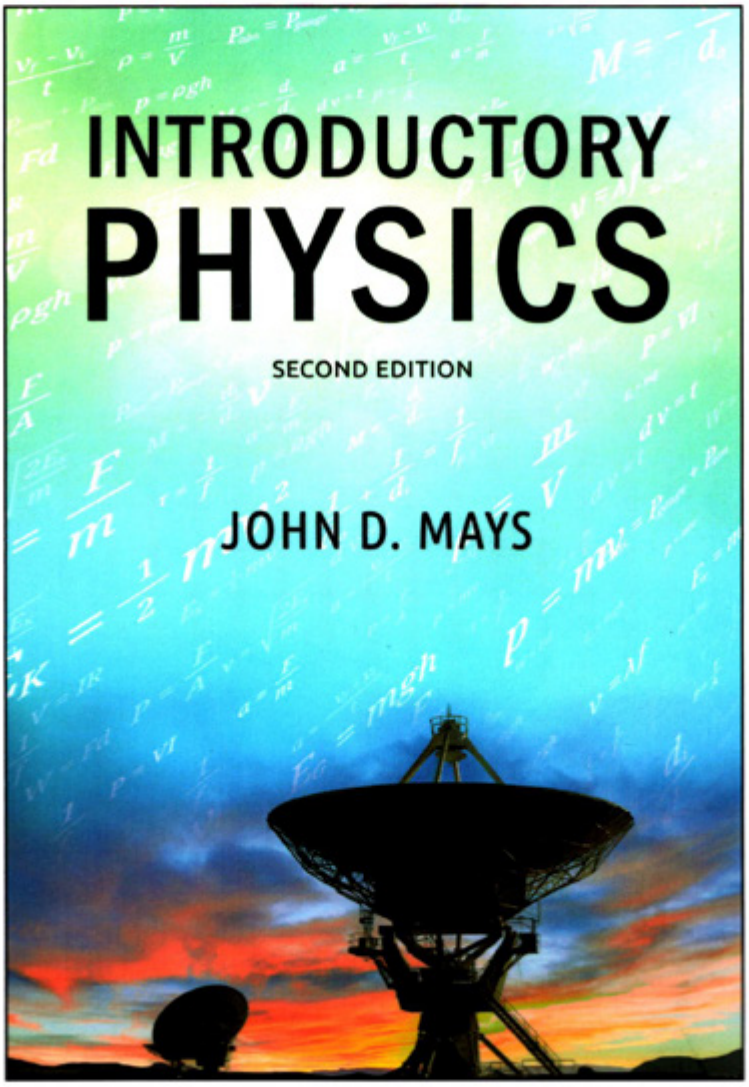
Solutions Manual to Accompany

Introductory Physics, Second Edition

Rebekah L. Mays and John D. Mays



Solutions Manual to Accompany Introductory Physics

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Contents


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Acknowledgement

I (John) wish to express my gratitude to my daughter Rebekah Mays for carefully and meticulously compiling these solutions. Any errors that remain in this volume are my own responsibility.

Preface

This solutions manual contains fully detailed solutions for all of the computational problems contained in my text *Introductory Physics*. Teachers and students using that text should find this manual to be a valuable resource.

When comparing your results to the results shown here and to those in the text, keep in mind that the last digit is always uncertain because of the way significant digits in measurements are defined. When two results match except for a small difference in the most precise digit, we say that the results match. Because of rounding in calculators, it will not be uncommon for results shown here to differ from the answer key in the text or from your result by or two in the most precise digit.

I have checked and double checked the solutions to make them as accurate as possible. However, in any manual of this kind it is inevitable that errors remain. If you find an error, we would be much obliged if you would inform us of it by sending an email to info@novarescienceandmath.com.

Chapter 2

Unit Conversions

1.

$$1{,}750\ \text{m}\cdot\frac{100\ \text{cm}}{1\ \text{m}}\cdot\frac{1\ \text{in}}{2.54\ \text{cm}}\cdot\frac{1\ \text{ft}}{12\ \text{in}}=5{,}740\ \text{ft}$$

2.

$$3.54\ \text{g}\cdot\frac{1\ \text{kg}}{1000\ \text{g}}=0.00354\ \text{kg}$$

3.

$$41.11\ \text{mL}\cdot\frac{1\ \text{L}}{1000\ \text{mL}}=0.04111\ \text{L}$$

4.

$$7\times10^{8}\ \text{m}\cdot\frac{100\ \text{cm}}{1\ \text{m}}\cdot\frac{1\ \text{in}}{2.54\ \text{cm}}\cdot\frac{1\ \text{ft}}{12\ \text{in}}\cdot\frac{1\ \text{mi}}{5{,}280\ \text{ft}}=4\times10^{5}\ \text{mi}$$

5.

$$1.5499\times10^{-12}\ \text{mm}\cdot\frac{1\ \text{m}}{1000\ \text{mm}}=1.5499\times10^{-15}\ \text{m}$$

6.

$$750\ \text{cm}^3\cdot\frac{1\ \text{mL}}{1\ \text{cm}^3}\cdot\frac{1\ \text{L}}{1000\ \text{mL}}\cdot\frac{1\ \text{m}^3}{1000\ \text{L}}=7.5\times10^{-4}\ \text{m}^3$$

7.

$$2.9979\times10^{8}\ \frac{\text{m}}{\text{s}}\cdot\frac{100\ \text{cm}}{1\ \text{m}}\cdot\frac{1\ \text{in}}{2.54\ \text{cm}}\cdot\frac{1\ \text{ft}}{12\ \text{in}}=9.836\times10^{8}\ \frac{\text{ft}}{\text{s}}$$

8.

$$168\ \text{hr}\cdot\frac{60\ \text{min}}{1\ \text{hr}}\cdot\frac{60\ \text{s}}{1\ \text{min}}=605{,}000\ \text{s}$$

9.

$$5{,}570\ \frac{\text{kg}}{\text{m}^3}\cdot\frac{1000\ \text{g}}{1\ \text{kg}}\cdot\frac{1\ \text{m}^3}{1000\ \text{L}}\cdot\frac{1\ \text{L}}{1000\ \text{mL}}\cdot\frac{1\ \text{mL}}{1\ \text{cm}^3}=5.57\ \frac{\text{g}}{\text{cm}^3}$$

10.

$$45\ \frac{\text{gal}}{\text{s}}\cdot\frac{3.786\ \text{L}}{1\ \text{gal}}\cdot\frac{1\ \text{m}^3}{1000\ \text{L}}\cdot\frac{60\ \text{s}}{1\ \text{min}}=1.0\times10^{1}\ \frac{\text{m}^3}{\text{min}}$$

11.

$$600{,}000\ \frac{\text{ft}^3}{\text{s}}\cdot\frac{(0.3048\ \text{m})^3}{1\ \text{ft}^3}\cdot\frac{1000\ \text{L}}{1\ \text{m}^3}\cdot\frac{60\ \text{s}}{1\ \text{min}}\cdot\frac{60\ \text{min}}{1\ \text{hr}}=6\times10^{10}\ \frac{\text{L}}{\text{hr}}$$

12.

$$5{,}200\ \text{mL}\cdot\frac{1\ \text{L}}{1000\ \text{mL}}\cdot\frac{1\ \text{m}^3}{1000\ \text{L}}=5.2\times10^{-3}\ \text{m}^3$$

13.

$$5.65\times10^{2}\ \text{mm}^2\cdot\frac{1\ \text{cm}}{10\ \text{mm}}\cdot\frac{1\ \text{cm}}{10\ \text{mm}}\cdot\frac{1\ \text{in}}{2.54\ \text{cm}}\cdot\frac{1\ \text{in}}{2.54\ \text{cm}}=0.876\ \text{in}^2$$

14.

$$32.16\ \frac{\text{ft}}{\text{s}^2}\cdot\frac{12\ \text{in}}{1\ \text{ft}}\cdot\frac{2.54\ \text{cm}}{1\ \text{in}}\cdot\frac{1\ \text{m}}{100\ \text{cm}}=9.802\ \frac{\text{m}}{\text{s}^2}$$

15.

$$5.001\ \frac{\mu\text{g}}{\text{s}}\cdot\frac{1\ \text{g}}{10^6\ \mu\text{g}}\cdot\frac{1\ \text{kg}}{1000\ \text{g}}\cdot\frac{60\ \text{s}}{1\ \text{min}}=3.001\times10^{-4}\ \frac{\text{kg}}{\text{min}}$$

16.

$$4.771\ \frac{\text{g}}{\text{mL}}\cdot\frac{1\ \text{kg}}{1000\ \text{g}}\cdot\frac{1000\ \text{mL}}{1\ \text{L}}\cdot\frac{1000\ \text{L}}{1\ \text{m}^3}=4{,}771\ \frac{\text{kg}}{\text{m}^3}$$

17.

$$13.6\ \frac{\text{g}}{\text{cm}^3}\cdot\frac{1000\ \text{mg}}{1\ \text{g}}\cdot\frac{100\ \text{cm}}{1\ \text{m}}\cdot\frac{100\ \text{cm}}{1\ \text{m}}\cdot\frac{100\ \text{cm}}{1\ \text{m}}=1.36\times10^{10}\ \frac{\text{mg}}{\text{m}^3}$$

18.

$$93{,}000{,}000\ \text{mi}\cdot\frac{5280\ \text{ft}}{1\ \text{mi}}\cdot\frac{0.3048\ \text{m}}{1\ \text{ft}}\cdot\frac{100\ \text{cm}}{1\ \text{m}}=1.5\times10^{13}\ \text{cm}$$

19.

$$65\ \frac{\text{mi}}{\text{hr}}\cdot\frac{5{,}280\ \text{ft}}{1\ \text{mi}}\cdot\frac{0.3048\ \text{m}}{1\ \text{ft}}\cdot\frac{1\ \text{hr}}{60\ \text{min}}\cdot\frac{1\ \text{min}}{60\ \text{s}}=29\ \frac{\text{m}}{\text{s}}$$

20.

$$633 \text{ nm} \cdot \frac{1 \text{ m}}{10^9 \text{ nm}} \cdot \frac{100 \text{ cm}}{1 \text{ m}} \cdot \frac{1 \text{ in}}{2.54 \text{ cm}} = 2.49 \times 10^{-5} \text{ in}$$

21.

$$0.05015 \cdot 3.00 \times 10^8 \ \frac{\text{m}}{\text{s}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{1 \text{ ft}}{0.3048 \text{ m}} \cdot \frac{1 \text{ mi}}{5{,}280 \text{ ft}} = 3.37 \times 10^7 \ \frac{\text{mi}}{\text{hr}}$$

Motion Exercises

1.

$$d = 25.1 \text{ mi} \cdot \frac{5{,}280 \text{ ft}}{1 \text{ mi}} \cdot \frac{0.3048 \text{ m}}{1 \text{ ft}} = 4.04 \times 10^4 \text{ m}$$

$$t = 0.50 \text{ hr} \cdot \frac{60 \text{ min}}{1 \text{ hr}} \cdot \frac{60 \text{ s}}{1 \text{ min}} = 1{,}800 \text{ s}$$

$$v = ?$$

$$d = vt$$

$$v = \frac{d}{t} = \frac{4.04 \times 10^4 \text{ m}}{1{,}800 \text{ s}} = 22 \ \frac{\text{m}}{\text{s}}$$

2.

$$22 \ \frac{\text{m}}{\text{s}} \cdot \frac{1 \text{ km}}{1000 \text{ m}} \cdot \frac{60 \text{ s}}{1 \text{ min}} \cdot \frac{60 \text{ min}}{1 \text{ hr}} = 79 \ \frac{\text{km}}{\text{hr}}$$

3.

$$t = 4.25 \text{ hr}$$

$$v = 5.0000 \ \frac{\text{km}}{\text{hr}}$$

$$d = ?$$

$$d = vt$$

$$d = 5.0000 \ \frac{\text{km}}{\text{hr}} \cdot 4.25 \text{ hr} = 21.3 \text{ km}$$

4.

$$21.3 \text{ km} \cdot \frac{1000 \text{ m}}{1 \text{ km}} \cdot \frac{1 \text{ ft}}{0.3048 \text{ m}} \cdot \frac{1 \text{ mi}}{5{,}280 \text{ ft}} = 13.2 \text{ mi}$$

5.

$$150.0\ \frac{\text{mi}}{\text{hr}} \cdot \frac{5{,}280\ \text{ft}}{1\ \text{mi}} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} \cdot \frac{1\ \text{km}}{1000\ \text{m}} = 241.4\ \frac{\text{km}}{\text{hr}}$$

6.

$$v = 150.0\ \frac{\text{mi}}{\text{hr}} \cdot \frac{1\ \text{hr}}{60\ \text{min}} = 2.50\ \frac{\text{mi}}{\text{min}}$$

$$d = 10.0\ \text{mi}$$

$$t = ?$$

$$d = vt$$

$$t = \frac{d}{v}$$

$$t = \frac{10.0\ \text{mi}}{2.50\ \frac{\text{mi}}{\text{min}}} = 4.00\ \text{min}$$

7.

$$d = 3.0\ \text{km} \cdot \frac{1000\ \text{m}}{1\ \text{km}} = 3.0 \times 10^3\ \text{m}$$

$$t = 1\ \text{hr}\ 20.0\ \text{min} = 80.0\ \text{min} \cdot \frac{60\ \text{s}}{1\ \text{min}} = 4.80 \times 10^3\ \text{s}$$

$$v = ?$$

$$d = vt$$

$$v = \frac{d}{t} = \frac{3.0 \times 10^3\ \text{m}}{4.80 \times 10^3\ \text{s}} = 0.63\ \frac{\text{m}}{\text{s}}$$

8.

$$v_i = 0$$

$$v_f = 45\ \frac{\text{mi}}{\text{hr}} \cdot \frac{1\ \text{hr}}{60\ \text{min}} \cdot \frac{1\ \text{min}}{60\ \text{s}} \cdot \frac{5{,}280\ \text{ft}}{1\ \text{mi}} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} = 20.1\ \frac{\text{m}}{\text{s}}$$

$$t = 36\ \text{s}$$

$$a = ?$$

$$a = \frac{v_f - v_i}{t} = \frac{20.1\ \frac{\text{m}}{\text{s}} - 0}{36\ \text{s}} = 0.56\ \frac{\text{m}}{\text{s}^2}$$

9.

$v_i = 31 \ \frac{\text{m}}{\text{s}}$

$t = 17 \text{ s}$

$v_f = 22 \ \frac{\text{m}}{\text{s}}$

$a = ?$

$$a = \frac{v_f - v_i}{t} = \frac{22 \ \frac{\text{m}}{\text{s}} - 31 \ \frac{\text{m}}{\text{s}}}{17 \text{ s}} = -0.53 \ \frac{\text{m}}{\text{s}^2}$$

10.

$d = 14.5 \text{ m}$

$v = c = 3.00 \times 10^8 \ \frac{\text{m}}{\text{s}}$

$t = ?$

$d = vt$

$$t = \frac{d}{v} = \frac{14.5 \text{ m}}{3.00 \times 10^8 \ \frac{\text{m}}{\text{s}}} = 4.83 \times 10^{-8} \text{ s} \cdot \frac{10^9 \text{ ns}}{\text{s}} 48.3 \text{ ns}$$

11.

$v_i = 0$

$v_f = 0.80 \cdot 3.00 \times 10^8 \ \frac{\text{m}}{\text{s}} = 2.40 \times 10^8 \ \frac{\text{m}}{\text{s}}$

$t = 18 \text{ hr } 6 \text{ min } 45 \text{ s} = 64800 \text{ s} + 360 \text{ s} + 45 \text{ s} = 65{,}205 \text{ s}$

$a = ?$

$$a = \frac{v_f - v_i}{t} = \frac{2.40 \times 10^8 \ \frac{\text{m}}{\text{s}} - 0}{65{,}205 \text{ s}} = 3{,}680 \ \frac{\text{m}}{\text{s}^2}$$

12.

$$d = 8.96\times10^{9}\ \text{km}\cdot\frac{1000\ \text{m}}{1\ \text{km}} = 8.96\times10^{12}\ \text{m}$$

$$v = 3.45\times10^{5}\ \frac{\text{m}}{\text{s}}$$

$$t = ?$$

$$d = vt$$

$$t = \frac{d}{v} = \frac{8.96\times10^{12}\ \text{m}}{3.45\times10^{5}\ \frac{\text{m}}{\text{s}}} = 2.597\times10^{7}\ \text{s}\cdot\frac{1\ \text{min}}{60\ \text{s}}\cdot\frac{1\ \text{hr}}{60\ \text{min}}\cdot\frac{1\ \text{day}}{24\ \text{hr}} = 301\ \text{days}$$

13.

$$a = 5.556\times10^{6}\ \frac{\text{cm}}{\text{s}^2}\cdot\frac{1\ \text{m}}{100\ \text{cm}} = 5.556\times10^{4}\ \frac{\text{m}}{\text{s}^2}$$

$$t = 45\ \text{ms}\cdot\frac{1\ \text{s}}{1000\ \text{ms}} = 4.5\times10^{-2}\ \text{s}$$

$$v_i = 0$$

$$v_f = ?$$

$$a = \frac{v_f - v_i}{t}$$

$$v_f = at + v_i = \left(5.556\times10^{4}\ \frac{\text{m}}{\text{s}^2}\right)\left(4.5\times10^{-2}\ \text{s}\right) + \left(0\ \frac{\text{m}}{\text{s}}\right) = 2.5\times10^{3}\ \frac{\text{m}}{\text{s}}$$

14.

$$v_i = 4.005\times10^{3}\ \frac{\text{m}}{\text{s}}$$

$$a = 23.1\ \frac{\text{m}}{\text{s}^2}$$

$$t = 13.5\ \text{s}$$

$$v_f = ?$$

$$a = \frac{v_f - v_i}{t}$$

$$v_f = at + v_i = \left(23.1\ \frac{\text{m}}{\text{s}^2}\cdot13.5\ \text{s}\right) + 4.005\times10^{3}\ \frac{\text{m}}{\text{s}} = 4.32\times10^{3}\ \frac{\text{m}}{\text{s}}$$

15.

$$v = c = 2.9979 \times 10^{8} \ \frac{\text{m}}{\text{s}}$$

$$d = 1.4965 \times 10^{8} \ \text{km} \cdot \frac{1000 \ \text{m}}{1 \ \text{km}} = 1.4965 \times 10^{11} \ \text{m}$$

$$t = ?$$

$$d = vt$$

$$t = \frac{d}{v} = \frac{1.4965 \times 10^{11} \ \text{m}}{2.9979 \times 10^{8} \ \frac{\text{m}}{\text{s}}} = 499.18 \ \text{s} \cdot \frac{1 \ \text{min}}{60 \ \text{s}} = 8.3197 \ \text{min}$$

Chapter 3

Newton's Second Law Practice Problems

1.

$m = 1{,}880 \text{ kg}$

$a = 1.50 \ \frac{\text{m}}{\text{s}^2}$

$F = ?$

$a = \frac{F}{m}$

$F = ma = 1{,}880 \text{ kg} \cdot 1.50 \ \frac{\text{m}}{\text{s}^2} = 2{,}820 \text{ N}$

2.

$m = 188.4 \text{ g} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} = 0.1884 \text{ kg}$

$g = 9.80 \ \frac{\text{m}}{\text{s}^2}$

$F_w = ?$

$F_w = 0.1884 \text{ kg} \cdot 9.80 \ \frac{\text{m}}{\text{s}^2} = 1.85 \text{ N}$

3.

$F = 250.0 \text{ N}$

$m = 144{,}000 \text{ mg} \cdot \frac{1 \text{ g}}{1000 \text{ mg}} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} = 0.144 \text{ kg}$

$a = ?$

$a = \frac{F}{m} = \frac{250.0 \text{ N}}{0.144 \text{ kg}} = 1{,}740 \ \frac{\text{m}}{\text{s}^2}$

4.

$$a = 2.3\ \frac{\text{m}}{\text{s}^2}$$

$$F = 230{,}000\ \text{N}$$

$$m = ?$$

$$a = \frac{F}{m}$$

$$m = \frac{F}{a} = \frac{230{,}000\ \text{N}}{2.3\ \frac{\text{m}}{\text{s}^2}} = 1.0 \times 10^5\ \text{kg}$$

5.

$$a = 0.0022\ \frac{\text{mi}}{\text{hr}^2} \cdot \frac{5{,}280\ \text{ft}}{1\ \text{mi}} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} \cdot \frac{1\ \text{hr}}{60\ \text{min}} \cdot \frac{1\ \text{hr}}{60\ \text{min}} \cdot \frac{1\ \text{min}}{60\ \text{s}} \cdot \frac{1\ \text{min}}{60\ \text{s}} = 2.732 \times 10^{-7}\ \frac{\text{m}}{\text{s}^2}$$

$$m = 2.2\ \text{Mg} \cdot \frac{10^6\ \text{g}}{1\ \text{Mg}} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 2.2 \times 10^3\ \text{kg}$$

$$F = ?$$

$$a = \frac{F}{m}$$

$$F = ma = 2.2 \times 10^3\ \text{kg} \cdot 2.732 \times 10^{-7}\ \frac{\text{m}}{\text{s}^2} = 6.0 \times 10^{-4}\ \text{N}$$

6.

$$F_w = 125.1\ \text{lb} \cdot \frac{4.45\ \text{N}}{1\ \text{lb}} = 556.7\ \text{N}$$

$$g = 9.80\ \frac{\text{m}}{\text{s}^2}$$

$$m = ?$$

$$F_w = mg$$

$$m = \frac{F_w}{g} = \frac{556.7\ \text{N}}{9.80\ \frac{\text{m}}{\text{s}^2}} = 56.8\ \text{kg}$$

7.

$m = 56.8 \text{ kg}$

$$F_w = 17.9 \text{ lb} \cdot \frac{4.45 \text{ N}}{1 \text{ lb}} = 79.66 \text{ N}$$

$g_m = ?$

$F_w = mg_m$

$$g_m = \frac{F_w}{m} = \frac{79.66 \text{ N}}{56.8 \text{ kg}} = 1.40 \frac{\text{m}}{\text{s}^2}$$

8.

$v_i = 0$

$$v_f = 125.0 \frac{\text{m}}{\text{s}}$$

$$t = 22.00 \text{ ms} \cdot \frac{1 \text{ s}}{1000 \text{ ms}} = 2.200 \times 10^{-2} \text{ s}$$

$F = 142.0 \text{ N}$

$m = ?$

$$a = \frac{v_f - v_i}{t} = \frac{125.0 \frac{\text{m}}{\text{s}} - 0}{2.200 \times 10^{-2} \text{ s}} = 5{,}681.8 \frac{\text{m}}{\text{s}^2}$$

$$a = \frac{F}{m}$$

$$m = \frac{F}{a} = \frac{142.0 \text{ N}}{5681.8 \frac{\text{m}}{\text{s}^2}} = 0.024992 \text{ kg} \cdot \frac{1000 \text{ g}}{1 \text{ kg}} = 24.99 \text{ g}$$

9.

$m = 4.5 \text{ kg}$

$v_i = 0$

$$v_f = 8.00 \frac{\text{mi}}{\text{hr}} \cdot \frac{1 \text{ hr}}{60 \text{ min}} \cdot \frac{1 \text{ min}}{60 \text{ s}} \cdot \frac{5{,}280 \text{ ft}}{1 \text{ mi}} \cdot \frac{0.3048 \text{ m}}{1 \text{ ft}} = 3.576 \frac{\text{m}}{\text{s}}$$

$$t = 500 \text{ ms} \cdot \frac{1 \text{ s}}{1000 \text{ ms}} = 0.5 \text{ s}$$

$F = ?$

$$a = \frac{v_f - v_i}{t} = \frac{3.576 \frac{\text{m}}{\text{s}} - 0}{0.5 \text{ s}} = 7.152 \frac{\text{m}}{\text{s}^2}$$

$$a = \frac{F}{m}$$

$$F = ma = 4.5 \text{ kg} \cdot 7.152 \frac{\text{m}}{\text{s}^2} = 30 \text{ N}$$

10.

$$v_i = 2{,}500.0 \frac{\text{km}}{\text{hr}} \cdot \frac{1 \text{ hr}}{60 \text{ min}} \cdot \frac{1 \text{ min}}{60 \text{ s}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} = 694.4 \frac{\text{m}}{\text{s}}$$

$t = 8.000 \text{ s}$

$F = 45{,}450 \text{ N}$

$$v_f = 2{,}750 \frac{\text{km}}{\text{hr}} \cdot \frac{1 \text{ hr}}{60 \text{ min}} \cdot \frac{1 \text{ min}}{60 \text{ s}} \cdot \frac{1000 \text{ m}}{1 \text{ km}} = 763.9 \frac{\text{m}}{\text{s}}$$

$m = ?$

$$a = \frac{v_f - v_i}{t} = \frac{763.89 \frac{\text{m}}{\text{s}} - 694.44 \frac{\text{m}}{\text{s}}}{8.000 \text{ s}} = 8.681 \frac{\text{m}}{\text{s}^2}$$

$$a = \frac{F}{m}$$

$$m = \frac{F}{a} = \frac{45{,}450 \text{ N}}{8.681 \frac{\text{m}}{\text{s}^2}} = 5{,}230 \text{ kg}$$

11.

$$m = 166\ \text{g} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 0.166\ \text{kg}$$

$$F = 0.0450\ \text{N}$$

$$v_i = 0$$

$$t = 2.1\ \text{s}$$

$$v_f = ?$$

$$a = \frac{F}{m} = \frac{0.0450\ \text{N}}{0.166\ \text{kg}} = 0.2711\ \frac{\text{m}}{\text{s}^2}$$

$$a = \frac{v_f - v_i}{t}$$

$$v_f = at + v_i = \left(0.2711\ \frac{\text{m}}{\text{s}^2} \cdot 2.1\ \text{s}\right) + 0 = 0.57\ \frac{\text{m}}{\text{s}}$$

12.

$$m = 1.673 \times 10^{-18}\ \mu\text{g} \cdot \frac{1\ \text{g}}{10^6\ \mu\text{g}} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 1.673 \times 10^{-27}\ \text{kg}$$

$$v_i = 0$$

$$v_f = c \cdot 0.0005 = 3.00 \times 10^8 \cdot 0.0005 = 1.50 \times 10^5\ \frac{\text{m}}{\text{s}}$$

$$t = 455\ \text{ns} \cdot \frac{1\ \text{s}}{10^9\ \text{ns}} = 4.55 \times 10^{-7}\ \text{s}$$

$$F = ?$$

$$a = \frac{v_f - v_i}{t} = \frac{1.50 \times 10^5\ \frac{\text{m}}{\text{s}} - 0}{4.55 \times 10^{-7}\ \text{s}} = 3.30 \times 10^{11}\ \frac{\text{m}}{\text{s}^2}$$

$$a = \frac{F}{m}$$

$$F = ma = 1.673 \times 10^{-27}\ \text{kg} \cdot 3.30 \times 10^{11}\ \frac{\text{m}}{\text{s}^2} = 5.52 \times 10^{-16}\ \text{N} \cdot \frac{1\ \text{GN}}{10^9\ \text{N}} = 5.52 \times 10^{-25}\ \text{GN}$$

13.

$$m = 6.548\ \text{Gg} \cdot \frac{10^9\ \text{g}}{1\ \text{Gg}} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 6.548 \times 10^6\ \text{kg}$$

$$v_i = 8.35\ \frac{\text{mi}}{\text{hr}} \cdot \frac{5{,}280\ \text{ft}}{1\ \text{mi}} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} \cdot \frac{1\ \text{hr}}{60\ \text{min}} \cdot \frac{1\ \text{min}}{60\ \text{s}} = 3.732\ \frac{\text{m}}{\text{s}}$$

$$v_f = 0$$

$$t = 0.288\ \text{min} \cdot \frac{60\ \text{s}}{1\ \text{min}} = 17.28\ \text{s}$$

$$F = ?$$

$$a = \frac{v_f - v_i}{t} = \frac{0 - 3.732\ \frac{\text{m}}{\text{s}}}{17.28\ \text{s}} = -0.216\ \frac{\text{m}}{\text{s}^2}$$

$$a = \frac{F}{m}$$

$$F = ma$$

$$F = 6.548 \times 10^6\ \text{kg} \cdot -0.216\ \frac{\text{m}}{\text{s}^2} = 1.41 \times 10^6\ \text{N}$$

14.

$$v_i = 3.5\ \frac{\text{cm}}{\text{s}} \cdot \frac{1\ \text{m}}{100\ \text{cm}} = 0.035\ \frac{\text{m}}{\text{s}}$$

$$v_f = 18.5\ \frac{\text{cm}}{\text{s}} \cdot \frac{1\ \text{m}}{100\ \text{cm}} = 0.185\ \frac{\text{m}}{\text{s}}$$

$$t = 220\ \text{ms} \cdot \frac{1\ \text{s}}{1000\ \text{ms}} = 0.22\ \text{s}$$

$$a = ?$$

$$a = \frac{v_f - v_i}{t} = \frac{0.185\ \frac{\text{m}}{\text{s}} - 0.035\ \frac{\text{m}}{\text{s}}}{0.22\ \text{s}} = 0.68\ \frac{\text{m}}{\text{s}^2}$$

15.

$m = 45{,}500 \text{ kg}$

$v_i = 0 \dfrac{\text{m}}{\text{s}}$

$v_f = 55 \dfrac{\text{m}}{\text{s}}$

$t = 6.4 \text{ s}$

$a = ?$

$F = ?$

$$a = \frac{v_f - v_i}{t} = \frac{55 \dfrac{\text{m}}{\text{s}} - 0}{6.4 \text{ s}} = 8.59 \frac{\text{m}}{\text{s}^2}$$

$$a = \boxed{8.6 \frac{\text{m}}{\text{s}^2}}$$

$$a = \frac{F}{m}$$

$$F = ma = 45{,}500 \text{ kg} \cdot 8.59 \frac{\text{m}}{\text{s}^2} = 3.9 \times 10^5 \text{ N}$$

16.

$$m = 8.5 \text{ g} \cdot \frac{1 \text{ kg}}{1000 \text{ g}} = 0.0085 \text{ kg}$$

$$a = 18{,}500 \frac{\text{m}}{\text{s}^2}$$

$F = ?$

$$a = \frac{F}{m}$$

$$F = ma = 0.0085 \text{ kg} \cdot 18{,}500 \frac{\text{m}}{\text{s}^2} = 160 \text{ N}$$

Chapter 4

Classroom Energy Computation Examples

1.

$m = 1.00 \times 10^5 \text{ kg}$

$h = 240 \text{ ft} \cdot \dfrac{0.3048 \text{ m}}{1 \text{ ft}} = 73.15 \text{ m}$

$g = 9.80 \dfrac{\text{m}}{\text{s}^2}$

$E_G = ?$

$E_G = mgh = 1.00 \times 10^5 \text{ kg} \cdot 9.80 \dfrac{\text{m}}{\text{s}^2} \cdot 73.15 \text{ m} = 72{,}000{,}000 \text{ J}$

2.

$m = 25 \text{ g} \cdot \dfrac{1 \text{ kg}}{1000 \text{ g}} = 0.025 \text{ kg}$

$v = 556 \dfrac{\text{ft}}{\text{s}} \cdot \dfrac{0.3048 \text{ m}}{1 \text{ ft}} = 169.5 \dfrac{\text{m}}{\text{s}}$

$E_K = ?$

$E_K = \dfrac{1}{2}mv^2 = \dfrac{1}{2} \cdot 0.025 \text{ kg} \cdot \left(169.5 \dfrac{\text{m}}{\text{s}} \right)^2 = 360 \text{ J}$

3.

$d = 75 \text{ cm} \cdot \dfrac{1 \text{ m}}{100 \text{ cm}} = 0.75 \text{ m}$

$m = 12{,}500 \text{ g} \cdot \dfrac{1 \text{ kg}}{1000 \text{ g}} = 12.5 \text{ kg}$

$W = ?$

$W = Fd$

$F_w = mg = 12.5 \text{ kg} \cdot 9.80 \dfrac{\text{m}}{\text{s}^2} = 122.5 \text{ kg}$

$W = 122.5 \text{ kg} \cdot 0.75 \text{ m} = 92 \text{ J}$

4.

$m = 12.5 \text{ kg}$

$h = 0.75 \text{ m}$

$$E_G = mgh = 0.75 \text{ m} \cdot 9.80 \frac{\text{m}}{\text{s}^2} \cdot 12.5 \text{ kg} = 92 \text{ J}$$

5.

$m = 12.5 \text{ kg}$

$h_i = 0.75 \text{ m}$

$h_f = 0$

$v_i = 0$

$v_f = ?$

$E_{Gi} + E_{Ki} = E_{Gf} + E_{Kf}$

$E_{Kf} = E_{Gi} + E_{Ki} - E_{Gf} = 92 \text{ J} + 0 - 0 = 92 \text{ J}$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 92 \text{ J}}{12.5 \text{ kg}}} = 3.8 \frac{\text{m}}{\text{s}}$$

6.

$$m = 255.8\ \text{g} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 0.2558\ \text{kg}$$

$$h_i = 10.4\ \text{ft} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} = 3.1699\ \text{m}$$

$$E_{Gi} = ?$$

$$E_{Gi} = mgh_i = 0.2558\ \text{kg} \cdot 9.80\ \frac{\text{m}}{\text{s}^2} \cdot 3.1699\ \text{m} = 7.95\ \text{J}$$

$$h_f = 0$$

$$v_i = 0$$

$$v_f = ?$$

$$E_{Gi} + E_{Ki} = E_{Gf} + E_{Kf}$$

$$E_{Ki} = 0$$

$$E_{Gf} = 0$$

$$E_{Kf} = E_{Gi} + E_{Ki} - E_{Gf} = 7.95\ \text{J} + 0\ \text{J} - 0\ \text{J} = 7.95\ \text{J}$$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 7.95\ \text{J}}{0.2558\ \text{kg}}} = 7.88\ \frac{\text{m}}{\text{s}}$$

Energy Calculations Set 1

1.

$$m = 1.31 \times 10^3\ \text{kg}$$

$$h = 177.44\ \text{ft} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} = 54.084\ \text{m}$$

$$E_G = ?$$

$$E_G = mgh = 1.31 \times 10^3\ \text{kg} \cdot 9.80\ \frac{\text{m}}{\text{s}^2} \cdot 54.084\ \text{m} = 694{,}000\ \text{J}$$

2.

$$m = 2{,}345\ \text{kg}$$

$$v = 31\ \frac{\text{mi}}{\text{hr}} \cdot \frac{5{,}280\ \text{ft}}{1\ \text{mi}} \cdot \frac{0.3048\ \text{m}}{1\ \text{ft}} \cdot \frac{1\ \text{hr}}{60\ \text{min}} \cdot \frac{1\ \text{min}}{60\ \text{s}} = 13.858\ \frac{\text{m}}{\text{s}}$$

$$E_K = \frac{1}{2}mv^2 = \frac{1}{2} \cdot 2{,}345\ \text{kg} \cdot \left(13.858\ \frac{\text{m}}{\text{s}}\right)^2 = 230{,}000\ \text{J}$$

3.

$$d = 61.7 \text{ cm} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 0.617 \text{ m}$$

$$m = 17.5 \text{ kg}$$

$$W = ?$$

$$a = \frac{F}{m}$$

$$F_w = mg = 17.5 \text{ kg} \cdot 9.80 \frac{\text{m}}{\text{s}^2} = 171.5 \text{ N}$$

$$W = F_w d = 171.5 \text{ N} \cdot 0.617 \text{ m} = 106 \text{ J}$$

4.

$$h = 61.7 \text{ cm} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 0.617 \text{ m}$$

$$m = 17.5 \text{ kg}$$

$$E_G = ?$$

$$E_G = mgh = 17.5 \text{ kg} \cdot 9.80 \frac{\text{m}}{\text{s}^2} \cdot 0.617 \text{ m} = 106 \text{ J}$$

5.

$$m = 17.5 \text{ kg}$$

$$h_f = 0.617 \text{ m}$$

$$h_i = 0$$

$$v_i = 0$$

$$v_f = ?$$

$$E_{Gi} + E_{Ki} = E_{Gf} + E_{Kf}$$

$$E_{Kf} = E_{Gi} + E_{Ki} - E_{Gf} = 106 \text{ J} + 0 \text{ J} - 0 \text{ J} = 106 \text{ J}$$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 106 \text{ J}}{17.5 \text{ kg}}} = 12.1 \frac{\text{m}}{\text{s}} = 3.48 \frac{\text{m}}{\text{s}}$$

6.

$$m = 122\ \text{g} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 0.122\ \text{kg}$$

$$v_i = 13.75\ \frac{\text{m}}{\text{s}}$$

$$v_f = 0$$

$$h_i = 0$$

$$h_f = ?$$

$$E_{Ki} = \frac{1}{2}mv^2 = \frac{1}{2} \cdot 0.122\ \text{kg} \cdot (13.75\ \frac{\text{m}}{\text{s}})^2 = 11.53\ \text{J}$$

$$E_{Gi} + E_{Ki} = E_{Gf} + E_{Kf}$$

$$E_{Gf} = E_{Gi} + E_{Ki} - E_{Kf} = 0 + 11.53\ \text{J} - 0 = 11.53\ \text{J}$$

$$E_{Gf} = mgh_f$$

$$h_f = \frac{E_{Gf}}{mg} = \frac{11.53\ \text{J}}{0.122\ \text{kg} \cdot 9.8\ \frac{\text{m}}{\text{s}^2}} = 9.65\ \text{m}$$

7.

$$m = 325\ \text{g} \cdot \frac{1\ \text{kg}}{1000\ \text{g}} = 0.325\ \text{kg}$$

$$h_i = 36.1\ \text{m}$$

$$h_f = 0$$

$$v_i = 0$$

$$v_f = ?$$

$$E_{Gi} = mgh_i = 0.325\ \text{kg} \cdot 9.80\ \frac{\text{m}}{\text{s}^2} \cdot 36.1\ \text{m} = 114.98\ \text{J}$$

$$E_{Gi} + E_{Ki} = E_{Gf} + E_{Kf}$$

$$E_{Kf} = E_{Gi} + E_{Ki} - E_{Gf} = 114.98\ \text{J} + 0 - 0$$

$$E_{Kf} = 114.98\ \text{J}$$

$$E_{Kf} = \frac{1}{2}mv^2$$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 114.98\ \text{J}}{0.325\ \text{kg}}} = 26.6\ \frac{\text{m}}{\text{s}}$$

8.

$F = 735 \text{ N}$

$d = 26 \text{ m}$

$W = ?$

$W = Fd = 735 \text{ N} \cdot 26 \text{ m} = 19{,}000 \text{ J}$

Energy Calculations Set 2

1.a.

$$F_w = 20 \cdot 80.0 \text{ lb} \cdot \frac{4.45 \text{ N}}{1 \text{ lb}} = 7{,}120 \text{ N}$$

$h = 8.5 \text{ m}$

$$g = 9.80 \frac{\text{m}}{\text{s}^2}$$

$m = ?$

$F_w = mg$

$$m = \frac{F_w}{g}$$

$$m = \frac{7{,}120 \text{ N}}{9.80 \frac{\text{m}}{\text{s}^2}} = 727 \text{ kg}$$

1.b

$F = 7{,}120 \text{ N}$

$d = 8.5 \text{ m}$

$W = Fd = 7{,}120 \text{ N} \cdot 8.5 \text{ m}$

$W = 6.0 \times 10^4 \text{ J}$

1.c.

$m = 727 \text{ kg}$

$$g = 9.80 \frac{\text{m}}{\text{s}^2}$$

$h = 8.5 \text{ m}$

$E_G = mgh$

$$E_G = 727 \text{ kg} \cdot 9.80 \frac{\text{m}}{\text{s}^2} \cdot 8.5 \text{ m} = 6.0 \times 10^4 \text{ J}$$

1.d.

$m = 727 \text{ kg}$

$v_i = 0$

$E_{Ki} = ?$

$$E_{Ki} = \frac{1}{2} m v_i^2 = \frac{1}{2} \cdot 727 \text{ kg} \cdot 0^2 = 0 \text{ J}$$

$E_{Gi} = 6.0 \times 10^4 \text{ J}$

$E_{Gf} = 0$

$E_{Kf} = ?$

$E_{Gi} + E_{Ki} = E_{Gf} + E_{Kf}$

$$E_{Kf} = E_{Gi} + E_{Ki} - E_{Gf} = 6.0 \times 10^4 \text{ J} + 0 - 0 = 6.0 \times 10^4 \text{ J}$$

1.e.

$m = 727 \text{ kg}$

$E_{Kf} = 6.0 \times 10^4 \text{ J}$

$v_f = ?$

$$E_{Kf} = \frac{1}{2} m v_f^2$$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 6.0 \times 10^4 \text{ J}}{727 \text{ kg}}} = 13 \frac{\text{m}}{\text{s}}$$

2.a.

$$F_W = 3{,}193 \text{ lb} \cdot \frac{4.45 \text{ N}}{1 \text{ lb}} = 14{,}209 \text{ N}$$

$$m = ?$$

$$F_W = mg$$

$$m = \frac{F_W}{g}$$

$$m = \frac{14{,}209 \text{ N}}{9.80 \frac{\text{m}}{\text{s}^2}} = 1{,}450 \text{ kg}$$

$$h = 16 \text{ m}$$

$$E_G = mgh = 1{,}450 \text{ kg} \cdot 9.80 \frac{\text{m}}{\text{s}^2} \cdot 16 \text{ m} = 227{,}360 \text{ J}$$

$$E_G = 230{,}000 \text{ J}$$

2.c.

$$E_{Kf} = ?$$

$$E_{G_i} + E_{Ki} = E_{Gf} + E_{Kf}$$

$$E_{Kf} = E_{G_i} + E_{Ki} - E_{Gf}$$

$$E_{Kf} = 230{,}000 \text{ J} + 0 - 0 = 230{,}000 \text{ J}$$

2.d.

$$E_{Kf} = 230{,}000 \text{ J}$$

$$m = 1{,}450 \text{ kg}$$

$$v_f = ?$$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 230{,}000 \text{ J}}{1{,}450 \text{ kg}}} = 18 \frac{\text{m}}{\text{s}}$$

Energy Calculations Set 3

1.a.

$$F_w = 27.05 \text{ lb} \cdot \frac{4.45 \text{ N}}{1 \text{ lb}} = 120.37 \text{ N}$$

$$d = 185 \text{ cm} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 1.85 \text{ m}$$

$$W = Fd = 120.37 \text{ N} \cdot 1.85 \text{ m} = 223 \text{ J}$$

1.b

$F_w = 120.37 \text{ N}$

$h = 1.85 \text{ m}$

$g = 9.80 \ \frac{\text{m}}{\text{s}^2}$

$m = ?$

$F_w = mg$

$m = \frac{F_w}{g}$

$m = \frac{120.37 \text{ N}}{9.80 \ \frac{\text{m}}{\text{s}^2}} = 12.28 \text{ kg}$

$E_G = ?$

$E_G = mgh = 12.28 \text{ kg} \cdot 9.80 \ \frac{\text{m}}{\text{s}^2} \cdot 1.85 \text{ m} = 223 \text{ J}$

1.c.

$m = 12.28 \text{ kg}$

$g = 9.80 \ \frac{\text{m}}{\text{s}^2}$

$h = 0 \text{ m}$

$E_G = ?$

$E_G = mgh = 12.28 \text{ kg} \cdot 9.80 \ \frac{\text{m}}{\text{s}^2} \cdot 0 \text{ m} = 0 \text{ J}$

1.d.

$E_{G_i} = 222.7 \text{ J}$

$E_{G_f} = 0 \text{ J}$

$E_{Ki} = 0 \text{ J}$

$E_{Kf} = ?$

$E_{Gi} + E_{Ki} = E_{G_f} + E_{Kf}$

$E_{Kf} = E_{Gi} + E_{Ki} - E_{G_f} = 222.7 \text{ J} + 0 - 0 = 223 \text{ J}$

1.e.

$E_{Kf} = 222.7 \text{ J}$

$m = 12.28 \text{ kg}$

$v_f = ?$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 222.7 \text{ J}}{12.28 \text{ kg}}} = 6.02 \frac{\text{m}}{\text{s}}$$

2.

$$d = 197 \text{ ft} \cdot \frac{0.3048 \text{ m}}{1 \text{ ft}} = 60.05 \text{ m}$$

$m = 6.016 \times 10^6 \text{ kg}$

$$F_w = mg = 6.016 \times 10^6 \text{ kg} \cdot 9.80 \frac{\text{m}}{\text{s}^2} = 5.896 \times 10^7 \text{ N}$$

$W = ?$

$W = F_w d = 5.896 \times 10^7 \text{ N} \cdot 60.05 \text{ m}$

$W = 3.54 \times 10^9 \text{ J}$

3.

$m = 5{,}122 \text{ kg}$

$h_i = 25.0 \text{ m}$

$v_f = ?$

$$E_{Gi} = mgh_i = 5{,}122 \text{ kg} \cdot 9.80 \frac{\text{m}}{\text{s}^2} \cdot 25.0 \text{ m} = 1.2549 \times 10^6 \text{ J}$$

$E_{Gi} = E_{Kf} = 1.2549 \times 10^6 \text{ J}$

$$v_f = \sqrt{\frac{2E_{Kf}}{m}} = \sqrt{\frac{2 \cdot 1.2549 \times 10^6 \text{ J}}{5{,}122 \text{ kg}}} = 22.1 \frac{\text{m}}{\text{s}}$$

4.a.

$$F_w = 104.6 \text{ lb} \cdot \frac{4.45 \text{ N}}{1 \text{ lb}} = 4.6547 \times 10^2 \text{ N}$$

$$d = 13 \text{ steps} \cdot \frac{16.5 \text{ cm}}{1 \text{ step}} \cdot \frac{1 \text{ m}}{100 \text{ cm}} = 2.145 \text{ m}$$

$W = ?$

$W = F_w d = 4.6547 \times 10^2 \text{ N} \cdot 2.145 \text{ m} = 998 \text{ J}$

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