宿題（２）（提出日:１９９７年５月１６日）

問題　等エントロピー流れ（$p/\rho^\kappa = C$）における Bernoulli の式を求めよ。

（解）

$$\frac{1}{2}v^2 + \int \frac{dp}{\rho} + gz = C$$

$$dp = C\kappa\rho^{\kappa-1}d\rho, \quad C = p\rho^{-\kappa}$$

$$\int \frac{dp}{\rho} = C\kappa \int \rho^{\kappa-2}d\rho = C\frac{\kappa}{\kappa-1}\rho^{\kappa-1} = \frac{\kappa}{\kappa-1}\frac{p}{\rho}$$

$$\frac{1}{2}v^2 + \frac{\kappa}{\kappa-1}\frac{p}{\rho} + gz = C$$

宿題（３）（提出日:１９９７年５月２３日）

[3]

$$Q = CA\sqrt{2gH}, \quad C = \frac{0.42/60}{(\pi 0.05^2/4)\sqrt{2g \times 2)}} = 0.569$$

[4]

$$H = \frac{v_a^2}{2g} = \frac{c_v^2(2gH')}{2g}, \quad H' = \frac{p}{\rho g}$$

$$p = \frac{\rho g H}{c_v^2} = 120.8kPa$$

[5]

$$v_1 = \frac{Q}{\pi d_1^2/4} = \frac{0.01 \times 4}{\pi 0.075^2} = 2.26m/s, \quad v_2 = \frac{Q}{\pi d_2^2/4} = \frac{0.01 \times 4}{\pi 0.05^2} = 5.09m/s$$

$$\frac{p_1 - p_2}{\rho g} = \frac{v_2^2 - v_1^2}{2g} = 1.06$$

$$\frac{p_1 - p_2}{\rho g} = 1.06 = h(\frac{\rho_g}{\rho} - 1), \quad h = 84.2mmHg$$

[6]

$$v = \sqrt{2gh(\frac{\rho_g}{\rho} - 1)} = \sqrt{2g \times 0.1(\frac{1594}{998} - 1)} = 1.08m/s$$

$$Q = \frac{\pi 0.15^2}{4} \times 1.08 = 0.0191m^3/s$$

宿題（４）（提出日: １９９７年５月３０日）

[16]

$$p_A + \rho_o g(3.33) + 10^3 g(1.67) = p_a + \rho_a g(5.00 - 0.33) + \rho_{Hg} g(0.33)$$
$$p_{gage} = p_A - p_a = 1.2g(4.67) + 13.6 \times 10^3 g(0.33) - 798g(3.33) - 10^3 g(1.67)$$
$$= (44.03 - 42.40) \times 10^3 = 1.63kPa$$

[17]

$$P = \rho g \overline{z} A, \quad \overline{z} = H + 1.5 \sin 60^o = 2 + 1.3 = 3.3m$$
$$P = 10^3 g \times 3.3 \times 6 = 194.04kN$$
$$\eta = \frac{I_G}{A\overline{y}} + \overline{y}, \quad I_G = \frac{3^3 \times 2}{12} = 4.5, \quad \overline{y} = \frac{2}{\sin 60^o} + 1.5 = 3.8$$
$$\eta = \frac{4.5}{6 \times 3.8} + 3.8 = 4.0m$$

宿題（５）（提出日: １９９７年６月６日）

[3]

$$p_A + 1.60 \times 10^3 g(0.46) + s_B \times 10^3 g(0.38) = p_a$$
$$s_B = \frac{10.88 \times 10^3}{10^3 g(0.38)} - \frac{1.6(0.46)}{0.38}$$
$$= 2.92 - 1.94 = 0.98$$

[2.3]

$$p_A + \rho_w g(x + h) - \rho_{Hg} gh + \rho_w gy = p_B$$
$$(p_A - p_B) + k\rho_w g(x + y) = hg(\rho_{Hg} - \rho_w)$$
$$x + y = 4 - 2 = 2m$$
$$h = \frac{(p_A - p_B) + \rho_w g(x + y)}{g(\rho_{Hg} - \rho_w)}$$
$$= \frac{10^3(280 - 140 + 2g)}{10^3 g(13.6 - 1)} = 1.29m$$

[2.6]
（長方形）

$$P = \rho g \overline{z} A = 10^3 g \times 2.2 \times 2 = 43kPa, \quad I_G = \frac{1 \times 2^3}{12} = \frac{2}{3}$$
$$\eta = \frac{I_G}{\overline{z}A} + \overline{z} = \frac{2/3}{2 \times 2.2} + 2.2 = 2.35m$$

（三角形）

$$\overline{y} = \frac{1}{\sin 45^o} + \frac{2}{3} \times 2 = 1.414 + \frac{4}{3} = 2.75m$$
$$\overline{z} = \frac{\overline{y}}{\sin 45^o} = 1.94m, \quad A = \frac{1.2 \times 2}{2} = 1.2m^3, \quad I_G = \frac{1.2 \times 2.0^3}{36} = 0.27$$
$$P = \rho g \overline{z} A = 10^3 g (1.94)(1.2) = 22.8kN$$
$$\eta = \frac{I_G}{\overline{y}A} + \overline{y} = \frac{0.27}{2.75(1.2)} + 2.75 = 2.83m, \quad z_c = 2.83 \sin 45^o = 2.0m$$

[2.7]

$$h = -\frac{p}{\rho g} = -\frac{15 \times 10^3}{10^3 g} = -1.53m, \quad 5.5 - 1.53 = 3.97m(0 - gage)$$
$$\overline{z} = (3.97 - 1.8) + \frac{1.8}{2} = 3.07m$$
$$P_w = \rho g \overline{z} A = 10^3 g (3.07)(1.8 \times 1.0) = 54.2kN$$
$$z_c = \frac{I_g}{\overline{z}A} + \overline{z} = \frac{1.0 \times (1.8^3/12)}{3.07(1.8 \times 1.0)} + 3.07 = 3.15$$
$$P_o = \rho g \overline{z} A = 0.8 \times 10^3 g (\frac{1.8}{2})(1.8 \times 1.0) = 12.7kPa$$
$$z_c = \frac{1.0 \times (1.8^3/12)}{0.9(1.8 \times 1.0)} + 0.9 = 1.2m$$
$$(3.15 - 2.17) P_w = 1.2 P_o + 1.8F, \quad F = 21.0kN \ to \ the \ left.$$

[2.8]

$$\eta = \frac{Ig}{\overline{y}A} + \overline{y} = \frac{\pi d^4/64}{(h+1)(\pi d^2/4)} + (h+1)$$
$$\eta - (h+1) = \frac{(\pi \times 2^4/64)}{(h+1)(\pi \times 2^2/4)} = 0.12, \quad h = 1.08m$$

宿題（６） （提出日:１９９７年6月１３日）

[7]

$$
\begin{aligned}
&-Adz = Qdt, \quad Q = cav = ca\sqrt{2gz} \\
&-Adz = ca\sqrt{2gz}dt, \quad dt = -\frac{A}{ca\sqrt{2g}}\frac{dz}{\sqrt{z}} \\
&T = \frac{2A}{ca\sqrt{2g}}\sqrt{(H-0)} \\
&T = \frac{2(\pi 1^2/4)}{0.6(\pi 0.05^2/4)\sqrt{2g}} \times \sqrt{2} = 426sec
\end{aligned}
$$

[18]

$$
P = \rho Qv\sin\theta = \rho Av^2\sin\theta = 10^3 \times \frac{\pi}{4}(3\times 10^{-2})^2 \times 40 \times \sin 45^o = 799N
$$

[19]

$$
\begin{aligned}
&P = \rho Q(v-V) = 10^3 \times \frac{3.36}{60}(8-2) = 336N \\
&L = PV = 336 \times 2 = 672w
\end{aligned}
$$

宿題（７） （提出日:１９９７年6月２０日）

[14]　省略

[20]

$$
\begin{aligned}
&P_x = \rho Q(v_1 - v_2\cos\theta) + p_1A_1 - p_2A_2\cos\theta \\
&P_y = -\rho Qv_2\sin\theta - p_2\sin\theta - Mg
\end{aligned}
$$

[21]

$$
\begin{aligned}
&P = -\rho Qv = -c\rho Av^2 = -c\rho A \times 2gh \\
&P = -0.95 \times 10^3 \times \frac{\pi}{4} \times 0.05^2 \times 2g \times 1.5 = 54.8N
\end{aligned}
$$

[22]

$$
\begin{aligned}
&v = \frac{Q}{2A} = \frac{2Q}{\pi d^2} = \frac{2\times 12\times 10^{-3}}{60\pi \times 4^2 \times 10^{-6}} = 7.96m/s \\
&T = (\rho Qw\cos 15^o \sin 60^o) \times r = 0.133N\cdot m
\end{aligned}
$$

宿題（８）（提出日:１９９７年6月２７日）

[4-15]　省略

[10]

$$H_f = \frac{v^2}{2g},\quad Q = \frac{\pi d^2}{4}v,\quad L = \frac{\rho g Q H_f}{\eta}$$

$$Q = \frac{\pi 0.4^2}{4} \times 30 = 3.77 m^3/s,\quad H_f = \frac{30^2}{2g} = 45.87 kg-m/kg$$

$$L = \frac{1.205g \times 3.77 \times 45.87}{0.75} = 2.73kw$$

[11]

$$H_p = \frac{v_2^2 - v_1^2}{2g} + (\frac{p_2}{\rho g} + z_2) - (\frac{p_1}{\rho g} + z_1)$$

$$\frac{\Delta p}{\rho g} = (\frac{p_2}{\rho g} + z_2) - (\frac{p_1}{\rho g} + z_1) = h(\frac{\rho_g}{\rho g} - 1) = 1.3(13.6 - 1) = 16.38$$

$$v_1 = \frac{7.0/60}{\pi 0.2^2/4} = 3.71 m/s,\quad v_2 = \frac{7.0/60}{\pi 0.15^2/4} = 6.60 m/s$$

$$H_p = 1.56 + 16.38 = 17.94,\quad Q = \frac{7.0}{60} = 0.1166$$

$$L = \rho g Q H_p = 10^3 g \times 0.1166 \times 17.94 = 20.5kw$$

[23]

$$-D_f + (p_1 A - p_2 A) = \int \rho v^2 dA - \rho v_1^2 A$$

$$v = v_{max}\{1 - \frac{r^2}{R^2}\}$$

$$\pi R^2 v_1 = \int_0^R v 2\pi r dr = \int_0^R v_{max}\{1 - \frac{r^2}{R^2}\} 2\pi r dr = v_{max}(\frac{\pi R^2}{2})$$

$$v_{max} = 2v_1$$

$$-D_f + \pi R^2 (p_1 - p_2) = \int_0^R \rho\{2v_1(1 - \frac{r^2}{R^2})\}^2 2\pi r dr - \rho \pi R^2 v_1^2$$

$$= 8\rho\pi R^2 v_1^2 (\frac{1}{2} + \frac{1}{6} - \frac{1}{2}) - \rho\pi R^2 v_1^2$$

$$D_f = (p_1 - p_2)\pi R^2 - \frac{1}{3}\pi R^2 v_1^2$$