QUESTION 1

Water is flowing at 3 m/s in a horizontal pipe under a pressure of 200kPa. The pipe narrows to half its original diameter.

(1) What is the speed of flow in the narrow section?

(2) What is the pressure in the narrow section?

QUESTION 2

Consider a smoke particle in the air with a mass of 3×10^{-16} kg. The smoke particle collides with air molecules and undergoes rapid, irregular motion (Brownian motion).

(1) Find the RMS speed of the particle at 300K

(2) Would the RMS speed be different if the particle were in hydrogen gas instead of air? Justify your answer.

QUESTION 3

100 moles of an ideal monatomic gas in a cylinder expands from a volume of 0.1 m^3 to 0.32 m^3. Heat flows into the gas just rapidly enough to keep the pressure constant at 1.8×10^5 Pa during the expansion.

(1) Draw a *pV*-diagram for this process. Find the work done by the gas.

(2) Calculate the change in temperature of the gas.

(3) Find the change in internal energy in the gas.

QUESTION 4

The point of a needle of a sewing machine moves in simple harmonic motion along the x-axis with a frequency of 2.5 Hz. At t=0 its position and velocity are +1.1 cm and -15 cm/s.

(1) find the acceleration of the needle at t=0

(2) write equations giving the position, velocity, and acceleration of the point as a function of time.

QUESTION 5

A 2-kg object oscillates with an initial amplitude of 3cm on a spring of force constant k = 400 N/m. Find

(a) the period

(b) the total initial energy

(c) If the energy decreases by 1 percent per period, find the damping constant b.

QUESTION 6

A certain transverse wave is described by $y(x,t) = (6.5\text{mm}) \cos [\, 2\pi\, (x / (2.8\text{cm}) - t / (0.036\text{s}))]$. Determine

(1) The wave's amplitude

(2) Wavelength and frequency

(3) Speed of propagation and direction of propagation.

QUESTION 7

Two loudspeakers, A and B, are driven by the same amplifier and emit sinusoidal waves in phase. Speaker B is 12.0 m to the right of speaker A. The frequency of the waves emitted by each speaker is 688 Hz.

(1) What is the wavelength of the waves?

(2) You are standing between the speakers, along the line connecting them and are at a point of constructive interference. How far must you walk toward speaker B along this line to move to a point of destructive interference?

FORMULA SHEET FOR PHY126
(all-inclusive)

Rotation of rigid bodies:

$\omega = \frac{d\theta}{dt}$, $\alpha = \frac{d\omega}{dt}$, $v = r\,\omega$, $\alpha_{\tan} = r\,\frac{d\omega}{dt}$, $\alpha_{\text{rad}} = \frac{v^2}{r}$, $I = \sum_i m_i\, r_i^2$, $E_{\text{rot}} = \frac{1}{2}\, I\,\omega^2$, $I_p = I_{cm} + M\, d^2$; $\vec{\tau} = \vec{r}\times\vec{F}$,

$\sum_i \tau_{z,,i} = I\,\alpha_z$, $E_{\text{kin,tot}} = \frac{1}{2}\,M\,v_{\text{cm}}^2 + \frac{1}{2}\,I_{\text{cm}}\omega^2$, $P = \tau_z\,\omega_z$,

$\vec{L} = \vec{r}\times\vec{p}$, $L = I\,\omega$, $\vec{\tau} = \frac{d\vec{L}}{dt}$

Fluid mechanics:

$\rho = \frac{m}{V}$, $p = \frac{dF_\perp}{dA}$, $\frac{dV}{dt} = A\,v$, $p_1 + \rho\,g\,y_1 + \frac{1}{2}\,\rho\,v_1^2 = p_2 + \rho\,g\,y_2 + \frac{1}{2}\,\rho\,v_2^2$

Temperature and heat:

$T_F = \frac{9}{5}\,T_c + 32^o$, $T_c = \frac{5}{9}\,(T_F - 32^o)$, $T_K = T_c + 273.15$,

$\Delta L = \alpha\,L_0\,\Delta T$, $\Delta V = \beta\,V_0\,\Delta T$, $Q = \pm m\,L$, $Q = m\;c\,\Delta T$, $H = \frac{dQ}{dt} = k\,A\,\frac{T_H - T_C}{L}$, $H = A\,e\,\sigma\,T^4$

Thermal properties of matter:

$p\,V = n\,R\,T$, $m = n\,M$, $M = N_A\,m$, $E_{kin,tot} = \frac{3}{2}\,n\,R\,T$, $\frac{1}{2}m\,\langle v^2\rangle = \frac{3}{2}k_B\,T$, $\lambda = \frac{V/N}{4\pi\sqrt{2}\;r^2}$

The first and second laws of thermodynamics:

$W = \int p\,dV$, $\Delta U = Q - W$, $C_p = C_V + R$, $\gamma = C_p / C_V$, $W = n\,C_V(T_1 - T_2)$

$e = \frac{W}{Q_H} = 1 - \frac{|Q_C|}{|Q_H|}$, $K = \frac{|Q_C|}{|W|} = \frac{|Q_C|}{|Q_H| - |Q_C|}$, $\frac{|Q_H|}{T_H} = \frac{|Q_C|}{T_C}$, $\Delta S = \int \frac{dQ}{T}$, $S = k \ln w$

$p = m\,v$, $F = \Delta p/\Delta t$, $\int \frac{dV}{V} = \ln V$

Periodic motion:

$f = \frac{1}{T}$, $\omega = 2\,\pi f = \frac{2\pi}{T}$, $F = -\,k\,x$, $\omega = \sqrt{\frac{k}{m}}$, $x = A\cos(\omega\,t + \varphi)$, $E = \frac{1}{2}m\,v^2 + \frac{1}{2}k\,x^2$, $\omega = \sqrt{\frac{g}{L}}$, $\omega = \sqrt{\frac{m\,g\,d}{I}}$, $x = A\,e^{-(b/2m)\,t}\cos$

$(\omega'\,t + \varphi)$, $\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4\,m^2}}$, $A = \frac{F_{max}}{\sqrt{\left(k - m\,\omega_d^2\right)^2 + b^2\,\omega_d^2}}$

Mechanical waves:

$v = \lambda\,f$, $k = 2\pi/\lambda$, $\omega = v\,k$, $y(x,t) = A\cos(kx \pm \omega\,t)$, $\frac{\partial^2 y(x,t)}{\partial x^2} = \frac{1}{v^2}\,\frac{\partial^2 y(x,t)}{\partial t^2}$, $v = \sqrt{\frac{F}{\mu}}$, $P_{\text{av}} = \frac{1}{2}\sqrt{\mu F}\;\omega^2 A^2$, $y(x,t) =$

$A_{\text{sw}}\sin(\omega\,t)\sin(k\,x)$, $f_n = n\,\frac{v}{2L}$, $\cos(a \pm b) = \cos a \cos b \mp \sin a \sin b$

Sound:

$p_{max} = B\,k\,A,\ v = \sqrt{\frac{B}{\rho}},\ v = \sqrt{\frac{\gamma R T}{M}},\ v = \sqrt{\frac{Y}{\rho}},\ I = \frac{1}{2}\sqrt{\rho B}\ \omega^2 A^2 = \frac{p_{max}{}^2}{2\rho v} = \frac{p_{max}{}^2}{2\sqrt{\rho B}},$

$\beta = 10\,\text{dB}\log\frac{I}{I_0},\ \sin a + \sin b = 2\sin\frac{a+b}{2}\cos\frac{a-b}{2},\ f_L = \frac{|v| \pm |v_L|}{|v| \pm |v_S|} f_S,\ \Delta x = m\lambda$ or $\Delta x = \left(m + \frac{1}{2}\right)\lambda$

Optics:

$\Theta_r = \Theta_a,\ n_a \sin\Theta_a = n_b \sin\Theta_b,\ n = \frac{c_0}{c},\ \lambda = \frac{\lambda_0}{n},\ \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right),\ \frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$

NUMBERS

R = 8.31 $\frac{J}{\text{mol}\,K}$, $N_A = 6.022 \times 10^{23}$ molecules/mol, $k_B = 1.381 \times 10^{-23}$ J/K
Specific heats: water: c=4190 J/(kg K), ice: c=2100 J/(kg K), aluminum: c=910 J/(kg K)
Heat of fusion for water: $L_f = 334 \times 10^3$ J/kg,
Density of water: ρ = 1000 kg/m^3, density of air ρ = 1.2 kg/m^3, gravity g = 9.81 m/s^2
speed of sound in air: 344 m/s