Instructor's Manual

to accompany

The Physical Universe

Fifteenth Edition

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THE PHYSICAL UNIVERSE, FIFTEENTH EDITION
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Published by McGraw-Hill Higher Education, an imprint of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020.

www.mhhe.com

Notes on Math in *The Physical Universe*, Fifteenth Edition

Physics and chemistry are quantitative sciences and some math is essential to understand and appreciate them. How much math is appropriate for a given classroom is for the instructor to decide. The math level of *The Physical Universe* is quite low, but it may still be too high in places for some students. Here is a list of material that can be omitted without loss of continuity. In most cases the instructor may well choose to outline the material in class without requiring the students to work out relevant problems.

2.2. Vectors. Pythagorean theorem. Can omit.
2.4. Distance, Time, and Acceleration. Although can be omitted, it is useful in providing the origin of Eq. 2-14 and especially in deriving the KE formula in Sec. 3.3. But calculations need not be required.
2.12. Circular Motion. Discuss, but need not require calculations.
5.2. Heat. Discuss Eq. 5-3, but need not require calculations.
5.7. The Gas Laws. Discuss, but need not require calculations.
6.3. Coulomb's Law. Discuss, but need not require calculations.
6.19. Transformers. Discuss, but need not require calculations.
7.12. Refraction. Can omit calculations that involve index of refraction.
7.13. Lenses. Can omit ray tracing, but really quite easy.
7.17. Diffraction. Discuss resolving power, but need not require calculations.
8.7. Binding Energy. Discuss, but need not require calculations.
9.2. Photons. Keep quantum energy calculations, but can omit those that involve the photoelectric effect.
10.17. Chemical Equations. Discuss, but need not require equation balancing.
12.3. The Mole. 12.4 Formula Units. Could omit entirely, but better to give at least brief discussion since this is how chemical ideas meet the real world.
Chapter 13. Organic Chemistry. Discuss the various aspects of structural formulas, but need not require solving problems that involve them.
14.2. Atmospheric Moisture. Discuss relative humidity, but need not require calculations using the graph.

Answers to Even-Numbered Exercises

CHAPTER ONE

Exercises:

2. The reliance of the scientific method on experiment and observation.

4. Because a model isolates the most important features of a complex phenomenon, it may permit scientists to determine the fundamental origin of the phenomenon with out being confused by secondary details.

6. A year is the time the sun takes to complete a circuit across the sky relative to the stars.

8. If the moon is seen near a particular star on one evening, by the next evening it will be some distance east of that star.

10. a. A year does not correspond to a whole number of days. In order that the seasons do not shift around the calendar, an extra day must be added to every fourth year with further adjustments at longer intervals.
b. A year does not correspond to a whole number of days. In order that the seasons do not shift around the calendar, an extra day must be added to every fourth year with further adjustments at longer intervals.

12. These observations suggest that the members of the solar system all lie in or near a plane not far from the earth's equator and that all move in the same direction about the sun or, in the case of the moon, about the earth.

14. The Copernican model, because in it the distances from the earth, and hence the apparent brightnesses of the other planets, vary with time.

16. Only elliptical orbits agree with observa-tional data.

18. a. No explanation is possible in the ptolemaic system, in which the stars are fixed at the same distance from the earth in a crystal ball that revolves around a stationary earth.
b. In the copernican system the explanation follows from the orbital motion of the earth relative to stars at different distances away.

20. The earth would then be more flattened at the poles and bulge to a greater extent at the equator.

22. Yesterday, because the length of the day has been increasing steadily since the earth's formation.

24. The moon.

26. (291 km)(0.621 mi/km) = 181 mi

28. 1 mm = 10^{-3} m so $d = (10^4)(10^{-3}\text{m}) = 10$ m and (10 m) (3.28 ft/m) = 32.8 ft

30. $(20.0\text{ m})(7.00\text{ m})(2.00\text{ m})(3.28\text{ ft/m})^3 = 9.88 \times 10^3\text{ ft}^3$

32. 2 m 35 s = (155 s)/(3600 s/h) = 0.0431 h;
1 mi = 1.61 km, speed = (1.61 km)/

(0.0431 h) = 37.4 km/h

34. 42; 7.5×10^5; 3.0×10^5

CHAPTER TWO

Exercises:

2. $t = d/v = 0.029$ s.

4. The snake covers 105 m in $t = d/v = 70$ s. Therefore your speed must be greater than v = (100 m)/(70 s) = 1.43 m/s.

6. 30 lb; 0.

8. a. Directly across the river.
b. $t = d/v$(boat) = 0.1875 h = 11 min 15 s.
c. $d = v$(river)t = 0.94 km.

10. $F = \sqrt{F_1^2 + F_2^2}$ = 7.1 tons.

12. No. An example is the curved path of a ball thrown at an angle with the ground.

14. $v_2 - at = 15$ m/s.

16. a. $a = (v_f - v_0)/t = -3.5\,\text{m/s}^2$.
b. $t = (v_f - v_0)/a = 5.71\,\text{s}$.
c. $t = (v_f - v_0)/a = 2.86\,\text{s}$.

18. a. $d = v_1 t + \frac{1}{2}at^2$, $a = 2d/t^2 - 2v_1/t =$
$-0.178\ \text{m/s}^2$.
b. $v_2 = v_1 + at = 6.65$ m/s.

20. Yes.

22. T = total time of flight = $2\sqrt{2h/g}$. Since g is smaller on Venus than on the earth, T will be greater and the ball will return to the ground later.

24. a. The crate appears to move vertically downward because both the crate and the observer have the same horizontal speed.
b. The crate appears to move in a curved path downward, as in Fig. 2-12.

26. a. The distance remains the same.
b. The distance increases.

28. v = $\sqrt{2gh}$ = 15.3 m/s.

30. $h = \frac{1}{2}gt^2 = 78.4$ m.

32. Time of rise = time of fall = $t = v/g = 1.0$ s. Hence the total time of flight = $2t = 2.0$ s.

34. a. $t = v/g = 2.04$ s.
b. $h = \frac{1}{2}gt^2 = 20.4$ m.

36. $t = d/v$, $h = \frac{1}{2}gt^2 = \frac{1}{2}gd^2/v^2 = 0.10$ m = 10 cm.

38. $v(\text{vert}) = \sqrt{2gh} = 19.8$ m/s; $v(\text{horiz}) = 30$ m/s; $v = \sqrt{v(\text{vert})^2 + v(\text{horiz})^2} = 35.9$ m/s.

40. The time of fall is $t = \sqrt{2h/g} = 10.1$ s. In this time the pump will have moved horizontally $d = vt = 606$ m.

42. a. The tensions are the same.
b. The front coupling is under greater tension because it is accelerating a greater mass.

44. a. $v = 55.6$ m/s, $a = v/t = 18.5$ m/s^2 = 1.89 g.
b. $F = ma = 222$ kN.

46. $m = F/a = 4$ kg.
a. $F = ma = 4$ N.
b. $F = ma = 40$ N.

48. $F = ma = mv_f/t$, $t = mv_f/F = 0.015$ s.

50. $v_2 - v_1 = 13.6$ m/s, $F = ma = m(v_2 - v_1)/t = -2.2$ kN.

52. $F = w = mg$, $a = F/m = g$.

54. $a = F/m = (m_1 - m_2)g/(m_1 + m_2) = 1.96$ m/s^2.

56. A force of ma is needed in addition to the force $w = mg$ needed just to lift the box without acceleration. Hence $F = mg + ma = 59$ N.

58. a. $a = F/m = 9$ m/s^2, so the elevator is falling with a downward acceleration of 0.8 m/s^2.
b. The elevator is either stationary or rising or falling with constant speed.
c. $a = F/m = 10$ m/s^2, so the elevator is rising with an upward acceleration of 0.2 m/s^2.

60. a. $F = mg + ma = 648$ N.
b. $F = mg - ma = 528$ N.

c. $F = mg = 588$ N.
d. $F = mg = 588$ N.

62. The first law is a special case of the second law, because when $F = 0$, $a = 0$. There is no connection between the second and third laws.

64. a. The upward forces are the reaction forces of the road on the car's tires.
b. The downward forces are these reaction forces plus the force of gravity on the car.

66. The second procedure is more likely to break the string because here the tension in the string is twice as great with the reaction force exerted by the tree being equal and opposite to the pull of the two children.

68. The equator; the poles.

70. At the bottom of the circle, since here the string must support all of the ball's weight as well as provide the centripetal force on the ball.

72. The outward pull is due to the reaction force of the stone that arises in response to the inward force applied to it, which is what causes it to move in a circle. When the string is released, there is no longer any inward force on the stone, and it proceeds along in a straight line as predicted by the first law of motion.

74. $F_c = mv^2/r$, $v = \sqrt{F_c r / m} = 20$ m/s.

76. a. $F_c = mv^2/r = 4.17 \times 10^5$ N.
b. $w = mg = 490$ N; $F_c/w = 850$.
c. No.

78. $F = mg + mv^2/r$, $r = mv^2/(F - mg) = 637$ m.

80. The force would be 4 times what it is today.

82. The stone's mass would be the same but its weight would be zero.

84. a. $d = \frac{1}{2}at^2 = 1.4$ mm/s.
b. Since 1 y = (365 days/y)(24 hr/day)
(60 min/hr)(60 s/min), this is 44 m/y.
c. The moon never comes closer to the earth because its "falling" causes it to move in an orbit around the earth.

86. a. $F = Gm_1m_2/R^2 = 1.67 \times 10^{-8}$ N.
b. 1.67×10^{-8} N.
c. $a_2 = F/m_2 = 8.3 \times 10^{-9}$ m/s^2; $a_5 = F/m_5 = 3.3 \times 10^{-9}$ m/s^2.

88. $R = m\sqrt{G/F} = 5.2$ m.

90. The earth rotates from west to east. Hence the satellite sent eastward will have its launching speed increased because of the earth's rotation, and the one sent westward will have its launching speed decreased. The satellite sent eastward will therefore have the larger orbit.