107 Answer Key - Chapters 6 & 8 assignments

Conceptual: Ch.6: 36, Ch.8: 8, 12, 30, 34
Problems: Ch.6: 14, 18, Ch.8: 2, 10

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1 Chapter 6

1.1 Conceptual Exercises

36.) "Figure 6.16 is a graph of a roller coaster's height above the ground versus the length of track it covers. The coaster is powered up to its high point at 100 m from the starting point. From the high point, the coaster coasts freely all the way to the end. Assume that the coaster starts from rest at the high point and encounters no friction or air resistance. Between 200 m and the finish, where is it moving slowest? Fastest?"

To find where the car will be moving the slowest or fastest, we need to use conservation of energy. Since the car is barely moving at the high point, all of its energy is potential energy. Conservation of energy says to set the initial energy equal to the energy of the point you're interested in: $E_{final} = \frac{1}{2} mass * (speed)^2 + mass * g * height$. If we want the speed as large as possible, we want the height at that point to be as small as possible - that means more of its energy is kinetic energy. The smallest height we can get on the Figure is $\boxed{\text{height} = 0 \text{ at } 600 \text{ m.}}$

If we want the speed to be as small as possible, we want the height to be large - that means that more of its energy is potential energy, not kinetic energy. The $\boxed{\text{largest height we can get}}$ (not including the starting point) is an elevation of 30 m $\boxed{\text{at a distance of } 500 \text{ m.}}$

Note that in both parts of the question we did not care about what happened before or after the fastest or slowest point, i.e. big/small hill, flat, start or end of the ride. Only the height matters - not how it got there!

1.2 Problems

14). "Jack, who has a mass of 30 kg and weighs 300 newtons, sits in a child's swing. You pull the swing back so that it is 2 m above its low point, and release it. What form of energy, and how much energy, does Jack have when he is pulled back and held at rest?"

If Jack is at rest, then he cannot have kinetic energy. Since the weight of Jack is displaced a certain height (and someone had to do work to put Jack there), Jack has gravitational potential energy. If we measure our heights from the low point of the swing, then Jack has $gravE = (weight) * (height)$ $= 300\ N * 2\ m = 600\ J.$

18.) "You do a pullup, lifting yourself by 0.5 m in 2 s. If your weight is 600 N, how much work did you do, and what was your power output during lifting?"

Work = (Force)*(distance) = $600\ N * 0.5\ m = 300\ J.$

Power = $\frac{Work\ done}{timeelapsed} = \frac{300\ J}{2\ s} = 150\ Watts.$

2 Chapter 8

2.1 Conceptual Exercises

8.) "What happens to the energy of the two waves in Figure 8.9 when they interfere destructively, as shown in the second of the three sketches? Did the energy vanish?"

Because the pulse is a transverse wave, the velocities of the small pieces of string are in the vertical direction (but the pulse itself travels horizontally). The leading edge of a pulse pushes the string up, while the trailing edge pushes the string down. When the waves overlap, the amplitudes cancel, but the velocities do not! On one side, part of the string is moving up due to the leading edge of one pulse and the trailing edge of the other, and on the other end, part is moving down due to the trailing edge of one and leading edge of the other. This means that the string has some velocity, even when there is complete destructive interference. A non-zero velocity means a non-zero kinetic energy, thus the energy is stored in the kinetic energy of the string.

12.) "You shine two flashlights on a wall. Why don't you see an interference pattern?"

You don't see an interference pattern because the light from the flashlight isn't coherent. Coherent light is light that is synchronized; the flashlight

light is not coherent because the thermal motion that generates the light is random. Synchronized light is necessary to view the interference pattern, which can be obtained from a laser. You would also need just one laser, since there wouldn't be the necessary synchronization between two.

30.) "According to Figure 8.24, what are the atomic numbers of carbon and helium? Roughly how much more massive is the carbon atom than the helium atom?"

The atomic number of an element is the number of protons in the nucleus. Counting the blue circles in the Figure, the atomic number of carbon is 6, and the atomic number of helium is 2. Since an electron's mass is much less than a proton's, we can compare the mass of carbon and helium by comparing the size of the nucleus - carbon is 3 times more massive than helium, counting protons alone. It turns out, though, that the mass of a neutron (white circle) is about the same as a proton's; comparing the total number of protons and neutrons for carbon (12) and helium (4), gives us the same result: carbon is 3 times more massive than helium.

34.) "**Making Estimates** About how many atoms thick is a sheet of paper?"

An atom is about $10^{-10} m/atom$ across. Our textbook looks roughly $4cm$ thick, and has about 600 pages. So a sheet of paper in this book is $0.04m/600 = 6.67X10^{-5}m$ thick. Since this is just an estimate, let's call it $10^{-4}m$. We can get $10^{-4}m/(10^{-10}m/atom) = 10^6$ *atoms* in this thickness, so a sheet of paper is about 10^6, or 1,000,000, atoms thick!

2.2 Problems

2.) "Typical AM radio wavelengths are about as long as a football field, while typical FM radio wavelengths are about a meter long. Which one then has the highest (largest) frequency? If an AM wavelength is 100 times longer than an FM radio wavelength, then how do the frequencies compare?"

The relation between wavelength and frequency is given by $speed = (wavelength)*(frequency)$, or dividing by wavelength, $frequency = (speed)/(wavelength)$. If the wavelength of AM radio waves is longer than FM, then the frequency of FM radio waves will be higher than AM, because there is a smaller number in the denominator for FM waves.

If we increase the wavelength by 100 times, then we need to divide the frequency by 100 to make the equation true:

$$frequency_{FM} = \frac{speed}{wavelength_{FM}} \Rightarrow \frac{frequency_{FM}}{100} = \frac{speed}{100 * wavelength_{FM}}, \tag{1}$$

where the speed for both waves is the same (speed of light). Thus, the frequency for AM radio waves is smaller by a factor of 100.

10.) "Find the wavelength of an AM radio wave whose frequency is 1000 kHz"

Once again we use the equation $speed = (wavelength) * (frequency)$, inverting it this time to get $wavelength = (speed)/(frequency)$. Using the speed of light as $3 * 10^8\ m/s$, and noting that $1000\ kHz = 1,000,000\ Hz = 10^6\ Hz$, we have $wavelength = 3 * 10^2 m/(s * Hz)$. Since $[Hz] = \frac{1}{sec}$, we get: wavelength = 300 m.