PHY 1321 and PHY 1331 Summer 2011

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ASSIGNMENT 1 Due: July 15, 2011 4:00 pm

1.7. Which of the following equations are dimensionally correct? (a) $v_f = v_i + ax$
(b) $y = (2\text{ m})\cos(kx)$, where $k = 2\text{ m}^{-1}$.

1.26. The radius of a solid sphere is measured to be (6.50 ± 0.20) cm, and its mass is measured to be (1.85 ± 0.02) kg. Determine the density of the sphere in kilograms per cubic meter and the uncertainty in the density.

1. 44. Vector $\vec{\mathbf{A}}$ has x and y components of –8.70 cm and 15.0 cm, respectively; vector $\vec{\mathbf{B}}$ has x and y components of 13.2 cm and –6.60 cm, respectively. If $\vec{\mathbf{A}} - \vec{\mathbf{B}} + 3\vec{\mathbf{C}} = 0$, what are the components of $\vec{\mathbf{C}}$?

2. 12. An object moves along the x axis according to the equation $x(t) = (3.00t^2 - 2.00t + 3.00)$ m, where t is in seconds. Determine (a) the average speed between t = 2.00 s and t = 3.00 s, (b) the instantaneous speed at t = 2.00 s and at t = 3.00 s, (c) the average acceleration between t = 2.00 s and t = 3.00 s, and (d) the instantaneous acceleration at t = 2.00 s and t = 3.00 s.

2. 25. A truck on a straight road starts from rest, accelerating at 2.00 m/s^2 until it reaches a speed of 20.0 m/s. Then the truck travels for 20.0 s at constant speed until the brakes are applied, stopping the truck in a uniform manner in an additional 5.00 s. (a) How long is the truck in motion? (b) What is the average velocity of the truck for the motion described?

2. 55. A rock is dropped from rest into a well. The sound of the splash is heard 2.40 s after the rock is released from rest. How far below the top of the well is the surface of the water? The speed of sound in air (at the ambient temperature) is 336 m/s.

Solutions

P1.7 (a) $\boxed{\text{This is incorrect}}$ since the units of $[ax]$ are m^2/s^2, while the units of $[v]$ are m/s.

(b) $\boxed{\text{This is correct}}$ since the units of $[y]$ are m, and $\cos(kx)$ is dimensionless if $[k]$ is in m^{-1}.

***P1.26** $r = (6.50 \pm 0.20)\ \text{cm} = (6.50 \pm 0.20) \times 10^{-2}\ \text{m}$

$m = (1.85 \pm 0.02)\ \text{kg}$

$\rho = \dfrac{m}{\left(\frac{4}{3}\right)\pi r^3}$

also, $\dfrac{\delta\rho}{\rho} = \dfrac{\delta m}{m} + \dfrac{3\delta r}{r}$. In other words, the percentages of uncertainty are cumulative. Therefore,

$$\frac{\delta\rho}{\rho} = \frac{0.02}{1.85} + \frac{3(0.20)}{6.50} = 0.103\ ,$$

$$\rho = \frac{1.85}{\left(\frac{4}{3}\right)\pi\left(6.5 \times 10^{-2}\ \text{m}\right)^3} = \boxed{1.61 \times 10^3\ \ \text{kg/m}^3}$$

and

$$\rho \pm \delta\rho = \boxed{(1.61 \pm 0.17) \times 10^3\ \ \text{kg/m}^3} = (1.6 \pm 0.2) \times 10^3\ \ \text{kg/m}^3\ .$$

P1.44 $\vec{\mathbf{A}} = -8.70\hat{\mathbf{i}} + 15.0\hat{\mathbf{j}}$ and $\vec{\mathbf{B}} = 13.2\hat{\mathbf{i}} - 6.60\hat{\mathbf{j}}$

$\vec{\mathbf{A}} - \vec{\mathbf{B}} + 3\vec{\mathbf{C}} = 0$:

$$3\vec{\mathbf{C}} = \vec{\mathbf{B}} - \vec{\mathbf{A}} = 21.9\hat{\mathbf{i}} - 21.6\hat{\mathbf{j}}$$
$$\vec{\mathbf{C}} = 7.30\hat{\mathbf{i}} - 7.20\hat{\mathbf{j}}$$

or

$$C_x = \boxed{7.30\ \text{cm}};\ C_y = \boxed{-7.20\ \text{cm}}$$

P2.12 (a) At $t = 2.00\text{ s}$, $x = \left[3.00(2.00)^2 - 2.00(2.00) + 3.00\right]\text{ m} = 11.0\text{ m}$.

At $t = 3.00\text{ s}$, $x = \left[3.00(9.00)^2 - 2.00(3.00) + 3.00\right]\text{ m} = 24.0\text{ m}$

so

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{24.0\text{ m} - 11.0\text{ m}}{3.00\text{ s} - 2.00\text{ s}} = \boxed{13.0\text{ m/s}}.$$

(b) At all times the instantaneous velocity is

$$v = \frac{d}{dt}\left(3.00t^2 - 2.00t + 3.00\right) = (6.00t - 2.00)\text{ m/s}$$

At $t = 2.00\text{ s}$, $v = \left[6.00(2.00) - 2.00\right]\text{ m/s} = \boxed{10.0\text{ m/s}}$.

At $t = 3.00\text{ s}$, $v = \left[6.00(3.00) - 2.00\right]\text{ m/s} = \boxed{16.0\text{ m/s}}$.

(c) $\bar{a} = \dfrac{\Delta v}{\Delta t} = \dfrac{16.0\text{ m/s} - 10.0\text{ m/s}}{3.00\text{ s} - 2.00\text{ s}} = \boxed{6.00\text{ m/s}^2}$

(d) At all times $a = \dfrac{d}{dt}(6.00t - 2.00) = \boxed{6.00\text{ m/s}^2}$. (This includes both $t = 2.00\text{ s}$ and $t = 3.00\text{ s}$).

P2.25 (a) The time it takes the truck to reach 20.0 m/s is found from $v_f = v_i + at$. Solving for t yields

$$t = \frac{v_f - v_i}{a} = \frac{20.0\text{ m/s} - 0\text{ m/s}}{2.00\text{ m/s}^2} = 10.0\text{ s}.$$

The total time is thus

$$10.0\text{ s} + 20.0\text{ s} + 5.00\text{ s} = \boxed{35.0\text{ s}}.$$

(b) The average velocity is the total distance traveled divided by the total time taken. The distance traveled during the first 10.0 s is

$$x_1 = \bar{v}t = \left(\frac{0 + 20.0}{2}\right)(10.0) = 100\text{ m}.$$

With a being 0 for this interval, the distance traveled during the next 20.0 s is

$$x_2 = v_i t + \frac{1}{2}at^2 = (20.0)(20.0) + 0 = 400\text{ m}.$$

The distance traveled in the last 5.00 s is

$$x_3 = \bar{v}t = \left(\frac{20.0 + 0}{2}\right)(5.00) = 50.0\text{ m}.$$

The total distance $x = x_1 + x_2 + x_3 = 100 + 400 + 50 = 550\text{ m}$, and the average velocity is given by $\bar{v} = \dfrac{x}{t} = \dfrac{550}{35.0} = \boxed{15.7\text{ m/s}}$.

P2.55 (a)

$$d = \frac{1}{2}(9.80)t_1^2 \qquad d = 336t_2$$

$$t_1 + t_2 = 2.40 \qquad 336t_2 = 4.90(2.40 - t_2)^2$$

$$4.90t_2^2 - 359.5t_2 + 28.22 = 0 \qquad t_2 = \frac{359.5 \pm \sqrt{359.5^2 - 4(4.90)(28.22)}}{9.80}$$

$$t_2 = \frac{359.5 \pm 358.75}{9.80} = 0.076\,5 \text{ s} \quad \text{so} \quad d = 336t_2 = \boxed{26.4 \text{ m}}$$

(b) Ignoring the sound travel time, $d = \frac{1}{2}(9.80)(2.40)^2 = 28.2 \text{ m}$, an error of $\boxed{6.82\%}$.