

Thermodynamics - Example Problems

Problems and Solutions

1 Examining a Power Plant

Consider a power plant. At point 1 the working gas has a temperature of $T = 25^\circ\text{C}$. The pressure is 1bar and the mass flow is $\dot{m} = 2\text{kg/s}$. After point 1, the air enters a compressor, at which the pressure is increased to 6 bar. (This is point 2.) After this, the flow is heated to $T_3 = 700^\circ\text{C}$. (This is stage 3.) Afterwards, the flow goes through a turbine, at which the pressure is decreased to 1bar again. (This is stage 4.) The flow is then cooled to $T_1 = 25^\circ\text{C}$. We're now back in stage 1.

We assume that:

1. air behaves like a thermally and calorically perfect gas with $C_p = 1004\text{J/kg K}$, $R = 287\text{J/kg K}$ and $\gamma = 1.4$.
2. the isentropic efficiency of the compressor is 0.88.
3. the polytropic efficiency of the turbine is 0.85.

Answer the following questions.

1. Depict the evolution of the cycle in the $T - s$ plane.
2. Determine the net power.
3. Determine the heat received from the hot source.
4. Determine the thermal efficiency of the power plant.
5. Determine the Carnot efficiency associated with the present power plant and compare it with the previous result.
6. Verify the first principle.

1 Solution

1. Let's draw the $T - s$ graph. We start by drawing two lines of constant pressure. (This can be seen in the graph below.)

We now start at point 1. At this point the pressure and temperature are low. When we go to point 2, we don't go straight up, since the process is not isentropic. Instead, we go up and slightly right as well, until we reach the line $p = 6\text{bar}$. We then have found point 2.

The heating takes place under constant pressure. So from point 2 to point 3 we stay on the isobaric line $p = 6\text{bar}$. This goes on until we reach $T = 973\text{K}$. This is the position of point 3.

The turbine isn't isentropic either. So from point 3 we don't go straight down. Instead, we go down and a bit to the right as well, until we reach the line $p = 1\text{bar}$. This is point 4.

From point 4 we return to point 1. Since the cooling occurs at constant pressure, we do this without leaving the line $p = 1\text{bar}$.

Thermodynamic Example Problems

Michael Pauken

A red circular graphic with a gradient, appearing as a semi-circle or a partial circle, located to the right of the author's name.

Thermodynamic Example Problems:

Thermodynamics Problem Solving in Physical Chemistry Kathleen E. Murphy, 2020-03-23 *Thermodynamics Problem Solving in Physical Chemistry Study Guide and Map* is an innovative and unique workbook that guides physical chemistry students through the decision making process to assess a problem situation create appropriate solutions and gain confidence through practice solving physical chemistry problems The workbook includes six major sections with 20 30 solved problems in each section that span from easy single objective questions to difficult multistep analysis problems Each section of the workbook contains key points that highlight major features of the topic to remind students of what they need to apply to solve problems in the topic area Key Features Provides instructor access to a visual map depicting how all equations used in thermodynamics are connected and how they are derived from the three major energy laws Acts as a guide in deriving the correct solution to a problem Illustrates the questions students should ask themselves about the critical features of the concepts to solve problems in physical chemistry Can be used as a stand alone product for review of Thermodynamics questions for major tests

Thermodynamics 1 With No Calculations Edenilson Brandl, Have you ever wanted to understand thermodynamics without getting lost in complex calculations This book provides a clear intuitive approach to one of the most important scientific fields making it accessible to students professionals and curious minds alike By focusing on concepts rather than equations it offers a fresh and engaging way to learn how energy works in the world around us Whether you re a beginner looking for an introduction or an expert seeking a new perspective this book will give you the tools to grasp the principles of thermodynamics with ease With real world examples simple explanations and insightful discussions you will walk away with a deeper appreciation of how thermodynamics shapes our daily lives and the technologies we rely on Don t let complex mathematics stand in the way of understanding thermodynamics Dive into this book and discover how energy heat and entropy govern everything from the engines that power our world to the fundamental processes of nature Get your copy today and unlock the secrets of thermodynamics in the simplest way possible

[Engineering Thermodynamics With Worked Examples \(Second Edition\)](#) Nihal E Wijesundera, 2016-11-25 The laws of thermodynamics have wide ranging practical applications in all branches of engineering This invaluable textbook covers all the subject matter in a typical undergraduate course in engineering thermodynamics and uses carefully chosen worked examples and problems to expose students to diverse applications of thermodynamics This new edition has been revised and updated to include two new chapters on thermodynamic property relations and the statistical interpretation of entropy Problems with numerical answers are included at the end of each chapter As a guide instructors can use the examples and problems in tutorials quizzes and examinations

Modern Engineering Thermodynamics - Textbook with Tables Booklet Robert T. Balmer, 2011-01-03 *Modern Engineering Thermodynamics Textbook with Tables Booklet* offers a problem solving approach to basic and applied engineering thermodynamics with historical vignettes critical thinking boxes and case studies throughout to help relate

abstract concepts to actual engineering applications It also contains applications to modern engineering issues This textbook is designed for use in a standard two semester engineering thermodynamics course sequence with the goal of helping students develop engineering problem solving skills through the use of structured problem solving techniques The first half of the text contains material suitable for a basic Thermodynamics course taken by engineers from all majors The second half of the text is suitable for an Applied Thermodynamics course in mechanical engineering programs The Second Law of Thermodynamics is introduced through a basic entropy concept providing students a more intuitive understanding of this key course topic Property Values are discussed before the First Law of Thermodynamics to ensure students have a firm understanding of property data before using them Over 200 worked examples and more than 1 300 end of chapter problems provide an extensive opportunity to practice solving problems For greater instructor flexibility at exam time thermodynamic tables are provided in a separate accompanying booklet University students in mechanical chemical and general engineering taking a thermodynamics course will find this book extremely helpful Provides the reader with clear presentations of the fundamental principles of basic and applied engineering thermodynamics Helps students develop engineering problem solving skills through the use of structured problem solving techniques Introduces the Second Law of Thermodynamics through a basic entropy concept providing students a more intuitive understanding of this key course topic Covers Property Values before the First Law of Thermodynamics to ensure students have a firm understanding of property data before using them Over 200 worked examples and more than 1 300 end of chapter problems offer students extensive opportunity to practice solving problems Historical Vignettes Critical Thinking boxes and Case Studies throughout the book help relate abstract concepts to actual engineering applications For greater instructor flexibility at exam time thermodynamic tables are provided in a separate accompanying booklet

Introduction to the Thermodynamics of Materials David R.

Gaskell, David E. Laughlin, 2017-08-15 Maintaining the substance that made Introduction to the Thermodynamic of Materials a perennial best seller for decades this Sixth Edition is updated to reflect the broadening field of materials science and engineering The new edition is reorganized into three major sections to align the book for practical coursework with the first Thermodynamic Principles and second Phase Equilibria sections aimed at use in a one semester undergraduate course The third section Reactions and Transformations can be used in other courses of the curriculum that deal with oxidation energy and phase transformations The book is updated to include the role of work terms other than PV work e g magnetic work along with their attendant aspects of entropy Maxwell equations and the role of such applied fields on phase diagrams There is also an increased emphasis on the thermodynamics of phase transformations and the Sixth Edition features an entirely new chapter 15 that links specific thermodynamic applications to the study of phase transformations The book also features more than 50 new end of chapter problems and more than 50 new figures

Engineering Thermodynamics D.C. Look, G.

Alexander, 2012-12-06 Energy its discovery its availability its use concerns all of us in general and the engineers of today and

tomorrow in particular The study of thermodynamics the science of energy is a critical element in the education of all types of engineers Engineering Thermodynamics provides a thorough introduction to the art and science of engineering thermodynamics It describes in a straightforward fashion the basic tools necessary to obtain quantitative solutions to common engineering applications involving energy and its conversion conservation and transfer This book is directed toward sophomore junior and senior students who have studied elementary physics and calculus and who are majoring in mechanical engineering it serves as a convenient reference for other engineering disciplines as well The first part of the book is devoted to basic thermodynamic principles essentially presented in the classic way the second part applies these principles to many situations including air conditioning and the interpretation of statistical phenomena **Engineering Thermodynamics**

Kavati Venkateswarlu, 2020-12-10 This textbook comprehensively covers the fundamentals and advanced concepts of thermodynamics in a single volume It provides a detailed discussion of advanced concepts that include energy efficiency energy sustainability energy security organic Rankine cycle combined cycle power plants combined cycle power plant integrated with organic Rankine cycle and absorption refrigeration system integrated coal gasification combined cycle power plants energy conservation in domestic refrigerators and next generation low global warming potential refrigerants Pedagogical features include solved problems and unsolved exercises interspersed throughout the text for better understanding This textbook is primarily written for senior undergraduate students in the fields of mechanical automobile chemical civil and aerospace engineering for courses on engineering thermodynamics thermodynamics and for graduate students in thermal engineering and energy engineering for courses on advanced thermodynamics It is accompanied by teaching resources including a solutions manual for instructors FEATURES Provides design and experimental problems for better understanding Comprehensively discusses power cycles and refrigeration cycles and their advancements Explores the design of energy efficient buildings to reduce energy consumption Property tables charts and multiple choice questions comprise appendices of the book and are available at <https://www.routledge.com/9780367646288> **Advanced**

Thermodynamics Engineering Kalyan Annamalai, Ishwar K. Puri, Milind A. Jog, 2011-03-22 Advanced Thermodynamics Engineering Second Edition is designed for readers who need to understand and apply the engineering physics of thermodynamic concepts It employs a self-teaching format that reinforces presentation of critical concepts mathematical relationships and equations with concrete physical examples and explanations of application **Thermodynamics and**

Energy Conversion Henning Struchtrup, 2024-06-27 This comprehensive textbook covers engineering thermodynamics from beginner to advanced level The presentation is concise with material for about three full-term university courses on 700 pages without compromising breadth or depth First and second law of thermodynamics are developed from everyday observations with accessible and rational arguments The laws of thermodynamics are applied to a multitude of systems and processes from simple equilibration processes over steam and gas power cycles refrigerators and heat pumps to chemical

systems including fuel cells Entropy and the second law are emphasized throughout with focus on irreversible processes and work loss Insightful development of theory is accompanied by detailed solutions of example problems which teach the required technical skills while giving insight into the multitude of thermodynamic processes and applications About 550 end of chapter problems highlight all important concepts and processes *Thermodynamics* Sanford Klein, Gregory Nellis, 2011-10-10 This book differs from other thermodynamics texts in its objective which is to provide engineers with the concepts tools and experience needed to solve practical real world energy problems The presentation integrates computer tools such as EES with thermodynamic concepts to allow engineering students and practising engineers to solve problems they would otherwise not be able to solve The use of examples solved and explained in detail and supported with property diagrams that are drawn to scale is ubiquitous in this textbook The examples are not trivial drill problems but rather complex and timely real world problems that are of interest by themselves As with the presentation the solutions to these examples are complete and do not skip steps Similarly the book includes numerous end of chapter problems both typeset and online Most of these problems are more detailed than those found in other thermodynamics textbooks The supplements include complete solutions to all exercises software downloads and additional content on selected topics These are available on the book's website www.cambridge.org Klein and Nellis *Statistical Thermodynamics* John W. Daily, 2018-12-20 Clearly connects macroscopic and microscopic thermodynamics and explains non equilibrium behavior in kinetic theory and chemical kinetics **Fundamentals of Engineering Thermodynamics** Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, 2010-12-07 This leading text in the field maintains its engaging readable style while presenting a broader range of applications that motivate engineers to learn the core thermodynamics concepts Two new coauthors help update the material and integrate engaging new problems Throughout the chapters they focus on the relevance of thermodynamics to modern engineering problems Many relevant engineering based situations are also presented to help engineers model and solve these problems *Physical and Chemical Equilibrium for Chemical Engineers* Noel de Nevers, 2012-03-20 This book concentrates on the topic of physical and chemical equilibrium Using the simplest mathematics along with numerous numerical examples it accurately and rigorously covers physical and chemical equilibrium in depth and detail It continues to cover the topics found in the first edition however numerous updates have been made including Changes in naming and notation the first edition used the traditional names for the Gibbs Free Energy and for Partial Molal Properties this edition uses the more popular Gibbs Energy and Partial Molar Properties changes in symbols the first edition used the Lewis Randal fugacity rule and the popular symbol for the same quantity this edition only uses the popular notation and new problems have been added to the text Finally the second edition includes an appendix about the Bridgman table and its use **An Introduction to Equilibrium Thermodynamics** Bernard Morrill, 2013-10-22 An Introduction to Equilibrium Thermodynamics discusses classical thermodynamics and irreversible thermodynamics It introduces the laws of

thermodynamics and the connection between statistical concepts and observable macroscopic properties of a thermodynamic system Chapter 1 discusses the first law of thermodynamics while Chapters 2 through 4 deal with statistical concepts The succeeding chapters describe the link between entropy and the reversible heat process concept of entropy the second law of thermodynamics Legendre transformations and Jacobian algebra Finally Chapter 10 provides an introduction to irreversible thermodynamics This book will be useful as an introductory text to thermodynamics for engineering students Practical Chemical Thermodynamics for Geoscientists Bruce Fegley, Rose Osborne, 2013 Presents brief historical summaries and biographies of key thermodynamics scientists alongside the fundamentals they were responsible for **Extended Irreversible Thermodynamics** D. Jou, J. Casas-Vazquez, G. Lebon, 2011-06-27 Covers a wide spectrum of applications and contains a wide discussion of the foundations and the scope of the most current theories of non equilibrium thermodynamics The new edition reflects new developments and contains a new chapter on the interplay between hydrodynamics and thermodynamics **Thermodynamics** Ibrahim Dincer, 2020-08-12 Presents a unique stepwise exergy based approach to thermodynamic concepts systems and applications Thermodynamics A Smart Approach redefines this crucial branch of engineering as the science of energy and exergy rather than the science of energy and entropy to provide an innovative step by step approach for teaching understanding and practicing thermodynamics in a clearer and easier way Focusing primarily on the concepts and balance equations this innovative textbook covers exergy under the second law of thermodynamics discusses exergy matters and relates thermodynamics to environmental impact and sustainable development in a clear simple and understandable manner It aims to change the way thermodynamics is taught and practiced and help overcome the fear of thermodynamics Author Ibrahim Dincer a pioneer in the areas of thermodynamics and sustainable energy technologies draws upon his multiple decades of experience teaching and researching thermodynamics to offer a unique exergy based approach to the subject Enabling readers to easily comprehend and apply thermodynamic principles the text organizes thermodynamics into seven critical steps property state process cycle first law of thermodynamics second law of thermodynamics and performance assessment and provides extended teaching tools for systems and applications Precise student friendly chapters cover fundamental concepts thermodynamic laws conventional and innovative power and refrigeration cycles and more This textbook Covers a unique approach in teaching design analysis and assessment of thermodynamic systems Provides lots of examples for every subject for students and instructors Contains hundreds of illustrations figures and tables to better illustrate contents Includes many conceptual questions and study problems Features numerous systems related examples and practical applications Thermodynamics A Smart Approach is an ideal textbook for undergraduate students and graduate students of engineering and applied science as well researchers scientists and practicing engineers seeking a precise and concise textbook and or reference work **Thermodynamics For Dummies** Michael Pauken, 2025-03-17 The thermodynamics knowledge you need to succeed in class and in your career

Thermodynamics For Dummies 2nd Edition covers the topics found in a typical undergraduate introductory thermodynamic course which is an essential course to nearly all engineering degree programs It also brings the subject to life with exciting content on where and how thermodynamics is being used today spoiler alert everywhere You ll grasp the basics of how heat and energy interact thermodynamic properties of reactions and mixtures and how thermodynamic cycles are used to make things go This useful guide also covers renewable energy systems new refrigerant technology and a more diverse perspective on the history of the field Within you ll Get clear explanations of the laws of thermodynamics thermodynamic cycles and beyond Read about real world examples to help you connect with the content Practice solving thermodynamic problems to internalize what you ve learned For students looking for resources to demystify thermodynamics Thermodynamics For Dummies 2nd Edition is the perfect choice Become thermodynamically savvy with this accessible guide

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