Problem Set 4 Solutions

1a. 30 seconds/19 revolutions, so 3/19 second, or 0.1579 seconds
1b. 19/3 Hz, or 6.333333 Hz
1c. 24 frames/second is greater than 2 times the frequency, so according to the Nyquist sampling criterion, it will display properly.
1d. Any exact multiple of the frame rate will make it appear to be standing still. The half as fast part wasn't really possible. But if the frame rate is 3/2 the frequency, or 9.5 frames per second, then it will appear to go backwards at half speed.

2a. 42 = 10 log(Bob/S), Bob = S*10^4.2 = 15848.93*S
36 = 10 log(Music/S), Music = S*10^3.6 = 3981.07*S
40 = 10 log(Mom/S), Mom = S*10^4 = 10000*S
2b. S*10^4/(S*10^3.6 + S*10^4.2) = .504286
2c. 3000Hz – 300 Hz = 2700 Hz
2d. C = 2700 Hz * lg(1 + .504286) = 1590.513 Hz
2e. To increase to 46 decibels, it's 10^4.6/10^4 times as loud, requiring 3.98 times as much power.

3a. .2MHz for the specific station. The question was unclear, however, and an answer that gave the width of the entire spectrum used for FM radio (20 MHz) was also acceptable.
3b. Here you must use the bandwidth for WHRB, not for the entire FM spectrum.
C = .2 MHz * lg(1 + 50000W/750W) = 1.216 MHz
3c. 44.1 KHz * 16 * 2 = 1411200 Hz (bits/second) = 1411.2 KHz = 1.4112 MHz
3d. 1.4112 MHz = .2 MHz * lg(1 + P/750)
7.056 = lg(1 + P/750)
2^7.056 = 1 + P/750
133.066 = 1 + P/750
132.066 = P/750
99049.626 Watts would be required, which is more than 50,000.
3e. 1.4112 MHz = 4 MHz * lg(1 + P/750)
0.3528 = lg(1 + P/750)
2^0.3528 = 1 + P/750
1.277 = 1 + P/750
0.277 = P/750
207.78 Watts, far lower because of the greater bandwidth.
3f. 44.1 KHz * 16 * 5 = 4 MHz * lg(1 + P/750)
3.528 MHz = 4 MHz * lg(1 + P/750)
0.882 = lg(1 + P/750)
2^0.882 = 1 + P/750
1.8429 = 1 + P/750
0.8429 = P/750
632.196 Watts for the surround sound because you need to be able to push more bits through the wire.
3e. XM is "greener" because it requires less power because of its greater bandwidth.

4a. Take the C and keep doubling it to get the frequencies. Middle C is 261.63 KHz. The next C up is 523.26 KHz. Then 1046.52, 2093.04, 4186.08, 8372.16, and 16744.32. Doubling again would get to a frequency too high, so the highest C a human ear can hear is at 16744.32 Hz. "6 octaves above middle C" was also an acceptable answer.
4b. Do the same thing here: 392, 784, 1568, 3136. Doubling further would take it up too high, so it's 3 octaves above the specified G.
4c. Now we are dealing with digital, so we have to handle sampling. According to the Nyquist sampling criterion, we have to be able to sample at greater than twice the frequency, so we can't get a G any higher than 4 kHz in order to sample it properly. Therefore, it's still 3 octaves above the 392 Hz G.
4d. It's the same situation here. We need to find the highest frequency of G that does not exceed 22.05 KHz. Start and 392 and repeatedly double: 392, 784, 1568, 3136, 6272, 12544, 25088 is too big, so 12544 is the highest one we can sample accurately. "5 octaves above the 392Hz G" was also an acceptable answer.