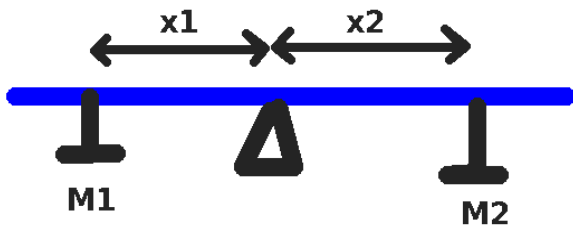


Time Start _____ Time finish _____ Pledged _____

Instructions: You have a total of 55 minutes to complete this test.**Answer each of the following questions completely.****Supply all details that led to your answer and correct SI units where required.****Do not discuss any aspect of this test with anyone until I return the test.**

[1] A **massless** bar is balanced as shown. 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.



(b) 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.

(c) Write each term in the sum of the forces acting on the bar.

(d) Find the force from the pivot in terms of M_1 , M_2 and g .

(e) Find the value of x_1 in terms of x_2 , M_1 , and M_2 .

(f) Suppose $M_2 = 3M_1$ and $x_2 = 2$ m. Provide a numerical value for x_1 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 frequency (f) of small oscillations about equilibrium with correct SI units when $k=2$ N/m and $m=0.3$ kg.

(b) Suppose at $t=0$ the mass is moving with a speed of 1 m/s. Find the maximum amplitude (A) of the oscillations with correct SI units.

(c) How long must a simple pendulum located near the surface of the earth be so that small oscillations about equilibrium have a period of 10 s?

(d) Suppose an equation has the form: $a+bx=0$, where a is an acceleration (involving the variable x), b is a positive constant and x is a position. Find the frequency (ω) of small oscillations about equilibrium, the frequency (f) and the period (T).

(e) A rod of length L and mass m has a moment of inertial about an end given by $I=\frac{1}{3}mL^2$. Find the angular frequency of small oscillations about equilibrium when $L=1$ m. **Hint:** the force of gravity acts at the center of mass of the rod which is at $L/2$.

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[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 $L=3\text{ m}$, $T=10\text{ N}$ and $\mu=0.05\text{ kg/m}$. Be sure to include correct SI units in your answers.

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

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

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

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

[4] An open and a closed organ pipe both have lengths of 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 closed pipe.

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

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

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