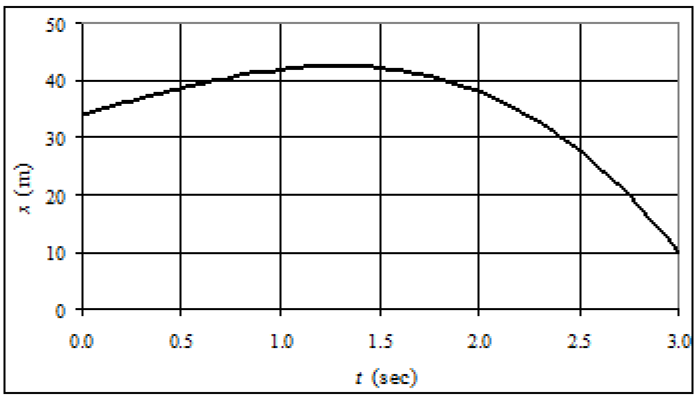
HW2 Solutions **PHYS 211** **Dr. Amir**

3. The average velocity is given by Eq. 2.2.

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{8.5\,\text{cm} - 4.3\,\text{cm}}{4.5\,\text{s} - (-2.0\,\text{s})} = \frac{4.2\,\text{cm}}{6.5\,\text{s}} = \boxed{0.65\,\text{cm/s}}$$

The average speed cannot be calculated. To calculate the average speed, we would need to know the actual distance traveled, and it is not given. We only have the displacement.

8. a)



(*b*) The average velocity is the displacement divided by the elapsed time.

$$\bar{v} = \frac{x(3.0) - x(0.0)}{3.0\,\text{s} - 0.0\,\text{s}} = \frac{\left[34 + 10(3.0) - 2(3.0)^3\right]\text{m} - (34\,\text{m})}{3.0\,\text{s}} = \boxed{-8.0\,\text{m/s}}$$

(*c*) The instantaneous velocity is given by the derivative of the position function.

$$v = \frac{dx}{dt} = \left(10 - 6t^2\right)\text{m/s} \qquad 10 - 6t^2 = 0 \;\rightarrow\; t = \sqrt{\frac{5}{3}}\,\text{s} = \boxed{1.3\,\text{s}}$$

This can be seen from the graph as the "highest" point on the graph.

12. Since the locomotives have the same speed, they each travel half the distance, 4.25 km. Find the time of travel from the average speed.

$$\bar{v} = \frac{\Delta x}{\Delta t} \rightarrow \Delta t = \frac{\Delta x}{\bar{v}} = \frac{4.25\text{ km}}{95\,\text{km/h}} = 0.0447\text{ h}\left(\frac{60\text{ min}}{1\text{ h}}\right) = 2.68\text{ min} \approx \boxed{2.7\text{ min}}$$

22. (*a*) The average acceleration of the sprinter is $\bar{a} = \frac{\Delta v}{\Delta t} = \frac{9.00\,\text{m/s} - 0.00\,\text{m/s}}{1.28\text{ s}} = \boxed{7.03\,\text{m/s}^2}$.

(*b*) $\bar{a} = \left(7.03\,\text{m/s}^2\right)\left(\frac{1\text{ km}}{1000\text{ m}}\right)\left(\frac{3600\text{ s}}{1\text{ h}}\right)^2 = \boxed{9.11\times10^4\text{ km/h}^2}$

27. The acceleration is the second derivative of the position function.

$$x = 6.8t + 8.5t^2 \quad \rightarrow \quad v = \frac{dx}{dt} = 6.8 + 17.0t \quad \rightarrow \quad a = \frac{d^2x}{dt^2} = \frac{dv}{dt} = \boxed{17.0\,\mathrm{m/s^2}}$$

29. (*a*) Since the units of *A* times the units of *t* must equal meters, the units of *A* must be $\boxed{\mathrm{m/s}}$.

Since the units of *B* times the units of t^2 must equal meters, the units of *B* must be $\boxed{\mathrm{m/s^2}}$.

(*b*) The acceleration is the second derivative of the position function.

$$x = At + Bt^2 \quad \rightarrow \quad v = \frac{dx}{dt} = A + 2Bt \quad \rightarrow \quad a = \frac{d^2x}{dt^2} = \frac{dv}{dt} = \boxed{2B\,\mathrm{m/s^2}}$$

(*c*) $v = A + 2Bt \quad \rightarrow \quad v(5) = \boxed{(A + 10B)\,\mathrm{m/s}} \qquad a = \boxed{2B\,\mathrm{m/s^2}}$

(*d*) The velocity is the derivative of the position function.

$$x = At + Bt^{-3} \quad \rightarrow \quad v = \frac{dx}{dt} = \boxed{A - 3Bt^{-4}}$$

46. During the final part of the race, the runner must have a displacement of 1100 m in a time of 180 s (3.0 min). Assume that the starting speed for the final part is the same as the average speed thus far.

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{8900\text{ m}}{(27 \times 60)\text{ s}} = 5.494\,\mathrm{m/s} = v_0$$

The runner will accomplish this by accelerating from speed v_0 to speed *v* for *t* seconds, covering a distance d_1, and then running at a constant speed of *v* for $t_1 = (180 - t)$ seconds, covering a distance d_2. We have these relationships from Eq. 2-12a and Eq. 2-12b.

$x = x_0 + v_0 t + 1/2\, at^2$ and

$x_0 = v_0\, t_1$

Substituting in $x = x_0 + v_0 t + 1/2\, at^2$

1100= (5.494m/s) (180s-t) +(5.494m/s)t +(1/2)(0.20m/s^2) t^2

Since we must have $t < 180$ s, the solution is t=33.4s