46th International Physics Olympiad

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Mumbai, INDIA

Homi Bhabha Centre for Science Education
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Contents

Chapter 1. Glimpses of India: The host country of 46th IPhO 2015

A. About India

India, a constitutional democracy, is the second most populous country in the world with a population of about 1.3 billion. It covers an area of about 3,287,590 sq km. India is federal union of 29 states and 7 union territories. The country is as diverse culturally as it is geographically. It is the seat of the ancient Indus Valley civilization which flourished here some four to five millennia ago. Its rich and vibrant history is attested by a large number of historical monuments in different parts of the country. India is a multi-cultural multi-religious society. Currently, the country is witnessing rapid economic change, with modern technology slowly seeping into its socio-cultural fabric. Yet, the charm of old India stays and allures millions of people around the world. Tourism is a major foreign exchange earner for the country.

B. Geography and Climate

India is bounded by the Indian Ocean in the south, the Arabian sea in the west and the Bay of Bengal in the east. It shares land borders with China, Nepal, Bhutan, Myanmar, Bangladesh and Pakistan.

The north of India is bordered by the Himalayas, the world's highest mountain ranges. Moving down south the terrain becomes flatter and more hospitable. The North-East part of India is defined by the foothills of the Himalayas. The Vindhyachal ranges are located in almost the centre of India. Along with the Western Ghats, they separate the high Deccan plateau from the low lying plains and coastal regions.

Extending from the Gujarat peninsula down to Goa, the western coast is lined with some of the best beaches of India. The Western Ghats and the eastern hill ranges meet in the south in the Nilgiri hills. The major river systems in the sub-continent are the Ganges river system (Ganga, Yamuna, Brahmaputra and others), the Indus river system (mainly in Pakistan) and the Peninsular river system (Mahanadi, Godavari, Krishna, Kaveri, Narmada and Tapti).

India lies to the north of the equator between 6° 44' and 35° 30' north latitude and 68° 7' and 97° 25' east longitude. Indian coastline measures 7,517 km in length. The four major climatic groupings of the country are: tropical wet, tropical dry, subtropical humid and alpine. The main three seasons are: summer, rainy season and winter. Broadly, the summer

heat peaks between April and June; July and August are the wettest months and the winter lasts from November to February, though there are considerable variations across different regions.

The Southwest monsoon arrives in Kerala around June 1, reaches Mumbai around June10, and by mid- July covers the entire country. It withdraws by October. The southeast coast is affected by the short and surprisingly wet northeast monsoon, which brings rain from mid-October to the end of December. The Indian climate is strongly influenced by the Himalayas and the Thar Desert. The Himalayas prevent the cold Central Asian katabatic winds from blowing in, keeping the major part of the Indian subcontinent warm.

C. Culture- Language, Art, Cinema and Food

India's culture at its best exemplifies the theme of unity in diversity. It is among the oldest civilizations of the world and is thought to date back to at least 3000 B.C. Most of the major religions of the world: Hinduism, Islam, Christianity, Sikhism, Buddhism and Jainism are practiced in the country; there are also a small but significant number of Parsis and Jews. A fascinating feature of the country is its enormous linguistic diversity. Hindi has the largest number of native speakers but there are several other major languages such as Bengali, Telugu, Marathi, and Tamil, to name a few, which have a large number of native speakers and rich literature of their own. The Eighth Schedule of the Constitution lists 22 languages. In addition, there are numerous dialects of these languages.

English is spoken and understood widely, particularly in metropolitan areas, but has limited penetration at the grassroots level. It is also the medium of instruction in higher education in most of the country. Hindi and English both serve as the official languages of the Union. Hindi and most other regional languages, except the languages of the south, relate linguistically to Sanskrit, the classical Indian language brought into India during the Vedic period (circa. 1750-500 BC) in which are written most of the scholastic and religious texts of ancient India. The South Indian languages (Kannada, Telugu, Tamil, Tulu and Malayalam) belong to a different linguistic group-the Dravidian group, though there has been much mutual influence between the two families of languages. The medieval period, especially the Mughal rule saw the influence of Persian and also Arabic under which a distinct variant of Hindi or Hindustani, namely Urdu, evolved in North India. The two languages have similar grammar and syntax and a large common vocabulary which makes them almost indistinguishable in common discourse.

India has rich and variegated classical and folk traditions in art, music, dance and other performing arts. Indian classical dance forms such as Kathak, Bharat Natyam, Odissi, Kathakali, Kuchipudi and Manipuri are well-known for their grace and exquisite skill, Indian classical music has two distinct genres: Hindustani and Carnatic. The huge range of folk and tribal art in India is seen through media such as paintings, pottery, metal work, paper art, designing and weaving objects like toys and jewellery.

India is also the world's largest producer of films. India's first full-length motion picture was Raja Harishchandra (1913) and its first talkie, Alam Ara, was made in 1931. Some of the most popular Hindi films have been Guru Dutt's Pyaasa (1957), Raj Kapoor's Awaara (1951), Dilip Kumar's Ganga Jumna (1961) and, more recently, Aamir Khan's 3 Idiots (2009). Satyajit Ray's Apu Triology (1955-1959) in Bengali won major film awards at the international film festivals. Several other films of the Regional cinema as well as Hindi cinema have received critical acclaim within the country and abroad. Currently, Indian film industry produces more than 1000 feature films every year in more than 20 languages.

India has a free press and a vibrant and powerful electronic media with a large number of news and entertainment channels watched everyday by millions of people throughout the country. Its broadband internet connectivity is growing rapidly.

Indian food is rich in taste, variety and flavours. Be it exotic gravys and kababs or the simple dal-chaawal, Indian cuisine has something to cater to each and everyone's taste. The basis of any Indian meal is rice, roti, dal and sabzi (vegetables). Depending on the circumstances and availability fish and meat are added. India is also well known for its street food, be it aloo tikkis and bondas (potato patties), paani puris, pakoras and bhajias (vegetables fritters) or the bhel puri on the Chowpatty beach of Mumbai.

An Indian meal is often not complete without pickles, chutney and raita (plain yogurt combined with vegetables or fruits). For people with sweet tooth, the Indian cuisine offers equally relishing menu; payasam or kheer (rice pudding) is one of the India's favourite dessert and so is Gajar ka Halwa (grated carrot and condensed milk pudding) . Another delicious item is Gulab Jamun ,deep fried balls of khoya (reduced milk) dipped in rose-flavoured syrup. Kulfi is a firm textured Indian ice cream. Indian cuisine is as colorful as the people of India.

D. Modern Science

Ancient and medieval India had notable scholarship in mathematics, linguistics, astronomy and medicine as well as excellence in several technologies and crafts. However, modern science was introduced in India in the 19th century during the British rule. Some of the early great pioneers were P. C. Ray (chemistry), J. C. Bose (plant life and electromagnetics), S. Ramanujan (mathematics), S. N. Bose (physics), C.V. Raman (physics -- Nobel Laureate) and M. N. Saha (astrophysics). Post-independence, there has been a massive effort towards

the growth of science in India. Today there is scarcely any area of science in which the country does not have world class experts.

In technology too, India has made great strides in the areas of atomic energy, space and information technology. Today India is one of the few countries in the world to have successfully carried out missions to the Moon and Mars.

There has also been much effort in improving science education in Indian schools and colleges, in universalizing its access to all sections of the society as well as in promoting excellence among young students in learning science. The Science Olympiad programme of the country is one such effort. To know more about it please visit www.hbcse.tifr.res.in

E. Know India

The National Emblem

The National Emblem showing three lions is adapted from the Lion Capital of Sarnath erected by Ashoka- the Mauryan king. In the centre of the abacus (the support below the capital of the column) there is a wheel symbolizing the *Dharma Chakra* (wheel of law) with a bull on the right and a horse on the left. The words *Satyameva Jayate* (truth alone triumphs) are in Devanagari script.

The National Flag

The National Flag is also called Tiranga or Tricolour. The top panel of the flag is saffron, the middle panel white and the bottom panel is in green colour. The center of the flag shows the Ashoka Chakra in blue colour with 24 equally spaced spokes.

The National Animal

The Tiger -- the lord of the Indian Jungles -- evokes royalty, majesty and power. With its position at the top of the ecological pyramid, the Tiger is the symbol of India's wealth of wildlife. India
is home to nearly half of the world-wide population of tigers.

The National Bird

The Indian peacock, Pavo cristatus (Linaeus), the national bird of India, is a colourful, swan-sized bird, with a fan-shaped crest of feathers, a white patch under the eye and a long, slender neck.

The male of the species is more colourful than the female, with a glistening blue breast and neck, and a spectacular bronze-green train of around 200 elongated feathers. The female is brownish, slightly smaller than the male, and lacks the train. It is symbolic of many qualities -- grace, joy, pride, beauty and love.

The National Anthem

The national anthem is the song called Jana-gana-mana, which is composed and scored by Rabindranath Tagore, the great Bengali poet who received the Nobel Prize in Literature in 1913. The anthem in roman script is given below:

Jana-gana-mana-adhinayaka, jaya he Bharata-bhagya-vidhata!

Punjab-Sindhu-Gujarata-Maraatha-Dravida-Utkala-Banga

Vindhya-Himachala-Yamuna-Ganga uchchala-jaladhi-taranga

Tava shubha name jage, tava shubha ashish mage,

Gahe tava jaya-gatha.

Jana-gana-mangala-dayaka jaya he Bharata-bhagya-vidhata!

Jaya he, jaya he, jaya he, jaya jaya jaya, jaya he

Chapter 2. The City of Mumbai

Know the city: Mumbai

Mumbai, the capital city of Maharashtra, was known as Bombay until recently. It is a cluster of seven islands and is situated on the west coast of India. It is the most populous metropolitan area of the country.

Since earlier times, Mumbai developed as a major port and commercial centre and attracted trade from all over India. It is often called the commercial and financial capital of India. Various important institutions such as Reserve Bank of India, Bombay Stock Exchange, National Stock Exchange of India, Securities and Exchange Board of India and several multinational companies have their headquarters situated in Mumbai. The city also houses premier scientific institutes such as BARC, TIFR, NPCL and IIT.

Because of its ability to offer ample opportunities Mumbai attracts population from all parts of India, which adds diversity to its existing demography. It is the most cosmopolitan city in India. Though Marathi is a commonly spoken language in Mumbai and is the official language of the State, other languages such as Hindi, Gujarati, Urdu, Tamil, Telugu are also spoken among the masses. Mumbai is divided into three zones: south, central and north. Navi Mumbai (New Bombay) is an urban township or a satellite city developed to the east of Mumbai.

A. Geographic and Location

Mumbai is situated on an island in 18^0 55' N and 72^0 54' E. It lies off the coast of the Northern Konkan to the mouth of River Ulhas. It covers an area of 58.22 square km and is united at its northern most extreme with the larger island of Salsette (Thane District). The city has tropical wet and dry climate. The average annual temperature is 27.2 °C (81 °F), and the average annual rainfall is 2,167 mm (85 in). The period between June to September is when the city receives the south west monsoon rain.

B. Culture

The city was under Portuguese rule for more than a century after which it was transferred to the British in 1668. Later it was leased to British East India Company, who made it their headquarters. The city was a strong base for India's Independence movement during the early 20^{th} century. Mumbai (then known as Bombay) continued to grow as the commercial hub of the country even after India's independence. The city was named Mumbai in the year 1995.

Mumbai is also the entertainment capital of India, with the major part of Indian film industry (often called 'Bollywood') situated here. It is one of the largest centres of film production in the world.

Two important public services of Mumbai are its large suburban railway network and the bus network (the red coloured ones), which carry millions of people daily to their work places and back home. One will also sight on Mumbai roads, a very common yellow and black taxi. These taxis can be hailed in the streets and the fares are metered. The meter is stationed inside the taxi near the driver. The yellow and black taxis are Non- AC, while the AC taxis (also called as Cool Cabs) are blue and grey in colour. There are also range of AC and Non-AC cabs run by private companies. To hire these cabs one has to book them in advance. *In case you need to book a cab in advance, feel free to contact the Hotel reception.*

Another common mode of transport is the three wheeled vehicle called Rickshaw or Auto. It is advisable to a tourist to hire a taxi rather than an auto to travel in the city. Mumbai also boasts of newly introduced mass rapid transport system: Metro rail and Mono rail. It runs only in some parts of the city.

At any point of time you may notice hundreds of hustling-bustling Mumbaikars. The people of Mumbai are a tireless lot who have adapted themselves to the fast-paced life of the city and carry on with their daily routine with much wit and passion.

C. Places of interest

Gateway of India, Apollo Bunder

The gateway was built to commemorate the visit of King George V and Queen Mary in 1911. It served as a landing ground for passengers coming to India by ship. It is a beautiful monument of architecture and is built in Indo- Saracenic style and is a combination of Islamic and Gujarati architectural styles.

Source: "Rhaessner"/wikimedia commons

Chhatrapati Shivaji Terminus (CST, formerly known as Victoria Terminus)

It is an architectural masterpiece and a UNESCO World Heritage site. It is one of the busiest and finest functional railway stations of India. It was built in 1887 to commemorate the Golden Jubilee of Queen Victoria. The style of architecture is a superb blend of Victorian Italianate Gothic Revival and traditional Indian buildings. It stands as a symbol of Mumbai as a major mercantile port city in the Indian subcontinent.

Source: Joe Ravi"/wikimedia commons

Jehangir Art Gallery

It is a well-known venue for exhibitions of contemporary art. It was built in 1952 and was founded by Sir Cowasji Jehangir. It is situated in South Mumbai and is the epicenter of the art in the city. The art gallery also houses a well-stocked reference library.

S***ource:*** "Suryanarayan Ganesh"/ wikimedia commons

University of Mumbai

The University of Mumbai, Fort campus was established in 1857. The three buildings of the University are designed by Gilbert Scott, the architect who designed St. Pancras in London. The main building is designed in Venetian Gothic style and the convocation hall is in French Gothic style. The other campus of the University is situated in Kalina, Santacruz, a suburban area of Mumbai.

Sou***rce*** " Stefan"/ wikimadia commons

Marine Drive

It was built in 1952 on the reclaimed land of Back Bay. The official name of the road is Netaji Subhash Chandra Bose Road. A promenade lies parallel to the road. It is a 4.3 km long sweeping stretch of an avenue with Arabian Sea on one side giving it an enchanting appearance. It is also called the Queen's Necklace.

Source " I, Greg O'Beirne"/ wikimedia commons

Haji Ali Dargah

It is a white-washed mosque which is also a tomb of Sayyed Peer Haji Ali Shah Bukhari, who gave up all his worldly possessions before making a pilgrimage to Mecca. It is situated on an islet off the coast of Worli, south of Mumbai. People of all religions visit Dargah to get blessings of the revered Saint. One can also have a splendid view of sunset from the Dargah in the evening.

Source: " Shootatsightfoto"/ wikimedia commons

Sanjay Gandhi National Park

It is a large protected park on the northernmost part of the city and has an area of 104 sq km. It was known as Borivali National Park previously. The park lies in the protected forested hills in the suburbs of Borivali. The park has interesting species of flora and fauna and also houses a small population of leopards. The park is home to the 2400 year- old Kanheri caves. The caves are sculpted out of the rocky cliffs which lie within the park. Kanheri caves were Buddhist learning centres and are a protected archaeological site.

Source:"Shubhanshu Shukla"/ wikimedia commons

Global Vipassana Pagoda

The pagoda is a meditation hall near Gorai, which is located in the Northwest part of Mumbai. The construction of the pagoda was completed in November 2008. The pagoda was inaugurated on 8th February 2009. The pagoda is constructed as gratitude to Buddhist teaching and to offer a place to practice Vipassana meditation. The Global Vipassana Pagoda is styled on the lines of Shwedagon Pagoda at Yangon, Myanmar.

Source "Joe Ravi"/ wikimedia commons

D. Cuisines

Vada Pav
(Potato fritters in a bun)

Source:Deepeshmd"/wikimedia commons

Pohey
(Flattened rice snack)

Source: rovingI"/ wikimedia commons

Chivada
(Bombay mix)

Suralichi Wadi/Khandavi
(Chick pea flour rolls)

Pav Bhaji
(mixed vegetable dish with buns)

Source: "Rishika Palvankar"/ wikimedia commons

Sabudana vada
(Deep fried Sago snack)

Source:"Nick Gray"/wikiwmdia commons

Aamti
(spicy lentil curry)

Shrikhanda
(dessert made of sweet strained yogurt)

Source: Secretlondon

Bhel Puri
(Puffed rice snack with tangy tamarind sauce)

Source:"stu_spivack"/ wikmedia commons

Ukadiche modak
(steamed sweet rice dumplings)

Source:"Coolgama"/ wikimedia commons

E. Talk the Talk

English	**Maraathi**	**Hindi**
Hello	Namaskaar	Namaste
Welcome	Swaagat Ahey	Swaagat Hain!
Good Morning	Shubha prabhaat	Shubhprabhaat
Good Evening	Shubha sandhyaakaal	Shubhsandhya
Good Night	Shubha raatri	Shubhraatri
Thank You	Dhanyawaad	Dhanyawaad
Sorry	Maaf karaa	Maaf Kijiye!
Please	Krupaya	Krupaya
How are you?	Aapan kasey aahaat?	Aap Kaise hain?
I am fine	Me thik ahey.	Main theek hoon.
What is your name?	Aaple naav kay?	Aapka naam kya hain?
My name is …..	Maaze naav .... aahey.	Mera naam...hain.
Where are you from?	Aapan kuthun aalat?	Aap kahanse aayen hain?
I am from …...	Me .... hoon aalo. (male) Me .... hoon aale. (female)	Main....se aaya hoon. (Male)/ Main..se aayi hoon. (Female)
What is the time?	Kiti vaajle aahet?	Kitne bajey hain?
I understand	Mala samazata.	Main samajhta hoon.
I did not understand	Mala samazale nahi.	Mujhe samajh mein nahi aaya.
Please speak slowly	Krupaya zaraa halu bola.	Krupaya jara dheere boliye.
Please say that again	Poonha saangaa.	Phirse kahiye.
Excuse me	Kshamaa karaa	Kshama kijiye.
Please write it down	Krupaya lihun dya.	Krupaya likhakar dijiye.
How do you say... in Marathi/Hindi?	..... la Marathi madhye kay mhantat?	....ko Hindi mein kya kehte hain?
Help!	Madat karaa.	Madat kijiye.
Stop!	Thaamba!	Thhahriye!
Fire!	Aag!	Aag!
Call the Police	Polisaanna bolva!	Police ko bulao!
Where is the toilet	Shauchalay kuthey aahey?	Shauchalay kahan hain?
Have you eaten?	Jevlaat ka?	Aapne khana khaya?
Congratulations	Abhinandan!	Badhaee!
Goodbye	Punhaa bhetu!	Phir Milenge!

F. Numbers in Maraathi and Hindi

English	Maraathi	Hindi
One	Ek	Ek
Two	Doan	Do
Three	Teen	Teen
Four	Chaar	Chaar
Five	Paach	Paanch
Six	Sahaa	Cheh
Seven	Saath	Saat
Eight	Aath	Aath
Nine	Naoo	Naun
Ten	Dahaa	Dus

G. Days in Maraathi and Hindi

English	Maraathi	Hindi
Sunday	Ravivaar	Itvaar
Monday	Somvaar	Somvaar
Tuesday	Mangalvaar	Mangalvaar
Wednesday	Budhvaar	Budhvaar
Thursday	Guruvaar	Brihaspativaar
Friday	Shukravaar	Shukravaar
Saturday	Shanivaar	Shanivaar

H. Directions in Maraathi and Hindi

English	Maraathi	Hindi
Right	Ujveekadey	Dahiney
Left	Daveekadey	Baayein
Front	Pudhey	Aagey
Back	Paathi	Peechhey
Inside	Aat	Andar
Outside	Baaher	Baahar
West	Paschim	Paschim
East	Poorva	Poorva
North	Uttar	Uttar
South	Dakshin	Dakshin

I. Basic Colours in Maraathi and Hindi

English	**Maraathi**	**Hindi**
White	Paandhra	Safed
Black	Kaala	Kaala
Green	Hirva	Haraa
Yellow	Peevla	Pilaa
Blue	Nila	Neelaa
Red	Laal	Laal

Chapter 3. Important Information for Visitors

A. General Advice

Please check for permission / tickets to photograph or film videos at any monument.

Do respect local traditions while visiting religious places.

Please keep your valuables in hotel lockers.

Students will always be accompanied by guides or other organizers and will not be permitted to venture into the city or elsewhere alone.

We suggest you shop at Government Emporia or Fixed Price shops to ensure quality and reasonable prices. Buying articles made from endangered species is a cognizable offence.

Please discourage beggars.

Smoking is not allowed in public places and institutions.

Do not eat at roadside vendors or accept food/drink from strangers. Consult the organizers or your Indian friend about the suitability of a restaurant.

Do take care and use clean drinking water. Seek advice from the organizers on this matter.

Do consult your physician about medical precautions (and vaccinations if needed) if you are not used to tropical climates.

Avoid densely crowded places as far as possible.

B. Frequently Asked Questions

What will be the weather like in Mumbai in July?

July in Mumbai is usually warm and humid, with average temperature around 30 °C.

What is local language of Mumbai?

The local language is Marathi. Hindi, the national language, is widely spoken and understood. English is also spoken/understood by many, but not all.

What are the provisions for medical aid?

Primary medical care will be available at the hotels. In case of medical or any other emergencies please contact the organizers at the help desk. Do inform us in advance if you are prone to any allergies or have any specific medical conditions.

What medium to pay in? Credit cards/ Debit cards/cash?

Most reputed shops accept international credit cards but it is desirable to carry some cash for minor purchases in the city.

Will the organizers of the 46th IPhO arrange pre and post Olympiad accommodation and tours?

The organizers will book the accommodation at the designated student and leader hotels for up to 3 days before and after the Olympiad, on request. Payment for such bookings have to be made directly to the hotels by you. Alternative options for accommodation are available on the IPhO 2015 website. The visitors should arrange pre or post Olympiad tours themselves by contacting the hotels and tour operators in India or in their country. Always hire a Government approved tourist guide who carries an Identity Card.

What is the type of electrical outlets (sockets) in India?

India uses 230 volts, 50 Hz alternating current as the power source. Plugs and sockets have either grounded/earthed 3-pin connections or ungrounded 2-pin connections. The common plug types are C/D/M and socket type are C/D/M. (Pictures below).

What is the currency used in India and how to do we get our currency exchanged?

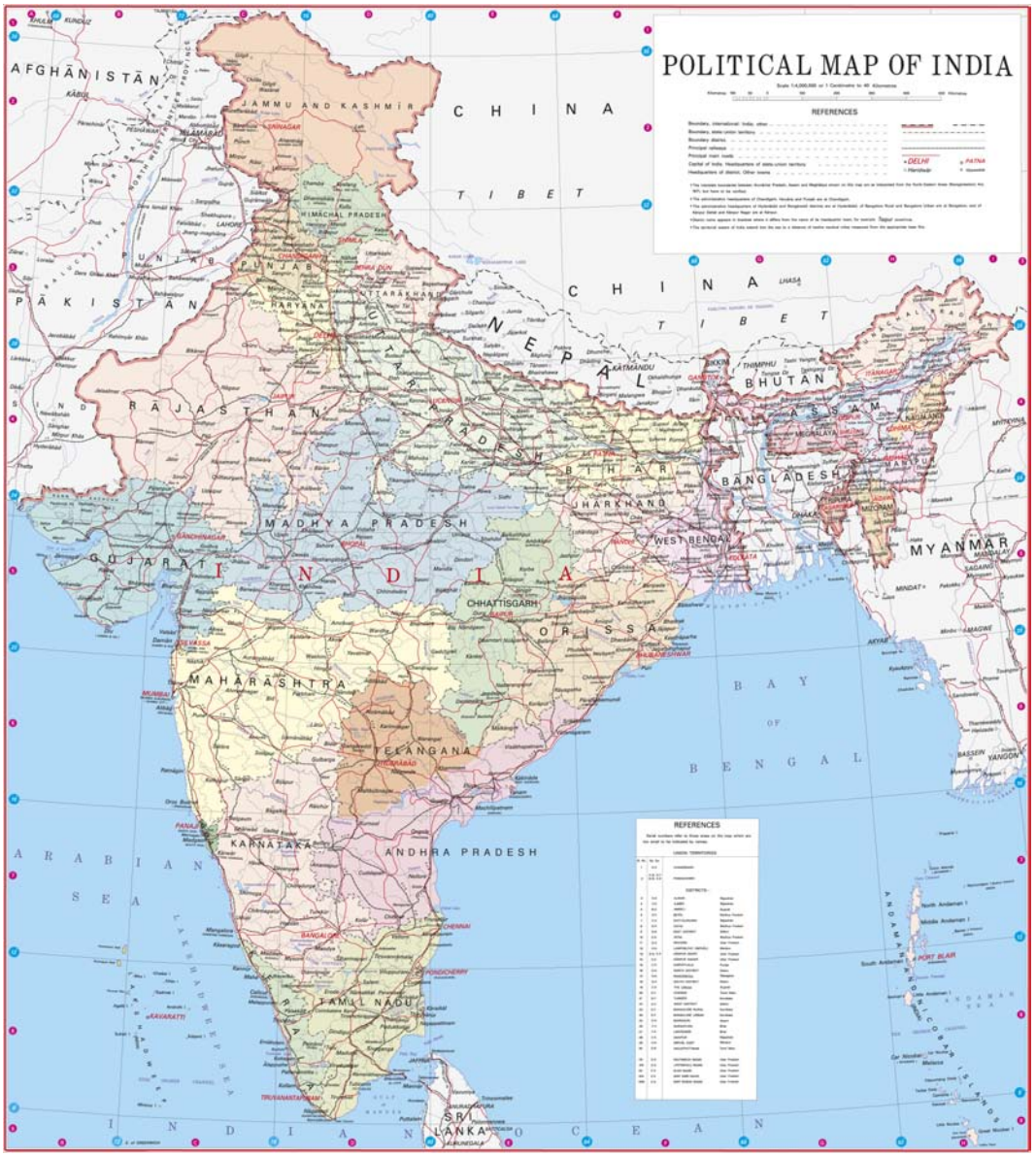
The Indian currency is Rupee (₹) available in denominations of 1000, 500, 100, 50, 20, 10 and coins of 5 and smaller denominations of ₹ 2 and ₹ 1 are also used (₹1/- = 100 paise). The receptions at both hotels booked for 46th IPhO allow the guests to exchange foreign currency.

What are the distances between the venues of 46th IPhO?

The distances are given with the map in Chapter 4 of this info book

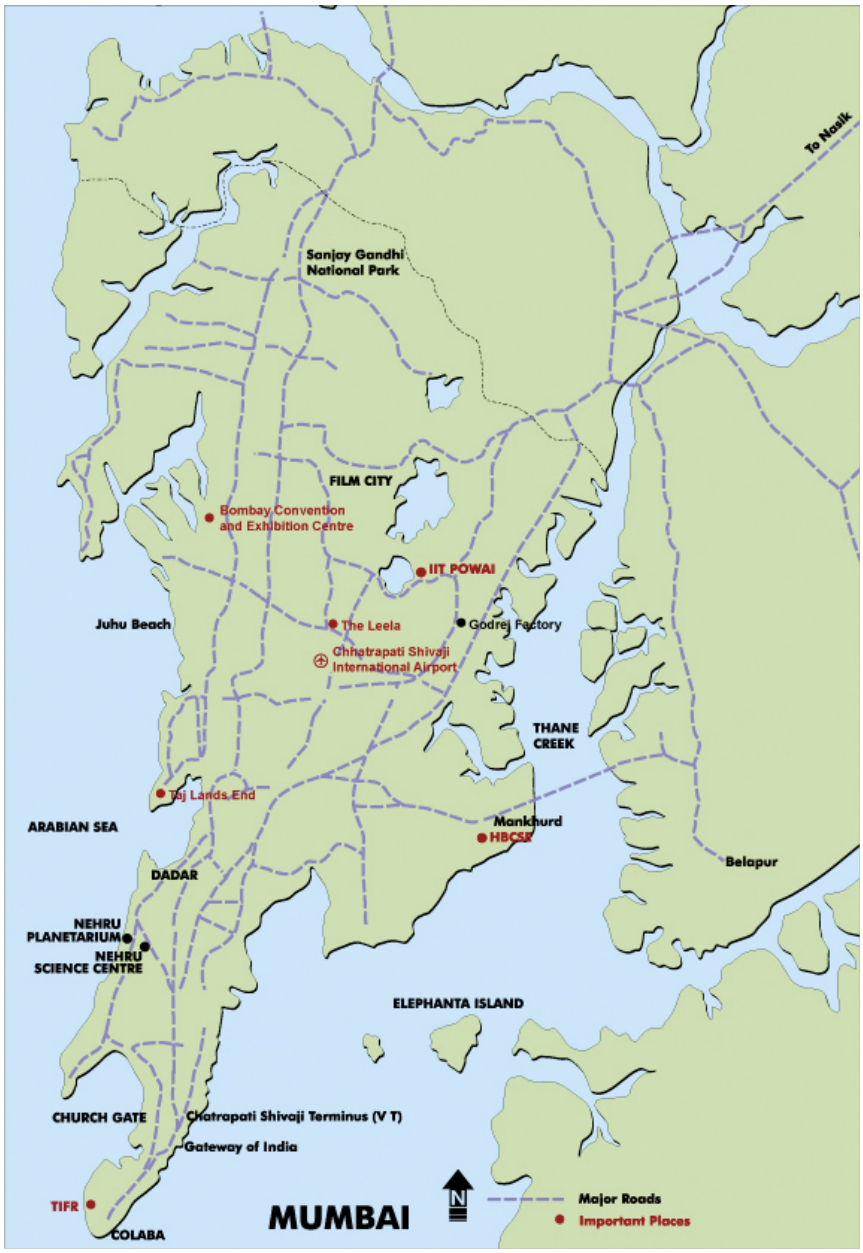
Chapter 4. Maps

India Map



Mumbai District Map

IPhO Specific Map of Mumbai



Chapter 5. International Physics Olympiad (IPhO)

A. Short history of the IPhO

(*abridged from official website of IPhO:* www.ipho.org)

The International Physics Olympiad (IPhO) is an international physics competition for secondary school students. The first such competition was organized by Prof. Czesław Ścisłowski in Warsaw (Poland) in 1967. Since that time the International Physics Olympiads have been organized, with a few exceptions, in a different country every year.

The possibility of organizing the International Physics Olympiads was suggested before 1967. It was clear that the International Physics Olympiads should be an annual event like the International Mathematics Olympiad, which was already in existence since 1959. The success of the International Mathematics Olympiads, and the positive experience gained from its organization, greatly stimulated physicists involved in physics education and interested in comparison of knowledge of the best students from different countries.

One should underline here an essential difference between the International Mathematics Olympiads and the International Physics Olympiads. At the International Physics Olympiads the participants solve not only theoretical problems but also the experimental problems. For this reason the organization of the competition in physics is more complicated and more expensive.

Five countries (Bulgaria, Czechoslovakia, Hungary, Romania and the host country, Poland) participated in the first Olympiad. The second Olympiad was organized by Prof. Rudolf Kunfalvi in Budapest, Hungary, in 1968. Eight countries took part in that competition – The German Democratic Republic, the Soviet Union and Yugoslavia joined the participating countries. Sometime before the second IPhO a preliminary version of the Statutes and the Syllabus was produced. Later the International Board consisting of the supervisors of the teams that participated in the competition officially accepted these documents. It is proper to underline that in spite of various changes made later, all the basic features of the first Statutes remain valid to this day.

The sixth IPhO held in Bucharest, Romania in 1972 was an important event because the participants there included for the first time a non-European country (Cuba) and a Western country (France).

In 1983, there was one important decision made at the IPhO held for the second time in Bucharest, Rumania. The International Board decided to establish a permanent Secretariat

(consisting of one person: Dr. Waldemar Gorzkowski) for co-ordination of the long-term work of the International Physics Olympiads and for popularising the Olympiads. At the same time it was decided that the Secretariat together with Prof. Lars Silverberg (Sweden), the organizer of the next competition in Sigtuna, Sweden, in 1984, should prepare a new version of the Statutes. One can say that the new version differed from the old one primarily in wording. The new version was much more precise.

The delegation heads, consisting of two persons from each participating country, form the, so-called, International Board, which is the highest authority of the International Physics Olympiads. The International Board does not change significantly from year to year. The majority of members know each other very well. In the International Board there is a very pleasant, friendly atmosphere. Thanks to this attitude and good will, many difficult problems can be solved without great effort.

In 1996 the International Board decided to create an Advisory Committee convened at the President. At present the Advisory Committee consists of 14 persons with great experience in the "Olympiad work".

Every year some changes in the Statutes are made. Usually they are minor changes, but sometimes the changes are major. The last version of the Statutes, Regulations, Syllabus and other Olympiad documents may be downloaded from the Olympic home page http://www.jyu.fi/ipho localized in Finland and maintained by Prof. Maija Ahtee. They are reproduced in this booklet for convenience.

B. Statutes of IPhO

(*as per the official website of IPhO:* www.ipho.org**)**

§1

In recognition of the growing significance of physics in all fields of science and technology, and in the general education of young people, and with the aim of enhancing the development of international contacts in the field of school education in physics, an annual physics competition has been organized for secondary school students. The competition is called the International Physics Olympiad and is a competition between individuals.

§2

The competition is organized by the Ministry of Education, the Physical Society or another appropriate institution of one of the participating countries on whose territory the competition is to be conducted. The organizing country is obliged to ensure equal participation of all the delegations, and to invite teams from all those countries that participated during the last three years. Additionally, it has the right to invite other countries. The list of such new countries must be presented to Secretariat of the IPhOs (**§** 8) at least six months prior to the competition. Within two months the Secretariat has the right to remove, after consultations with the Advisory Committee (# 8), from the suggested list the teams that in opinion of Secretariat or Advisory Committee do not meet the criteria of participation in the IPhOs. The new countries not accepted by the Secretariat or Advisory Committee may, however, participate as "guest teams" but such participation does not create any commitments with respect to inviting these countries to the next competition(s).

No country may have its team excluded from participation on any political reasons resulting from political tensions, lack of diplomatic relations, lack of recognition of some country by the government of the organizing country, imposed embargoes 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.

The competition is conducted in the friendly atmosphere designed to promote future collaborations and to encourage the formation of friendship in the scientific community. Therefore 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.

§3

Each participating country shall send a delegation, normally consisting of five students (contestants) and two accompanying persons (delegation leaders) at most.

The contestants shall be students of general or technical secondary schools i.e. schools which cannot be considered technical colleges. Students who have finished their school examinations in the year of the competition can be members of the team as long as they have not commenced their university studies. The age of the contestants should not exceed twenty years on June 30th of the year of the competition.

The delegation leaders must be specialists in physics or physics teachers, capable of solving the problems of the competition competently. Each of them should be able to speak English.

§4

The Organizers of the Olympiad determine in accordance to the program the day of arrival and the day of departure as well as the place in their country from which the delegations are supposed to arrive and depart. The costs for each delegation as a result of activities connected to the Olympiad from the day of arrival till the day of departure are covered by the Organizing Committee.

§5

The competition shall be conducted over two days, one for the theoretical examination and one for the experimental examination. There will be at least one full day of rest between the examinations.

The theoretical examination shall consist of three theoretical problems and shall be of five hours total duration.

The experimental examination shall consist of one or two problems and shall be of five hours total duration.

Contestants may bring into the examination drawing instruments and approved calculators. No other aids may be brought into the examination.

The theoretical problems should involve at least four areas of physics taught at secondary school level, (see Syllabus). Secondary school students should be able to solve the competition problems with standard high school mathematics and without extensive numerical calculation.

The competition tasks are chosen and prepared by the host country and have to be accepted by the International Board (§ 7).

The host country has to prepare at least one spare problem, which will be presented to the International Board if one of the first three theoretical problems is rejected by two thirds of members of the International Board. The rejected problem cannot be considered again.

§6

The total number of marks awarded for the theoretical examination shall be 30 and for the experimental examination 20. The competition organizer shall determine how the marks are allocated within the examinations.

After preliminary grading (prior to discussion of the grading with the delegation leaders) the organizers establish minima (expressed in points) for Gold Medals, Silver Medals, Bronze Medals, and Honorable Mentions according to the following rules:

(a) Gold Medals should be awarded to 8% of the contestants (rounded up the nearest integer).

(b) Gold or Silver Medals should be awarded to 25% of the contestants (rounded up the nearest integer).

(c) Gold, Silver or Bronze Medals should be awarded to 50% of the contestants (rounded up the nearest integer).

(d) An Olympic Medal or Honorable Mention should be awarded to 67% of the contestants (rounded up the nearest integer).

The minima corresponding to the above percentages should be expressed without rounding. The suggested minima shall be considered carried if one half or more of the number of the Members of the International Board cast their vote in the affirmative.

Results of those candidates who only receive a certificate of participation should strictly remain to the knowledge of the Members of the International Board and persons allowed to attend its meetings.

§7

The governing body of the IPhO is the International Board, which consists of the delegation leaders from each country attending the IphO.

The chairman of the International Board shall be a representative of the organizing country when tasks, solutions and evaluation guidelines are discussed and the President of the IPhO in all other topics.

A proposal placed to the International Board, except Statutes, Regulations and Syllabus (see § 10), shall be considered carried if more than 50% of all delegation leaders present at the meeting vote in the affirmative. Each delegation leader is entitled to one vote. In the case of equal number of votes for and against, the chairman has the casting vote. The quorum for a

meeting of the International Board shall be one half of those eligible to vote.

The International Board has the following responsibilities:

(a) to direct the competition and supervise that it is conducted according to the regulations;

(b) to ascertain, after the arrival of the competing teams, that all their members meet the requirements of the competition in all aspects. The Board will disqualify those contestants who do not meet the stipulated conditions;

(c) to discuss the Organizers' choice of tasks, their solutions and the suggested evaluation guidelines before each part of the competition. The Board is authorized to change or reject suggested tasks but not to propose new ones. Changes may not affect experimental 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 participants;

(d) to ensure correct and just classification of the students. All grading has to be accepted by the International Board;

(e) to establish the winners of the competition and make a decision concerning presentation of the medals and honorable mentions. The decision of the International Board is final;

(f) to review the results of the competition;

(g) to select the countries which will be assigned the organization of future competitions;

(h) to elect the members of the Secretariat of the IPhO.

§8

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

The members of the Secretariat of the IPhO should be invited to the Olympiads as the members and heads of the International Board; their relevant expenses should be paid by the organizers of the competition. The members of the Secretariat should not be leaders of any national team.

There shall be an Advisory Committee convened by the President of the IPhOs. The Advisory Committee consists of:

1. The President,
2. The Secretary,
3. The Treasurer,
4. The host of the past Olympiad,
5. The hosts of the next two Olympiads,
6. Such other persons appointed by the President.

§9

The working language of the IPhO is English.

The competition problems should be presented to the International Board in English, Russian, German, French and Spanish.

The solutions to the problems should be presented in English.

It is the responsibility of the delegation leaders to translate the problems into languages required by their students.

These statutes and other IPhO-documents shall be written in English.

Meetings of the International Board shall be held in English.

§10

These statutes are supplemented by

Regulations concerning the details of the organization

the Syllabus mentioned in **§** 5.

Proposals for amendment to these Statutes and the supplementing documents may be submitted to the president or his nominee no later than December 15th prior to consideration.

The President shall circulate, no later than March 15th, all such proposals together with the recommendation of the President's Advisory Committee, to the last recorded address of each delegation leader who attended at the last IPhO.

Such proposals shall be considered by a meeting of the International Board at the next IPhO and shall be considered carried if

in case of Statutes and Syllabus two thirds or more and

in case of Regulations more than one half
of the number of the members of the International Board present at the meeting cast their vote in the affirmative. Such changes shall take effect from the end of the current IPhO and cannot affect the operation of the competition in progress. The vote can only take place if at least 2/3 of the all leaders are present at the meeting.

§11

Participation in an International Physics Olympiad signifies acceptance of the present Statutes by the Ministry of Education or other institution responsible for sending the delegation.

Regulations Associated with the Statutes of the International Physics Olympiads

Regulations to §2

The Ministry of Education, or the institution organizing the competition, allots the task of preparation and execution of the Competition to an appropriate body.

Official invitations to the participating countries should be sent at least six months before the Olympiad. They normally are sent to the national institution that sent the delegation to the previous Olympiad. Copies of the invitation are also sent to the previous years' delegation leaders. The invitation should specify the place and time of the Competition plus the address of the organizing secretariat.

Countries wishing to attend the current IPhO must reply to the invitation before March 15, nominating a contact person. Each participating country must in addition supply the host country with the contestants' personal data (surname, given name, sex, address, date of birth and address of school) by May 15 or as soon as possible.

The host country is only obliged to invite delegations from countries that participated in one of the last three competitions. It may refuse

applications for participation from any other country

applications from participating countries not belonging to the delegation as defined in §3 (observers, guests).

Each country should, within five years of entry, declare its intention to host for a future Olympiad, suggesting possible years. A country that is unable to organize the competition may be prevented from participating in IPhOs by decision of the International Board.

Regulations to §3

The accompanying persons are considered by the organizers of the next Olympiad and by the Secretariat of the IPhOs (§ 8) as contact persons until the next Olympiad (unless new accompanying persons or other contact persons are nominated by the participating country).

Each participating country must ensure that the contestants are all secondary school pupils when they announce the names of the members of their delegations. In addition to the delegations, teams may be accompanied by observers and guests.

Observers may attend all Olympiad meetings, including the meetings of the International Board. However they may not vote or take part in the discussions.

Guests do not attend the meetings of the International Board.

If possible, the host country should accept as observers any of the following persons:

- the organizer(s), or nominee(s), from the host country in the subsequent three years
- a representative of any country expressing an intention to participate in the following IPhO.

Regulations to §4
The host country must pay for organization of IPhO, food, lodging, transport and excursions of the delegations plus prizes.

However it is not responsible for medical costs and sundry expenses of the participants.

Observers and guests may be asked to pay the full cost of their stay plus an attendance fee.

The host country may ask the delegations for a contribution to the obligatory costs. Delegations with economic difficulties may ask waving this fee by sending a motivated appeal to the Secretariat of the IPhO.

Regulations to §5
It is recommended that the Competition should last 10 days (including arrival and departure days).

The host country is obliged to ensure that the Competition is conducted according to the Statutes. It should provide full information for participating countries, prior to their arrival, concerning venue, dates, accommodation, transport from airports, ports and railway stations. The addresses, telephone, fax, e-mail of all IPhO officers should be provided, together with

information concerning relevant laws and customs of the host country.

A program of events during the IPhO should be prepared for the leaders and contestants. It should be sent to the participating countries, prior to the Olympiad.

The organizers of the IPhO are responsible for devising all the problems. They must be presented in English and the other official languages of the Olympiad as indicated in § 9. The examination topics should require creative thinking and knowledge contained within the Syllabus. Factual knowledge from outside the Syllabus may be introduced provided it is explained using concepts within the Syllabus.

Everyone participating in the preparation of the competition problems must not divulge their content. The standard of problems should attempt to ensure that approximately half the students obtain over half marks.

The International Board shall be given time to consider the examination papers. It may change or reject problems. If a problem is rejected, the alternative problem must be accepted. The host country will be responsible for grading the examination papers. The delegation leaders shall have an opportunity to discuss with the examiners the grading of their students' papers. If an agreement, between graders and leaders, to the final marks cannot be reached, the International Board has to decide.

A calculator shall be an approved calculator if it is not a graphical calculator, its display has no more than three lines, and if its user memory is completely cleared immediately prior to each examination.

The host country may provide calculators to students which are approved calculators. If the country chooses to do this then the team leaders of the countries attending IPhO must be advised of the exact model at least two months in advance of the competition. Students who bring their own approved calculators shall be permitted to use them.

The organizers shall provide the delegation leaders with copies of their students' scripts and allow at least 12 hours for them to mark the scripts.

The host country shall provide medals and certificates in accordance with the Statutes. They must also produce a list of all contestants receiving awards with their marks and associated award. The awards are presented at the Closing Ceremony.

The host country is obliged to publish the Proceedings of the Competition, in English, in the subsequent twelve months. A free copy of the Proceedings should be sent to all delegation leaders and competitors.

Regulations to §6
Special prizes may be awarded. The participant who obtains the highest score should receive a special prize.

Regulations to §7

During the meeting of the graders where the final and most detailed version of the grading scheme is set, 3 members of the International Board will be present. They have the right to give advice to the group of graders in order to keep the grading scheme within the tradition of the IPhOs.

If it is found that leaders, observers or students from a country have been in collusion to cheat in one of the International Olympiad examinations, the students concerned should be disqualified from that Olympiad. In addition, the leaders, observers and students involved should not be allowed to return to any future Olympiad. Appropriate decisions are taken by the International Board.

Regulations to §8

Election of the members of the Secretariat

a. All members of the Secretariat have to have been for the five years prior to the nomination

a member of the International Board for at least three of these years,

or an observer or member of the International Board, who has attended all these five IPhOs.

b. All members of the Secretariat will hold office for a period of five years commencing at the conclusion of the final meeting of the International Board at which the concerned person has been chosen.

c. The members of the Secretariat must be appointed at different IPhOs. If this is the case, however, the period of the Secretary and/or the Treasurer will have to be shortened in such a way that the elections can be held at different IPhOs.

d. The members of the Secretariat must come from different delegations.

e. If the term of one of the members of the Secretariat comes to an end, the International Board has to be informed one year in advance that there will be the ballots of a new member of the Secretariat during the following IPhO. In addition to that, the Secretariat

is responsible to send a letter to all leaders of the last three IPhOs with this information and with the question if any leader will be ready to run for these positions for the coming period by 31st January. This is normally done by e-mail.

f. If someone is willing to be a candidate for the ballot, he or she will have to tell this to the current Secretary by 31st March, normally by e-mail. A nominee has to send his/her curriculum vitae up to 31st March. A nomination may not be made by a person from the same country as one of the current members of the Secretariat who holds chair on another position than the one that becomes vacant.

g. The Secretariat is responsible to collect all these answers and has to make a list with all the names.

If the current members of the Secretariat are willing to continue his/her term, he or she has to enter his/her name in this list and has to follow the same rules as all the other candidates.

If the current secretary is willing to continue his/her activity as secretary, he or she has to enter his/her name in this list and has to follow the same rules as all the other candidates.

h. The list with the candidates for the new member of the Secretariat has to be published on the IPhO-home-page and the home page of the IPhO during which the ballot will be held.

i. If there is just one candidate for the vacant position of the Secretariat, the current Secretary has to inform the current President about that. In that case this candidate is accepted as the elected one.

j. The Secretariat and the organizers of the IPhO during which the election will be held are responsible for a democratic, secret ballot of the member of the Secretariat during the last meeting of the International Board:

k. If the current member of the Secretariat resigns or becomes incapable of continuing his/her work, the remaining members of the Secretariat shall appoint a replacement to act as provisional President, Secretary or Treasurer up to the next IPhO. The ballot of the new one has to be made as soon as possible.

C. Syllabus of IPhO

(as per the official website of IPhO: www.ipho.org)

1. Introduction

1.1 Purpose of this syllabus

This syllabus lists topics which may be used for the IPhO. Guidance about the level of each topic within the syllabus is to be found from past IPhO questions.

1.2 Character of the problems

Problems should focus on testing creativity and understanding of physics rather than testing mathematical virtuosity or speed of working. The proportion of marks allocated for mathematical manipulations should be kept small. In the case of mathematically challenging tasks, alternative approximate solutions should receive partial credit. Problem texts should be concise; the theoretical and the experimental examination texts should each contain fewer than 12000 characters (including white spaces, but excluding cover sheets and answer sheets).

1.3 Exceptions

Questions may contain concepts and phenomena not mentioned in the Syllabus providing that sufficient information is given in the problem text so that students without previous knowledge of these topics would not be at a noticeable disadvantage. Such new concepts must be closely related to the topics included in the syllabus. Such new concepts should be explained in terms of topics in the Syllabus.

1.4 Units

Numerical values are to be given using SI units, or units officially accepted for use with the SI. It is assumed that the contestants are familiar with the phenomena, concepts, and methods listed below, and are able to apply their knowledge creatively.

2. Theoretical skills

2.2 Mechanics
2.2.1 Kinematics

Velocity and acceleration of a point particle as the derivatives of its displacement vector. Linear speed; centripetal and tangential acceleration. Motion of a point particle with a constant acceleration. Addition of velocities and angular velocities; addition of accelerations without the Coriolis term; recognition of the cases when the Coriolis acceleration is zero. Motion of a rigid body as a rotation around an instantaneous center of rotation; velocities and accelerations of the material points of rigid rotating bodies.

2.2.2 Statics

Finding the center of mass of a system via summation or via integration. Equilibrium conditions: force balance (vectorially or in terms of projections), and torque balance (only for one-and two-dimensional geometry). Normal force, tension force, static and kinetic friction force; Hooke's law.

2.2.3 Dynamics

Newton's second law (in vector form and via projections (components)); kinetic energy for translational and rotational motions. Potential energy for simple force fields (also as a line integral of the force field). Momentum, angular momentum, energy and their conservation laws. Mechanical work and power; dissipation due to friction. Inertial and non-inertial frames of reference: inertial force, centrifugal force, potential energy in a rotating frame. Moment of inertia for simple bodies (ring, disk, sphere, hollow sphere, rod), parallel axis theorem; finding a moment of inertia via integration.

2.2.4 Celestial mechanics

Law of gravity, gravitational potential, Kepler's laws (no derivation needed for first and third law). Energy of a point mass on an elliptical orbit.

2.2.5 Hydrodynamics

Pressure, buoyancy, continuity law.

2.3 Electromagnetic fields

2.3.1 Basic concepts

Concepts of charge and current; charge conservation and Kirchhoff's current law. Coulomb force; electrostatic field as a potential field; Kirchhoff's voltage law. Magnetic B-field; Lorentz force; Ampère's force; B-field on the axis of a circular current loop and for simple symmetric systems like straight wire, circular loop and long solenoid.

2.3.2 Integral forms of Maxwell's equations

Gauss' law (for E-and B-fields); Ampère's law; Faraday's law.
2.3.3 Interaction of matter with electric and magnetic fields

Resistivity and conductivity; differential form of Ohm's law. Dielectric and magnetic permeability; energy density of electric and magnetic fields; ferromagnetic materials; hysteresis and dissipation; eddy currents; Lenz's law. Energy of a magnetic dipole in a magnetic field; dipole moment of a current loop.

2.3.4 Circuits

Linear resistors and Ohm's law; Joule's law; work done by an electromotive force; ideal and non-ideal batteries, constant current sources, ammeters, voltmeters and ohmmeters. Nonlinear elements of given V -I characteristic. Capacitors and capacitance; self-induction and inductance; energy of capacitors and inductors; mutual inductance; time constants for RL and RC circuits. AC circuits: complex amplitude; impedance of resistors, inductors, capacitors, and combination circuits; phasor diagrams; current and voltage resonance; active power.

2.4 Oscillations and waves

2.4.1 Single oscillator

Harmonic oscillations: equation of motion, frequency, angular frequency and period. Physical pendulum and its reduced length. Behavior near unstable equilibria.

2.4.3 Waves

Propagation of harmonic waves: phase as a linear function of space and time; wave length, wave vector, phase and group velocities; transverse and longitudinal waves; the classical Doppler effect. Waves in inhomogeneous media: Fermat's principle, Snell's law. Sound waves. Energy carried by waves: proportionality to the square of the amplitude, continuity of the energy flux.
2.4.4 Interference and diffraction

Superposition of waves: coherence, beats, standing waves, Huygens' principle, interference due to thin films (conditions for intensity minima and maxima only). Diffraction from one and two slits, diffraction grating, Bragg reflection.

2.4.5 Interaction of electromagnetic waves with matter

Dependence of electric permittivity on frequency (qualitatively); refractive index; dispersion and dissipation of electromagnetic waves in transparent and opaque materials. Linear polarization; Brewster angle; polarizers.

2.4.7 Optical devices

Telescopes and microscopes: magnification and resolving power; diffraction grating and its resolving power; interferometers.

2.5 Relativity

Principle of relativity and Lorentz transformations for the time and spatial coordinate, and for the energy and momentum; mass-energy equivalence; invariance of the space time interval and of the rest mass. Addition of parallel velocities; time dilation; length contraction; relativity of simultaneity; energy and momentum of photons and relativistic Doppler effect; relativistic equation of motion; conservation of energy and momentum for elastic and non-elastic interaction of particles.

2.6 Quantum Physics

2.6.1 Probability waves

Particles as waves: relationship between the frequency and energy, and between the wave vector and momentum. Energy levels of hydrogen-like atoms (circular orbits only) and of parabolic potentials; quantization of angular momentum. Uncertainty principle for the conjugate pairs of time and energy, and of coordinate and momentum

2.6.2 Structure of matter

Emission and absorption spectra for hydrogen-like atoms (for other atoms —qualitatively), and for molecules due to molecular oscillations; spectral width and lifetime of excited states. Atomic nuclei, energy levels of nuclei (qualitatively); alpha-, beta-and gamma-decays; fission, fusion and neutron capture; mass defect; half-life and exponential decay. Photoelectric effect.

2.7 Thermodynamics and statistical physics

2.7.1 Classical thermodynamics

Concepts of thermal equilibrium and reversible processes; internal energy, work and heat; entropy; open, closed, isolated systems; first and second laws of thermodynamics. Kinetic theory of ideal gases: Avogadro number, Boltzmann factor and gas constant; translational

motion of molecules and pressure; ideal gas law; translational, rotational and oscillatory degrees of freedom; equipartition theorem; internal energy of ideal gases; root-mean-square speed of molecules. Isothermal and adiabatic processes; specific heat for isobaric and isochoric processes; forward and reverse Carnot cycle on ideal gas and its efficiency; efficiency of non-ideal heat engines.

2.7.2 Heat transfer and phase transitions

2.7.3 Statistical physics

Planck's law (explained qualitatively, does not need to be remembered), the Stefan-Boltzmann law.

3. Experimental skills

3.1 Introduction

The theoretical knowledge required for carrying out the experiments must be covered by Section 2 of this Syllabus.

The students should have the following skills.

3.2 Safety

Knowing standard safety rules in laboratory work. Nevertheless, if the experimental set-up contains any safety hazards, the appropriate warnings should be included in the text of the problem. Experiments with major safety hazards should be avoided.

3.3 Measurement techniques and apparatus
Being familiar with the most common experimental techniques for measuring physical quantities mentioned in the theoretical part. Knowing commonly used simple laboratory instruments and digital and analog versions of simple devices, such as calipers, the Vernier scale, stop watches, thermometers, multimeters (including ohmmeters and AC/DC voltmeters and ammeters), potentiometers, diodes, transistors, lenses, prisms, optical stands, calorimeters, and so on. Sophisticated practical equipment likely to be unfamiliar to the students should not dominate a problem. In the case of moderately sophisticated equipment (such as oscilloscopes, counters, rate meters, signal and function generators, photo gates, etc), instructions must be given to the students.

3.4 Accuracy

Being aware that instruments may affect the outcome of experiments. Being familiar with basic techniques for increasing experimental accuracy (e.g. measuring many periods instead

of a single one, minimizing the influence of noise, etc). Knowing that if a functional dependence of a physical quantity is to be determined, the density of taken data points should correspond to the local characteristic scale of that functional dependence. Expressing the final results and experimental uncertainties with a reasonable number of significant digits, and rounding off correctly.

3.5 Experimental uncertainty analysis

Identification of dominant error sources, and reasonable estimation of the magnitudes of the experimental uncertainties of direct measurements (using rules from documentation, if provided). Distinguishing between random and systematic errors; being able to estimate and reduce the former via repeated measurements. Finding absolute and relative uncertainties of a quantity determined as a function of measured quantities us ing any reasonable method (such as linear approximation, addition by modulus or Pythagorean addition).

3.6 Data analysis

Transformation of a dependence to a linear form by appropriate choice of variables and fitting a straight line to experimental points. Finding the linear regression parameters (gradient, intercept and uncertainty estimate) either graphically, or using the statistical functions of a calculator (either method acceptable). Selecting optimal scales for graphs and plotting data points with error bars.

4. Mathematics

4.1 Algebra

Simplification of formulae by factorization and expansion. Solving linear systems of equations. Solving equations and systems of equations leading to quadratic and biquadratic equations; selection of physically meaningful solutions. Summation of arithmetic and geometric series.

4.2 Functions

Basic properties of trigonometric, inverse-trigonometric, exponential and logarithmic functions and polynomials. Solving simple equations involving trigonometric, inverse-trigonometric, logarithmic and exponential functions.

4.3 Geometry and stereometry

Degrees and radians as alternative measures of angles. Equality of alternate interior and exterior angles, equality of corresponding angles. Recognition of similar triangles. Areas of

triangles, trapezoids, circles and ellipses; surface areas of spheres, cylinders and cones; volumes of spheres, cones, cylinders and prisms. Sine and cosine rules, property of inscribed and central angles, Thales' theorem.

4.4 Vectors

Basic properties of vectorial sums, dot and cross products. Double cross product and scalar triple product. Geometrical interpretation of a time derivative of a vector quantity.

4.5 Complex numbers

Summation, multiplication and division of complex numbers; separation of real and imaginary parts. Conversion between algebraic, trigonometric, and exponential representations of a complex number. Complex roots of quadratic equations and their physical interpretation.

4.6 Statistics

Calculation of probabilities as the ratio of the number of objects or event occurrence frequencies. Calculation of mean values, standard deviations, and standard deviation of group means.

4.7 Calculus

Finding derivatives of elementary functions, their sums, products, quotients, and nested functions. Integration as the inverse procedure to differentiation. Finding definite and indefinite integrals in simple cases: elementary functions, sums of functions, and using the substitution rule for a linearly dependent argument. Making definite integrals dimensionless by substitution. Geometric interpretation of derivatives and integrals. Finding constants of integration using initial conditions. Concept of gradient vectors (partial derivative formalism is not needed).

4.8 Approximate and numerical methods

Using linear and polynomial approximations based on Taylor series. Linearization of equations and expressions. Perturbation method: calculation of corrections based on unperturbed solutions. Numerical integration using the trapezoidal rule or adding rectangles.

Chapter 6. 46th IPhO 2015 Host Institution and Logo

A. Host Institution

The 46th IPhO, 2015 is held at Mumbai from 5th July, 2015 to 12th July, 2015. The event is being organised by Homi Bhabha Centre for Science Education (HBCSE), a national centre of the Tata Institute of Fundamental Research, Mumbai. HBCSE aims to promote equity and excellence in science and mathematics from school to undergraduate levels. The Centre is involved in carrying out basic research in science education and bringing out good educational material; it also has a strong outreach programme. HBCSE is the national Centre of the country for Olympiad programmes in mathematics and sciences including astronomy. It is responsible for the selection and training of the Indian delegations to the international Olympiads in six subjects, a process involving nearly 200,000 students annually. Its research programmes include mapping the structure and dynamics of knowledge, design and technology, mathematics education, visuo-spatial reasoning and alternative conceptions in different areas of science.

B. Logo of 46th IPhO 2015

The logo of the 46th IPhO combines the depiction of a well-known concept in physics and a representation of the Indian flag. The bending of light due to a massive object is a prediction of classical physics as well as Einstein's general theory of relativity. This bending enables a star directly behind the Sun to be viewed during a total solar eclipse, a phenomenon which is depicted in the logo. However the angle of deflection is underestimated in a classical approach, but can be correctly obtained using the general theory of relativity. The confirmation of the exact amount of bending predicted by Einstein's theory during a total solar eclipse in 1919 was one of most celebrated events in the history of science.

The three colours, saffron, white and green, are from the national flag of India. The top band is of saffron colour, indicating strength and courage, the white middle band symbolizes peace and truth while the green band represents fertility and growth of the nation.