

# Chapter 12: Wave properties

## Knowledge organiser

### Waves in air, fluids, and solids

Waves transfer energy from one place to another without transferring matter. Waves may be \_\_\_\_\_ or \_\_\_\_\_.

For waves in \_\_\_\_\_ and \_\_\_\_\_, it is the wave and not the substance that moves.

- When a light object is dropped into still water, it produces \_\_\_\_\_ (waves) on the water which \_\_\_\_\_, but neither the object nor the water moves with the ripples.
- When you speak, your voice has \_\_\_\_\_ making sound waves travel through the \_\_\_\_\_. The air itself does not travel away from your throat, otherwise a \_\_\_\_\_ would be created.



Mechanical waves require a \_\_\_\_\_ (a medium) to travel through.

Examples of mechanical waves include \_\_\_\_\_ waves, \_\_\_\_\_ waves, waves on \_\_\_\_\_ and ropes, and \_\_\_\_\_ waves produced by earthquakes.

When waves travel through a substance, the particles in the substance \_\_\_\_\_ (vibrate) and pass energy on to neighbouring particles.

### Transverse waves

The oscillations of a transverse wave are \_\_\_\_\_ (at right angles) to the direction in which the waves transfer energy.

\_\_\_\_\_ are an example of transverse waves.



### Longitudinal waves

The oscillations of a longitudinal wave are \_\_\_\_\_ to the direction in which the waves transfer energy.

Longitudinal waves cause particles in a substance to be \_\_\_\_\_ close together and \_\_\_\_\_ further apart, producing areas of \_\_\_\_\_ and \_\_\_\_\_ in the substance.

\_\_\_\_\_ in air are an example of longitudinal waves.



Wave motion is described by a number of properties.

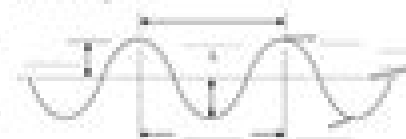
Property	Description	Unit
amplitude $A$		
frequency $f$		
period $T$		
wavelength $\lambda$		
wave speed $v$		

### Properties of waves

Frequency and period are related by the equation:

$$\text{period } (s) = \frac{1}{\text{frequency } (Hz)} \quad T = \frac{1}{f}$$

Label the diagram.



All waves obey the wave equation:

$$\text{wave speed } (m/s) = \text{frequency } (Hz) \times \text{wavelength } (m) \quad v = f\lambda$$

When waves travel from one medium to another, their speed and wavelength may change but the frequency stays the same.

The speed of ripples on water can be slow enough to measure using a stopwatch and ruler, and applying the equation:

$$\text{speed } (m/s) = \frac{\text{distance}}{\text{time}}$$

The speed of sound in air can be measured by using a \_\_\_\_\_ to measure the time taken for a sound to travel a known distance, and applying the same equation.

### Reflection of waves

When waves arrive at the boundary between two different substances, one or more of the following things can happen:

- \_\_\_\_\_ - the energy of the waves is transferred to the energy stores of the substance they travel into (for example, when food is heated in a microwave)
- \_\_\_\_\_ - the waves bounce back
- \_\_\_\_\_ - the waves change speed and direction as they cross the boundary
- \_\_\_\_\_ - the waves carry on moving once they've crossed the boundary, but may be reflected

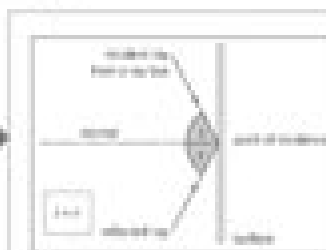
\_\_\_\_\_ can be used to show what happens when a wave is reflected at a surface.

To correctly draw a ray diagram for reflection:

1. use a \_\_\_\_\_ to draw all lines for the rays.
2. draw a single \_\_\_\_\_ on the rays to show the direction the wave is travelling.
3. draw a dashed line at \_\_\_\_\_ to the surface at the point of \_\_\_\_\_ (this line is normal to the surface).
4. label the normal, angle of incidence (\_\_\_\_), and angle of reflection (\_\_\_\_).

When reflection happens at a surface, the angle of incidence is always equal \_\_\_\_\_.

$$i = r$$



### Key terms

Make sure you can write a definition for these key terms.

direction amplitude compression frequency incidence longitudinal mechanical wave oscillate period ray diagram reflection refraction transmission transverse wavelength wave speed

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## **Murray Chapter 12 Answers Waves:**

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Solutions In Action Karl Lanngren, 2012-12-02 Solitons in Action is a collection of papers that discusses the concept of a wave packet or pulse known as a soliton One paper reviews the development of the solitary wave concept with emphasis on the difference between a solitary wave and a soliton The Korteweg de Vries KdV equation shows the interactions between infinite sets of conservation laws and the inverse scattering transform method The Backlund transform technique produces hierarchies of multisoliton solutions for nonlinear wave equations The Gel'fand Levitan algorithm can effect an inverse scattering calculation that relates changes in the scattering data to changes in the solution of corresponding wave equation One paper points out that concepts in differential geometry can show the fundamental nature of soliton behavior and the relationship between inverse scattering and the Backlund transformation Solitons in action can be viewed as magnetic flux propagates through a gap between two closely spaced superconductors in quantum units This view results in a simplified procedure for perturbation

expansions around multisoliton solutions This collection can prove useful for researchers involved in the study of fluid mechanics of pure and applied sciences of mathematical sciences and of wave theory *Introductory Physics for the Life Sciences* Simon Mochrie, Claudia De Grandi, 2023-04-05 This classroom tested textbook is an innovative comprehensive and forward looking introductory undergraduate physics course While it clearly explains physical principles and equips the student with a full range of quantitative tools and methods the material is firmly grounded in biological relevance and is brought to life with plenty of biological examples throughout It is designed to be a self contained text for a two semester sequence of introductory physics for biology and premedical students covering kinematics and Newton's laws energy probability diffusion rates of change statistical mechanics fluids vibrations waves electromagnetism and optics Each chapter begins with learning goals and concludes with a summary of core competencies allowing for seamless incorporation into the classroom In addition each chapter is replete with a wide selection of creative and often surprising examples activities computational tasks and exercises many of which are inspired by current research topics making cutting edge biological physics accessible to the student *Mathematics for Dynamic Modeling* Edward Beltrami, 2014-05-10 Mathematics for Dynamic Modeling provides an introduction to the mathematics of dynamical systems This book presents the mathematical formulations in terms of linear and nonlinear differential equations Organized into two parts encompassing nine chapters this book begins with an overview of the notions of equilibrium and stability in differential equation modeling that occur in the guise of simple models in the plane This text then focuses on nonlinear models in which the limiting behavior of orbits can be more complicated Other chapters consider the problems that illustrate the concepts of equilibrium and stability limit cycles chaos and bifurcation This book discusses as well a variety of topics including cusp catastrophes strange attractors and reaction diffusion and shock phenomena The final chapter deals with models that are based on the notion of optimization This book is intended to be suitable for students in upper undergraduate and first year graduate course in mathematical modeling

**Physics for Scientists and Engineers** Paul A. Tipler, 1999-10-13 For nearly 25 years Tipler's standard setting textbook has been a favorite for the calculus based introductory physics course With this edition the book makes a dramatic re emergence adding innovative pedagogy that eases the learning process without compromising the integrity of Tipler's presentation of the science For instructor and student convenience the Fourth Edition of *Physics for Scientists and Engineers* is available as three paperback volumes Vol 1 Mechanics Oscillations and Waves Thermodynamics 768 pages 1 57259 491 8 Vol 2 Electricity and Magnetism 544 pages 1 57259 492 6 Vol 3 Modern Physics Quantum Mechanics Relativity and The Structure of Matter 304 pages 1 57259 490 X or in two hardcover versions Regular Version Chaps 1 35 and 39 0 7167 3821 X Extended Version Chaps 1 41 0 7167 3822 8 To order the volume or version you need use the links above to go to each volume or version's specific page Download errata for this book This errata is for the first printing of Tipler's PSE 4 e The errors have been corrected in subsequent printings of the book but we continue to make this errata available for those

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*Introduction to Traveling Waves* Anna R. Ghazaryan, Stéphane Lafortune, Vahagn Manukian, 2022-11-14 Introduction to Traveling Waves is an invitation to research focused on traveling waves for undergraduate and masters level students Traveling waves are not typically covered in the undergraduate curriculum and topics related to traveling waves are usually only covered in research papers except for a few texts designed for students This book includes techniques that are not covered in those texts Through their experience involving undergraduate and graduate students in a research topic related to traveling waves the authors found that the main difficulty is to provide reading materials that contain the background information sufficient to start a research project without an expectation of an extensive list of prerequisites beyond regular undergraduate coursework This book meets that need and serves as an entry point into research topics about the existence and stability of traveling waves Features Self contained step by step introduction to nonlinear waves written assuming minimal prerequisites such as an undergraduate course on linear algebra and differential equations Suitable as a textbook for a special topics course or as supplementary reading for courses on modeling Contains numerous examples to support the theoretical material Supplementary MATLAB codes available via GitHub [Laser Physics](#) Murray, Iii Sargent, 2018-03-05 This book treats the interaction of radiation with matter particular attention being paid to the laser Knowledge is assumed of the usual half year introduction of quantum mechanics found in undergraduate physics curricula The material can be covered in two semesters or alternatively the first part Chaps 1 13 can be used as a one semester course in which quantum mechanical aspects of the electromagnetic field are ignored Each chapter is accompanied by problems that illustrate the text and give useful occasionally new results Existing laser media are intrinsically quantum mechanical and are most easily studied with the quantum theory Understanding the laser along these lines enlivens one's understanding of quantum mechanics itself In fact the material constitutes a viable applied alternative for the usual second and third semesters of quantum mechanics *Partial Differential Equations and Solitary Waves Theory* Abdul-Majid Wazwaz, 2010-05-28 Partial Differential Equations and Solitary Waves Theory is a self contained book divided into two parts Part I is a coherent survey bringing together newly developed methods for solving PDEs While some traditional techniques are presented this part does not require thorough understanding of abstract theories or compact concepts Well selected worked examples and exercises shall guide the reader through the text Part II provides an extensive exposition of the solitary waves theory This part handles nonlinear evolution equations by methods such as Hirota's bilinear method or the tanh coth method A self contained treatment is presented to discuss complete integrability of a wide class of nonlinear equations This part presents in an accessible manner a systematic presentation of solitons multi soliton solutions kinks peakons cuspons and compactons While the whole book can be used as a text for advanced undergraduate and graduate students in applied mathematics physics and engineering Part II will be most useful for graduate students and researchers in mathematics engineering and other related

fields Dr Abdul Majid Wazwaz is a Professor of Mathematics at Saint Xavier University Chicago Illinois USA 41st  
AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit 10-13 July 2005, Tucson, Arizona: 05-4350 - 05-4399 ,2005

**ICIAM 91** Robert E. O'Malley,1992-01-01 Proceedings Computer Arithmetic Algebra OOP **Beyond Dispute** Daniel Taub,2025-05-22 Fiercely divisive times call for radically different arguments In our age of seemingly irreconcilable differences argument is increasingly seen as a plague to be avoided or a contest to be won Daniel Taub an experienced peace negotiator and diplomat argues that ancient Jewish wisdom offers a third way Drawing from this tradition and from his own experience at the heart of some of the world s toughest negotiations in Beyond Dispute he makes the case for a radically different approach to help us come closer to truth and to each other This approach sees argument not as a combat zone but as a joint enterprise and its disputants not as jealous custodians of competing truths but collaborative explorers It seeks to create safe spaces not by outlawing controversial opinions but by welcoming them and it offers a set of practical tools to rethink our own preconceptions In fractious times it charts a way to build communities and societies that are resilient enough to face new and challenging ideas without fear Weaving ancient insights with contemporary research in conflict resolution as well as behind the scenes personal stories of diplomacy and negotiations Beyond Dispute is a passionate call to rediscover and harness the vital and surprising power of a good argument **Nonlinear Reaction-Diffusion-Convection Equations** Roman Cherniha,Mykola Serov,Oleksii Pliukhin,2017-11-02 It is well known that symmetry based methods are very powerful tools for investigating nonlinear partial differential equations PDEs notably for their reduction to those of lower dimensionality e g to ODEs and constructing exact solutions This book is devoted to 1 search Lie and conditional non classical symmetries of nonlinear RDC equations 2 constructing exact solutions using the symmetries obtained and 3 their applications for solving some biologically and physically motivated problems The book summarises the results derived by the authors during the last 10 years and those obtained by some other authors Journal of Research of the National Bureau of Standards United States. National Bureau of Standards,1965 **Applied Mechanics Reviews** ,1967 *Transducers '01 Eurosensors XV* Ernst Obermeier,2016-05-12 The Conference is the premier international meeting for the presentation of original work addressing all aspects of the theory design fabrication assembly packaging testing and application of solid state sensors actuators MEMS and microsystems **Jacaranda Physics 2 VCE Units 3 and 4, 5e learnON and Print** Murray Anderson,Dan O'Keeffe,Barbara McKinnon,Michael Rosenbrock,Graeme Lofts,Ross Phillips,Peter Pentland,2023-12-18 Everything your students need to succeed The best Physics series for the new VCE Study Design Developed by expert Victorian teachers for VCE students Understand Physics: Teach Yourself Jim Breithaupt,2010-02-26 Brilliant book well written and easy to follow along with Reader review Highly recommended a handy reference guide Reader review Essential for those wishing to understand long forgotten science classes Reader review All you need for a clear understanding of physics Physics does not have to be daunting This book complete with practice questions and answers forms a course which

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### **Nonlinear Equations:**

**Methods, Models and Applications** Daniela Lupo, Carlo Pagani, Bernhard Ruf, 2003-09-25 A collection of research articles originating from the Workshop on Nonlinear Analysis and Applications held in Bergamo in July 2001 Classical topics of nonlinear analysis were considered such as calculus of variations variational inequalities critical point theory and their use in various aspects of the study of elliptic differential equations and systems equations of Hamilton Jacobi Schrödinger and Navier Stokes and free boundary problems Moreover various models were focused upon travelling waves in supported beams and plates vortex condensation in electroweak theory information theory non geometrical optics and Dirac Fock models for heavy atoms

**Elements of Quantum Optics** Pierre Meystre, Murray Sargent, 2007-09-04 With a new chapter on quantum entanglement and quantum information as well as added discussions of the quantum beam splitter electromagnetically induced transparency slow light and the input output formalism this fourth edition of the brilliant work on quantum optics has been much updated It still gives a self contained and broad coverage of the basic elements necessary to understand and carry out research in laser physics and quantum optics including a review of basic quantum mechanics and pedagogical introductions to system reservoir interactions and to second quantization The text reveals the close connection between many seemingly unrelated topics such as probe absorption four wave mixing optical instabilities resonance fluorescence and squeezing

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