

UNIT 1 ANSWERS TO PROBLEMS

DIMENSIONAL ANALYSIS

4. distance = 152 100 000 km

a. distance = $152\,100\,000\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ ym}}{10^{-24}\text{ m}} = \boxed{1.521 \times 10^{35}\text{ ym}}$

b. distance = $152\,100\,000\text{ km} \times \frac{1000\text{ m}}{1\text{ km}} \times \frac{1\text{ Ym}}{10^{24}\text{ m}} = \boxed{1.521 \times 10^{-13}\text{ Ym}}$

5. energy = $2.1 \times 10^{15}\text{ W}\cdot\text{h}$

a. energy = $2.1 \times 10^{15}\text{ W}\cdot\text{h} \times \frac{1\text{ J/s}}{1\text{ W}} \times \frac{3600\text{ s}}{1\text{ h}} = \boxed{7.6 \times 10^{18}\text{ J}}$

b. energy = $7.6 \times 10^{18}\text{ J} \times \frac{1\text{ GJ}}{10^9\text{ J}} = \boxed{7.6 \times 10^9\text{ GJ}}$

AVERAGE VELOCITY AND DISPLACEMENT

Givens

Solutions

1. $\Delta x = 443\text{ m}$

$v_{avg} = 0.60\text{ m/s}$

$\Delta t = \frac{\Delta x}{v_{avg}} = \frac{443\text{ m}}{0.60\text{ m/s}} = \boxed{740\text{ s} = 12\text{ min}, 20\text{ s}}$

2. $v_{avg} = 72\text{ km/h}$

$\Delta x = 1.5\text{ km}$

$\Delta t = \frac{\Delta x}{v_{avg}} = \frac{1.5\text{ km}}{\left(72 \frac{\text{km}}{\text{h}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)} = \boxed{75\text{ s}}$

3. $\Delta x = 5.50 \times 10^2\text{ m}$

$v_{avg} = 1.00 \times 10^2\text{ km/h}$

$v_{avg} = 85.0\text{ km/h}$

a. $\Delta t = \frac{\Delta x}{v_{avg}} = \frac{5.50 \times 10^2\text{ m}}{\left(1.00 \times 10^2 \frac{\text{km}}{\text{h}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)} = \boxed{19.8\text{ s}}$

b. $\Delta x = \Delta v_{avg} \Delta t$

$\Delta x = (85.0\text{ km/h})\left(\frac{1\text{ h}}{3600\text{ s}}\right)\left(\frac{10^3\text{ m}}{1\text{ km}}\right)(19.8\text{ s}) = \boxed{468\text{ m}}$

AVERAGE ACCELERATION

Givens

1. $v_i = 0 \text{ km/h} = 0 \text{ m/s}$
 $a_{avg} = 1.8 \text{ m/s}^2$
 $\Delta t = 1.00 \text{ min}$

Solutions

$$v_f = a_{avg} \Delta t + v_i = (1.80 \text{ m/s}^2)(1.00 \text{ min}) \left(\frac{60 \text{ s}}{1 \text{ min}} \right) + 0 \text{ m/s} = \boxed{108 \text{ m/s}}$$

$$v_f = 108 \text{ m/s} = (108 \text{ m/s}) \left(\frac{3600 \text{ s}}{1 \text{ h}} \right) \left(\frac{1 \text{ km}}{10^3 \text{ m}} \right) = \boxed{389 \text{ km/h}}$$

2. $\Delta t = 2.0 \text{ min}$
 $a_{avg} = 0.19 \text{ m/s}^2$
 $v_i = 0 \text{ m/s}$

$$v_f = a_{avg} \Delta t + v_i = (0.19 \text{ m/s}^2)(2.0 \text{ min}) \left(\frac{60 \text{ s}}{1 \text{ min}} \right) + 0 \text{ m/s} = \boxed{23 \text{ m/s}}$$

3. $\Delta t = 45.0 \text{ s}$
 $a_{avg} = 2.29 \text{ m/s}^2$
 $v_i = 0 \text{ m/s}$

$$v_f = a_{avg} \Delta t + v_i = (2.29 \text{ m/s}^2)(45.0 \text{ s}) + 0 \text{ m/s} = \boxed{103 \text{ m/s}}$$

9. $\Delta x = 3.00 \text{ km}$
 $\Delta t = 217.347 \text{ s}$
 $a_{avg} = -1.72 \text{ m/s}^2$
 $v_f = 0 \text{ m/s}$

$$v_i = v_{avg} = \frac{\Delta x}{\Delta t} = \frac{3.00 \times 10^3 \text{ m}}{217.347 \text{ s}} = 13.8 \text{ m/s}$$

$$t_{stop} = \frac{v_f - v_i}{a_{avg}} = \frac{0 \text{ m/s} - 13.8 \text{ m/s}}{-1.72 \text{ m/s}^2} = \frac{-13.8 \text{ m/s}}{-1.72 \text{ m/s}^2} = \boxed{8.02 \text{ s}}$$

10. $\Delta x = +5.00 \times 10^2 \text{ m}$
 $\Delta t = 35.76 \text{ s}$
 $v_i = 0 \text{ m/s}$
 $\Delta t' = 4.00 \text{ s}$
 $v_{max} = v_{avg} + (0.100) v_{avg}$

$$v_f = v_{max} = (1.100) v_{avg} = (1.100) \left(\frac{\Delta x}{\Delta t} \right) = (1.100) \left(\frac{5.00 \times 10^2 \text{ m}}{35.76 \text{ s}} \right) = +15.4 \text{ m/s}$$

$$a_{avg} = \frac{\Delta v}{\Delta t'} = \frac{v_f - v_i}{\Delta t'} = \frac{15.4 \text{ m/s} - 0 \text{ m/s}}{4.00 \text{ s}} = \boxed{+3.85 \text{ m/s}^2}$$

DISPLACEMENT WITH CONSTANT ACCELERATION

1. $\Delta x = 115 \text{ m}$
 $v_i = 4.20 \text{ m/s}$
 $v_f = 5.00 \text{ m/s}$

$$\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(115 \text{ m})}{4.20 \text{ m/s} + 5.00 \text{ m/s}} = \frac{(2)(115 \text{ m})}{9.20 \text{ m/s}} = \boxed{25.0 \text{ s}}$$

2. $\Delta x = 180.0 \text{ km}$
 $v_i = 3.00 \text{ km/s}$
 $v_f = 0 \text{ km/s}$

$$\Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(180.0 \text{ km})}{3.00 \text{ km/s} + 0 \text{ km/s}} = \frac{360.0 \text{ km}}{3.00 \text{ km/s}} = \boxed{1.2 \times 10^2 \text{ s}}$$

3. $v_i = 0 \text{ km/h}$
 $v_f = 1.09 \times 10^3 \text{ km/h}$
 $\Delta x = 20.0 \text{ km}$

$$\text{a. } \Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(20.0 \times 10^3 \text{ m})}{(1.09 \times 10^3 \text{ km/h} + 0 \text{ km/h}) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right)}$$

$$\Delta t = \frac{40.0 \times 10^3 \text{ m}}{(1.09 \times 10^3 \text{ km/h}) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right)} = \boxed{132 \text{ s}}$$

- $\Delta x = 5.00 \text{ km}$
 $v_i = 1.09 \times 10^3 \text{ km/h}$
 $v_f = 0 \text{ km/h}$

$$\text{b. } \Delta t = \frac{2\Delta x}{v_i + v_f} = \frac{(2)(5.00 \times 10^3 \text{ m})}{(1.09 \times 10^3 \text{ km/h} + 0 \text{ km/h}) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right)}$$

$$\Delta t = \frac{10.0 \times 10^3 \text{ m}}{(1.09 \times 10^3 \text{ km/h}) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{1000 \text{ m}}{1 \text{ km}} \right)} = \boxed{33.0 \text{ s}}$$

1. $v_i = 186 \text{ km/h}$
 $v_f = 0 \text{ km/h} = 0 \text{ m/s}$
 $a = -1.5 \text{ m/s}^2$

$$\Delta t = \frac{v_f - v_i}{a} = \frac{0 \text{ m/s} - (186 \text{ km/h}) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)}{-1.5 \text{ m/s}^2} = \frac{-51.7 \text{ m/s}}{-1.5 \text{ m/s}^2} = \boxed{34 \text{ s}}$$

2. $v_i = -15.0 \text{ m/s}$
 $v_f = 0 \text{ m/s}$
 $a = +2.5 \text{ m/s}^2$
 $v_i = 0 \text{ m/s}$
 $v_f = +15.0 \text{ m/s}$
 $a = +2.5 \text{ m/s}^2$

For stopping:

$$\Delta t_1 = \frac{v_f - v_i}{a} = \frac{0 \text{ m/s} - (-15.0 \text{ m/s})}{2.5 \text{ m/s}^2} = \frac{15.0 \text{ m/s}}{2.5 \text{ m/s}^2} = 6.0 \text{ s}$$

For moving forward:

$$\Delta t_2 = \frac{v_f - v_i}{a} = \frac{15.0 \text{ m/s} - 0.0 \text{ m/s}}{2.5 \text{ m/s}^2} = \frac{15.0 \text{ m/s}}{2.5 \text{ m/s}^2} = 6.0 \text{ s}$$

$$\Delta t_{\text{tot}} = \Delta t_1 + \Delta t_2 = 6.0 \text{ s} + 6.0 \text{ s} = \boxed{12.0 \text{ s}}$$

3. $v_i = 24.0 \text{ km/h}$
 $v_f = 8.0 \text{ km/h}$
 $a = -0.20 \text{ m/s}^2$

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

$$\Delta t = \frac{(8.0 \text{ km/h} - 24.0 \text{ km/h}) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)}{-0.20 \text{ m/s}^2}$$

$$\Delta t = \frac{\left(-16.0 \frac{\text{km}}{\text{h}} \right) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right) \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)}{-0.20 \text{ m/s}^2} = \boxed{22 \text{ s}}$$

5. $\Delta x = 2.00 \times 10^2 \text{ m}$
 $v = 105.4 \text{ km/h}$

$v_{i,car} = 0 \text{ m/s}$

a. $\Delta t = \frac{\Delta x}{v} = \frac{2.00 \times 10^2 \text{ m}}{\left(105.4 \frac{\text{km}}{\text{h}}\right) \left(\frac{1 \text{ h}}{3600 \text{ s}}\right) \left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)} = 6.83 \text{ s}$

b. $\Delta x = v_{i,car} \Delta t + \frac{1}{2} a_{car} \Delta t^2$

$a_{car} = \frac{2\Delta x}{\Delta t^2} = \frac{(2)(2.00 \times 10^2 \text{ m})}{(6.83 \text{ s})^2} = 8.57 \text{ m/s}^2$

VELOCITY AND DISPLACEMENT WITH CONSTANT ACCELERATION

13. $v_i = 0 \text{ m/s}$

$\Delta x = 1.00 \times 10^2 \text{ m}$

$\Delta t = 12.11 \text{ s}$

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

Because $v_i = 0 \text{ m/s}$,

$a = \frac{2\Delta x}{\Delta t^2} = \frac{(2)(1.00 \times 10^2 \text{ m})}{(12.11 \text{ s})^2} = 1.36 \text{ m/s}^2$

14. $v_i = 3.00 \text{ m/s}$

$\Delta x = 1.00 \times 10^2 \text{ m}$

$\Delta t = 12.11 \text{ s}$

$a = \frac{2(\Delta x - v_i \Delta t)}{\Delta t^2} = \frac{(2)[1.00 \times 10^2 \text{ m} - (3.00 \text{ m/s})(12.11 \text{ s})]}{(12.11 \text{ s})^2}$

$a = \frac{(2)(1.00 \times 10^2 \text{ m} - 36.3 \text{ m})}{(12.11 \text{ s})^2}$

$a = \frac{(2)(64 \text{ m})}{(12.11 \text{ s})^2} = 0.87 \text{ m/s}^2$

15. $v_f = 30.0 \text{ m/s}$

$v_i = 18.0 \text{ m/s}$

$\Delta t = 8.0 \text{ s}$

$a = \frac{v_f - v_i}{\Delta t} = \frac{30.0 \text{ m/s} - 18.0 \text{ m/s}}{8.0 \text{ s}} = \frac{12.0 \text{ m/s}}{8.0 \text{ s}} = 1.5 \text{ m/s}^2$

FINAL VELOCITY AFTER ANY DISPLACEMENT

3. $v_f = 9.70 \times 10^2 \text{ km/h}$
 $v_i = (0.500)v_f$
 $a = 4.8 \text{ m/s}^2$

$$\Delta x = \frac{v_f^2 - v_i^2}{2a} = \frac{(9.70 \times 10^2 \text{ km/h})^2 - (0.50)^2 (9.70 \times 10^2 \text{ km/h})^2}{(2)(4.8 \text{ m/s}^2)} \left(\frac{1 \text{ h}}{3600 \text{ s}} \right)^2 \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)^2$$

$$\Delta x = \frac{(9.41 \times 10^5 \text{ km}^2/\text{h}^2) - 2.35 \times 10^5 \text{ km}^2/\text{h}^2}{(2)(4.8 \text{ m/s}^2)} \left(\frac{1 \text{ h}}{3600 \text{ s}} \right)^2 \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)^2$$

$$\Delta x = \frac{(7.06 \times 10^5 \text{ km}^2/\text{h}^2) \left(\frac{1 \text{ h}}{3600 \text{ s}} \right)^2 \left(\frac{10^3 \text{ m}}{1 \text{ km}} \right)^2}{(2)(4.8 \text{ m/s}^2)}$$

$$\Delta x = \frac{5.45 \times 10^4 \text{ m}^2/\text{s}^2}{9.6 \text{ m/s}^2} = 5.7 \times 10^3 \text{ m} = \boxed{5.7 \text{ km}}$$

4. $v_i = 8.0 \text{ m/s}$
 $\Delta x = 40.0 \text{ m}$
 $a = 2.00 \text{ m/s}^2$

$$v_f = \sqrt{2a\Delta x + v_i^2} = \sqrt{(2)(2.0 \text{ m/s}^2)(40. \text{m}) + (8.0 \text{ m/s})^2} = \sqrt{1.60 \times 10^3 \text{ m}^2/\text{s}^2 + 64 \text{ m}^2/\text{s}^2}$$

$$v_f = \sqrt{224 \text{ m}^2/\text{s}^2} = \pm 15 \text{ m/s} = \boxed{15 \text{ m/s}}$$

5. $\Delta x = +9.60 \text{ m}$
 $a = -2.0 \text{ m/s}^2$
 $v_f = 0 \text{ m/s}$

$$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(0 \text{ m/s})^2 - (2)(-2.0 \text{ m/s}^2)(9.60 \times 10^3 \text{ m})}$$

$$v_i = \sqrt{3.84 \times 10^4 \text{ m}^2/\text{s}^2} = \pm 196 \text{ m/s} = \boxed{+196 \text{ m/s}}$$

6. $a = +0.35 \text{ m/s}^2$
 $v_i = 0 \text{ m/s}$
 $\Delta x = 64 \text{ m}$

$$v_f = \sqrt{2a\Delta x + v_i^2} = \sqrt{(2)(0.35 \text{ m/s}^2)(64 \text{ m}) + (0 \text{ m/s})^2}$$

$$v_f = \sqrt{45 \text{ m}^2/\text{s}^2} = \pm 6.7 \text{ m/s} = \boxed{+6.7 \text{ m/s}}$$

FALLING OBJECTS

1. $\Delta y = -343 \text{ m}$
 $a = -9.81 \text{ m/s}^2$
 $v_i = 0 \text{ m/s}$

$$v_f = \sqrt{2a\Delta y + v_i^2} = \sqrt{(2)(-9.81 \text{ m/s}^2)(-343 \text{ m}) + (0 \text{ m/s})^2} = \sqrt{6730 \text{ m}^2/\text{s}^2}$$

$$v_f = \pm 82.0 \text{ m/s} = \boxed{-82.0 \text{ m/s}}$$

2. $\Delta y = +4.88 \text{ m}$
 $v_i = +9.98 \text{ m/s}$
 $a = -9.81 \text{ m/s}^2$

$$v_f = \sqrt{2a\Delta y + v_i^2} = \sqrt{(2)(-9.81 \text{ m/s}^2)(4.88 \text{ m}) + (9.98 \text{ m/s})^2} = \sqrt{-95.7 \text{ m}^2/\text{s}^2 + 99.6 \text{ m}^2/\text{s}^2}$$

$$v_f = \sqrt{3.90 \text{ m}^2/\text{s}^2} = \pm 1.97 \text{ m/s} = \boxed{\pm 1.97 \text{ m/s}}$$

3. $\Delta y = -443 \text{ m} + 221 \text{ m}$
 $= -222 \text{ m}$
 $a = -9.81 \text{ m/s}^2$
 $v_i = 0 \text{ m/s}$

$$v_f = \sqrt{2a\Delta y + v_i^2} = \sqrt{(2)(-9.81 \text{ m/s}^2)(-222 \text{ m}) - (0 \text{ m/s})^2} = \sqrt{4360 \text{ m}^2/\text{s}^2}$$

$$v_f = \pm 66.0 \text{ m/s} = \boxed{-66.0 \text{ m/s}}$$

4. $\Delta y = +64 \text{ m}$
 $a = -9.81 \text{ m/s}^2$
 $\Delta t = 3.0 \text{ s}$

$$\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$v_i = \frac{\Delta y - \frac{1}{2} a \Delta t^2}{\Delta t} = \frac{64 \text{ m} - \frac{1}{2} (-9.81 \text{ m/s}^2)(3.0 \text{ s})^2}{3.0 \text{ s}} = \frac{64 \text{ m} + 44 \text{ m}}{3.0 \text{ s}}$$

$$v_i = \frac{108 \text{ m}}{3.0 \text{ s}} = 36 \text{ m/s} \quad \text{initial speed of arrow} = \boxed{36 \text{ m/s}}$$