

PROBLEM 9.6

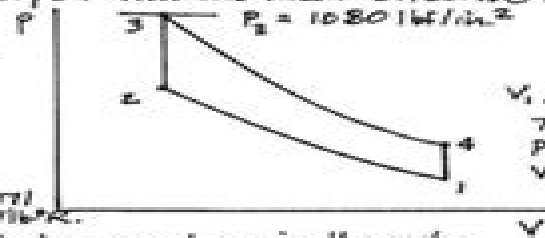
KNOWN: A four-cylinder, four-stroke engine operates at a known RPM. The processes in each cylinder are modeled as a cold air-standard Otto cycle with a specified state at the beginning of compression, a known compression ratio, and a specified maximum cycle pressure.

Find: Determine the power developed and the mean effective pressure.

SCHEMATIC & GIVEN DATA:

①

Four-cylinder
Four-stroke
2800 RPM



$V_1/V_2 = 10$
 $T_1 = 80^\circ\text{F} = 540^\circ\text{R}$
 $P_1 = 14.7 \text{ lbf/in}^2$
 $V_1 = 0.0196 \text{ ft}^3$

ENGINEERING MODEL: See Example 9.1. Also, $k = 1.4$ and $c_v = 0.171 \text{ Btu/lb}\cdot^\circ\text{R}$.

ANALYSIS: First, determine each temperature in the cycle.

State 2: Using Eq. 9.6, $T_2 = (V_1/V_2)^{k-1} T_1 = (10)^{0.4} (540^\circ\text{R}) = 1356.4^\circ\text{R}$

Also, $P_2 = (V_1/V_2)^k P_1 = (10)^{1.4} (14.7) = 369.2 \text{ lbf/in}^2$

State 3: $V_3 = V_2 \Rightarrow T_3 = (P_3/P_2) T_2 = (1080/369.2)(1356.4) = 3967.8^\circ\text{R}$

State 4: $T_4 = (V_3/V_4)^{k-1} T_4 = (1/10)^{0.4} (3967.8) = 1579.6^\circ\text{R}$

To get the power, first determine the net work per cycle. The mass in the cylinder is

$$m = \frac{P_1 V_1}{RT_1} = \frac{(14.7 \text{ lbf/in}^2)(0.0196 \text{ ft}^3)}{\left(\frac{1545 \text{ ft}\cdot\text{lbf}}{28.97 \text{ lb}\cdot^\circ\text{R}}\right)(540^\circ\text{R})} \left| \frac{144 \text{ in}^2}{1 \text{ ft}^2} \right| = 0.001441 \text{ lb}$$

$$W_{\text{cycle}} = W_{12} + W_{34}$$

$$= m c_v [(T_1 - T_2) + (T_3 - T_4)]$$

$$= (0.001441 \text{ lb})(0.171 \frac{\text{Btu}}{\text{lb}\cdot^\circ\text{R}}) [(540 - 1356.4) + (3967.8 - 1579.6)]^\circ\text{R}$$

$$= 0.3873 \text{ Btu/cycle}$$

$$\dot{W}_{\text{net}} = (4 \text{ cyl}) \left(\frac{2800 \text{ cycle}}{2 \text{ min}} \right) (0.3873 \text{ Btu/cycle}) \left| \frac{60 \text{ min}}{1 \text{ h}} \right| \left| \frac{1 \text{ hp}}{2545 \text{ Btu/h}} \right|$$

$$= 51.1 \text{ hp} \leftarrow \dot{W}_{\text{net}}$$

The mean effective pressure is

$$mep = \frac{W_{\text{cycle}}}{V_1 - V_2} = \frac{W_{\text{cycle}}}{V_1 (1 - V_2/V_1)}$$

$$= \frac{0.3873 \text{ Btu}}{(0.0196 \text{ ft}^3)(1 - 0.1)} \left| \frac{7.78 \text{ ft}\cdot\text{lbf}}{1 \text{ Btu}} \right| \left| \frac{1 \text{ ft}^2}{144 \text{ in}^2} \right| = 118.6 \text{ lbf/in}^2 \leftarrow mep$$

9.6 A four-cylinder, four-stroke internal combustion engine operates at 2800 RPM. The processes within each cylinder are modeled as an air-standard Otto cycle with a pressure of 14.7 lbf/in.², a temperature of 80°F, and a volume of 0.0196 ft³ at the beginning of compression. The compression ratio is 10, and maximum pressure in the cycle is 1080 lbf/in.². Determine, using a cold air-standard analysis with $k = 1.4$, the power developed by the engine, in horsepower, and the mean effective pressure, in lbf/in.²

Otto Cycle Problems And Solutions

William Norris



Otto Cycle Problems And Solutions:

Problems and Solutions in Thermal Engineering Shiv Kumar, 2023-07-15 This book is a collection of over 225 multiple choice type questions MCQs and more than 40 practice exam questions with solutions This book complements a 2 volume textbook set titled Thermal Engineering by the same author The answers are adequately supported by well illustrated diagrams wherever necessary for better understanding of the concepts The book also included steam tables as an appendix to aid in problem solving This book proves useful for undergraduate students of mechanical engineering and related disciplines The book is used in conjunction with the author's textbook set on thermal engineering or as a supplement to other core textbooks and lecture materials It is used to support classroom teaching or as a self study guide The problem solution format also proves useful for students and professionals involved in exam prep for graduate university entrance tests and professional certifications

A Practical Treatise on the 'Otto' Cycle Gas Engine William Norris, 1896 *Princeton Problems in Physics with Solutions* Nathan Newbury, Mark Newman, 2015-03-25 Aimed at helping the physics student to develop a solid grasp of basic graduate level material this book presents worked solutions to a wide range of informative problems These problems have been culled from the preliminary and general examinations created by the physics department at Princeton University for its graduate program The authors all students who have successfully completed the examinations selected these problems on the basis of usefulness interest and originality and have provided highly detailed solutions to each one Their book will be a valuable resource not only to other students but to college physics teachers as well The first four chapters pose problems in the areas of mechanics electricity and magnetism quantum mechanics and thermodynamics and statistical mechanics thereby serving as a review of material typically covered in undergraduate courses Later chapters deal with material new to most first year graduate students challenging them on such topics as condensed matter relativity and astrophysics nuclear physics elementary particles and atomic and general physics

Solutions Manual for an Introduction to Thermodynamics Y.V.C. Rao, 2005-02 This manual contains the complete solution for all the 505 chapter end problems in the textbook An Introduction to Thermodynamics and will serve as a handy reference to teachers as well as students The data presented in the form of tables and charts in the main textbook are made use of in this manual for solving the problems

1000 Solved Problems in Classical Physics Ahmad A. Kamal, 2011-03-18 This book basically caters to the needs of undergraduates and graduates physics students in the area of classical physics specially Classical Mechanics and Electricity and Electromagnetism Lecturers Tutors may use it as a resource book The contents of the book are based on the syllabi currently used in the undergraduate courses in USA U K and other countries The book is divided into 15 chapters each chapter beginning with a brief but adequate summary and necessary formulas and Line diagrams followed by a variety of typical problems useful for assignments and exams Detailed solutions are provided at the end of each chapter

Science Education at the Nexus of Theory and Practice, 2008-01-01 This book is a

compilation of papers from the inaugural International Science Education Conference held at the National Institute of Education Singapore The title Science Education at the Nexus of Theory and Practice reflects a pressing yet ongoing concern worldwide to integrate theory and practice in science education and the reader will find something of interest to both science education practitioners and researchers The editors have decided to engage in written dialogue before each of the three sections to enrich the experience Divided into three key sections A Concepts conceptual change and science learning B science teacher development and learning and C access to science accessible science the 19 chapters will engender food for thought and in all likelihood transform classroom practices All the contributors here provide important insights into the diverse education systems cultural backgrounds and societal norms through which science education can be realized

Fluid and Thermal Sciences Nuggenhalli S. Nandagopal, PE, 2022-04-05 This text provides a clear understanding of the fundamental principles of thermal and fluid sciences in a concise manner in a rigorous yet easy to follow language and presentation Elucidation of the principles is further reinforced by examples and practice problems with detailed solutions Firmly grounded in the fundamentals the book maximizes readers capacity to take on new problems and challenges in the field of fluid and thermal sciences with confidence and conviction Standing also as a ready reference and review of the essential theories and their applications in fluid and thermal sciences the book is applicable for undergraduate mechanical and chemical engineering students students in engineering technology programs as well as practicing engineers preparing for the engineering license exams FE and PE in USA and abroad Explains the concepts and theory with a practical approach that readers can easily absorb Provides the just the right amount of theoretical and mathematical background needed making it less intimidating for the reader Covers fluid and thermal sciences in a straight forward yet comprehensive manner facilitating a good understanding of the subject matter Includes a wide spectrum and variety of problems along with numerous illustrative solved examples and many practice problems with solutions *The Electrical Engineer*, 1908

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hour sample exam with 120 morning AM questions 60 general afternoon PM questions and complete step by step solutions to all problems 918 problems total 60% text 40% problems and solutions *Automotive Development* United States. Congress. Senate. Committee on Commerce, Science, and Transportation,1979 **Science Education from People for People**

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Council of Examiners for Engineering and Surveying,2003 **The Heat Engine Problem ...** Charles Edward Lucke,1902

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