

Instructor Solutions Manual

for

Modern Physics

Sixth Edition

Paul A. Tipler

Ralph A. Llewellyn

Prepared by

Mark J. Llewellyn

Department of Electrical Engineering and Computer Science

Computer Science Division

University of Central Florida



W. H. Freeman and Company

New York

Instructor Solutions Manual to Accompany Tipler & Llewellyn Modern Physics, Sixth Edition

© 2012, 2008, 2003 by W.H. Freeman and Company

All rights reserved.

Published under license, in the United States by
W. H. Freeman and Company
41 Madison Avenue
New York, NY 10010

www.whfreeman.com

Preface

This book is an Instructor Solutions Manual for the problems which appear in *Modern Physics, Sixth Edition* by Paul A. Tipler and Ralph A. Llewellyn. This book contains solutions to every problem in the text and is not intended for class distribution to students. A separate Student Solutions Manual for *Modern Physics, Sixth Edition* is available from W. H. Freeman and Company. The Student Solutions Manual contains solutions to selected problems from each chapter, approximately one-fourth of the problems in the book.

Figure numbers, equations, and table numbers refer to those in the text. Figures in this solutions manual are not numbered and correspond only to the problem in which they appear. Notation and units parallel those in the text.

Please visit W. H. Freeman and Company's website for *Modern Physics, Sixth Edition* at www.whfreeman.com/tiplermodernphysics6e. There you will find 30 More sections that expand on high interest topics covered in the textbook, the Classical Concept Reviews that provide refreshers for many classical physics topics that are background for modern physics topics in the text, and an image gallery for Chapter 13. Some problems in the text are drawn from the More sections.

Every effort has been made to ensure that the solutions in this manual are accurate and free from errors. If you have found an error or a better solution to any of these problems, please feel free to contact me at the address below with a specific citation. I appreciate any correspondence from users of this manual who have ideas and suggestions for improving it.

Sincerely,

Mark J. Llewellyn

Department of Electrical Engineering and Computer Science
Computer Science Division
University of Central Florida
Orlando, Florida 32816-2362
Email: markl@cs.ucf.edu

Table of Contents

Chapter 1 – Relativity I	1
Chapter 2 – Relativity II	31
Chapter 3 – Quantization of Charge, Light, and Energy	53
Chapter 4 – The Nuclear Atom	79
Chapter 5 – The Wavelike Properties of Particles	109
Chapter 6 – The Schrödinger Equation	127
Chapter 7 – Atomic Physics	157
Chapter 8 – Statistical Physics	187
Chapter 9 – Molecular Structure and Spectra	209
Chapter 10 – Solid State Physics	235
Chapter 11 – Nuclear Physics	259
Chapter 12 – Particle Physics	309
Chapter 13 – Astrophysics and Cosmology	331

Chapter 1 – Relativity I

- 1-1. (a) Speed of the droid relative to Hoth, according to Galilean relativity, u_{Hoth} , is

$$\begin{aligned} u_{Hoth} &= u_{spaceship} + u_{droid} \\ &= 2.3 \times 10^8 \text{ m/s} + 2.1 \times 10^8 \text{ m/s} \\ &= 4.4 \times 10^8 \text{ m/s} \end{aligned}$$

- (b) No, since the droid is moving faster than light speed relative to Hoth.

1-2. (a) $t = \frac{2L}{c} = \frac{2(2.74 \times 10^4 \text{ m})}{3.00 \times 10^8 \text{ m/s}} = 1.83 \times 10^{-4} \text{ s}$

(b) From Equation 1-6 the correction $\delta t = \frac{2L}{c} \times \frac{v^2}{c^2}$

$$\delta t = (1.83 \times 10^{-4} \text{ s})(10^{-4})^2 = 1.83 \times 10^{-12} \text{ s}$$

(c) From experimental measurements $\frac{\delta c}{c} = \frac{4 \text{ km/s}}{299,796 \text{ km/s}} = 1.3 \times 10^{-5}$

No, the relativistic correction of order 10^{-8} is three orders of magnitude smaller than the experimental uncertainty.

1-3. $\frac{0.4 \text{ fringe}}{(29.8 \text{ km/s})^2} = \frac{1.0 \text{ fringe}}{(v \text{ km/s})^2} \rightarrow v^2 = \frac{1.0}{0.4} (29.9 \text{ km/s})^2 = 2.22 \times 10^3 \rightarrow v = 47.1 \text{ km/s}$

- 1-4. (a) This is an exact analog of Example 1-1 with $L = 12.5 \text{ m}$, $c = 130 \text{ mph}$, and $v = 20 \text{ mph}$. Calling the plane flying perpendicular to the wind plane #1 and the one flying parallel to the wind plane #2, plane #1 will win by Δt where

$$\Delta t = \frac{Lv^2}{c^3} = \frac{(12.5 \text{ mi})(20 \text{ mi/h})^2}{(130 \text{ mi/h})^3} = 0.0023 \text{ h} = 8.2 \text{ s}$$

- (b) Pilot #1 must use a heading $\theta = \sin^{-1}(20/130) = 8.8^\circ$ relative to his course on both legs. Pilot #2 must use a heading of 0° relative to the course on both legs.

1-5. (a) In this case, the situation is analogous to Example 1-1 with $L = 3 \times 10^8 m$,
 $v = 3 \times 10^4 m/s$, and $c = 3 \times 10^8 m/s$. If the flash occurs at $t = 0$, the interior is dark until $t = 2s$ at which time a bright circle of light reflected from the circumference of the great circle plane perpendicular to the direction of motion reaches the center, the circle splits in two, one moving toward the front and the other moving toward the rear, their radii decreasing to just a point when they reach the axis $10^{-8} s$ after arrival of the first reflected light ring. Then the interior is dark again.

(b) In the frame of the seated observer, the spherical wave expands outward at c in all directions. The interior is dark until $t = 2s$ at which time the spherical wave (that reflected from the inner surface at $t = 1s$) returns to the center showing the entire inner surface of the sphere in reflected light, following which the interior is dark again.

1-6. Yes, you will see your image and it will look as it does now. The reason is the second postulate: All observers have the same light speed. In particular, you and the mirror are in the same frame. Light reflects from you to the mirror at speed c relative to you and the mirror and reflects from the mirror back to you also at speed c , independent of your motion.

1-7. $\Delta N = \frac{2Lv^2}{\lambda c^2}$ (Equation 1-10) Where $\lambda = 590 nm$, $L = 11 m$, and $\Delta N = 0.01 fringe$

$$v^2 = \frac{\Delta N \lambda c^2}{2L} = (0.01 fringe)(590 \times 10^{-9} m)(3.00 \times 10^8 m/s)^2 2(11m)$$

$$v = 4.91 \times 10^3 m/s \approx 5 km/s$$

1-8. (a) No. Results depends on the relative motion of the frames.

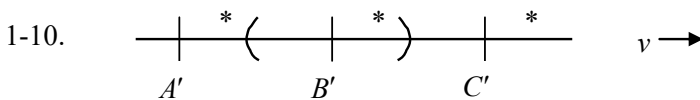
(b) No. Results will depend on the speed of the proton relative to the frames. (This answer anticipates a discussion in Chapter 2. If by “mass”, the “rest mass” is implied, then the answer is “yes”, because that is a fundamental property of protons.)

(Problem 1-8 continued)

- (c) Yes. This is guaranteed by the 2nd postulate.
- (d) No. The result depends on the relative motion of the frames.
- (e) No. The result depends on the speeds involved.
- (f) Yes. Result is independent of motion.
- (g) Yes. The charge is an intrinsic property of the electron, a fundamental constant.

1-9. The wave from the front travels 500 m at speed $c + (150/3.6) \text{ m/s}$ and the wave from the rear travels at $c - (150/3.6) \text{ m/s}$. As seen in Figure 1-14, the travel time is longer for the wave from the rear.

$$\begin{aligned} \Delta t = t_r - t_f &= \frac{500m}{3.00 \times 10^8 \text{ m/s} - (150/3.6) \text{ m/s}} - \frac{500m}{3.00 \times 10^8 \text{ m/s} + (150/3.6) \text{ m/s}} \\ &= 500 \left[\frac{3 \times 10^8 + (150/3.6) - 3 \times 10^8 + (150/3.6)}{(3 \times 10^8)^2 - 2(150/3.6)(3 \times 10^8) - (150/3.6)^2} \right] \\ &= 500 \frac{2(150/3.6)}{(3 \times 10^8)^2} \approx 4.63 \times 10^{-13} \text{ s} \end{aligned}$$



While the wavefront is expanding to the position shown, the original positions of A' , B' , and C' have moved to the * marks, according to the observer in S .

- (a) According to an S' observer, the wavefronts arrive simultaneously at A' and B' .
- (b) According to an S observer, the wavefronts do not arrive at A' and C' simultaneously.
- (c) The wavefront arrives at A' first, according to the S observer, an amount Δt before arrival at C' , where