

Physics 260 Homework Assignment 2

1 PSE6 15.CQ.004

- In simple harmonic motion, one-half of the time, the velocity is in the same direction as the displacement away from equilibrium.
- Velocity and acceleration are in the same direction half of the time.
- Acceleration is always opposite to the position vector, and never in the same direction.

2 PSE6 15.CQ.010

If the pendulum's length is doubled, then $L_f = 2L_i$. From the equation of period of a simple pendulum, we have

$$T_f = \frac{2\pi}{\omega_f} = 2\pi\sqrt{\frac{L_f}{g}} = 2\pi\sqrt{\frac{2L_i}{g}} = \sqrt{2}(2\pi\sqrt{\frac{L_i}{g}}) = \sqrt{2}T_i$$

If the mass of the suspended bob is doubled, the period of the pendulum is unaffected because the period equation doesn't depend on the mass of the suspended bob.

3 PSE6 15.CQ.011

- the elevator accelerates upward. Tension provided by the string needs to overcome the gravity and provide enough force for the mass to accelerate upward at acceleration a , so $g_{eff} = g + a$. From the period equation we know that $T = 2\pi\sqrt{L/g_{eff}}$. Since $g_{eff} > g$, T decreases.
- the elevator accelerates downward, $g_{eff} = g - a$, therefore, T increases.
- the elevator moves with constant velocity, there is no net acceleration. g_{eff} stays the same. So does the period.

4 PSE6 15.P.002

a. Plug in $t = 0$ and calculate x .

b.

$$v = \frac{dx}{dt} = -2(5.00\text{cm}) \sin(2t + \frac{\pi}{6})$$

Plug in $t = 0$ and calculate t

c.

$$a = \frac{dv}{dt} = 4(5.00\text{cm}) \cos(2t + \frac{\pi}{6})$$

Plug in $t = 0$ and calculate a

d. The amplitude is the number in front of centimeter. The value before t gives the angular frequency ω of the motion. $T = 2\pi/\omega$.

5 PSE6 14.P.007

a. uses the number of seconds divide by the number of complete cycles to get period.

b. There are two ways to find this. We can either use one over period to get the frequency or use the number of complete cycles divide by the number of seconds.

c.

$$\omega = 2\pi f = 2\pi/T$$

6 PSE6 14.P.009

$$\frac{2\pi}{T} = \omega = \sqrt{\frac{k}{m}}$$
$$k = \frac{4m\pi^2}{T^2}$$

7 PSE6 14.P.015

a. Energy is conserved for the block-spring system between the maximum-displacement and the half-maximum points:

$$(K + U)_{max} = (K + U)_{halfmax}$$

AT half maximum, $x_{halfmax} = \frac{1}{2}A$

$$0 + \frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx_{halfmax}^2 = \frac{1}{2}mv^2 + \frac{1}{8}kA^2$$

Rearrange the terms and solve for v

$$v = \sqrt{\frac{3kA^2}{4m}}$$

8 PSE6 14.P.018

a. $E = K + U = 0 + \frac{1}{2}kA^2$

The amplitude needs to be converted to meters.

b. $E = \frac{1}{2}mv_{max}^2$ $v_{max} = \sqrt{\frac{2E}{m}}$

c. The block has maximum acceleration when it is at maximum displacement.

$$ma_{max} = F = -kA \quad a_{max} = -\frac{kA}{m}$$

9 PSE6 14.P.032

a. The string tension must support the weight of the bob, accelerate it upward, and also provide the restoring force, just as if the elevator were at rest in a gravity field $g_{eff} = g + a$ (same argument in problem 3).

$$T = 2\pi\sqrt{\frac{L}{g_{eff}}} = 2\pi\sqrt{\frac{L}{g+a}}$$

b. The concept used here is exactly the same as part (a) except $g_{eff} = g - a$.

c. The effective g should now be $g_{eff} = \sqrt{g^2 + a^2}$ (vector addition). Again, use the period equation used in part(a).

10 PSE6 14.P.045

a. We are given the angular frequency of the motion, $\omega = 2\pi$. So, $T = 2\pi/\omega$.

b. $\omega_0 = \sqrt{k/m}$. We are given $F_0 = 3.00\text{N}$ and $b = 0$. Applying Equation(15.36) in the textbook, we have the amplitude of a driven oscillator as follows,

$$A = \frac{F_0/m}{\sqrt{(\omega^2 - \omega_0^2)^2 + (\frac{b\omega}{m})^2}}$$

11 PSE6 14.P.063

a. $T = 2\pi\sqrt{\frac{L}{g}}$

b. $E = \frac{1}{2}mv_i^2$

c. Energy is conserved. Initially, the pendulum has only kinetic energy($y = 0$). At maximum angular displacement, all the kinetic energy transform into potential energy($y = h$). Hence,

$$mgh = \frac{1}{2}mv_i^2 \qquad h = \frac{v_i^2}{2g}$$

Also, $L = L \cos \theta + h$. So

$$\cos \theta = 1 - \frac{h}{L} \qquad \theta = \cos^{-1}\left(1 - \frac{h}{L}\right)$$