

# Homework 10: The Job of a Lens

Name: \_\_\_\_\_

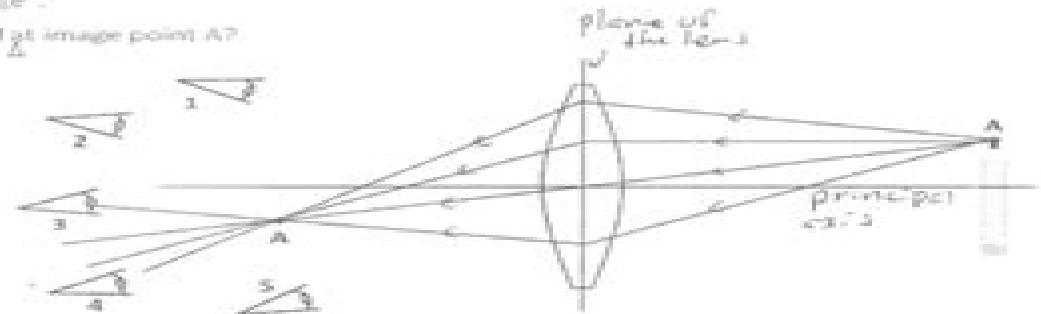
- Reason.** You and your friends are huddled around a lens trying to look at a pencil. The ray diagram shows object point A and image point A but it is incomplete.

- Label the plane of the lens and the principal axis.
- Label the points "object" or "image".
- Is there anything in space located at image point A?  
*yes, the image of pencil A*

- Four rays leave the object point, pass through the lens, and pass through the image point. Draw arrows on these rays.

- Five of your friends are looking into the lens. Who can see the image of the pencil tip? *eye 3 and 4*

- What are the characteristics of the image they see? (type, attitude)  
*real, inverted*

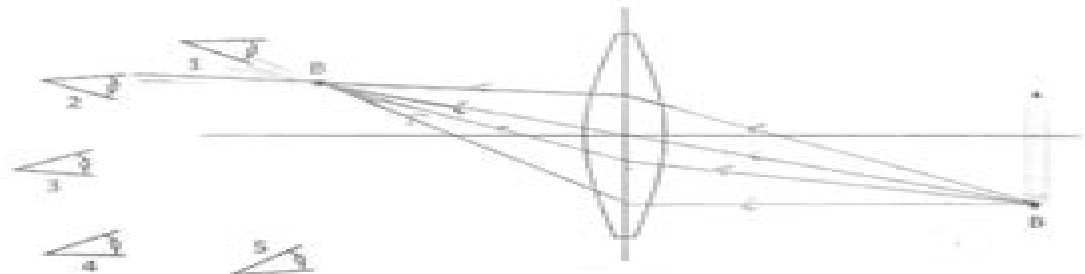


- Reason.** Now you and your friends try to look at the eraser of the pencil. Object point B and image point B are shown in the ray diagram.

- Draw four rays that leave the object point, refract at the lens, and pass through image point B.

- Who can see the pencil's eraser through the lens?

*eye 1 and 2  
can see through  
the lens as the  
rays pass through  
both eyes*



- Two ray diagrams show a central ray: a ray traveling through the centre of a lens. The diagram A is the most realistic. Diagram B uses the thin-lens assumption.

- Describe.** In diagram A, how many times does light refract? Draw each refraction point.  
*It refracts twice*

- Reason.** In diagram A, how does the direction of the outgoing ray compare with the incoming ray?  
*it is relatively the same*



- Explain.** Diagram B shows a central ray using the thin-lens assumption. This is how we will usually draw our central rays. How does diagram B agree with diagram A? Explain.

*It agrees with diagram A as the incoming and outgoing rays are the same direction in diagram B*

# Optics Homework Solutions

**Suresh Subramaniam, Maïté Brandt-  
Pearce, Piet Demeester, Chava Vijaya  
Saradhi**

## Optics Homework Solutions:

*Manufacture of Optical Glass and of Optical Systems, a War-time Problem, May 1921* United States. Army. Ordnance Department. War Department, 1921      *Hydrologic Optics* Rudolph W. Preisendorfer, 1976      **Nonimaging Optics** Roland Winston, Lun Jiang, Vladimir Olier, 2020-10-07 This book provides a comprehensive look at the science methods designs and limitations of nonimaging optics It begins with an in depth discussion on thermodynamically efficient optical designs and how they improve the performance and cost effectiveness of solar concentrating and illumination systems It then moves into limits to concentration imaging devices and their limitations and the theory of furnaces and its applications to optical design Numerous design methods are discussed in detail followed by chapters of estimating the performance of a nonimaging design and pushing their limits of concentration Exercises and worked examples are included throughout      Routing and Wavelength Assignment for WDM-based Optical Networks Bijoy Chand Chatterjee, Nityananda Sarma, Partha Pratim Sahu, Eiji Oki, 2016-10-01 This book presents an in depth treatment of routing and wavelength assignment for optical networks and focuses specifically on quality of service and fault resiliency issues It reports on novel approaches for the development of routing and wavelength assignment schemes for fault resilient optical networks which improve their performance in terms of signal quality call blocking congestion level and reliability without a substantial increase in network setup cost The book first presents a solution for reducing the effect of the wavelength continuity constraint during the routing and wavelength assignment phase Further it reports on an approach allowing the incorporation of a traffic grooming mechanism with routing and wavelength assignment to enhance the effective channel utilization of a given capacity optical network using fewer electrical optical electrical conversions As a third step it addresses a quality of service provision scheme for wavelength division multiplexing WDM based optical networks Lastly the book describes the inclusion of a tree based fault resilience scheme in priority based dispersion reduced wavelength assignment schemes for the purpose of improving network reliability while maintaining a better utilization of network resources Mainly intended for graduate students and researchers the book provides them with extensive information on both fundamental and advanced technologies for routing and wavelength assignment in optical networks The topics covered will also be of interest to network planners and designers      Provisioning, Recovery, and In-Operation Planning in Elastic Optical Networks Luis Velasco, Marc Ruiz, 2017-09-01 Explains the importance of Elastic Optical Networks EONs and how they can be implemented by the world s carriers This book discusses Elastic Optical Networks EONs from an operational perspective It presents algorithms that are suitable for real time operation and includes experimental results to further demonstrate the feasibility of the approaches discussed It covers practical issues such as provisioning protection and defragmentation It also presents provisioning and recovery in single layer elastic optical networks EON The authors review algorithms for provisioning point to point anycast and multicast connections as well as transfer based connections for datacenter interconnection They also include algorithms for recovery

connections from failures in the optical layer and in operation planning algorithms for EONs Provisioning Recovery and In operation Planning in Elastic Optical Network also examines multi layer scenarios It covers virtual network topology reconfiguration and multi layer recovery and includes provisioning customer virtual networks and the use of data analytics in order to bring cognition to the network In addition the book Presents managing connections dynamically and the flexibility to adapt the connection bitrate to the traffic needs fit well for new types of services such as datacenter interconnection and Network Function Virtualization NFV Examines the topic in a holistic and comprehensive way addressing control and management plane issues for provisioning recovery and in operation planning Covers provisioning recovery and in operation planning for EONs at the proposed exhaustive level The rapid expanse of new services has made the use of EONs a relatively new concept a necessity That s why this book is perfect for students and researchers in the field of technologies for optical networks specifically EONs including network architectures and planning dynamic connection provisioning on line network re optimization and control and management planes It is also an important text for engineers and practitioners working for telecom network operators service providers and vendors that require knowledge on a rapidly evolving topic

*Phase in Optics* Vlasta Peřinová, Antonín Lukš, Jan Peřina, 1998 The history of the quantum phase problem characterized by renewed interest in the solution to the problem is included and brought up to date

*Biomedical Optics* Lihong V. Wang, Hsin-i Wu, 2012-09-26 This entry level textbook covering the area of tissue optics is based on the lecture notes for a graduate course Bio optical Imaging that has been taught six times by the authors at Texas A to obtain a copy please email the editorial department at [ialine@wiley.com](mailto:ialine@wiley.com)

**Shaping Light in Nonlinear Optical Fibers** Sonia Boscolo, Christophe Finot, 2017-05-30 This book is a contemporary overview of selected topics in fiber optics It focuses on the latest research results on light wave manipulation using nonlinear optical fibers with the aim of capturing some of the most innovative developments on this topic The book s scope covers both fundamentals and applications from both theoretical and experimental perspectives with topics including linear and nonlinear effects pulse propagation phenomena and pulse shaping solitons and rogue waves novel optical fibers supercontinuum generation polarization management optical signal processing fiber lasers optical wave turbulence light propagation in disordered fiber media and slow and fast light With contributions from leading edge scientists in the field of nonlinear photonics and fiber optics they offer an overview of the latest advances in their own research area The listing of recent research papers at the end of each chapter is useful for researchers using the book as a reference As the book addresses fundamental and practical photonics problems it will also be of interest to and benefit broader academic communities including areas such as nonlinear science applied mathematics and physics and optical engineering It offers the reader a wide and critical overview of the state of the art within this practical as well as fundamentally important and interesting area of modern science providing a useful reference which will encourage further research and advances in the field

**Optical Measurements, Modeling, and Metrology, Volume 5** Tom

Proulx,2025-08-07 Optical Measurements Modeling and Metrology represents one of eight volumes of technical papers presented at the Society for Experimental Mechanics Annual Conference on Experimental and Applied Mechanics held at Uncasville Connecticut June 13 16 2011 The full set of proceedings also includes volumes on Dynamic Behavior of Materials Mechanics of Biological Systems and Materials Mechanics of Time Dependent Materials and Processes in Conventional and Multifunctional Materials MEMS and Nanotechnology Experimental and Applied Mechanics Thermomechanics and Infra Red Imaging and Engineering Applications of Residual Stress      **Optical SuperComputing** Shlomi Dolev,2008-08-12 This book constitutes the refereed proceedings of the The International Workshop on Optical SuperComputing OSC 2008 held in Vienna Austria August 2008 in conjunction with the 7th International Conference on Unconventional Computation UC 2008 OCS is a new annual forum for research presentations on all facets of optical computing for solving hard computation tasks Topics of interest include but are not limited to Design of optical computing devices electrooptics devices for interacting with optical computing devices practical implementations analysis of existing devices and case studies optical and laser switching technologies applications and algorithms for optical devices alpha practical x rays and nano technologies for optical computing      Dissemination of Information in Optical Networks: Subir Bandyopadhyay,2007-10-24 Optical networks and the related technologies network management software and services have undergone remarkable developments and such networks are now the ultra high speed backbone networks for communication Wavelength Division Multiplexing WDM the ability to support multiple communication pathways over the same fiber enables efficient use of the enormous capability for data communication of optical networks This book gives a broad overview of techniques used in the design of WDM networks for efficient dissemination of information in computer networks It starts with an overview of the hardware components then provides a thorough review of WDM wavelength routed networks algorithms for route and wavelength assignment design of broadcast and select networks logical topology design and techniques to handle faults and algorithms for efficient use of optical networks Each topic has been covered rigorously with emphasis on detailed explanations of the approaches used starting from the fundamentals up to the state of the art The optimization techniques covered in the book include graph theoretic algorithms mixed integer linear programming and heuristics The book is intended for beginners as well as for specialists and the reader should be able to design WDM networks and follow developments in the field Each chapter contains a detailed annotated bibliography There are numerous exercises for the reader to test understanding of the subject while readers unfamiliar with mathematical programming techniques and network flow optimization are offered short easy to understand appendices at the end of the book      **Optical WDM Networks** Devi Chadha,2019-05-03 Provides a comprehensive and updated account of WDM optical network systems Optical networking has advanced considerably since 2010 A host of new technologies and applications has brought a significant change in optical networks migrating it towards an all optical network This book places great emphasis on the network concepts technology and methodologies that will

stand the test of time and also help in understanding and developing advanced optical network systems The first part of Optical WDM Networks From Static to Elastic Networks provides a qualitative foundation for what follows presenting an overview of optical networking the different network architectures basic concepts and a high level view of the different network structures considered in subsequent chapters It offers a survey of enabling technologies and the hardware devices in the physical layer followed by a more detailed picture of the network in the remaining chapters The next sections give an in depth study of the three basic network structures the static broadcast networks wavelength routed networks and the electronic optical logically routed networks covering the characteristics of the optical networks in the access metropolitan area and long haul reach It discusses the networking picture network control and management impairment management and survivability The last section of the book covers the upcoming technologies of flex grid and software defined optical networking Provides concise updated and comprehensive coverage of WDM optical networks Features numerous examples and exercise problems for the student to practice Covers in detail important topics such as access local area metropolitan wide area all optical and elastic networks Includes protocols design and analysis along with the control and management of the networks Offers exclusive chapters on advance topics to cover the present and future technological trends such as software defined optical networking and the flexible grid optical networks Optical WDM Networks From Static to Elastic Networks is an excellent book for under and post graduate students in electrical communication engineering It will also be very useful to practicing professionals in communications networking and optical systems

Classical and Evolutionary Algorithms in the Optimization of Optical Systems Darko Vasiljevic, 2012-12-06 The optimization of optical systems is a very old problem As soon as lens designers discovered the possibility of designing optical systems the desire to improve those systems by the means of optimization began For a long time the optimization of optical systems was connected with well known mathematical theories of optimization which gave good results but required lens designers to have a strong knowledge about optimized optical systems In recent years modern optimization methods have been developed that are not primarily based on the known mathematical theories of optimization but rather on analogies with nature While searching for successful optimization methods scientists noticed that the method of organic evolution well known Darwinian theory of evolution represented an optimal strategy of adaptation of living organisms to their changing environment If the method of organic evolution was very successful in nature the principles of the biological evolution could be applied to the problem of optimization of complex technical systems

**Optical WDM Networks** Biswanath Mukherjee, 2006-06-15 Research and development on optical wavelength division multiplexing WDM networks have matured considerably While optics and electronics should be used appropriately for transmission and switching hardware note that intelligence in any network comes from software for network control management signaling traffic engineering network planning etc The role of software in creating powerful network architectures for optical WDM networks is emphasized Optical WDM Networks is a

textbook for graduate level courses Its focus is on the networking aspects of optical networking but it also includes coverage of physical layers in optical networks The author introduces WDM and its enabling technologies and discusses WDM local access metro and long haul network architectures Each chapter is self contained has problems at the end of each chapter and the material is organized for self study as well as classroom use The material is the most recent and timely in capturing the state of the art in the fast moving field of optical WDM networking      Cross-Layer Design in Optical Networks Suresh Subramaniam, Maïté Brandt-Pearce, Piet Demeester, Chava Vijaya Saradhi, 2013-03-23 This work addresses the topic of optical networks cross layer design with a focus on physical layer impairment aware design Contributors captures both the physical layer aware network design as well as the latest advances in service layer aware network design Treatment of topics such as optical transmissions which are prone to signal impairments dense packing of wavelengths dispersion crosstalk etc as well as how to design the network to mitigate such impairments are all covered      *Intelligent Systems for Optical Networks Design: Advancing Techniques* Kavian, Yousef S., Ghassemlooy, Z., 2013-03-31 As the increased demand for high speed communication creates an interest in the development of optical networks intelligent all optical networks have emerged as the next generation for reliable and fast connections Intelligent Systems for Optical Networks Design Advancing Techniques is a comprehensive collection of research focused on theoretical and practical aspects of intelligent methodologies as applied to real world problems This reference source is useful for research and development engineers scholars and students interested in the latest development in the area of intelligent systems for optical networks design      **Optical WDM Networks** Jun Zheng, Hussein T. Mouftah, 2004-08-04 The essential guide to the state of the art in WDM and its vast networking potential As a result of its huge transmission capacity and countless other advantages fiber optics has fostered a bandwidth revolution addressing the constantly growing demand for increased bandwidth Within this burgeoning area Wavelength Division Multiplexing WDM has emerged as a breakthrough technology for exploiting the capacity of optical fibers Today WDM is deployed by many network providers for point to point transmission but there is strong momentum to develop it as a full fledged networking technology in its own right The telecommunications industry network service providers and research communities worldwide are paying close attention Optical WDM Networks presents an easy to follow introduction to basic concepts key issues effective solutions and state of the art technologies for wavelength routed WDM networks Responding to the need for resources focused on the networking potential of WDM the book is organized in terms of the most important networking aspects such as Network control architecture Routing and wavelength assignment Virtual topology design and reconfiguration Distributed lightpath control and management Optical layer protection and restoration IP over WDM Trends for the future in optical networks Each chapter includes examples and problems that illustrate and offer practical application of concepts as well as extensive references for further reading This is an essential resource for professionals and students in electrical engineering computer engineering and computer science as well as network

engineers designers planners operators and managers who seek a backbone of knowledge in optical networks      **Towards an Optical Internet** Admela Jukan, 2013-06-05 In these exciting times of quotidianly progressing developments in communication techniques where more than ever in the history of a technological progress society's reliance on communication networks for medicine education data transfer commerce and many other endeavours dominates the human's everyday life the optical networks are certainly one of the most promising and challenging networking options Since their commercial arrival in the nineties they have fundamentally changed the way of dealing with traffic engineering by removing bandwidth bottlenecks and eliminating delays Today after the revolutionary bandwidth expansion the networking functionality migrates more and more to the optical layer and the need to establish fast wavelength circuits and capacity on demand for the higher layer networks in particular data networks based on Internet Protocol IP has become one of the central networking issues for the new century The unifying trends toward configurable all optical network infrastructure open up a wide range of new network engineering and design choices dealing with networks interoperability and common platforms for control and management The Fifth Working Conference on Optical Network Design and Modelling held in the Austrian capital Vienna February 5-7 2001 aims at presenting the most recent progress in optical communication techniques new technologies standardisation process emerging markets and carriers A short look at the Table of Contents of this book tells us in fact that this year's conference program reflects the current state of the art precisely      *Traffic Grooming for Optical Networks* Rudra Dutta, Ahmed E. Kamal, George N. Rouskas, 2008-08-06 The objective of this book is to provide timely and comprehensive coverage of the principles technology practice and future of traffic grooming in optical networks Traffic grooming considerations are already shaping new switch designs and standards including next generation Synchronous Optical Network Synchronous Digital Hierarchy SONET SDH and Generic Framing Procedure GFP are affecting future optical network technologies and are creating new business opportunities Yet information on the topic is scattered and there is a shortage of technical sources where relevant material can be accessed in a single location The motivation for this book was to bridge this gap by providing a single authoritative point of reference to the traffic grooming state of the art Traffic grooming is a complex subject involving a number of interrelated concepts standards and technologies It is also a rapidly growing field of study making it difficult for a single book to cover all aspects in detail To cope with this scope and complexity this book provides appropriate background information followed by an in-depth study of a few key issues and challenges It has been our intention to bring together a broad range of perspectives from preeminent researchers in both academia and industry We believe that these multiple diverse points of view add considerable value and make the contents more interesting to the reader      *Multiwavelength Optical Networks* Thomas E. Stern, Georgios Ellinas, Krishna Bala, 2009 Second edition of the acclaimed Multiwavelength Optical Networks describing architectures enabling technologies and analytical tools

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