AP Physics C
Drozdoff 8–9
Quiz Solutions — Chapter 7, 10/3/2007

Scored out of 20 points; maximum of 22 points possible.

1a $W = F\,\Delta d\cos\theta$ or $W = F\,\Delta x\cos\theta$ (deltas not required)

1b $W = \mathbf{F}\cdot\Delta\mathbf{d}$ or $W = \mathbf{F}\cdot\Delta\mathbf{x}$ (deltas not required)

1c $W = \int_{\mathcal{C}} \mathbf{F}\cdot d\mathbf{s}$ is the ideal answer, but do not require $\mathcal{C}$, accept (reasonable) limits or lack thereof, and allow $\cdot d\mathbf{x}$ or, though horrendous, $\cdot d\mathbf{d}$ for the differential element

Scoring: one point per correct answer

2 $W = \int \mathbf{F}\cdot d\mathbf{x} = \int\left(-kx^3\right)dx = \frac{1}{4}kx^4$ (accept the use of a constant of integration)

Scoring: one point for $W = \int \mathbf{F}\cdot d\mathbf{x}$ or similar, one point for plugging in $\|\mathbf{F}\| = -kx^3$, one point for correct evaluation of the integral

3 The work-kinetic energy theorem states that $W = \Delta K$ (accept delta on the opposite side). For example, if a force brings a moving object to a stop, the work done by the force can be determined by the change in kinetic energy (from $\frac{1}{2}m\|\mathbf{v}_0\|^2$ to 0); answers may vary for this part.

Scoring: one point for correctness of theorem, two for example of application

4 Fish ladders do not reduce the amount of work that the fish must do to get past the dam; they are advantageous merely because they allow the fish to do the necessary work in smaller individual jumps.

Scoring: one point for "no", two points for explanation

5 $\mathscr{P} = \frac{dW}{dt} = \frac{d}{dt}\left(\mathbf{F}\cdot\Delta\mathbf{x}\right) = \mathbf{F}\cdot\frac{d\mathbf{x}}{dt} + \Delta\mathbf{x}\cdot\frac{d\mathbf{F}}{dt} = \mathbf{F}\cdot\mathbf{v} + \Delta\mathbf{x}\cdot\frac{d\mathbf{F}}{dt}$. Now $\frac{d\mathbf{F}}{dt}$ is typically zero (that is, the object has no jerk), so $\mathscr{P} = \mathbf{F}\cdot\mathbf{v} + \Delta\mathbf{x}\cdot\left(\mathbf{0}\right) = \mathbf{F}\cdot\mathbf{v}$, which was what we wanted.

Scoring: one point for $\mathscr{P} = \frac{dW}{dt}$; one point for $\frac{d}{dt}\left(\mathbf{F}\cdot\Delta\mathbf{x}\right)$; one point for the product rule expansion; one point for assuming $\frac{d\mathbf{F}}{dt} = \mathbf{0}$ and the correct answer

6a $K_A = \frac{1}{2}\left(2m_B\right)\|\mathbf{v}_B\|^2$ and $K_B = \frac{1}{2}m_B\|\mathbf{v}_B\|^2$, so the ratio is $\frac{1}{\frac{1}{2}} = 2$.

6b $K_A = \frac{1}{2}m_B\left\|\frac{1}{4}\mathbf{v}_B\right\|^2 = \frac{1}{2}m_B\cdot\frac{1}{16}\|\mathbf{v}_B\|^2 = \frac{1}{32}m\|\mathbf{v}_B\|^2$ and $K_B = \frac{1}{2}m_B\|\mathbf{v}_B\|^2$, so the ratio is $\frac{1}{16}$.

6c $K_A = \frac{1}{2}\left(\frac{1}{3}m_B\right)\|\mathbf{v}_A\|^2 = \frac{1}{6}m_B\|\mathbf{v}_A\|^2$ and $K_B = \frac{1}{2}m_B\|2\mathbf{v}_A\|^2 = \frac{1}{2}m_B\cdot 4\|\mathbf{v}_A\|^2 = 2m_B\|\mathbf{v}_A\|^2$, so the ratio is $\frac{1}{12}$.

Scoring: one point per correct answer

7a $\mathbf{F} = -k\mathbf{x} \Rightarrow k = \frac{\|\mathbf{F}\|}{\|\mathbf{x}\|} = \frac{230.\ \text{N}}{0.400\ \text{m}} = 575\ \text{N} \cdot \text{m}^{-1}$

7b $W = \overline{\mathbf{F}} \cdot \Delta\mathbf{x} = \left(\frac{230.\ \text{N}}{2}\right) \cdot 0.400\ \text{m} = 46.0\ \text{J}$

7c $\mathscr{P} = \frac{\Delta W}{\Delta t} = \frac{46.0\ \text{J}}{4.50\ \text{s}} = 10.2\ \text{W}$ (if the student did **7b** incorrectly but applied the wrong answer correctly to this part, full credit is granted)

Scoring: one point per correct answer, noting comment on part **c**