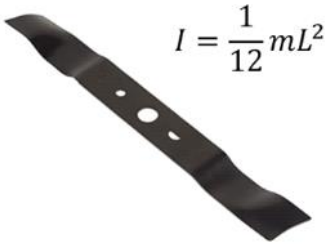
Final Exam - Part 1 - Question 1

Tuesday, March 16, 2021 4:31 PM

A 55-cm-long lawn mower blade takes half of a second to reach a full speed of 3500 RPMs (revolutions per minute). The mass of the blade is 450 grams. Model the blade as a uniform rod rotating about its center, which has the moment of inertia in the figure.



(a) When rotating at full speed, what is the angular momentum of the mower blade?

$L_f = I\omega_f$, $\omega_f = \frac{3500\ \text{rev}}{\text{min}} \left| \frac{2\pi\ \text{rad}}{1\ \text{rev}} \right| \frac{1\ \text{min}}{60\ \text{s}} = 366.5\ \frac{\text{rad}}{\text{s}}$

So, $L_f = \frac{1}{12} mL^2 \omega_f = 4.16\ \text{N·m·s}$

(b) What is the average net torque applied to the blade while reaching full speed?

$\Sigma\tau_{ext} = \frac{\Delta L}{\Delta t} = \frac{L_f}{\Delta t} = 8.32\ \text{N·m}$, or, $\Sigma\tau = I\alpha = I\frac{\Delta\omega}{\Delta t}$

$\Sigma\tau = I\frac{\omega_f}{\Delta t}$

(c) How much power is required to accelerate the mower blade while reaching full speed?

$P = \frac{\text{Energy}}{\text{time}} = \frac{\Delta K}{\Delta t} = \frac{K_f}{\Delta t}$, w/ $K_f = \frac{1}{2} I\omega_f^2 = \frac{L_f^2}{2I}$

$P = \frac{I\omega_f^2}{2\Delta t} = 1524\ \text{W}$

Rubric

Part (a)
1 pt - Angular momentum equation
1 pt - Omega unit conversion
0.5 pt - Application
0.5 pt - Answer and units

Part (b)
1 pt - 2nd law for rotation equation
1 pt - Alpha = delta_W/delta_t eq.
2 pt - Application
0.5 pt - Answer and units

Part (c)
1 pt - power = energy/time eq.
1 pt - rotational energy equation
2 pt - Application
0.5 pt - Answer and units

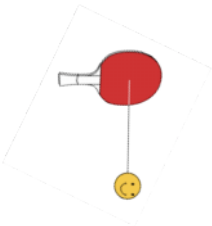
Final Exam - Part 1 - Question 2

Wednesday, March 17, 2021 10:09 AM

A child's game called *paddle ball* consists of a small rubber ball attached to a rubber band, the other end of the rubber band is then attached to a paddle. You notice a small child holding the paddle out in front of them with the ball hanging below. They jerk up on the paddle quickly throwing the ball into a vertical oscillation.

(a) How could you determine, by observing the oscillation of the ball, whether the rubber band acts like a Hooke's Law spring, and thus creates simple harmonic motion?

SHO - period is constant



(b) If you estimate the ball to be about 50 g, and the period of oscillation to be constant 1.2 seconds, what would be an estimate of the spring constant of the rubber band?

$$\omega = \frac{2\pi}{T} = \sqrt{\frac{k}{m}} \Rightarrow k = \frac{4\pi^2}{T^2} m = 1.37 \frac{N}{m}$$

Rubric

Part (a)
1 pt - Answer

Part (b)
1 pt - omega = 2*pi/T eq.
1 pt - omega = sqrt(k/m) eq.
1 pt - Combining and solving
0.5 pt - Answer and units

Part (c)
1.5 pts - Answer

(c) Where did the energy in the oscillation originally come from?

Energy comes from source generating the oscillation.
So if comes from the child when they jerk up on paddle

Printout

Tuesday, March 16, 2021 2:15 PM

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During this quiz you are not to receive information, nor communicate with anyone, about the form, content, length, or difficulty of this quiz. Additionally, you are not to use any unauthorized resources while taking this quiz.

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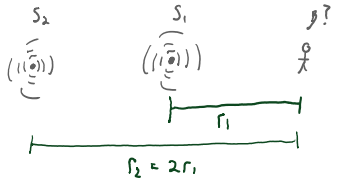
Physics 202

Final Exam | Part 2 (35 minutes) | Cascades

3/15/2021

Collaboration is not allowed. You will have 35 minutes to download, solve, take pictures, AND upload this exam to Gradescope.

1. (6 points) Consider two speakers that emit sound symmetrically in all 3 directions (point source of sound). Speaker 1 has a power of 15.0 W and is 3.00 meters away from your location. Speaker two has twice the power of speaker 1, and is twice the distance away from you compared to speaker 1. The minimum threshold for human hearing is 10^{-12} W/m^2. What is the sound intensity level (in dB) at the location you are at?



$$\Sigma I = I_1 + I_2$$

$$= \frac{P_1}{A_1} + \frac{P_2}{A_2} \quad P_2 = 2P_1$$

$$= \frac{P_1}{A_1} + \frac{2P_1}{A_2} \quad A = 4\pi r^2$$

$$= \frac{P_1}{4\pi r_1^2} + \frac{2P_1}{4\pi r_2^2} \quad r_2 = 2r_1$$

$$= \frac{P_1}{4\pi r_1^2} + \frac{2P_1}{4\pi (2r_1)^2}$$

$$\Sigma I = \frac{P_1}{4\pi r_1^2} + \frac{P_1}{8\pi r_1^2}$$

$0.1326491\ W/m^2$ $\quad 0.06631456\ W/m^2$

$$\Sigma I = \frac{3P_1}{8\pi r_1^2}$$

$0.1989437\ W/m^2$

$$\beta = 10\ dB \log_{10}\left(\frac{\Sigma I}{I_0}\right)$$

$$\beta = 10\ dB \log_{10}\left(\frac{\left(\frac{3P_1}{8\pi r_1^2}\right)}{I_0}\right)$$

$$= 10\ dB \log_{10}\left(\frac{0.1989437}{10^{-12}}\right)$$

$$= 112.987\ dB$$

$$\beta = 113\ dB$$

Question 2 on next page

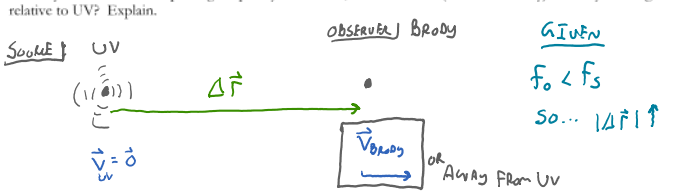
~~Rubric~~

(0.5 points) Beta equation
(3.0 points) Add intensities at persons location (high level)
- (2.0 points) Adds power at persons location instead of intensities (medium level)
- (1.0 points) Adds beta at persons location instead of intensities (low level)

(0.5 points) P2 = 2 P1 used
(0.5 points) A = 4 pi r2
(0.5 points) R2 = r1 used
(0.5 points) Algebra - uses log_base_10 instead of ln
(0.5 points) Consistent answer with "units"

2. (6 points) Consider UV the cat sitting at rest purring at 30.0 Hz. A nearby dog, Brody, hears UV's purr and begins to run. The speed of sound is about 343 m/s.

(a) If Brody was to hear UV's purring frequency as 27.5 Hz, what direction (towards or away) is Brody running relative to UV? Explain.



(b) How fast must Brody run to hear a purring frequency of 27.5 Hz?

$f_o = f_s\left(\frac{v \pm v_o}{v \pm v_s}\right)$ $\quad v_s = 0$, use $-v_o$

$f_o = f_s\left(\frac{v - v_o}{v}\right)$

$27.5\ Hz = 30\ Hz\left(\frac{343\ m/s - v_o}{343\ m/s}\right)$

$0.916\bar{6} = \left(\frac{343\ m/s - v_o}{343\ m/s}\right)$

$314.416\bar{6}\ m/s = 343\ m/s - v_o$

$v_o = 28.58\bar{3}\ m/s$

$\boxed{v_o = 28.6\ m/s}$

(c) Brody is an amazing dog, but with regards to running, he can run about as fast as a normal dog can (about 30 miles per hour). Use known quantities sense making to determine if your answer to part (b) makes sense.

$v_o = 28.6\ m/s \xrightarrow{\text{UNIT CONVERSION}} 64\ MPH > 30\ MPH$

$\boxed{v_o > v_{AVERAGE\ DOG}}$

So this situation does not make sense.

Plus, I'd like to believe Brody and UV would be friends if they met, so Brody would run towards UV. :)

Question 3 on next page

~~Rubric~~

Part (a) - 1.5 points

- (0.5 points) indicates observed frequency is less than source
- (0.5 points) indicates distance between obs and source must be increasing
- (0.5 points) concludes that Brody is running away from UV.

Part (b) - 3 points

- (0.5 points) identifies doppler shift equation
- (0.5 points) uses vs = 0
- (0.5 points) uses - vo
- (1.0 points) algebra
- (0.5 points) correct answer with units

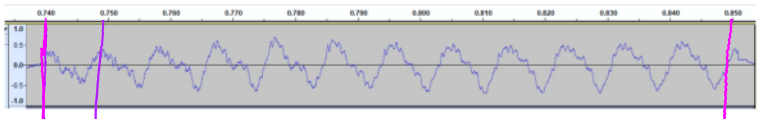
Part (c) - 1.5 points

- (0.5 points) converts vo and 30mph to same units
- (0.5 points) indicates that vo is greater than 30 mph
- (0.5 points) Consistent answer with observation if comparing same units

3. (6 points) A guitar has 6 strings, which are characterized by their note (A, B, C, D, E, F, or G), and the frequency. The table summarizes each strings characteristics. The strings on a guitar are fixed on both ends and when played normally, the string vibrates in it's 1st harmonic.

String #	Note	Frequency
1	E	330 Hz
2	B	247 Hz
3	G	196 Hz
4	D	147 Hz
5	A	110 Hz
6	E	82.4 Hz

(a) One of the 6 guitar strings was played normally while recording the sound produced. A graph of this sound is shown below, where the vertical axis is the displacement and the horizonal axis is the time in seconds. What is the approximate frequency of the guitar string that was played normally? Which string (1 through 6) was this string?



$12T$

T

CAN USE THIS BUT THE UNCERTAINTY IS LARGE ... INCLUDE UNCERTAINTY OR USE MORE CYCLES

$12T = (0.850\ \text{sec} - 0.740\ \text{sec})$

$12T = 0.11\ \text{sec}$

$T = 0.00916\ \text{sec}$

$f = \frac{1}{T}$

$f = 109\ \text{Hz}$ → STRING #5 / NOTE A

(b) If the same string from part (a) was played in it's 3rd harmonic, what would be the frequency? .Which string (1 though 6) would the third harmonic sound closest to?

$f_1 = 109\ \text{Hz}$ $\quad f_m = mf_1$ $\quad m = 3$

$f_3 = 3f_1$

$f_3 = 327\ \text{Hz}$ → STRING #1 / NOTE E

~~Rubric~~

Part (a) - 3.5 points

(1.5 points) uses uncertainty in finding period from single cycle or uses multiple cycles (with our without uncertainty) to find period (high level)

(1.0 points) finds period from one cycle only and mentions something about uncertainty but doesn't attempt to quantify (mid level)

(0.5 points) finds period from one cycle (low level)

(1.0 points) f = 1/T
(0.5 points) consistent f with units
(0.5 points) identifies closest string with calculated f

Part (b) - 2.5 points

(1.0 points) fm = m f1
(0.5 points) m = 3
(0.5 points) consistent f3 with units
(0.5 points) identifies closest string with calculated f3

Final Exam - Part 3 - Questions 1 & 2

Monday, March 15, 2021 11:00 AM

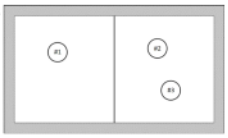
Physics 202

Final Exam | Cascades Campus

3/18/2021

Collaboration is not allowed. You will have 30 minutes to download this PDF, solve, take pictures, AND upload this exam to Gradescope. You will have an additional 5 minute buffer in case technological issues arise.

1. (6 points) Three particles are in an isolated box with a divider. Particle #1 is initially on the left side, while particles #2 and #3 are initially on the right side. The divider disappears, and we are curious about which side of the box particles inhabit, left or right. The possible macrostates are given in a table below.



(a) For each macrostate, find the probability that you would find the system in that state. Show your work. Very little credit will be given without work shown.

Macrostate	Probability
3 particles on left, 0 particles on right	$1/8 = 12.5\%$
2 particles on left, 1 particle on right	$3/8 = 37.5\%$
1 particle on left, 2 particles on right	$3/8 = 37.5\%$
0 particles on left, 3 particles on right	$1/8 = 12.5\%$

123 | 0 ← 1 microstate

12 | 3 13 | 2 23 | 1 ← 3 microstates

1 | 23 2 | 13 3 | 12 ← 3 microstates

0 | 123 ← 1 microstate

4 pts total

+3 pts – Work shown explains possible microstates

+1.5 pts – relevant work is shown, incomplete or incorrect

+1 pt – correct %s (or fractions)

8 total microstates

probability of macrostate = $\frac{\#\text{ microstates that satisfy macrostate}}{\text{total \# of microstates of system}}$

(b) Which macrostate(s) has/have the largest entropy? Explain.

microstates ↑ ⇒ entropy ↑ ⇒ 2:1 & 1:2 have the largest entropy

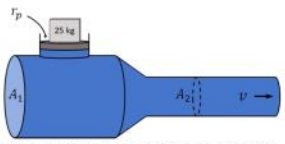
2 pts total

+1.5 pts – high level expl. (mentions microstates or entropy)

+0.5 pts – attempted expl.

+0.5 pts – answer correct (2:1, 1:2)

2. (9 points) Dr. Badnoulli has invented a new device for measuring the velocity of fluid in a pipe. They discover that a particular pipe, which has water flowing through it, is supporting a **20 kg** mass and **5 kg** piston. The piston has a radius, r_p, of **4 cm** and is in a frictionless opening at the top of the pipe with water exerting a pressure on the underside of the piston. The pipe narrows from a cross sectional area A_1 to cross sectional area A_2 where the water pressure is $P_{atm} = 101{,}325$ Pa. A_1 is five times larger than A_2. The pipe diameter is sufficiently small that we can ignore any height/depth differences within the water.



$y_1 = y_2$

What is the velocity of the water, v, in the smaller diameter section of pipe?

$$P_1 = \frac{F}{A_{piston}} + P_{atm} = P_{atm} + \frac{mg}{\pi r_p^2}$$

↑ also pushes down on piston

$\frac{force}{Area} = pressure$

$$A_1 v_1 = A_2 v \Rightarrow v_1 = \frac{A_2}{A_1} v \Rightarrow v_1 = \frac{1}{5} v$$

Continuity

$y_1 = y_2$

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v^2 + \rho g y_2$$

Bernoullis + synthesis

$$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v^2$$

$$P_{atm} + \frac{mg}{\pi r_p^2} + \frac{1}{2}\rho\left(\frac{1}{5}v\right)^2 = P_{atm} + \frac{1}{2}\rho v^2$$

$$\frac{mg}{\pi r_p^2} = \frac{1}{2}\rho\left(v^2 - \frac{1}{25}v^2\right)$$

$$v = \sqrt{\frac{25}{24}\frac{2mg}{\pi r_p^2 \rho}} = 10.1 \text{ m/s}$$

9 pts total

+1.5 pts – uses $P = \frac{F}{A}$
+0.5 pts – finds Force & Area appropriately
+0.5 pt – includes P_{atm} in P_1
] +2.5 pts

+1.5 pts – uses continuity
+0.5 pts – uses correct proportionality argument for area
] + 2 pts

+1 pt – writes Bernoullis argument
+1 pt – uses Bernoullis appropriately
+1.5 pts – connects $P_1 = \cdots$ & $v_1 = \cdots(v)$ with Bernoullis argument
] + 3.5 pts

+1pt – Correct answer mag. & units] + 1 pt