Flipping Physics Lecture Notes:

Average and Instantaneous Power Example

Example: An 8.53 kg pumpkin is dropped from a height of 8.91 m. What is the power delivered by the force of gravity (a) over the whole displacement of the pumpkin, (b) right after the pumpkin is dropped and (c) right before the pumpkin strikes the ground?

First we need to understand that part (a) is asking for the *average power* delivered by the force of gravity because it is the power over a time duration, whereas parts (b) and (c) are asking for *instantaneous power* because it is at a specific time.

(a) $P = \frac{W}{\Delta t} = Fv\cos\theta \Rightarrow P_{F_g} = \frac{F_g d\cos\theta}{\Delta t} = \frac{(mg)d\cos\theta}{\Delta t} = \frac{(8.53)(9.81)(8.91)\cos(0)}{\Delta t}$

The Force of Gravity and the displacement are both down, so θ, the angle between those two directions, is zero. We need the change in time. The ball is in free fall so …

Knowns: $\Delta y = -8.91m;\ a_y = -g = -9.81\frac{m}{s^2};\ v_{iy} = 0;\ \Delta t = ?$

$$\Delta y = v_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2 \Rightarrow -8.91 = (0)\Delta t + \frac{1}{2}(-9.81)\Delta t^2$$

$$\Rightarrow \Delta t^2 = \frac{(-8.91)(2)}{-9.81} \Rightarrow \Delta t = \sqrt{\frac{(8.91)(2)}{9.81}} = 1.34778\text{sec}$$

$$\&\ P_{F_g} = \frac{(8.53)(9.81)(8.91)\cos(0)}{1.34778} = 553.193 \approx \boxed{553\,watts}$$

(Average power delivered by the force of gravity during the entire event.)

Alternate solution: $P_{F_g} = F_{F_g}v_{avg}\cos\theta = (mg)v_{avg}\cos\theta\ \&\ v_{avg} = \frac{\Delta y}{\Delta t} = \frac{-8.91}{1.34778} = -6.61087\frac{m}{s}$

$$\&\ P_{F_g} = (mg)v_{avg}\cos\theta = (8.53)(9.81)(6.61087)\cos(0) = 553.193 \approx 553\,watts$$

(b) $P_{F_g} = \frac{W_{F_g}}{\Delta t} = \frac{F_g d\cos\theta}{\Delta t}$ Actually, we can't use this equation because the question asks for the instantaneous power and therefore, we need to use the equation for power which has instantaneous velocity in it: $P_{F_g} = F_g v_{inst}\cos\theta = F_g v_{iy}\cos\theta = F_g(0)\cos\theta = \boxed{0}$

(Instantaneous power delivered by the force of gravity at the very start.)

Note: The equation, $P = \frac{W}{\Delta t}$, only works for *average* power. The equation, $P = Fv\cos\theta$, works for both *average and instantaneous* power.

(c) Again we need to use $P_{F_g} = F_g v_{inst} \cos\theta$ because this is instantaneous velocity, however, we need the velocity right before the ball strikes the ground. Again, the ball is in free fall.

$$v_{fy}^{\ 2} = v_{iy}^{\ 2} + 2a_y \Delta y = 0^2 + (2)(-9.81)(-8.91) \Rightarrow v_{fy} = \sqrt{(2)(-9.81)(-8.91)} = -13.2217\frac{m}{s}$$

$$\& \ P_{F_g} = F_g v_{inst} \cos\theta = (mg) v_{fy} \cos\theta = (8.53)(9.81)(13.2217)\cos(0) = 1106.386 \approx \boxed{1110 watts}$$

$$P_{F_g} = 1106.386 watts \times \frac{1hp}{746 watts} = 1.48369 \approx 1.48hp$$

(Instantaneous power delivered by the force of gravity at the very end.)

Note: Remember in the Work and Power equations, you only use the magnitude of the force, displacement, and velocity.