Physics 1B-1 (8:00am - 8:50am) Spring 2019 Midterm 1

[redacted]

TOTAL POINTS

91 / 100

QUESTION 1

1 1 **16 / 25**

✓ **+ 5 pts** **Approximate sinθ to θ**

+ 15 pts Give correct equations of motion

+ 20 pts Give correct angular frequency

+ 25 pts Give correct period

✓ **+ 3 pts** **Give correct relation between period and angular frequency**

✓ **+ 8 pts** **Give almost correct equations of motion**

+ 0 pts Click here to replace this description.

QUESTION 2

2 25 pts

2.1 2a **15 / 15**

✓ **+ 15 pts** **Correct**

+ 3 pts Correctly match mass with n

+ 8 pts Correct relation between v and T

+ 0 pts Click here to replace this description.

+ 5 pts Know T=mg

+ 2 pts Solve the equation of frequency and n

2.2 2b **10 / 10**

✓ **+ 10 pts** **Correct**

+ 7 pts n=1

+ 5 pts Know the relation between tension and velocity

+ 0 pts Click here to replace this description.

+ 9 pts Almost correct

QUESTION 3

3 25 pts

3.1 3a **5 / 5**

✓ **- 0 pts** **Correct**

- 2 pts Higher frequency to lower frequency as train passes

- 4 pts Low frequency as train recedes

- 4 pts High frequency during approach

- 5 pts incorrect

3.2 3b **20 / 20**

✓ **+ 20 pts** **Correct**

+ 2 pts Frequency of conductor = Frequency of source

+ 2 pts $$f_{approach} - f_{recede} = 80 Hz$$

+ 6 pts Correct formula for $$f_{approach}$$

+ 6 pts Correct formula for $$f_{recede}$$

+ 1 pts Correct numerical answer

+ 0 pts Incorrect

+ 3 pts Correct general doppler shift equation

QUESTION 4

4 4 **25 / 25**

✓ **+ 25 pts** **Correct**

+ 5 pts $$B=10*$$log$$(I_s / I_0)$$

+ 9 pts Correctly solve for Intensity with half students

+ 9 pts Correctly solve for noise level w/ calculated intensity

+ 2 pts Correct numerical answer

+ 0 pts incorrect

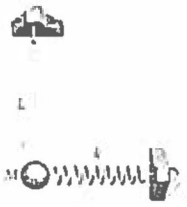
Physics 1B – Spring 2019: Midterm 1

Name [redacted] [redacted] UID [redacted] Lecture Time 8-8:50 (Lecture 1)

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.



$T = \frac{2\pi}{\omega} = \frac{1}{f} \Rightarrow \sum F = F_{spring}$ (going to the right if we pull to the left)

$F_{spring} = -kx \Rightarrow$ $\therefore \Delta x = L\sin\theta = L\theta$

$\therefore F_{spring} = -kx = -k(L\theta) = ma$

$I = mr^2 = I\left(\frac{a}{r}\right) = -kL\theta$

$\therefore ma + kL\theta = 0$

$\Rightarrow \frac{m\partial^2\theta}{\partial t} + kL\theta = 0$

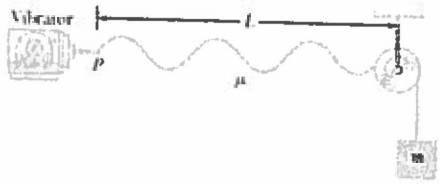
$\Rightarrow \frac{\partial^2\theta}{\partial t^2} + \frac{kL}{m}\theta = 0$

$\therefore \omega = \sqrt{\frac{kL}{m}}$

$\Rightarrow T = \frac{2\pi}{\sqrt{\frac{kL}{m}}} = \frac{2\pi\sqrt{m}}{\sqrt{kL}}$

$$\boxed{T = \frac{2\pi\sqrt{m}}{\sqrt{kL}}}$$

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?

Fixed at both ends: $L = \frac{n\lambda}{2} = \frac{n}{2}\left(\frac{v}{f}\right)$. Frequency: fixed. Length: fixed

$\therefore f = \frac{nv}{2L} = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

$L = 2$ m

$\mu = 0.00200$ kg/m

$m = 16$ kg $\rightarrow T = 156.96$ N

$m_2 = 25$ kg $\rightarrow T = 245.25$ N

Use 16 kg:

$f = \frac{n}{2(2)}\sqrt{\frac{156.96}{0.002}} = \frac{n}{4}(280.1428) = (70.035)n$

Velocity $= 280.1428\ ms^{-1}$ ($n=1$ means $\lambda = 2L$)

~~$\therefore f_1 = \frac{v}{\lambda_1} = 70.035$ Hz~~

$L = \frac{n\lambda}{2} \Rightarrow \lambda = \frac{2L}{n} \Rightarrow f = \frac{nV}{2L}$

N.B. Can't assume same harmonic number.

$\therefore$ As frequency = constant, $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{\frac{2L}{n+1}}{\frac{2L}{n}} = \frac{n}{n+1} = \frac{v_1}{v_2} = \frac{\sqrt{\frac{156.96}{0.002}}}{\sqrt{\frac{245.25}{0.002}}} = 0.8 = \frac{4}{5}$ $\therefore$ $n=4$ for v_2, $n=5$ for 16 kg

Using 16 kg $\Rightarrow \frac{5}{2L}(v_1) =$ **$f = 350$ Hz**

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

$v = \sqrt{\frac{T}{\mu}} \Rightarrow T = v^2\mu = (f\lambda)^2\mu$

$f = 350.18$ Hz (from above). $v = \sqrt{\frac{T}{\mu}} = f\lambda$

for f, $\lambda = 2L = 4$ m

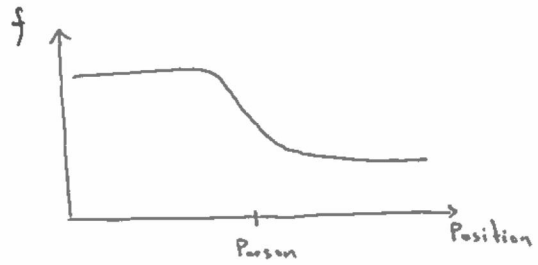
$(f^2\lambda^2)0.002 = T = mg$

$\lambda_1 = 2L = 4$ m

$m = \frac{f^2\lambda^2 0.002}{g} =$ **399.6 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)

$T_v = 33.3\ ms^{-1}$.

$f_{o\ towards} = f_s\left(\frac{v \pm v_o}{v \pm v_s}\right)$. $v_o = 0$. v_s = negative (first towards observer).

$f_{o\text{-}towards} = f_s\left(\frac{v}{v - v_s}\right) = f_s\left(\frac{333}{299.7}\right) = f_{o\ towards}$

$f_{o\ away} = f_s\left(\frac{v \pm v_o}{v \pm v_s}\right)$. $v_o = 0$. v_s = positive (away from observer).

$f_{o\ away} = f_s\left(\frac{v}{v + v_s}\right) = f_s\left(\frac{333}{366.3}\right) = f_{o\ away}$

$f_o\ (towards) - f_o\ (away) = 80 = f_s\left(\frac{333}{299.7}\right) - f_s\left(\frac{333}{366.3}\right) = f_s\left(\left(\frac{333}{299.7}\right) - \left(\frac{333}{366.3}\right)\right)$

$= f_s(0.\overline{20})$

$f_s = \frac{80}{0.\overline{20}} = 396\ Hz$

$f_s = 396\ Hz$

Conductor stands next to so hears f_s

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.

$60\ dB = 10\ dB \log\left(\frac{I_2}{I_0}\right)$

$40\ dB = 10\ dB \log\left(\frac{I_1}{I_0}\right)$

$60 - 40 = 20\ dB = 10dB(\log I_2 - \log I_0 - \log I_1 + \log I_0)$

$= 10\ dB\left(\log\left(\frac{I_2}{I_1}\right)\right) = 20\ dB$

$2 = \log\left(\frac{I_2}{I_1}\right)$

$\frac{I_2}{I_1} = 10^2 = 100 \quad \therefore I_2 = 100\, I_1 \quad \therefore I_{(50\ students)} = 50\, I_1$

$10\ dB \log\left(\frac{50\, I_1}{I_1}\right) = 10\ dB \log(50) = 16.98$

Noise Level $= 40\ dB + 16.98\ dB = \boxed{56.99\ dB}$

Scratch paper