Physics 1B-2 (9:00 am-9:50 am) Spring 2019 Midterm 1

Param Shah

TOTAL POINTS

87 / 100

QUESTION 1

1 1 25 / 25

+ **1 pts** Correct relationship between displacement and angle

+ **1 pts** potential energy equals kinetic energy

+ **1 pts** Hooke's law (or potential energy of the spring)

+ **1 pts** Correct force of gravity (or potential energy of the gravitational field)

+ **1 pts** Correct potential energy

+ **1 pts** Correct sum of forces on y axis (if didn't get correct equation of motion)

+ **1 pts** Small angle approximation for sin

+ **1 pts** Small angle approximation for cos

- **2 pts** Minor mistake involving wrong units

- **1 pts** Minor mistake

- **1 pts** Usage of the variable that is not given

+ **0 pts** Nothing from above

- **1 pts** Only frequency, not period

- **2 pts** Wrong small angle approximation

- **2 pts** Wrong projection to x axis (if got equations of motions)

- **2 pts** Wrong sign (makes the final result unphysical)

+ **10 pts** Differential equation is obtained

✓ **+ 25 pts Correct**

+ **2 pts** Correct sum of forces on x axis (if didn't get correct equation of motion)

- **1 pts** Wrong projection to y axis (if differential equation is obtained)

QUESTION 2

2 25 pts

2.1 2a 15 / 15

+ **3 pts** formulae for f vs. lambda, v vs. T, etc.

+ **3 pts** relate n's and m's

+ **3 pts** match f's

+ **3 pts** solve

+ **3 pts** correct f

+ **0 pts** 0

+ **0 pts** N/A

+ **0 pts** N/A

+ **0 pts** need to associate mode number n and n+1 to masses; v in terms of tension, but two different tensions; but f must be constant, so match and solve for n=4; plug back in to find f = 350 Hz

✓ **+ 15 pts ALL**

2.2 2b 10 / 10

+ **2 pts** f, T = Mg where M is the unknown "largest mass"

+ **3 pts** m vs n, f, L, etc.

+ **2 pts** limit max m = min n

+ **3 pts** correct

+ **0 pts** 0

+ **0 pts** N/A

+ **0 pts** N/A

+ **0 pts** N/A

+ **0 pts** the smaller the mass the more modes are allowed since the tension is less; conversely, there will be a mass and corresponding tension so great only the fundamental mode is possible, i.e. n=1; you must find the mass for this case

✓ **+ 10 pts ALL**

QUESTION 3

3 25 pts

3.1 3a 2 / 5

✓ **+ 0 pts note: full credit ONLY for (roughly) constant frequencies when approaching and receding, with**

allowance for a smooth transition between the two... any other shape - e.g. semi-circle, pulse, linear, sinusoidal, etc. - NOT sufficient for full credit

✓ **+ 2 pts** **plot**

+ 1 pts approaching

+ 1 pts receding

+ 1 pts transition

+ 0 pts N/A

+ 0 pts N/A

+ 0 pts N/A

+ 0 pts N/A

+ 5 pts ALL

3.2 3b **20 / 20**

+ 4 pts Doppler effect

+ 2 pts moving source, stationary listener

+ 2 pts approaching sign

+ 2 pts receding sign

+ 4 pts correct difference

+ 2 pts solve

+ 4 pts final

+ 0 pts N/A

+ 0 pts note: you're given the value of the difference f_approach - f_recede, NOT the individual values... you must take the correct difference (v_L=0, signs, etc) and invert to solve for f_0 which should be the same in both individual expresses (don't use output from one as input to another); if your final answer is 80 Hz the max is 4 points

✓ **+ 20 pts** **ALL**

QUESTION 4

4 4 **15 / 25**

+ 25 pts Correct

✓ **+ 10 pts** **FORMULA FOR NOISE INTENSITY**

✓ **+ 5 pts** **BACKGROUND NOISE INTENSITY CALCULATION**

+ 10 pts NOISE INTENSITY CALCULATION FOR 1 STUDENT AND AFTER 50 STUDENTS LEFT (Full points for correct calculation)

+ 0 pts INCORRECT APPROACH OR NO SOLUTION

Noise level after 50 students left is 57dB. Please check calculations.

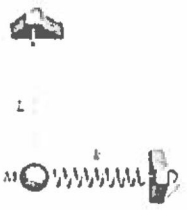
Physics 1B– Spring 2019: Midterm 1

Name Param Shah UID 205143347 Lecture Time 9:10 - 9:50 am

PLEASE READ:

- This exam is closed book and closed notes. You may use one calculator; no other electronics are permitted.
- Please show your full solution in the boxes provided (where the scanners can pick them up). The size of the boxes provided do not indicate the difficulty of the problem.
- Indicate final answers by circling them.
- Your solutions will be graded on correctness and coherence; results given with no details will receive zero credit. There is additional scratch paper attached so you can collect your thoughts first.
- Academic dishonesty is reported to the Office of the Dean of Students.

Problem 1. The figure below shows a pendulum of length L with a bob of mass M. The bob is attached to a spring of spring constant k as shown. When the bob is directly below the pendulum support, the spring is at its equilibrium length. What is the period of this oscillating system for small amplitude vibrations? You may consider angles small enough that a small angle approximation for both $\sin\theta$ and $\cos\theta$ is valid and that the system moves approximately in the horizontal direction. The mass of the rod is negligible.



$\Rightarrow x = L\sin\theta$
$= L\theta$

$$mg\sin\theta - kx = ma$$

$$Mg\theta - kL\theta = M\frac{d^2\theta}{dt^2}$$

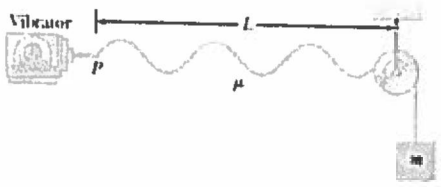
$$\theta(Mg - kL) = M\frac{d^2\theta}{dt^2}$$

$$\frac{d^2\theta}{dt^2} - \theta\left(\frac{kL}{M} - g\right) = 0$$

$$\Rightarrow \quad \omega = \sqrt{\frac{kL}{M} - g}$$

$$\Rightarrow \boxed{T = 2\pi\sqrt{\frac{M}{kL - Mg}}}$$

Problem 2. In the arrangement shown in the figure below, an object can be hung from a string (with linear mass density $\mu = 0.00200$ kg/m) that passes over a light pulley. The string is connected to a vibrator (of constant frequency f), and the length of the string between point P and the pulley is L = 2.00 m. When the mass m of the object is either 16.0 kg or 25.0 kg, standing waves are observed; no standing waves are observed with any mass between these values, however.



a. What is the frequency of the vibrator?

Weight of the object = Tension in the string

$$f = \frac{n}{4}\sqrt{\frac{T}{\mu}} = \frac{n+1}{4}\sqrt{\frac{T}{\mu}}$$

$T = 25g$ ↙ ↘ $16(g)$

$$f = \frac{4}{4}\sqrt{\frac{T}{\mu}} \quad \text{with} \quad T = (16+25)g$$

$$\Rightarrow \boxed{f = 350\ Hz}$$

b. What is the largest object mass for which standing waves could be observed?

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

$$T = 4f^2L^2\mu$$

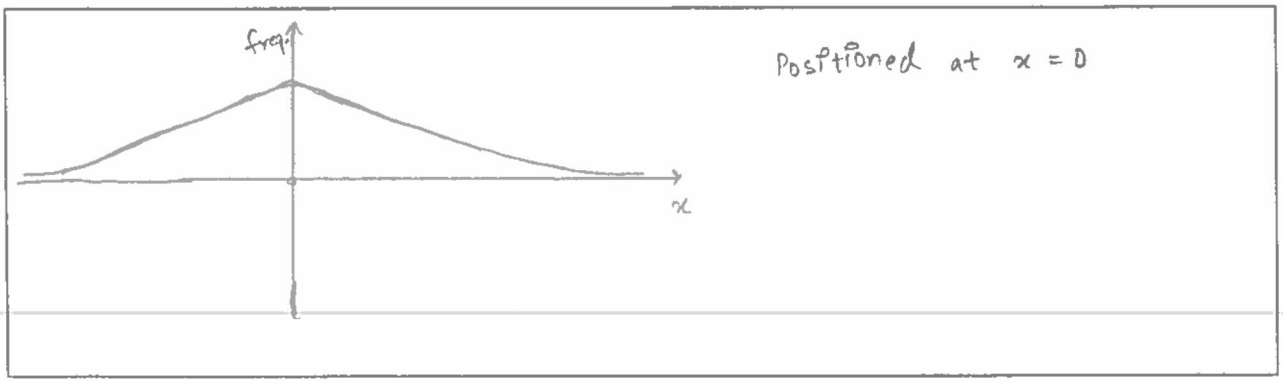
$$= 4(350)^2 2^2 (0.02)$$

$$= 3920\ N$$

$$\Rightarrow m = \frac{T}{9.8} = \boxed{400\ kg}$$

Problem 3. You are standing next to the train tracks as a train passes at constant velocity of 33.3 m/s. During the time that the train whistle is audible, there is an 80 Hz difference between the lowest and highest frequencies that you hear. The speed of sound in your town that day is 333 m/s.

a. The train passes you (it is initially approaching you and then moves away from you). Qualitatively draw a graph of frequency you observe versus position of the train including the motion before it reaches you and also moves away from you. Indicate your position on the graph. Numerical values are not needed.



b. Calculate the frequency of the whistle as heard by a conductor on the train. The conductor is standing next to the whistle and is not moving with respect to the whistle. (15 pts)

f_{obs} when train is moving towards me: $f_{obs} = f_s \left(\frac{v}{v - v_s}\right)$

f_{obs} when train is moving away from me: $f_{obs}' = f_s \left(\frac{v}{v + v_s}\right)$

$$f_{obs} - f_{obs}' = 80\,Hz = f_s \left(\frac{v}{v - v_s} - \frac{v}{v + v_s}\right)$$

$$80 = f_s \left(\frac{333}{333 - 33.3} - \frac{333}{333 + 33.3}\right)$$

$$80 = f_s \cdot 0.2$$

$$\Rightarrow f_s = \frac{80}{0.2} = \boxed{400\,Hz}$$

Problem 4.

The noise level in an empty examination hall is 40 dB. When 100 physics students are writing an exam, the sounds of heavy breathing and pens traveling rapidly over paper cause the noise level to rise to 60 dB (not counting the occasional groans). Assuming that each student contributes an equal amount of noise power, find the noise level when half of the students have left the examination hall.

$\beta = (10\,dB)\log_{10}\frac{I}{I_0}$

$40 = (10\,dB)\log\frac{I}{10^{-12}} \Rightarrow \frac{I}{10^{-12}} = 10^4 \Rightarrow I = 10^{-8}$

$I = \frac{P_{max}^2}{2\sqrt{\beta B}}$ $\because$ All students have equal P, when students are halved, $P' = \frac{P}{2}$

$\Rightarrow I' = \frac{P'^2}{2\sqrt{\beta B}} = \frac{I}{4}$

$\Rightarrow \Delta\beta = (10\,dB)\log\left(\frac{I}{I'}\right)$

$= 10\log(4)$

$= 6.02$

$\Rightarrow 60 - \beta' = 6.02$

$\Rightarrow \boxed{\beta' = 53.98\,dB}$

Scratch paper