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.

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

$$f_1 = \frac{343}{30} = 11.4\,\text{Hz}$$
$$f_2 = 2f_1 = 22.8\,\text{Hz}$$
$$f_3 = 3f_1 = 34.2\,\text{Hz}$$

[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.

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

$$f_1 = \frac{343}{60} = 5.72\,\text{Hz}$$
$$f_3 = 3f_1 = 17.15\,\text{Hz}$$
$$f_5 = 5f_1 = 28.6\,\text{Hz}$$

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

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

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

T=_____

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

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

m=_____

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

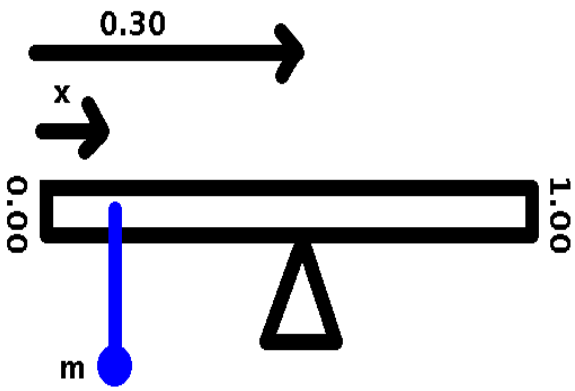
$$E=U=\frac{1}{2}k\,A^2=\frac{1}{2}k\,A^2=0.5\,J$$

E=_____

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

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

v=_____



[3] A meter stick of mass m_1=0.5kg and length L=1m is on a pivot at x_1=0.30m. Find the position that a mass m=4 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 Fp.

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

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

F_p =_____

[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.

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

ΣΓ=_____.

[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.

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

$$x=.3\frac{(,5+4)}{4}-(.2)\frac{1}{4}=.0.3375-.05=0.2875\,m$$

x=_____

[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 μ=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.

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

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.

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

t=_____

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

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

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..

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

f=_____