8. *The friction coefficient between the two blocks shown in figure (12-W4) is μ and the horizontal plane is smooth. (a) If the system is slightly displaced and released, find the time period. (b) Find the magnitude of the frictional force between the blocks when the displacement from the mean position is x. (c) What can be the maximum amplitude if the upper block does not slip relative to the lower block ?*

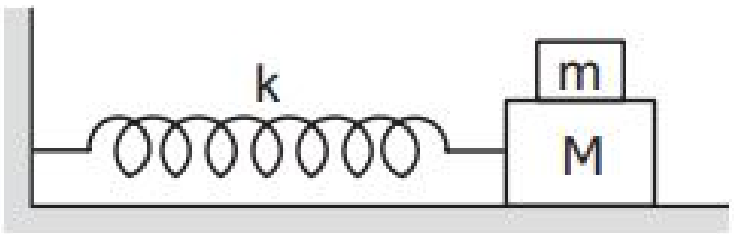
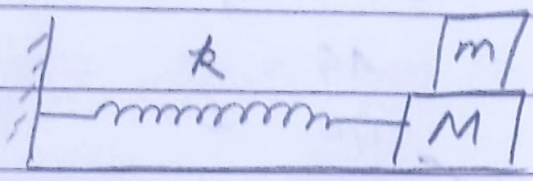


Figure 12-W4

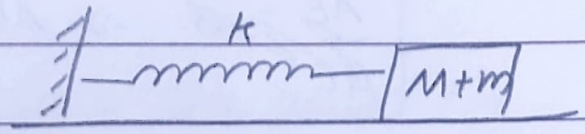
HC VERMA

SOLUTION:

(a) Surface is smooth, friction is just between blocks.



Since for small oscillations both masses will move together as a system, so

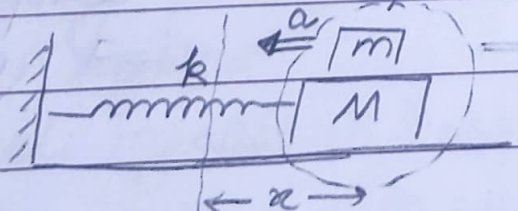


for this general case

$$T = \frac{2\pi}{\omega} \quad \text{where } \omega = \sqrt{\frac{k}{M+m}}$$

$$T = 2\pi\sqrt{\frac{M+m}{k}}$$

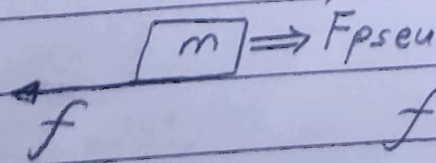
(b) when displacement from mean position is 'x', then $a = -\omega^2 x$ now



eqm

Since 'm' moves along with M, with no relative motion from 'M'.

so, using pseudo-force on 'm' w.r.t 'M', we have



f = Fpseudo { No relative acceleration }

- No slipping

So,

$$f = ma = m\omega^2 x \Rightarrow \frac{mkx}{M+m}$$

(c) Maximum amplitude if upper block does not slip.

from (b) we have frictional force at 'x' is $f = \frac{mkx}{M+m}$

so, maximum frictional force 'm' can experience

$$f_{max} = \mu mg$$

and so

$$f_{max} = \frac{mk\, x_{amp}}{M+m}$$

$$\mu mg = \frac{mk\, x_a}{M+m}$$

$$\boxed{x_a = \frac{\mu(M+m)g}{k}}$$

This is the maximum amplitude for no-slip condition.