PHYSICS 2C QUIZ 3 WINTER QUARTER 2018
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Formulas:

$T_3 = 273.16K = 0.01^oC$; water freezes/boils at $T = 0^oC = 32^oF / T = 100^oC = 212^oF$

$1cal = 4.1868J$; $N_A = 6.02 \times 10^{23}$

Thermal expansion: $\Delta L = L\alpha\Delta T$; $\Delta V = V\beta\Delta T$; $\beta = 3\alpha$

Heat capacity and specific heat: $Q = C\Delta T$; $Q = cm\Delta T$

Heat of vaporization, fusion: $Q = L_V m$; $Q = L_F m$

First law of thermodynamics: $\Delta E_{\text{int}} = Q - W$; $dE_{\text{int}} = dQ - dW$; $W = \int_{V_i}^{V_f} p\,dV$ work

Conduction: $P_{cond} = \frac{Q}{t} = kA\frac{T_H - T_L}{L}$; $R = \frac{L}{k}$ k,R=thermal conductivity, resistance

Radiation: $P_{rad} = \sigma\varepsilon AT^4$; $\sigma = 5.67 \times 10^{-8} W/m^2K^4$ $\varepsilon = 1$ for black body

Ideal gas: $PV = nRT = NkT = nN_AkT$; R=8.31J/molK ; $k = 1.38 \times 10^{-23} J/K$

Pressure: $P = \frac{Nm}{3V}(v^2)_{avg}$ Kinetic energy: $K_{avg} = \frac{1}{2}m(v^2)_{avg} = \frac{3}{2}kT$

Internal energy: $E_{\text{int}} = NK_{avg}$; $C_V = \frac{3}{2}R$ for monoatomic gas; $C_P = C_V + R$

C_V, C_P = molar heat capacity at constant volume, pressure

$C_V = \frac{f}{2}R$ for polyatomic gases with f degrees of freedom per molecule

Adiabatic expansion of ideal gas: $PV^\gamma = const$, $TV^{\gamma-1} = const$; $\gamma = C_P / C_V$

Distribution of molecular speeds: $P(v) = 4\pi(\frac{m}{2\pi kT})^{3/2} v^2 e^{-mv^2/(2kT)}$

Velocity distribution: $F(v_x, v_y, v_z) = f(v_x)f(v_y)f(v_z)$, $f(v_x) = (\frac{m}{2\pi kT})^{1/2} e^{-mv_x^2/(2kT)}$

Mean free path: $\lambda = 1/(\sqrt{2}\pi d^2 N/V)$, d=diameter ; $v_{rms} = \sqrt{(v^2)_{avg}}$

Entropy: $dS = dQ/T$ in a reversible process. S is a function of state. $\Delta S = \int_i^f dQ/T$

$\Delta S \geq 0$ for a closed system. = if reversible process, > if irreversible process

Ideal gas: $S(T,V) = nR\ln V + nC_v \ln T + const$

Heat engine: $\varepsilon = \frac{|W|}{|Q_H|}$; Carnot engine: $\varepsilon = 1 - \frac{|Q_L|}{|Q_H|} = 1 - \frac{T_L}{T_H}$

Refrigerator coefficient of performance $K = \frac{|Q_L|}{|W|}$; Carnot refrigerator $K_C = \frac{T_L}{T_H - T_L}$

Statistical view of entropy: $S = k\ln W$; $W = N!/(n_1!\ n_2!\ ....)$; $N! \approx N(\ln N) - N$

Fluids: $\rho = m/V$, $p = F/A$, $1atm = 1.01x10^5 Pa = 760torr$

Fluid at rest: $p_2 + \rho g y_2 = p_1 + \rho g y_1$; gauge pressure=p-$p_{atmospheric}$

Pascal's principle: $\Delta p = F_1 / A_1 = F_2 / A_2$

Archimedes principle: buoyant force $F_b = m_{fluid} g$

Continuity equation: volume flow rate = $R_V = Av$ = a constant

Bernoulli equation: $p + \frac{1}{2}\rho v^2 + \rho g y$ = a constant

Oscillations: simple harmonic motion: $x(t) = x_m \cos(\omega t + \phi)$; $\omega = 2\pi f = 2\pi / T$

spring: $F = -kx$, $\omega = \sqrt{k/m}$, energy: $E = U + K = \frac{1}{2}kx_m^2$; $U = \frac{1}{2}kx^2$, $K = \frac{1}{2}mv^2$

torsion pendulum: $\tau = -\kappa\theta$, $\omega = \sqrt{\kappa / I}$; simple pendulum: $\omega = \sqrt{g/L}$

physical pendulum: $\omega = \sqrt{mgh/I}$; $I = I_{CM} + mh^2 = \int r^2 dm$

Damped shm: $F_d = -bv$, $x(t) = x_m e^{-bt/2m}\cos(\omega' t + \phi)$, $\omega' = \sqrt{\omega^2 - (b/2m)^2}$

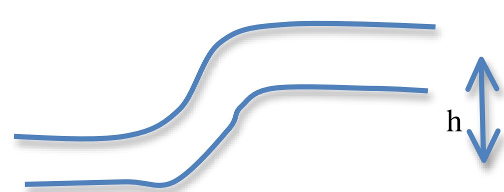
Forced oscillations: $F_f = f\cos(\omega_d t)$, $x(t) = x_m \cos(\omega_d t + \phi)$; resonance: $\omega_d = \omega$

$$x_m = (f/m) / \sqrt{(\omega_d^2 - \omega^2) + b^2\omega_d^2 / m^2}, \tan\phi = (b/m)\omega_d / (\omega_d^2 - \omega^2)$$

Problem 1

You weigh 70 kg and are standing on a block of ice that is floating in the middle of a lake. Your feet are unavoidably starting to get very wet. What is approximately the mass of the ice block?
Ice density: 0.92 g/cm^3. Water density 1 g/cm^3. Your density 0.95 g/cm^3.
A: 64 kg; B: 220 kg; C: 480 kg; D: 800 kg; E: 875 kg

Problem 2



In the cylindrical tubes shown in the figure, the diameter of the wide region is twice the diameter of the narrow region. Water if flowing from left to right, in the narrow region its speed is 5m/s. If the pressure is the same at the center of the narrow region as it is at the center of the wide region,what is their vertical distance h?
A: 0.99m; B: 1.09m; C: 1.19m; D: 1.29m; E: 1.39m

Problem 3
In a tank that holds 100,000 liters of water there is a hole of area $10cm^2$ at distance 5m below the water level. Approximately how long will it take for 10 liters of water to flow out?
A: 1s; B: 2s; C: 3s; D: 4s; E: 5s

Problem 4
A mass undergoing simple harmonic motion moves in a straight line between positions -5m and +5m. Its maximum speed is 5m/s. What is the shortest time interval during which it will travel a distance of 5m?
A: 1.09s; B: 2.09s; C: 3.09s; D: 4.09s; E: 5.09s

Problem 5
A thin homogeneous rod of length L oscillates with period 1s when the pivot is at the end of the rod. What is the period of oscillation when the pivot is at distance L/4 from the end of the rod?
The moment of inertia of a rod of mass m, length L, around its center of mass is $mL^2/12$.
A: 1s; B: 0.86s; C: 0.78s; D: 1.05s; E: 0.94s

Problem 6
After undergoing 20 oscillations a damped harmonic oscillator has lost 1/4 of its initial energy. After how many more oscillations will it have lost another ¼ of its initial energy?
A: 20; B: 24; C: 28; D: 32; E: 16

Problem 7 (for extra credit)
A wooden cylinder of height 10cm is floating in water in vertical position, 90% of it is submerged. If you tap it slightly on the top it will start oscillating up and down, with period:
A: 0.6s; B: 0.8s; C: 1s; D: 1.2s; E: 1.4s