

EXHIBIT 1023

PHYSICS

for Scientists and Engineers

Seventh Edition

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Physics for Scientists and Engineers, Seventh Edition

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 Technologies, Lachina Publishing Services
 Cover Designer: Patrick Devine Design
 Cover Image: Front: © 2005 Tony Dunn; Back: © 2005 Kurt
 Hoffmann, Abra Marketing
 Cover Printer: R.R. Donnelley/Willard
 Compositor: Lachina Publishing Services
 Printer: R.R. Donnelley/Willard

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 1 2 3 4 5 6 7 11 10 09 08 07

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Library of Congress Control Number: 2006936870

Student Edition:
 ISBN-13: 978-0-495-01312-9
 ISBN-10: 0-495-01312-9

Instructor Edition:
 ISBN-13: 978-0-495-11375-1
 ISBN-10: 0-495-11375-1

Thomson Higher Education
 10 Davis Drive
 Belmont, CA 94002-3098
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Human ears have evolved to detect sound waves and interpret them as music or speech. Some animals, such as this young bat-eared fox, have ears adapted for the detection of very weak sounds. (Getty Images)

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17 Sound Waves

Sound waves travel through any material medium with a speed that depends on the properties of the medium. As sound waves travel through air, the elements of air vibrate to produce changes in density and pressure along the direction of motion of the wave. If the source of the sound waves vibrates sinusoidally, the pressure variations are also sinusoidal. The mathematical description of sinusoidal sound waves is very similar to that of sinusoidal waves on strings, which were discussed in Chapter 16.

Sound waves are divided into three categories that cover different frequency ranges. (1) *Audible waves* lie within the range of sensitivity of the human ear. They can be generated in a variety of ways, such as by musical instruments, human voices, or loudspeakers. (2) *Infrasonic waves* have frequencies below the audible range. Elephants can use infrasonic waves to communicate with one another, even when separated by many kilometers. (3) *Ultrasonic waves* have frequencies above the audible range. You may have used a “silent” whistle to retrieve your dog. Dogs easily hear the ultrasonic sound this whistle emits, although humans cannot detect it at all. Ultrasonic waves are also used in medical imaging.

This chapter begins with a discussion of the speed of sound waves and then wave intensity, which is a function of wave amplitude. We then provide an alterna-