Multiple choice: Each question is worth 5 points (30 points total).

1. The following is a graph of position versus time for a mass oscillating on a spring. Clearly circle one point on the graph for which the velocity is a maximum, positive value.

2. Earth is currently orbiting the Sun. We would be orbiting the Sun faster if

A. the Earth were closer to the Sun.
B. the Earth were farther from the Sun.
C. the Earth were more massive.
D. the Earth were less massive.
E. More than one answer is correct.

3. It's often stated that astronauts in orbit around the Earth are "weightless" because we see pictures of the astronauts seeming to float about in their spacecraft. Why is this?

A. Because the astronauts are outside of the Earth's gravity.
B. Because the astronauts are falling at the same rate as the spacecraft.
C. Because the Moon pulls the astronauts in the opposite direction as the Earth.
D. Because the astronauts have been sprinkled with pixie dust.
E. More than one answer is correct.

4. To measure the "decibel level" (dB) of a sound wave, you would take the logarithm of the intensity, I, like so:

\[ \text{"dB"} = 10 \log \left( \frac{I}{I_0} \right) \]

(Note: This "f" is different than other uses of "f" that you would use for rotational motion.) This means that if you double the intensity, the decibel level must

A. increase by less than a factor of 2.
B. increase by the same factor of 2.
C. increase by more than a factor of 2.
D. decrease.

5. A tube that is producing a resonating frequency (i.e., a standing wave) of sound is closed at one end. At the end where the tube is closed, you know that

A. there is a node.
B. there is an antinode.
C. Neither A or B are possible.
D. Both A and B are possible.

6. If a sound wave's frequency increases, then which of the following must also increase?

A. the wave's speed
B. the wavelength
C. the wave's amplitude
D. None of these features will increase.
Situation #1: Collisions and oscillations

A. [15 points] You throw (v=9.00 m/s) a piece of clay (m=0.430 kg) horizontally so that it sticks to a mass (M=1.55 kg) on a spring. The mass on the spring is initially at its equilibrium position. Immediately after the mass is struck by the clay (but before the spring is compressed), what is the speed of the clay-mass combination?

\[ \begin{align*}
\text{\textbf{P}}_{\text{clay}} &= \text{\textbf{P}}_{\text{stuck}} \\
M_{\text{clay}}V_{\text{clay}} + M_{\text{mass}}V_{\text{mass}} &= (M_{\text{clay}} + M_{\text{mass}})V_{\text{final}} \\
V_{\text{final}} &= \frac{M_{\text{clay}}V_{\text{clay}}}{M_{\text{clay}} + M_{\text{mass}}} = \frac{(450 \text{ kg})(3.00 \text{ m/s})}{450 \text{ kg} + 1.55 \text{ kg}} = 1.675 \frac{\text{m}}{\text{s}}
\end{align*} \]

B. [5 points] How much kinetic energy is lost in this collision?

\[ \Delta K = K_{\text{clay}} - K_{\text{final}} = \frac{1}{2}M_{\text{clay}}V_{\text{clay}}^2 - \frac{1}{2}(M_{\text{clay}} + M_{\text{mass}})V_{\text{final}}^2 = \frac{1}{2}(450 \text{ kg})(3.00 \text{ m/s})^2 - \frac{1}{2}(450 \text{ kg})(1.675 \text{ m/s})^2 = 1.57 \text{ J} \]

C. [15 points] The spring constant of the spring described above is 15.0 N/m. How much is the spring compressed after the mass has slowed to half of its original (after the collision) speed?

\[ \frac{1}{2}(M_{\text{clay}} + M_{\text{mass}})V_{\text{final}}^2 = \frac{1}{2}(M_{\text{clay}} + M_{\text{mass}})(\frac{N_{\text{final}}}{2})^2 = \frac{1}{2}kx^2 \]

\[ \frac{1}{2}(M_{\text{clay}} + M_{\text{mass}})(\frac{3}{4}N_{\text{final}}) = \frac{1}{2}kx^2 \]

\[ \frac{(M_{\text{clay}} + M_{\text{mass}})(3N_{\text{final}})}{4k} = x^2 \quad \Rightarrow \quad x = \sqrt{\frac{3(2.00 \text{ m/s})}{4(15.0 \text{ N/m})}(1.675 \text{ m/s})} \]

\[ x = 0.213 \text{ m} \]
Situation #2: Spinning in circles

A. [15 points] Adam Johnston is singing his favorite song in the key of C, in which he is continuously screaming a high note of 1024 Hz. However, not only is he daring to sing high notes, he’s doing so while spinning around on the outer edge of a merry-go-round! The merry-go-round has a 2.00 m radius, and it is spinning at an amazing rate of 3.00 revolutions per second! What is the highest frequency that you, an outside observer, will be able to hear coming from Adam? (The speed of sound is 340 m/s.)

\[ f = \frac{\omega}{2\pi} = \left(8 \frac{m}{s}\right) \left(\frac{2.00\ m}{1\ m}\right) \left(3.00\ rev/s\right) = 1150 Hz\]

\[ \omega = \frac{2\pi}{T} = \frac{2\pi}{1} = 2\pi \]

\[ \frac{\omega}{2\pi} = \frac{2\pi}{2\pi} = 1 \]

\[ f = \frac{\omega}{2\pi} = \left(8 \frac{m}{s}\right) \left(\frac{2.00\ m}{1\ m}\right) \left(3.00\ rev/s\right) = 1150 Hz\]

\[ 1150 + 12 \]

B. [15 points] You happen to know that the mass of the merry-go-round described above is 500 kg, and it’s shaped like a big disk. Adam, who is shaped very much like a physics teacher, has a mass of 70.0 kg. He decides to stop singing and walks to the center of the merry-go-round. What is the final rotational speed of the merry-go-round after he does this?

\[ I = I_f = \frac{1}{2} Mr^2 \]

\[ I \omega_f = I \omega_i \]

\[ \left(\frac{3}{2} Mr^2\right) \omega_f = \frac{1}{2} Mr^2 \omega_i \]

\[ \omega_f = \frac{\omega_i}{2} \]

\[ \omega_f = 3.84 \frac{rad}{s} \]

(= 241 rad/s)

C. [5 points] As Adam walks to the center of the merry-go-round, the total kinetic energy of himself and the disk:

\( K = \frac{1}{2} I \omega^2 \)

\( K_f = \frac{1}{2} I_f \omega_f^2 \)

\( = \frac{1}{2} \left(\frac{3}{2} Mr^2\right) \left(\frac{\omega_f}{2}\right)^2 \)

\( = \frac{1}{2} \left(\frac{3}{2} Mr^2\right) \left(\frac{241 \frac{rad}{s}}{2}\right)^2 \)

\( = 3.22 \times 10^5 \) J

(Justify your answer with a calculation in order to get full or partial credit.)