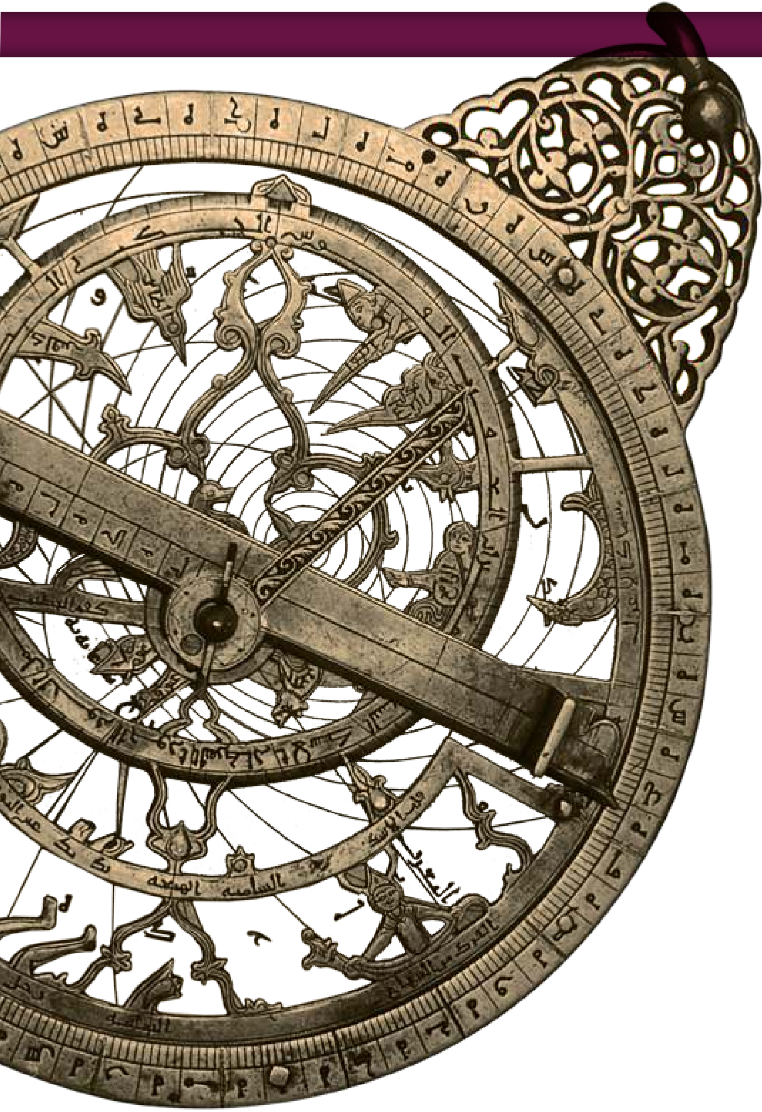
Proceedings of The Third International Olympiad on Astroniomy And Astrophysics

TEHRAN, IRAN, 17-26 OCTOBER 2009



Proceedings of The Third International Olympiad on Astroniomy And Astrophysics

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3rd IOAA

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Foreword

It is our pleasure to be host of the Third International Olympiad on Astronomy and Astrophysics. Exceptional students and their delegate team leaders from 19 countries have participated. This is certainly a great event in history of astronomy education in Iran.

Iran has a great legacy in astronomy going back to more than 1000 years ago when famous astronomers like Abdurrahman Sofi and Nasiredin Tousi have criticized geocentric idea with their precise naked eye observation. During Islamic period great observatories were established in Maraghe and Samarghand which their observation enlightened European scholars during 15 and 16 centuries when they made the new solar system model.

United Nations has declared 2009 to be the international year of astronomy. This make a unique opportunity for IOAA to establish how astronomy as the oldest science, can influence to human community. During thousands of years peoples with different cultures, religions and ethnic have tried to observe and understand the same borderless sky. This shows that how astronomy can make people united.

International Astronomy Olympiad has had great impact in astronomy education in Iranian high schools. We started to participate in International Astronomy Olympiad (IAO) in 2003. Since seven years many small size observatories with 20 to 40 cm telescopes are constructed. Astronomy classes are now part of regular educational program in intermediate and high schools and amateur activities are raised to such high level that they arrange nationwide performance to popularize astronomy.

By the third IOAA, it is clear that this international event is now a mature event to give energy and to motivate talented student for further study and research in astronomy.

Local Organizing Committee
Third International Olympiad on Astronomy and Astrophysics

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Welcoming Address by The Acting Minister of Education

Distinguished scholars, professors, organizers, honorable participants, dear guests to the 3rd International Olympiad of Astronomy and Astrophysics.

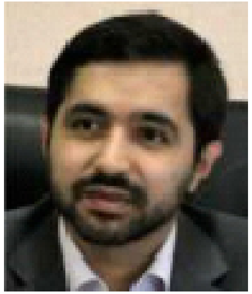
It is indeed my great pleasure to witness a lively and dynamic presence of lovers of astronomy in a warm atmosphere of friendship, brotherhood and affection, in which one can feel the scent of venture for knowledge and understanding.We are privileged to be your host in a great land with an ancient historical and scientific background in terms of astronomy.

This country is proud to be the cradle of prominent scientists namely Khajeh Nasir al-Din Tousi, Abdolrahman Soufi-Razi, Qiaseddin Jamshid-Kashani and tens of other renowned figures, each of them is truly the origin of significant developments and breakthroughs in the whole world.We are honored to have such national scientific assets as well as tireless young generation who have guaranteed our remarkable place in scientific developments.

I hope this year competition would create a suitable ground for growth of merits and talents, enhancement of astronomy and international congruity.
To conclude, I would like to express my sincere thanks to all founders and organizers of this scientific forum and such valuable competition and wish you prosperity and success.

Seyed Ramezan Mohsenpour
Acting Minister of Education

Speech by Head of the Organizing Committee



Dear Students, Distinguished Professors, Honorable Guests;

It is to my greatest delight to have the Young Scholars Club honored with hosting the third International Olympiad in Astronomy and Astrophysics. It is our hope that you will find your stay in Iran fruitful and enjoyable, and that you return home with pleasant memories to keep forever.

Your eager and wholehearted participation will undoubtedly help us achieve the goals for which international Olympiads have always been organized.
Realizing these goals gives hope that today's turbulent world can be brought together, through the ethical and cultural roots that we all share and by relying on human virtues and compassion, to fulfill our mission of disseminating, and furthering international collaboration on, knowledge and education.
Once again I would like to thank you for joining us and wish everybody success and fulfillment in their life.

Mohsen Jamaali,

Head of the Organizing Committee,
Third International Olympiad in Astronomy and Astrophysics

Speech by The President of IOAA

Dear Organizing committee, Team Leaders, Students, Honor Guests, Ladies & Gentlemen

On Behalf of the IOAA secretariat, including me as an IOAA president and Dr.Chatief Kunjaya as an IOAA general secretary would like to express our deep appreciation to the Islamic Republic of Iran for hosting the 3rd International Olympiad On astronomy and astrophysics. From 2006, the representative from five countries namely, Iran, Indonesia, Poland, China and Thailand gathering together to discuss the possibility to organize the IOAA and establish statue and syllabus. Finally in 2007 the first IOAA was organized in the city of Chiang Mai in Thailand and was very successfully when 20 countries sent students to participate in this competition.
The second IOAA was also successfully organized by Indonesia in 2008 in the city of Bundung at that time 22 countries were involved.
So, I strongly believe that the 3rd IOAA organized by the Islamic Republic of Iran in 2009 with 20 participating countries would be as successful as those previous IOAA. IOAA is established to promote competitions in the subject of astronomy and astrophysics among students from different countries around the world in friendship atmospheres. This activity, not only give students opportunity to show their best potencies in the area of astronomy and astrophysics, but also give them opportunities to make friends with students from other countries. I would like to commend the LOC for the 3rd IOAA for their hard work that make today's event possible. I hope again for the successful of the 3rd IOAA and wish for the best to all participants.

Thank you very much.

Professor Boonrucksar Soonthornthum,
President of IOAA

Speech by Head of Academic Committee

Ladies and gentlemen, Dear honorable guests;

Three years ago when we did accept to be the host of the third international Olympiad on astronomy and astrophysics in 2009, we did know that putting together 20 countries, evaluating most exceptional students and preserving high standards of IOAA need hard works accuracy and discipline. To achieve this goals more than 150 professionals including faculty members, PhD and MSc Students in Physics and astronomy were employed as examiners jury members and assistants.

The theoretical exam was the major challenge for the academic committee. 15 short and 2 long problems take at least 6 months to design. Long discussion between academic committee was performed to be sure that they are correct and qualificative.

Practical exam was another issue, data analysis is a major field in modern astronomy. Designing a problem which simulates what taking place in real astronomical researches and executable with a simple calculator was not easy. Among more that ten different ideas we chose, two where adequate to student understanding.

Observation has been hart of astronomy from the beginning. Iran is the land of big deserts with clear sky which invites the naked eye to explore the beauty of universe. During observational exam students not only had opportunity to explore one of the darkest skies in Iran but also to visit an old Karvansara where placed in the famous silk road. Skillful amateur astronomers and well trained physics students helped us during this exam.

Ladies and Gentlemen; IOAA was a huge event, after ten days of hard work we are now one step closer to the main IOAA aim: "Enhancing the development of international contacts between different in the field of education in astronomy and astrophysics".

Taghi Mirtorabi

Head Of Academic Committee

People

- Steering Committee
- Organizing Committee
- Academic Committee
- Juries
- Team Guides, Tour Guides
- Medical Team
- Help desk
- press
- Staff

Steering Committee

- Gholam Ali Haddad Adel
- Ali Akbar Velaiaty
- Sayed Ramezan Mohsen Poor
- Mahdi Navid Adham
- Abbas Sadri
- Bahram Mohammadian
- Sayed Mohamad Etemadi
- Mohsen Jamali

Organizing Committee

- Mohsen Jamali — Head of The Organizing Committee
- Yaghoub Hosseinzadeh — Head (Executive Manager)
- Dr. A. Moradi
- Dr. Gh. RezaKarimi
- Rahim Ali Hassanpoor
- Mostafa Hassannejad
- Mehrzad Goodarzinia
- Hossein Shiri
- Farhad Fathinejad
- Mir Omid Haji Mir Sadeghi
- Mahmoud Hashemi Zadeh
- Behzad Sowlatian
- Gholam Hossein Rastegarnasab

Academic Committee

- Mohammad Taghi Mirtorabi — Head of the Academic Committee
- Mahdi Khakian — Head of the Juries
- Alireza Molaeinejad — Organizer of the Observation Exam
- Saeed Shami — Organizer of the Practical and Theoretical Exams
- Sohrab Rahvar
- Hossein Haghi
- Shahram Abbasi
- Mohhamad Malekjani

Academic Collaborators

- Masoud Seyfikar
- Shahin Jafarzadeh
- Niloufar Javid Khalili
- Somayeh Gholipour
- Saeedeh Kamgar
- Arash Danesh

Collaborators Of Observational Exam

- Sepideh kianfar
- Faezeh Aghaei Gargoj
- Amir Atar
- Armin Rasekh
- Armita Bayesteh
- Athar Ehtiati
- Ehsan Gholami
- Elaheh Hayati
- Farhaz Zekavat
- Fatemeh Ahmadipour
- Fatemeh Hasheminiari
- Fatemeh Nikzat
- Fatemeh Omani
- Gelareh Alizadeh
- Hamideh Alinazari
- Hovisineh Safarlou
- Maryam Saberi
- Masoumeh Mirza Hossein
- Pouya Karim Babanejad
- Reyhaneh Ghane Motlagh
- Saeedeh Saberi
- Sepideh Sherbaf
- Taraneh Andalib
- Zahra Sorouri

Juries For Theoretical And Practical Exams

- Akram Hassani Zonouzi
- Amin Mossallanejad
- Amir Ghari
- Asadollah Safaie
- Ayda Torabi
- Azadeh Khoshkroudi
- Aziz Khodadadi
- Davoud Manzouri
- Ehsan Koorkchi
- Ehsan Moraveji
- Ehsan Tavabi
- Farideh Motaghian
- Fatemeh Amirkhanlou
- Fatemeh Azizi
- Fatemeh Kazemizadeh
- Ghasem Gozali Asl
- Ghodsieh Mousavi Khorshidi
- Habibollah Osareh
- Hadi Hedayati Khalilabad
- Motahareh Mohammadpour
- Nafiseh Masoumzadeh
- Nastaran Shakeri
- Nazila Divani
- Hashem Hamedivafa
- Hoda Hesari
- Hossein Safari
- Jafar Khodagholizadeh
- Jamileh Fehri
- Khodad Kokabi
- Mahboubeh Agha Babaeinejad
- Mahdi Khadem
- Mahmoud Reza Oshagh
- Mahsa Rahimi
- Maryam Farahmand
- Maryam Ghasemnejad
- Marzieh Hamidi
- Masoumeh Delband
- Mohammad Arab
- Mohammad Karim Saeed Ghalati
- Mohammad Nilforoushan
- Mohammad Vahedi
- Monireh Abedzeydi
- Sayed Kaveh Vaseizadeh
- Setareh Ostadnejad
- Shayesteh Ghafari
- Shervin Ziyaei

- Parvin Mostafavi
- Pouria Khalaj
- Rouhollah Shakernejad
- Sadigheh Sajadian
- Sara Fazlollahpour
- Sara Jabbari
- Sareh Ataei
- Sareh Eftekharzadeh
- Shima Bayesteh
- Siamak Dehghan
- Somayeh Sheykhnezami
- Zahra Hassani
- Zohreh Dehghani
- Zohreh Ghafari
- Zohreh Safarzadeh Kermani

Juries For The Observational Exam

- Alireza Chenani
- Mohammad Hossein Almasi
- Asadolah Ghamarinejad
- Amir Asghar Sharghi
- Ayrin Shivaei
- Behnam Javanmardi
- Davoud Afshari
- Faraz Enayati Ahangar
- Farzin Ghane Golmohammadi
- Fatemeh Kamali
- Hamed Altafi
- Hamed Zare
- Hamid Zare
- Jaber Dehghani
- Kamak Ebadi

Organizer of the Observation Examiners

Technical Supporter of Observation Exam

- Mahdi Lotfi Kalhori
- Mehdi Lotfi Kalhori
- Mohammad Javad Torabi
- Ramin Shomali
- Reza Tayeb Taher
- Saeed Hojjatpanah
- Samir Vartbi Kashanian
- Sara Khalafinejad
- Siavash Neshatpour
- Teymour Seyfollahi
- Zahra Foroutaninia
- Zahra Pahlevan
- Zeinab Khorami

Examiners

- Zahra bakhtiari Safgholi
- Ali Basaligheh
- Ali Eslambolichi Moghadam
- Farid Daryayar
- Fatemeh Ebrahimi Zolirani
- Maryam Gharehzadeh Sharabyani
- Masoumeh Gohari
- Mersa Fehrest Avanlou
- Meysam Teymouri
- Narges Ajdani
- Roghiyeh Oroujlou

Technical Supporters

- Reza Mohammadi Ghayeghchi
- Mohammad Ali Rostami
- Azin Azadi
- Ali Ershadi
- Mahtab Mahboub
- Marzieh Ghasempour

Team Guides

- Ali Mazinani
- Ali Miri Dabesfani
- Amin Rezaeezadeh
- Amir Masoum
- Arman Daneshian
- Behnoosh Meskoub
- Ehsan Gholami
- Ehsan Mehrjoo
- Farnaz Pirasteh
- Farzaneh Moosavi
- Hamid Almasi
- Hossein Mazaheri Fard
- Mahdieh Maleki
- Mahmood Gholami
- Mahshid Bastanipoor Moghadam
- Marzieh Hamidia
- Masoud Khabazian
- Masoud Khabaziani
- Mehdi Karazmoodeh
- Mohammad AminAdab
- Mohammad Javad Ebrahimi Varzaneh
- Mohammad MahdiAsef Zadeh
- Mohammad Zargar Poor
- Mohammad Amin Adab
- Mohammad Khalkhali
- Mohsen Mahdavizadeh
- Negar Zahedimehr
- Payam Ahmadi Roozbahani
- Ramin Amini
- Rasool Rostami
- Sahel Ramezanitabar
- Sayed Hesam Mousavimehr
- Sayed Masih Alavi
- Sayed Omid Sayed Aghaee
- Seyedeh Zeinab Hashemi
- Shahab Khodamoradi
- Shahab Saeedmehr
- Shahram Alipoor Azadi
- Zahra Bagheri
- Zohreh Siahpoush

Tour Guides

- Hossein Amini
- Mahmood Shafee Abianeh
- Maryam Shafee Abianeh
- Milad Eslami
- Mohammad AminNazari
- Mohammad Rostami
- Saaeb Moafee
- Sareh Jannati
- Satar Nasirzadeh
- Shiva Shahrokhi

Medical Team

- Dr. A. Heisami
- Dr. M. Chinian
- Dr. R. Heshmati Poor
- Dr. R. Nāvi Poor

Help Desk

- AkramShaikh Alishahi
- Amin noori
- Amir EbrahimRezaeeyan
- Bijan Aghdasi
- Elham Faghani Mehr
- Elham Fozhi
- Fariba Mousavi
- Fariba Mousavi
- Farid Faraji Vafa
- Fartash Farghi
- Hesam al-dinAkhlagh Poor
- Maedeh Khademi Hedayat
- Mahsa Khademi Hedayat
- Mehran Pālidi
- Mohammad Jahangoshaee
- Mohammad Javad Baei
- Mohammad JavadBaee
- Mohammad Saleh Zare Poor
- Omid Hatami Varzaneh
- Saam Nariman
- Sara Ramezani Tabar
- Shahrzad Feghhi

Press

- Ali Ghasemi
- Amir Bameh
- Amir Zolfaghari
- Marzieh Monzavi
- Masoumeh Niknam
- Mrs. Jahanshahi
- Mrs.Rahim Del
- MansourehFarahani
- Sedigheh Hashemi
- Siavash Safarianpour
- Zeinab Botkan
- Zohreh Bal

Staff

- Abbas Beroghani
- Abbas Daneshfar
- Abbas Hashemi
- Abbas Namaki
- Abdollah Bagheri
- Abdollah Bakhtiari
- Abolfazl Barati
- Abolfazl Fazli
- Afra Gholami
- Ahmad Delkhani
- Alaedin Noroozi
- Ali AghaeeFatideh
- Ali AhmadiBastami
- Ali Eskandari
- Ali RezaSheikh
- Ali Nosrati
- Alireza Niknafas
- Alireza Niknafs
- Alireza Sadeghparvar
- Ali Soltan Ali
- Amir Hossein Rezaee
- MercedehKhatibinoor
- Michaeel Ali Poor
- Anbia Madani
- Asghar Adelkhani
- Atefeh Zaghari
- Bagher Behzadi
- Bahram Madadi
- Bakhshali Khoshnavaz
- Behrooz Shooshi
- Davood Aghaee
- Davood Jaberi
- Ebrahim Bourghani
- Einollah Sadeghparvar
- Faranak Bayat
- Firooz Rezaee
- Firouzeh Yavapoor
- Ghasem Nazari
- Gholam HassanRajabi
- G.Hossein Mohammadinasab
- Habib Azar Dar
- Hamid Hedayat
- Hamid Reza Hoori
- Hamid Reza Kheir Andish
- Sadegh Afshari
- Saeed Boorboor
- Hamid RezaKhoda Bandeh
- Hassan Maleki
- Hassan Navaser
- Hassan Rashidi
- Hassan Rashidi
- Hojatollah Samiee
- Hossein Gholivand
- Jahangir Nasiri
- Kambi zNaeemi
- KhalilKheir Andish
- Mahdeih Razavi Ashtiani
- Mahdi Rahimzadeh
- Mahmoud Gholami
- Mahnaz Naghdali
- Manouchehr Zeinali
- Maryam Shahidian
- Maryam Sharbatdar Ghods
- Masoud Moghadasi
- Mehdi Ghasemi
- Mehdi Khazaee
- Mehdi Rasouzadeh
- Abbas Khanbeygi
- Alireza Eskandari

Staff

- Mina Hamidi
- Mohammad Eslami
- Mohammad Jafari
- MohammadJavad Shabanzadeh
- Mohsen Faridi
- Mohsen Khodabakhsh
- Mohsen Mostafavi
- Mojtaba Ahmadi
- Morteza Ansari
- Mostafa Bakhtoor
- Mrs. Jalali
- Najme Golabatooni
- Naser Abdollahi
- Omid Zabih
- Reza Kasaee
- RezaK hodadadi
- Rouhodin Moradian
- Rouhollah Mahmoudabadi
- Sabr AliSadeghi
- Safar AliLaleh
- Samad Mostafavi
- Samad Torabi
- Sayed Ahmad Hassani Tabar
- Sayed Alireza Khoram
- Sayed Mohsen Momeni
- Sayed MortezaSeyedi
- Seyedeh Sakineh Jalili
- Seyedeh Zeinab Hashemi
- Shahrzad Nazemi
- Soltan AliRahimi
- Touraj Mohammadi
- VahidDoost Mohammadi
- Valimorad Ganji Poor
- Yahy aMohammadi
- Yoones Abdollahi
- Amir Kazemi
- Arash Abbasi Yadkouri
- Azadeh Fattahi
- Elaheh Sadat Naghib
- Erfan Esmaili Fakhabi
- naavid Matin Moghaddam
- Parvin Teymouri
- Reza Montazeri Namin
- Sadra Jazayeri
- Sajedeh Manzeli
- Sara Feyzbakhsh
- Sayed Amir Sadat Mousavi
- Sayed Sadra Sadroddini
- Sayyedeh Shirin montazeri
- Sepideh Hassan Moghaddam
- Zahra Arjmandi Lari

Academic staff

- Abbas Alizadeh
- Pouria Akbari Meyestani

☙ 3rd IOAA

- Contestants
- Leaders and Observers

☙ Contestants

- ## Bangladesh

  Pritom Mojumdar

  Md. Shahriar Rahim Siddiqui

  Md. Marzuk Shalvi

- ## Belarus

  Anastasiya Meishutovich

  Katsiaryna Shakhorka

  Raman Samusevich

  Vladimir Horoshko

  Dzmitry Yemelyanau

- ## Bolivia

  Alvaro Ruben Hurtado Maldonado

  Anita Carol Padilla Vaca

- ## Brazil

  Otávio Menezes

  Daniel Soares

  Leonardo Stedile

  Thiago Hallak

  Hugo Araujo

- ## Cambodia

  Wathna Ly

  Sok Eng Van

  Ly Sorng Oeng

  Duong Dyraden

  Phorn Sopheak

- ## China

  Yanbin Feng

  Wenxiong Li

  Yunpeng Li

  Mu Bai

  Jiarui Huang

☙ Contestants

- **Greece**

  Georgios Valogiannis
  Angelos Tsiaras
  Orfefs Voutyras
  Athanasios Mitrakis
  Georgios Lioutas

- **India**

  Sujeet Gholap
  Nidhi Pashine
  Nitin Jain
  Kedar Tatwawadi
  Aniruddha Bapat

- **Indonesia**

  Veena Salim
  Alfiah Rizky Diana Putri
  Dyah Arini Hutaminingtyas
  Stevanus Kristianto Nugroho
  Anas Maulidi Utama

- **Iran (A)**

  HamidReza Akbari
  Mehrnoosh Shafieezade Abade
  Shahab Sarmashghi
  Shadi Farahzadi
  Ramyad Hadidi

- **Iran (B)**

  Ali Aliyari
  Mohsen Rezaei Zadeh
  Nima Chartab Soltani
  Niloufar Nilforoushan

Contestants

- **Kazakhstan**

  Otemissov Adilet

  Sultangazin Adil

- **Korea**

  Ho Jin Cho

  Hyun Kyu Choi

  Donghyeon Kim

  Uiryeol Lee

  Yoonsoo Park

- **Lithuania**

  Ilona Kovieraite

  Dainius Kilda

  Motiejus Valiunas

  Povilas Kanapickas

- **Poland**

  Piotr Godlewski

  Patryk Pjanka

  Grzegorz Gajda

  Przemysław Mróz

  Rafal Sikora

Contestants

- **Romania**

Constantin Marius

Zelko Ioana Alexandra

Kruk Şandor Josef

Oprescu Miruna Antonia

Mărgărint Vlad Dumitru

- **Srilanka**

Galabada Dewage Ashan Ariyawansa

Eranga Thilina Jayashantha Bannack Gedara

Yasith Mathangasinghe

Basnayake Mudiyanselage Shyaminda Bandara Basnayake

Godagama Rajapakshage Danula Sochiruwan Godagama

- **Thailand**

Thanawuth Thanathibodee

Taweewat Somboonpanyakul

- **Serbia**

Aleksandar Vasiljkovic

Natasa Dragovic

Milena Milosevic

Filip Zivanovic

- **Slovakia**

Miroslav Jagelka

Fridrich Valach

Peter Kosec

Eugen Hruska

Nathanan Tantivasadakarn

Puttiwat Kongkaew

Yossathorn Tawabutr

௸ Leaders And Observers

- **Bangladesh**
  Ronald Cruz
  Moshurl Amin

- **Belarus**
  Alexander Poplavsky
  Stanislaw Sekerzhitsky

- **Bolivia**
  Roy Omar Edgar Bustos Espinoza

- **Brazil**
  Thais Mothe Diniz
  Bruno L'astorina

- **Cambodia**
  Ing Heng
  Tharith Sriv
  Koy Hen

- **China**
  Jin Zhu
  Dongni Chen

- **Greece**
  Loukas Zachilas
  John Seiradakis
  Maria Kontaxi

- **India**
  Aniket Sule
  Mayank Vahia

Leaders And Observers

- **Indonesia**
  Hakim Luthfi Malasan
  Mochamad Irfan

- **Iran**
  Sepehr Arbabi Bidgoli
  Leila Ramezan

- **Kazakhstan**
  Baranovskaya Svetlana

- **Korea**
  Yong Hee Kang
  Yoojea Kim

- **Lithuania**
  Jokubas Sudzius
  Audrius Bridzius

- **Poland**
  Grzegorz Stachowski
  Jacek Szczepanik

- **Romania**
  Trocaru Sorin
  Petru Craciun

- **Serbia**
  Slobodan Ninkovic
  Ivan Milic

- **Srilanka**

  Dr. Kalu Pathirannahelage Sarath Chandana Jayaratne

  Ranawaka Arachchige Sujith Saraj Gunasekera

- **Slovakia**

  Ladislav Hric

  Maria Bartolomejova

- **Thailand**

  Arthit Laphirattanakul

  Sathon Vijarnwannaluk

- **Ukraine**

  Volodymyr Reshetnyk

Timetable

- Contestants
- Leaders,Observers

Contestants

• Day 1 Sat,Oct.17,2009

18:45		Arrival, Registration
19:00	22:00	Welcome Ceremony

• Day 2 Sun,Oct.18,2009

6:30	8:00	Breakfast (Laleh Restaurant-Bkc Complex)
9:00	12:00	Observation Exam Briefing
12:00	14:00	Lunch (Laleh Restaurant)
14:00	17:00	Checking Equipments For Observational Exam
17:00	18:00	Leaving Bkc Complex For Water & Energy Hall
18:15	21:00	Opening Ceremony
21:00	23:00	Dinner

• Day 3 Mon,Oct.19,2009

6:30	8:00	Breakfast (Laleh Restaurant-Bkc Complex)
9:00	12:00	Visiting Sa'ad Abad Palace
12:00	14:00	Lunch (Laleh Restaurant)

		Group A	Group B
14:00	16:00	Visiting Dar-Abad Wild Life Museum	Visiting Fan-Amooz (Technology)Park
16:00	18:00	Visiting Fan-Amooz (Technology)Park	Visiting Dar-Abad Wild Life Museum
19:00	20:00	Dinner (Laleh Restaurant)	Dinner (Laleh Restaurant)
21:00		Theoretical Exam Briefing	Theoretical Exam Briefing

Contestants

• Day 4 Tues,Oct.20,2009

6:30	8:00	Breakfast (Laleh Restaurant)
8:30	9:00	Leaving For Exam Venue
9:00	14:00	Theoretical Exam
14:00	15:00	Lunch (Laleh Restaurant)
17:00	19:00	Scientific Theatre
19:30		Dinner

• Day 5 Wed,Oct.21,2009

6:00	8:00	Breakfast(Laleh Restaurant)
9:00	12:00	Photometer Making Workshop
12:00	14:00	Lunch (Laleh Restaurant)
15:00	17:00	Astrolabe Making Workshop
17:00	20:00	Visiting Eram Park & Italian Circus
20:00	21:30	Dinner

• Day 6 Thurs,Oct.22,2009

6:30	8:00	Breakfast(Laleh Restaurant)
9:00	12:00	Data Analysis Exam
12:00	14:00	Lunch (Laleh Restaurant)
15:30	20:00	Leaving For Deh-Namak Caravanserai
17:00	20:00	Dinner In Deh-Namak Caravanserai
20:00	21:30	Observational Exam

Contestants

• Day 7 Fri,Oct.23,2009

6:30	8:00	Breakfast(Laleh Resturant-Bkc Complex)
9:00	12:00	Tochal Tele-Cabin
12:00	14:00	Lunch(Laleh Restaurant)
14:00	20:00	Meeting With Members Of Niavaran Astronomical Center
20:00	21:00	Dinner(Laleh Restaurant)

• Day 8 Sat,Oct.24,2009

6:30	8:00	Breakfast(Laleh Restaurant)
9:00	11:00	Visiting Milad Tower
12:00	14:00	Lunch
15:00	18:00	Group Competition
20:00	22:00	Dinner Banquet Hosted By Municipality In Sheean Hotel

• Day 9 Sun,Oct.25,2009

6:30	8:00	Breakfast(Laleh Restaurant)
9:00	11:00	Visiting Tehran Bazaar & Shopping
12:00	14:00	Lunch
15:00	18:00	Sundials Making Workshop
20:00	22:00	Dinner Banquet Hosted By Sharif

● Day 10 Mon,Oct.26,2009

6:30	8:00	Breakfast(Laleh Restaurant)
9:00	12:00	Free Time
12:00	14:00	Lunch
15:00	18:00	Closing Ceremony
20:00	22:00	Dinner

● Day 11 Tue,Oct.27,2009

6:30	8:00	Breakfast(Laleh Restaurant)

Departure

Leaders

● Day 1 Sat,Oct.17,2009

18:45		Arrival, Registration
19:00	22:00	Welcome Ceremony

● Day 2 Sun,Oct.18,2009

6:30	8:00	Breakfast(Persian Evin Hotel)
9:00	12:00	International Board Meeting (I)
12:00	14:00	Lunch(Evin Hotel)
14:00	17:00	Free Time
17:00	18:00	Leaving Bkc Complex For Water & Energy Hall
18:15	21:00	Opening Ceremony
21:00	23:00	Dinner

● Day 3 Mon,Oct.19,2009

6:30	8:00	Breakfast
9:00	12:00	Theoretical Exam: Discussion
12:00	14:00	Lunch In Parsian Evin Hotel
14:00	20:00	Theoretical Exam: Translation
20:00	21:30	Dinner In Parsian Evin Hotel

• Day 4 Tues,Oct.20,2009

Leaders

6:30	8:30	Breakfast
9:00	12:00	Visiting Sa'ad-Abad Palace
12:00	14:00	Lunch (Hotel)
15:00	17:00	Visiting Contemporary Arts Museum
17:00	19:00	Visiting Iran Carpet Museum
20:00	21:00	Dinner

• Day 5 Wed,Oct.21,2009

6:30	8:00	Breakfast
9:00	12:00	Practical And Observational Exams: Discussion
12:00	14:00	Lunch
14:00	20:00	Practical And Observational Exams :Translation
20:00	21:00	Dinner

• Day 6 Thurs,Oct.22,2009

6:30	8:00	Breakfast
9:00	12:00	Ray Sightseeing
12:00	13:30	Lunch
15:00	18:00	Visiting Iran Bastan Museum
20:00	21:00	Dinner

Day 7 Fri,Oct.23,2009

6:30	8:30	Breakfast
9:00	12:00	Tochal Tele-Cabin
12:00	14:00	Lunch
16:00	17:30	Visiting Imam Khomeini House (Jamaran)
20:00	21:00	Dinner

Day 8 Sat,Oct.24,2009

6:30	8:00	Breakfast
9:00	11:00	Moderation
12:00	14:00	Lunch
16:00	19:00	Moderation
20:00	22:00	Dinner Banquet Hosted By Municipality In Sheean Hotel

Day 9 Sun,Oct.25,2009

6:30	8:00	Breakfast
9:00	12:00	Visiting Tehran Bazaar & Shopping
12:00	14:00	Lunch
16:00	19:00	International Board Meeting (Ii)
20:00	22:00	Dinner Banquet By Sharif University Of Technology

● Day 10 Mon,Oct.26,2009 Leaders

6:30	8:00	Breakfast
9:00	12:00	Free Time
12:00	14:00	Lunch
15:00	18:00	Closing Ceremony
20:00	22:00	Dinner

● Day 11 Tue,Oct.27,2009

6:30	8:00	Breakfast

DEPARTURE

Problems and solutions

- Theoretical Problems
- Practical Problems
- Observasional Problems
- Students Answer sheets

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 available time 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 is provided on your desk.
4. Do **Not** use the back side of your writing sheets. Write only inside the boxed area.
5. Yellow scratch papers are not considered in marking.
6. Begin answering each problem in separate sheet.
7. Fill in the boxes at the top of each sheet of your paper with your "country name", your "student code", "problem number", and total number of pages which is used to answer to that problem.
8. **Write the final answer for each problem in the box, labeled "Answer Sheet".**
9. Starting and the end of the exam will be announced by ringing a bell.
10. The final answer in each question must be accompanied by units, which should be in SI or appropriate units as specified in the problem. 20% of the marks available for that part will be deducted for a correct answer without units.
11. The required numerical accuracy for the final answer depends on the number of significant figures given in the data values in the problem. 20% of the marks available for the final answer in each question part will be deducted for answers without required accuracy as given in the problem. Use the constant values exactly as given in the table of constants.
12. At the end of the exam put all papers, including scratch papers, inside the envelope and leave everything on your desk.

Table of Constants

(All constants are in SI)

Parameter	Symbol	Value
Gravitational constant	G	$6.67 \times 10^{-11} N\, m^2\, kg^{-2}$
Plank constant	h	6.63×10^{-34}J s
	$\hbar$	$1.05 \times 10^{-34}\ J\, s$
Speed of light	c	$3.00 \times 10^{8}\ m\, s^{-1}$
Solar Mass	$M_{\odot}$	$1.99 \times 10^{30}\ kg$
Solar radius	$R_{\odot}$	$6.96 \times 10^{8}\ m$
Solar luminosity	$L_{\odot}$	$3.83 \times 10^{26}\ W$
Apparent solar magnitude (V)	$m_{\odot}$	-26.8
Solar constant	$b_{\odot}$	$1.37 \times 10^{3}\ W\, m^{-2}$
Mass of the Earth	$M_{\oplus}$	$5.98 \times 10^{24}\ kg$
Radius of the Earth	$R_{\oplus}$	$6.38 \times 10^{6}\ m$
Mean density of the Earth	$\rho_{\oplus}$	$5 \times 10^{3}\ kg\, m^{-3}$
Gravitational acceleration at sea level	g	$9.81\ m\, s^{-2}$
Tropical year		365.24 days
Sidereal year		365.26 days
Sidereal day		86164 s
Inclination of the equator with respect to the ecliptic	ε	23.5°
Parsec	pc	$3.09 \times 10^{16}\ m$
Light year	ly	$9.46 \times 10^{15}\ m$
Astronomical Unit	AU	$1.50 \times 10^{11}\ m$
Solar distance from the center of the Galaxy	R	$8 \times 10^{3} pc$
Hubble constant	H	$75\ kms^{-1}\, M\, pc^{-1}$
Mass of electron	m_e	$9.11 \times 10^{-31}\ kg$
Mass of proton	m_p	$1.67 \times 10^{-27}\ kg$
Central wavelength of V-band	λ	$550\ n\, m$
Refraction of star light at horizon		$34'$
	π	3.1416

Useful mathematical formula:

$$\ln(1 + x) \sim x \qquad for\ \ x \to 0$$

Short Problems: (10 points each)

Problem 1: Calculate the mean mass density for a super massive black hole with total mass of $1\times10^8\ M_{\odot}$ inside the Schwarzschild radius.

Problem 2: Estimate the number of photons per second that arrive on our eye at $\lambda = 550\ nm$ (V-band) from a G2 main sequence star with apparent magnitude of $m = 6$ (the threshold of naked eye visibility). Assume the eye pupil diameter is $6\ mm$ and all the radition from this star is in $\lambda = 550\ nm$.

Problem 3: Estimate the radius of a planet that a man can escape its gravitation by jumping vertically. Assume density of the planet and the Earth are the same.

Problem 4: In a typical Persian architecture, on top of south side windows there is a structure called "Tabeshband" (shader), which controls sunlight in summer and winter. In summer when the Sun is high, Tabeshband prevents sunlight to enter rooms and keeps inside cooler. In the modern architecture it is verified that the Tabeshband saves about 20% of energy cost. Figure (1) shows a vertical section of this design at latitude of $36^\circ.0$ N with window and Tabeshband.

Using the parameters given in the figure, calculate the maximum width of the Tabeshband, "x", and maximum height of the window , "h" in such a way that:

i) No direct sunlight can enter to the room in the summer solstice at noon.
ii) The direct sunlight reaches the end of the room (indicated by the point **A** in the figure) in the winter solstice at noon.

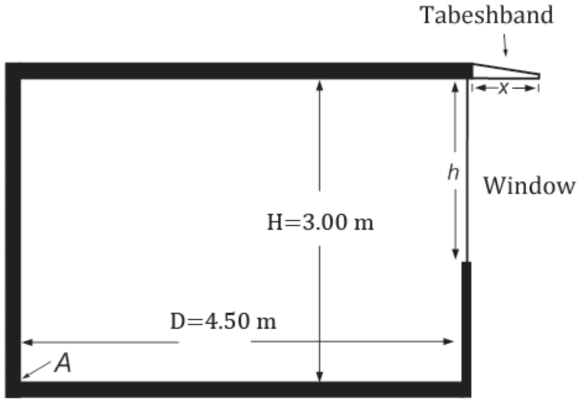


Figure (1)

Problem 5: The Damavand Mountain is located at the North part of Iran, in south coast of Caspian Sea. Consider an observer standing on the Damavand mountain top (latitude = $35°\,57'$N; longitude = $52°\,6'$E; altitude $5.6 \times 10^3\ m$ from the mean sea level) and looking at the sky over the Caspian Sea. What is the minimum declination for a star, to be seen marginally circumpolar for this observer. Geodetic radius of the Earth at this latitude is $6370.8\ km$. Surface level of the Caspian Sea is approximately equal to the mean sea level.

Problem 6: Derive a relation for the escape velocity of an object, launched from the center of a proto-star cloud. The cloud has uniform density with the mass of M and radius R. Ignore collisions between the particles of the cloud and the launched object. If the object were allowed to fall freely from the surface, it would reach the center with a velocity equal to $\sqrt{\frac{GM}{R}}$.

Problem 7: A student tries to measure field of view (FOV) of the eyepiece of his/her telescope, using rotation of the Earth. To do this job, the observer points the telescope towards Vega (alpha Lyr., RA: 18.5^h , Dec: +39°), turns off its "clock drive" and measures trace out time, t=5.3 minutes, that Vega crosses the full diameter of the FOV. What is the FOV of this telescope in arc-minutes?

Problem 8: Estimate the mass of a globular cluster with the radius of $r = 20\,pc$ and root mean square velocity of stars equal to $v_{rms} = 3\ kms^{-1}$.

Problem 9: The Galactic longitude of a star is $l = 15°$. Its radial velocity with respect to the Sun is $V_r = 100\ kms^{-1}$. Assume stars in the disk of the Galaxy are orbiting the center with a constant velocity of $V_0 = 250\ kms^{-1}$ in circular orbits in the same sense in the galactic plane. Calculate distance of the star from the center of the Galaxy.

Problem 10: A main sequence star with the radius and mass of $R = 4R_{\odot}$, $M = 6M_{\odot}$ has an average magnetic field of 1×10^{-4} T. Calculate the strength of the magnetic field of the star when it evolves to a neutron star with the radius of $20\ km$.

Problem 11: Assume the mass of neutrinos is $m_{\nu} = 10^{-5}m_e$. Calculate the number density of neutrinos (n_{ν}) needed to compensate the dark matter of the universe. Assume the universe is flat and 25 % of its mass is dark matter. Hint: Take the classical total energy equal to zero

Problem 12: Calculate how much the radius of the Earth's orbit increases as a result of the Sun losing mass due to the thermo-nuclear reactions in its center in 100 years. Assume the Earth's orbit remains circular during this period.

Problem 13: Assume that you are living in the time of Copernicus and do not know anything about Kepler's laws. You might calculate Mars-Sun distance in the same way as he did. After accepting the revolutionary belief that all the planets are orbiting around the Sun, not around the Earth, you measure that the orbital period of Mars is 687 days, then you observe that 106 days after opposition of Mars, the planet appears in quadrature. Calculate Mars-Sun distance in astronomical unit (AU).

Problem 14: A satellite is orbiting around the Earth in a circular orbit in the plane of the equator. An observer in Tehran at the latitude of $\varphi = 35.6^{\circ}$ N observes that the satellite has a zenith angle of $z = 46.0°$, when it transits the local meridian. Calculate the distance of the satellite from the center of the Earth (in the Earth radius unit).

Problem 15: An eclipsing close binary system consists of two giant stars with the same sizes. As a result of mutual gravitational force, stars are deformed from perfect sphere to the prolate spheroid with $a = 2b$, where a and b are semi-major and semi-minor axes (the major axes are always co-linear). The inclination of the orbital plane to the plane of sky is $90°$. Calculate the amplitude of light variation in magnitude (Δm) as a result of the orbital motion of two stars. Ignore temperature variation due to tidal deformation and limb darkening on the surface of the stars. Hint: A prolate spheroid is a geometrical shape made by rotating of an ellipse around its major axis, like rugby ball or melon.

Long Problems:

Problem 16: High Altitude Projectile (45 points)

A projectile which initially is put on the surface of the Earth at the sea level is launched with the initial speed of $v_\circ = \sqrt{(GM/R)}$ and with the projecting angle (with respect to the local horizon) of $\theta = \frac{\pi}{6}$. M and R are the mass and radius of the Earth respectively. Ignore the air resistance and rotation of the Earth.

a) Show that the orbit of the projectile is an ellipse with a semi-major axis of $a = R$.
b) Calculate the highest altitude of the projectile with respect to the Earth surface (in unit of Earth radius).
c) What is the range of the projectile (distance between launching point and falling point)?
d) What is eccentricity (e) of the ellipse?
e) Find the flying time for the projectile.

Problem 17: Apparent number density of stars in the Galaxy (45 points)

Let us model the number density of stars in the disk of Milky Way Galaxy with a simple exponential function of $n = n_0 \exp\left(-\frac{r-R_0}{R_d}\right)$, where r represents the distance from the center of the Galaxy, R_0 is the distance of the Sun from the center of the Galaxy, R_d is the typical size of disk and n_0 is the stellar density of disk at the position of the Sun. An astronomer observes the center of the Galaxy within a small field of view. We take a particular type of Red giant stars (red clump) as the standard candles for the observation with approximately constant absolute magnitude of $M = -0.2$,

a) Considering a limiting magnitude of $m = 18$ for a telescope, calculate the maximum distance that telescope can detect the red clump stars. For simplicity we ignore the presence of interstellar medium so there is no extinction.

b) Assume an extinction of $0.70\ mag/kpc$ for the interstellar medium. Repeat the calculation as done in the part (a) and obtain a rough number for the maximum distance these red giant stars can be observed.

c) Give an expression for the number of these red giant stars per magnitude within a solid angle of Ω that we can observe with apparent magnitude in the range of m and $m + \Delta m$, (i.e. $\frac{\Delta N}{\Delta m}$). Red giant stars contribute f of overall stars. In this part assume no extinction in the interstellar medium as part (a).

Hint : the Tylor expansion of $y = \log_{10} x$ is :

$$y = y_0 + \frac{1}{ln10} \frac{x - x_0}{x}$$

Solutions

Solution 1:

Schwarzschild radius of a black hole with mass M is

$$R = \frac{2GM}{c^2} \quad \text{(4 points)}$$

Then the mass density can be estimated as

$$\rho = \frac{M}{\frac{4}{3}\pi\frac{8G^3M^3}{c^6}} = \frac{3c^6}{32\pi}\frac{1}{G^3M^2} \quad \text{(2 points)}$$

$$= \frac{3 \times (3.00 \times 10^8)^6}{32 \times 3.1416}\frac{1}{(6.67 \times 10^{-11})^3(10^8 \times 1.99 \times 10^{30})^2}$$

$$= 1.85 \times 10^3\ kg\ m^{-3} \quad \text{(4 points)}$$

Solution 2:

To calculate flux of a $m = 6$ star we use the Sun as standard candle

$$m_1 - m_2 = -2.5 \log\frac{f_1}{f_2} \quad \text{(1 point)}$$

$$6 - (-26.8) = -2.5 \log\frac{f_1}{1.37 \times 10^3}$$

$$f_1 = 1.04 \times 10^{-10}(w/m^2) \quad \text{(3 points)}$$

We need to know how much energy a visual photon has (at 550 nm)

$$E_p = h\nu = \frac{hc}{\lambda}$$

$$= \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{550 \times 10^{-9}}$$

(3 points)

$$= 3.62 \times 10^{-19}\, J$$

Then number of photon which arrive to our eye per second is

(3 points)

$$N = \frac{f_1 \pi r_e^2}{E_p} = \frac{1.04 \times 10^{-10}}{3.62 \times 10^{-19}} \times 3.1416 \times 0.003^2 = 8 \times 10^3 \ s^{-1}$$

Solution 3:

We must compare the jumping speed of a normal human with escape velocity of the planet .
A normal human can jump up to 50 cm then his initial velocity is

$$v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 0.5}$$
$$v = 3.13\, ms^{-1}$$

(3 points)

Comparing this velocity with escape velocity of the planet

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

(3 points)

$$v^2 = \frac{2GM}{R} = \frac{2G}{R}\frac{4\pi}{3}\rho\, R^3$$

$$= \frac{8\pi G}{3}\rho\, R^2$$ (2 points)

$$R^2 = \frac{3v^2}{8\pi G\rho}$$

$$R = 2 \times 10^3\ m$$ (2 points)

Solution 4:

The zenith angle of the sun at summer solstice will be

$$z_s\ =\ \phi - 23.5 = 12.5$$ (1.5 points)

And in the winter solstice

$$z_w\ =\ \phi + 23.5 = 59.5$$ (1.5 points)

Figures shows that in summer solstice we have

$$\tan(z_s) = \frac{x}{h} = 0.22$$ (1.5 points)

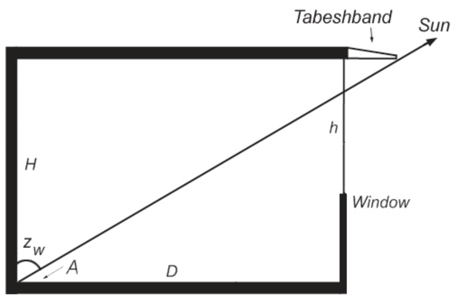
And in the winter solstice

Then

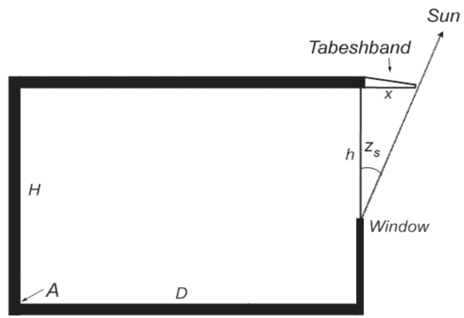
$$\tan(z_w) = \frac{D + x}{H} = 1.70$$ (1.5 points)

$$x = 1.70H - D = 0.60\ m$$ (2 points)

$$h = 2.73\ m$$ (2 points)



Winter solstice



Summer solstice

Solution 5:

To calculate accurate value for minimum declination for circumpolar stars two major effect must be considered.

1. Refraction in earth atmosphere, which is 34′ at horizon. (3 points)
2. Horizon depression which is

$$\text{Cos}\,\theta = \frac{R}{R+h} = \frac{6370.8}{6370.8+5.6} \Longrightarrow \theta = 2°\,24^{'}$$ (3 points)

Then

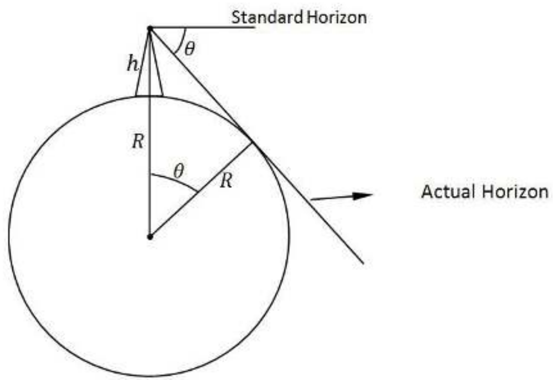
$$\delta_{min} = 90 - Latitude - Refraction - Horizon\ depression$$

(2 points)

$$= 90 - 35°\,57^{'} - 34' - 2°\,24'$$

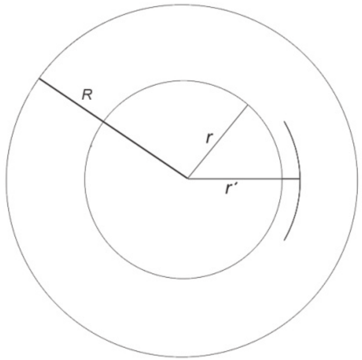
(2 points)

$$\Longrightarrow \delta_{min} = 51°\,5'$$



Solution 6:

To solve this problem we must calculate gravitational potential at the center of the cloud, letting $\phi(\infty) = 0$. For a uniform density and spherical mass distribution we have



$$\frac{1}{2}\,m\,v^2(r=R)-\frac{GMm}{R}=E=\frac{1}{2}mv^2(r=0)+\varphi(0)$$ (4 points)

$$v(r=R)=0 \qquad \& \qquad v(r=0)=\sqrt{\frac{GM}{R}}$$ (1 point)

$$\varphi(0)=-\frac{1}{2}mv_0^2-\frac{GmM}{R}$$ (1 point)

$$\varphi(0)=\frac{-1}{2}m\left(\sqrt{\frac{GM}{R}}\right)^2-\frac{GmM}{R}$$ (2 points)

$$\varphi(0) = \frac{-3}{2} \times \frac{GMm}{R}$$

To escape from the cloud, the particle should have total energy equal to zero

$$E = \frac{1}{2}mv_e^{\,2} + \phi(r=0) = \frac{1}{2}mv_e^{\,2} - \frac{3}{2}\left(\frac{GMm}{R}\right) = 0$$

$$v_e^{\,2} = \frac{3GM}{R} \quad \rightarrow \quad v_e = \sqrt{\frac{3GM}{R}}$$ (2 points)

Solution 7:

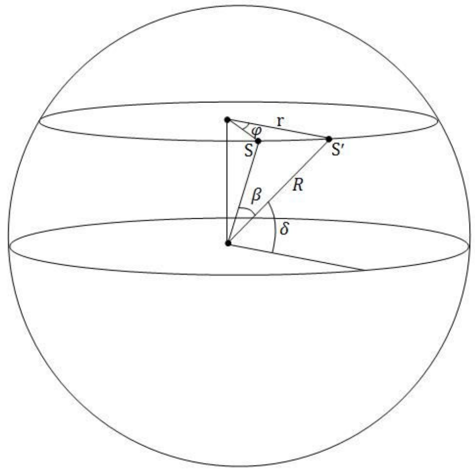


Figure shows that if FOV of telescope is β then we have :

$$\beta = \phi cos\delta$$ (4 points)

As the earth rotate, Vega moves through the FOV with constant angular velocity of the earth

$$\omega = \frac{2\pi}{86164} = 7.29 \times 10^{-5}(rad/s)$$ (2 points)

$$\phi = \omega t = 7.29 \times 10^{-5} \times 5.3 \times 60 = 0.023\ (\mathrm{rad})$$

$$FOV = \beta = \phi cos\delta = 0.023 cos 39^{\circ} = 0.018\ (\mathrm{rad}) \simeq 62\ min$$ (4 points)

Solution 8:

$$\frac{1}{2}Mv_{esc}^2 = \frac{1}{2}M\frac{2GM}{R}$$ (4 points)

The velocity must be smaller than the escape velocity ($v_{esc} \approx \sqrt{2}v_{rms}$) and since the problem is an estimation, any velocities smaller than escape velocity is accepted and therefore the escape velocity can be replaced by v_{rms}.

$$Mv_{rms}^2 = \frac{GM^2}{R}$$ (2 points)

$$M = \frac{Rv_{rms}^2}{G} = \frac{20 \times 3.09 \times 10^{16} \times 9 \times 10^6}{6.67 \times 10^{-11}} = 8.3 \times 10^{34} Kg$$

(4 points)

$$M = 4.2 \times 10^4 M_{\odot}$$

Solution 9:

In the figure, S is the Sun and R_0 and V_0 are Sun distance and velocity. The distance and velocity of star P is denoted by R and $V = V_0$. The radial velocity of star P respect to the Sun is

$$V_r = V\cos\alpha - V_0 \sin l = V_0(\cos\alpha - \sin l)$$ (4 points)

In SCP triangle we have

$$\frac{\sin l}{R} = \frac{\cos\alpha}{R_0} \Rightarrow \cos\alpha = \frac{R_0}{R}\sin l$$ (1 point)

So

$$V_r = V_0\left(\frac{R_0}{R} - 1\right)\sin l$$ (2 points)

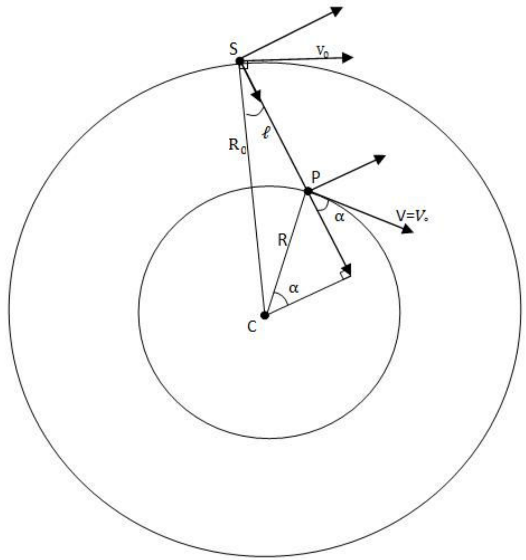
$$\frac{R_0}{R} - 1 = \frac{V_r}{V_0 sinl}$$

$$\frac{R_0}{R} = \frac{V_r + V_0 sinl}{V_0 \sin l}$$

$$R = R_0 \frac{V_0 \sin l}{V_r + V_0 sinl}$$ (2 points)

$$R = 8 \times 10^3 \frac{250 sin15^\circ}{100 + 250 sin15^\circ}$$

$$R = 3 \times 10^3\, pc$$ (1 point)



Solution 10:

Because of high conductivity of plasma inside the star, flux of magnetic field will be conserved through contraction then:

$$4\pi R^2 B = 4\pi R_n^2 B_n$$ (6 points)

Where R_n and B_n are radius and magnetic field of neutron star, thus:

$$B_n = \left(\frac{R}{R_n}\right)^2 B = \left(\frac{4 \times 6.96 \times 10^5}{20}\right)^2$$ (2 points)

$$B_n = 1.93 \times 10^{10}\ Gauss$$

$$= 1.93 \times 10^6\ T$$ (2 points)

Solution 11:

In a flat universe

$$\rho = \rho_c = \frac{3H^2}{8\pi G}$$ (4 points)

$$H = 75\ kms^{-1}Mpc^{-1} = 2.4 \times 10^{-18}s^{-1}$$ (2 points)

$$\rho_c = 1.1 \times 10^{-26}\ kgm^{-3}$$ (2 points)

$$n_v = \frac{0.25\ \rho_c}{10^{-5}\ m_e} = 3 \times 10^8\ m^{-3}$$ (2 points)

Solution 12:

The rate of change of solar mass could be estimated from solar luminosity:

(2 points)

$$L_\odot = -\frac{\Delta E}{\Delta t} = -\frac{\Delta M c^2}{\Delta t} = -\dot{M}c^2$$

$$\dot{M} = -\frac{L_{\odot}}{c^2} = -\frac{3.83 \times 10^{26}}{(3.00 \times 10^8)^2} = -4.26 \times 10^9 (kgs^{-1})$$

Newton second law will give us:

$$\frac{v^2}{r} = \frac{GM}{r^2} \Longrightarrow v^2 = \frac{GM}{r}$$ (2 points)

where v and r are orbital velocity and orbital radius of the Earth.
From conservation of angular momentum:

$$l = rmv \Longrightarrow v = \frac{l}{mr}$$ (2 points)

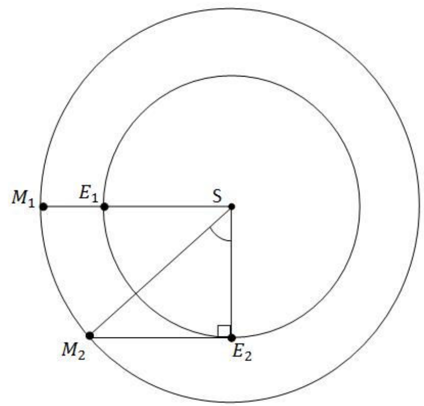
Where m and l are the Earth mass and angular momentum which are constant:

$$\left.\begin{aligned}
&\frac{l^2}{m^2r^2} = \frac{GM}{r} \Rightarrow r = \frac{l^2}{GMm^2} \Rightarrow \dot{r} = -\frac{l^2}{Gm^2}\frac{\dot{M}}{M^2} = -\frac{r^2m^2v^2}{GM^2m^2}\dot{M} \\
&\Rightarrow \dot{r} = -\frac{(GM/r)r^2}{G}\frac{\dot{M}}{M^2} = -r\frac{\dot{M}}{M} \Rightarrow \frac{\dot{r}}{r} = -\frac{\dot{M}}{M} \Rightarrow \dot{r} = -r\frac{\dot{M}}{M} \\
&\Rightarrow \dot{r} = -\frac{1.50 \times 10^{11} \times 4.26 \times 10^9}{1.99 \times 10^{30}} = 3.21 \times 10^{-10} (m/s)
\end{aligned}\right\} \text{(2 points)}$$

$$\Delta r = 3.19 \times 10^{-10} \times 100 \times 86400 \times 365.24 = 1.01m \quad (for\ 100\ years)$$ (2 points)

Solution 13:

We know the orbital period of Mars then the angle $\angle M_1SM_2$ can be determined simply



$$\angle M_1SM_2 = \frac{106}{687} \times 360 = 55.5°$$ (2 points)

By the same way we determine $\angle E_1SE_2$:

$$\angle E_1SE_2 = \frac{106}{365} \times 360 = 104.5°$$ (2 points)

Then angle $\angle M_2SE_2$ is:

$$\angle M_2SE_2 = 104.5 - 55.5 = 49.0°$$ (2 points)

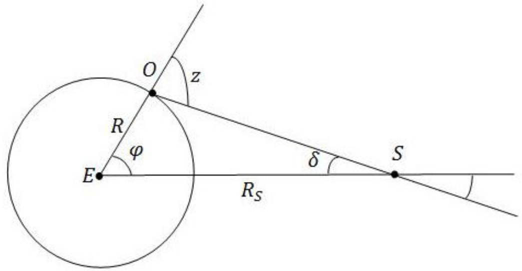
$$\cos(\angle M_2SE_2) = \frac{SE_2}{SM_2}$$ (2 points)

$$r_{mars} = \frac{SM_2}{SE_2} = \frac{1}{\cos(\angle M_2SE_2)} = \frac{1}{\cos(49°)} = 1.52 \;\; AU$$ (2 points)

Solution 14:

In the figure, the observer is at *O* and the satellite is in *S* the angle $\angle EOS$ will be

$$\angle EOS = 180 - z = 180 - 46.0 = 134° \quad \text{(2 points)}$$



$$\delta = 180 - \varphi - \angle EOS = 10.4° \quad \text{(3 points)}$$

In *EOS* triangle we have:

$$\frac{R_S}{\sin(\angle EOS)} = \frac{R}{\sin\delta} \quad \text{(3 points)}$$

$$\frac{R_S}{R} = \frac{\sin(\angle EOS)}{\sin\delta} = 3.98 \quad \text{(2 points)}$$

Solution 15:

Ignoring temperature variation on the stars surface, the brightness of star system will be proportional to projected surface of both stars on plane of the sky. Maximum brightness will occur when two stars are seen like figure 1 and minimum light will happen when one of the stars is in total eclipse and projected surface of the other is a circle with radius *b* (Figure 2). In maximum brightness

$$I_{max} \propto 2\pi ab \quad \text{(3 points)}$$

In minimum brightness

$$I_{min} \propto \pi b^2 \quad \text{(3 points)}$$

So

$$\Delta m = -2.5\log\frac{I_{max}}{I_{min}} = -2.5\log\frac{2\pi ab}{\pi b^2} = -2.5\log 4$$ (2 points)

$$\Delta m = -1.5$$ (2 points)

Solution 16:

a) Total energy of the projectile is

$$E = \frac{1}{2}mv_\circ^2 - \frac{GMm}{R} = -\frac{GMm}{2R} < 0$$

$E < 0$ means that orbit might be ellipse or circle. As $\theta > 0$, the orbit is an ellipse.
Total energy for an ellipse is

$$E = -\frac{GMm}{2a}$$

Then

$$a = R$$ (7 points)

b) In figure (1) we have

$$OA + O'A = 2a$$

$$O'A = a$$

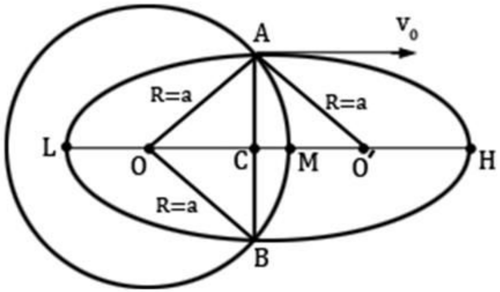


Figure (1)

In OAO' triangle it is obvious that

$$OC = CO'$$

Then C must be the center of the ellipse with the initial velocity vector $v_\circ$ parallel to the ellipse major-axis (LH).

In figure (2)

$$HM = CH - CM = a - (R - R\sin\theta) = R - R + R\sin\theta = R\sin\theta = \frac{R}{2}$$ (15 points)

c) Range of the projectile is $\widehat{AB}$

$$\widehat{AB} = 2\left(\frac{\pi}{2} - \theta\right)R = (\pi - 2\theta)R = \frac{2\pi}{3}R$$

(6 points)

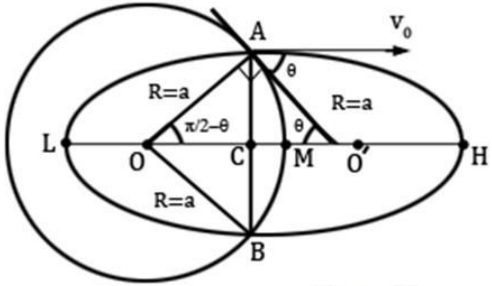


Figure (2)

d) Start with ellipse equation in polar coordinates

$$r = \frac{a(1-e^2)}{1+ecos\varphi}$$

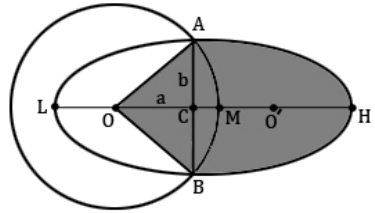
For point A

$$R = \frac{R(1-e^2)}{1-ecos(\frac{\pi}{2}+\theta)}$$

$$e = sin\theta = \frac{1}{2}$$

(5 points)

e) Using Kepler's second law



$$\frac{\Delta S}{S_0} = \frac{\Delta T}{T}$$

$$\Delta S = S_{AOBH} = S_{\Delta AOB} + \frac{S_0}{2}$$

$$= 2 \times \frac{\text{bae}}{2} + \frac{\pi\text{ab}}{2} = \text{bae} + \frac{\pi\text{ab}}{2}$$

$$\frac{\Delta S}{S} = \frac{\text{bae} + \frac{\pi\text{ab}}{2}}{\pi ab} = \frac{e + \frac{\pi}{2}}{\pi} = \frac{0.5 + \frac{\pi}{2}}{\pi}$$

Kepler’s third law

$$T = \sqrt{\frac{4\pi^2 R^3}{GM}} = 84.5\ min$$

$$\Delta T = T \times \frac{0.5 + \frac{\pi}{2}}{\pi} = 55.7\ min$$

(12 points)

Solution 17:

a) Relation between the apparent and absolute magnitude is given by

$$m = M + 5log\left(\frac{d}{10}\right)$$ (3 points)

where d is in terms of parsec. Substituting $m = 18$ and $M = -0.2$, results in

(5 points)

$$d = 4.37 \times 10^4\ pc$$

b) Adding the term for the extinction, changes the magnitude distance relation as follows

$$m = M + 0.7x + 5\log(100x)$$

where x is given in terms of kilo parsec. To have a rough value for x, after substituting m and M, this equation reduces to

$$8.2 = 0.7x + 5\log(x)$$ (6 points)

To solve this equation, we examine

$$x = 5\,, 5.5\,, 6\,, 6.5$$

where the best value is obtained roughly $x \cong 6.1\ kpc$. (8 points)

c) For a solid angle Ω, the number of observed red clump stars at the distance in the range of x and $x + \Delta x$ is given by

$$\Delta N = \Omega\, x^2\, n(x) f\, \Delta x$$

So the number of stars observed in Δx is given by

$$\frac{\Delta N}{\Delta x} = \Omega \, x^2 \, n(x) f$$ (6 points)

From the relation between the distance and apparent magnitude we have

$$m_1 = M + 5log\left(\frac{x}{10}\right)$$

$$m_2 = M + 5log\left(\frac{x + \Delta x}{10}\right)$$

$$\Delta m = 5log\left(\frac{x + \Delta x}{x}\right)$$

$$\Delta m = 5log\left(1 + \frac{\Delta x}{x}\right)$$

$$\Delta m = \frac{5}{ln10} ln\left(1 + \frac{\Delta x}{x}\right)$$

$$\Delta m = \frac{5}{ln10}\left(\frac{\Delta x}{x}\right)$$

Replacing Δx with Δm, results in

$$\frac{\Delta N}{\Delta m} = \frac{\Delta N}{\Delta x} \times \frac{\Delta x}{\Delta m}$$

So the number of stars for a given magnitude is obtained by (5 points)

$$\frac{\Delta N}{\Delta m} = \frac{\Omega ln10}{5} n(x)x^3 f$$

Finally we substituting x in terms of apparent magnitude using $\mathrm{x} = 10^{\frac{\mathrm{m}+5.2}{5}}$.

In the case of no extinction, we are able to observe the Galaxy beyond the center. So $\frac{dN}{dm}$ has two terms in

$x < R_0$ and $x > R_0$. The relation between x and r for these two cases are

$$x = R_0 - r \qquad\qquad x < R_0$$

(6 points)

and

$$x = R_0 + r \qquad\qquad x > R_0$$

So in general we can write $\frac{\Delta N}{\Delta m}$ as

(6 points)

$$\frac{\Delta N}{\Delta m}=\frac{\Omega ln10}{5}n_0\exp\left(\frac{10^{\frac{\mathrm{m}-5.2}{5}}}{R_d}\right)\times 10^{\frac{3(m-5.2)}{5}}f \qquad x<R_0$$

$$\frac{\Delta N}{\Delta m}=\frac{\Omega ln10}{5}\mathrm{n}_0\exp\left(\frac{2\mathrm{R}_0}{R_d}\right)\exp\left(-\frac{10^{\frac{\mathrm{m}-5.2}{5}}}{R_d}\right)\times 10^{\frac{3(m-5.2)}{5}}f\,\Theta(x_0-x\,) \quad x>R_0$$

where $\Theta(x)$ is the step function and x_0 is the maximum observable distance.

Practical completion

Problem 1: CCD Image Processing (60 points)

As an exercise of image processing, this problem involves use of a simple calculator and tabular data. Table 1.1 contains the pixel values of an image during the given exposure time. (table 1.1 is given in the accompanying CD). This image, which is a part of a larger CCD image, was taken by a small CCD camera, installed on an amateur telescope and using a *V* band filter. Figure 1.1 shows this 50×50 pixels image that contains 5 stars.

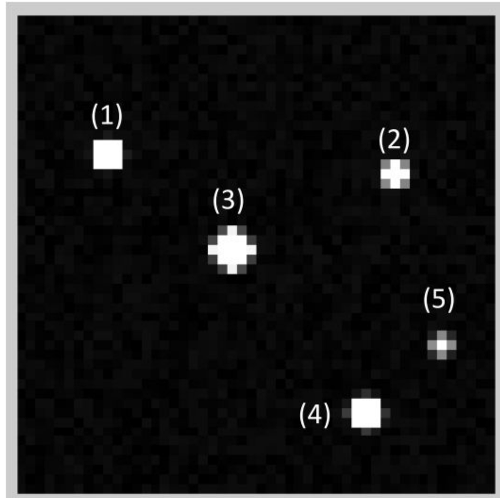


Figure (1.1)

In table 1.1 the first row and column indicates the pixels' x and y coordinates. Table 1.2 gives the telescope and the image specifications.

Table 1.2

Telescope focal length	$1.20\ m$
CCD pixel size	$25 \times 25\ \mu m$
Exposure time	$450\ s$
Telescope zenith angle	25°
Average extinction coefficient in V band	0.3 mag/airmass

The observer identified stars 1, 3 and 4 by comparing this image with standard star catalogues. Table 1.3 shows stars true magnitudes (m_t) as given in the catalogue.

Table 1.3

Star	m_t
1	9.03
3	6.22
4	8.02

a. Using the available data, determine the instrumental magnitudes of the stars in the image. Assume the dark current is negligible and the image is flat fielded. For simplicity you can use a square aperture.
Hint: The instrumental magnitude is calculated using the difference between the measured flux from the star in the aperture and the flux from an equivalent area of dark sky.

b. The instrumental magnitude of a star in a CCD image is related to true magnitude as

$$m_I = m_t + KX - Zmag$$

where K is extinction, X is airmass, m_I and m_t are respectively instrumental and true magnitude of star and $Zmag$ is zero point constant. Calculate the zero point constant $(Zmag)$ for identified stars. Calculate average zero point constant ($Zmag$). **Hint**: Zero point constant is the constant reducing extinction-free magnitudes to the true magnitude.

c. Calculate true magnitudes of stars 2 and 5.
d. Calculate CCD pixel scale for the CCD camera in units of arcsec.
e. Calculate average brightness of dark sky in magnitude per square arcsec (m_{sky}).
f. Use a suitable plot to estimate astronomical seeing in arcsec.

Problem 2: Venus(60 point)

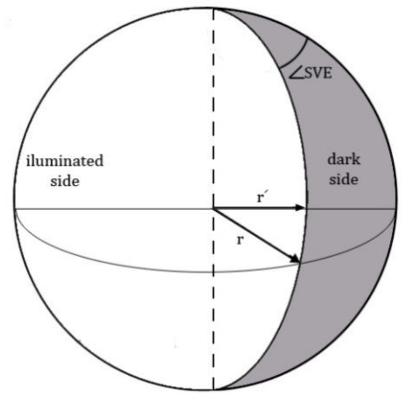
An observer in Deh-Namak (you will be taking the observational part of the exam in this region tonight) has observed Venus for seven months, started from September 2008 and continued until March 2009. During the observation, a research CCD camera and an image processing software were used to take high resolution images and to extract high precision data. Table 2.1 shows the collected data during the observation.

Table 2.1 description:

Column 1	Date of observation.
Column 2	Earth-Sun distance in astronomical unit (AU) for observation date and time. This value is taken from high precision tables.
Column 3	Phase of Venus, Percent of Venus disk illuminated by the Sun as observed from the Earth.
Column 4	Elongation of Venus, the angular distance between center of the Sun and center of Venus in degrees as observed from the Earth.

a) Using given data in table 2.1, calculate the Sun-Venus-Earth angle($\angle SVE$) . This is angular separation between the Sun and the Earth as seen from Venus. Write $\angle SVE$ angle in column 2 of Table 2.2 in your answer sheet for the all observing dates.

Hint: Remember that the line between light and shadow, in the phases, is an ellipse arc.



b) Calculate Sun – Venus distance in AU and write it down in column 3 of table 2.2 for all observation dates.

c) Plot Sun – Venus distance versus observing date.

d) Find perihelion $(r_{v,min})$ and aphelion $(r_{v,max})$ distances of Venus from the Sun.

e) Calculate semi-major axis (a) of the Venus orbit.

f) Calculate eccentricity (e) of Venus orbit.

Table 2.1

Column 1	Column 2	Column 3	Column 4
Date	Earth - Sun Distance (AU)	Phase (%)	Elongation (SEV; degree)
20/9/2008	1.0043	88.4	27.56
10/10/2008	0.9986	84.0	32.29
20/10/2008	0.9957	81.6	34.53
30/10/2008	0.9931	79.0	36.69
9/11/2008	0.9905	76.3	38.71
19/11/2008	0.9883	73.4	40.62
29/11/2008	0.9864	70.2	42.38
19/12/2008	0.9839	63.1	45.29
29/12/2008	0.9834	59.0	46.32
18/1/2009	0.9838	49.5	47.09
7/2/2009	0.9863	37.2	44.79
17/2/2009	0.9881	29.6	41.59
27/2/2009	0.9904	20.9	36.16
19/3/2009	0.9956	3.8	16.08

Solutions

Solution 1: CCD Image Processing

a) To measure instrumental magnitude we should choose an aperture. Careful investigation of the image, shows that a 5×5 pixel aperture is enough to measure m_I for all stars. m_I can be calculated using:

$$m_I = -2.5\log\left(\frac{\sum_{i=1}^{N} \mathrm{I}_{\mathrm{i(star)}} - \mathrm{N}\bar{\mathrm{I}}_{\mathrm{Sky}}}{\mathrm{Exp}}\right)$$

where $\mathrm{I}_{\mathrm{i(star)}}$ is the pixel value for each pixel inside the aperture, N is number of pixels inside the aperture, $\bar{\mathrm{I}}_{\mathrm{Sky}}$ is the average of sky value per pixel taken from dark part of image and Exp is the exposure time. Table (1.4) lists values for m_I and $Zmag$ calculated for all three identified stars.

$$\bar{\mathrm{I}}_{\mathrm{Sky}} = 4.42$$

$$N = 25$$

$$Exp = 450$$

Table (1.4)

Star	m_I	m_t	$Zmag$
1	-3.02	9.03	12.38
3	-5.85	6.22	12.40
4	-4.04	8.02	12.39

b) Average $Zmag$ = 12.4

c) Following part (a) for stars 2 and 5, we can calculate true magnitudes (m_t) for these stars

Table (1.5)

Star	m_I	m_t
2	-2.13	9.93
5	-0.66	11.4

d) Pixel scale for this CCD is calculated as

$$p = \frac{pixel\ size}{focal\ length} \times \frac{180 \times 3600}{\pi}$$

$$= 4.30''$$

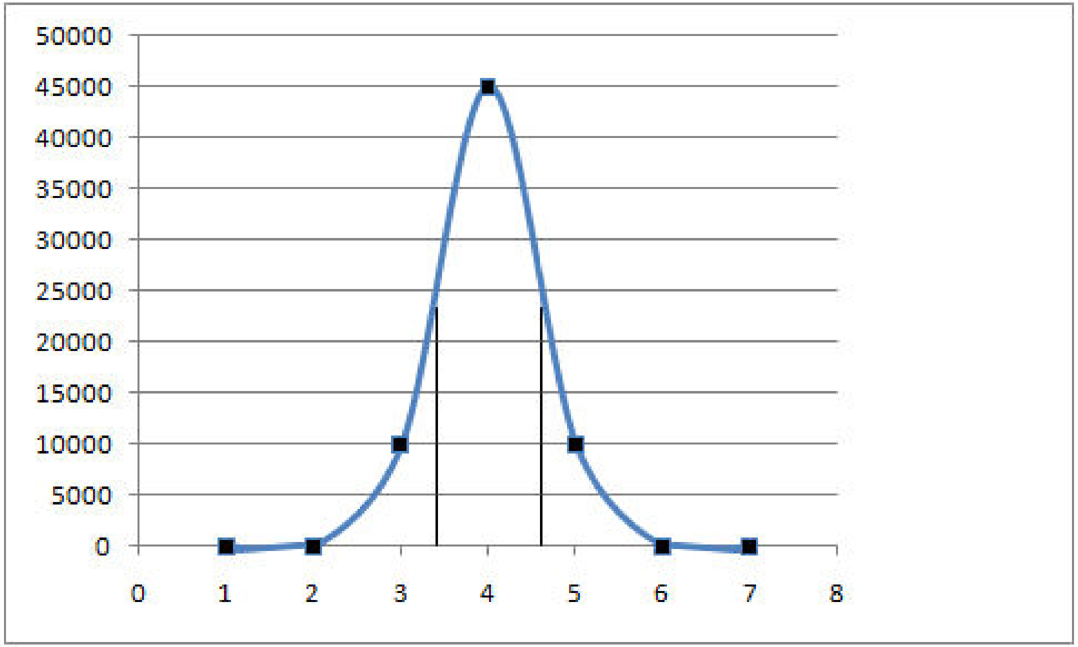
e) Average sky brightness:

$$m_{sky} = -2.5 \log \frac{\bar{\mathrm{I}}_{\mathrm{Sky}}}{(Exp)(p)^2} + Zmag$$

$$= 20.6$$

f) To estimate astronomical seeing, first we plot pixel values in x or y direction for one of the bright stars in the image. As plot (1) shows, the FWHM of pixel values which is plotted for star 3, is 1 pixel , hence astronomical seeing is equal to

$$seeing \cong 4''$$



Plot (1)

CCD Image Problem Marking Scheme

Part	Tot. Pts.	Details	Max.	Explanation
a	10	Relation	2	Each value :+2 $\bar{I}_{sky}$ (within calculation) : +2 m_I relation (in calculation) +2
		m_I	6	
		$\bar{I}_{sky}$	2	
b	10	Z_{mag}	10	$3Z_{mag}$ and average , for each less: - 2
c	10	m_t	10	For each one:+ 5, for each numerical mistake: -2
d	10	P (pixel Scale)	10	
e	10	Relation of m_{sky}	5	
		Value of m_{sky}	5	
f	10	Seeing	10	Seeing: +4, Gaussian profile: +3, FWHM: +3

Solution 2: Venus

a) The $\angle SVE$ angle should be calculated from the phase of Venus. Figure 2.1 shows that projected area of Venus disk which is illuminated by the Sun is

$$\frac{\pi r^2}{2} + \frac{\pi r r'}{2}$$

where

$$r' = r\cos(\angle SVE)$$

Then,

$$Phase = \left(\frac{\frac{\pi r^2}{2} + \frac{\pi r^2 \cos(\angle SVE)}{2}}{\pi r^2}\right) \times 100 = \frac{100}{2}(1 + \cos(\angle SVE)) = 100\cos^2\left(\frac{\angle SVE}{2}\right)$$

The angle $\angle SVE$ is calculated and written in table 2.2, column 2.

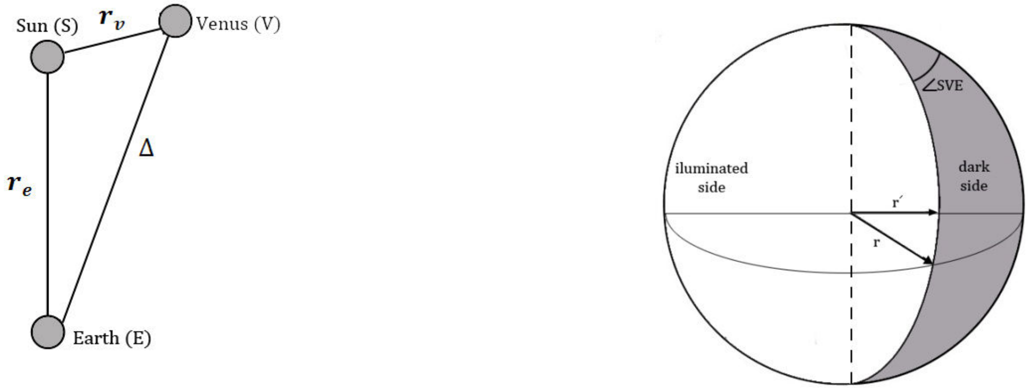


Figure 2.1

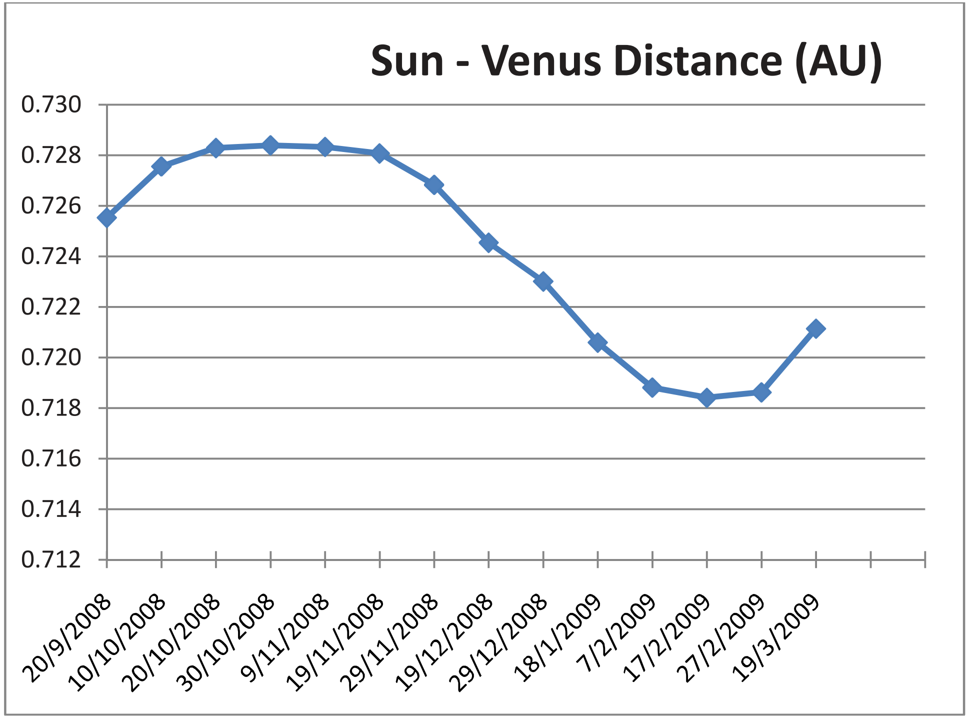
b) As in figure 2.1, in SEV triangle we have,

$$\frac{r_e}{\sin(\angle SVE)} = \frac{r_v}{\sin(\angle SEV)}$$

$$r_v = r_e \frac{\sin(\angle SEV)}{\sin(\angle SVE)}$$

where r_e and $\angle SEV$ (elongation) is given in table 2.1 then, r_v for all observing dates is calculated and written in table 2.2 column 3.

c)



Sun - Venus Distance (AU)
0.730
0.728
0.726
0.724
0.722
0.720
0.718
0.716
0.714
0.712
20/9/2008
10/10/2008
20/10/2008
30/10/2008
9/11/2008
19/11/2008
29/11/2008
19/12/2008
29/12/2008
18/1/2009
7/2/2009
17/2/2009
27/2/2009
19/3/2009

d) According to the obtained values written in table 2.2 column 3,

$$r_v^{max} = 0.728\ AU$$
$$r_v^{min} = 0.718\ AU$$

e) Semi-major axis is

$$a = \frac{(r_v^{max} + r_v^{min})}{2} = 0.723\ AU$$

f) Eccentricity could be calculated from both of aphelion and perihelion distances as

$$e = \frac{r_v^{max} - r_v^{min}}{2a} = 6.92 \times 10^{-3}$$

Table 2.2

Column 1	Column 2	Column 3
Date	SVE (°)	Sun - Venus Distance (AU)
2008-Sep-20	39.83	0.726
2008-Oct-10	47.16	0.728
2008-Oct-20	50.80	0.728
2008-Oct-30	54.55	0.728
2008-Nov-09	58.26	0.728
2008-Nov-19	62.10	0.728
2008-Nov-29	66.17	0.727
2008-Dec-19	74.81	0.725
2008-Dec-29	79.63	0.723
2009-Jan-18	90.57	0.721
2009-Feb-07	104.83	0.719
2009-Feb-17	114.08	0.718
2009-Feb-27	125.59	0.719
2009-Mar-19	157.52	0.721

Venus Problem Marking Scheme

part	Tot. Pts	Details	Max
a	16	Angle derivation	6
		Calculation of $\angle SVE$	10
b	14	Relation	4
		Sun-Venus distance	10
c	6	Plotting Sun-Venus distance	6
d	8	Perihelion	4
		Aphelion	4
e	8	a (relation)	4
		a (value)	4
f	8	e (relation)	4
		e (value)	4

Note: reported numbers in table 2 are not acceptable if they are out of 0.75 and 1.25 times of designer answer.

Observational Competition

Please read these instructions carefully:

1. All participants will receive a question set, a writing board, a pen, a ruler and a headlight by the organizers.
2. This competition consists of two parts:
   a) Two questions on “Naked Eye observation”. You have 12 minutes to answer these two questions.
   b) One question on “Using a telescope”. Each part of this question has a specific time, which is mentioned in your question sheet.
3. All participants will be guided by assistants to the observing site until returning to the waiting hall. Assistants will collect the answer and problem sheets.
4. **Do not forget** to fill out the boxes at the top of each answer sheet with your <u>country name</u> and your <u>student code</u>.
5. You have 2 minutes to familiarize yourself with observing ground and darkness of your environment, just before starting the exam time in observing ground.
6. Examiner’s alarm will indicate the beginning and the end of each part of your exam.
7. Each problem has a specific guideline which helps you during the exam.

Naked Eye Observations

You Have 12 minutes to answer the questions of the Naked Eye Observations (Question 1 and Question 2)

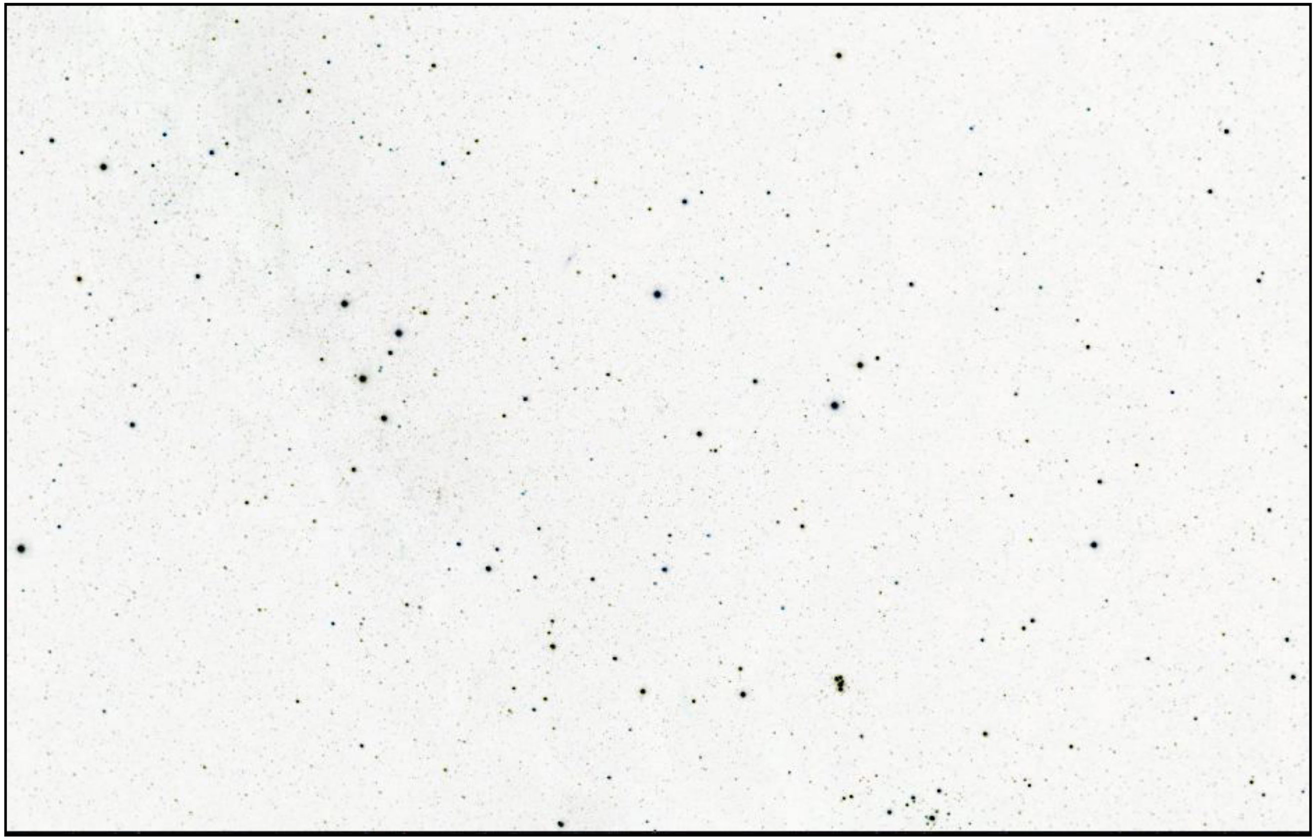
Question 1: (40 Points)

1.1: Figure 1 (frame size $\cong 100^{\circ} \times 70^{\circ}$) shows a part of the sky, for 22 October 2009 at 21:00 local time. Four bright stars in Perseus and Andromeda constellations are missing in this chart. Find these missing stars by looking at the sky. Then, draw a cross on the location of each missing bright star in these two constellations on the chart (i.e. figure 1). Use numbers in table 1 to indicate these crosses.

Table 1

Number	Common Name	Bayer Names
1	Mirfak	Alpha Persei
2	Alpheratz	Alpha Andromeda
3	-	Epsilon Persei
4	Menkib	Xi Persei
5	-	Gamma Persei
6	Algol	Beta Persei
7	Almach	Gamma Andromeda
8	-	Delta Andromeda
9	-	51 Andromeda
10	Mirach	Beta Andromeda
11	Atik	Zeta Persei

Question 1 - Figure 1



Question 2:

2.1: Figure 2 shows a part of the sky which contains **Cepheus constellation**, for 22 October 2009 at 22:00 local time. Five bright stars in Cepheus constellation are identified by numbers (1, 2, … , 5) and common names. Estimate the angular distances (in units of degrees) between two pairs of stars shown in table 2 and complete this table with your answers. **(40 Points)**

Table 2

Angular Distance	
Pairs of stars	**Angular Distance (degrees)**
1 (Errai) and 2 (Alfirk)	
1 (Errai) and 3 (Alderamin)	

2.2: Use table 3 and figure 2, then estimate the “apparent visual magnitude” of stars 2 (Alfirak) and 3 (Alderamin) and complete table 4. **(40 Points)**

Table 3

Star Name	**Apparent Visual Magnitude**
Polaris	1.95
Altais	3.05
Segin	3.34
All of these stars, are marked in the figure 2	

Table 4

Magnitude Estimation		
Star Number	**Star Name**	**Apparent Visual Magnitude**
2	Alfirk	
3	Alderamin	

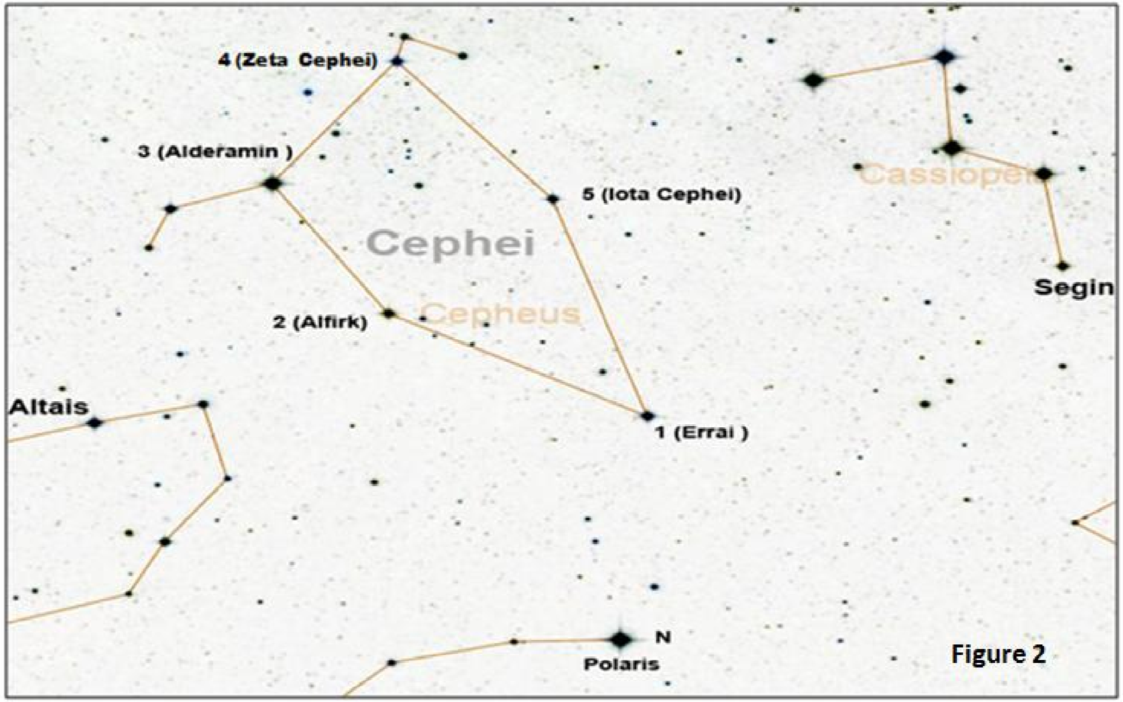


Figure 2

Telescopic Observations

Note: You have only 13 Minutes to answer all parts of this Question

Question 3

Before starting this part, please note:

The telescope is pointed by the examiner towards Caph (α Cas). Please note the readings on the grade circles before moving the telescope (to be used in 3.2).

3.1: Choose one of the 4 recommended stars listed below; write down the name of the selected star in table 5 and point the telescope to that star. Then, notify the examiner to check it. **(6 minutes; 40 Points)**

1- Deneb (Alpha Cygni)
2- Alfirk (Beta Cephei)
3- Algol (Beta Persei)
4- Capella (Alpha Aurigae)

Table 5

Name of selected star

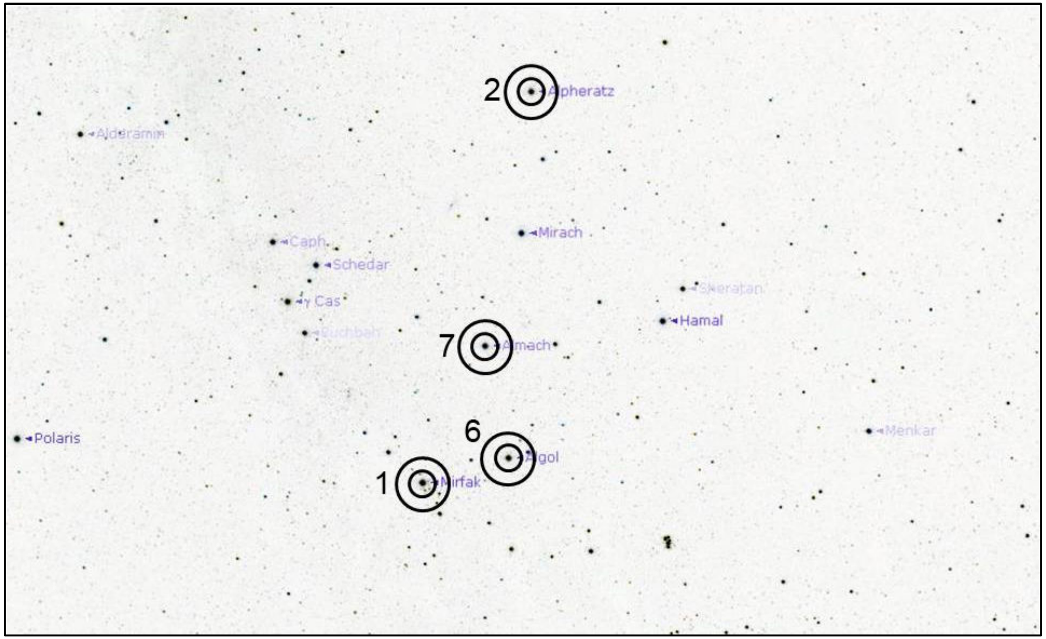
3.2**:** The Telescope is pointed to Caph in Cassiopeia constellation (RA: 0h:9.7m ; Dec: 59°:12’). Using the clock beside the telescope write down the local time (with the format of HH:MM:SS) in the appropriate field in table 6. Then, by using the graded circle on the telescope mount, estimate “declination” and “hour angle” of the target measured from South, which you chose in part one of this question. Then, complete Table 6. **(7 minutes; 40 Points)**

Table 6

Name and Coordinates of the Selected Star			Local Time :
Name of Selected Star	Hour Angle (hh:mm)	Declination (°:’)	

Solution 1:

Figure 2 – Solution of Problem 1



Marking Scheme:

Part 1: Location of each bright star:

A) Small Circle + Correct Number: +10 points.
B) Large Circle+ Correct Number: +5 Points.
C) Small Circle without Identifier Number : +5 Points
D) Large Circle without Identifier Number: 0 Point.
E) Small or Large Circle+ Incorrect Identifier Number: 0 Point.

Solution 2:

Part 1:

Table 2

Angular Distance	
Stars Name	**Angular Distance (Degree)**
1 (Errai) and 2 (Alfirk)	$11^{\circ}:09':10'' \sim 11^{\circ}$
1 (Errai) and 3 (Alderamin)	$18^{\circ}:36':50'' \sim 19^{\circ}$

Marking Scheme:

Part 1: $\Delta =$ Error in estimation of angular distance.

$\Delta \leq 2^{\circ}$: 20 points
$2^{\circ} < \Delta \leq 4^{\circ}$: 10 Points
$\Delta > 4^{\circ}$: 0 Point

Part 2:

Table 4

Magnitude Estimation		
Number	**Star Name**	**Visible Magnitude**
2	Alfirk	3.2
3	Alderamin	2.4

For Each Star:

$\Delta m \leq 0.2$: 20 points
$0.2 < \Delta m \leq 0.5$: 15 Points
$0.5 < \Delta m \leq 0.8$: 10 Points
$0.8 < \Delta m \leq 1.0$: 5 Points
$1.0 < \Delta m \leq 1.2$: 2 Points
$\Delta m > 1.2$: 0 Point

Solution 3:

<table>
<tr><th colspan="4">Coordinate of Selected Star</th><th rowspan="3">Local Time :</th></tr>
<tr><th>Star</th><th>Hour Angle</th><th>R.A.</th><th>Dec.</th></tr>
<tr><td>Deneb (Alpha Cygni)</td><td>ST-RA</td><td>20h 41m</td><td>+45°</td></tr>
<tr><td>Alfirk (Beta Cephei)</td><td>ST-RA</td><td>21h 28m</td><td>+71°</td><td rowspan="3">Sidereal Time :</td></tr>
<tr><td>Algol (Beta Persei)</td><td>RA-ST</td><td>03h 08m</td><td>+41°</td></tr>
<tr><td>Capella (Alpha Aurigae)</td><td>RA-ST</td><td>05h 18m</td><td>+46°</td></tr>
</table>

Marking Scheme:

Part 1: Point the Telescope to the coordinates of the selected stars.
If the examiner confirms the star in the 32 mm eyepiece: 40 Points
If the examiner confirms the star in the finder scope: 20 Points
If the examiner doesn't see the star in Finder : No Point

Part2: Estimate Hour Angle and Declination. ($\Delta =$ Error)

HA: $\Delta \leq 30\ min$: 20 points
$30\ min < \Delta \leq 45\ min$: 15 Points
$45\ min < \Delta \leq hour$: 10 Points
$1\ hour < \Delta \leq 1.5\ hour$: 5 Points
$\Delta > 1.5\ hour$: 0 Point
If Participant estimates R.A. Instead of H.A.: 20 Point

Dec: $\Delta \leq 2^{\circ}$: 20 points
$2^{\circ} < \Delta \leq 4^{\circ}$: 15 Points
$4^{\circ} < \Delta \leq 8^{\circ}$: 10 Points
$8^{\circ} < \Delta \leq 10^{\circ}$: 5 Points
$\Delta > 10^{\circ}$: 0 Point

Theoretical Competition

Country	Student Code	Problem Number	Page Number	Total Number of Pages for this Problem
Indonesia	IDN 1	3	2	2

Writing Sheet:

$\rho_{planet} = \rho_{bumi}$

$\frac{M_p}{\frac{4}{3}\pi r_p^3} = \frac{M_\oplus}{\frac{4}{3}\pi r_\oplus^3}$

$M_p = \frac{M_\oplus \cdot r_p^3}{r_\oplus^3}$

M_p : massa planet
$M_\oplus$: massa bumi
r_p : radius planet
$r_\oplus$: radius bumi

$V_{esc} = \sqrt{\frac{2GM_p}{r_p}}$

$r_p = \frac{2GM_p}{V_{esc}^2}$

$r_p = \frac{2 \cdot G \cdot M_\oplus r_p^3}{r_\oplus^3 V_{esc}^2}$

$r_p^2 = \frac{r_\oplus^3 V_{esc}^2}{2GM_\oplus}$

$r_p = \sqrt{\frac{(6{,}38 \cdot 10^6)^3 \cdot 4{,}429^2}{2 \cdot 6{,}67 \cdot 10^{-11} \cdot 5{,}98 \cdot 10^{24}}}$

$= 3527{,}017$ m

Answer Sheet: $r_p = 3527{,}017$ m

r_p = radius of the planet

Do not write outside the boxed area.

For Examiners Use Only:

Theoretical Competition

Country	Student Code	Question Number	Page Number	Total Number of Pages for this Problem
India	IND 1	6	1	2

Writing Sheet:

The object will escape the protostar if its velocity at the surface of protostar is $\longrightarrow$ $V_s = \sqrt{\frac{2GM}{R}}$

Subscripts $s \rightarrow$ surface
$c \rightarrow$ centre

By conservation of energy,

$KE_s + PE_s = KE_c + PE_c$

as given in problem,

$0 - \frac{GMm}{R} = \frac{1}{2} m \frac{GM}{R} + PE_c$

$\Rightarrow PE_c = \frac{-3}{2} \frac{GMm}{R}$

Now, for the object to escape, again, $KE_c + PE_c = KE_s + PE_s$

Do not write outside the boxed area.

For Examiners Use Only:

Theoretical Competition

Country	Student Code	Problem Number	Page Number	Total Number of Pages for this Problem
India	IND 10	7	2	2

Writing Sheet:

but $\frac{\theta_1}{2} = \frac{360 \times t}{2 \times \text{sidereal day}}$

$= \cancel{360\times} \frac{180 \times 318}{86164}$

$\theta_2 = 2 \sin^{-1}\left(\cos 39° \sin \frac{180 \times 318}{86164}\right)$

$= 1° 1' 57''$

$\therefore \boxed{\theta_2 = 1° 2'}$

Answer Sheet:

FOV of telescope $= 1° 2'$

Do not write outside the boxed area.

Theoretical Competition

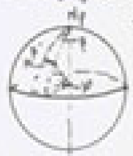
Country	Student Code	Problem Number	Page Number	Total Number of Pages for this Problem
China	CHN1	7	1	1

Writing Sheet:

t 时间内地球因自转运动转过的角度为：

$\beta = \frac{t}{T_{day}} \times 360° = \left(\frac{5.3 \times 60}{86164}\right) \times 360° = 1.33°$

~~t时间内 [illegible] 相对于 [illegible] 转过的角度为~~



设 t 时间内恒星相对于望远镜中心转过的角度为β'，由球面三角公式得：

$\frac{\sin\beta'}{\sin\beta} = \frac{\sin(90°-\varphi)}{\sin 90°}$

$\therefore \sin\beta' = \cos\varphi \cdot \sin\beta$

$= \cos 39° \cdot \sin 1.33°$

$\therefore \beta' = \sin^{-1}(\cos\varphi \cdot \sin\beta) = 1.03°$

∴望远镜的视场大小为：

$\omega = \beta' = 1.03° = 62.0'$

Answer Sheet:

$\omega = 62.0'$

Do not write outside the boxed area.

Theoretical Competition

Country	Student Code	Question Number	Page Number	Total Number of Pages for this Problem
China	CHN1	2	1	1

Writing Sheet:

用太阳的视星等作对比，我们有：

$m - m_0 = -2.5 \lg\left(\frac{E}{E_0}\right)$ 其中m_0为太阳视星等，E_0为太阳照度。

$\therefore E = E_0 \times 10^{(m-m_0)/(-2.5)}$

$= \left[1.37\times10^3 \times 10^{[6-(-26.8)]/(-2.5)}\right] W\,m^{-2}$

$= 1.04\times10^{-10}\ W\,m^{-2}$

人眼接收到的光子能量功率为：

$P_e = E\cdot\pi\left(\frac{d}{2}\right)^2$

$= [1.04\times10^{-10} \times 3.1416 \times (6\times10^{-3}/2)^2]\ W$

$= 2.94\times10^{-15}\ W$

一个波长为λ=550nm的光子能量为：

$E' = hc/\lambda = (6.63\times10^{-34}\times3\times10^8/(5.5\times10^{-7}))\ J$

$= \cancel{[illegible]}\ 3.62\times10^{-19}\ J$

人眼每秒接收到的光子个数为：

$N = \frac{P_e}{E'}\times1 = \left(\frac{2.94\times10^{-15}}{3.62\times10^{-19}}\times1\right) = 8.12\times10^3$

$\cancel{= \left(\frac{2.94\times10^{-15}}{3.98\times10^{-19}}\times1\right)}$

$\cancel{= 7.39\times10^3}$

Answer Sheet:

$N = 8.12\times10^3$

Do not write outside the boxed area.

For Examiners Use Only:

Theoretical Competition

Country	Student Code	Question Number	Page Number	Total Number of Pages for this Problem
India	IND 1	3	1	2

Writing Sheet:

Assuming that an average man can jump vertically upto an height of 0.5 m, = h

Initial velocity

$v_i = \sqrt{2gh}$ where g is the gravitational acceleration at the surface of the planet.

$= \sqrt{g}$

$= 3.13$ m/s

This is the velocity of man with respect to the planet.

Mass of planet is comparable with that of the man. Hence we apply ~~any~~ conservation of momentum.

$m_p v_p = m_m v_m \qquad v_p + v_m = \sqrt{g}$

also $\frac{1}{2}m_p v_p^2 + \frac{1}{2}m_m v_m^2 = \frac{G m_m v_m}{R}$

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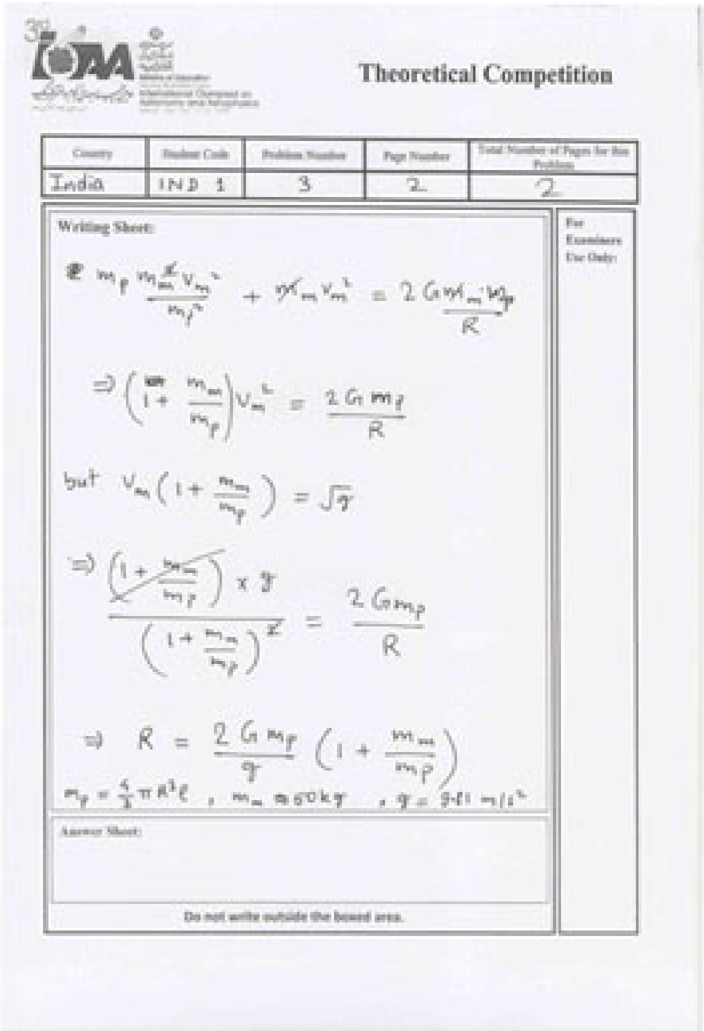


Theoretical Competition

Country	Student Code	Problem Number	Page Number	Total Number of Pages for the Problem
India	IND 1	3	2	2

Writing Sheet:

$$m_p \frac{m_m^2 v_m^2}{m_p^2} + m_m v_m^2 = \frac{2 G m_m m_p}{R}$$

$$\Rightarrow \left(1+\frac{m_m}{m_p}\right) v_m^2 = \frac{2 G m_p}{R}$$

but $v_m\left(1+\frac{m_m}{m_p}\right) = \sqrt{g}$

$$\Rightarrow \frac{\cancel{\left(1+\frac{m_m}{m_p}\right)} \times g}{\left(1+\frac{m_m}{m_p}\right)^{\cancel{2}}} = \frac{2 G m_p}{R}$$

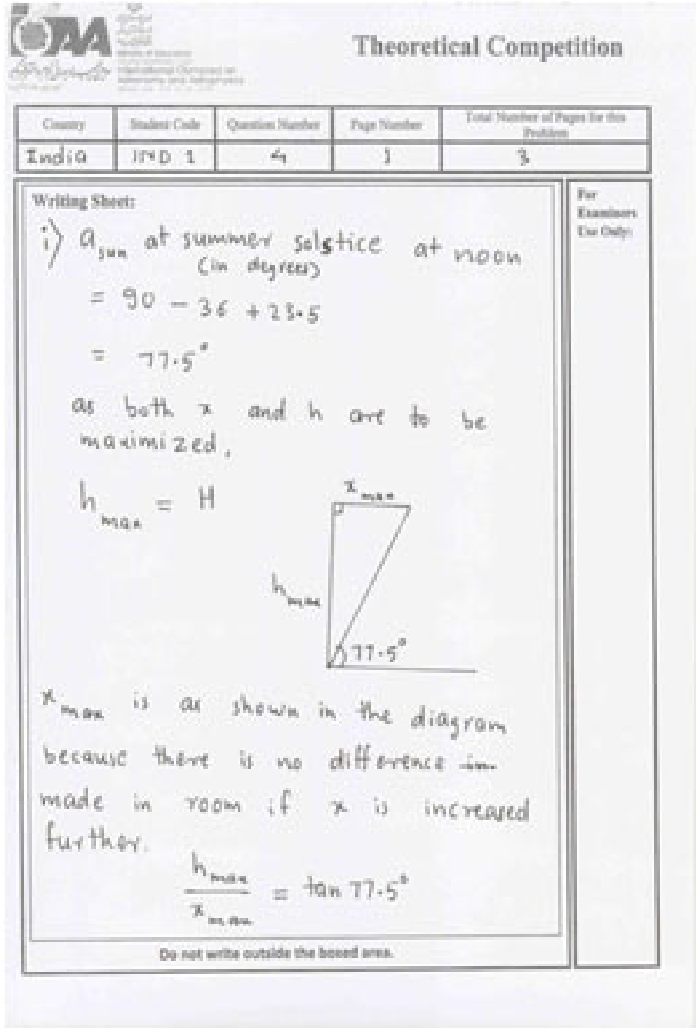
$$\Rightarrow R = \frac{2 G m_p}{g}\left(1+\frac{m_m}{m_p}\right)$$

$m_p = \frac{4}{3}\pi R^3 \rho$, $m_m = 50$ kg, $g = 9.81$ m/s^2

Answer Sheet:

Do not write outside the boxed area.

For Examiners Use Only:



Theoretical Competition

Country	Student Code	Question Number	Page Number	Total Number of Pages for the Problem
India	IND 1	4	1	3

Writing Sheet:

i) a_{sun} at summer solstice at noon (in degrees)

$= 90 - 36 + 23.5$

$= 77.5°$

as both x and h are to be maximized,

$h_{max} = H$

x_{max}

h_{max}

$77.5°$

x_{max} is as shown in the diagram because there is no difference ~~in~~ made in room if x is increased further.

$$\frac{h_{max}}{x_{max}} = \tan 77.5°$$

Do not write outside the boxed area.

For Examiners Use Only:

Theoretical Competition

Country	Student Code	Question Number	Page Number	Total Number of Pages for the Problem
India	IND 1	6	2	3

Writing Sheet:

$$\Rightarrow x_{max} = \frac{H}{\tan 77.5°}$$

$$\boxed{\begin{aligned} x_{max} &= \cancel{6.65 \times 10^{-4}}\ 0.66 \text{ m} \\ h_{max} &= H = 3.00 \text{ m} \end{aligned}}$$

ii) a_{sun} at winter solstice at noon

$$= 90 - 36 - 23.5$$

$$= 30.5°$$

again $h_{max} = H$

$$\tan 30.5 = \frac{H}{D + x_{max}}$$

$$\Rightarrow x_{max} = \frac{H}{\tan 30.5} - D$$

$$\Rightarrow \boxed{x_{max} = 0.59 \text{ m}}$$

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For Examiners Use Only:

Theoretical Competition

Country	Student Code	Question Number	Page Number	Total Number of Pages for the Problem
India	IND 1	5	1	2

Writing Sheet:

Let θ be the angle which the observer sees 'extra' compared to if he were at sea level.

ie, the observer can see stars of altitude $-\theta$ for observer at sea level.

$$\cos\theta = \frac{R}{R+h}$$

hence maximum pole distance of a circumpolar star is $\phi + \theta$

$$\therefore \delta_{min} = 90 - (\phi + \theta)$$

$$= 90 - \theta - \phi$$

$$= \sin^{-1}\frac{R}{R+h} - \phi$$

Do not write outside the boxed area.

For Examiners Use Only:

Theoretical Competition

Country	Student Code	Problem Number	Page Number	Total Number of Pages for this Problem
India	IND 1	6	2	2

Writing Sheet:

$$\frac{1}{2} m v_i^2 - \frac{3}{2}\frac{GMm}{R} = \frac{1}{2} m \frac{2GM}{R} - \frac{GMm}{R}$$

$$= 0$$

$$\Rightarrow m v_i^2 = \frac{3GMm}{R}$$

$$\Rightarrow \boxed{v_i = \sqrt{\frac{3GM}{R}}}$$

Answer Sheet:

escape velocity $v_i = \sqrt{\frac{3GM}{R}}$

Do not write outside the boxed area.

For Examiners Use Only:

Results

- Theoretical Exam Marks
- Practical Exam Marks
- Observational Exam Marks
- 3 RD IOAA Medalists and Honorable Mentions
- Special Prizes

Theoretical Exam

Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Total
BGD1	9.2	7.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	9.6	0.0	3.6	2.0	0.0	38.7
BGD2	9.2	6.0	7.0	4.6	0.0	10.0	5.6	8.0	0.0	0.0	0.0	2.0	7.6	0.0	0.0	0.0	8.5	68.5
BGD3	8.2	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	4.0	0.0	15.2
BGD4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BGD5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BLR1	7.0	0.0	8.0	3.0	3.0	0.0	10.0	2.0	0.0	0.0	0.0	4.0	10.0	8.0	10.0	31.0	21.2	117.2
BLR2	10.0	3.0	7.0	7.6	3.0	0.0	9.6	6.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	4.0	19.2	78.4
BLR3	9.2	10.0	9.6	0.0	3.0	10.0	9.6	0.0	0.0	0.0	0.0	10.0	10.0	10.0	7.0	0.0	20.5	108.9
BLR4	9.2	10.0	9.0	9.6	8.0	10.0	10.0	6.0	9.4	0.0	0.0	9.6	10.0	7.0	10.0	42.0	40.0	199.8
BLR5	9.2	9.0	5.0	8.0	10.0	10.0	10.0	10.0	0.0	0.0	4.0	8.0	10.0	9.6	4.0	25.0	13.0	144.8
BOL1	9.2	9.0	9.0	7.6	5.0	10.0	8.0	0.0	0.0	0.0	4.0	6.0	4.0	9.6	10.0	0.0	19.5	110.9
BOL2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOL3	6.0	3.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	12.0
BOL4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BOL5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BRA1	6.0	7.0	10.0	3.0	6.6	10.0	10.0	0.0	10.0	0.0	0.0	0.0	9.6	9.6	10.0	0.0	13.0	104.8
BRA2	7.2	9.0	8.0	10.0	5.0	10.0	6.0	6.0	2.0	9.6	9.8	8.0	10.0	10.0	7.0	16.0	10.0	143.6
BRA3	9.2	9.0	7.0	9.6	10.0	10.0	8.0	8.0	6.0	2.0	0.0	10.0	10.0	10.0	10.0	43.0	20.0	181.8
BRA4	10.0	9.0	9.6	0.0	0.0	10.0	10.0	0.0	8.4	0.0	0.0	0.0	9.6	9.6	10.0	36.0	22.0	144.2
BRA5	7.0	10.0	8.0	9.6	10.0	10.0	9.6	0.0	9.4	0.0	6.0	2.0	9.6	9.6	10.0	43.0	21.0	174.8
CHN1	8.2	10.0	8.0	4.5	10.0	10.0	9.6	6.0	9.4	2.0	3.5	10.0	10.0	10.0	0.0	45.0	17.0	173.2
CHN2	9.2	10.0	6.0	10.0	10.0	10.0	9.6	10.0	9.4	0.0	5.0	8.0	10.0	10.0	10.0	43.0	23.0	193.2
CHN3	9.2	0.0	5.0	4.2	4.0	0.0	5.6	10.0	0.0	0.0	2.0	3.6	7.6	9.6	0.0	2.0	14.0	76.8

Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Total
CHN4	8.2	0.0	8.0	6.1	4.6	0.0	3.0	10.0	2.0	0.0	0.0	2.0	10.0	10.0	0.0	13.0	14.0	90.9
CHN5	9.2	9.0	8.0	9.2	10.0	10.0	9.6	10.0	9.4	0.0	0.0	2.0	9.6	9.6	10.0	40.0	25.5	181.1
GRC1	6.0	9.0	0.0	4.5	0.0	2.0	9.6	0.0	0.0	0.0	4.0	2.0	0.0	0.0	0.0	14.0	13.0	64.1
GRC2	8.4	9.0	5.0	3.0	0.0	1.0	4.6	0.0	2.0	0.0	2.5	6.0	9.6	10.0	0.0	7.0	20.5	88.6
GRC3	4.0	9.0	2.0	7.2	1.0	2.0	0.0	0.0	0.0	0.0	0.0	4.0	1.0	10.0	0.0	3.0	7.5	50.7
GRC4	9.2	6.0	0.0	9.6	0.0	0.0	9.6	0.0	0.0	0.0	0.0	2.0	0.0	9.6	2.0	0.0	17.5	65.5
GRC5	9.2	0.0	1.0	8.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	17.5	45.7
IDN1	9.2	9.0	10.0	0.0	3.0	0.0	5.6	8.0	2.0	0.0	0.0	4.0	10.0	10.0	0.0	0.0	20.5	91.3
IDN2	9.2	10.0	8.0	10.0	10.0	2.0	6.0	6.0	0.0	0.0	9.8	3.6	9.6	10.0	10.0	0.0	22.5	126.7
IDN3	6.0	0.0	9.6	0.0	0.0	2.0	5.6	4.0	0.0	0.0	0.0	6.0	9.6	0.0	9.6	4.0	17.5	73.9
IDN4	9.2	9.0	7.0	0.0	0.0	0.0	6.0	10.0	2.0	0.0	7.0	2.0	10.0	0.0	10.0	0.0	11.5	83.7
IDN5	10.0	9.0	10.0	8.0	10.0	2.0	10.0	10.0	10.0	0.0	9.5	10.0	10.0	10.0	10.0	29.0	14.5	172.0
IND1	9.0	10.0	3.0	7.6	2.6	10.0	10.0	0.0	6.0	10.0	0.0	2.0	10.0	10.0	10.0	44.0	37.5	181.7
IND2	9.2	9.0	7.0	4.5	10.0	10.0	9.6	10.0	2.0	9.6	2.0	4.0	8.0	8.5	8.0	19.0	29.0	159.4
IND3	9.2	9.0	10.0	9.6	10.0	10.0	10.0	10.0	9.4	10.0	9.8	10.0	10.0	10.0	10.0	43.0	41.5	231.5
IND4	10.0	10.0	8.0	3.0	10.0	10.0	10.0	6.0	9.4	10.0	0.0	9.6	10.0	10.0	10.0	42.0	37.5	205.5
IND5	10.0	10.0	10.0	10.0	7.6	10.0	7.6	10.0	8.4	8.0	9.8	10.0	10.0	8.0	10.0	43.0	26.0	208.4
IRG1	9.2	10.0	7.0	6.1	4.6	4.0	9.6	10.0	2.0	9.6	0.0	8.0	10.0	10.0	5.0	41.0	30.5	176.6
IRG2	9.2	10.0	7.0	4.5	9.6	10.0	8.0	6.0	8.4	9.6	9.8	8.0	9.6	10.0	10.0	44.0	24.5	198.2
IRG3	9.2	10.0	7.0	9.6	4.6	10.0	8.0	8.0	9.4	9.6	6.0	9.6	10.0	10.0	10.0	42.5	30.0	203.5
IRG4	6.0	9.0	10.0	7.6	5.0	0.0	9.6	6.0	7.4	0.0	0.0	5.0	10.0	10.0	0.0	42.0	15.0	142.6
IRN1	9.2	10.0	7.0	7.6	3.0	10.0	8.0	10.0	10.0	10.0	9.8	10.0	10.0	8.0	10.0	42.0	41.0	215.6
IRN2	10.0	10.0	10.0	7.6	10.0	7.0	9.6	10.0	9.4	10.0	9.5	10.0	10.0	10.0	7.0	42.0	30.0	212.1
IRN3	10.0	10.0	10.0	3.0	5.0	10.0	9.6	10.0	10.0	9.6	10.0	10.0	10.0	10.0	10.0	37.0	40.0	214.2
IRN4	9.2	10.0	9.0	4.5	4.6	10.0	10.0	10.0	6.0	10.0	9.8	10.0	10.0	10.0	10.0	29.0	32.0	194.1

Theoretical Exam

Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Total
IRN5	10.0	9.0	10.0	3.0	10.0	2.0	8.0	10.0	10.0	0.0	0.0	5.0	10.0	9.5	6.0	44.0	28.0	174.5
KAZ1	9.2	10.0	5.0	7.6	10.0	10.0	10.0	8.0	3.0	0.0	0.0	0.0	10.0	9.6	0.0	1.0	0.0	93.4
KAZ2	9.2	1.0	2.0	3.0	3.0	3.0	8.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	48.2
KHM1	9.2	9.0	6.0	1.5	0.0	0.0	5.6	0.0	0.0	0.0	0.0	6.0	2.0	10.0	0.0	0.0	20.5	69.8
KHM2	1.0	0.0	2.0	1.5	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	1.0	0.0	10.5
KHM3	6.0	8.4	4.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	26.4
KHM4	9.2	3.0	4.0	0.0	0.0	4.0	0.0	6.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0	0.0	28.2
KHM5	0.0	0.0	5.0	0.0	0.0	2.0	0.0	6.0	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	7.0	25.6
KOR1	9.2	9.0	10.0	9.2	10.0	10.0	8.6	10.0	2.0	9.6	9.8	9.6	10.0	9.6	6.0	44.0	37.5	214.1
KOR2	6.0	9.0	4.0	4.5	3.4	0.0	5.6	0.0	9.4	10.0	5.0	8.0	10.0	9.6	5.0	12.0	37.0	138.5
KOR3	9.2	7.0	10.0	8.0	10.0	10.0	9.6	2.0	7.4	9.6	6.0	4.0	9.6	9.6	10.0	42.0	22.5	186.5
KOR4	9.2	9.0	8.0	3.0	5.0	4.0	6.0	6.0	0.0	0.0	0.0	10.0	10.0	5.0	10.0	17.0	33.0	135.2
KOR5	9.2	9.0	7.0	8.0	9.6	2.0	9.6	8.0	9.4	0.0	5.0	4.0	9.6	10.0	10.0	32.0	22.5	164.9
LKA1	2.0	9.0	6.0	3.9	4.6	10.0	9.6	10.0	0.0	0.0	4.0	4.0	10.0	9.6	4.0	32.0	19.0	137.7
LKA2	2.0	3.0	3.0	6.0	2.6	0.0	5.6	4.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	18.0	47.2
LKA3	6.0	10.0	8.0	4.5	5.0	10.0	9.6	6.0	0.0	0.0	0.0	4.0	10.0	0.0	0.0	0.0	17.0	90.1
LKA4	9.2	9.0	3.0	2.4	0.0	0.0	5.6	0.0	0.0	0.0	4.0	2.0	9.6	0.0	0.0	0.0	15.5	60.3
LKA5	6.0	10.0	7.0	0.0	0.0	0.0	5.6	4.0	0.0	0.0	0.0	4.0	0.0	0.0	1.0	0.0	17.5	55.1
LTU1	7.2	0.0	3.0	7.7	1.0	0.0	2.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	15.7	46.6
LTU2	9.2	9.0	9.0	0.0	1.0	0.0	5.6	6.0	0.0	0.0	0.0	0.0	0.0	9.6	8.0	1.0	18.0	76.4
LTU3	9.2	10.0	0.0	9.6	5.0	0.0	10.0	0.0	10.0	0.0	0.0	0.0	10.0	10.0	0.0	31.0	8.0	112.8
LTU4	9.2	8.0	6.0	10.0	8.0	10.0	10.0	8.0	0.0	2.0	0.0	8.0	0.0	10.0	10.0	12.0	13.5	124.7
POL1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POL2	9.2	9.0	10.0	7.6	7.2	10.0	9.6	2.0	7.4	0.0	0.0	8.0	10.0	10.0	10.0	28.0	16.0	154.0

Theoretical Exam

Code	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Total
POL3	9.2	10.0	0.0	10.0	5.0	10.0	9.6	0.0	3.0	0.0	9.8	8.0	0.0	0.0	10.0	34.0	23.5	142.1
POL4	9.2	10.0	8.0	9.6	10.0	10.0	10.0	10.0	2.0	9.6	9.8	9.6	9.6	9.6	8.0	40.0	38.0	213.0
POL5	8.2	1.0	0.0	0.0	9.6	0.0	8.6	4.0	0.0	0.0	0.0	4.0	9.6	9.6	9.6	3.0	19.5	86.7
ROM1	8.2	10.0	7.0	9.2	10.0	10.0	9.6	10.0	1.0	8.0	9.8	5.6	10.0	10.0	4.0	41.0	44.5	207.9
ROM2	9.2	10.0	4.0	10.0	10.0	10.0	10.0	0.0	9.4	10.0	9.5	4.0	10.0	10.0	10.0	45.0	30.0	201.1
ROM3	8.2	9.0	7.0	7.6	9.6	2.0	5.6	6.0	0.0	8.6	5.0	6.0	9.6	3.0	4.0	8.0	17.0	116.2
ROM4	8.2	9.0	10.0	9.2	10.0	10.0	9.6	10.0	7.4	0.0	9.5	10.0	10.0	10.0	10.0	44.0	11.0	187.9
ROM5	9.2	8.0	10.0	7.6	9.4	10.0	5.6	10.0	2.0	9.6	6.0	8.0	10.0	10.0	4.0	43.0	16.0	178.4
SRB1	9.2	10.0	9.0	9.6	10.0	10.0	6.0	10.0	2.0	0.0	0.0	6.0	10.0	9.5	10.0	45.0	34.5	190.8
SRB2	9.2	9.0	4.0	7.6	9.6	8.0	5.6	6.0	6.0	10.0	0.0	4.0	9.6	10.0	10.0	33.0	25.0	166.6
SRB3	9.2	10.0	10.0	7.6	4.6	5.0	5.6	0.0	2.0	0.0	0.0	4.0	9.6	9.5	0.0	10.0	16.6	103.7
SRB4	6.0	10.0	6.0	9.2	10.0	2.0	5.6	8.0	9.4	9.6	0.0	9.6	9.6	0.0	9.6	41.0	22.0	167.6
SVK1	8.2	3.0	9.5	4.5	6.0	0.0	10.0	10.0	0.0	0.0	0.0	2.0	9.6	9.6	0.0	32.0	21.5	125.9
SVK2	8.2	9.0	0.0	8.0	10.0	0.0	9.6	10.0	0.0	0.0	0.0	4.0	6.0	8.0	10.0	3.0	21.0	106.8
SVK3	9.2	10.0	8.0	9.6	4.0	2.0	10.0	10.0	2.0	10.0	0.0	4.0	10.0	10.0	10.0	4.0	8.0	120.8
SVK4	9.2	10.0	10.0	10.0	6.0	10.0	9.0	10.0	0.0	10.0	0.0	9.1	6.5	10.0	10.0	16.0	26.5	162.3
THA1	8.2	10.0	7.0	9.6	5.0	10.0	10.0	9.0	0.0	9.6	9.8	8.0	10.0	10.0	10.0	44.3	17.0	187.5
THA2	9.2	10.0	10.0	3.0	4.6	2.0	8.0	9.0	2.0	0.0	9.8	2.0	10.0	2.0	4.0	41.0	21.5	148.1
THA3	7.0	10.0	10.0	4.5	10.0	10.0	10.0	10.0	9.4	10.0	9.5	10.0	10.0	8.0	10.0	42.5	29.0	209.9
THA4	10.0	9.0	6.0	4.5	5.0	0.0	9.6	9.0	0.0	6.0	2.0	8.0	10.0	0.0	6.0	19.0	19.5	123.6
THA5	10.0	9.4	10.0	4.5	8.0	5.0	5.6	9.0	0.0	0.0	5.0	4.0	10.0	10.0	4.0	45.0	19.0	158.5

Practical Exam

Code	CCD	VENUS	Total
BGD1	0	13	13
BGD2	0	21	21
BGD3	0	4	4
BGD4	0	0	0
BGD5	0	0	0
BLR1	50	60	110
BLR2	0	4	4
BLR3	40	60	100
BLR4	40	60	100
BLR5	15	57.6	72.6
BOL1	0	44	44
BOL2	0	0	0
BOL3	0	10	10
BOL4	0	0	0
BOL5	0	0	0
BRA1	12	60	72
BRA2	27	58.8	85.8
BRA3	19	60	79
BRA4	12	58	70
BRA5	13	60	73
CHN1	32	60	92
CHN2	34	36	70
CHN3	7	4	11

Code	CCD	VENUS	Total
CHN4	20	56	76
CHN5	31	60	91
GRC1	5	54	59
GRC2	20	50	70
GRC3	0	57	57
GRC4	14	56	70
GRC5	3	38	41
IDN1	36	58.4	94.4
IDN2	33	60	93
IDN3	38	19	57
IDN4	34.4	12	46.4
IDN5	42	60	102
IND1	43	60	103
IND2	4	60	64
IND3	35	60	95
IND4	32	57.6	89.6
IND5	24	49	73
IRG1	22	54	76
IRG2	36	56	92
IRG3	12	52.9	64.9
IRG4	14	56	70
IRN1	27	57.2	84.2
IRN2	29	59.4	88.4

Practical Exam

Code	CCD	VENUS	Total	Code	CCD	VENUS	Total
IRN3	19	60	79	POL1	0	0	0
IRN4	13	53.8	66.8	POL2	25	60	85
IRN5	29	59.2	88.2	POL3	38	60	98
KAZ1	14	50.4	64.4	POL4	31	60	91
KAZ2	12	0	12	POL5	37	60	97
KHM1	0	28	28	ROM1	31	60	91
KHM2	0	1	1	ROM2	20	60	80
KHM3	0	12	12	ROM3	11	56	67
KHM4	0	29	29	ROM4	20	60	80
KHM5	0	0	0	ROM5	10	46	56
KOR1	36	59	95	SRB1	25	60	85
KOR2	27	51	78	SRB2	22	60	82
KOR3	29	60	89	SRB3	1	60	61
KOR4	11	57	68	SRB4	23	60	83
KOR5	34	59	93	SVK1	27	52	79
LKA1	14	52	66	SVK2	22	60	82
LKA2	13	24	37	SVK3	12	15	27
LKA3	22	26.5	48.5	SVK4	16	52	68
LKA4	12	28	40	THA1	5	60	65
LKA5	2	3	5	THA2	10	51	61
LTU1	16	31	47	THA3	50	60	110
LTU2	14	15	29	THA4	34	60	94
LTU3	14	60	74	THA5	37	54	91
LTU4	56	52	108				

Observational Exam

Code	P2	P3	Total	Code	P2	P3	Total
BGD1	75	60	135	CHN4	35	40	75
BGD2	0	40	40	CHN5	50	70	120
BGD3	0	50	50	GRC1	35	40	75
BGD4	0	0	0	GRC2	35	40	75
BGD5	0	0	0	GRC3	25	70	95
BLR1	30	0	30	GRC4	45	65	110
BLR2	52	55	107	GRC5	40	50	90
BLR3	65	75	140	IDN1	60	65	125
BLR4	57	65	122	IDN2	50	10	60
BLR5	60	60	120	IDN3	70	60	130
BOL1	80	65	145	IDN4	40	50	90
BOL2	0	0	0	IDN5	35	0	35
BOL3	15	0	15	IND1	80	40	120
BOL4	0	0	0	IND2	15	60	75
BOL5	0	0	0	IND3	80	75	155
BRA1	80	40	120	IND4	80	60	140
BRA2	80	80	160	IND5	80	45	125
BRA3	80	60	140	IRG1	75	60	135
BRA4	80	40	120	IRG2	75	50	125
BRA5	55	60	115	IRG3	75	50	125
CHN1	55	55	110	IRG4	80	65	145
CHN2	65	65	130	IRN1	80	60	140
CHN3	70	60	130	IRN2	80	60	140

Observational Exam

Code	P2	P3	Total	Code	P2	P3	Total
IRN3	80	70	150	POL1	0	0	0
IRN4	80	45	125	POL2	75	75	150
IRN5	80	60	140	POL3	60	62	122
KAZ1	65	0	65	POL4	80	55	135
KAZ2	0	0	0	POL5	80	50	130
KHM1	25	0	25	ROM1	70	65	135
KHM2	5	0	5	ROM2	80	62	142
KHM3	35	0	35	ROM3	80	60	140
KHM4	0	0	0	ROM4	70	50	120
KHM5	0	0	0	ROM5	80	65	145
KOR1	27	60	87	SRB1	50	55	105
KOR2	40	70	110	SRB2	60	70	130
KOR3	45	60	105	SRB3	35	55	90
KOR4	55	60	115	SRB4	80	80	160
KOR5	75	40	115	SVK1	60	40	100
LKA1	55	0	55	SVK2	70	40	110
LKA2	30	50	80	SVK3	40	60	100
LKA3	40	0	40	SVK4	45	50	95
LKA4	35	0	35	THA1	65	62	127
LKA5	45	25	70	THA2	0	60	60
LTU1	70	65	135	THA3	75	60	135
LTU2	45	75	120	THA4	50	70	120
LTU3	80	0	80	THA5	40	40	80
LTU4	0	0	0				

Medalists and Honorable Mentions of 3rd IOAA

First name	Last name	Code	Country	Total	Normalized Score	Medal
Nitin	Jain	IND3	India	921.98	104.33	Gold
Nathanan	Tantivasadakarn	THA3	Thailand	880.48	99.64	Gold
Przemyslaw	Mroz	POL4	Poland	848.65	96.03	Gold
Mehrnoosh	Shafieezade Abade	IRN2	Iran	845.67	95.70	Gold
HamidReza	Akbari	IRN1	Iran	845.67	95.70	Gold
Shahab	Sarmashghi	IRN3	Iran	840.71	95.13	Gold
Constantin	Marius	ROM1	Romania	835.90	94.59	Gold
Kedar	Tatwawadi	IND4	India	831.67	94.11	Gold
Valadimir	Horoshko	BLR4	Belarus	822.21	93.04	Gold
Ho Jin	Cho	KOR1	Korea	814.73	92.20	Gold
Nima	Chartab Soltani	IRG2	Iran (Guest)	804.35	91.02	Gold
Zelko	Ioana Alexandra	ROM2	Romania	802.54	90.82	Gold
Aniruddha	Bapat	IND5	India	790.27	89.43	Silver
Sujeet	Gholap	IND1	India	781.33	88.42	Silver
Niloufar	Nilforoushan	IRG3	Iran (Guest)	761.15	86.13	Silver
Jiarui	Huang	CHN5	China	754.83	85.42	Silver
Aleksandar	Vasiljkovic	SRB1	Serbia	752.52	85.16	Silver
Ramyad	Hadidi	IRN5	Iran	751.25	85.01	Silver
Wenxiong	Li	CHN2	China	750.71	84.95	Silver
Leonardo	Stedile	BRA3	Brazil	750.33	84.91	Silver
Donghyeon	Kim	KOR3	Korea	750.10	84.88	Silver

ଓ Medalists and Honorable Mentions of 3rd IOAA

First name	Last name	Code	Country	Total	Normalized Score	Medal
Oprescu	Miruna Antonia	ROM4	Romania	748.92	84.75	Silver
Filip	Zivanovic	SRB4	Serbia	741.92	83.96	Silver
Shadi	Farahzadi	IRN4	Iran	741.60	83.92	Silver
Yanbin	Feng	CHN1	China	727.79	82.36	Silver
Ali	Aliyari	IRG1	Iran (Guest)	726.40	82.20	Silver
Thanawuth	Thanathibodee	THA1	Thailand	723.10	81.83	Silver
Yoonsoo	Park	KOR5	Korea	713.81	80.78	Silver
Natasa	Dragovic	SRB2	Serbia	709.21	80.25	Silver
Patryk	Pjanka	POL2	Poland	702.71	79.52	Silver
Margarint	Vlad Dumitru	ROM5	Romania	698.60	79.05	Silver
Hugo	Araujo	BRA5	Brazil	696.90	78.86	Silver
Daniel	Soares	BRA2	Brazil	687.75	77.83	Silver
Anas Maulidi	Utama	IDN5	Indonesia	675.31	76.42	Bronze
grzegorz	Gajda	POL3	Poland	673.79	76.25	Bronze
yossathorn	Tawabutr	THA5	Thailand	660.83	74.78	Bronze
Mohsen	Rezaei Zadeh	IRG4	Iran (Guest)	638.27	72.23	Bronze
Eugen	Hruska	SVK4	Slovakia	636.48	72.02	Bronze
Dzmitry	Yemelyanau	BLR5	Belarus	625.75	70.81	Bronze
Thiago	Hallak	BRA4	Brazil	618.83	70.03	Bronze
Puttiwat	Kongkaew	THA4	Thailand	617.33	69.86	Bronze
Hyun Kyu	Choi	KOR2	Korea	611.88	69.24	Bronze

Medalists and Honorable Mentions of 3rd IOAA

First name	Last name	Code	Country	Total	Normalized Score	Medal
Raman	Samusevich	BLR3	Belarus	611.83	69.24	Bronze
Nidhi	Pashine	IND2	India	602.15	68.14	Bronze
Uiryeol	Lee	KOR4	Korea	587.48	66.48	Bronze
Miroslav	jagelka	SVK1	Slovakia	573.08	64.85	Diploma
Alfiah Rizky Diana	Putri	IDN2	Indonesia	566.75	64.13	Diploma
Kruk	Sandor Josef	ROM3	Romania	561.33	63.52	Diploma
Taweewat	Somboonpanyakul	THA2	Thailand	553.58	62.64	Diploma
Anastasiya	Meishutovich	BLR1	Belarus	550.29	62.27	Diploma
Veena	Salim	IDN1	Indonesia	542.10	61.34	Diploma
Fridrich	Valach	SVK2	Slovakia	540.96	61.22	Diploma
Rafal	Sikora	POL5	Poland	540.71	61.19	Diploma
Povilas	Kanapickas	LTU4	Lithuania	536.75	60.74	Diploma
Galabada Devage Ashan	Ariyawansa	LKA1	Sri Lanka	533.31	60.35	Diploma
Otavio	Menezes	BRA1	Brazil	524.50	59.35	Diploma
Motiejus	valiunas	LTU3	Lithuania	511.17	57.84	Diploma
Alvaro Ruben	Hurtado Maldonado	BOL1	Bolivia	504.85	57.13	Diploma
Milena	Milosevic	SRB3	Serbia	470.71	53.27	Diploma
Mu	Bai	CHN4	China	455.90	51.59	Diploma
Peter	Kosec	SVK3	Slovakia	452.00	51.15	Diploma
Angelos	Tsiaras	GRC2	Greece	437.65	49.52	Diploma
Otemissov	Adilet	KAZ1	Kazakhstan	428.60	48.50	Diploma

☙ Medalists and Honorable Mentions of 3rd IOAA

First name	Last name	Code	Country	Total	Normalized Score	Medal
Dyah Arini	hutaminingtyas	IDN3	Indonesia	425.38	48.14	Diploma
Athanasios	Mitrakis	GRC4	Greece	412.71	46.70	Diploma
Stevanus Kristianto	Nugroho	IDN4	Indonesia	390.29	44.17	Diploma
Dainius	Kilda	LTU2	Lithuania	363.92	41.18	
Yasith	Mathangasinghe	LKA3	Sri Lanka	363.79	41.17	
Georgios	Valogiannis	GRC1	Greece	353.48	40.00	
Ilona	Kovieraite	LTU1	Lithuania	341.00	38.59	
Yunpeng	Li	CHN3	China	336.79	38.11	
Orfefs	Voutyras	GRC3	Greece	334.56	37.86	
katsiaryna	shakhorka	BLR2	Belarus	304.65	34.47	
Georgios	Lioutas	GRC5	Greece	284.04	32.14	
Eranga Thilina Jayashantha	Bannack Gedara	LKA2	Sri Lanka	270.08	30.56	
Basnyake Mudiyanselage Shyaminda bandara	basnayake	LKA4	Sri Lanka	266.90	30.20	
Wathna	Ly	KHM1	Cambodia	256.27	29.00	
Md. Shahriam arahim	Siddiqui	BGD2	Bangladesh	252.50	28.57	
Pritom	Mojumdar	BGD1	Bangladesh	250.40	28.33	
Godagama Rajapakshage Danula Sochiruwan	Godagama	LKA5	Sri Lanka	213.79	24.19	
Sultangazin	Adil	KAZ2	Kazakhstan	145.50	16.46	
Duong	Dyraden	KHM4	Cambodia	130.92	14.81	
Ly Sorng	Oeng	KHM3	Cambodia	123.81	14.01	

☙ Medalists and Honorable Mentions of 3rd IOAA

First name	Last name	Code	Country	Total	Normalized Score	Medal
Md. Marzuk	Shalvi	BGD3	Bangladesh	93.21	10.55	
Anita Carol	Padilla Vaca	BOL3	Bolivia	64.90	7.34	
Phorn	Sopheak	KHM5	Cambodia	64.00	7.24	
Sok Eng	Van	KHM2	Cambodia	33.02	3.74	
Hugo Roberto	Gutierrez	BOL2	Bolivia	0.00	0.00	
Md.Shahreer	Zahan	BGD4	Bangladesh	0.00	0.00	
Nibirh	Jawad	BGD5	Bangladesh	0.00	0.00	
Hesser Russell	Taboada Michel	BOL4	Bolivia	0.00	0.00	
Gustavo	Tobalin Cardenas	BOL5	Bolivia	0.00	0.00	
Piotr	Godlewski	POL1	Poland	0.00	0.00	

Special Prizes

Absolute Winner And Best In Theoretical Exam:

Nitin Jain(India)

- **Best In Practical Exam:**

Anastasia
Meishutovich
(Belarus)

Nathanan
Tantivasadakarn
(Thiland)

- **Best In Observational Exam:**

Flip
Zivanovic
(Serbia)

Daniel
Soares
(Brazil)

ↀ Special Prizes

❖ **Most Creative Solution:**

Yasith Mathangasinghe (Srilanka)

❖ **Most Concise Answer:**

Valadimir Horoshko (Belarus)

❖ **Most Organized Answer:**

Antonia Oprescu Miruna(Romania)

❖ **Most Skilful Observer:**

Kedar Tatwawadi (India)

❖ **Most Calm Observer:**

Flip Zivanovic (Serbia)

International Board Meeting

- Officers
- statues of the ioaa
- syllabus
- notes on international board meeting

Officers

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Associate Professor Boonrucksar Soonthornthum
Director of National Astronomical Institute of Thailand

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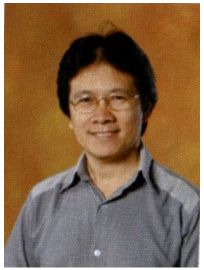
Fax: +66 5322 5524

Secretary:



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#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 period 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 finished 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 whole delegation), and the other –as pedagogical leader (responsible for the students). The accompanying persons become members of the International Board, where they have equal rights. Members of the International Board are treated as contact persons in participating countries concerning the affairs of the International Olympiad on Astronomy and Astrophysics until the next 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 between 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 one 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 the duties of the leaders of the regular teams.
Participation of a guest team always needs the agreement of 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 are classified in the same way as regular teams. They may receive diplomas and prizes, their names should be associated 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 two 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 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 the 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.

Syllabus of the 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. stellar systems : 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. Cosmology : Contents	Remarks
Elementary Cosmology	Cluster of galaxies, Dark matter, Gravitational lenses, Hubble’s Law, Big Bang, Cosmic Microwave Background Radiation

6. 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.

Note on International Board Meeting

For continuation of International Olympiad on Astronomy and Astrophysics, these countries declared their candidacy to host future IOAA events in the specified year.

China	2010
Poland	2011
Slovakia or Brazil	2012
Greece	2013
Romania	2014
Korea or Bangladesh	2015
Bolivia	2016
India	2017
Lithuania	2018

Appendices

- Gallery
- Newsletters

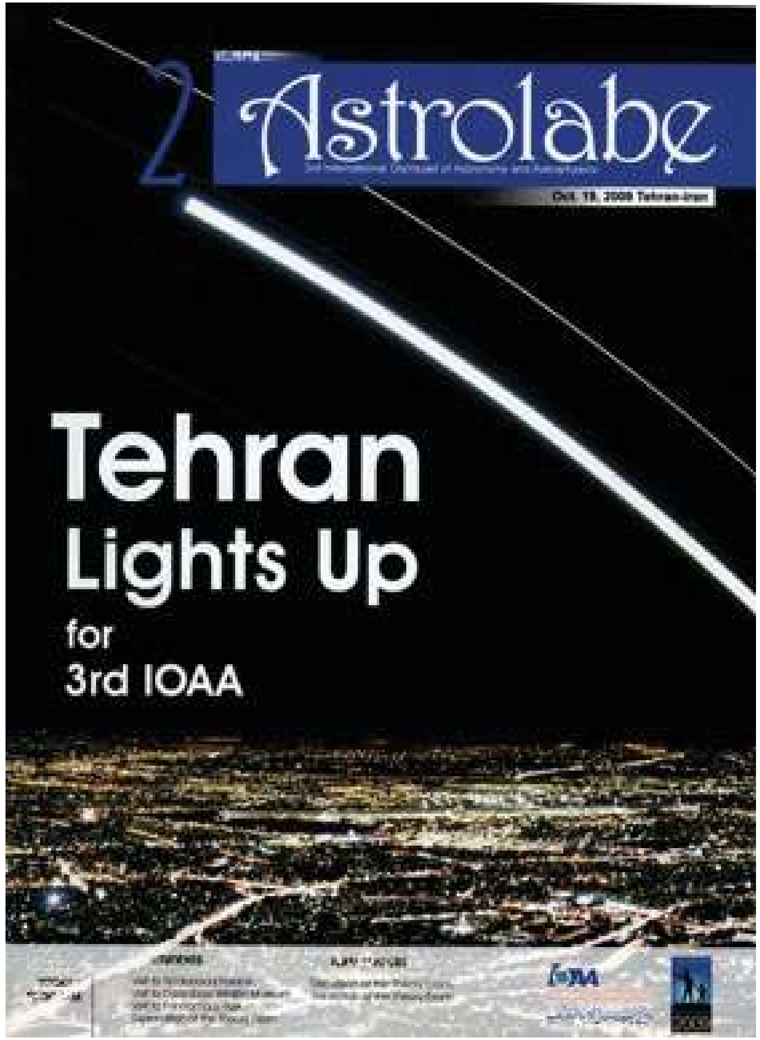

NGLADESH


WELCOME
TO
IRAN


Astronomy and Astrophysics



1
Astrolabe
Welcome to Iran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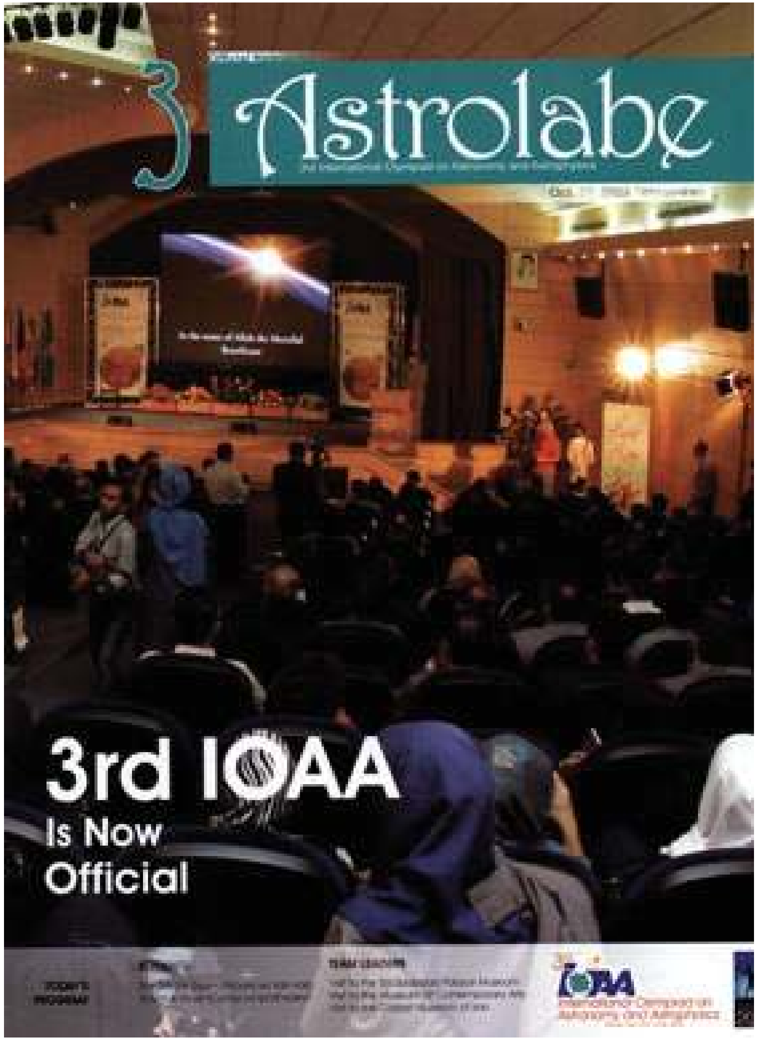
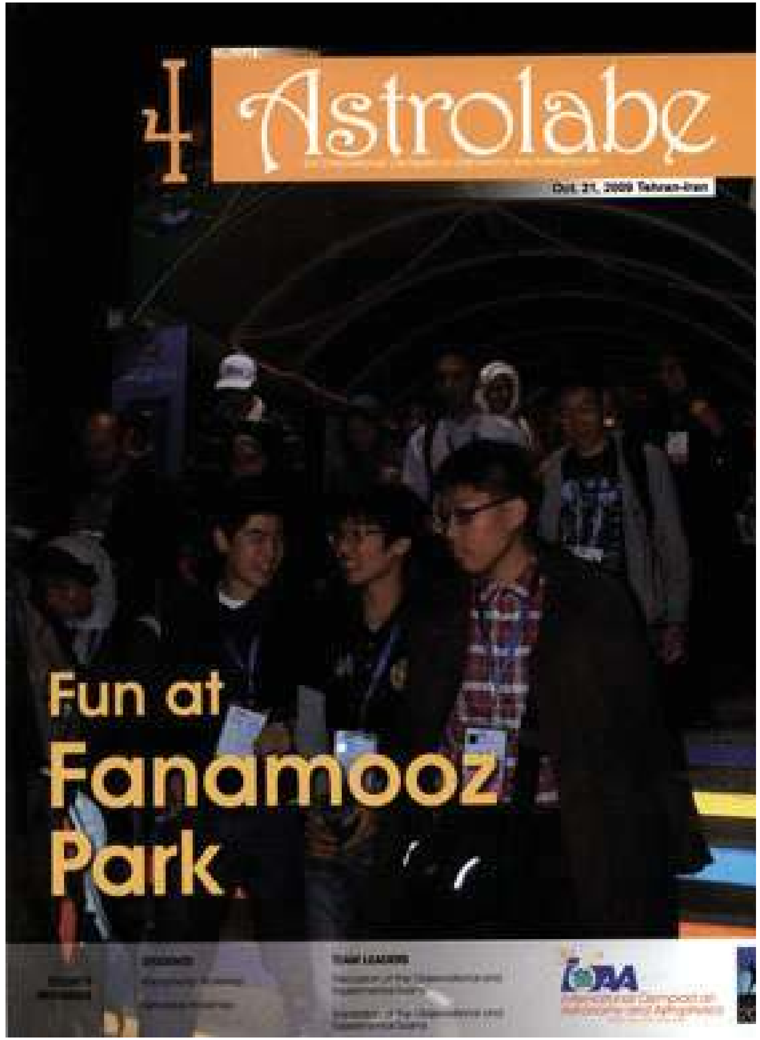
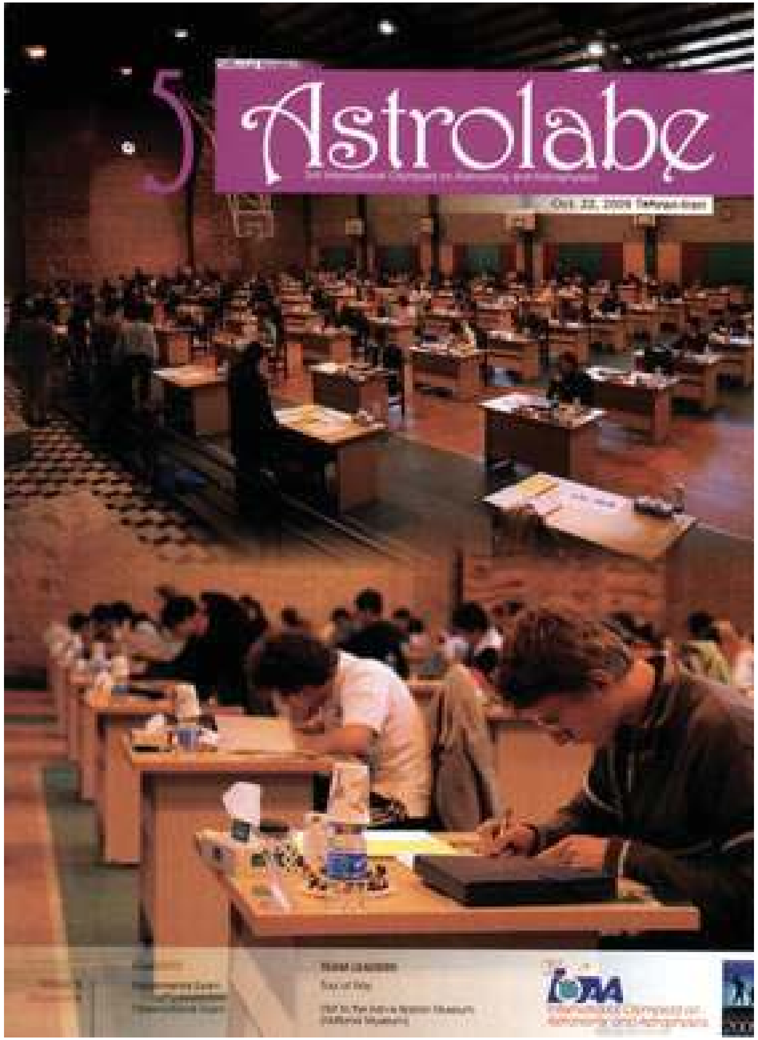
Tehran Lights Up for 3rd IOAA


3
Astrolabe
3rd IOAA
Is Now
Official
IOAA
International Olympiad on
Astronomy and Astrophysics


4
Astrolabe
Oct. 21, 2009 Tehran-Iran
Fun at
Fanamooz
Park
IOAA
International Olympiad on
Astronomy and Astrophysics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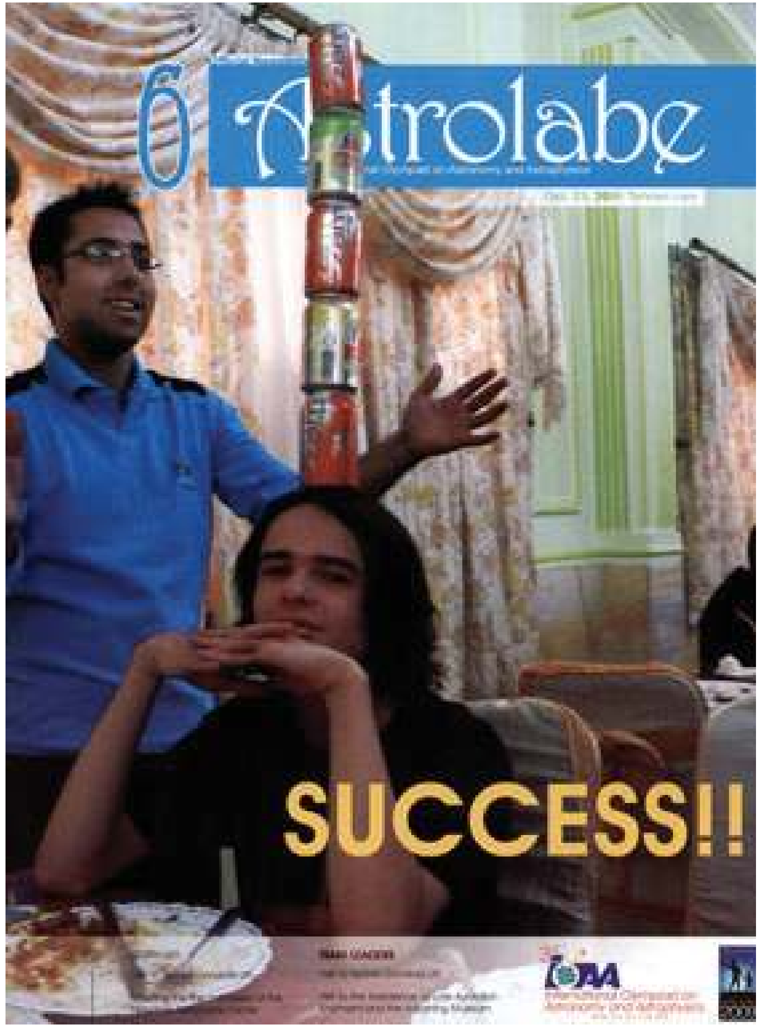
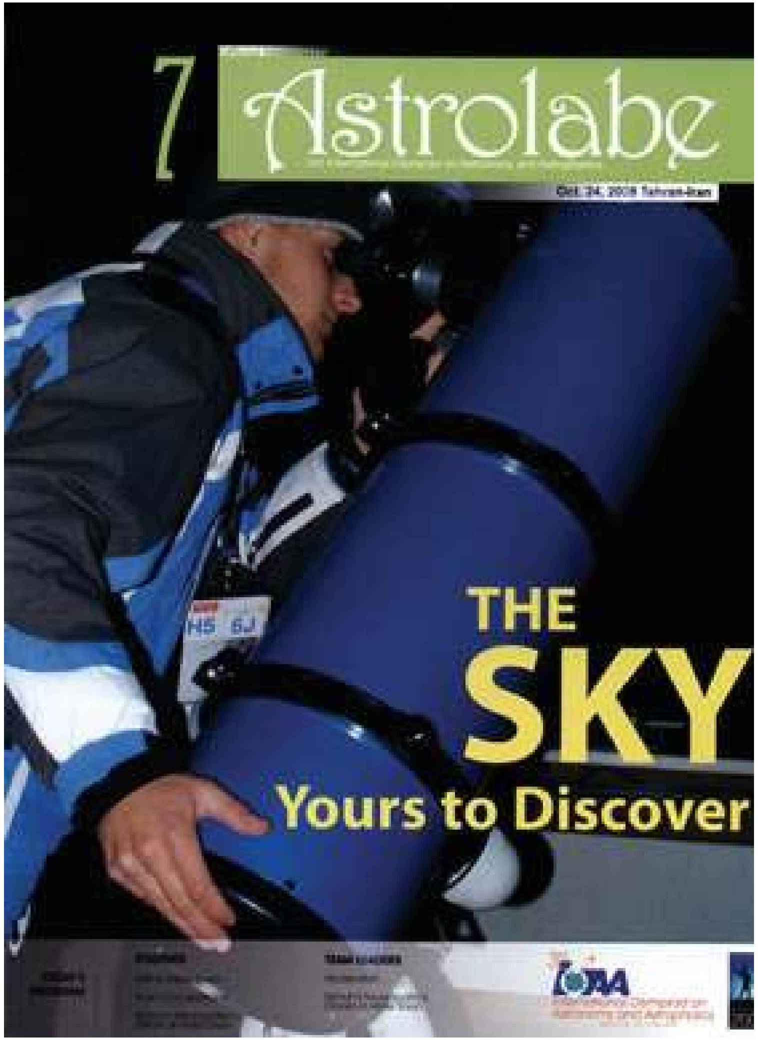
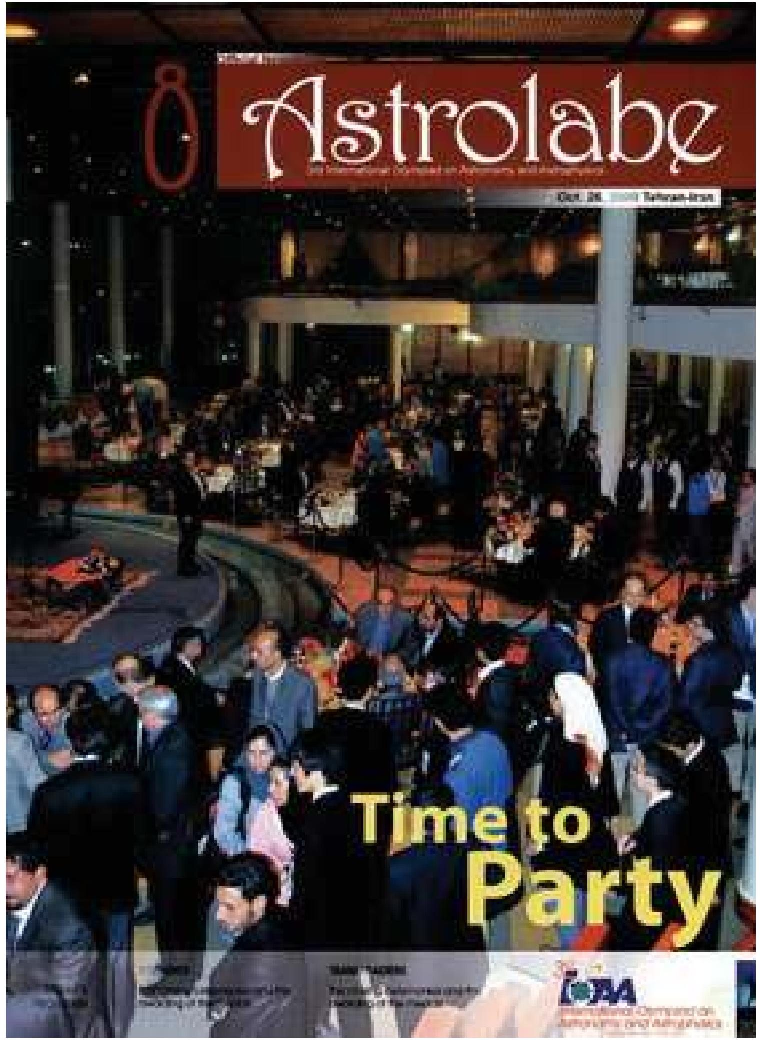
Astrolabe
IOAA


6
Astrolabe
SUCCESS!!
IOAA


7
Astrolabe
THE
SKY
Yours to Discover
IOAA
International Olympiad on Astronomy and Astrophysics


8
Astrolabe
Time to
Party
IOAA
International Olympiad on Astronomy and Astrophysics

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