

**Instructions: You have a total of 50 minutes to complete this test.
Answer each of the following questions completely.**

Time Start _____ Time finish _____ Pledged _____

You must supply all details that led to your answer.

You must provide correct SI units where required.

Do not discuss any aspect of this test with anyone until I return the test.

[1] An open and a closed organ pipe both have lengths of 15m. If the speed of sound is 343 m/s, find the following:

[1a] Sketch the wave forms (of molecular displacement, Δs) for the lowest 3 modes of oscillations for the open pipe.

[1b] Find the frequencies (f) of the lowest 3 modes of oscillations for the open pipe.



$$f_n = n f_1; n = 1, 2, 3, \dots; f_1 = \frac{v}{2L}$$

$$f_1 = \frac{343}{30} = 11.4 \text{ Hz}$$

$$f_2 = 2f_1 = 22.8 \text{ Hz}$$

$$f_3 = 3f_1 = 34.2 \text{ Hz}$$

[1c] Sketch the wave forms (of molecular displacement, Δs) for the lowest 3 modes of oscillations for the closed pipe.



[1d] Find the frequencies (f) of the lowest 3 modes of oscillations for the closed pipe.

$$f_n = n f_1; n = 1, 3, 5, \dots; f_1 = \frac{v}{4L}$$

$$f_1 = \frac{343}{60} = 5.72 \text{ Hz}$$

$$f_3 = 3f_1 = 17.15 \text{ Hz}$$

$$f_5 = 5f_1 = 28.6 \text{ Hz}$$

[2] Suppose a simple pendulum has a length of 10.0 m. You may assume the acceleration due to gravity is $g=9.8 \text{ m/s}^2$. Be sure to use correct SI units in your answers.

[2a] What is the period (T) of small oscillations about the equilibrium position?

$$\omega = \sqrt{\frac{g}{L}} = \frac{2\pi}{T} \Rightarrow \frac{T}{2\pi} = \sqrt{\frac{L}{g}} \Rightarrow T = 2\pi \sqrt{\frac{L}{g}} = 2\pi \sqrt{\frac{10}{9.8}} = 6.35 \text{ s}$$

T = _____

[2b] What mass should be placed on a spring with a spring constant of $k=4 \text{ N/m}$ in order to produce the same frequency as the pendulum has?

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{g}{L}} \Rightarrow \frac{k}{m} = \frac{g}{L} \Rightarrow m = k \frac{L}{g} = 4.08 \text{ kg}$$

m = _____

[2c] If a spring mass system with $k=4 \text{ N/m}$ and $m=6 \text{ kg}$ is displaced through a maximum displacement of $x_{\text{max}}=0.5 \text{ m}$, what is the total energy of the system?

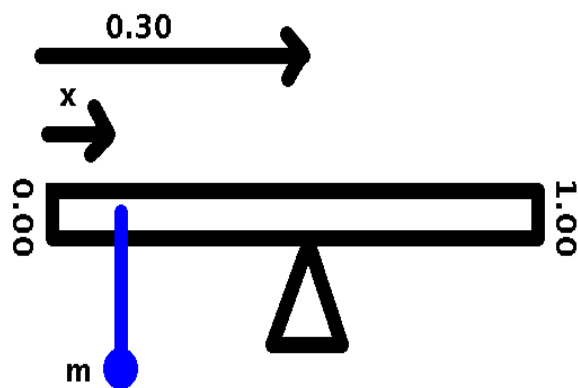
$$E = U = \frac{1}{2} k A^2 = \frac{1}{2} k A^2 = 0.5 \text{ J}$$

E = _____

[2d] What is the speed of the mass in problem [2c] when it passes through the equilibrium position?

$$E = K = \frac{1}{2} m v^2 \Rightarrow v = \sqrt{2 \frac{E}{m}} = \sqrt{2 \times \frac{0.5}{6}} = 0.408 \text{ m/s}$$

v = _____



[3] A meter stick of mass $m_1=0.5\text{kg}$ and length $L=1\text{m}$ is on a pivot at $x_1=0.30\text{m}$. Find the position that a mass $m=4\text{ kg}$ would need to be placed so that the system would be in static equilibrium by answering the following questions.

[3a] Sketch in and properly **label all forces** on the diagram above. Indicate the force from the pivot as F_p .

[3b] Apply Newton's law to find the force exerted by the pivot in terms of m, m_1 and g .

$$\sum F=0 \Rightarrow -mg + F_p - m_1g = 0 \Rightarrow F_p = (m + m_1)g$$

$$F_p = \underline{\hspace{2cm}}$$

[3c] Now, consider the axis to be located at the end marked 0.00. Write the torque equation required to achieve static equilibrium in terms of m, m_1, g, F_p and distances. Be sure to include proper signs here.

$$\sum \Gamma = 0 \Rightarrow -mg(x) + F_p(.3) - m_1g(.5) = 0 \Rightarrow .3F_p - .5m_1g = mgx \Rightarrow x = .3 \frac{F_p}{mg} - .5 \frac{m_1}{m}$$

$$\Sigma \Gamma = \underline{\hspace{2cm}}$$

[3d] Solve for the position x where the mass m would be placed for static equilibrium to result. Your answer here is numerical with correct SI units.

$$.3F_p - .5m_1g = mgx \Rightarrow x = .3 \frac{F_p}{mg} - .5 \frac{m_1}{m} = .3 \frac{(m + m_1)g}{mg} - .5 \frac{m_1}{m}$$

$$x = .3 \frac{(4 + 0.5)}{4} - (.2) \frac{1}{4} = .0.3375 - .05 = 0.2875 \text{ m}$$

$$x = \underline{\hspace{2cm}}$$

[4] A wire has a length L is under a tension T and has a mass per unit length μ . For each of the sections below, you may assume $L=10$ m, $T=20$ N and $\mu=0.05$ kg/m. **Be sure to include correct SI units in your answers.**

[4a] Find the wave speed of a transverse pulse on this string.

$$v = \sqrt{\frac{T}{\mu}} = 20 \text{ m/s}$$

$v =$ _____

[4b] How long will it take for a pulse to travel through the wire and return if both ends are fixed. You may assume the wire was plucked on the end.

$$2L = vt \Rightarrow t = \frac{2L}{v} = \frac{20}{20} = 1 \text{ s}$$

$t =$ _____

[4c] Suppose both ends of the wire are fixed. Find the lowest frequency (f) of (standing) transverse oscillations on this wire.

$$\lambda_1 = 2L \Rightarrow f_1 = \frac{20}{20} = 1 \text{ Hz}$$

$f =$ _____

[4d] Suppose for the same wire, one end is fixed and one end is free. Find the lowest frequency (f) of (standing) transverse oscillations on this wire..

$$\frac{1}{4}\lambda_1 = L \Rightarrow \lambda_1 = 4L \Rightarrow f_1 = \frac{20}{40} = 0.5 \text{ Hz}$$

$f =$ _____