Physics – Midterm Exam
Free-Response Practice Problems

Significant Figures and Scientific Notation

1. a) **Exercises:** Change each of the following numbers to scientific notation.

1. 50. _____
2. 0.00078 _____
3. 40.25 _____
4. 0.004523 _____
5. 1,023,300 _____

Change each of the following numbers to ordinary notation.

6. 3.46×10^{-4} _____
7. 1.1×10^{7} _____
8. 3.985×10^{0} _____
9. 4.92×10^{3} _____
10. 4.0×10^{-1} _____

Answers: (1) 5.0×10^{1}; (2) 7.8×10^{-4}; (3) 4.025×10^{1}; (4) 4.523×10^{-3}; (5) 1.0233×10^{6}; (6) 0.000 346; (7) 11,000,000; (8) 3.985; (9) 4920; (10) 0.40

b) 7. How many significant figures are there in each of the following?

a. 156.18	5	e. 9,000,000	1	i. $176\overline{0}$	4
b. 381,000	3	f. $42\overline{0},000$	3	j. 0.020750	5
c. 905	3	g. 0.00236	3	k. 9.73×10^{-2}	3
d. $40\overline{00}$	3	h. 70.040	5	l. 8.020×10^{5}	4

8. In the following, convert numbers in common notation to scientific notation, and convert numbers in scientific notation to common notation.

a. 61,000,000 =	6.1×10^{7}	d. 3.629×10^{10} =	36,290,000,000
b. 0.000048 =	4.8×10^{-5}	e. 7.04×10^{-5} =	0.0000704
c. 502.78 =	5.0278×10^{2}	f. 9.5133×10^{2} =	951.33

9. Give the order of magnitude of each of the following.

a. 7.3×10^{6}	10^{7}	d. 1.415×10^{-2}	10^{-2}
b. 3.75×10^{4}	10^{4}	e. 8.608×10^{-8}	10^{-7}
c. 6.02×10^{23}	10^{24}	f. 4.99×10^{-13}	10^{-13}

10. Round off each of the following to the number of digits indicated.

Number	5 digits	4 digits	3 digits	2 digits
a. 5.13159	5.1316	5.132	5.13	5.1
b. 8.59530	8.5953	8.595	8.60	8.6

11. In the following, which is the rightmost column to be retained in the result expressed in the proper number of significant figures?

a. $20.7\text{ m} + 7.01\text{ m} + 151.110\text{ m} =$ **tenths** 11a

b. $3053\text{ L} - 70\text{ L} =$ **tens** 11b

c. $68.57\text{ km} + 358.01\text{ km} + 59\text{ km} =$ **units** 11c

d. $2000\text{ g} - 60.0\text{ g} =$ **units** 11d

e. $0.04050\text{ cm} + 9.80\text{ cm} + 3000.240\text{ cm} =$ **hundredths** 11e

f. $10.790\text{ mL} - 7.0\text{ mL} =$ **tenths** 11f

12. In the following, how many digits should appear in a result expressed in the proper number of significant figures?

a. $781.6 \times 54 =$ **2** 12a

b. $952 \times 17.3 =$ **3** 12b

c. $95.4 \div 10.875 =$ **3** 12c

d. $6.02 \times 10^{23} \times 16.00 \times 1.660 \times 10^{-24} =$ **3** 12d

One-Dimensional Kinematics

General Motion

2. A cheetah is known to be the fastest mammal on Earth, at least for short runs. Cheetahs have been observed running a distance of 5.50×10^2 m with an average speed of 1.00×10^2 km/h.

a. How long would it take a cheetah to cover this distance at this speed?

b. Suppose the average speed of the cheetah were just 85.0 km/h. What distance would the cheetah cover during the same time interval calculated in (a)?

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

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

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

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

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

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

3. In 1992, Maurizio Damilano, of Italy, walked 29 752 m in 2.00 h.

a. Calculate Damilano's average speed in m/s.

b. Suppose Damilano slows down to 3.00 m/s at the midpoint in his journey, but then picks up the pace and accelerates to the speed calculated in (a). It takes Damilano 30.0 s to accelerate. Find the magnitude of the average acceleration during this time interval.

$\Delta x = 29\,752\text{ m}$

$\Delta t = 2.00\text{ h}$

a. $$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{29\,752\text{ m}}{(2.00\text{ h})\left(\frac{3600\text{ s}}{1\text{ h}}\right)} = \boxed{4.13\text{ m/s}}$$

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

$v_f = 4.13\text{ m/s}$

$\Delta t = 30.0\text{ s}$

b. $$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{4.13\text{ m/s} - 3.00\text{ m/s}}{30.0\text{ s}} = \frac{1.13\text{ m/s}}{30.0\text{ s}} = \boxed{3.77 \times 10^{-2}\text{ m/s}^2}$$

Uniform Acceleration

4. Starting at a certain speed, a bicyclist travels 2.00×10^2 m. Suppose the bicyclist undergoes a constant acceleration of 1.20 m/s^2. If the final speed is 25.0 m/s, what was the bicyclist's initial speed?

$\Delta x = 2.00 \times 10^2$ m

$a = 1.20$ m/s^2

$v_f = 25.0$ m/s

$$v_i = \sqrt{v_f^2 - 2a\Delta x} = \sqrt{(25.0 \text{ m/s})^2 - (2)(1.20 \text{ m/s}^2)(2.00 \times 10^2 \text{ m})}$$

$$v_i = \sqrt{625 \text{ m}^2/\text{s}^2 - 4.80 \times 10^2 \text{ m}^2/\text{s}^2}$$

$$v_i = \sqrt{145 \text{ m}^2/\text{s}^2} = \pm 12.0 \text{ m/s} = \boxed{12.0 \text{ m/s}}$$

Free-Fall

5. The tallest roller coaster in the world is the Desperado in Nevada. It has a lift height of 64 m. If an archer shoots an arrow straight up in the air and the arrow passes the top of the roller coaster 3.0 s after the arrow is shot, what is the initial speed of the arrow?

$\Delta y = +64$ m

$a = -9.81$ m/s^2

$\Delta t = 3.0$ s

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

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

$$v_i = \frac{108 \text{ m}}{3.0 \text{ s}} = 36 \text{ m/s}$$

initial speed of arrow = $\boxed{36 \text{ m/s}}$

Vectors

Resultant

6. The emperor penguin is the best diver among birds: the record dive is 483 m. Suppose an emperor penguin dives vertically to a depth of 483 m and then swims horizontally a distance of 225 m. What angle would the vector of the resultant displacement make with the water's surface? What is the magnitude of the penguin's resultant displacement?

$\Delta y = -483$ m

$\Delta x = 225$ m

$$\theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) = \tan^{-1}\left(\frac{-483}{225 \text{ m}}\right) = -65.0° = \boxed{65.0° \text{ below the waters surface}}$$

$$d = \sqrt{\Delta x^2 + \Delta y^2} = \sqrt{(225 \text{ m})^2 + (-483 \text{ m})^2}$$

$$d = \sqrt{5.06 \times 10^4 \text{ m}^2 + 2.33 \times 10^5 \text{ m}^2} = \sqrt{2.84 \times 10^5 \text{ m}^2}$$

$$d = \boxed{533 \text{ m}}$$

Components

7. The landing speed of the space shuttle *Columbia* is 347 km/h. If the shuttle is landing at an angle of 15.0° with respect to the horizontal, what are the horizontal and the vertical components of its velocity?

$v = 347$ km/h

$\theta = 15.0°$

$v_x = v(\cos\theta) = (347 \text{ km/h})(\cos 15.0°) = \boxed{335 \text{ km/h}}$

$v_y = v(\sin\theta) = (347 \text{ km/h})(\sin 15.0°) = \boxed{89.8 \text{ km/h}}$

Projectiles

8. In 1991, Doug Danger rode a motorcycle to jump a horizontal distance of 76.5 m. Find the maximum height of the jump if his angle with respect to the ground at the beginning of the jump was 12.0°.

$\Delta x = 76.5$ m

$\theta = 12.0°$

$g = 9.81 \text{ m/s}^2$

At maximum height, $v_{y,f} = 0$ m/s.

$$v_{y,f}^2 = v_{y,i}^2 - 2g\Delta y = 0$$

$$\Delta y_{max} = \frac{v_{y,i}^2}{2g} = \frac{v_i^2(\sin\theta)^2}{2g}$$

Using the derivation for v_i^2 from problem 1,

$$\Delta y_{max} = \left[\frac{g\Delta x}{2(\sin\theta)(\cos\theta)}\right]\frac{(\sin\theta)^2}{2g} = \frac{\Delta x(\sin\theta)}{4(\cos\theta)} = \frac{\Delta x(\tan\theta)}{4}$$

$$\Delta y_{max} = \frac{(76.5 \text{ m})(\tan 12.0°)}{4} = 4.07 \text{ m}$$