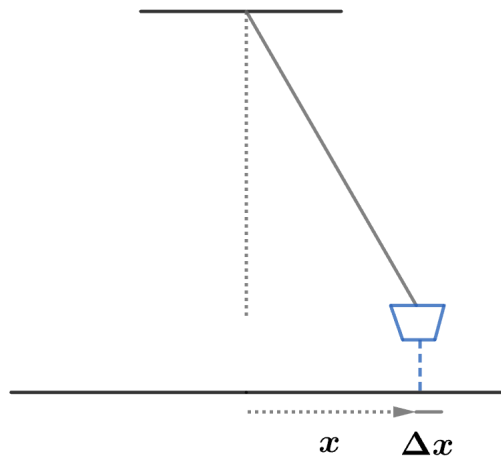# 2024 F=ma Exam: Problem 6

Kevin S. Huang

The amount of water $\Delta V(x)$ (in an interval Δx) at position x is proportional to the amount of time $\Delta t(x)$ the bucket is there. Since $v = dx/dt$, we estimate

$$\Delta t(x) = \frac{\Delta x}{v(x)} \propto \frac{1}{v(x)}$$

To find $v(x)$, we conserve energy for simple harmonic motion,

$$\frac{1}{2}kA^2 = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$$
$$v^2 \propto A^2 - x^2$$
$$v \propto \sqrt{A^2 - x^2}$$

Thus,

$$\Delta V(x) \propto \frac{1}{\sqrt{A^2 - x^2}}$$

so the answer is $\boxed{\text{C}}$.