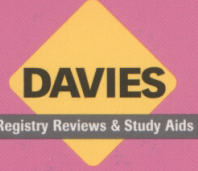


DAVIES



L I F E I S A T E S T . . .
P A S S I T



**1-2-3 Step
Ultrasound Education**

Step 1
Review text

Step 2
Mock examination

Step 3
Q&A memory skills
flashcard drill

Vascular **Physics**

Vascular Physics Review

A Q&A Review for the ARDMS Vascular Physics Exam

SDMS-Approved
Continuing Education Activity
Approved for **7.5** hours CME Credit

BEAN

OWEN

RIDGWAY

SALLES-CUNHA

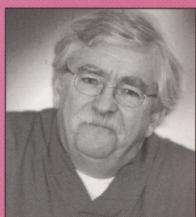
ZAGZEBSKI

Vascular Physics Review

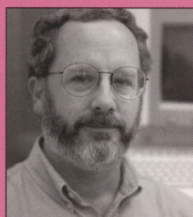
Looking for guidance and a clear understanding of the principles and facts on which you will be tested? With registry-like questions and clear explanations, *Vascular Physics Review* illuminates this challenging topic from the point of view of experts who themselves have taken and passed the ARDMS vascular physics exam. *Vascular Physics Review* reveals your strengths and weaknesses, hones your exam-taking skills, and assesses your progress as you study. Based on the exam outline published by ARDMS, this edition contains more than 450 questions that cover ultrasound physics, ultrasonic imaging, physiology and fluid dynamics, physical principles, and ultrasound safety and quality assurance. Especially effective in combination with the other two exam reviews and study aids in our 1-2-3 Step Ultrasound Education and Test Preparation program—*Vascular Technology: An Illustrated Review* and *ScoreCards for Vascular Technology*. Why are our mock exams so popular and effective? Because they contain the same kinds of thought-provoking questions you will find on the exam! 7.5 hours SDMS-approved CME credit. \$55. Davies catalog #11031.

Ready to score? You can!

About the editors . . .



Barton Bean, RVT, founding president of the Society of Vascular Technology and seminal figure in the history of the field, is editor emeritus of *Vascular Physics Review* and *Vascular Technology Review*.



Don Ridgway, RVT, is author of the popular and unique *Introduction to Vascular Scanning: A Guide for the Complete Beginner* and editor of *Vascular Technology Review*.



Cindy Owen, RT, RVT, RDMS, is the author of *Ultrasound Physics Review*, *ScoreCards for Vascular Technology*, and the forthcoming *Ultrasound Physics: An Illustrated Review*. A former ARDMS and ICAVL

board member, Cindy lives with her family in Memphis, where she consults, practices, and rides her horse Gus.

Sergio X. Salles-Cunha, PhD, RVT, Director of Clinical Development at the Jobst Vascular Center, is the author of *Atlas of Duplex Ultrasonography* and an internationally renowned speaker on vascular ultrasound.

James A. Zagzebski, PhD, Professor and Chair of Medical Physics at the University of Wisconsin, lectures widely on ultrasound physics for registry candidates and wrote *Essentials of Physics*.

Also! CD-ROM mock exams from Davies.

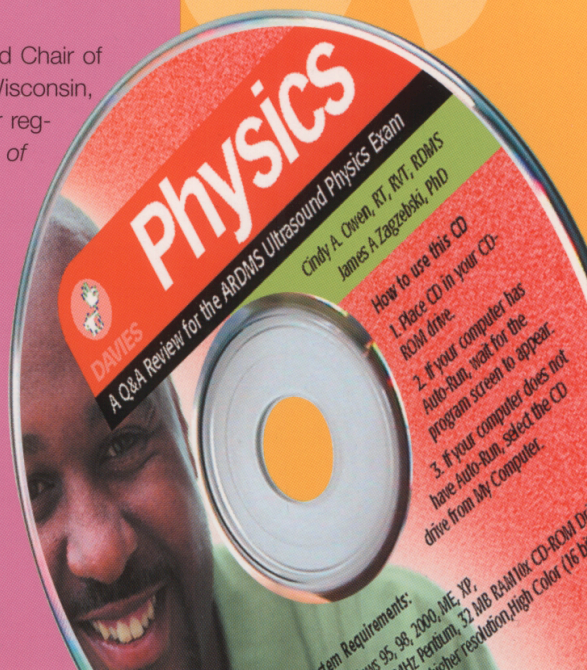
The source you can trust. ✦ 550 questions and answers in registry format. ✦ 100+ image-based questions to sharpen your wits. ✦ Clear, simple explanations. ✦ Mini-tutorials for difficult questions. ✦ Automatic timer to pace you. ✦ Performance analysis to score and guide you. ✦ CME credit. ✦ A snap to use. ✦ Fun. Davies catalog #11040. Order toll-free 1-877-792-0005.

**DAVIES
PUBLISHING**

ISBN 0-941022-54-4



www.daviespublishing.com



Vascular Physics

A QUESTION / ANSWER / REFERENCE REVIEW FOR THE
VASCULAR PHYSICAL PRINCIPLES &
INSTRUMENTATION EXAM

2011

Barton A. Bean, RVT
Editor

Donald P. Ridgway, RVT
Sergio X. Salles-Cunha, PhD
James A. Zagzebski, PhD
Associate Editors

We dedicate this work to
Dr. Eugene Bernstein.
His untimely death has stilled a giant in our field.

Copyright © 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011
by Davies Publishing, Inc.

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic or mechanical, including photocopying, scanning, and recording, without the prior written permission of the publisher.

Davies Publishing, Inc.
Publishers in Medicine and Surgery
32 South Raymond Avenue
Pasadena, California 91105-1935
Phone 626.792.3046
Facsimile 626.792.5308
E-mail info@daviespublishing.com

Printed and bound in the United States of America

ISBN 0-941022-54-4

Contents

Contributors

Preface

PART I Ultrasound Physics 1

DEFINITION OF SOUND 1

Sound versus ultrasound

Propagation velocity

Frequency

Wavelength

Frequency versus depth

Frequency ranges

PROPAGATION OF SOUND IN TISSUE 7

Sound versus ultrasound

Propagation velocity

Frequency

Wavelength

Frequency versus depth

Frequency ranges

TRANSDUCERS: ULTRASOUND 15

Piezoelectric effect

Transducer characteristics

Sound beam characteristics

Lateral resolution

Axial resolution

Mechanical transducers

Electronic transducers

DOPPLER SIGNAL PROCESSING 26

Doppler effect

Doppler frequency shift

Effect of transmitting frequency on Doppler frequency shift

Effect of insonation angle on Doppler frequency shift

Reflector speed (velocity)

Extracting the Doppler signal

Audible Doppler signal analysis

Analog Doppler waveform generation

Spectral display characteristics

Sample volume size

Aliasing

DOPPLER INSTRUMENTS 46

Continuous wave instruments

Pulsed wave instruments

Bidirectional Doppler

Unidirectional Doppler

Color flow

Transcranial

PART II Ultrasonic Imaging 53

IMAGING PRINCIPLES 53

A-mode definition

B-mode definition

Real-time definition

Gray scale display

Dynamic range

Frame rate

Scan converter

Gain

Time gain compensation

Recording techniques

Duplex instrumentation

Image resolution

IMAGING ARTIFACTS 66

Artifact definition

Origin of artifacts: technique

- Origin of artifacts: instrumentation
- Enhancement
- Multiple reflections
- Reverberation
- Shadowing
- Refraction

PART III Physiology & Fluid Dynamics 73

ARTERIAL HEMODYNAMICS 73

- Energy gradient
- Effects of viscosity, friction, inertia
- Pressure/flow relationships
- Velocity
- Steady versus pulsatile flow
- Effects of stenosis on flow characteristics

VENOUS HEMODYNAMICS 83

- Venous resistance
- Hydrostatic pressure
- Pressure/volume relationship
- Effects of edema
- Effects of muscle pump mechanism
- Other

PART IV Physical Principles 88

GENERAL CONSIDERATIONS 88

- Energy
- Power
- Graphical recording
- Calibration
- AC/DC coupling
- Units of measure

TISSUE MECHANICS/PRESSURE TRANSMISSION 97

- Venous occlusion by limb positioning
- Superficial venous occlusion by tourniquets

Venous occlusion by cuffs
Volume changes by blood inflow/outflow
Arterial occlusion by cuffs

PLETHYSMOGRAPHY 99

Displacement (pneumatic cuff)
Photoplethysmography
Oculoplethysmography—pressure

PRESSURE MEASUREMENTS 102

Legs
Arms

OTHER CONSIDERATIONS 105

Skin temperature
Transcutaneous oximetry

PART V Ultrasound Safety & Quality Assurance 108

INSTRUMENT PERFORMANCE 108

Evaluation of image quality
Evaluation of Doppler quality
Preventive maintenance

BIOLOGICAL EFFECTS 112

Minimizing exposure time
Mechanisms of production
Scientific data
Preventing electrical hazards

PART VI Answers 117

BIBLIOGRAPHY 176

CME APPLICATION 177

Ultrasound Physics

DEFINITION OF SOUND
PROPAGATION OF SOUND IN TISSUE
TRANSDUCERS
DOPPLER SIGNAL PROCESSING
DOPPLER INSTRUMENTS

DEFINITION OF SOUND

Sound versus ultrasound

Propagation velocity

Frequency

Wavelength

Frequency versus depth

Frequency ranges

.....

- 1.1 Sound wave frequency is determined by:
 - A. The medium through which sound travels.
 - B. The propagation speed.
 - C. The sound source.
 - D. The boundary layer.
 - E. The number of reflections.

- 1.2 Sound wave variables include all the following EXCEPT:
 - A. Frequency.
 - B. Amplitude.
 - C. Perpendicular incidence.
 - D. Period.
 - E. Propagation speed.

- 1.3 As the frequency of the sound wave increases, the wavelength:
- A. Decreases.
 - B. Increases.
 - C. Stays the same.
 - D. Wavelength is not related to frequency changes.
 - E. Doubles.
- 1.4 The term "period" is related to frequency by the fact that it:
- A. Equals frequency.
 - B. Increases as frequency increases.
 - C. Is one tenth of frequency.
 - D. Is the reciprocal of frequency.
 - E. Equals frequency squared.

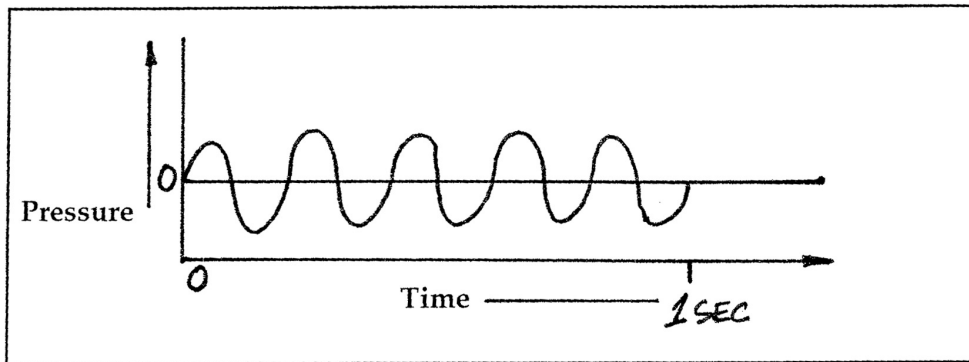


Figure 1.

See Question 1.5—What is the frequency?

- 1.5 What is the frequency of the sound wave in Figure 1?
- A. 10 Hertz.
 - B. 7 Hertz.
 - C. 5 Hertz.
 - D. 2.5 Hertz.
 - E. 16 Hertz.

- 1.6 What is the period of the signal in Figure 1?
- A. 0.5 seconds.
 - B. 0.25 seconds.
 - C. 2.0 seconds.
 - D. 0.20 seconds.
 - E. 0.02 seconds.
- 1.7 Wavelength may be measured in:
- A. Hertz.
 - B. Microseconds.
 - C. Millimeters.
 - D. Newtons.
 - E. Rayls.
- 1.8 With an ultrasound frequency of 10 MHz the period is:
- A. 1.00 microseconds.
 - B. 1.00 seconds.
 - C. 0.13 microseconds.
 - D. 0.20 microseconds.
 - E. 0.10 microseconds.
- 1.9 Which of the following ultrasound frequencies would result in the shallowest penetration depth?
- A. 2 MHz.
 - B. 20 MHz.
 - C. 8 MHz.
 - D. 10 MHz.
 - E. 4 MHz.
- 1.10 To be classified as ultrasound, the frequency of the sound wave must be:
- A. Less than 20 Hz.
 - B. Greater than 20 Hz.
 - C. Less than 20 kHz.
 - D. Greater than 20 kHz.
 - E. Greater than 20 MHz.

- 1.11 Which of the following is NOT true regarding frequency?
- A. It is defined as the number of complete cycles per unit of time.
 - B. 1 cycle per second equals 1 hertz.
 - C. 1000 cycles per second equals 1 kilohertz.
 - D. It is the inverse of period.
 - E. It is measured in units of time (seconds).
- 1.12 Which ONE of the following cannot travel through a vacuum:
- A. Radio waves.
 - B. Sound.
 - C. Light.
 - D. X-rays.
 - E. Infrared light.
- 1.13 Which of the following terms refers to regions of decreased particle density:
- A. Attenuation.
 - B. Transmission.
 - C. Compression.
 - D. Rarefaction.
 - E. Reverberation.
- 1.14 Hertz is a unit of measure used to quantify the _____ of a sound wave:
- A. Frequency.
 - B. Amplitude.
 - C. Power.
 - D. Intensity.
 - E. Half wave height.
- 1.15 Units of measure used to quantify intensity are:
- A. Hertz.
 - B. Milliwatts.
 - C. Watts/meter².
 - D. Meters/second.
 - E. Megahertz.

- 1.16 A decrease in sound beam intensity in a fixed area is accompanied by _____ in pressure amplitude:
- A. A decrease.
 - B. An increase.
 - C. No change.
 - D. A doubling.
 - E. A tripling.
- 1.17 $10^{-3} =$ _____ :
- A. +1000.
 - B. -1000.
 - C. +1/1000.
 - D. -1/1000.
 - E. +10000.
- 1.18 If the intensity of one sound wave is 1000 times as great as the intensity of a second sound wave, the ratio of the two intensities can be expressed as _____ decibels:
- A. 3.
 - B. 30.
 - C. 3000.
 - D. 10,000.
 - E. 2^{10} .
- 1.19 The number 1215 can be expressed in scientific notation as:
- A. 0.1215.
 - B. 0.1215×10^3 .
 - C. 1215×10^1 .
 - D. 1215×10^{-1} .
 - E. 1.215×10^3 .

- 1.20 One Megahertz = _____ hertz:
- A. 10^3 .
 - B. 10^{-3} .
 - C. 10^6 .
 - D. 10^{-6} .
 - E. 10^{10} .
- 1.21 Ultrasound used for medical diagnosis falls within which of the following frequency ranges:
- A. <20 kHz.
 - B. 20 kHz to 2 MHz.
 - C. 2 to 20 MHz.
 - D. 500 to 20,000 Hz.
 - E. 1 to 20 kHz.
- 1.22 For a sinusoidal ultrasound wave:
- A. Frequency is proportional to period.
 - B. Period is proportional to frequency.
 - C. Frequency and period are unrelated.
 - D. Frequency divided by period is equal to 1.
 - E. Frequency multiplied by period is equal to 1.
- 1.23 The strength of a sound beam is best described by:
- A. Amplitude and impedance
 - B. Amplitude and wavelength.
 - C. Amplitude and intensity.
 - D. Intensity and impedance.
 - E. Frequency and wavelength.