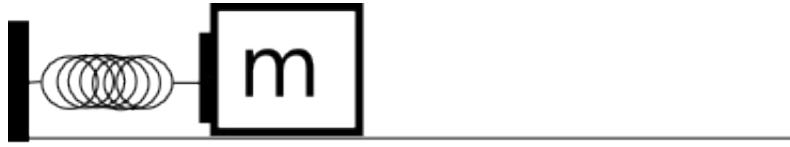


## Oscillation – Set 2

1

A block of mass  $m$  is attached to a spring with spring constant  $k$  and allowed to move on a frictionless surface.



- 1) Draw a Free Body Diagram for this system.
- 2) Let the equilibrium position of the spring be  $x=0$ , write **Newton's Second Law**, and solve it for the acceleration of the system.
- 3) Show that the **Simple Harmonic Oscillator** equation satisfies the differential equation above using substitution.
- 4) What did you find for the angular frequency of the oscillator?

## Oscillation – Set

2

A block of mass  $m$  is attached to a spring with spring constant  $k$  and allowed to move on a frictionless surface.



At  $t=0$ , the block is at  $x=0$  (the spring's equilibrium point), and is moving to the right with a velocity  $v=v_0$ .

Find the amplitude  $A$  and the phase angle  $\phi$ .

What happens to  $A$  as  $v_0$  is increased?

What happens to  $\phi$  as  $v_0$  is increased?

A block of mass  $m$  is attached to a spring with spring constant  $k$  and allowed to move on a frictionless surface.



At  $t=0$ , the block is compressed a distance  $d$  and released from rest.

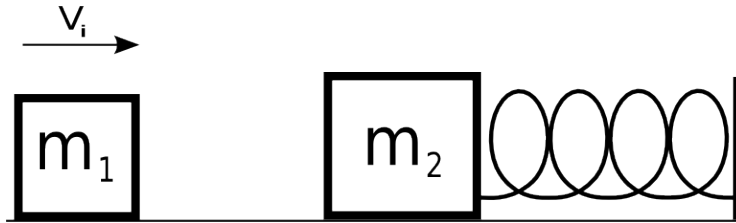
Find the amplitude  $A$  and the phase angle  $\varphi$ .

What happens to  $A$  as  $d$  is increased?

What happens to  $\varphi$  as  $d$  is increased?

Why is  $\varphi$  different than it was in the last problem?

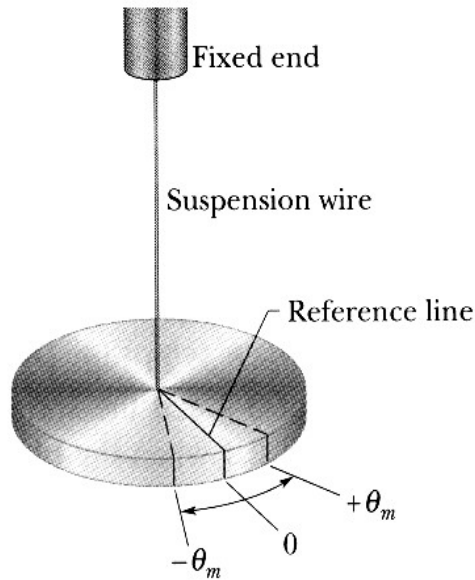
A block with a mass of  $m_1 = 10$  kg is moving to the right with a velocity  $V_i$ . It collides and sticks to a block with a mass of  $m_2 = 15$  kg. The second mass is attached to a spring with spring constant  $k=3$  N/m. Before the collision, the spring is at rest in its equilibrium position.



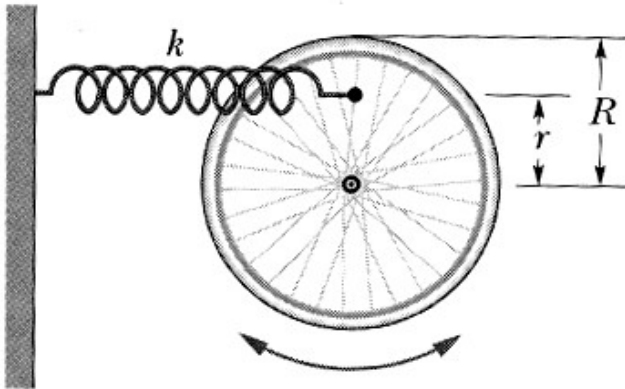
- What is the angular frequency of the resulting oscillator after the collision?
- Assuming that the moment of collision is  $t=0$ , find the phase constant of the oscillator.
- If the resulting amplitude of the oscillator is  $A = 3$  m, what was the initial velocity of  $m_1$ ?

The device in the picture below is known as a torsion pendulum. It is a flat disk attached to a length of stiff wire. When the wire is twisted, it responds by providing a torque on the disk, much the same way a spring provides a force when it is stretched. The torque provided by the wire is  $\tau = -\kappa\theta$ , where  $\kappa$  (greek letter kappa) is the torsion constant and  $\theta$  is the angular displacement from equilibrium.

- a) The moment of Inertia of the disk is  $I$ . Using the rotational version of Newton's Second Law, find the oscillator frequency of the torsion pendulum.
- b) If a solid bar of length  $L$ ,  $M$ , were suspended from the wire, what would the oscillator frequency be?



- 4) A wheel is free to rotate about a fixed axle. A spring with a spring constant  $k$  is attached to one of its spokes at a distance  $r$  from the axle, as shown in the picture. Assume that the wheel is a hoop of mass  $m$  and radius  $R$  (the spokes have negligible mass).
- Using **Newton's Second Law**, find the angular frequency of small oscillations in terms of  $m$ ,  $R$ ,  $r$  and the spring constant  $k$ .
  - What is the angular frequency if  $r = R$ .
  - What is the angular frequency if  $r = 0$ .



## Oscillation – Set

7

A block with a mass of  $m = 2.00$  kg is attached to a spring with a spring constant  $k = 100$  N/m. When  $t = 1.00$  s, the position and velocity of the block are  $x(1) = 0.129$  m and  $v(1) = 3.415$  m/s.

- a) Find the angular frequency,  $\omega$ , of the oscillator.
- b) Find the phase constant,  $\phi$ .
- c) Find the amplitude,  $A$ .
- d) What was the position of the block at  $t = 0.00$  s?

A block of mass  $m_b$  is attached to a spring of spring constant  $k$  where it is allowed to oscillate horizontally on a frictionless surface. The spring is compressed a distance  $d_0$  from equilibrium and released. As the block passes  $x=+d/2$ , a wad of clay,  $m_c$  kg, falls from directly above and sticks to the block.

- a) What is the angular frequency of the block/clay oscillator system after the collision?
- b) What is the phase angle of the block/clay oscillator after the collision?
- c) What is the amplitude of the block/clay oscillator after the collision?



## Oscillation – Set

9

A solid cylinder of mass  $M$  is attached to a horizontal spring with force constant  $k$ . The cylinder can roll without slipping along the horizontal plane. When the system is displaced from the equilibrium position, it executes simple harmonic motion. Derive an expression for the period of the oscillations in terms of  $M$ ,  $k$ ,  $I$  and  $R$ .

