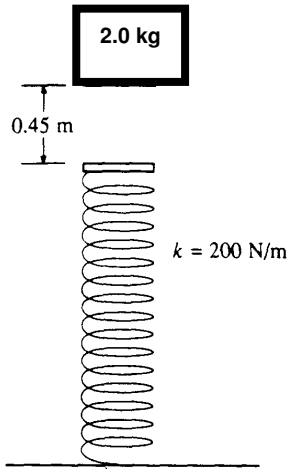
AP Physics – Oscillations Olympics

1. A 2.0 kg block is dropped from a height of 0.45 m above an uncompressed spring, as shown above. The spring has an elastic constant of 200. N/m and negligible mass. The block strikes the end of the spring and sticks to it.



A. Determine the speed of the block at the instant it hits the end of the spring.

B. Determine the period of the simple harmonic motion that ensues.

C. Determine the distance that the spring is compressed at the instant the speed of the block is maximum.

D. Determine the maximum compression of the spring.

E. Determine the amplitude of the simple harmonic motion.

2. Consider identical twins each part of a separate oscillating system. One twin is swinging on a strong, thin cable of length L and the other is hanging from an ideal spring with constant k. Each twin has mass M and undergoes small amplitude oscillations.

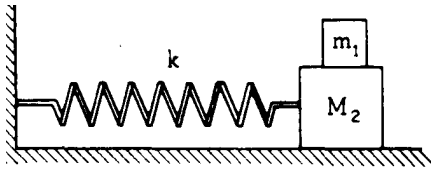
L = 2.40 m k = 240. N/m M = 24.0 kg

A. If the twins start in phase, from rest at their maximum amplitudes estimate the "phase period", the time before they are back in phase again.

(To be in phase means the twins have returned to their initial positions, initial speeds and initial accelerations both at the same time. Back in phase would result in the "matching" oscillatory motion starting all over again.)

B. What value of k would allow the twin hanging from the spring to always be in phase with the twin swinging on a strong cable of length L = 2.40 m ?

C. What value of L would allow the twin swinging to always be in phase with the twin hanging from the spring where k = 240. N/m ?



3. A small mass m_1 rests on but is not attached to a large mass M_2 that slides on its base without friction. The maximum frictional force between m_1 and M_2 is f. An ideal spring of spring constant k is attached to the large mass M_2 and to the wall as shown in the diagram above.

A. Determine the maximum horizontal acceleration that M_2 may have without causing m_1 to slip.

B. Determine the maximum amplitude A for simple harmonic motion of the two *masses if* they are to move together, i.e., m_1 must not slip on M_2.

C. The two-mass combination is pulled to the right the maximum amplitude A found in part (b) and released. Describe the frictional force on the small mass m_1 during the first half cycle of oscillation.

D. The two-mass combination is now pulled to the right a distance of A' greater than A and released.

   i. Determine the acceleration of m_1 at the instant the masses are released.
   ii. Determine the acceleration of M_2 at the instant the masses are released.