3e

Physics Galaxy

Volume IV

Optics & Modern Physics

Ashish Arora
Mentor & Founder

PHYSICSGALAXY.COM

World's largest encyclopedia of online video courses on High School Students preparing for
JEE Main * JEE Advanced * NEET * NSEP/INPhO/IPhO

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Dedicated

to

My Parents, Son, Daughter

and

My beloved wife

In his teaching career since 1992 Ashish Arora personally mentored more than 10000 IITians and students who reached global heights in various career and profession chosen. It is his helping attitude toward students with which all his students remember him in life for his contribution in their success and keep connections with him live. Below is the list of some of the successful students in International Olympiad personally taught by him.

NAVNEET LOIWAL	***International GOLD Medal in IPhO-2000 at LONDON***, Also secured **AIR-4** in **IIT JEE 2000**
	PROUD FOR INDIA : Navneet Loiwal was the first Indian Student who won first International GOLD Medal for our country in International Physics Olympiad.
DUNGRA RAM CHOUDHARY	**AIR-1** in **IIT JEE 2002**
HARSHIT CHOPRA	***National Gold Medal in INPhO-2002*** and got **AIR-2** in **IIT JEE-2002**
KUNTAL LOYA	A Girl Student got position **AIR-8** in **IIT JEE 2002**
LUV KUMAR	***National Gold Medal in INPhO-2003*** and got **AIR-3** in **IIT JEE-2003**
RAJHANS SAMDANI	***National Gold Medal in INPhO-2003*** and got **AIR-5** in **IIT JEE-2003**
SHANTANU BHARDWAJ	***International SILVER Medal in IPhO-2002 at INDONESIA***
SHALEEN HARLALKA	***International GOLD Medal in IPhO-2003 at CHINA*** and got **AIR-46** in **IIT JEE-2003**
TARUN GUPTA	***National GOLD Medal in INPhO-2005***
APEKSHA KHANDELWAL	***National GOLD Medal in INPhO-2005***
ABHINAV SINHA	***Hon'ble Mension Award in APhO-2006*** **at** ***KAZAKHSTAN***
RAMAN SHARMA	***International GOLD Medal in IPhO-2007*** **at** ***IRAN*** and got **AIR-20** in **IIT JEE-2007**
PRATYUSH PANDEY	***International SILVER Medal in IPhO-2007*** **at** ***IRAN*** and got **AIR-85 in IIT JEE-2007**
GARVIT JUNIWAL	***International GOLD Medal in IPhO-2008*** **at** ***VIETNAM*** and got **AIR-10** in **IIT JEE-2008**
ANKIT PARASHAR	***National GOLD Medal in INPhO-2008***
HEMANT NOVAL	***National GOLD Medal in INPhO-2008*** and got **AIR-25** in **IIT JEE-2008**
ABHISHEK MITRUKA	***National GOLD Medal in INPhO-2009***
SARTHAK KALANI	***National GOLD Medal in INPhO-2009***
ASTHA AGARWAL	***International SILVER Medal in IJSO-2009*** **at** ***AZERBAIJAN***
RAHUL GURNANI	***International SILVER Medal in IJSO-2009*** **at** ***AZERBAIJAN***
AYUSH SINGHAL	***International SILVER Medal in IJSO-2009*** **at** ***AZERBAIJAN***
MEHUL KUMAR	***International SILVER Medal in IPhO-2010*** **at** ***CROATIA*** and got **AIR-19** in **IIT JEE-2010**
ABHIROOP BHATNAGAR	***National GOLD Medal in INPhO-2010***
AYUSH SHARMA	***International Double GOLD Medal in IJSO-2010*** at ***NIGERIA***
AASTHA AGRAWAL	***Hon'ble Mension Award in APhO-2011*** at ***ISRAEL*** and got **AIR-93** in **IIT JEE 2011**
ABHISHEK BANSAL	***National GOLD Medal in INPhO-2011***
SAMYAK DAGA	***National GOLD Medal in INPhO-2011***
SHREY GOYAL	***National GOLD Medal in INPhO-2012*** and secured **AIR-24** in **IIT JEE 2012**
RAHUL GURNANI	***National GOLD Medal in INPhO-2012***
JASPREET SINGH JHEETA	***National GOLD Medal in INPhO-2012***
DIVYANSHU MUND	***National GOLD Medal in INPhO-2012***
SHESHANSH AGARWAL	***International SILVER Medal in IAO-2012 at KOREA***
SWATI GUPTA	***International SILVER Medal in IJSO-2012 at IRAN***
PRATYUSH RAJPUT	***International SILVER Medal in IJSO-2012 at IRAN***
SHESHANSH AGARWAL	***International BRONZE Medal in IOAA-2013 at GREECE***
SHESHANSH AGARWAL	***International GOLD Medal in IOAA-2014 at ROMANIA***
SHESHANSH AGARWAL	***International SILVER Medal in IPhO-2015 at INDIA*** and secured **AIR-58** in **JEE(Advanced)-2015**
VIDUSHI VARSHNEY	***International SILVER Medal in IJSO-2015 at SOUTH KOREA***
AMAN BANSAL	**AIR-1 in JEE Advanced 2016**
KUNAL GOYAL	**AIR-3 in JEE Advanced 2016**
GOURAV DIDWANIA	**AIR-9 in JEE Advanced 2016**
DIVYANSH GARG	***International SILVER Medal in IPhO-2016 at SWITZERLAND***
NALIN KHANDELWAL	**AIR-1 in NEET 2019**
MRIDUL AGARWAL	**AIR-1 in JEE Advanced 2021**

ABOUT THE AUTHOR

The complexities of Physics have given nightmares to many, but the homegrown genius of Jaipur- Ashish Arora has helped millions of students to live their dreams by decoding it.

Newton Law of Gravitation and Faraday's Magnetic induction force apply perfectly well with this unassuming genius. A Pied Piper of students, his webportal https://www.physicsgalaxy.com, The world's largest encyclopedia of video lectures on high school Physics possesses strong gravitational pull and magnetic attraction for students who want to make it big in life.

Ashish Arora, gifted with rare ability to train masterminds, has mentored over 10,000 IITians and Medicos in his past over three decades of teaching sojourn including lots of students made it to Top 100 in IIT-JEE/JEE(Advance) including multiple times AIR-1 and many in Top-10. Apart from that, he has also groomed hundreds of students for cracking International Physics Olympiad. No wonder his student Navneet Loiwal brought laurel to the country by becoming the first Indian to win a Gold medal at the 2000 - International Physics Olympiad in London (UK).

His special ability to simplify the toughest of the Physics theorems and applications rates him as one among the best Physics teachers in the world. With this, Arora simply defies the logic that perfection comes with age. Even at 18 when he started teaching Physics while pursuing engineering, he was as engaging as he is now. Experience, besides graying his hair, has just widened his horizon.

Now after encountering all tribes of students - some brilliant and some not-so-intelligent - this celebrated teacher has embarked upon a noble mission to make the entire galaxy of Physics inform of his webportal PHYSICSGALAXY.COM to serve and help global students in the subject. Today students from 183 countries are connected with this webportal. On any topic of physics students can post their queries in INTERACT tab of the webportal on which many global experts with Ashish Arora reply to several queries posted online by students.

Dedicated to global students of middle and high school level, his website *www.physicsgalaxy.com* also has teaching sessions dubbed in American accent and subtitles in 87 languages. For students in India preparing for JEE & NEET, his online courses will be available soon on PHYSICSGALAXY.COM.

FOREWORD

It has been pleasure for me to follow the progress Er. Ashish Arora has made in teaching and professional career. In the last about three decades he has actively contributed in developing several new techniques for teaching & learning of Physics and driven important contribution to Science domain through nurturing young students and budding scientists. Physics Galaxy is one such example of numerous efforts he has undertaken.

The third edition of Physics Galaxy provides a good coverage of various topics of Mechanics, Thermodynamics and Waves, Optics & Modern Physics and Electricity & Magnetism through dedicated volumes and many new questions included. It would be an important resource for students appearing in competitive examination for seeking admission in engineering and medical streams.

The structure of book is logical and the presentation is innovative. Importantly the book covers some of the concepts on the basis of realistic experiments and examples. The book has been written in an informal style to help students learn faster and more interactively with better diagrams and visual appeal of the content. Each chapter has variety of theoretical and numerical problems to test the knowledge acquired by students. The book also includes solution to all practice exercises with several new illustrations and problems for deeper learning.

I am sure the book will widen the horizons of knowledge in Physics and will be found very useful by the students for developing in-depth understanding of the subject.

Date : April 12, 2023

Prof. Sandeep Sancheti
Ph. D. (U.K.), B.Tech. FIETE, FIE (I), SMIEEE

Vice-Chancellor (Provost) Marwadi University, Rajkot
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Former-Member JEE Apex Board (JAB), MHRD, GoI
Former-Chairman, Central Counselling Board (CCB), AIEEE, MHRD, GoI
Former-Chairman, Direct Admission of Students Abroad (DASA), MHRD, GoI

PREFACE

For a science student, Physics is the most important subject, unlike to other subjects it requires logical reasoning and high imagination of brain. Without improving the level of physics it is very difficult to achieve a goal in the present age of competitions. To score better, one does not require hard working at least in physics. It just requires a simple understanding and approach to think a physical situation. Actually physics is the surrounding of our everyday life. All the six parts of general physics-Mechanics, Heat, Sound, Light, Electromagnetism and Modern Physics are the constituents of our surroundings. If you wish to make the concepts of physics strong, you should try to understand core concepts of physics in practical approach rather than theoretical. Whenever you try to solve a physics problem, first create a hypothetical approach rather than theoretical. Whenever you try to solve a physics problem, first create a hypothetical world in your imagination about the problem and try to think psychologically, what the next step should be, the best answer would be given by your brain psychology. For making physics strong in all respects and you should try to merge and understand all the concepts with the brain psychologically.

The book PHYSICS GALAXY is designed in a totally different and friendly approach to develop the physics concepts psychologically. The book is presented in five volumes, which covers almost all the core branches of general physics. This part of book, volume 4 covers Modern Physics and Optics. These are most scoring topics of Physics for any competitive or school level exams which helps in building strong applications of the subject. The things you will learn in this book will help in building your overall strength in the branch of Modern Physics and Optics. In this book every chapter is explained in a simple, interactive and experimental way. The book is divided in the six major chapters, first chapters is covering applications of atomic structure followed by the next chapter on photoelectric effect and matter waves. Both of these initial chapters builds foundation of modern physics by understanding characteristics of an atom and atomic spectrum. This chapter also includes the calculation and analysis of electron transition between energy levels of atom and ionization of atom. Photoelectric effect builds a good level of understanding for electron transition effects by absorption of energy. Third chapter covers production and properties of X-Rays and its applications. Next chapter on radioactivity and nuclear physics forms the basis of understanding of nucleus of an atom and also the detailed analysis of stability of nucleus is discussed along with properties of radioactive radiations. The last two chapters at the end, ray optics and wave optics covers the major application of light in form of ray and a wave respectively.

The best way of understanding physics is the experiments and this methodology I am using in my lectures and I found that it helps students a lot in concept visualization. In this book I have tried to translate the things as I used in lectures. After every important section there are several solved examples included with simple and interactive explanations. It might help a student in a way that the student does not require to consult any thing with the teacher. Everything is self explanatory and in simple language.

One important factor in preparation of physics I wish to highlight that most of the student after reading the theory of a concept start working out the numerical problems. This is not the efficient way of developing concepts in brain. To get the maximum benefit of the book students should read carefully the whole chapter at least three or four times with all the illustrative examples and with more stress on some illustrative examples included in the chapter. Practice exercises included after every theory section in each chapter is for the purpose of in-depth understanding of the applications of concepts covered. Illustrative examples are explaining some theoretical concept in the form of an example. After a thorough reading of the chapter students can start thinking on discussion questions and start working on numerical problems.

Exercises given at the end of each chapter are for circulation of all the concepts in mind. There are two sections, first is the discussion questions, which are theoretical and help in understanding the concepts at root level. Second section is of conceptual MCQs which helps in enhancing the theoretical thinking of students and building logical skills in the chapter. Third section of numerical MCQs helps in the developing scientific and analytical application of concepts. Fourth section of advance MCQs with one or more options correct type questions is for developing advance and comprehensive thoughts. Last section is the Unsolved Numerical Problems which includes some simple problems and some tough problems which require the building fundamentals of physics from basics to advance level problems which are useful in preparation of NSEP, INPhO or IPhO.

In this third edition of the book I have included many new questions and solutions in different exercises at practice, conceptual, numerical and advance MCQs to support students who are dependent on their self study and not getting access to teachers for their preparation.

This book has taken a shape just because of motivational inspiration by my mother in 1997 when I just thought to write something for my students. She always motivated and was on my side whenever I thought to develop some new learning methodology for my students.

I don't have words for my best friend my wife Anuja for always being together with me to complete this book in the unique style and format.

I would like to pay my gratitude to Sh. Dayashankar Prajapati in assisting me to complete the task in Design Labs of PHYSICSGALAXY.COM and presenting the book in totally new format of third edition.

At last but the most important person, my father who has devoted his valuable time in finally presenting the book in such a format and a simple language, thanks is a very small word for his dedication in building the base structure of this book.

In this third edition I have tried my best to make this book error free but owing to the nature of work, inadvertently, there is possibility of errors left untouched. I shall be grateful to the readers, if they point out me regarding errors and oblige me by giving their valuable and constructive suggestions via emails for further improvement of the book.

Date : April 12, 2023

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