ Corulus, another planet, also orbits Sola in a circular orbit. Corulus has one moon.
★ The distance between Sola and Corulus is 9 Tarislengths.
★ The tarisyear begins when Solaptic longitude of the Sola is zero.

Korribianese	**English Translation**
Corulus	A planet orbiting Sola
Endor	(i) Goddess of the night; (ii) a moon of Taris
Endorlength	The distance between Taris and Endor
Extor	(i) God of peace; (ii) a moon of Taris
Sola	(i) God of life; (ii) the star which Taris and Corulus orbit
Solaptic	Apparent path of Sola and Corulus as viewed from Taris
Taris	A planet orbiting the star Sola, home of the Korribians
Tarisday	The time between successive midnights on the planet Taris
Tarislength	The distance between Sola and Taris
Tarisyear	Time taken by Taris to make one revolution around Sola

Table 1: Korribianese-English dictionary

Questions:

(a) Draw the Sola-system, and indicate all planets and moons.

(b) How often does Taris rotate around its axis during one Tarisyear?

(c) What is the distance between Taris and Extor, in Endorlengths?

(d) What is the orbital period of Corulus, in Tarisyears?

(e) What is the distance between Taris and Corulus when Corulus is in opposition?

(f) If at the beginning of a particular tarisyear, Corulus and taris were in opposition, what would be Solaptic longitude (as observed from Taris) of Corulus *n* tarisdays from the start of that year?

(g) What would be the area of the triangle formed by Sola, Taris and Corulus exactly one tarisday after the opposition?

(a) 5 points

(b) 5 points

(c) 3 points

(d) 2 points

(e) 5 points

(f) 5 points

(g) 5 points

Solution: (a) Drawing scaled diagram is impossible. Rough sketch is accepted.

(b) There are 10 days and nights per taris year. The obliquity is 3^o, which means that the planet's rotation is in the same direction as its orbit. Thus, total number of rotations per year is $10 + 1 = 11$.

Note: The obliquity is positive (similar to the Earth / Mars / Jupiter). This means, we have ADD one rotation. Subtracting one rotation by assuming opposite rotation (like the Venus) is incorrect.

(c) By Kepler's third law, $\frac{T^2}{R^3} =$ Constant

$$\frac{T_{en}^2}{R_{en}^3} = \frac{T_{ex}^2}{R_{ex}^3} \quad (1)$$

$$R_{ex}^3 = \frac{1.6^2 R_{en}^3}{0.2^2} \quad (2)$$

$$R_{ex} = \sqrt[3]{64} \quad \text{endorlengths} \quad (3)$$

$$= 4 \quad \text{endorlengths} \quad (4)$$

(d) Using same logic as above

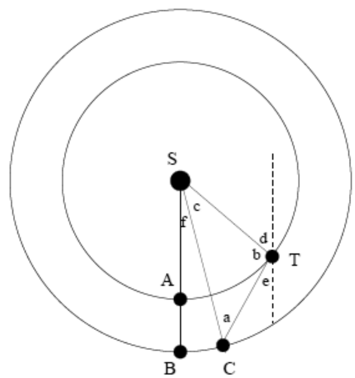
$$\frac{T_C^2}{R_C^3} = \frac{T_T^2}{R_T^3} \quad (5)$$

$$T_C^2 = \frac{9^3 R_T^3 T_T^2}{R_T^3} \quad (6)$$

$$T_C = \sqrt{729} \quad \text{tarisyears} \tag{7}$$
$$= 27 \quad \text{tarisyears} \tag{8}$$

(e) As Corulus is in Opposition, Sola - Taris - Corulus form straight line (in that order).
Distance = 9 - 1 = 8 tarislengths.

(f) In the figure, S is Sola, A and B are start of the year positions of Taris and Corulus, T and C are their positions after 'n' days. Angles are named from a to f. The dashed line is parallel to line SB. Triangle(SCT) is used for sine rule as well as answer in the next part. Figure is not to the scale.



$$
\begin{aligned}
a+b+c &= \pi & (9)\\
b+d+e &= \pi & (10)\\
d &= f+c & (11)\\
f+c &= \frac{2\pi n}{10} & (12)\\
f &= \frac{2\pi n}{270} & (13)\\
\sin b &= 9\sin a \text{ (By Sine Rule)} & (14)
\end{aligned}
$$

$$
\begin{aligned}
e &= \pi - b - d & (15)\\
&= \pi - b - c - f & (16)\\
&= a - f & (17)
\end{aligned}
$$

$$
\begin{aligned}
b &= \pi - (a+c) & (18)\\
&= \pi - \left(a + \frac{2\pi n}{10} - \frac{2\pi n}{270}\right) & (19)\\
&= \pi - \left(a + \frac{52\pi n}{270}\right) & (20)
\end{aligned}
$$

$$9\sin a = \sin\left(\pi - \left(a + \frac{52\pi n}{270}\right)\right) \quad (21)$$
$$= \sin\left(a + \frac{52\pi n}{270}\right) \quad (22)$$
$$= \left[\sin a \cos\left(\frac{52\pi n}{270}\right) + \cos a \sin\left(\frac{52\pi n}{270}\right)\right] \quad (23)$$
$$9 = \cos\left(\frac{52\pi n}{270}\right) + \cot a \sin\left(\frac{52\pi n}{270}\right) \quad (24)$$
$$\cot a = \frac{9 - \cos\left(\frac{52\pi n}{270}\right)}{\sin\left(\frac{52\pi n}{270}\right)} \quad (25)$$
$$a = \tan^{-1}\left[\frac{\sin\left(\frac{52\pi n}{270}\right)}{9 - \cos\left(\frac{52\pi n}{270}\right)}\right] \quad (26)$$

$$\lambda = \pi - e \quad (27)$$
$$= \pi + f - a \quad (28)$$
$$\lambda = \pi + \frac{2\pi n}{270} - \tan^{-1}\left[\frac{\sin\left(\frac{52\pi n}{270}\right)}{9 - \cos\left(\frac{52\pi n}{270}\right)}\right] \quad (29)$$

(g)

$$\text{Area} = \frac{1}{2} \times l(ST) \times l(SC) \times \sin \mathbf{c}$$
$$= \frac{1}{2} \times 1 \times 9 \times 0.568$$
$$= 2.56$$

The area is about 3(tarislength)^2

The 4^{th} IOAA
Practical Competition
Data Analysis

Please read these instructions carefully:

1. You should use the ruler and calculator provided by LOC.
2. The time available for answering data analysis problems is 4 hours. You will have 2 problems.
3. Use only the pen that has been provided on your desk.
4. Begin answering each problem on a new page of the notebook. Write down the number of the problem at the beginning.
5. Write down your "country name" and your "student code" on the cover of the notebook.
6. At the end of the exam put all paper and the notebook inside the envelope and leave everything on your desk.
7. Write down logically step by step with intermediate equations/calculations to get the final solution.

Problem I CCD image (35 points)

Information:

Picture 1 presents a negative image of sky taken by a CCD camera attached to a telescope whose parameters are presented in the accompanying table (which is part of the FITS datafile header).

Picture 2 consists of two images: one is an enlarged view of part of Picture 1 and the second is an enlarged image of the same part of the sky taken some time earlier.

Picture 3 presents a sky map which includes the region shown in the CCD images.

The stars in the images are far away and should ideally be seen as point sources. However, diffraction on the telescope aperture and the effects of atmospheric turbulence (known as 'seeing') blur the light from the stars. The brighter the star, the more of the spread-out light is visible above the level of the background sky.

Questions:

1. Identify any 5 bright stars (mark them by Roman numerals) from the image and mark them on both the image and map.
2. Mark the field of view of the camera on the map.
3. Use this information to obtain the physical dimensions of the CCD chip in mm.
4. Estimate the size of the blurring effect in arcseconds by examining the image of the star in Picture 2. (Note that due to changes in contrast necessary for printing, the diameter of the image appears to be about 3.5 times the full width at half maximum (FWHM) of the profile of the star.)
5. Compare the result with theoretical size of the diffraction disc of the telescope.

6. Seeing of 1 arcsecond is often considered to indicate good conditions. Calculate the size of the star image in pixels if the atmospheric seeing was 1 arcsecond and compare it with the result from question 4.
7. Two objects observed moving relative to the background stars have been marked on Picture 1. The motion of one ("Object 1") was fast enough that it left a clear trail on the image. The motion of the other ("Object 2") is more easily seen on the enlarged image (Picture 2A) and another image taken some time later (Picture 2B).

Using the results of the first section, determine the angular velocity on the sky of both objects. Choose which of the statements in the list below are correct, assuming that the objects are moving on circular orbits. (Points will be given for each correct answer marked and deducted for each incorrect answer marked.)The probable causes of the different angular velocities are:

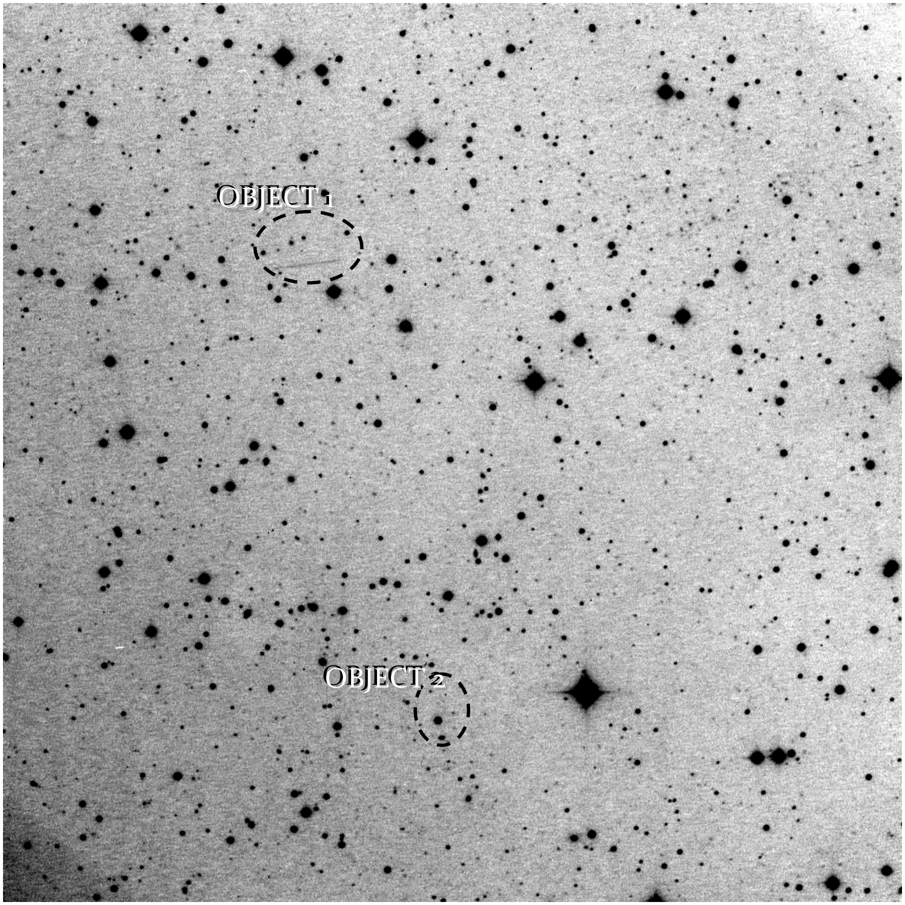
a) different masses of the objects,
b) different distances of the objects from Earth,
c) different orbital velocities of the objects,
d) different projections of the objects' velocities,
e) Object 1 orbits the Earth while Object 2 orbits the Sun.

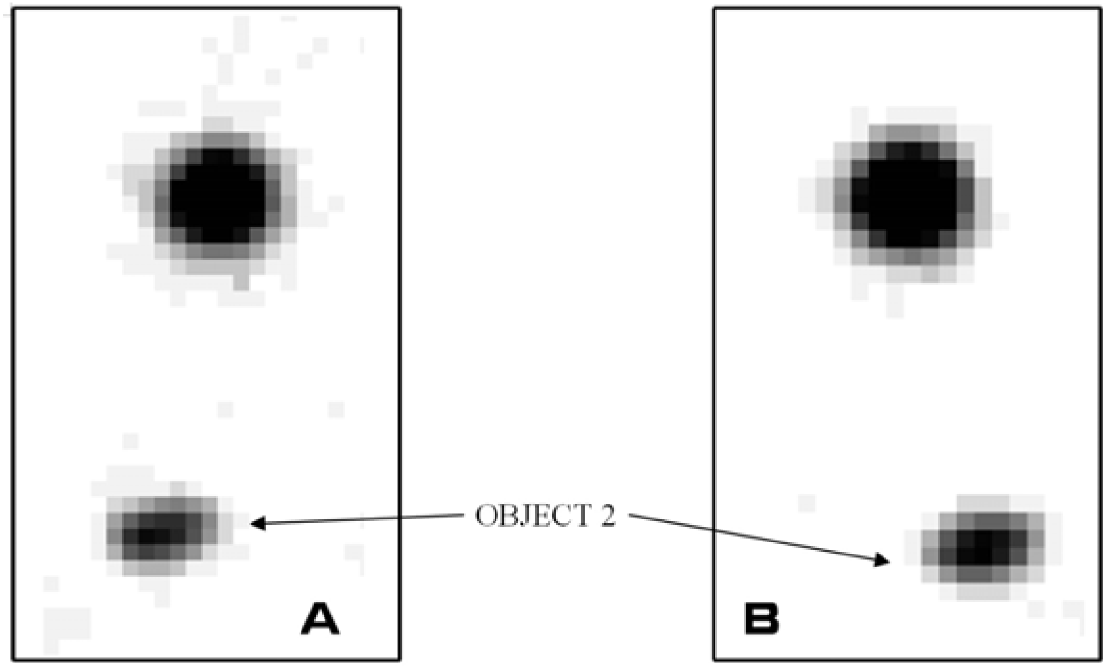
Data:

For Picture 1, the data are,

BITPIX =	16	/ Number of bits per pixel
NAXIS =	2	/ Number of axes
NAXIS1 =	1024	/ Width of image (in pixels)
NAXIS2 =	1024	/ Height of image (in pixels)
DATE-OBS= '2010-09-07	05:00:40.4'	/ Middle of exposure
TIMESYS = 'UT'		/ Time Scale
EXPTIME =	300.00	/ Exposure time (seconds)
OBJCTRA = '22 29 20.031'		/ RA of center of the image
OBJCTDEC= '+07 20 00.793'		/ DEC of center of the image
FOCALLEN= '3.180m'		/ Focal length of the telescope
TELESCOP= '0.61m '		/ Telescope aperture

Picture 1 for Problem I





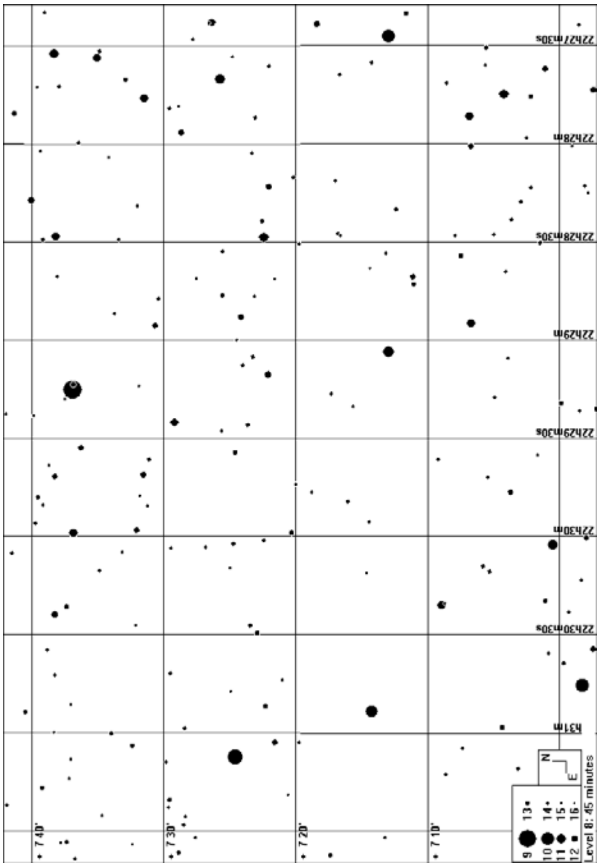
Picture 2 for Problem I:

A: The same area observed some time earlier. For this image the data are :

DATE-OBS= '2010-09-07 04:42:33.3' / Middle of exposure

B: Enlargement of Picture 1 around Object 2,

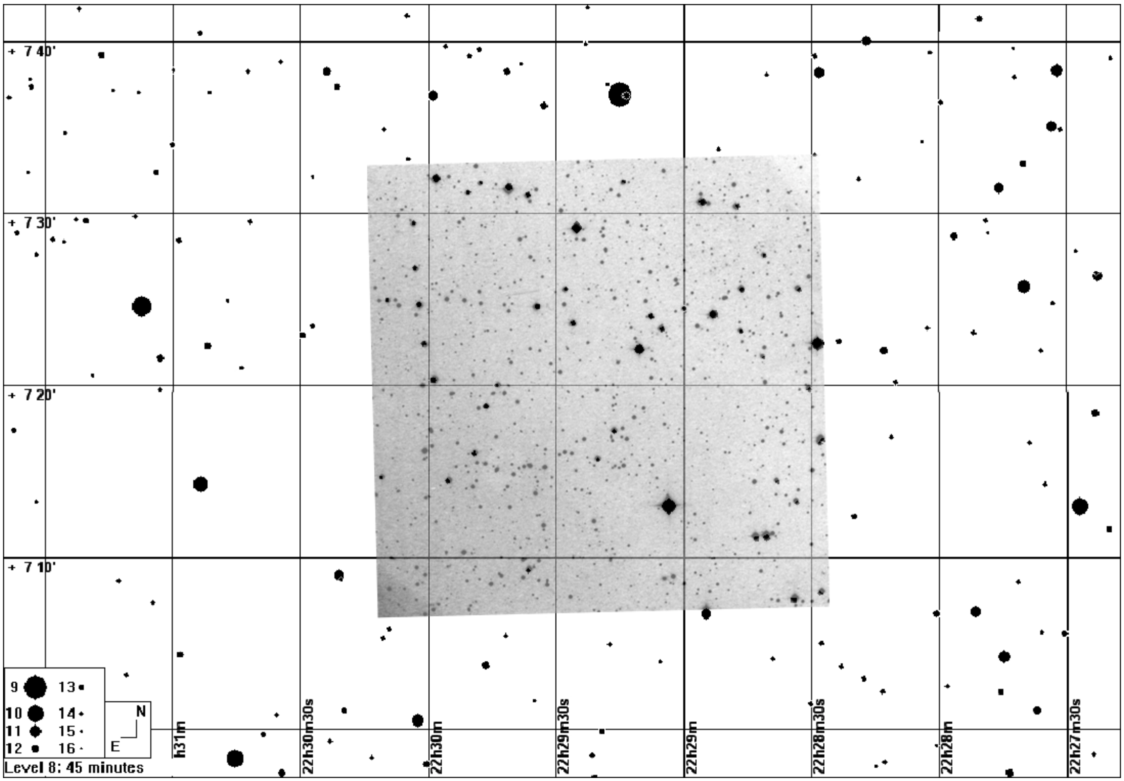
Picture 3 for Problem I:



Solution:

1) 0.5 point for one star, totally 2 points

2)



(2 p)

3) According to the pic of A2, it's easy to find the field of view of the telescope. It's about 26’, and the

declination of the center of the CCD image is 7.3°. Thus the side length of the field of view is :

$$26' \times \cos 7.3° = 1550''$$

Image scale is $d = f\theta$, so, $s = f/206.265$ mm/arcsec = 0.0154 mm/arcsec.
The chip size is 1550 × 0.0154 = 24mm. (4p)

4) The star is 10 pixels across, so the FWHM is 10/3.5 = 2.9 pixels. (4p)
Seeing is S = 2.9 pixels × 1.5"/pixel (from Q3 and 1024 pixels) = 4.4".

5) Theoretical (Airy) diffraction disc is 2.44λ/D radians in diameter:

$$A = 2.44 \times 550\times10^{-9} / 0.61 \text{ rad} = 0.45'' \sim 0.3 \text{ pixels}$$

A << S (seeing).*(Accept all reasonable wavelengths: 450-650nm)* (4p)

6) Seeing = FWHM × 1.5"/pixel (from Q3) =1" . So, FWHM=1/1.5 pixel=1pixel
Printed image of star would then be s2=3.5×FWHM =3.5 pixels. (3p)
Note: if use : s2=1"*10 pix/4.4"=2.3 pix, 2 points.

7) For object 1, the trail of the object is about 107" (measured from pic 1, 300s exposure). It's angular velocity is:

$$\omega_1 = 107''/300\text{s} = 0.36 \text{ ''/s}$$

Note: accept to v±10% . (3p)

For object 2, it's moves about 8 pixels between pic 2A and 2B. 8 pixels ~ 12", and the time between exposures is 17m27s. It's angular velocity is: (3p)

$$\omega_2 = 12''/1047\text{s} = 0.012 \text{ ''/s (accept } \pm10\%)$$

a) **wrong**: different masses of the objects, (+2/-1p)
b) **right**: different distances of the objects from Earth, (+3/-1p)

c) **right**: different orbital velocities of the objects, (+3/-1p)

d) **wrong**: different projections of the objects' velocities, (+2/-1p)

e) **rejected**: Object 1 orbits the Earth while Object 2 orbits the Sun. (0p)

Problem II: Light curves of stars (35 points)

A pulsating variable star KZ Hydrae was observed with a telescope equipped with a CCD camera. Figure 1 shows a CCD image of KZ Hya marked together with the comparison star and the check star. Table 1 lists the observation time in Heliocentric Julian dates, the magnitude differences of KZ Hya and the check star relative to the comparison star in V and R band.

The questions are:

1) Draw the light curves of KZ Hya relative to the comparison star in V and R band, respectively.

2) What are the average magnitude differences of KZ Hya relative to the comparison star in V and R, respectively?

3) What are the photometry precisions in V and R, respectively?

4) Estimate the pulsation periods of KZ Hya in V and R.

5) Give the estimation of the pulsation amplitudes of KZ Hya in V and R

6) What is the phase delay between the V and R bands, in term of the pulsation period?

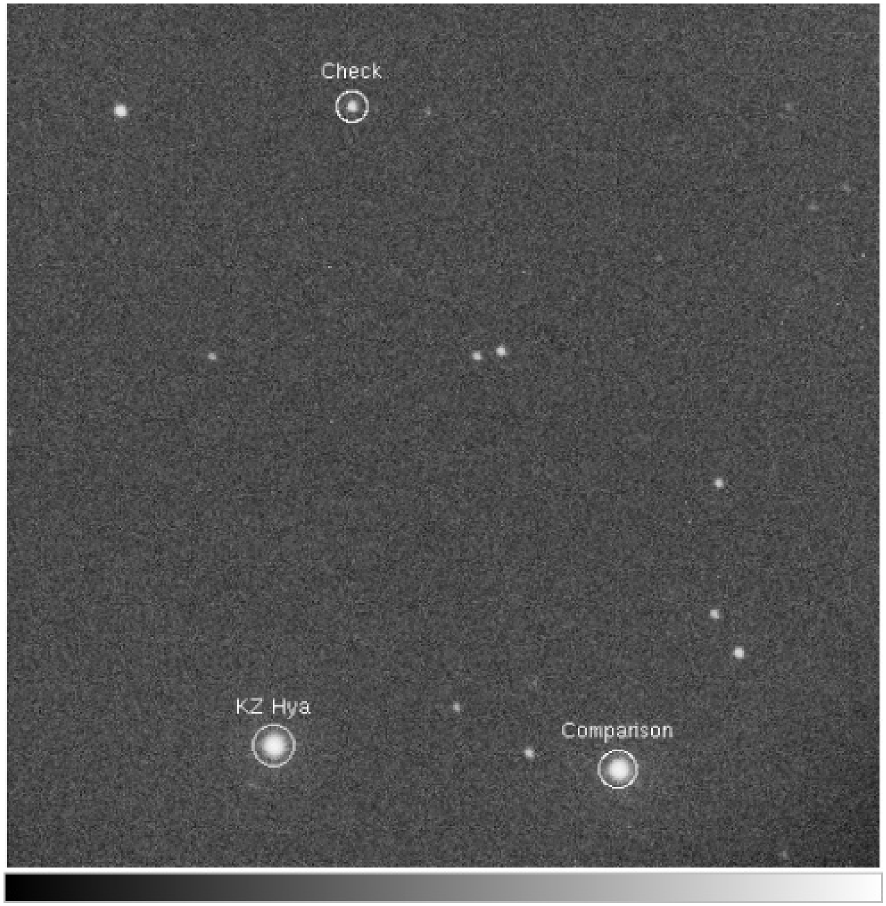


Fig. 1 for Problem II: A CCD image of KZ Hya.

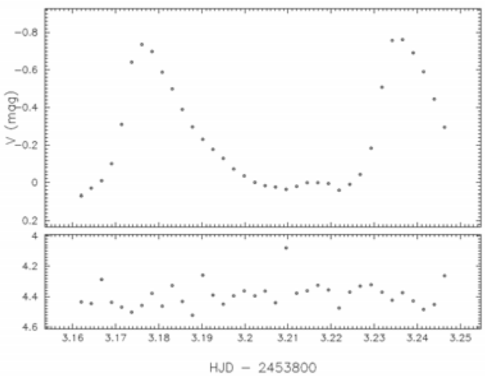
Table 1 for Problem II: Data for the light curves of KZ Hya in V and R. ΔV and ΔR are KZ Hya relative to the comparison in V and R. ΔV_{chk} and ΔR_{chk} are the check star relative to the comparison in V and R.

HJD-2453800(t)	ΔV(mag)	ΔV_{chk}	HJD-2453800(t)	ΔR(mag)	ΔR_{chk}
3.162	0.068	4.434	3.1679	0.260	2.789
3.1643	0.029	4.445	3.1702	0.185	2.802
3.1667	-0.011	4.287	3.1725	-0.010	2.789
3.1691	-0.100	4.437	3.1749	-0.147	2.809
3.1714	-0.310	4.468	3.1772	-0.152	2.809
3.1737	-0.641	4.501	3.1796	-0.110	2.789
3.1761	-0.736	4.457	3.1820	-0.044	2.803
3.1784	-0.698	4.378	3.1866	0.075	2.805
3.1808	-0.588	4.462	3.1890	0.122	2.793
3.1831	-0.499	4.326	3.1914	0.151	2.793
3.1855	-0.390	4.431	3.1938	0.177	2.782
3.1878	-0.297	4.522	3.1962	0.211	2.795
3.1902	-0.230	4.258	3.1986	0.235	2.796
3.1926	-0.177	4.389	3.2011	0.253	2.788
3.195	-0.129	4.449	3.2035	0.277	2.796
3.1974	-0.072	4.394	3.2059	0.288	2.783
3.1998	-0.036	4.362	3.2083	0.296	2.796
3.2023	-0.001	4.394	3.2108	0.302	2.791

3.2047	0.016	4.363	3.2132	0.292	2.806
3.2071	0.024	4.439	3.2157	0.285	2.779
3.2096	0.036	4.078	3.2181	0.298	2.779
3.2120	0.020	4.377	3.2206	0.312	2.787
3.2145	0.001	4.360	3.2231	0.313	2.804
3.2169	0.001	4.325	3.2255	0.281	2.796
3.2194	0.005	4.355	3.2280	0.239	2.795
3.2219	0.041	4.474	3.2306	0.115	2.792
3.2243	0.009	4.369	3.2330	-0.111	2.788
3.2267	-0.043	4.330	3.2354	-0.165	2.793
3.2293	-0.183	4.321	3.2378	-0.152	2.781
3.2318	-0.508	4.370	3.2403	-0.088	2.787
3.2342	-0.757	4.423	3.2428	-0.014	2.780
3.2366	-0.762	4.373	3.2452	0.044	2.766
3.2390	-0.691	4.427	3.2476	0.100	2.806
3.2415	-0.591	4.483	3.2500	0.119	2.791
3.2440	-0.445	4.452	3.2524	0.140	2.797
3.2463	-0.295	4.262	3.2548	0.190	2.825

Solution:

1)



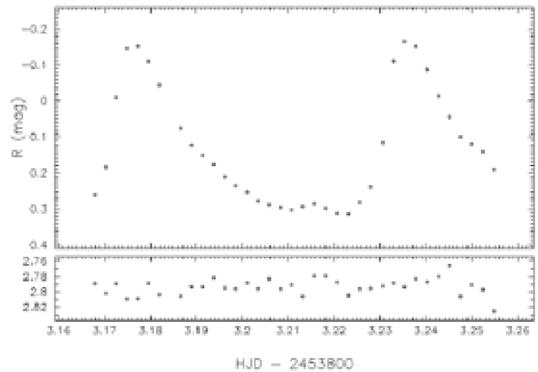


Fig.1. Light curves of KZ Hya in V. Fig. 2. Light curves of KZ Hya in R.

6p

2) $\langle \Delta V \rangle = \frac{1}{n}\sum_{i=1}^{n} \Delta V_i = -0.248mag$ 4p

$\langle \Delta R \rangle = \frac{1}{n}\sum_{i=1}^{n} \Delta R_i = 0.127mag$ 4p

3) $\sigma_{\Delta V} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} (\Delta V_i - \langle \Delta V \rangle)^2} = 0.083mag$ 4p

$$\sigma_{\Delta R} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\Delta R_i - \langle \Delta R \rangle)^2} = 0.011 mag$$ 4p

4) measured from the differences of times at the maximum values of the fits of the two peaks in V and R, respectively: 0.06 days, 0.06 days.

4p

5) measured from the differences of magnitudes at the maximum values of the fits of the two peaks in V and R, respectively: 0.79 mag, 0.49 mag.

4p

6) measured from the differences of times at the maximum values of the fits of the first peaks in V and R: 0(±0.025) P.

5p

The 4th IOAA
Observational Competition

I. Telescope Tests

1. Find M15, M27 or one specified star.
2. Estimate the magnitude of a specified star.
3. Evaluate the angle distance of two stars.

II. Tests in the Planetarium

1. The showing is the night sky in Beijing on 21 o'clock tonight. You have two minutes to observe it.
The examiner will point 5 constellations using the laser pen one by one. Each constellation will be pointed about 1 minute. Write down the name of the five constellations. 25 points in total and 5 points per constellation.
Answer:
Cygnus (Cyg), south fish place (Psa), Delphinus (Del), corona borealis (Crb), proxima centauri (Sgr)

2. Write down any five constellations that lie on current celestial equator. 10 minutes, 25 points. More than five constellations, no additional points.
marking criterion:
Virgo (Vir), Serpens (Ser), Ophiuchus (Oph), Aquila (Aql), Aquarius (Aqr), Pisces (Psc), Cetus (Cet).
-- One constellation (included in the above 7 constellations), 5 points.
Libra (Lib), Hercules (Her), Scutum (Sct), Delphinus (Del), Equuleus (Equ), Pegasus

(Peg).

-- One constellation (included in the above 6 constellations), 2 points

3. The showing is the night sky in Beijing on a specified night. Determine the month that the night belongs to. What's the age of the moon for this night? Be accurate to one unit. 10 minutes, 20 points.

marking criterion:

The time is 19h30m, February 15, 2008.

The month: February ~ 10 points
January or March ~ 5 points
Other ~ 0 points

Moon's age: about 9. ~ 10 points
8 or 10 ~ 7 points
7 or 11 ~ 3 points
Other ~ 0 pints

The 4^{th} IOAA

Team Competition

Assembling Telescope (indoor)

The Problem

Every team is given 10 minutes to assemble a telescope with an equatorial mount, so that it is ready for tonight's observation.

Once the competition starts, the assembling procedure will be monitored and judged by a jury, for any mistake in the process. And the assembling process will be timed. When the assembling is finished, the students of the group should raise their hands to indicate the assembling is completed. The jury should record the time taken for the assembling, after which the students should not be allowed to touch the telescope again. After the jury has checked the assembled telescope for the assembling quality, the participating group should take apart the telescope assembly and restore the various parts to the condition as they were before the assembling process.

The coordinates of Beijing is (116°48', 40°32')

Procedure:

The competition is divided into 4 rounds, with each round having 6 teams participating. The team with highest overall score wins.

Marking scheme

1. Time taken for the assembly: 50%
2. Team participation and collaborating skills: 20%
3. Major mistakes: 30%:
   a) The balance of the telescope, in both axes.
   b) Is the parts corrected put together: finder scope, fine adjustment knobs in both axes, and eyepieces, etc.
   c) Are all the screws and knobs securely fastened?
   d) Is the polar axis roughly adjusted? (The participants will be given the rough condition of the North.)

The 4th IOAA
Samples of Problems
in Different Languages

4 Międzynarodowa Olimpiada Astronomiczno-Astrofizyczna

Krótkie zadania teoretyczne

(10 punktów za zadanie)

Proszę przeczytać uważnie niniejszą instrukcję:

1. Każdy zawodnik otrzymuje listę zadań w języku angielskim oraz języku narodowym
2. Czas trwania zawodów wynosi 5 godzin. Lista zadań zawiera 15 zadań krótkich (zadania 1-15) oraz 2 zadania długie (16 i 17).
3. Można korzystać jedynie z długopisu znajdującego się na biurku
4. Rozwiązania kolejnych zadań wpisywać od nowej strony, na początku podać numer zadania
5. Na okładce notatnika podać nazwę kraju oraz kod zawodnika
6. Odpowiedzi liczbowe powinny być podane z odpowiednią liczbą cyfr znaczących oraz podając jednostki. Zaleca się stosowanie układu SI lub jednostek stosowanych zwyczajowo. Brak jednostek lub nieodpowiednia liczba cyfr znaczących obniża ocenę zadania o 20%
7. Na zakończenie testu wszystkie kartki oraz notatnik należy włożyć do koperty i zostawić na biurku.
8. W przedstawionych rozwiązaniach zapisz kolejne kroki postępowania oraz wyniki pośrednie obliczeń koniecznych do uzyskania ostatecznego rezultatu.

Zadania:

1) Układ wizualnie podwójny; jasność pierwszej gwiazdy wynosi 1.0 mag a drugiej 2.0 mag. Oblicz sumaryczną jasność całego układu.

2) Jeśli prędkość ucieczki z powierzchni ciała o masie Słońca byłaby równa prędkości światła, to jaki byłby promień tego ciała?

3) Obserwowane przesunięcie ku czerwieni widma kwazara wynosi $z = 0.2$. Oszacuj odległość do tego kwazara. Stała Hubble'a wynosi 72 km s^{-1} Mpc^{-1}

4) Układ podwójny znajduje się w odległości 10 pc, największa odległość kątowa składników wynosi 7.0", a najmniejsza 1.0". Załóż, że okres orbitalny wynosi 100 lat oraz, że płaszczyzna orbity jest prostopadła do kierunku obserwacji. Jeśli wielka półoś orbity pierwszego składnika ma rozmiar kątowy a_1=3.0", oszacuj masę każdego ze składników układu podwójnego. Wynik podaj w masach Słońca.

5) Oszacuj ile lat trwał by maksymalny czas życia Słońca, gdyby w tym czasie 0.8 % całkowitej jego masy uległo transformacji w energię. Należy założyć, że jasność Słońca jest stała.

6) Statek kosmiczny wylądował na powierzchni kulistej planetoidy o średnicy 2.2 km i średniej gęstości 2.2 g/cm^3 Czy astronauci mogą pieszo obejść planetoidę w ciągu 2.2 godziny idąc wzdłuż jej równika? Rotacja planetoidy jest zaniedbywanie mała. Wpisz **YES** lub **NO** na karcie odpowiedzi oraz przedstaw obliczenia, uzasadniające swoją odpowiedź.

7) Jedną z metod poszukiwania planet poza Układem Słonecznym jest obserwacja ich tranzytów na tle gwiazd macierzystych, w czasie których część światła gwiazdy jest zasłaniana przez tarczę planety. Oszacuj największy możliwy stosunek maksymalnej mocy promieniowania gwiazdy do minimalnej mocy promieniowania gwiazdy osłabionej na skutek tranzytu planety ziemiopodobnej. Gwiazda zaćmiewana przez planetę jest podobna do Słońca.

8) Podejrzewa się, że w centrum Drogi Mlecznej znajduje się supermasywna czarna dziura o masie 4×10^6 $M_{\odot}$. Trudnym wyzwaniem dla astronomów jest uzyskanie zdolności

rozdzielczej umożliwiającej obserwację obiektu wielkości horyzontu zdarzeń czarnej dziury. (Dla nierotujących czarnych dziur promień Schwarzschilda wynosi: R_S=(3 M/$M_\odot$) km). Na jakiej długości fali należy przeprowadzić obserwacje aby uzyskać potrzebną rozdzielczość, zakładając że dysponujemy teleskopem o rozmiarach całej Ziemi (system VLBI). Słońce znajduje się w odległości 8.5 kpc od centrum Drogi Mlecznej.

9) Obserwowana jasność gwiazdy w filtrze I wynosi 22.0 mag. Ile fotonów w ciągu jednej sekundy zostanie zarejestrowanych przez detektor teleskopu Gemini (średnica 8m). Przyjąć, że wydajność kwantowa detektora wynosi 40% oraz funkcja przepustowości filtra I ma kształt prostokątny.

Przyjąć następujące dane dla obserwacji Wegi:

Filtr:	λ_0 (nm)	$\Delta\lambda$(nm)	F_{Wega} [W m^{-2} nm^{-1}]
I	8.00×10^2	24.0	8.30×10^{-12}

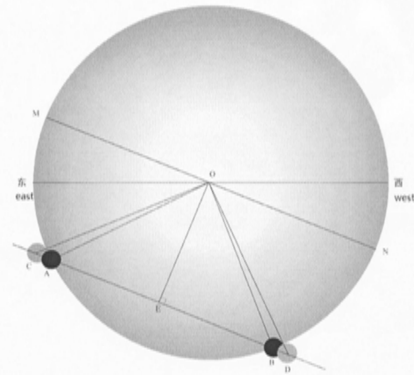
10) Zakładając, że gwiazdy ciągu głównego typu G (jak nasze Słońce) leżące w dysku Drogi Mlecznej układają się zgodnie z eksponencjalnym spadkiem gęstości liczby gwiazd wraz ze wzrostem wysokości (tzn w kierunku prostopadłym) od dysku. Charakterystyczna stała zaniku gęstości z wysokością wynosi 300pc. Oblicz o jaki czynnik zmienia się gęstość liczbowa gwiazd w odległości 0.5kpc i 1.5 kpc od płaszczyzny dysku względem gęstości gwiazd w płaszczyźnie dysku.

11) Ostatnia Wielka Opozycja Marsa nastąpiła 28 sierpnia 2003 roku, o godzinie $17^h\,56^m$ czasu UT. Następna Wielka Opozycja wypadnie w roku 2018. Oszacuj dokładnie datę tej Wielkiej Opozycji. Wielka półoś orbity Marsa ma długość 1.524 j.a.

12) Różnica wielkości dwóch gwiazd ciągu głównego, należących do pewnej gromady otwartej wynosi 2 magnitudo. Ich temperatury efektywne to odpowiednio: 6000 K oraz 5000 K. Oszacuj stosunek ich promieni.

13) Na podstawie koloru Słońca oszacuj temperaturę efektywną fotosfery Słońca

14) Obserwator znajdujący się w pobliżu północnego bieguna Ziemi, obserwował zjawisko tranzytu Wenus. Ścieżkę tranzytu na tle tarczy przedstawia poniższy rysunek:



Punkty A,B,C,D leżą na Ścieszce tranzytu i oznaczają środek tarczy Wenus. W chwili A i B środek tarczy Wenus leży dokładnie na brzegu tarczy słonecznej. C oznacza pierwszy, a D czwarty kontakt tranzytu. Kąt ∠AOB=90°, odcinek MN jest równoległy do odcinka AB. Pierwszy kontakt nastąpił o 9:00 UT. Oblicz moment czwartego kontaktu.

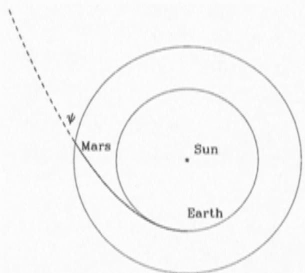
T_{Wenus}=224.70 dni, T_{Ziemi}=365.25 dni, a_{Wenus}=0.723 j.a., r_{Wenus}=0.949 r_{Ziemi}

15) Zwykle kątowe rozmiary tarczy Księżyca są trochę mniejsze niż Słońca, dlatego częstość występowania zaćmień obrączkowych jest wyższa niż zaćmień całkowitych. Dla obserwatora ziemskiego najdłuższe zaćmienie całkowite może trwać 7.5 minuty a najdłuższe zaćmienie obrączkowe może trwać 12.5 minuty. Przez czas trwania zaćmienia rozumiany jest odstęp pomiędzy 2 i 3 kontaktem. Zakładając, że możemy obserwować zaćmienia przez bardzo wiele lat, oszacuj stosunek liczby zaćmień obrączkowych do liczby zaćmień całkowitych. Przyjmij, że orbita Ziemi jest okręgiem, a mimośród orbity Księżyca wynosi 0.0549. Wszystkie zaćmienia hybrydowe potraktuj jako zaćmienia obrączkowe.

Dłuższe zadania teoretyczne.

(30 punktów za zadanie)

16) Statek kosmiczny wystrzelony z Ziemi zostaje raptownie przyspieszony do swojej maksymalnej prędkości w kierunku heliocentrycznego ruchu Ziemi. Orbita statku jest parabolą styczną do orbity ziemskiej o ognisku w Słońcu. Orbity Marsa i Ziemi są okręgami leżącymi w tej samej płaszczyźnie o promieniach odpowiednio 1.5 j.a. oraz 1 j.a. Można przyjąć następujące uproszczenie: w czasie lotu na statek działa jedynie grawitacja Słońca,.



Rys. 1.
Trajektoria statku widziana od strony południowego bieguna ekliptyki (rysunek nie zachowuje proporcji). Wewnętrzny okrąg to orbita Ziemi, zewnętrzny przedstawia orbitę Marsa.

Pytania:

a) Jaka jest wartość kąta ψ , pomiędzy orbitą Marsa a trajektorią statku w chwili przecinania tej orbity? Pominąć wpływ grawitacji Marsa na statek.
b) Załóż, że Mars znalazłby się w punkcie przecięcia w tej samej chwili co statek. Jaka byłaby prędkość statku dla obserwatora na północnym biegunie Marsa oraz i kierunek nadlatywania statku względem Słońca zanim grawitacja Marsa zmieni tor lotu statku?

17) Planeta Taris zamieszkała jest przez cywilizację Korribian, obcej i inteligentnej formy życia, posługującej się językiem Korribańskim. Słownik Korribańsko-Polski podany jest w tabeli, przeczytaj go uważnie! Korribańscy astronomowie badający swe niebo od tysięcy lat ustalili że:

- Taris obiega Sola (gwiazdę centralną) po orbicie kołowej o promieniu 1 tarismetra.
- Jeden obieg trwa 1 tarisrok
- Nachylenie płaszczyzny równika Taris do płaszczyzny jej orbity wynosi 3°
- 1 tarisrok trwa 10 tarisdób
- Taris posiada dwa księżyce: Endor i Extor poruszające się po orbitach kołowych
- Gwiazdowy okres orbitalny Endora to dokładnie 0.2 taridób
- Gwiazdowy okres orbitalny Extora to dokładnie 1.6 taridób
- Odległość Endora od Taris to 1 endormetr
- Corulus to inna planeta obiegająca Sola po orbicie kołowej, posiada jeden księżyc
- Odległość Sola-Corulus wynosi 9 tarismetrów
- Tarisrok rozpoczyna się gdy długość solaptyczna Sola wynosi 0°

Pytania:

- Narysuj układ Sola oznaczając wszystkie planety i księżyce
- Ile razy w ciągu 1 tarisroku obraca się Taris wokół własnej osi?
- Podaj odległość Taris-Extor w endormetrach
- Jaki jest okres orbitalny Corulusa wyrażony w tarisrokach
- Jaka jest odległość Taris-Corulus w czasie opozycji Corulusa
- Jeśli na początku danego tarisroku, Corulus i Taris były w opozycji to jaka byłaby długość solaptyczna Corulusa (widziana z Taris) w *n*-tej tarisdobie od początku roku
- Jaki byłoby pole trójkąta stworzonego przez Sola-Taris-Corulus dokładnie jedną tarisdobę po opozycji

Korribański	**Polski**
Corulus	Planeta krążąca wokół Sola
Endor	(i) Bogini nocy; (ii) księżyc obiegający Taris
Endormetr	Odległość Taris - Endor
Extor	(i) bóg świetego spokoju; (ii) księżyc obiegający Taris
Sola	(i) bóg życia; (ii) gwiazda centrala dla Taris I Corulusa
Solaptyka	Droga Sola i Corulusa na tle gwiazd widziana z Taris
Taris	Planeta obiegająca Sola, siedlisko Korribian
Tarisdoba	Czas pomiędzy dwoma kolejnymi momentami północy na Taris
Tarislmetr	Odległość Sola-Taris
Tarisrok	Czas obiegu Taris wokół Sola

Tabela 1: Słownik Korribańsko-Polski

Stala	Wartość
Jednostka astronomiczna j.a.	1.496×10^{8} km
Rok świetlny (ly)	9.4605×10^{15} m = 63 240 j.a.
Parsek (pc)	3.0860×10^{16} m = 206 265 j.a
Rok gwiazdowy	365.2564 dni
Rok zwrotnikowy	365.2422 dni
Rok kalendarzowy	365.2425 dni
Doba gwiazdowa	$23^h56^m4^s.091$
Doba słoneczna	$24^h3^m56^s.555$ jednostek czasu gwiazdowego
Średnia odległość Ziemia-Księżyc	384 399 km
Masa Ziemi ($M_{\oplus}$)	5.9736×10^{24} kg
Średnia prędkość Ziemi na orbicie	29.783 km/s
Masa Księżyca ($M_{\text{☾}}$)	7.3490×10^{22} kg
Średni promień Księżyca	1 738 km
Masa Słońca ($M_{\odot}$)	1.9891×10^{30} kg
Średni promień Ziemi	6 371 km
Promień Słońca ($R_{\odot}$)	6.96×10^{5} km
Moc promieniowania Słońca ($L_{\odot}$)	3.96×10^{26} J s^{-1}
Obserwowana jasność Słońca w filtrze V ($m_{\odot}$)	-26.8^m
Jasność absolutna Słońca w filtrze V ($M_{\odot}$)	4.75^m
Absolutna bolometryczna jasność Słońca ($M_{bol_{\odot}}$)	4.72^m
Prędkość światła (c)	2.9979×10^{8} m/s
Stała grawitacji (G)	6.6726×10^{-11} N m^2 kg^{-2}
Stała Boltzmana (k)	1.381×10^{-23} m^2 kg s^{-2} K^{-1}
Stała Stefana-Boltzmanna (σ)	5.6704×10^{-8} kg s^{-3} K^{-4}
Stała Plancka (h)	6.6261×10^{-34} J s

第四届 IOAA 理论题

请仔细阅读以下说明

1、每个学生都将得到一套用英语或本国语言注明的答题纸。
2、理论考试的时间为 5 小时。分为 15 道短问题（1~15 题）、2 道长问题（16~17 题）。
3、只能使用你桌子上提供的笔答题。
4、答题时，每道题目都要从一页新的答题纸开始，并在前面写上题号。
5、在答题本的封面上写下你的国家名称和学生编号。
6、对每个问题的答案都必须写明数值的单位并且保留到合理的有效数字（用国际单位制）。如果答案正确但没有写明单位，最多会被扣掉 20%的分数。
7、考试结束时把所有的纸张和答题纸放进信封，不要带走桌上的任何物品。
8、在解题时，请按照逻辑关系写出每一个详细步骤，包括推导的中间公式和计算过程。

短问题

每题 10 分

1）一对目视双星的两个子星，一个星等为 1.0 等，另一个星等为 2.0 等，这个双星系统的总星等最大为多少等？

2）如果一个质量和太阳相同的天体的表面物质的逃逸速度超过光速，它的半径会是多少？

3）一个类星体红移为 0.20，估算它的距离。哈勃常数为 72 km s^{-1} Mpc^{-1}。

4）有一对双星离我们的距离是 10pc，两个子星的最大角距离是 7.0"，最小角距离是 1.0"，轨道周期是 100 年，假定这个双星的轨道平面和视线是垂直的。已知一个子星的轨道半长轴所张的角度为 a_1=3.0"，求双星的两个子星的质量。

5）假设太阳的一生中只有 0.8%的质量转化为能量，太阳的寿命最长可能是多少年？假定太阳的光度保持不变。

6）宇宙飞船在一颗直径 2.2 km、平均密度 2.2 g/cm^3 的球状小行星上着陆，这颗小行星的自转可以忽略。宇航员决定用 2.2 小时的时间沿着这颗小行星的赤道走一圈，他们的这种想法是否能够实现？请用英文“YES”或“NO”写出答案，并且用必要的数值计算加以解释。

7）我们对寻找适合人类居住的太阳系外行星一直很感兴趣。一种探测系外行星的方法就是观测恒星的亮度变化情况，因为当行星从其宿主恒星前穿过时，就会遮挡住一部分来自恒星的光。估算一个类地行星围绕一个类太阳恒星公转时，引起的恒星亮度变化相对于未遮挡的恒星亮度，最大比值能达到多少。

1

8）人们相信在银河系的中心存在一个超大质量黑洞，其质量为 4×10^6 $M_\oplus$，天文学家正在努力测定它的视界范围，这是一项非常艰巨的任务。对一个没有旋转的黑洞来说，视界就是它的史瓦西半径，$R_s=3(M/M_\oplus)$ km。假设我们拥有一架地球尺度的望远镜（使用甚长基线干涉仪，VLBI），为了分辨出黑洞的视界大小，我们应该在什么波段观测？太阳到银心的距离为 8.5 kpc。

9）一颗恒星在 I 波段的视星等为 22.0 等。请计算"双子望远镜（Gemini Telescope，口径为 8 米）"每秒钟能接收到多少个来自这颗恒星的光子？假定整个望远镜系统的光子探测效率为 40%，并且所用的滤光片的透光曲线为矩形。

你可以使用以下信息：

滤光片	滤光片中心波长 λ_0	滤光片透光范围 $\Delta\lambda$	织女星辐射流量 F
I 波段	800 nm（纳米）	24.0 nm	8.30×10^{-12} W m^{-2} nm^{-1}

10) 假设银盘中光谱型为 G 的主序星（例如太阳）的数密度在垂直于银盘的方向遵循 e 指数分布，标高为 300pc，计算离银盘中心面垂直距离为 0.5kpc 和 1.5kpc 处，恒星的数密度各为多少？以银盘中心面上的恒星数密度为单位。

11) 2003 年 8 月 28 日世界时 17^h56^m 发生了火星大冲，下一次火星大冲发生在 2018 年，估算那次大冲的具体日期。火星轨道半长轴为 1.524 AU。

12）一个疏散星团里的两颗主序星的星等之差为 2 等，它们的有效温度分别为 6000 K 和 5000 K，估算二者的半径比。

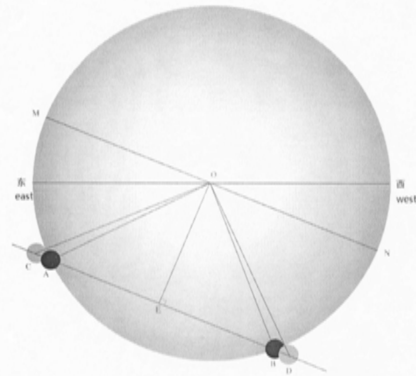
13）根据肉眼看到的太阳颜色，估算太阳光球层的有效温度。

14）在北极点附近观测到一次金星凌日。凌日时金星的路径如下图所示，A、B、C、D 在金星凌日的路径上，且均为金星的视圆面中心，A、B 处金星的视圆面中心与日面边缘重合；C、D 分别对应凌始外切和凌终外切，且 $\angle AOB=90^o$，MN 平行于 AB。若凌始外切（first contact）的时间为世界时 9:00，计算凌日结束（凌终外切, fourth contact）的时刻。

金星公转周期为 224.70 天，地球公转周期为 365.25 天，金星轨道半径为 0.723 AU，金星半径为 0.949 倍地球半径。

$$T_{venus}=224.70days, T_{earth}=365.25days, a_{venus}=0.723AU ; r_{venus}=0.949r_\oplus$$

2



15) 平均而言，月亮的视直径略小于太阳的视直径，因此日环食比日全食的发生频率略高一些。已知在地球上观测，日全食的最长持续时间约为 7.5 分钟，日环食的最长持续时间约为 12.5 分钟。这里的最长持续时间是指从凌始内切到凌终内切的时间。

如果我们在足够长的时间里对这两类日食的发生次数进行统计，估算日环食与日全食的发生次数之比。假设地球公转轨道是正圆，月球公转轨道的偏心率为 0.0549。在统计中，我们把全环食视为日环食。

长问题

每题 30 分

16）一艘宇宙飞船从地球发射，它很快就被加速到速度最大值，并与地球公转方向同向飞行。它的轨道是一个以太阳为焦点的抛物线，且与地球轨道相切。假定地球和火星的公转轨道共面，而且都是正圆，半径分别为 r_E=1 AU 和 r_M=1.5 AU。做如下近似：飞船在轨道上的绝大多数时间，只需考虑太阳的引力。

问题：

（1）不考虑火星引力，当飞船穿越火星轨道时，飞船轨道与火星轨道间的夹角 ψ 是多少（如图 1 所示）？

（2）如果当飞船穿越火星轨道时，火星恰好非常接近飞船的穿越点，那么对于火星上的观测者，在飞船显著受到火星引力影响之前，他看到的飞船接近火星的速度是多大（相对于这个观测者）？方向如何（相对于太阳）？

3

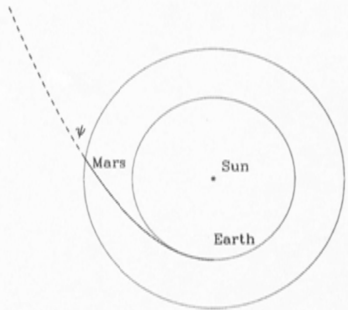


图 1：飞船的轨迹（未按比例）。内圆表示地球轨道，外圆表示火星轨道。

17）行星 Taris 是 Korribian 文明的家园。Korribian 人是高度发达的外星生命。他们使用的语言为 Korribianese 语。表 1 给出“Korribianese—英语”词典，请仔细阅读。Korribian 的天文学家已经对星空进行了几千年的观察。他们对于星空的了解可以归纳为：

★ Taris 绕其母恒星 Sola 公转的轨道为圆，与 Sola 的距离为 1 个 Taris 长度（1 Tarislength）。
★ Taris 绕 Sola 公转的周期为 1 个 Taris 年（1 Tarisyear）。
★ Taris 的赤道面与公转轨道面的夹角为 3°。
★ 1 个 Taris 年精确地等于 10 个 Taris 日。
★ Taris 有两个卫星（月亮），Endor 和 Extor，都在绕 Taris 的圆轨道上运行。
★ Endor 的恒星月长度为 0.2 Taris 日（绕 Taris）。
★ Extor 的恒星月长度为 1.6 Taris 日（绕 Taris）。
★ Taris 与 Endor 之间的距离为 1 个 Endor 长度（Endorlength）。
★ Corulus 是另一个以圆轨道绕母恒星 Sola 运行的行星，Corulus 有一个卫星。
★ Corulus 到 Sola 的距离为 9 个 Taris 长度（9 Tarislengths）。
★ 在 Taris 上看 Sola，当 Sola 的“黄经”（Solaptic longitude）为 0 度时，是 Taris 新年的开始。

表 1：“Korribianese 语—英语”词典

Korribianese 语言	英语（翻译为汉语）
Corulus	绕 Sola 运行的一颗行星
Endor	（i）夜空之神；（ii）Taris 的一颗卫星的名字
Endorlength（Endor 长度）	Taris 与 Endor 之间的距离
Extor	（i）和平之神；（ii）Taris 的一颗卫星的名字
Sola	（i）生命之神；（ii）Taris 和 Corulus 绕转的母恒星的名字
Solptic（Sola 黄道）	在 Taris 上观测，Sola 和 Corulus 的视运动轨道
Taris	围绕恒星 Sola 运行的一颗行星，是 Korribians 人的家园
Tarisday（Taris 日）	行星 Taris 上连续两个子夜的间隔时间
Tarisyear（Taris 年）	行星 Taris 绕其母恒星 Sola 的轨道周期
Tarislength（Taris 长度）	母恒星 Sola 和行星 Taris 之间的距离

问题：
(a) 画出 Sola 系统的示意图，标示出各行星和卫星。
(b) 在 1 个 Taris 年里，行星 Taris 绕其自转轴自转多少圈？
(c) 计算 Taris 与其卫星 Extor 的距离，以 Endor 长度（Endorlength）为单位。
(d) 计算行星 Corulus 的轨道周期，以 Taris 年（Tarisyear）为单位。
(e) 在 Taris 上观测，当 Corulus 处于“冲”的位置时，Taris 与 Corulus 间的距离为多少？以 Taris 长度（Tarislength）为单位。
(f) 如果在某个 Taris 新年之初，在 Taris 上观测，Corulus 处于“冲”的位置，在此后的“n”个 Taris 日（Tarisday）后，Corulus 的“黄经”（Solptic longitude）为多少？
(g) Corulus“冲”整一天后，Sola、Taris 和 Corulus 构成的三角形的面积为多少？

IV MOAA
Praktični deo takmičenja
Analiza podataka

4th IOAA
Beijing 2010

Molimo vas pročitajte pažljivo ovo uputstvo:

1. Koristi lenjir i kalkulator koji ti daje LOC (Lokalni organizacioni komitet).
2. Za rešavanje zadataka iz analize podataka na raspolaganju je vreme od 4 časa. Ima 2 zadatka.
3. Koristi samo olovku koju nadješ na svom stolu.
4. Svaki zadatak počni na novoj stranici sveske. Na početku napiši redni broj zadatka.
5. Napiši naziv svoje zemlje i svoj takmičarski kod na prednjoj korici sveske.
6. Na kraju ovoga dela takmičenja stavi sve listove i svesku u koverat i ostavi ga na stolu.
8. Piši sve medjurezultate logično korak po korak na putu do konačnog rešenja.

Zadatak I, CCD slika (35 poena)

Informacije:

Slika 1 predstavlja negativ neba snimljen CCD kamerom postavljenom na teleskop čiji su parametri dati u tablici 1 (tablica je deo zaglavlja datoteke FITS formata u kojoj se čuva slika).

Slika 2 ima dva dela: jedan je uvećan segment sa slike 1 (B), drugi je uvećana slika istog dela neba, ali snimljena nešto ranije (A).

Slika 3 predstavlja kartu neba koja sadrži oblast prikazanu na CCD snimcima.

Zvezde na snimcima su medjusobno udaljene pa bi u idealnom slučaju trebalo da se vide kao razdvojeni tačkasti izvori. Medjutim, difrakcija na otvoru teleskopa i atmosferska turbulencija (engl. 'seeing') pretvaraju likove zvezda u mrlje . Što je zvezda sjajnija, veća je i mrlja u poredjenju sa sjajem pozadine neba.

Pitanja:

1) Identifikuj bilo kojih 5 zvezda (označi ih rimskim brojevima) sa slike 1 i označi ih i na slici (sl. 1) i na karti neba (sl. 3).

2) Označi vidno polje CCD kamere na karti neba (sl. 3).

3) Iskoristi dobijene informacije iz prethodnog pitanja i odredi fizičke dimenzije CCD čipa u mm.

4) Odredi veličinu mrlje u lučnim sekundama ispitujući lik zvezde na slici 2. Napominjemo da je, usled povećanja kontrasta prilikom štampanja, veličina (najveći prečnik) lika oko 3,5 puta veća od pune širine na polovini maksimuma (Full Width at Half Maximum, FWHM) profila sjaja zvede.

5) Uporedi rezultat sa prečnikom difrakcionog diska teleskopa koji daje teorija (razdvojna moć teleskopa).

6) Turbulencija od jedne lučne sekunde se često smatra kao indikacija dobrih uslova. Izračunaj veličinu lika zvezde u pikselima ako je atmosferska turbulencija bila 1 lučna sekunda i to uporedi sa rezultatom iz pitanja 4).

7) Dva posmatrana objekta koja se kreću u odnosu na pozadinu označena su na slici 1. Kretanje jednog od njih (objekt 1) bilo je dovoljno brzo pa je on ostavio jasan trag na slici. Kretanje drugog (objekt 2) nije dovoljno brzo da bi se uočilo na jednom snimku, zato koristimo jos jednu sliku snimljenu nesto ranije. Slika 2 B prikazuje objekt 2 u istom trenutku kao slika 1, a slika 2 A prikazuje isti objekat (objekat 2) nešto ranije.

Koristeći dosadašnje rezultate, odredi ugaonu brzinu po nebeskoj sferi za oba objekta.

Odredi koja su od dole datih tvrdjenja tačna, pod pretpostavkom da se objekti kreću po kružnim putanjama. (Za svaki tačno zaokružen odgovor dobijate pozitivne poene, a za netačno negativne.) Verovatni uzroci različitih ugaonih brzina mogu biti:

a) različite mase objekata,
b) različite udaljenosti objekata od Zemlje,
c) objekti se na svojim orbitama kreću različitim brzinama,
d) projekcije brzina objekata se razlikuju,
e) objekt 1 obilazi oko Zemlje, a objekt 2 obilazi oko Sunca.

Podaci:
Za sliku 1 podaci su:

BITPIX	=	16	/ Broj bitova po pikselu
NAXIS	=	2	/ Broj koordinatnih osa
NAXIS1	=	1024	/ Širina slike (u pikselima)
NAXIS2	=	1024	/ Visina slike (u pikselima)
DATE-OBS	=	'2010-09-07 05:00:40.4'	/ Sredina trajanja ekspozicije
TIMESYS	=	'UT'	/ Vremenska skala
EXPTIME	=	300.00	/ Vreme eksponiranja (sekunde)
OBJCTRA	=	'22 29 20.031'	/ Rektascenzija centra slike
OBJCTDEC	=	'+07 20 00.793'	/ Deklinacija centra slike
FOCALLEN	=	'3.180m'	/ Žižna daljina teleskopa
TELESCOP	=	'0.61m '	/ Otvor teleskopa

Table 1: Podaci o slici iz zaglavlja FITS datoteke.

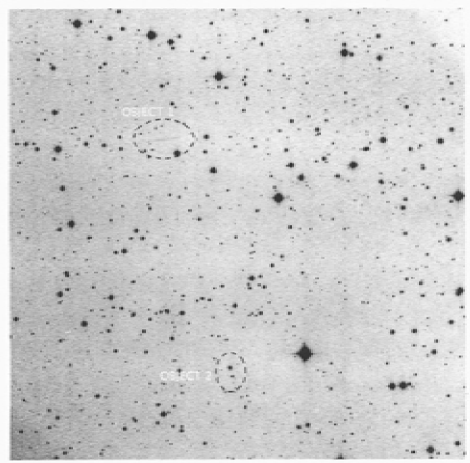


Figure 1: CCD snimak.

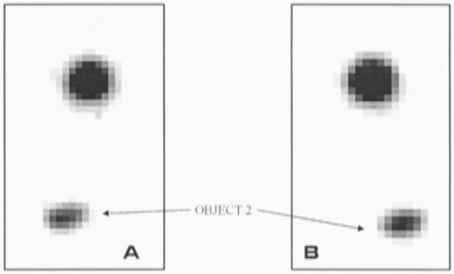


Figure 2: A: Uvećan deo oblasti sa slike 1 posmatran nešto ranije. Podaci za ovaj snimak su: DATE-OBS= '2010-09-07 04:42:33.3' / Sredina trajanja ekspozicije. B: Uvećan deo oblasti sa slike 1 oko objekta 2.

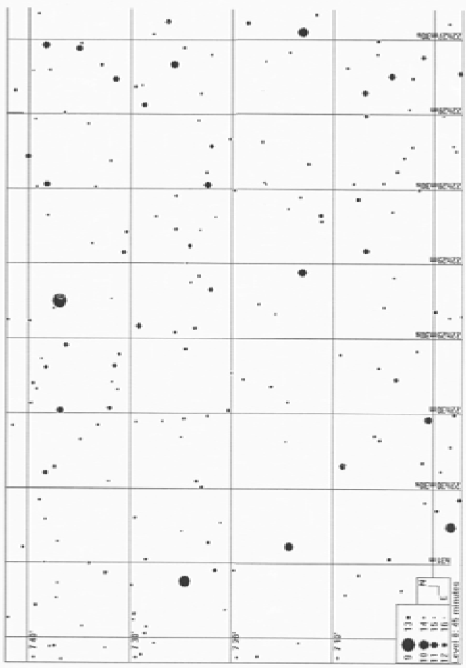


Figure 3: Karta neba.

Zadatak II:Krive sjaja zvezda (35 poena)

Pulsirajuća promenljiva zvezda KZ Hydrae posmatrana je telreskopom sa CCD kamerom. Slika 4 pokazuje CCD snimak KZ Hydrae koja je data zajedno sa zvezdom za poredjenje (Comparison) i zvezdom za proveru (Check). U tablici 1 (slika 5) nalazimo trenutke posmatranja u julijanskim danima i razlike zvezdanih veličina KZ Hydrae (ΔV(mag)) i zvezde za proveru (ΔV_{Chk}) u odnosu na zvezdu za poredjenje za dva filtra, V i R.

Pitanja:

1) Nacrtaj krive sjaja za zvezdu KZ Hya u odnosu na zvezdu za poredjenje za V i R filtre.

2) Kolike su srednje razlike zvezdanih veličina zvezde KZ Hye u odnosu na zvezdu za poredjenje za V I R filtre?

3) Kolika je fotometrijska preciznost za filter V i za filter R?

4) Odrediti periode pulsacije KZ Hye za filter V i za filter R.

5) Odredi amplitude pulsacija KZ Hye za filter V i za filter R.

6) Koliko je fazno kašnjenje izmedju V i R filtra u jedinicama perioda pulsacije?

Figure 5: Tabela 1. Kriva sjaja zvezde KZ Hye za filter V i za filter R. ΔV i ΔR su razlike prividnih veličina zvezde KZ Hye i zvezde za poredjenje za filtre V i R za date trenutke; ΔV_{chk} su razlike prividnih veličina zvezde za proveru i zvezde za poredjenje za filtre V i R za iste trenutke.

HJD-2453800(t)	ΔV(mag)	ΔV_{chk}	HJD-2453800(t)	ΔR(mag)	ΔR_{chk}
3.162	0.068	4.434	3.1679	0.260	2.789
3.1643	0.029	4.445	3.1702	0.185	2.802
3.1667	-0.011	4.287	3.1725	-0.010	2.789
3.1691	-0.100	4.437	3.1749	-0.147	2.809
3.1714	-0.310	4.468	3.1772	-0.152	2.809
3.1737	-0.641	4.501	3.1796	-0.110	2.789
3.1761	-0.736	4.457	3.1820	-0.044	2.803
3.1784	-0.698	4.378	3.1866	0.075	2.805
3.1808	-0.588	4.462	3.1890	0.122	2.793
3.1831	-0.499	4.326	3.1914	0.151	2.793
3.1855	-0.390	4.431	3.1938	0.177	2.782
3.1878	-0.297	4.522	3.1962	0.211	2.795
3.1902	-0.230	4.258	3.1986	0.235	2.796
3.1926	-0.177	4.389	3.2011	0.253	2.788
3.195	-0.129	4.449	3.2035	0.277	2.796
3.1974	-0.072	4.394	3.2059	0.288	2.783
3.1998	-0.036	4.362	3.2083	0.296	2.796
3.2023	-0.001	4.394	3.2108	0.302	2.791
3.2047	0.016	4.363	3.2132	0.292	2.806
3.2071	0.024	4.439	3.2157	0.285	2.779
3.2096	0.036	4.078	3.2181	0.298	2.779
3.2120	0.020	4.377	3.2206	0.312	2.787
3.2145	0.001	4.360	3.2231	0.313	2.804
3.2169	0.001	4.325	3.2255	0.281	2.796
3.2194	0.005	4.355	3.2280	0.239	2.795
3.2219	0.041	4.474	3.2306	0.115	2.792
3.2243	0.009	4.369	3.2330	-0.111	2.788
3.2267	-0.043	4.330	3.2354	-0.165	2.793
3.2293	-0.183	4.321	3.2378	-0.152	2.781
3.2318	-0.508	4.370	3.2403	-0.088	2.787
3.2342	-0.757	4.423	3.2428	-0.014	2.780
3.2366	-0.762	4.373	3.2452	0.044	2.766
3.2390	-0.691	4.427	3.2476	0.100	2.806
3.2415	-0.591	4.483	3.2500	0.119	2.791
3.2440	-0.445	4.452	3.2524	0.140	2.797
3.2463	-0.295	4.262	3.2548	0.190	2.825

The 4^{th} IOAA
Samples of Solutions

BA-S-4 Date: Page: 4

Ans to ques 1

Given

$m_1 = 1$

$m_2 = 2$

$\therefore \log\left(\frac{B_1}{B_2}\right) = -.4(m_1 - m_2)$, where B_1 = Brightness of 1st star, B_2 = " " 2nd "

$\therefore \log\left(\frac{B_1}{B_2}\right) = -.4(1-2) = -.4 \times -1 = .4$

$\therefore \frac{B_1}{B_2} = 10^{.4} = 2.512$

$\therefore B_1 = 2.512 B_2$

$\therefore$ combined brightness, $B = B_1 + B_2$

$= (2.512+1) B_2$

$= 3.512 B_2$

Let their combined magnitude be M.

$\therefore \log\left(\frac{B}{B_1}\right) = -.4(M - m_1)$

$\Rightarrow \log\left(\frac{3.512 B_2}{2.512 B_2}\right) = -.4(M-1)$

$\Rightarrow \log 1.3981 = -.4(M-1)$

$\Rightarrow .1455 = -.4(M-1)$

$\Rightarrow M =$ ~~0.6362~~ 0.636162819

$\therefore$ combined magnitude is 0.636162819^m

BE-S-1 DATE: PAGE:

(2)

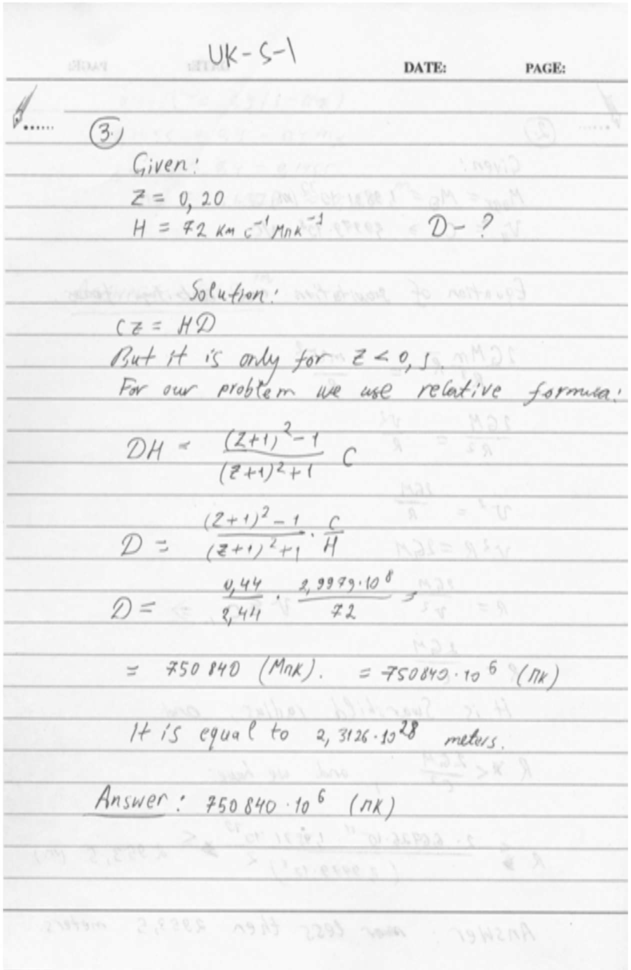
$\sqrt{\frac{2GM}{R}} > c \qquad \frac{2GM}{c^2} > R$

$R < 21476.78\,m$

~~$R < 21472\,m$~~

$R < 2953.6\,m$

Answer: $R < 2953.6\,m$



UK-S-1 DATE: PAGE:

(3)

Given:

$z = 0,20$

$H = 72 \text{ km s}^{-1} \text{ Mpc}^{-1}$ $D - ?$

Solution:

$cz = HD$

But it is only for $z < 0,1$.

For our problem we use relative formula:

$$DH = \frac{(z+1)^2 - 1}{(z+1)^2 + 1} c$$

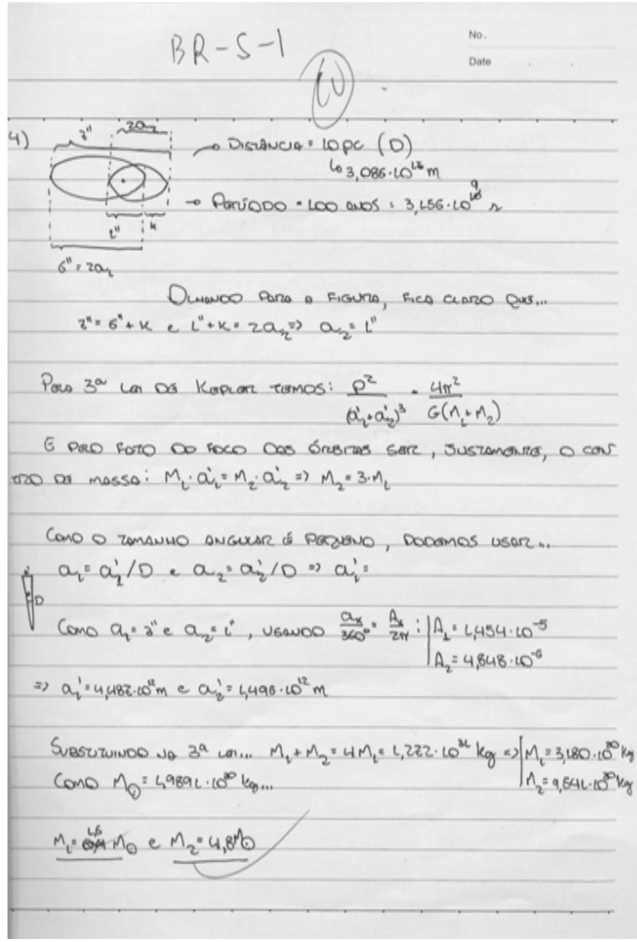
$$D = \frac{(z+1)^2 - 1}{(z+1)^2 + 1} \cdot \frac{c}{H}$$

$$D = \frac{0,44}{2,44} \cdot \frac{2,9979 \cdot 10^8}{72} =$$

$= 750\,840$ (Mpc). $= 750840 \cdot 10^6$ (pc)

It is equal to $2,3126 \cdot 10^{28}$ meters.

Answer: $750\,840 \cdot 10^6$ (pc)



BR-S-1 No. Date

4) → Distância = 10 pc (D) ↳ $3,086 \cdot 10^{16}$ m

→ Período = 100 anos = $3,156 \cdot 10^9$ s

$6'' = 2a_1$

Olhando para a figura, fica claro que...

$7'' = 6'' + k$ e $1'' + k = 2a_2 \Rightarrow a_2 = 1''$

Pela 3ª lei de Kepler temos: $\frac{P^2}{(a'_1 + a'_2)^3} = \frac{4\pi^2}{G(M_1 + M_2)}$

E pelo fato do foco das órbitas ser, justamente, o centro de massa: $M_1 \cdot a'_1 = M_2 \cdot a'_2 \Rightarrow M_2 = 3 \cdot M_1$

Como o tamanho angular é pequeno, podemos usar...

$a_1 = a'_1/D$ e $a_2 = a'_2/D \Rightarrow a'_1 =$

Como $a_1 = 3''$ e $a_2 = 1''$, usando $\frac{a_x}{360°} = \frac{A_x}{2\pi}$: $A_1 = 1,454 \cdot 10^{-5}$, $A_2 = 4,848 \cdot 10^{-6}$

$\Rightarrow a'_1 = 4,487 \cdot 10^{12}$ m e $a'_2 = 1,496 \cdot 10^{12}$ m

Substituindo na 3ª lei... $M_1 + M_2 = 4M_1 = 1,272 \cdot 10^{31}$ kg $\Rightarrow$ $M_1 = 3,180 \cdot 10^{30}$ kg, $M_2 = 9,541 \cdot 10^{30}$ kg

Como $M_\odot = 1,9891 \cdot 10^{30}$ kg...

$M_1 = 1,6 M_\odot$ e $M_2 = 4,8 M_\odot$

GR-S-1

No.
Date

Short Problem 5:

- We will find the initial solar mass:
- $L_\odot = \frac{E}{t} = \frac{m \cdot c^2}{t} \Rightarrow$

$$m = \frac{L_\odot \cdot t}{c^2} = \left(\frac{3.96 \cdot 10^{26} \cdot 5 \cdot 10^9 \cdot 365.25 \cdot 24 \cdot 3{,}600}{2.9979^2 \cdot 10^{16}} \right) kg \Rightarrow$$

~~m = 208,426,058 · 10^26 kg = 2 · 10^34 kg~~

$$m \simeq 7 \cdot 10^7 \cdot 10^{26} \cdot 10^9 \cdot 10^{-16} \Rightarrow \boxed{m \simeq 7 \cdot 10^{26} \text{ kg}}$$

is the mass that the sun has lost from the beginning of its life, $5 \cdot 10^9$ years ago (almost).

So, the initial mass was

$$M = M_\odot + m = 1.9898 \cdot 10^{30} \text{ kg}$$

- So, the total life of the sun is:

$$L_\odot = E/t = \frac{0.008 \cdot M \cdot c^2}{t} \Rightarrow$$

$$t = \frac{0.008 \cdot 1.9898 \cdot 10^{30} \cdot 2.9979^2 \cdot 10^{16}}{3.96 \cdot 10^{26}} \text{ s} =$$

$$= 0.03612755 \cdot 10^{22} \text{ s} \simeq 1.1448 \cdot 10^{-9} \cdot 10^{22} \text{ years} \Rightarrow$$

$$\boxed{t_{max} \simeq 1.1448 \cdot 10^{11} \text{ years}}$$

KA-S-1

No.
Date

Задача № 6

Дано: $D_A = 2{,}2$ км $= 2200$ м

$\rho_A = 2{,}2$ г/см³ $= 2200$ кг/м³

$T = 2{,}2$ часа $= 7920$ с

Решение: Чтобы астронавт осуществил круговой обход надо чтобы его скорость не превышала первую космическую скорость для астероида $v_к < \sqrt{\frac{GM_A}{R_A}}$

$R_A = 1{,}1$ км $= 1100$ м

$$M_A = \rho_A \cdot \frac{4}{3} \cdot \pi \cdot R_A^3 = 1{,}23 \cdot 10^{13} \text{ кг}$$

$$v = \frac{2\pi R_A}{T} = 0{,}873 \text{ м/с}$$

$$v_x = \sqrt{\frac{GM_A}{R_A}} = 0{,}864 \text{ м/с}$$

Теперь сделаем вывод так как чтобы сделать круговой обход надо скорость не более $v_x = 0{,}864$ м/с у нас за $T = 2{,}2$ часа скорость $v = 0{,}873$ м/с. Это немного превышает v_x. И так ответ нет

$$v_x < v$$

Ответ: Нет

KO-S-2 6은 뒤에 위둥 , P7

7.

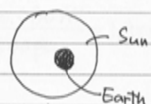
$L = 4\pi R^2 \sigma T^4$ L : 광도

R : 반지름

T : 유효온도

태양의 광도 : $L_\odot = 4\pi R_\odot^2 \sigma T_\odot^4$

지구과 통과할때의 광도 : L



광도변화율

= 면적변화율

(지구는 빛을 내지 X)

빛을 내는

$$\frac{L}{L_\odot} = \frac{R_\odot^2 - R_\oplus^2}{R_\odot^2}$$

$$= \frac{(6.96\times10^5 km)^2 - (6371 km)^2}{(6.96\times10^5 km)^2}$$

$$= 99.99\%$$

$$\frac{\Delta L}{L_\odot} = \frac{L_\odot - L}{L_\odot} = \frac{\left(1-\frac{R_\odot^2 - R_\oplus^2}{R_\odot^2}\right)L_\odot}{L_\odot} = \frac{R_\oplus^2}{R_\odot^2} = \left(\frac{6371 km}{6.96\times10^5 km}\right)^2$$

$$= 8.38\times10^{-5}$$

$8.38\times10^{-3}\ \%$

IRG-S-3 DATE: PAGE:

8...

برای آشکارسازی باید هم توان تفکیک مناسبی را داشت

رابطه توان تفکیک :

$$\text{توان تفکیک} = A_{rad} = 1.22 \times \frac{\lambda}{D}$$

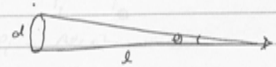
λ = طول موج

D = قطر دهانه

شعاع شوارتزشیلد برابر است با

$$R_{sch} = 3 \times \frac{M}{M_\odot}$$

$$= 1.2\times10^7 km$$



قطر زاویه‌ای :

$$\theta = \frac{d}{l}$$

d = قطر

l = فاصله $= 85\ kpc$

$$\theta = \frac{d}{l} = \frac{2R_{sch}}{l} = 9\times10^{-11}$$

$\rightarrow A < \theta$ ⇐ A باید از θ کمتر باشد تا دیده شود

(I) $9\times10^{-11} > 1.22\times\frac{\lambda}{D}$

LI-S-3

DATE: PAGE:

(9)

$M_1 = 22$ mag

$M_2 = 0{,}03$ mag (Vega) $\qquad M_1 - M_2 = -2{,}5 \lg\left(\frac{J_1}{J_2}\right)$

$$\frac{J_1}{J_2} = 10^{\frac{M_1 - M_2}{-2{,}5}} = 1{,}6 \cdot 10^{-9}$$

$$F_1 = \underset{\text{Vega}}{F_2} \cdot \frac{J_1}{J_2} = 8{,}3 \cdot 10^{-12} \cdot 1{,}6 \cdot 10^{-9} = 1{,}3 \cdot 10^{-20}\ \mathrm{W\,m^{-2}\,nm^{-1}}$$

One photon:

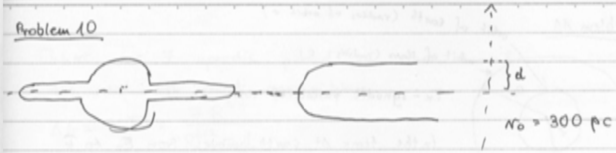
$$E_0 = h \cdot \nu_0 = \frac{h \cdot c}{\lambda_0} = \frac{6{,}626 \cdot 10^{-34} \cdot 3 \cdot 10^{8}}{800 \cdot 10^{-9}} = 2{,}5 \cdot 10^{-19}\ \mathrm{J}$$

$$n = \eta \frac{F_1 \cdot S \cdot \Delta\lambda}{E_0} = \eta \frac{F_1 \cdot \frac{\pi d^2}{4} \cdot \Delta\lambda}{E_0} = \frac{0{,}4 \cdot 1{,}3 \cdot 10^{-20} \cdot \frac{3{,}14 \cdot 8^2}{4} \cdot 24}{2{,}5 \cdot 10^{-19}} \approx 63 \cdot 0{,}4 = 25\ \frac{\text{phot}}{\text{s}}$$

PO-S-2

S M T W T F S | Weather conditions

Problem 10



The density of stars in mid-plane is n_0.
in the distance d from the galactic plane,
the density is equal to:

$$n = n_0 \cdot \exp\left(-\frac{d}{r_0}\right), \text{ so:}$$

$$\frac{n}{n_0} = \exp\left(-\frac{d}{r_0}\right)$$

For $d = 0{,}5$ kpc $= 500$ pc : $\frac{n}{n_0} = e^{-5/3} \approx 0{,}19$

For $d = 1{,}5$ kpc $= 1500$ pc : $\frac{n}{n_0} = e^{-5} \approx 0{,}0067$

HongJing paper

RO-5-4

DATE: PAGE:

Problem 11

$\frac{T_M^2}{a_M^3} = 1$; $a_M = 1.524$ AU

$T_M = \sqrt{a_M^3} = 1.881$ years

$\frac{1}{S} = \frac{1}{1} - \frac{1}{T_M}$

$\Rightarrow S = \frac{T_M}{T_M - 1} = 2.135$ year (sideral years)

$7S = 14.945$ years (sideral years)

(2004)
2005
2006
2007
(2008)
2009
2010
2011
(2012)
2013
2014
2015
(2016)
2017

$t_1 = 4\cdot 366 + 10\cdot 365$

$= 5114$ days (◯ = ~~leap~~ 366 days - year)

$t_0 = 14.945$ years $= 5458.76$ days

28 Aug UT $17^h 56^m$ ~~2003~~ → 2004

$t_2 = 125.71$ days

DATE: PAGE:

$\Delta t = t_0 - t_1 - t_2$

$= 5458.76$ days $- 5114$ days $- 125.71$ days

$\Delta t = 219.05$ days

$\Rightarrow$ **T : 7 ~~July~~ August UT $1^h\ 10^m$**

SE - S - 1

DATE: PA

12) $\Delta m = 2^m$ $T_1 = 6{,}000\,K$ $T_2 = 5\,000\,K$ $\frac{R_1}{R_2} \to ?$

$\Delta m = \Delta M = 2^m$

$\Delta m = 2.5 \log_{10} \frac{L_1}{L_2}$

$\frac{L_1}{L_2} = 10^{0.4\Delta m} = 10^{0.8}$

$L_1 \sim T_1^4 R_1^2$

$L_2 \sim T_2^4 R_2^2$

$\frac{L_1}{L_2} \propto \left(\frac{T_1}{T_2}\right)^4 \cdot \left(\frac{R_1}{R_2}\right)^2$

$\left(\frac{R_1}{R_2}\right)^2 = \frac{L_1}{L_2} \cdot \left(\frac{T_2}{T_1}\right)^4 = 10^{0.8} \cdot \left(\frac{T_2}{T_1}\right)^4$

$\frac{R_1}{R_2} = 10^{0.4} \left(\frac{T_2}{T_1}\right)^2$

$\frac{R_1}{R_2} = 10^{0.4} \left(\frac{5000}{6000}\right)^2 = 1.744$

$\boxed{\frac{R_1}{R_2} = 1.74}$

SL - S - 2

Date Page

Problem 13,

Keď sa pozrieš Slnko má pri pohľade voľným okom a žltú farbu. To zrejme znamená, že najviac energie vyžaruje v žltej farbe. Žltá farba má vlnovú dĺžku asi ~~470~~ 500 nm.

Z Wienovho zákona posunu:

$b = \lambda_{max} \cdot T$ $\qquad b = 2{,}898 \cdot 10^{-3}\,m \cdot K$

$T = \frac{b}{\lambda_{max}}$

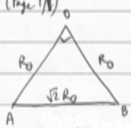
$T = 5800\,K$

TH-S-4

Date: Page:

Problem 14 (Page 1/1)

Solution

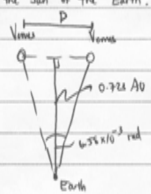


$R_\odot = \frac{6.96\times10^5}{1.496\times10^8}$ rad

$= 4.65\times10^{-3}$ rad

$\sqrt{2}R_\odot = 6.58\times10^{-3}$ rad

~~At first~~, We will neglect the revolution around the Sun of the Earth. (Earth move only a little in one day)



$\therefore D \approx 4.78\times10^{-3}$ AU

~~$D = 7.15\times10^8$ m~~

Venus moves $2\pi\times(0.723\text{ AU}) = 4.54$ AU use 224.70 days

~~∴ If Venus moves 4.78×10^{-3} AU It will use $\frac{4.78\times10^{-3}}{4.54}\times224.70$ days~~

~~$= 0.237$ days~~

~~$= 5$ hours 16 minutes~~

From A to D Venus move $= 4.78\times10^{-3} + \frac{2\times0.949\times6374}{1.496\times10^8} = 4.86\times10^{-3}$ AU

$\therefore$ It will use $\frac{4.86\times10^{-3}}{4.54}\times224.7 = 0.24$ days

$= 5$ hours 19 minutes

$\therefore$ The time of fourth contact is 14:19 UT Ans

~~Assume that the Earth also moves~~

~~Venus move 4.86×10^{-3} AU means its move 0.39 degrees respect to the Sun~~

~~Earth move 0.986 per day~~

~~Venus move 1.602 per day~~

~~Venus need to move faster than Earth for 0.39 degree.~~

CN-S-2

DATE: PAGE:

15) 设太阳的视圆面半径为 1

月球的视半径为 ε.

月球轨道半长轴为 a.

某时刻地月距离为 r.

有 $\varepsilon = \frac{c}{r}$, c 是 const.

活力积分：

$$v_{moon}^2 = \mu\left(\frac{2}{r} - \frac{1}{a}\right), \quad \mu = G(M_{earth} + M_{moon})$$

$$\therefore v_{moon} \propto \sqrt{\frac{2}{r} - \frac{1}{a}}$$

$$\therefore t_{食} \propto \frac{1}{v_{moon}} \propto \frac{1}{\sqrt{\frac{2}{r} - \frac{1}{a}}}, \quad t_{食} \propto |\varepsilon - 1|$$

① 最长日环食发生在月球位于远日点之时，此时 ε 最小，v_{moon} 最小.

$$t_{最长日环食} \propto \frac{1-\varepsilon}{\sqrt{\frac{2}{a(1+e)} - \frac{1}{a}}} = \frac{1 - c/a(1+e)}{\sqrt{\frac{2}{a(1+e)} - \frac{1}{a}}}.$$

② 日全食时有，

$$t_{日全食} \propto \frac{\varepsilon - 1}{\sqrt{2/r - 1/a}} = \frac{c/r - 1}{\sqrt{2/r - 1/a}}.$$

$$\frac{dt_{日全食}}{dr} < 0 \quad \therefore t_{日全食} \text{ 随 } r \text{ 增大而减小.}$$

RU-S-3

N 16. Date, Page,

$a_M = 1{,}524$ а.е.

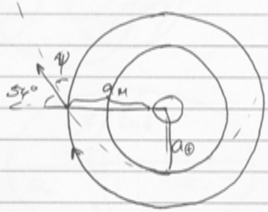
$a_\oplus = 1$ а.е.

$M = M_\odot$

ψ - ?

v - ?

α - ?



1) Т.к аппарат выходит на параболическую орбиту, он получит скорость v_{II}, отн. Солнца на расстоянии орбиты Земли. $\Rightarrow$ $E_{мех} = 0$.

$$\frac{m v_{II}^2}{2} - \frac{GMm}{a_\oplus} = \frac{m v^2}{2} - \frac{GMm}{a_M}.$$

т.к $v_{II} = \sqrt{\frac{2GM}{a_\oplus}}$. $\Rightarrow$

$$\frac{m v^2}{2} = \frac{GMm}{a_M}.$$

$$v = \sqrt{\frac{2GM}{a_M}}$$

$v = 34{,}1$ км/с

$v_M = 24{,}2$ км/с

2) По II закону Кеплера:

$\bar{v}_1 \times \bar{r}_1 = \bar{v}_2 \times \bar{r}_2$

Date, Page,

$v_{II} \cdot a_\oplus = v \cdot a_M \cdot \sin(90 + \psi)$

$$\sin(90+\psi) = \frac{a_\oplus}{a_M} \cdot \sqrt{\frac{a_M}{a_\oplus}} = \sqrt{\frac{a_\oplus}{a_M}}$$

$90 - \psi = 54{,}1°$

$\psi = 35{,}9°$

3) При этом если мы смотрим с южного полюса эклиптики, и Марс и Земля будут двигаться по часовой стрелке. тогда ~~$v_{отн} =$~~

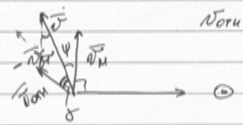
$v_M = v_{пер}$ сист. отсч.

$v = v_{отн}$ неподв. сист. отсч.

~~$\bar{v}_{отн}$ подв. сист. отсч. $= \bar{v}_M - \bar{v}$~~

$\bar{v} = \bar{v}_M + \bar{v}_{отн}$.

$v_{отн} = v - v_M$.



4) По т. косинусов:

$v_{отн}^2 = v^2 + v_M^2 - 2 v_M v \cdot \cos\psi$

$v_{отн} = 20{,}3$ км/с.

5) По т. синусов:

$\frac{v_M}{\sin\gamma} = \frac{v_{отн}}{\sin\psi}$; $\sin\gamma = \sin\psi \cdot \frac{v_M}{v_{отн}}$.

$\gamma = 44{,}35° = 44°21'$

6) $\alpha = \gamma + \psi + 90° = 170°15'$

Ответ: $\psi = 35{,}9°$

$v_{отн} = 20{,}3$ км/с

$\alpha = 170°15'$

IN-S-3

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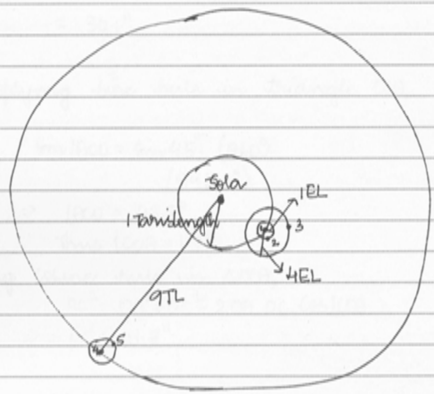
7) a) Sola system. (Not to scale) (All are circular orbits)



* 1 Tarislength ≡ 1TL
1 Endorlength ≡ 1 EL

1 – Taris
2 – Endor
3 – Extor
4 – Corulus
5 – Moon of Corulus

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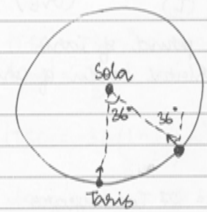
b) For every one tarisday, Taris should rotate 36° extra than 360° (as shown)

(Not to scale)



Degrees rotated per day $= 360° + 36°$
$= 396°$

Thus after 10 Tarisdays (or 1 Tarisyear),

No. of rotations $= \frac{396° \times 10}{360°} = 11$ rotations.

c) From Kepler's law, we have $R \propto T^{2/3}$

Thus distance between Taris and Extor (d_{EX})

$$= d_{EN}\left(\frac{T_{EX}}{T_{EN}}\right)^{2/3}$$

$$= 4d_{EN}$$

$d_{EX} = 4d_{EN} \Rightarrow$ Distance between Taris and Extor is 4EL

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d) Applying Kepler's law again,

$$\text{Time period of Corulus } (T_c) = T_t \left(\frac{r_c}{r_t}\right)^{3/2}$$

where T_t - Time period of Taris

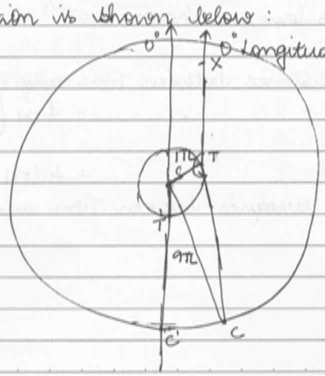
r_c, r_t - orbital radii of Corulus, Taris resp

$$T_c = T_t \cdot 9^{3/2} = 27 T_t$$

Time period of Corulus (orbital) = 27 Tarisyears

e) When Corulus and Taris are in opposition, distance between them is 8TL (Corulus and Taris)

f) The situation is shown below :



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T', C' are positions at start of Tarisyear.

T, C are positions after n tarisdays.

Clearly, $\angle TSC' = 36n°$

$\angle CSC' = \frac{36n°}{27}$

$$\angle TSC = 36\left(1 - \frac{1}{27}\right)n° = \left(\frac{36 \times 26n}{27}\right)°$$

We need longitude = $\angle XTC$ in shown direction.

In ΔSTC, $CT^2 = ST^2 + SC^2 - 2 \cdot ST \cdot SC \cos \angle TSC$

$$CT \text{ (in TL)} = \sqrt{82 - 18\cos\left(36\left(\frac{26}{27}\right)n°\right)}$$

In ΔSTC, applying sine rule,

$$\frac{\sin \angle STC}{\sin \angle CST} = \frac{9}{CT} \text{ (in TL)}$$

$$\Rightarrow \angle STC = \sin^{-1}\left[\frac{9}{CT} \sin\left(\frac{36 \times 26n}{27}\right)°\right]$$

$$\text{Longitude} = \angle XTC = \angle XTS + \angle STC$$

$$= \angle TSC' + \angle STC \quad \text{(parallel lines)}$$

$$= 36n° + \sin^{-1}\left[\frac{9}{CT} \sin\left(\frac{36}{27} \times 26n\right)°\right]$$

where $CT = \sqrt{82 - 18\cos\left(\frac{36}{27} \times 26n\right)°}$

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g) After one tarisday, $n = 1$.

~~$CT = \sqrt{82^2 - 18 \cos 25 / 36}$~~

$\angle TSC = \frac{36}{27} \times 26^{\circ}$

Area of $\Delta^{le} = \frac{1}{2} \cdot r_c \cdot r_t \sin \angle TSC$

$= 2.56\ TL^2$

Thus Area of $\Delta^{le} = 2.6\ TL^2$

Results of the 4^{th} IOAA

- Theoretical Problems' Marks
- Data Analysis Problems' and Observational Problems' Marks
- Medalists and Honorable Mentions

Theoretical Problems' Marks of the 4th IOAA

Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
BA-S-1	8	10	2	0	7.5	10	5	4	4	0	5	3	10	3	0	0	26	97.5
BA-S-2	0	10	10	1	7	4	0	4	0	0	5	6	5	0.5	0	0	14.5	67
BA-S-3	10	10	10	4	10	3	5	4	0	10	0	6	10	2.5	1	8	23	117
BA-S-4	10	10	0	2	0	4	0	0	0	0	0	3	5	0	0	0	16.5	50.5
BA-S-5	10	10	8	10	7.5	10	5	2	7	0	5	6	10	0	0	19	19	129
BE-S-1	10	10	10	3	10	10	5	2	7	10	5	10	10	2	3.5	10	28	146
BE-S-2	10	6	10	9	10	10	5	6	7	10	10	10	10	2	0	30	20	165
BE-S-3	10	10	10	10	10	10	10	6	7	0	8	6	10	4	0	11	21.5	144
BE-S-4	10	10	2	3	10	10	10	6	7	10	10	10	10	4.5	0	0	26	139
BE-S-5	10	10	10	10	10	10	10	0	4	10	3	6	10	0	0	0	18.5	122
BO-S-1	8	6	8	4	8	3	5	4	0	0	2	0	10	1	0	2	19	80
BO-S-2	0	10	0	2	1	2.5	0	4	0	0	2	0	5	1.5	0	0	18	46
BO-S-3	10	10	2	2	0	0	0	4	0	0	0	10	10	0	0	0	10	58
BR-S-1	10	10	6	10	10	8	10	10	7	0	8	10	10	2	1	12.5	27.5	152
BR-S-2	10	10	2	10	10	4	5	8	2	0	5	8	10	0	0	4.5	22	111
BR-S-3	10	10	8	10	8	7	10	8	4	2	10	10	5	4	4	28.5	24	163
BR-S-4	10	10	10	7	10	5	5	6	5	8	8	6	10	3.5	0	24	17.5	145
BR-S-5	10	10	10	2	10	8	0	10	4	0	8	6	10	2	2.5	4	21.5	118
CNG-S-1	10	10	4	10	10	10	10	10	0	0	8	10	10	6.5	0	9	18.5	136
CNG-S-2	8	10	10	2	10	10	10	10	3	0	8	6	10	6	0	14.5	18.5	136
CNG-S-3	10	2	10	10	10	6	10	4	8	10	8	6	10	5	1	7.5	21	139
CNG-S-4	10	10	10	1.5	10	6	10	6	7	1	8	6	10	2.5	2	30	20	150
CNG-S-5	10	10	10	10	10	8	10	10	7	10	10	8	10	4	4	14	29	174
CN-S-1	10	10	10	10	10	10	5	0	10	0	10	6	10	10	4	8.5	21.5	145
CN-S-2	10	10	10	10	10	6	10	8	0	10	8	6	10	6	7	18	24	163
CN-S-3	10	10	10	9	10	10	5	8	2	2	8	6	10	4.5	0	8	26.5	139
CN-S-4	10	10	8	10	10	10	10	10	9	2	8	10	10	7	0.5	11.8	19.8	156

CN-S-5	10	10	10	10	10	10	10	6	4	0	8	6	6	7	0	4	29	140
CZ-S-1	10	10	10	6.5	5	10	10	10	3	10	10	6	10	4	0	23	26	164
GR-S-1	10	3	10	7.5	10	7.5	10	10	4	0	8	10	10	3	0	0	30	133
GR-S-2	10	10	2	2	10	5	10	10	4	10	8	6	10	3	1.5	11	21	134
GR-S-3	10	10	10	3	4	5	0	10	0	0	10	6	10	1	0	0	15.5	94.5
GR-S-4	10	10	2	2.5	8.5	4	5	10	0	10	2	6	10	2	0	7	16	105
GR-S-5	10	10	10	0	0	0	5	0	0	0	0	3	10	0	0	2	15	65
IN-S-1	10	10	10	10	10	8.5	10	6	0	10	8	10	10	5.5	7	30	28	183
IN-S-2	10	10	10	10	10	10	7	10	8	10	10	6	10	6	6	27	30	190
IN-S-3	10	10	10	10	10	10	0	10	10	2	5	10	10	4.5	0	28	30	170
IN-S-4	10	10	10	10	10	10	10	10	10	10	10	10	10	3	6	29	30	198
IN-S-5	10	10	2	10	10	10	5	10	10	0	10	6	10	2.5	2.5	7.5	17	133
IO-S-1	10	10	10	10	10	10	10	10	10	0	8	10	10	10	4	5.5	26	164
IO-S-2	10	10	10	10	10	10	5	10	3	2	10	10	10	10	0	5.5	22	148
IO-S-3	10	10	2	10	10	7	5	10	4	2	10	10	10	4	0.5	2	16.5	123
IO-S-4	10	10	10	5	10	10	5	10	3	10	8	10	10	5.5	1	7	26	151
IO-S-5	10	10	10	10	10	6	5	10	10	5	8	6	10	7	0	5.5	22	145
IRG-S-1	10	10	10	10	7	8	10	9	8	10	2	10	1	0.5	0	13	24.5	143
IRG-S-2	10	10	4	10	8	5.5	5	6	10	8	8	6	10	0	0	22.5	22.5	146
IRG-S-3	10	10	4	3	10	3	10	10	2	10	8	10	10	6.5	4	29	22.5	162
IRG-S-4	10	10	10	10	10	2	5	4	10	10	5	10	10	4	0	27	17.5	155
IRG-S-5	10	10	10	10	10	7	5	2	4	0	10	10	10	3	0	20	25.5	147
IR-S-1	10	10	10	10	10	8	10	10	7	0	10	10	10	4.5	6	30	17	173
IR-S-2	10	10	6	10	6.5	8	10	10	4	10	8	6	10	3.5	7	30	19	168
IR-S-3	10	10	10	8	10	8	5	10	8	5	8	6	10	4	5	18	23.5	159
IR-S-4	10	10	10	10	10	8	10	10	7	10	8	10	10	8	3	18	20	172
IR-S-5	10	10	10	10	10	2	10	10	3	0	8	6	10	7	0	30	22	158
KA-S-1	10	10	10	1	0	10	0	0	0	0	10	0	10	1	1.5	0	20	83.5
KA-S-2	10	8	2	4	9	8	5	4	0	0	8	6	10	3	0	0	16.5	93.5
KA-S-3	0	0	0	0	0	0.5	0	0	0	0	2	0	10	0	0	0	0	12.5

KA-S-4	10	1	2	5.5	3	4	5	2	0	0	0	6	10	1	0	0	15	64.5
KA-S-5	10	10	2	2	9.5	10	10	0	0	0	5	8	10	0	0	0	12	88.5
KO-S-1	10	10	10	10	10	10	7	6	10	10	8	6	10	3	4.5	28.5	15	168
KO-S-2	10	10	10	10	10	10	10	10	7	10	8	10	10	5	6.5	18	26	181
KO-S-3	10	10	10	10	10	4	10	10	4	10	8	9	10	2	0	20	25	162
KO-S-4	10	10	10	3	10	3.5	10	4	4	10	8	10	10	4	3.5	22.5	14	147
LI-S-1	10	10	10	5	10	10	10	6	10	10	5	10	10	5	0	16	20.5	158
LI-S-2	10	10	10	5	10	10	10	6	7	10	8	6	10	7.5	0	4	25	149
LI-S-3	10	10	10	10	10	8	10	10	10	10	8	6	5	2	4	30	28	181
LI-S-4	10	10	10	3	10	10	10	6	10	10	10	6	10	10	0	0	25	150
LI-S-5	10	0	10	10	8	7	0	0	0	2	8	10	10	0	0	1	9	85
PH-S-1	0	10	2	0	10	10	0	0	0	0	2	6	10	1	0	1	20	72
PH-S-2	0	0	2	2	2.5	3	0	2	0	0	2	3	10	4	0	2	15	47.5
PH-S-3	10	10	10	0	10	1	5	10	0	0	8	10	10	4.5	0	5.5	23	117
PH-S-4	2	2	5	0	9	4.5	0	2	0	0	2	0	10	0	0	0	20	56.5
PH-S-5	3	10	10	1	10	6	0	0	0	0	5	10	10	3	1.5	0	22	91.5
PO-S-1	10	10	2	10	10	10	7	10	7	0	8	10	10	4.5	5	5	25	144
PO-S-2	10	10	10	10	10	10	7	6	7	10	8	10	10	6	6	29.5	27.5	187
PO-S-3	0	10	2	6	10	4	5	2	0	0	2	10	10	3.5	1	2	17	84.5
PO-S-4	10	10	2	10	10	10	7	4	0	10	5	10	5	3.5	0	25	29	151
RO-S-1	10	10	10	8	10	9	10	6	5	0	8	6	3	5	0.5	10	21.5	132
RO-S-2	10	10	4	4	10	8	10	6	4	8	8	6	10	3	5.5	11	25	143
RO-S-3	9	6	10	10	9	10	3	10	1	10	5	8	10	4	4.5	3	22	135
RO-S-4	10	10	10	10	10	10	10	6	10	10	10	6	10	4.5	2	15	29	173
RO-S-5	10	10	10	10	10	10	10	8	10	10	8	10	10	7	6	20	20.5	180
RU-S-1	10	10	2	5	10	7.5	5	6	0	10	8	10	10	4	0	2	20	120
RU-S-2	10	10	2	2	6	7	5	6	4	8	8	10	10	5.5	4	0	15	113
RU-S-3	10	10	2	4.5	10	10	5	10	7	10	8	6	10	8	4	30	26	171
SE-S-1	10	10	10	10	10	7	5	10	7	10	8	10	10	6	0	30	25	178
SE-S-2	8	8	10	3	10	10	5	2	7	10	2	6	10	8	0	14	20.5	134

SE-S-3	10	10	10	10	10	10	5	10	0	10	10	10	10	0	0	30	23.5	169
SE-S-4	10	10	10	10	3	8	5	10	0	8	8	10	10	10	3	19	20	154
SE-S-5	10	0	10	10	1	8	10	10	0	0	8	10	5	0.5	0	2	20	105
SL-S-1	10	8	10	7	10	6	9	5	0	10	10	6	10	5.5	3	6	28.5	144
SL-S-2	10	10	10	9	10	10	7.5	10	10	2	3	8	10	3	4	25	26	168
SL-S-3	10	10	2	2	4	5	7.5	10	0	0	8	6	10	1.5	0	3	20	99
SR-S-1	8	10	10	0	10	8	5	4	4	0	5	6	10	1.5	0	1	20.5	103
SR-S-2	8	10	10	10	8.5	10	10	6	7	0	8	10	10	3.5	0	0	15.5	127
SR-S-3	10	10	10	2	6.5	10	5	4	4	0	5	6	2	2	0	0	13	89.5
SR-S-4	8	10	10	10	10	10	10	4	0	0	5	6	10	3.5	0	0	6	103
SR-S-5	10	10	10	10	8	8	5	10	4	0	8	6	10	1.5	0	2	10.5	113
TH-S-1	8	10	10	10	10	10	10	6	4	10	10	10	10	3.5	5.5	26.5	26.8	180
TH-S-2	10	8	2	10	10	4	10	10	7	10	10	10	10	4	2	29	29	175
TH-S-3	2	10	10	10	10	6	5	10	4	0	8	9	10	6	1	29.5	26	157
TH-S-4	10	10	10	5	10	5	5	6	0	0	10	6	10	10	0	5.5	20	123
TH-S-5	8	10	8	5	10	3	10	4	1	10	8	6	5	3	1	16	24	132
UK-S-1	10	10	10	2	10	10	3	6	7	10	10	6	10	4	0	4	23	135
UK-S-2	10	10	3	0	1	10	10	0	2	10	5	6	2	2	0	2	20	93
UK-S-3	10	10	2	3	10	10	10	8	4	10	8	10	10	3.5	2	0	22	133
UK-S-4	10	0	2	3	10	10	4	8	0	10	10	6	10	4.5	4	2	20	114

Data Analysis Problems' and Observational Problems' Marks of the 4th IOAA

Code	Data Analysis Part I								Data Analysis Part II							DA Tot	Observation				Sum
	1	2	3	4	5	6	7	Tot	1	2	3	4	5	6	Tot		1	2	3	Tot	
BA-S-1	0	0	0	0	0	0	0	0	6	4	0	0	0	0	10	10	20	25	8	53	63
BA-S-2	2	2	0	0	0	0	0	4	5	0	0	0	0	0	5	9	25	25	5	55	64
BA-S-3	2	2	2	0	0	0	2	8	3	0	0	0	0	0	3	11	10	17	5	32	43
BA-S-4	0	0	0	0	0	0	0	0	6	8	0	4	0	0	18	18	5	10	8	23	41
BA-S-5	2	2	1	2	2	0	0	9	6	8	0	4	0	0	18	27	10	17	10	37	64
BE-S-1	2	0	4	3	2	0	0	11	6	0	8	0	2	2	18	29	25	12	10	47	76
BE-S-2	2	2	0	3	2	1	16	26	6	8	2	4	4	5	29	55	15	20	8	43	98
BE-S-3	2	2	4	1	0	2	13	24	6	8	0	0	4	5	23	47	20	22	15	57	104
BE-S-4	2	2	4	4	0	0	0	12	6	8	0	4	0	5	23	35	20	25	5	50	85
BE-S-5	2	2	4	4	0	2	4	18	3	0	0	0	0	0	3	21	15	0	10	25	46
BO-S-1	2	2	3.5	0	0	4	10	21.5	6	8	0	2	0	0	16	37.5	10	15	10	35	72.5
BO-S-2	2	2	0	0	0	0	16	20	3	4	0	0	0	0	7	27	15	20	0	35	62
BO-S-3	2	2	0	0	0	0	3	7	0	2	0	2	0	4	8	15	10	15	0	25	40
BR-S-1	2	2	4	1	0	0	13	22	6	8	1	5	2	2	24	46	25	25	20	70	116
BR-S-2	0	0	0	0	2	0	1	3	0	0	0	0	0	0	0	3	25	25	8	58	61
BR-S-3	3	3	4	1	2	1	10	24	2	2	0	0	2	0	6	30	20	25	0	45	75
BR-S-4	0	0	1	1	0	0	6	8	6	8	0	4	2	3	23	31	15	20	5	40	71
BR-S-5	2	2	4	1	1	0	0	10	6	8	8	4	2	3	31	41	25	22	15	62	103
CNG-S-1	2	2	4	1	1	2	9	21	6	1	0	4	4	5	20	41	25	25	20	70	111
CNG-S-2	2	2	4	4	1	2	13	28	6	8	0	4	2	0	20	48	20	22	20	62	110
CNG-S-3	2	2	4	2	2	0	16	28	6	8	8	4	4	5	35	63	25	25	15	65	128
CNG-S-4	2	2	4	0	2	2	13	25	6	0	2	4	4	1	17	42	20	22	15	57	99
CNG-S-5	2	2	4	1	1	0	9	19	6	8	0	4	4	5	27	46	25	25	15	65	111

CN-S-1	2	2	4	1	0	2	6	17	6	8	0	4	4	5	27	44	25	25	15	65	109
CN-S-2	2	2	4	4	4	0	6	22	6	8	0	4	4	0	22	44	10	22	10	42	86
CN-S-3	2	2	4	1	1	3	16	29	6	2	0	4	4	4	20	49	25	25	20	70	119
CN-S-4	2	2	2	0	3	0	0	9	6	8	4	4	4	3	29	38	15	20	5	40	78
CN-S-5	2	2	4	4	4	2	3	21	0	8	0	4	2	0	14	35	25	25	20	70	105
CZ-S-1	2	2	4	2	4	1	13	28	6	8	4	4	4	5	31	59	25	25	20	70	129
GR-S-1	2	2	0	0	0	0	5	9	6	8	0	4	2	3	23	32	25	25	13	63	95
GR-S-2	2	2	4	0	2	0	0	10	6	8	4	4	4	1	27	37	20	20	13	53	90
GR-S-3	1	2	2	2	0	1	4	12	6	8	4	4	4	6	32	44	10	25	0	35	79
GR-S-4	2	2	0	2	2	0	3	11	2	8	0	0	0	0	10	21	5	15	3	23	44
GR-S-5	2	2	0	0	0	0	6	10	6	8	0	3	4	3	24	34	10	17	13	40	74
IN-S-1	2	2	4	4	0	2	13	27	6	0	0	4	2	5	17	44	25	25	13	63	107
IN-S-2	2	2	3	2	3	3	15	30	6	6	2	4	2	5	25	55	25	25	20	70	125
IN-S-3	2	2	2	1	2	0	7	16	6	0	0	4	0	2	12	28	15	20	5	40	68
IN-S-4	2	2	4	2	2	0	13	25	6	0	0	4	4	2	16	41	25	22	10	57	98
IN-S-5	2	2	4	1	4	1	7	21	6	2	4	4	2	5	23	44	15	25	20	60	104
IO-S-1	2	2	4	3	2	1	16	30	6	1	4	4	2	5	22	52	25	25	13	63	115
IO-S-2	2	2	1	2	2	1	11	21	6	1	4	4	2	5	22	43	25	22	15	62	105
IO-S-3	2	2	0	0	0	0	4	8	6	8	5	3	2	0	24	32	25	22	0	47	79
IO-S-4	2	2	0	1	1	2	7	15	6	7	3	4	2	6	28	43	25	25	15	65	108
IO-S-5	0	0	0	0	2	1	7	10	3	0	4	4	2	0	13	23	10	25	13	48	71
IRG-S-1	2	2	4	2	4	3	1	18	3	8	0	4	2	5	22	40	25	25	3	53	93
IRG-S-2	2	2	2	2	4	0	0	12	6	8	0	0	0	0	14	26	20	25	10	55	81
IRG-S-3	2	2	4	0	4	1	0	13	6	8	0	4	4	0	22	35	25	25	0	50	85
IRG-S-4	0.5	0	0	0	4	1	0	5.5	6	8	0	2	4	5	25	30.5	20	10	10	40	70.5
IRG-S-5	0.5	0	0	0	0	0	2	2.5	0	8	0	4	0	0	12	14.5	15	20	3	38	52.5
IR-S-1	2	2	4	4	4	0	10	26	3	8	0	4	4	5	24	50	25	25	5	55	105
IR-S-2	2	2	4	4	2	3	5	22	6	8	4	4	4	5	31	53	25	25	10	60	113
IR-S-3	0.5	0	2	0	4	1	4	11.5	6	8	0	4	0	5	23	34.5	25	22	0	47	81.5
IR-S-4	2	2	4	0	0	0	0	8	6	8	8	4	4	5	35	43	25	10	20	55	98

IR-S-5	2	2	3	0	4	1	10	22	6	0	0	4	2	5	17	39	25	25	8	58	97
KA-S-1	2	2	4	2	0	0	0	10	0	0	0	0	0	0	0	10	25	17	10	52	62
KA-S-2	2	0	0	2	0	0	0	4	0	8	0	0	4	5	17	21	20	15	8	43	64
KA-S-3	2	2	0	0	0	0	0	4	0	0	0	0	0	0	0	4	10	17	0	27	31
KA-S-4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	7	0	12	12
KA-S-5	2	0	0	0	0	0	0	2	0	4	0	2	4	0	10	12					12
KO-S-1	2	2	4	1	1	0	16	26	6	0	0	4	4	0	14	40	25	12	8	45	85
KO-S-2	2	2	4	4	2	2	10	26	6	8	6	4	2	5	31	57	25	22	20	67	124
KO-S-3	2	2	4	3	2	1	16	30	6	2	1	4	2	5	20	50	15	25	15	55	105
KO-S-4	2	2	4	2	2	1	13	26	4	2	1	4	2	5	18	44	25	19	15	59	103
LI-S-1	0	2	2	1	2	0	12	19	6	6	3	4	4	5	28	47	20	25	13	58	105
LI-S-2	2	2	1	1	2	0	2	10	6	1	1	4	2	2	16	26	25	20	10	55	81
LI-S-3	2	2	4	2	1	0	13	24	6	8	8	4	4	5	35	59	15	17	10	42	101
LI-S-4	2	4	4	0	2	1	4	17	6	4	4	4	2	5	25	42	25	17	15	57	99
LI-S-5	2	2	4	0	0	0	2	10	6	8	8	4	4	3	33	43	25	20	13	58	101
PH-S-1	2	2	0	0	0	0	10	14	6	8	0	0	0	5	19	33	5	12	0	17	50
PH-S-2	2	2	0	0	0	0	0	4	6	4	0	4	0	0	14	18	25	12	3	40	58
PH-S-3	2	2	0	1	0	0	5	10	6	8	8	4	0	5	31	41	10	0	8	18	59
PH-S-4	2	2	0	0	0	0	2	6	0	0	0	0	0	0	0	6	5	12	10	27	33
PH-S-5	2	2	0	2	0	0	10	16	6	8	0	4	4	0	22	38	5	15	10	30	68
PO-S-1	2	2	4	4	4	1	16	33	6	8	4	4	0	5	27	60	25	25	20	70	130
PO-S-2	2	2	4	4	4	3	13	32	6	8	8	4	4	5	35	67	25	25	15	65	132
PO-S-3	1	2	4	2	0	3	7	19	6	8	8	0	0	5	27	46	15	17	15	47	93
PO-S-4	2	2	4	4	4	0	13	29	0	0	2	4	0	5	11	40	25	25	20	70	110
RO-S-1	1	2	4	2	4	2	3	18	6	0	0	4	4	5	19	37	25	25	13	63	100
RO-S-2	2	2	2	0	4	0	13	23	6	8	8	4	4	5	35	58	25	25	10	60	118
RO-S-3	2	2	2	4	4	0	9	23	6	8	0	0	0	5	19	42	25	20	8	53	95
RO-S-4	2	2	4	2	4	2	11	27	6	0	0	4	2	5	17	44	25	25	20	70	114
RO-S-5	2	2	4	2	4	1	10	25	6	8	4	4	2	5	29	54	25	25	15	65	119
RU-S-1	2	2	4	0	0	2	10	20	6	4	0	4	2	5	21	41	20	15	10	45	86

RU-S-2	2	2	4	0	0	2	6	16	6	4	0	4	0	0	14	30	20	0	0	20	50
RU-S-3	2	2	0	0	0	0	2	6	5	4	0	4	0	0	13	19	20	0	8	28	47
SE-S-1	2	2	4	4	4	2	0	18	6	6	2	4	2	3	23	41	25	17	20	62	103
SE-S-2	2	2	4	4	4	3	10	29	4	0	0	0	0	0	4	33	25	15	10	50	83
SE-S-3	2	2	4	3	4	2	8	25	0	2	0	4	4	4	14	39	25	25	13	63	102
SE-S-4	2	2	4	4	4	1	9	26	5	8	8	4	4	3	32	58	20	22	5	47	105
SE-S-5	2	2	3	1	4	0	16	28	5	0	0	0	0	0	5	33	20	14	3	37	70
SL-S-1	2	2	4	3	0	2.5	9	22.5	6	4	6	4	4	4	28	50.5	25	25	20	70	121
SL-S-2	2	2	4	3	2	2	16	31	6	8	8	4	4	5	35	66	25	25	15	65	131
SL-S-3	2	2	4	1	0	1	6	16	6	0	0	4	3	0	13	29	25	25	15	65	94
SR-S-1	2	2	0	1	3	0	2	10	6	0	4	4	2	0	16	26	5	5	0	10	36
SR-S-2	2	2	4	0	1	2	14	25	4	8	0	4	0	0	16	41	10	12	0	22	63
SR-S-3	2	0	2	1	0	0	9	14	3	0	0	0	0	0	3	17	0	7	3	10	27
SR-S-4	2	2	4	1	0	0	5	14	0	8	0	0	0	0	8	22	10	10	5	25	47
SR-S-5	2	2	1	0	0	0	10	15	0	0	0	0	0	0	0	15	0	7	5	12	27
TH-S-1	2	2	2	2	2	0	16	26	6	8	4	4	0	5	27	53	20	25	20	65	118
TH-S-2	2	2	2	2	2	1	16	27	6	0	0	4	2	0	12	39	25	25	20	70	109
TH-S-3	2	2	4	2	2	0	16	28	6	4	8	4	4	5	31	59	20	25	10	55	114
TH-S-4	2	2	4	1	2	0	4	15	6	8	4	4	2	5	29	44	20	25	10	55	99
TH-S-5	2	2	4	2	0	0	6	16	0	8	0	4	0	0	12	28	25	22	20	67	95
UK-S-1	2	2	4	2	4	3	13	30	6	8	0	4	0	0	18	48	20	25	0	45	93
UK-S-2	2	2	0	2	0	4	11	21	6	0	4	4	4	5	23	44	25	19	3	47	91
UK-S-3	2	2	4	4	0	1	13	26	6	8	0	0	4	5	23	49	10	15	10	35	84
UK-S-4	2	2	4	0	4	0	8	20	6	8	0	4	0	5	23	43	10	25	15	50	93

Medalists and Honorable Mentions of The 4th IOAA

Rank	Code	Team Name	Name	Medal	Sex
1	PO-S-2	Poland	Przemysław Mróz	G/BP/BO	M
2	IN-S-2	India	Mr. Chirag Modi	G	M
3	KO-S-2	Korea	Seo Jin Kim	G	F
4	RO-S-5	Romania	KRUK SANDOR IOZSEF	G	M
5	SL-S-2	Slovakia	Peter Kosec	G	M
6	TH-S-1	Thailand	Mr.Patchara Wongsutthikoson	G	M
7	IN-S-4	India	Mr. Nitesh Kumar Singh	G/BT	M
8	CZ-S-1	Czech Republic	Stanislav Fort	G	M
9	IN-S-1	India	Mr. Aniruddha Bapat	G	M
10	RO-S-4	Romania	OPRESCU ANTONIA MIRUNA	G	F
11	CNG-S-5	China (Guest)	DONG Chenxing	G	M
12	TH-S-2	Thailand	Mr.Ekapob Kulchoakrungsun	G	M
13	LI-S-3	Lithuania	Rimas Trumpa	G	M
14	IR-S-2	Iran	Ali Izadi Rad	G	M
15	SE-S-1	Serbia	Aleksandar Vasiljkovic	G	M
16	IO-S-1	Indonesia	Raymond D	S	M

17	IR-S-1	Iran	Behrad Toughi	S	M
18	PO-S-1	Poland	Damian Puchalski	S	M
19	SE-S-3	Serbia	Filip Zivanovic	S	M
20	TH-S-3	Thailand	Mr.Yossathorn Tawabutr	S	M
21	IR-S-4	Iran	Ehsan Ebrahmian Arehjan	S	M
22	BR-S-1	Brazil	Thiago Saksanian Hallak	S	M
23	KO-S-3	Korea	Yunseo Jang	S	M
24	CNG-S-3	China (Guest)	ZHAN Zhuchang	S	M
25	SL-S-1	Slovakia	Miroslav Jagelka	S	M
26	BE-S-2	Belarus	Zakhar Plodunov	S	M
27	LI-S-1	Lithuania	Dainius Kilda	S	M
28	PO-S-4	Poland	Maksymilian Sokołowski	S	M
29	RO-S-2	Romania	POP ANA ROXANA	S	F
30	SE-S-4	Serbia	Ognjen Markovic	S	M
31	IO-S-4	Indonesia	Hans T. Sutanto	S	M
32	CN-S-3	China	CAI Tengyu	S	M
33	IR-S-5	Iran	Mohammad Sadegh Riazi	S	M
34	CN-S-1	China	WU Bin	S	M
35	KO-S-1	Korea	Hyungyu Kong	S	M
36	IO-S-2	Indonesia	Anas M. Utama	S	M
37	KO-S-4	Korea	Seongbeom Heo	S	M
38	CNG-S-4	China (Guest)	YU Wenxuan	S	F
39	CN-S-2	China	SU Jianlin	S	M
40	LI-S-4	Lithuania	Motiejus Valiunas	S	M

41	BE-S-3	Belarus	Halina Aluf	S	F
42	CNG-S-1	China (Guest)	LIU Runxuan	S	M
43	IRG-S-3	Iran (Guest)	Kamyar Aziz Zade Neshele	S	M
44	CNG-S-2	China (Guest)	GU Xinyu	S	M
45	CN-S-5	China	XIE Yonghao	S	M
46	IR-S-3	Iran	Amirreza Sedaghat	B	M
47	BR-S-3	Brazil	Gustavo Haddad Francisco e Sampaio Braga	B	M
48	IN-S-3	India	Mr. Kottur Satwik	B	M
49	IN-S-5	India	Mr. Shantanu Agarwal	B	M
50	IRG-S-1	Iran (Guest)	Seyed Fowad Motahari	B	M
51	CN-S-4	China	XU Yongchen	B	M
52	RO-S-1	Romania	CONSTANTIN ANA-MARIA	B	F
53	LI-S-2	Lithuania	Povilas Milgevicius	B	M
54	RO-S-3	Romania	MĂRGĂRINT VLAD DUMITRU	B	M
55	GR-S-1	Greece	Orfefs Voutyras	B	M
56	UK-S-1	Ukraine	Dmytriyev Anton	B	M
57	TH-S-5	Thailand	Mr.Noppadol Punsuebsay	B	M
58	IRG-S-2	Iran (Guest)	Asma Karimi	B	F
59	IRG-S-4	Iran (Guest)	Nabil Etehadi	B	M
60	BE-S-4	Belarus	Hanna Fakanava	B	F
61	GR-S-2	Greece	Georgios Lioutas	B	M

62	BE-S-1	Belarus	Svetlana Dedunovich	B	F
63	TH-S-4	Thailand	Mr.Krittanon Sirorattanakul	B	M
64	BR-S-5	Brazil	Luiz Filipe Martins Ramos	B	M
65	RU-S-3	Russia	Borukha Maria	B	F
66	SE-S-2	Serbia	Stefan Andjelkovic	B	M
67	UK-S-3	Ukraine	Kandymov Emirali	B	M
68	BR-S-4	Brazil	Tábata Cláudia Amaral de Pontes	B	F
69	IO-S-5	Indonesia	Raditya Cahya	B	M
70	UK-S-4	Ukraine	Vasylenko Volodymyr	B	M
71	RU-S-1	Russia	Krivoshein Sergey	B	M
72	IO-S-3	Indonesia	Widya Ageng	B	M
73	IRG-S-5	Iran (Guest)	Sina Fazel	HM	M
74	SL-S-3	Slovakia	Jakub Dolinský	HM	M
75	BA-S-5	Bangladesh	Pritom Mozumdar	HM	M
76	SR-S-2	Sri Lanka	Bannack Gedara Eranga Thilina Jayashantha	HM	M
77	LI-S-5	Lithuania	Arturas Zukovskij	HM	M
78	UK-S-2	Ukraine	Gorlatenko Oleg	HM	M
79	PO-S-3	Poland	Jakub Bartas	HM	M
80	PH-S-3	Philippines	Gerico Arquiza Sy	HM	M
81	SE-S-5	Serbia	Milena Milosevic	HM	F
82	GR-S-3	Greece	Nikolaos Flemotomos	HM	M
83	BR-S-2	Brazil	Tiago Lobato Gimenes	HM	M

84	BE-S-5	Belarus	Pavel Liavonenka	HM	M
85	RU-S-2	Russia	Apetyan Arina	HM	F
86	BA-S-1	Bangladesh	Md. Shahriar Rahim Siddiqui	HM	M
87	BA-S-3	Bangladesh	Nibirh Jawad	HM	M
88	PH-S-5	Philippines	Rigel Revillo Gomez	HM	M
89	KA-S-2	Kazakhstan	Maukenov Bexultan	HM	M

BP	best performance
BO	best practical
BT	best theory
G	Golden 金牌
S	Silver 银牌
B	Bronze 铜牌
HM	Honorable mention

The 4th IOAA International Board Meeting

- Statues of IOAA
- Syllabus

Statues of International Olympiad on Astronomy and Astrophysics

#1

In recognition of the growing significance of astronomy and related subjects in all fields of our life, including the general education of young people, and with the aim of enhancing the development of international contacts between different countries in the field of school education in astronomy and astrophysics, an annual competition in these subjects has been organized for high school students; the competition is called the "International Olympiad on Astronomy and Astrophysics" (IOAA). The International Olympiad on Astronomy and Astrophysics should be organized during the within of August - December.

#2

The competition is organized by the Ministry of Education or other appropriate institution of one of the participating countries on whose territory the competition is to be conducted. Hereunder, the term "Ministry of Education" is used in the above meaning. The organizing country is obliged to ensure equal participation of all delegations, and to invite all the participants of any of the latest three competitions. Additionally, it has the right to invite other countries.

The International Olympiad on Astronomy and Astrophysics is a purely educational event. No country may have its team excluded from participation on any political ground resulting from political tension, lack of diplomatic relation, lack of recognition of some countries by the

government of the organizing country, imposed embargo and similar reasons. When difficulties preclude formal invitation of the team representing a country, students from such a country should be invited to participate as individuals.
Within five years of its entry in the competition a country should declare its intention to be the host for a future Olympiad. This declaration should propose a timetable so that a provisional list of the order of countries willing to host Olympiads can be compiled.
A country that refuses to organize the competition may be barred from participation, even if delegations from that country have taken part in previous competitions.
Any kind of religious or political propaganda against any other country at the Olympiad is forbidden. A country that violates this rule may be barred from participation.

#3

The Ministries of Education of the participating countries, as a rule, assign the organization, preparation and execution of the competition to a scientific society or other institution in the organizing country. The Ministry of Education of the organizing country notifies the Ministries of Education of the participating countries of the name and address of the institution assigned to organize the competition.

#4

Each participating country sends one regular team consisting of high school students. Also students who finish their high school in the year of the competition can be members of a team. The age of the contestants must not exceed twenty on December 31st of the year of the competition. Each team should normally have 5 students.

In addition to the students, two accompanying persons are invited from each country, one of which is designated as delegation head (responsible for the whole delegation), and the other – as pedagogical leader (responsible for the students). The accompanying persons become members of the International Board, where in they have equal rights. Members of the International Board are treated as contact persons for the participating countries concerning the affairs of the International Olympiad on Astronomy and Astrophysics until the following competition.

The competition is conducted in a friendly atmosphere designed to promote future collaborations and to encourage friendships in the scientific community. To that effect all possible political tensions among the participants should not be reflected in any activity during the competition. Any political activity directed against any individuals or countries is strictly prohibited.

The delegation head and pedagogical leader must be selected from scientists or teachers, capable of solving the problems of the competition competently. Normally each of them should be able to speak English.

The delegation head of each participating team should, on arrival, hand over to the organizers a list containing the contestants' personal data (first name, family name, date of birth, home address and address of the school attended) and certificates (in English) from the schools confirming the contestants attendance or graduation in the year of the competition.

#5

The organizing country has the right to invite guest teams in addition to the regular teams (no

more than one guest team per country). Normally the guest team consists also of five students and two leaders. However, the leaders of the guest teams are not members of the International Board. Except for that, their duties are the same as those of the leaders of the regular teams.
Participation of a guest team always needs approval from the organizing country. The country sending a guest team pays all the expenses arising from its participation.
The next organizers are not obliged to invite guest teams present at the previous competition. Countries present with guest teams only are not obliged to organize the IOAA in the future.
Contestants from guest teams and guest teams are classified in the same way as regular teams. They may receive diplomas and prizes, their names should be identified with the letter “G” (“Guest”) in all official documents.

#6

The working language of the International Olympiad in Astronomy and Astrophysics is English. Competition problems and their solutions should be prepared in English; the organizers, however, may prepare those documents in other languages as well.

#7

The financial principles of the organization of the competition are as follows:

- The Ministry which sends the students to the competition covers the roundtrip travel expenses of the students and the accompanying persons to the place where the competition is held.

- The Ministry of the organizing country covers all other costs from the moment of arrival until the moment of departure. In particular, this concerns the costs for board and lodging for the students and the accompanying persons, the costs of excursions, awards for the winners, etc.

#8

The competition consists of 2 parts: the theoretical competition (including short and long questions) and practical competition (including observations and data analysis). There should normally be 15 short and 2 or 3 long questions for the theoretical part. For the practical part, the organizer may give a set task on 1) observation, 2) paper-based practical problem, 3) computer-based problem, 4) planetarium simulation or combination of the four, which is expected to be solvable in 5 hours. The problems should involve at least four areas mentioned in the Syllabus.

The sequence of the competition days is decided by the organizers of the competition. There should be one free day between the two parts of the competition. The time allotted for solving the problems should normally be five hours for the theoretical part and five hours for the practical part. The duration of the Olympiad (including the arrival and departure days) should normally be 10 days.

When solving the problems the contestants may use non-programmable pocket calculators without graphics and drawing materials, which are brought by the contestants themselves. Collections of formulae from mathematics, chemistry, physics, etc., are not allowed.

The host country has to prepare 5 short and 1 long spare of theoretical problems and 2 spare practical problems. They will be presented to the International Board if some of the originally presented is/are rejected by two thirds of members of the International Board. The rejected problem cannot be reconsidered.

#9

The competition tasks are prepared by the host country.

#10

The theoretical part makes 60 % of the total mark, and the practical part 40 % of the total mark. The practical solutions should consist of theoretical analysis (plan and discussion) and practical execution. The solution to each problem should contain an answer and its complete justification.

#11

The contestants will receive diplomas and medals or honorable mentions in accordance with the number of points accumulated as follows:

- The mean number of points accumulated by the three best contestants is considered as 100%.
- The contestants who accumulated at least 90% of points receive first prize (diplomas and gold medals).

- The contestants who accumulate 78% or more but less than 90% receive second prize (diplomas and silver medals).
- The contestants who accumulate 65% or more but less than 78% receive third prize (diplomas and bronze medals).
- The contestants who accumulate 50% or more but less than 65% receive an honorable mention (diplomas).
- The contestants who accumulate less than 50% of points receive certificates of participation in the competition.
- The participant who obtains the highest score (Absolute Winner) will receive a special prize and diploma.
- Other special prizes may be awarded.

#12

In addition to the individual classification one establishes the team classification according to the following rules:

- Teams consisting of less than three contestants are not classified.
- For judging the best team, a task to be performed by the team as a whole will be designed.This task may form either a part of the theory exam, practical exam, or be held at a different time. In case it is included in the theory or practical exam, the duration of the individual exam may be suitably reduced. The test may contain theory, practical or observation aspect or any combination thereof. The host country will be free to decide

which option to use or propose a different format in consultation with the Secretariat. This should be announced to all participants in advance.

#13

The obligations of the organizer:

1. The organizer is obliged to ensure that the competition is organized in accordance with the Statutes.
2. The organizer should produce a set of "Organization Rules", based on the Statutes, and send them to the participating countries in good time. These Organization Rules shall give details of the Olympiad not covered in the Statutes, and give names and addresses of the institutions and persons responsible for the Olympiad.
3. The organizer establishes a precise program for the competition (schedule for the contestants and the accompanying persons, program of excursions, etc.), which is sent to the participating countries in advance.
4. The organizer should check immediately after the arrival of each delegation whether its contestants meet the conditions of the competitions.
5. The organizer chooses (according to the Syllabus) the problems and ensures their proper formulation in English and in other languages set out in # 6. It is advisable to select problems where the solutions require a certain creative capability and a considerable level of knowledge. Everyone taking part in the preparation of the competition problems is obliged to preserve complete secrecy.
6. The organizer must provide the teams with guides.

7. The organizer should provide the delegation leaders with Photostat copies of the solutions of the contestants in their delegation at least 24 hours before the moderation.
8. The organizer is responsible for organizing the grading of the problem solutions and moderation.
9. The organizer drafts a list of participants proposed as winners of the prizes and honorable mentions.
10. The organizer prepares the prizes (diplomas and medals), honorable mentions and awards for the winners of the competition.
11. The organizer is obliged to publish the proceedings (in English) of the Olympiad. Each of the participants of the competition (delegation heads, pedagogical leaders and contestants) should receive one copy of the proceedings free of charge not later than one year after the competition.

#14

The International Board is chaired by a representative of the organizing country. He/she is responsible for the preparation of the competition and serves on the Board in addition to the accompanying persons of the respective teams.

All decisions, except those described separately, are passed by a majority of votes. In the case of equal number of votes for and against, the chairman has the casting vote.

#15

The delegation leaders are responsible for the proper translation of the problems from English (or other languages mentioned in # 6) to the mother tongue of the participants.

#16

The International Board has the following responsibilities:

1. To direct and supervise the competition to ensure that it is conducted according to the regulations.
2. To discuss the organizers' choice of tasks, their solutions and the suggested evaluation guidelines before each day of the competition. The Board can change or reject suggested tasks but cannot propose new ones. Changes may not affect practical equipment. There will be a final decision on the formulation of tasks and on the evaluation guidelines. The participants in the meeting of the International Board are bound to preserve secrecy concerning the tasks and to be of no assistance to any of the contestants.
3. To ensure correct and just classification of the prize winners.
4. To establish the winners of the competition and make decisions concerning the presentation of prizes and honorable mentions. The decision of the International Board is final.
5. To review the results of the competition.
6. To select the country which will be the organizer of the next competition.

The International Board is the only body that can make decisions on barring countries from participation in the International Olympiad in Astronomy and Astrophysics for the violation of these Statutes.

Observers may be present at meetings of the International Board, but may not vote or take part in the discussions.

#17

The institution in charge of the Olympiad announces the results and presents the awards and diplomas to the winners at an official ceremony. It invites representatives of the organizing Ministry and scientific institutions to the closing ceremony of the competition.

#18

The long term work involved in organizing the Olympiads is coordinated by a "Secretariat for the International Olympiad in Astronomy and Astrophysics". This Secretariat consists of the President and Secretary. They are elected by the International Board for a period of five years when the chairs become vacant.

The President and Secretary are members of the International Board in addition to the regular members mentioned in # 4. They are invited to each International Olympiad in Astronomy and Astrophysics at cost (including travel expenses) of the organizing country.

#19

Changes in the present Statutes, the insertion of new paragraphs or exclusion of old ones, can only be made by the International Board and requires qualified majority (2/3 of the votes).

No changes may be made to these Statutes or Syllabus unless each delegation obtained written text of the proposal at least 3 months in advance.

#20

Participation in the International Olympiad in Astronomy and Astrophysics signifies acceptance of the present Statutes by the Ministry of Education of the participating country.

#21

The originals of these Statutes are written in English.

#22

Notes on the IOAA IBM 2010

- Because there are some countries which still do not agree with the proposal of marking composition of theoretical and practical round the decision is postponed to IBM 6 of IOAA 2010. The composition used in the 4 IOAA still the 60% - 40%

- About the team competition

It is decided that two teams which has less than the minimum required number of student for team competition is allowed to merge voluntarily if the students and team leaders of the teams agree.

- The proposal submitted in the IBM of the fourth IOAA cannot be decided, in the fourth IOAA, because according to the statute it must be proposed in printed version three months before decision is made.

- IBM is agree to form a working group to modify syllabus

- It is proposed that the proceedings are in printed and electronic version.

Syllabus of International Olympiad on Astronomy and Astrophysics

General Notes

1. Extensive contents in basic astronomical concepts are required in theoretical and practical problems.
2. Basic concepts in physics and mathematics at high school level are required in solving the problems. Standard solutions should not involve calculus.
3. Astronomical software packages may be used in practical and observational problems. The contestants will be informed the list of software packages to be used at least 3 months in advance.
4. Contents not included in the Syllabus may be used in questions but sufficient information must be given in the questions so that contestants without previous knowledge of these topics would not be at a disadvantage.
5. Sophisticated practical equipments may be used in the questions but sufficient information must be provided

A. Theoretical Part

The following theoretical contents are proposed for the contestants.

1. Basic Astrophysics

Contents	Remarks
Celestial Mechanics	Kepler's Laws, Newton's Laws of Gravitation
Electromagnetic Theory & Quantum Physics	Electromagnetic spectrum, Radiation Laws, Blackbody radiation, Doppler effect
Thermodynamics	Thermodynamic equilibrium, Ideal gas, Energy transfer
Spectroscopy and Atomic Physics	Absorption, Emission, Scattering, Spectra of Celestial objects, Line formations
Nuclear Physics	Basic concepts

2. Coordinates and Times

Contents	Remarks
Celestial Sphere	Spherical trigonometry, Celestial coordinates, Equinox and Solstice, Circumpolar stars, Constellations and Zodiac
Concept of Time	Solar time, Sidereal time, Julian date, Heliocentric Julian date, Time zone, Universal Time, Local Mean Time

3. Solar System

Contents	Remarks
The Sun	Solar structure, Solar surface activities, Solar rotation, Solar radiation and Solar constant, Solar neutrinos, Sun-Earth relations, Role of magnetic fields,

	Solar wind
The Solar System	Earth-Moon System, Formation of the Solar System, Structure and components of the Solar System, Structure and orbits of the Solar System objects, Sidereal and Synodic periods
Phenomena	Tides, Seasons, Eclipses, Aurorae, Meteor Showers

4. Stars

Contents	**Remarks**
Stellar Properties	Distance determination, Radiation, Luminosity and magnitude, Color indices and temperature, Determination of radii and masses, Stellar motion, Stellar variabilities
Stellar Interior and Atmospheres	Stellar nucleosynthesis, Energy transportation, stellar atmospheres and spectra
Stellar Evolution	Stellar formation, Hertzsprung-Russell diagram, Pre-Main Sequence, Main Sequence, Post-Main Sequence stars, End states of stars

5. Stellar Systems

Contents	**Remarks**
Binary Star Systems	Classification, Mass determination in binary star systems, Light and radial velocity curves of eclipsing binary systems, Doppler shifts in binary systems
Star Clusters	Classification and Structure
Milky Way Galaxy	Structure and composition, Rotation, Interstellar medium

Normal and Active Galaxies	Classification, Distance determination
Accretion Processes	Basic concepts

6. Cosmology

Contents	**Remarks**
Elementary Cosmology	Cluster of galaxies, Dark matter, Gravitational lenses, Hubble's Law, Big Bang, Cosmic Microwave Background Radiation

7. Instrumentation and Space Technologies

Contents	**Remarks**
Multi-wavelength Astronomy	Observations in radio, microwave, infrared, visible, ultraviolet, X-ray, and gamma-ray wavelength bands, Earth's atmospheric effects
Instrumentation and Space Technologies	Ground- and space-based telescopes and detectors (e.g. charge-coupled devices, photometers, spectrographs), Magnification, resolving and light-gathering powers of telescopes

B. Practical Part

This part consists of 2 sections: observations and data analysis sections. The theoretical part of the Syllabus provides the basis for all problems in the practical part.

The observations section focuses on contestant's experience in

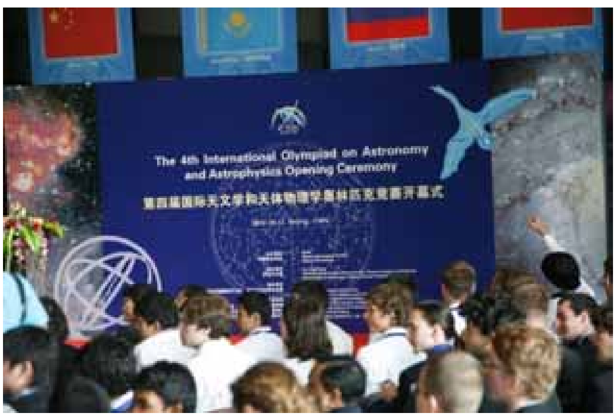
1. naked-eye observations,
2. usage of sky maps and catalogues,
3. usage of basic astronomical instruments–telescopes and various detectors for observations but enough instructions must be provided to the contestants.

Observational objects may be from real sources in the sky or imitated sources in the laboratory. Computer simulations may be used in the problems but sufficient instructions must be provided to the contestants.

The data analysis section focuses on the calculation and analysis of the astronomical data provided in the problems. Additional requirements are as follows:

1. Proper identification of error sources, calculation of errors, and estimation of their influence on the final results.
2. Proper use of graph papers with different scales, i.e., polar and logarithmic papers.
3. Basic statistical analysis of the observational data.

Photo Gallery




国际天文学和天体物理学奥林匹
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四届国际天文学和天体
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中国天文学会
National Astronomical

Group Photo of the 4th IOAA