Physics 2110 Quiz 11 v1 Name Key

Please **show all work** for the problem. An answer without enough work shown to justify it will not receive credit even if it is correct. Calculators are allowed, but no notes or books. Please express your answers in the appropriate units.

Problem:
Water (density = $1.00 \times 10^3$ kg/m$^3$) at a pressure of $3.00 \times 10^5$ Pa flows in a horizontal pipe at 3.00 m/s. The pipe narrows to 1/4 of its former area.
a. What is the speed of the water after the pipe narrows?
b. What is the pressure of the water after the pipe narrows?

Use "1" subscripts for broader section of pipe
Use "2" subscripts for narrow section of pipe

a. $v_1 A_1 = v_2 A_2 \qquad A_2 = \frac{1}{4} A_1 \qquad v_1 = 3.00 \text{ m/s}$

$$v_2 = v_1 \frac{A_1}{A_2} = v_1 \frac{A_1}{\frac{1}{4} A_1} = 4 v_1 = 12.0 \text{ m/s}$$

b. $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$y_1 = y_2$

$P_1 = 3.00 \times 10^5 \text{ Pa}$

$P_2 = P_1 + \frac{1}{2}\rho(v_1^2 - v_2^2)$

$P_2 = 3.00 \times 10^5 \text{ Pa} + \frac{1}{2}\left(1.00 \times 10^3 \frac{\text{kg}}{\text{m}^3}\right)\left((3.00 \text{ m/s})^2 - (12.0 \text{ m/s})^2\right)$

$P_2 = \underline{2.33 \times 10^5 \text{ Pa}}$

Physics 2110 Quiz 11 Equation Sheet Name ______________

The following equations, physical constants, and relationships may be useful.

1 mile = 1609 meters   1 foot = 0.3048 m   1 foot = 12 inches   1 year = 365 days
1 day = 24 hours   1 hour = 3600 s   g = 9.8 m/s$^2$   $\rho = \frac{m}{V}$   $\Delta x = x_2 - x_1$   $v = v_0 + at$

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} \quad s_{avg} = \frac{\text{total distance}}{\Delta t} \quad v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \quad a_{avg} = \frac{\Delta v}{\Delta t} \quad a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$$

$x - x_0 = v_0 t + \frac{1}{2}at^2$   $v^2 = v_0^2 + 2a(x - x_0)$   $x - x_0 = \frac{1}{2}(v_0 + v)t$   $x - x_0 = vt - \frac{1}{2}at^2$
$a_x = a\cos\theta$   $a_y = a\sin\theta$   $a = \sqrt{a_x^2 + a_y^2}$   $\tan\theta = \frac{a_y}{a_x}$   $\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$
$r_x = a_x + b_x$, $r_y = a_y + b_y$, $r_z = a_z + b_z$   $\vec{a}\cdot\vec{b} = ab\cos\phi$   $\vec{a}\times\vec{b} = \vec{c}$ where $c = ab\sin\phi$
$\vec{a}\cdot\vec{b} = (a_x\hat{i} + a_y\hat{j} + a_z\hat{k})\cdot(b_x\hat{i} + b_y\hat{j} + b_z\hat{k})$   $\vec{a}\times\vec{b} = (a_x\hat{i} + a_y\hat{j} + a_z\hat{k})\times(b_x\hat{i} + b_y\hat{j} + b_z\hat{k})$
$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$   $\Delta\vec{r} = \vec{r}_2 - \vec{r}_1$   $\Delta\vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k} = \Delta x\hat{i} + \Delta y\hat{j} + \Delta z\hat{k}$

$$\vec{v}_{avg} = \frac{\Delta\vec{r}}{\Delta t} \quad \vec{v} = \frac{d\vec{r}}{dt} \quad \vec{v} = v_x\hat{i} + v_y\hat{j} + v_z\hat{k} \quad \vec{a}_{avg} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \frac{\Delta\vec{v}}{\Delta t} \quad \vec{a} = \frac{d\vec{v}}{dt}$$

$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$   $x - x_0 = (v_0\cos\theta_0)t$   $y - y_0 = (v_0\sin\theta_0)t - \frac{1}{2}gt^2$   $v_y = v_0\sin\theta_0 - gt$
$v_y^2 = (v_0\sin\theta_0)^2 - 2g(y - y_0)$   $\vec{v}_{PA} = \vec{v}_{PB} + \vec{v}_{BA}$   Circumference of Circle $= 2\pi r$

$$y = (\tan\theta_0)x - \frac{gx^2}{2(v_0\cos\theta_0)^2} \quad R = \frac{v_0^2}{g}\sin 2\theta_0 \quad a = \frac{v^2}{r} \quad T = \frac{2\pi r}{v}$$

$$\text{If } ax^2 + bx + c = 0, \text{ then } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$\vec{F}_{net} = m\vec{a}$   $F_{net,x} = ma_x$   $F_{net,y} = ma_y$   $F_{net,z} = ma_z$   $F_g = mg$   $W = mg$   $\vec{F}_{BC} = -\vec{F}_{CB}$
$f_{s,max} = \mu_s F_N$   $f_k = \mu_k F_N$   $D = \frac{1}{2}C\rho Av^2$   $v_t = \sqrt{\frac{2F_g}{C\rho A}}$   $a = \frac{v^2}{R}$   $F = \frac{mv^2}{R}$
$K = \frac{1}{2}mv^2$   $W = Fd\cos\phi = \vec{F}\cdot\vec{d}$   $\Delta K = K_f - K_i = W$   $K_f = K_i + W$   $K_f = K_i + W$
$W_g = mgd\cos\phi$   $\Delta K = K_f - K_i = W_a + W_g$   $\vec{F}_s = -k\vec{d}$   $F_x = -kx$   $W_s = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$
$W = \int_{x_i}^{x_f} F_x dx + \int_{y_i}^{y_f} F_y dy + \int_{z_i}^{z_f} F_z dz$   $W = \int_{x_i}^{x_f} F(x)dx$   $P_{avg} = \frac{W}{\Delta t}$   $P = \frac{dW}{dt}$   $P = Fv\cos\phi = \vec{F}\cdot\vec{v}$
$\Delta U = -W$   $\Delta U = -\int_{x_i}^{x_f} F(x)dx$   $\Delta U = mg(y_f - y_i) = mg\Delta y$   $U(y) = mgy$   $U(x) = \frac{1}{2}kx^2$
$E_{mec} = K + U$   $K_2 + U_2 = K_1 + U_1$   $\Delta E_{mec} = \Delta K + \Delta U = 0$   $F(x) = -\frac{dU(x)}{dx}$   $K(x) = E_{mec} - U(x)$
$W = \Delta E_{mec} = \Delta K + \Delta U$   $W = \Delta E_{mec} + \Delta E_{th}$   $\Delta E_{th} = f_k d$   $W = \Delta E = \Delta E_{mec} + \Delta E_{th} + \Delta E_{int}$
If $W = 0$, $\Delta E_{mec} + \Delta E_{th} + \Delta E_{int} = 0$ and $E_{mec,2} = E_{mec,1} - \Delta E_{th} - \Delta E_{int}$   $P_{avg} = \frac{\Delta E}{\Delta t}$   $P = \frac{dE}{dt}$

$$x_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i x_i \quad y_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i y_i \quad z_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i z_i \quad \vec{r}_{com} = \frac{1}{M}\sum_{i=1}^{n} m_i\vec{r}_i \quad \vec{F}_{net} = M\vec{a}_{com}$$

$\vec{p} = m\vec{v}$   $\vec{F}_{net} = \frac{d\vec{p}}{dt}$   $\vec{P} = M\vec{v}_{com}$   $\vec{F}_{net} = \frac{d\vec{P}}{dt}$   $\vec{p}_f - \vec{p}_i = \Delta\vec{p} = \vec{J}$   $\vec{J} = \int_{t_i}^{t_f} \vec{F}(t)dt$
$J = F_{avg}\Delta t$   $F_{avg} = -\frac{n}{\Delta t}\Delta p = -\frac{n}{\Delta t}m\Delta v$   $\vec{P} =$ constant   $\vec{P}_i = \vec{P}_f$   $\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$
$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$   $v_{1f} = \frac{m_1 - m_2}{m_1 + m_2}v_{1i}$   $v_{2f} = \frac{2m_1}{m_1 + m_2}v_{1i}$   $\vec{P}_{1i} + \vec{P}_{2i} = \vec{P}_{1f} + \vec{P}_{2f}$
$K_{1i} + K_{2i} = K_{1f} + K_{2f}$   $Rv_{rel} = Ma$   $v_f - v_i = v_{rel}\ln\frac{M_i}{M_f}$
$\theta = \frac{s}{r}$   1 rev = 360° = $2\pi$ rad   $\Delta\theta = \theta_2 - \theta_1$   $\omega_{avg} = \frac{\Delta\theta}{\Delta t}$   $\omega = \frac{d\theta}{dt}$   $\alpha_{avg} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\Delta\omega}{\Delta t}$   $\alpha = \frac{d\omega}{dt}$
$\omega = \omega_0 + \alpha t$   $\theta - \theta_0 = \omega_0 t + \frac{1}{2}\alpha t^2$   $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$   $\theta - \theta_0 = \frac{1}{2}(\omega_0 + \omega)t$   $\theta - \theta_0 = \omega t - \frac{1}{2}\alpha t^2$
$s = \theta r$   $v = \omega r$   $a_t = \alpha r$   $a_r = \frac{v^2}{r} = \omega^2 r$   $T = \frac{2\pi r}{v} = \frac{2\pi}{\omega}$   $K = \frac{1}{2}I\omega^2$   $I = \sum m_i r_i^2$   $I = \int r^2 dm$

$I = I_{com} + Mh^2$ $\tau = rF_t = r_\perp F = rF\sin\phi$ $\tau_{net} = I\alpha$ $W = \int_{\theta_i}^{\theta_f} \tau d\theta$ $P = \frac{dW}{dt} = \tau\omega$ $W = \tau(\theta_f - \theta_i)$
$\Delta K = K_f - K_i = \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = W$ $v_{com} = \omega R$ $K = \frac{1}{2}I_{com}\omega^2 + \frac{1}{2}Mv_{com}^2$ $a_{com} = \alpha R$

$$a_{com,x} = -\frac{g\sin\theta}{1 + I_{com}/MR^2} \quad \vec{\tau} = \vec{r} \times \vec{F} \quad \tau = rF\sin\phi = rF_\perp = r_\perp F \quad \vec{\ell} = \vec{r} \times \vec{p} = m(\vec{r} \times \vec{v})$$

$$\ell = rmv\sin\phi = rp_\perp = rmv_\perp = r_\perp p = r_\perp mv \quad \vec{\tau}_{net} = \frac{d\vec{\ell}}{dt} \quad \vec{L} = \vec{\ell}_1 + \vec{\ell}_2 + \cdots + \vec{\ell}_n = \sum_{i=1}^{n} \vec{\ell}_i \quad \vec{\tau}_{net} = \frac{d\vec{L}}{dt}$$

$L = I\omega$ $\vec{L} = \text{a constant}$ $\vec{L}_i = \vec{L}_f$ $\vec{F}_{net} = 0$ $F_{net,x} = 0$ $F_{net,y} = 0$ $\vec{\tau}_{net} = 0$ $\tau_{net,z} = 0$

$$F = G\frac{m_1 m_2}{r^2} \quad G = 6.67\times10^{-11}\ N\cdot m^2/kg^2 \quad \vec{F}_{1,net} = \sum_{i=2}^{n} \vec{F}_{1i} \quad \vec{F}_1 = \int d\vec{F} \quad F = ma_g \quad a_g = \frac{GM}{r^2} \quad M_{ins} = \rho\frac{4\pi r^3}{3}$$

$$U = -\frac{GMm}{r} \quad U = -\left(\frac{Gm_1m_2}{r_{12}} + \frac{Gm_1m_3}{r_{13}} + \frac{Gm_2m_3}{r_{23}}\right) \quad v = \sqrt{\frac{2GM}{R}} \quad T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$$

$$U = -\frac{GMm}{r} \quad K = \frac{GMm}{2r} \quad E = -\frac{GMm}{2r} \quad E = -\frac{GMm}{2a} \quad \rho = \frac{\Delta m}{\Delta V} \quad \rho = \frac{m}{V} \quad p = \frac{\Delta F}{\Delta A} \quad p = \frac{F}{A}$$

$p_2 = p_1 + \rho g(y_1 - y_2)$ $p = p_0 + \rho gh$ $F_b = m_f g$ $\text{weight}_{app} = \text{weight} - F_b$ $R_V = Av = \text{a constant}$
$R_m = \rho R_V = \rho Av = \text{a constant}$ $p + \frac{1}{2}\rho v^2 + \rho gy = \text{a constant}$