Name____

Physics 110 Quiz #7, November 13, 2020

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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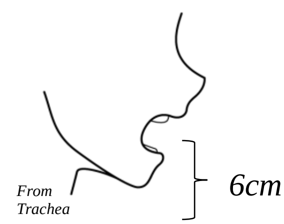
1. When you cough, you expel air at a high speed through the trachea and upper bronchi (of the lungs) so that the air will remove excess mucus lining the pathway. In order to cough, you must breath in a large amount of air, trap it by closing the glottis (the narrow opening of the larynx or vocal cords), increase the air pressure behind the glottis by contracting the lungs, partially collapse the trachea, and then expel the air through the pathway by suddenly reopening the glottis. Assuming that the volume flow rate of the air from the lungs is $7 \times 10^{-3}\,\frac{m^3}{s}$, what is the difference in pressure between the trachea and the mouth? Assume that the contracts to a circle of diameter $5.2mm$, the mouth is a circle of diameter $2.5cm$, the mouth is $6cm$ above the trachea, and the density of air is $\rho_{air} = 1.3\,\frac{kg}{m^3}$.



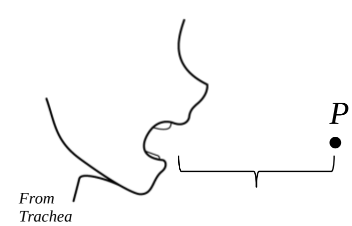
$$P_T + \frac{1}{2}\rho_{air}v_T^2 + \rho_{air}gy_T = P_m + \frac{1}{2}\rho_{air}v_m^2 + \rho_{air}gy_m \text{ where, } Q = A_Tv_T = A_mv_m$$

$$\Delta P = P_m - P_T = \frac{1}{2}\rho_{air}\left[\left(\frac{Q}{A_T}\right)^2 - \left(\frac{Q}{A_m}\right)^2\right] + \rho_{air}g(y_T - y_m)$$

$$\Delta P = \frac{1}{2} \times 1.3\,\frac{kg}{m^3} \times \left(7 \times 10^{-3}\,\frac{m^3}{s}\right)^2\left[\left(\frac{1}{\pi(0.0052m)^2}\right)^2 - \left(\frac{1}{\pi(0.025m)^2}\right)^2\right] + 1.3\,\frac{kg}{m^3} \times 9.8\,\frac{m}{s^2} \times (-0.06m)$$

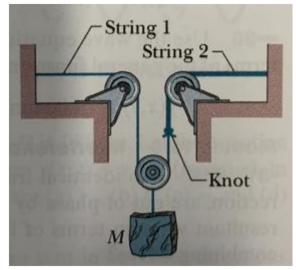
$$\Delta P = 70467\,\frac{N}{m^2}$$

2. The air, from the cough moves out of your mouth (assumed to be a circular opening with a diameter $2.5cm$). As the air passes out through your mouth it moves in a straight line towards point P. Which of the following statements is true regarding the airflow from the air leaving your mouth to point P?



   1. As the air exits your mouth it slows down and as it approaches point P it continutes to slow and the cross-sectional area of the air from the cough increases.
   2. As the air exits your mouth it slows down and as it approaches point P it continutes to slow and the cross-sectional area of the air from the cough decreases.
   3. As the air exits your mouth it speeds up and as it approaches point P it continutes to speed up and the cross-sectional area of the air from the cough increases.
   4. As the air exits your mouth it speeds up and as it approaches point P it continutes to speed up and the cross-sectional area of the air from the cough decreases.
   5. There is not enough information to answer this question.

In the figure on the right, string 1 has a linear mass density of $\mu_1 = 3\frac{g}{m}$ while string 2 has a linear mass density of $\mu_2 = 5\frac{g}{m}$. The strings are under tension due to the hanging block of mass $M = 500g$.



3. What is the magnitude of the tension force in the strings?

   Assuming up is the positive y-direction and since the pulley's do not rotate, the tension forces in each string is the same. Thus,

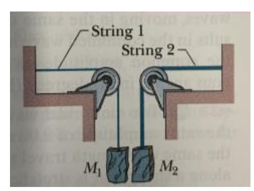
   $$F_T + F_T - F_w = Ma_y = 0 \rightarrow 2F_T = Mg \rightarrow F_T = \frac{Mg}{2} = \frac{0.5kg \times 9.8\frac{m}{s^2}}{2} = 2.45N$$

4. What are the speeds $v_1$and v_2 in each segment of rope?

   $$v_1 = \sqrt{\frac{F_T}{\mu_1}} = \sqrt{\frac{2.45N}{0.003\frac{kg}{m}}} = 28.6\frac{m}{s}$$

   $$v_2 = \sqrt{\frac{F_T}{\mu_2}} = \sqrt{\frac{2.45N}{0.005\frac{kg}{m}}} = 22.1\frac{m}{s}$$

5. Suppose that the hanging block is divided into two pieces (with $M_1 + M_2 = M$) and the apparatus is rearranged as shown on the right. What are the values of $M_1$and M_2 if the wave speeds in the ropes are equal?



   Here the tension force in each cable is the weight of the mass hanging from each cable. Thus, $F_{T1} = M_1 g$ and $F_{T2} = M_2 g$

   $$v_1 = \sqrt{\frac{F_{T1}}{\mu_1}} = v_2 = \sqrt{\frac{F_{T2}}{\mu_2}} \rightarrow \frac{M_1 g}{\mu_1} = \frac{M_2 g}{\mu_2} = \frac{(M - M_1)g}{\mu_2} \rightarrow \mu_2 M_1 = \mu_1 M - \mu_1 M_1$$

   $$M_1 = \left(\frac{\mu_1}{\mu_1 + \mu_2}\right)M = \left(\frac{0.003\frac{kg}{m}}{0.003\frac{kg}{m} + 0.005\frac{kg}{m}}\right) \times 0.5kg = 0.188kg$$
   $$M_2 = M - M_1 = 0.5kg - 0.188kg = 0.312kg$$

Physics 110 Formulas

Motion

$\Delta x = x_f - x_i$ $\quad v_{avg} = \frac{\Delta x}{\Delta t}$ $\quad a_{avg} = \frac{\Delta v}{\Delta t}$

Equations of Motion

displacement: $\begin{cases} x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2 \\ y_f = y_i + v_{iy}t + \frac{1}{2}a_y t^2 \end{cases}$

velocity: $\begin{cases} v_{fx} = v_{ix} + a_x t \\ v_{fy} = v_{iy} + a_y t \end{cases}$

time-independent: $\begin{cases} v_{fx}^2 = v_{ix}^2 + 2a_x \text{D}x \\ v_{fy}^2 = v_{iy}^2 + 2a_y \text{D}y \end{cases}$

Uniform Circular Motion

$F_r = ma_r = m\frac{v^2}{r}; \quad a_r = \frac{v^2}{r}$

$v = \frac{2pr}{T}$

$F_G = G\frac{m_1 m_2}{r^2}$

Geometry /Algebra

Circles *Triangles* *Spheres*

$C = 2pr \quad A = \frac{1}{2}bh \quad A = 4pr^2$

$A = pr^2 \quad V = \frac{4}{3}pr^3$

Quadratic equation : $ax^2 + bx + c = 0$,

whose solutions are given by : $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Vectors

magnitude of a vector: $v = |\vec{v}| = \sqrt{v_x^{\ 2} + v^2_{\ y}}$

direction of a vector: $\phi = \tan^{-1}\left(\frac{v_y}{v_x}\right)$

Useful Constants

$g = 9.8 \,{}^{m}/_{s^2} \quad G = 6.67´\ 10^{-11} \,{}^{Nm^2}/_{kg^2}$

$N_A = 6.02´\ 10^{23} \,{}^{atoms}/_{mole} \quad k_B = 1.38´\ 10^{-23} \,{}^{J}/_{K}$

$s = 5.67´\ 10^{-8} \,{}^{W}/_{m^2K^4} \quad v_{sound} = 343 \,{}^{m}/_{s}$

Linear Momentum/Forces

$\vec{p} = m\vec{v}$

$\vec{p}_f = \vec{p}_i + \vec{F}\text{D}t$

$\vec{F} = m\vec{a}$

$\vec{F}_s = -k\vec{x}$

$F_f = mF_N$

Work/Energy

$K_t = \frac{1}{2}mv^2$

$K_r = \frac{1}{2}Iw^2$

$U_g = mgh$

$U_S = \frac{1}{2}kx^2$

$W_T = FdCos\,q = \text{D}E_T$

$W_R = tq = \text{D}E_R$

$W_{net} = W_R + W_T = \text{D}E_R + \text{D}E_T$

$\text{D}E_R + \text{D}E_T + \text{D}U_g + \text{D}U_S = 0$

$\text{D}E_R + \text{D}E_T + \text{D}U_g + \text{D}U_S = -\text{D}E_{diss}$

Heat

$T_C = \frac{5}{9}[T_F - 32]$

$T_F = \frac{9}{5}T_C + 32$

$L_{new} = L_{old}(1 + a\text{D}T)$

$A_{new} = A_{old}(1 + 2a\text{D}T)$

$V_{new} = V_{old}(1 + b\text{D}T) : b = 3a$

$PV = Nk_BT$

$\frac{3}{2}k_BT = \frac{1}{2}mv^2$

$\text{D}Q = mc\text{D}T$

$P_C = \frac{\text{D}Q}{\text{D}t} = \frac{kA}{L}\text{D}T$

$P_R = \frac{\text{D}Q}{\text{D}T} = esA\text{D}T^4$

$\text{D}U = \text{D}Q - \text{D}W$

Rotational Motion

$\theta_f = \theta_i + \omega_i t + \frac{1}{2}\alpha t^2$

$\omega_f = \omega_i + \alpha t$

$\omega^2{}_f = \omega^2{}_i + 2\alpha\Delta\theta$

$\tau = I\alpha = rF$

$L = I\omega$

$L_f = L_i + \tau\Delta t$

$\Delta s = r\Delta\theta : v = r\omega : a_t = r\alpha$

$a_r = r\omega^2$

Fluids

$\rho = \frac{M}{V}$

$P = \frac{F}{A}$

$P_d = P_0 + \rho gd$

$F_B = \rho gV$

$A_1v_1 = A_2v_2$

$\rho_1A_1v_1 = \rho_2A_2v_2$

$P_1 + \frac{1}{2}\rho v^2{}_1 + \rho gh_1 = P_2 + \frac{1}{2}\rho v^2{}_2 + \rho gh_2$

Simple Harmonic Motion/Waves

$w = 2pf = \frac{2p}{T}$

$T_S = 2p\sqrt{\frac{m}{k}}$

$T_P = 2p\sqrt{\frac{l}{g}}$

$v = \pm\sqrt{\frac{k}{m}}A\left(1 - \frac{x^2}{A^2}\right)^{\frac{1}{2}}$

$x(t) = A\sin\left(\frac{2pt}{T}\right)$

$v(t) = A\sqrt{\frac{k}{m}}\cos\left(\frac{2pt}{T}\right)$

$a(t) = -A\frac{k}{m}\sin\left(\frac{2pt}{T}\right)$

$v = fl = \sqrt{\frac{F_T}{m}}$

$f_n = nf_1 = n\frac{v}{2L}$

$I = 2p^2f^2rvA^2$

Sound

$v = fl = (331 + 0.6T)\,\frac{m}{s}$

$b = 10\log\frac{I}{I_0}; \quad I_o = 1´\ 10^{-12}\,\frac{W}{m^2}$

$f_n = nf_1 = n\frac{v}{2L}; \quad f_n = nf_1 = n\frac{v}{4L}$