ADVANCED PHYSICS CLUB

NOVEMBER 11, 2018

Today's meeting

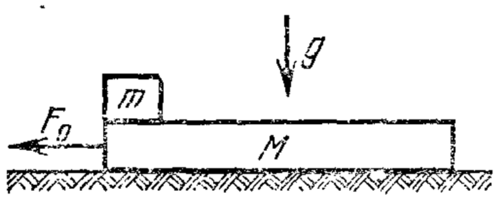
Today we briefly discussed damped harmonic oscillator. If there is damping force proportional to the velocity of the oscillator the second Newton's law can be written as $ma = -kx - cv$ or $m\ddot{x} = -kx - c\dot{x}$, where c is the damping coefficient. The qualitative picture of the motion of the damped oscillator depends on size of the damping. A convenient quantity is a dimensionless ration $\zeta = \frac{c}{2\sqrt{mk}}$ known as "damping ratio". For $\zeta > 1$ the motion is "overdamped" decaying without any oscillations. For $\zeta < 1$ the motion is underdamped – oscillations with exponentially decaying amplitude. The Q-factor is defined as the ratio of the energy stored in the oscillator to the energy lost per unit cycle (times 2π). $Q = \frac{1}{2\zeta}$. The bigger Q(uality) factor the "better" oscillator, i.e., oscillator performs more oscillations before stopping. You can find some basic information about oscillators with damping on Wikipedia page:
`https://en.wikipedia.org/wiki/Harmonic_oscillator`

We started talking about new topic: friction force. We discussed "Coulomb's law of friction" $F_{fr} \leq \mu N$ for dry friction. We talked about static and kinetic friction. We introduced the "angle of friction" as a way to measure the friction coefficient μ. You can read about standard friction model here:
`http://hyperphysics.phy-astr.gsu.edu/hbase/frict.html`

Discussed problems

1. Compute "the angle of friction" – the angle of the slope at which the objects start sliding down the slope. Assume that the static friction coefficient μ is known.

2. Find the maximal force F_0 such that the block m does not slide relative to the block M (see figure). Assume that there is no friction between the block M and horizontal surface but there is one with static friction coefficient μ_s between two blocks.



Next time

Next time we continue solving problems with friction. We plan to talk about work done by friction, braking distance, turn radius etc.

Homework

1. Try to estimate the Q-factor for the glassware available at your house as a "number of oscillations". Of course, this is only an estimate as it is very hard to determine the intensity of the sound by ear. Nevertheless, you, probably, can say whether the quality factor for wine glasses is lower or higher than the one for coffee mugs.

2. Assume that the maximal force F_0 found in the problem 2 above is applied to the block M. What is the acceleration of the block m if the kinetic friction coefficient μ_k is smaller than the static one μ_s? How long will it take for the block m to slide off the block M if the length of the latter is L?

***3.** Two children stand on a large, sloping hillside that can be considered as a plane. The ground is just sufficiently icy that a child would fall and slide downhill with a uniform speed as the result of receiving even the slightest impulse. For fun, one of the children (leaning against a tree) pushes the other with a horizontal initial speed $v_0 = 1$ m/s. The latter slides down the slope with a velocity that changes in both magnitude and direction. What will be the child's final speed if air resistance is negligible and the frictional force is independent of the speed?

Hint: Calculate by how much the speed of the pushed child and its velocity component down the slope change in unit time. Find a relationship between the rates of change of these two quantities.