## Worksheet 5 – SHM - Springs and Pendulums

### Hooke's Law Questions and Problems

1. a) A load of 45 N is attached to a spring that is hanging vertically. The spring is stretched 0.14 m from its equilibrium position. What is the spring constant? (321.429 N/m)
   b) If a 60 N weight is used instead, what would you expect the spring stretch to be instead? (0.187 m)

2. a) A slingshot consists of a light leather cup attached between two rubber bands. If it takes a force of 32 N to stretch the bands 1.2cm, what is the equivalent spring constant of the rubber bands? (2667 N/m)
   b) How much force is required to pull the cup of the slingshot 3.0 cm from the equilibrium position? (80.01 N)

3. If a spring constant is 40 N/m and an object hanging from it stretches it 0.50 m, what is the mass of the object? (2.04 kg)

4. Base on the pervious problem, what would be the period of oscillation associated with the spring pendulum? (1.42 s)

5. A 1.0 kg mass on a spring is stretched and released. The period of oscillation is measured to be 0.46 s. What is the spring constant? (34800 N/m)

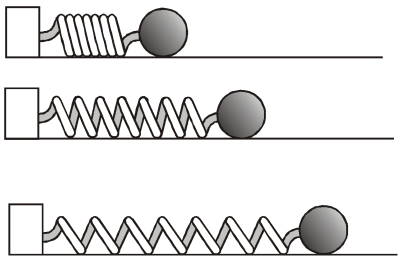
### Pendulum Questions and Problems

6. What would be the period of a pendulum that is 1.0 m long? (2.0 s)

7. Imagine you could travel to the moon where the acceleration due to gravity is 1.6 m/s$^2$. What would be the period of a pendulum that is 1.0 m? (5.0 s)

8. A trapeze artist wants a period of 3.8 s. How long should the cables be? (*Do not consider the height of the trapeze artist*) (3.6 m)

9. The drawing shows the harmonic motion of a mass on a spring at the extremes of its motion. The middle drawing shows the midpoint of travel. Indicate on the drawing (a) the points of greatest and least velocity, (b) the points of greatest and least acceleration, (c) the points of greatest and least potential E and kinetic E.



10. A 255 g mass is hooked up to a spring ($k$ = 175 N/m) and moves back and forth on your basic frictionless surface. If the mass is released from rest at $x$ = 0.200 m, (a) find the force acting on the mass, (b) the max acceleration, (c) it's acceleration at $x$ = 0 m, (d) its energy, and (e) its period.

(a) $F = -kx \quad = -175 \frac{N}{\cancel{m}}(0.200\ \cancel{m}) \quad = \quad \boxed{-35.0N}$

(b) $F = ma_{max}$ $a_{max} = \frac{F}{m} = \left(-35.0 \frac{kg \cdot m}{s^2}\right)\left(\frac{1}{0.255\ kg}\right) = \boxed{-137 \frac{m}{s^2}}$

(c) $F_{max} = ma_{max} = \frac{1}{2}kx^2$ $a_{max} = \frac{kx^2}{2m} = 175 \frac{kg \cdot m}{m \cdot s^2}(0\ m)\left(\frac{1}{2(0.255\ kg)}\right) = \boxed{0}$

(d) $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.255\ kg}{175 \frac{kg \cdot m}{s^2 \cdot m}}} = \boxed{0.240\ s}$

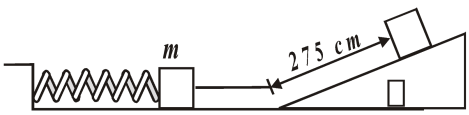
11. A 355 g mass is attached to a spring (k = 435 N/m). If the system is allowed to oscillate on a frictionless surface, what is the period and frequency of the motion?

$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.355\ kg}{435 \frac{kg \cdot m}{s^2 \cdot m}}} = \boxed{0.179\ s}$ $f = \frac{1}{T} = \frac{1}{0.179\ s} = \boxed{5.59\ Hz}$

12. You are designing a pendulum clock escapement. You have determined that the pendulum must have a period of 0.500 s. What should be the length of the thing?

$T = 2\pi\sqrt{\frac{L}{g}}$ $T^2 = 4\pi^2 \frac{L}{g}$ $L = \frac{T^2 g}{4\pi^2} = \frac{(0.500\ s)^2 9.8 \frac{m}{s^2}}{4\pi^2} = \frac{2.45\ m}{39.48} = \boxed{0.0621\ m}$

13. A 545 g block is pushed into a spring (k = 485 N/m) a distance of 18.0 cm. (a) When the ball is released, what is its velocity? The block slides across a smooth surface once it leaves the spring and then up a ramp. It travels up the ramp a distance of 275 cm. (b) What is the elevation angle of the ramp?




(a) $\frac{1}{2}mv^2 = \frac{1}{2}kx^2$ $v = x\sqrt{\frac{k}{m}} = 0.18\ m\sqrt{\frac{485 \frac{kg \cdot m}{s^2 \cdot m}}{0.545\ kg}} = \boxed{5.37 \frac{m}{s}}$

$\frac{1}{2}mv^2 = mgh$ $h = d\sin\theta$ $\sin\theta = \frac{v^2}{2gd} = \frac{\left(5.37 \frac{m}{s}\right)^2}{2\left(9.8 \frac{m}{s^2}\right)(2.75\ m)}$ $\theta = \boxed{35.9^o}$

14. A 165 g plastic block is set up against a spring. The block rests on a smooth horizontal surface. The block is pushed into the spring, compressing it a distance of 15.0 cm and then released. The spring constant is *k* = 677 N/m. (a) What is the speed of the block when it leaves the spring? (b) If the table is 0.875 m in height, what horizontal distance does the block travel after it leaves the table edge?

(a)
$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \qquad v = \sqrt{\frac{kx^2}{m}} = \sqrt{\frac{\left(677\frac{\cancel{kg}\cdot m}{m\cdot s^2}\right)(0.15\ m)^2}{0.165\ \cancel{kg}}} = \boxed{9.61\frac{m}{s}}$$

(b)
$$y = \frac{1}{2}at^2 \quad t = \sqrt{\frac{2y}{a}} = \sqrt{\frac{2(0.875\ \cancel{m})}{9.8\frac{\cancel{m}}{s^2}}} = 0.423\ s \qquad v = \frac{x}{t} \quad x = vt = 9.61\frac{m}{\cancel{s}}(0.423\ \cancel{s}) = \boxed{4.06\ m}$$