HYDRAULICS

Column 1:

$$\rho = \frac{m}{v} ; \frac{kg}{m^3} \ \textit{Density}$$

$$V_s = \frac{1}{\rho} ; \frac{m^3}{kg} \ \textit{Specific Volume}$$

$$\gamma = \frac{w}{v} = \rho g ; \frac{N}{m^3} \ \textit{Unit Weight}$$

$$Gs = \frac{\rho_s}{\rho_w} = \frac{\rho_s}{\rho_w} = \frac{\gamma_s}{\gamma_w} \ \textit{Specific gravity}$$
water at 4°C
$\gamma = 62.5 \ lb/ft^3 = 9.81 \ kN/m^3$
$\rho = 1.94 \ slugs/ft^3 = 1000 \ kg/m^3$
$s = 1$

$$\mu = \frac{\tau}{\frac{dv}{dy}} ; pa \cdot sec \ \textit{Absolute Viscosity}$$
where
$\tau = lb/ft^2 \ or \ Pa$
$\mu = lb \cdot sec/ft^2 \ or \ Pa \cdot sec$
$y = ft \ or \ m$
$U = ft/s \ or \ m/s$

$$v = \frac{\mu}{\rho} ; m^2/s \ \textit{Kinetic Viscosity}$$
where
$\mu = Pa \cdot sec$
$\rho = kg/m^3$
note:
1 poise = 1 dyne $\cdot s/cm^2$
1 stroke = 0.0001 m^2/s
1dyne = $10^{-5}N$

$$p = \frac{4\sigma}{d} ; \frac{N}{m} \ \textit{Surface Tension } \sigma$$

$$h = \frac{4\sigma \cos\theta}{Sd} ; m \ \textit{Capillary}$$

$$h = \frac{4\sigma}{Sd} ; m \ \textit{Capillary (non circular)}$$

$$h = \frac{2\sigma \cos\theta}{\rho g r} ; m \ \textit{Capillary (tube)}$$

$$I_g = \frac{bh^3}{36} ; \textit{Triangle}$$

Flow rate
$Q = Av ; \textbf{Volume flow rate}$
$M = \rho Q ; \textbf{Mass flow rate}$
$W = \gamma Q ; \textbf{Weight flow rate}$
where
$Q = discharge ; m^3/s$
$A = cross - sectional \ Area \ m^2$
$v = velocity ; m/s$
$\rho = density ; kg/m^3$
$\gamma = weight \ density ; N/m^3$

$z ; \textit{Elevation Head}$

Column 2:

$$E_B = \frac{\Delta P}{\frac{\Delta V}{V}} ; MPa \ \textit{Bulk Modulus}$$

$$\beta = \frac{1}{E_B} ; \frac{1}{MPa} \ \textit{Compressibility}$$

$$\rho = \frac{P}{RT} ; \textit{Ideal Gas}$$
where
$P = absolute \ Pressure ; Pa$
$R = J/kg \ °K$
$T = °K$
$R = 287 \ J/kg \cdot °K) \ 1.716 \ lb \cdot ft/slug \cdot °R$
$°K = °C + 273 = °F + 460$

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} ; \textit{New Ideal Gas}$$

$$p_1 V_1 = p_2 V_2 ; \textit{Isothermal}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} ; \textit{Isobaric}$$

$$c = \sqrt{\frac{E_B}{\rho}} = \sqrt{\frac{1}{\beta r}} ; \textit{Pressure Disturbance}$$

$$P_{abs} = P_{gage} + P_{atm} \ \textit{Pressure abs}$$
$$P_{atm} = 101.325 \ kPa$$

$$p = \frac{F}{A} ; \ \textit{stress formula}$$

$$h = \frac{p}{\gamma} ; m \ \textit{Pressure Head}$$

$$F = pA ; N \ \textit{force on plane surface}$$

$$F = \gamma \bar{h} A \ \textit{Force}$$
$\bar{h} = distance \ from \ centroid$

$$F = pA ; N \ \textit{force on plane surface}$$

$$I_g = \frac{bh^3}{12} ; \textit{Triangle}$$

$$Q_1 = Q_2 = Q_3$$
$A_1 v_1 = A_2 v_2 = A_3 v_3 ; \textbf{Incompressible}$
$\rho_1 A_1 v_1 = \rho_2 A_2 v_2 = \rho_3 A_3 v_3 ; \textbf{Compressible}$
$\gamma_1 A_1 v_1 = \gamma_2 A_2 v_2 = \gamma_3 A_3 v_3 ; \textbf{Compressible}$

$$\frac{v^2}{2g} ; \textit{Velocity Head}$$

$$\frac{p}{\gamma} ; \textit{Pressure Head}$$

$$E = \frac{v^2}{2g} + \frac{p}{\gamma} + z ; \textit{Total Head}$$

Column 3:

$$T = \frac{PD}{2} ; \ \textit{Tensile Force}$$

$$S = \frac{PD}{2t} ; \ \textit{Tensile (thickness)}$$

$$P = \gamma_w h ; Kpa \ \textit{Pressure}$$

$$Bf = W ; \textit{Bouyancy Force}$$
$\gamma V = W$
$Bf = W_{obj} + W_{applied} ; \textbf{Total BF}$

$$\tan\theta = \frac{a}{g} ; \textit{Horizontal}$$

$$\tan\theta = \frac{a_h}{g \pm a_v} ; \textit{Inclined}$$

$$p = \delta h \left(1 \pm \frac{a}{g}\right) ; \textit{Vertical}$$

Note:
downward —
upward +
acceleration +
decceleration —

Rotating Vessels
$$y = \frac{\omega r^2}{2g} ; (radius)$$
$$y = \frac{\omega^2 x^2}{2g} ; (x \ is \ given)$$
where
$\omega = Angular \ velocity \ (rpm)$
$y = height$
note
$1 \ rev = 2\pi \ rad$
$1 \ \frac{rad}{sec} = \frac{30}{\pi} \ rpm$

$$P = Q\gamma E ; Power$$
$$\eta = \frac{Output}{Input} \times 100\% ; Efficiency$$
note
1 hp = 746 Watts = 550ft $\cdot$ lb/sec
1 watt = 1 N $\cdot$ m/s = 1 Joules/sec

$$RN = \frac{VD}{v} ; \textit{Reynolds Number}$$
Where
$V = Velocity$
$D = Inside \ Diameter$
$v = kinetic \ Density$
$$RN = \frac{\rho VD}{\mu}$$
where
$\rho = density$
$\mu = dynamic \ viscosity$
note
< 2100 — Laminar
> 2100 — turbulent

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