UNIVERSITY OF NAIROBI

DEPARTMENT OF PHYSICS

SPH 201: MECHANICS II

Problem Set 1– Oscillatory motion

These Problems are Group based. Each individual to SUBMIT SOLUTIONS TO ANY THREE problems

1. A spiral spring extends 0.2m when a small mass is placed on it. The mass is then pulled down a short distance and released. Determine
   (i) The differential equation of motion
   (ii) The period of the motion
   (iii) The new period of motion if the same mass was used but the spring was cut in half and only one half was used

2 A 50-g mass hangs at the end of a Hookelian spring. When 20g more are added to the end of the spring, it stretches 7.0 cm more
   (i) Find the spring constant
   (ii) If the 20-g is now removed, determine the period of the motion?

3. A 50-g mass vibrates in SHM at the end of a spring on a horizontal table. The amplitude of the motion is 12cm and the period is 0.70s. Find
   (i) The frequency
   (ii) The spring constant
   (ii) The maximum speed of the mass
   (iii) The maximum acceleration of the mass
   (iv) The speed when the displacement is 6cm from the origin

4. A spring stretches 4 cm when a mass of 50 g is hung on it. If a total of 150 g is hung on the spring and the mass is started in a vertical oscillation, Determine the period of the oscillation.

5. A block of mass 4 Kg hangs from a spring of force constant K = 400 Nm^{-1}. The block is pulled down 15 cm below equilibrium and released. Find
   (i) The amplitude, frequency and period of the motion
   (ii) The K.E when the block is 10 cm above equilibrium

6. A stone is swinging in a horizontal circle 0.8 m in diameter, at 30 rev/min. a distant light causes a shadow of the stone to be formed on a nearby wall. Determine
   (i) The amplitude of the motion of the shadow
   (ii) The period of the motion

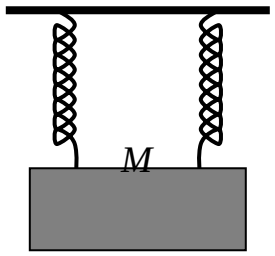
7. An Oscillator consists of a block of mass 512 g connected to a spring. When set into oscillation with amplitude 34.7 cm, it is observed to repeat its motion every 0.484 s. Find

(i) The period
(ii) The frequency
(iii) The angular Frequency
(iv) The Force constant
(iv) The maximum speed, and
(v) The maximum force exerted on the block

8. A 5.22-Kg object is attached to the bottom of a vertical spring and set vibrating. The maximum speed of the object is 15.3 cm/s and the period is 645 ms. Find
   (i) The Force constant of the spring,
   (ii) The amplitude of the motion, and
   (ii) The frequency of the oscillation

9. A metal strip clamped at one end vibrates with a frequency of 20 Hz and amplitude of 5 mm at the free end, where a small mass of 2g is positioned. determine
   (i) The velocity of the end when passing through the zero position
   (ii) The acceleration at maximum displacement
   (iii) The maximum kinetic energy of the mass

10. A massless spring of force constant 3.60 Ncm-1 is cut into halves.
    (i) Determine the force constant of each half?
    (ii) The two halves, suspended separately, support a block of mass ***M*** as shown below. The system vibrates at a frequency of 2.87 Hz. Find the value of the mass ***M***.



11. (a) A body of mass 36 g moves with SHM of amplitude A = 13cm and period T = 12s. At time t = 0, the displacement, x, is +13 cm. Find
    (i) The velocity when x = 5 cm
    (ii) The force acting on the body when t = 2s.

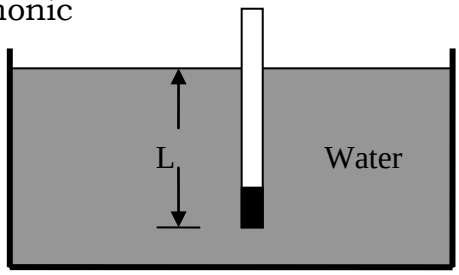
    (b) On the same axes, plot the variation of the following parameters as a function of displacement x for the system in (b) above. Use x values from x =A, x =A/2, x = 0, x =-A/2 and x =-A
    (i) Velocity, ***v***
    (ii) The acceleration ***a***
    (iii) Restoring Force, F
    (c) On a separate graph, plot also the variation of the K.E, P.E and Total Energy E as a function of displacement x.

12 At a certain harbor, the tides cause the ocean surface to rise and fall in simple harmonic motion, with a period of 12.5 h. How long does it take for the water to fall from its maximum height to one-half its maximum height above its average (equilibrium) level?

13 A Cylindrical wooden log is loaded with lead at one end so that it floats upright in water as in Fig below. The length of the submerged portion is L = 2.56 m. The log is set into vertical oscillation

(i) Show that the oscillation is simple harmonic

(ii) Find the period of the oscillation. Neglect the fact that the water has a damping effect on the motion.



14 A particle of mass *m* moves in a fixed plane along the trajectory r = ***i***A cos ωt + ***j***A cos 3ωt.

(i) Sketch the trajectory of the particle.

(ii) Find the force acting on the particle

(iii) Find the potential energy of the particle

(iv) Find the total energy of the particle as functions of time

(v) Determine if the motion is periodic and if so, find the period

15 Two springs are attached to a block of mass ***m***, free to slide on a frictionless horizontal surface, as shown below. Show that the frequency of the oscillation of the block is

$$f = \frac{1}{2\pi}\sqrt{\frac{k_1 + k_2}{m}} = \sqrt{f_1^2 + f_2^2}$$

where f_1 and f_2 are the frequencies at which the block would oscillate if connected only to spring 1 or spring 2.