

55. (a) The frequency for small amplitude oscillations is $f = (1/2\pi)\sqrt{g/L}$, where L is the length of the pendulum. This gives $f = (1/2\pi)\sqrt{(9.80 \text{ m/s}^2)/(2.0 \text{ m})} = 0.35 \text{ Hz}$.
- (b) The forces acting on the pendulum are the tension force \vec{T} of the rod and the force of gravity $m\vec{g}$. Newton's second law yields $\vec{T} + m\vec{g} = m\vec{a}$, where m is the mass and \vec{a} is the acceleration of the pendulum. Let $\vec{a} = \vec{a}_e + \vec{a}'$, where \vec{a}_e is the acceleration of the elevator and \vec{a}' is the acceleration of the pendulum relative to the elevator. Newton's second law can then be written $m(\vec{g} - \vec{a}_e) + \vec{T} = m\vec{a}'$. Relative to the elevator the motion is exactly the same as it would be in an inertial frame where the acceleration due to gravity is $\vec{g} - \vec{a}_e$. Since \vec{g} and \vec{a}_e are along the same line and in opposite directions we can find the frequency for small amplitude oscillations by replacing g with $g + a_e$ in the expression $f = (1/2\pi)\sqrt{g/L}$. Thus

$$f = \frac{1}{2\pi} \sqrt{\frac{g + a_e}{L}} = \frac{1}{2\pi} \sqrt{\frac{9.8 \text{ m/s}^2 + 2.0 \text{ m/s}^2}{2.0 \text{ m}}} = 0.39 \text{ Hz} .$$

- (c) Now the acceleration due to gravity and the acceleration of the elevator are in the same direction and have the same magnitude. That is, $\vec{g} - \vec{a}_e = 0$. To find the frequency for small amplitude oscillations, replace g with zero in $f = (1/2\pi)\sqrt{g/L}$. The result is zero. The pendulum does not oscillate.