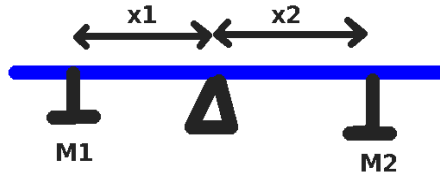


[1] A **massless** bar is balanced as shown (it is in static equilibrium). Two masses M_1 and M_2 are placed at distances x_1 and x_2 from the pivot as shown.

(a) Sketch and label on the diagram below all forces acting on the bar. You may label the force for the pivot as F_p .



(b) Write **each term** in the sum of the forces acting on the bar in terms of M_1 , M_2 , and g . Be sure to get your signs included here.

(c) Assume the pivot and axis are located at the same location (shown in the diagram above). Write **each term** in the sum of torques about this axis in terms of M_1 , M_2 , g , x_1 and x_2 . Be sure to get your signs included here.

(d) Assuming static equilibrium, find the force from the pivot (F_p) in terms of M_1 , M_2 and g .

(e) Assuming static equilibrium, find the value of x_2 in terms of x_1 , M_1 , and M_2 .

(f) Suppose $M_1 = 3M_2$ and $x_1 = 1$ m. Provide a numerical value for x_2 with correct SI units.

[2] A spring-mass system has a spring constant k and a mass m is attached to the spring.

(a) Find the period (T) of small oscillations about equilibrium with correct SI units when $k=2$ N/m and $m=8$ kg.

$T=$ _____

(b) Suppose at $t=0$ the mass is at an amplitude which is seen to be $0.5m$. Find the maximum velocity with correct SI units, again with $k=2$ N/m and $m=8$ kg.

$V_{\max}=$ _____

(c) How long must a simple pendulum located near the surface of the earth be so that small oscillations about equilibrium have a frequency (f) of 0.5 Hz?

$L=$ _____

(d) Suppose a system has an equation of motion given by $\frac{d^2x}{dt^2}+bx=0$ where b is a positive quantity. What is the frequency (ω) of small oscillations about equilibrium?

$\omega=$ _____

[3] A wire has a length L and is under a tension T and has a mass per unit length μ . For each of the sections below, you may assume $L=4$ m, $T=50$ N and $\mu=0.02$ kg/m.

(a) Calculate the speed of a pulse on the wire.

$v =$ _____

(b) If the wire is plucked on one end, how long would it take for a pulse to **return**?

$t =$ _____

(c) Suppose for the same wire, one end is fixed and one end is free. Find the lowest frequency (f) of (standing) transverse oscillations.

$f =$ _____

(d) Suppose both ends of the wire are fixed. Find the lowest frequency (f) of (standing) transverse oscillations.

$f =$ _____

[4] An open and a closed organ pipe both have lengths of 3.5m. If the speed of sound is 343 m/s, find the following:

(a) Sketch the wave forms (of molecular displacement, Δs) for the lowest 3 modes of oscillations for the open pipe.

(b) Find the frequencies (f) of the lowest 3 modes of oscillations for the open pipe.

(c) Sketch the wave forms (of molecular displacement, Δs) for the lowest 3 modes of oscillations for the closed pipe.

(d) Find the frequencies (f) of the lowest 3 modes of oscillations for the closed pipe.