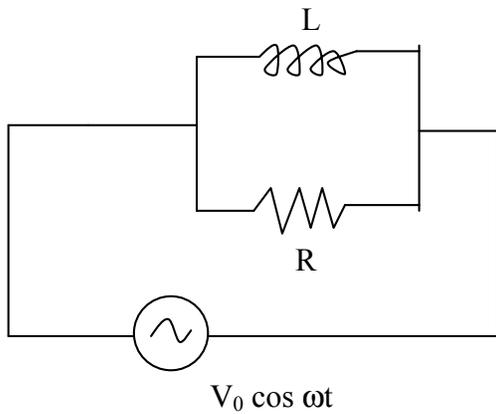


PHYS 2022 - Homework – Practice problems

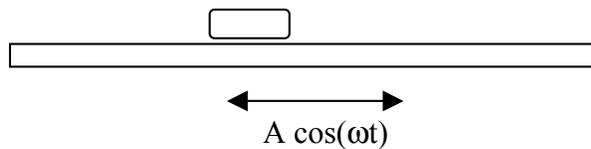
Problems:

1. In the material of an automobile tire, elastic “bending” waves propagate with a speed of 200 km/h. What will happen when the automobile speed approaches this value?
2. An oscillating circuit consisting of a coil and a capacitor connected in series is fed an alternating emf. The coil inductance is chosen to provide the maximum current in the circuit. Find the quality factor of the system if an  $n$ -fold increase in inductance results in an  $m$ -fold decrease of the current in the circuit.
3. A pendulum clock is mounted in an elevator which starts going up with a constant acceleration  $w$ , with  $w < g$ . At a height  $h$ , the acceleration of the elevator reverses its direction, its magnitude remaining the same. How soon after the start of the motion will the clock show the correct time again?
4. If you know the resonance frequency of a bridge and start throwing pebbles at the bridge with the time interval corresponding to that frequency, can you eventually cause the bridge to collapse?
5. \* One of the oxygen atoms in a  $\text{CO}_2$  molecule is given an initial velocity  $v$  in the direction towards the carbon atom. What will be the closest distance between the atoms of oxygen and carbon in that molecule? The oxygen atom has mass  $M$ , the carbon atom has mass  $m$ , and the stiffness of the inter-atomic bond is  $k$ .
6. The potential energy of a particle is described by  $U(x) = -mgH_0 \exp(-x^2/a^2)$ , where  $m$  is the mass,  $g$  is the gravity constant,  $x$  is the space coordinate, and  $H_0$  and  $a$  are constants. Find the period of small oscillations of the particle. The Taylor expansion of the exponential function is  $e^y = 1 + y + y^2/2! + y^3/3! + \dots$ .
7. A harmonic force of frequency  $\omega$  is applied to one end of a long free-hanging solid rod of length  $L$ . This generates a standing wave of wavelength  $\lambda=L/2$  within the rod. Sketch the positions of nodes of the standing wave.

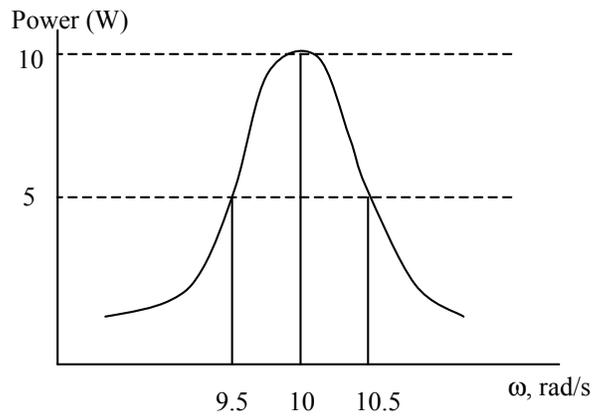
8. Calculate the impedance of the circuit using the complex-variable method and the phasor method.



9. A 100 kg weight is hung at the end of a rope, the other end of which is attached at the top of a building. The length of the rope is 20 m and its mass is 1 kg. A worker hits the weight with a hammer. How long will it take before the disturbance reaches the upper end of the rope?
10. A small bar is placed on a much larger plank, which is in horizontal harmonic motion with amplitude  $A=10$  cm. Initially, the bar does not slide and moves with the plank. Then the frequency of the oscillations is gradually increased, and, when the oscillation period is  $T = 1$  s, the bar starts sliding. Find the coefficient of friction between the bar and the plank.



11. The graph shows the power dissipated in a R-L-C series circuit as a function of source frequency. Find the amplitude of the current at resonance if  $L = 0.5 \text{ H}$ .  
Hint: Recall what determines the width of the resonance curve.



12. The amplitude of a pendulum decays by 1% in each period. If the period is 1 second, what is the quality factor of the pendulum?