Problem 2.45

example 1.10 from Book Frank M.White.

Problem 1.26

either on FLtT or MLTΘ

(a) Power: $\frac{\text{Energy}}{\text{Time}} = \frac{\text{Force} \times \text{Distance}}{\text{Time}}$ $[\text{Power}] = FLt^{-1}$. $\frac{kg \cdot m^2}{s^3}$ or $\frac{slug \cdot ft^2}{s^3}$

(c)≡(b) Young's Modulus (E) MPa = Pressure = $\frac{\text{Force}}{\text{Area}}$ $[E] = FL^{-2}$ $\frac{kg}{m\,s^2}$ or $\frac{slug}{ft\,s^2}$

(d) Angular Velocity (rad/s) $= t^{-1}$ $1/s$

(e) Energy: $F \cdot L$ $\frac{kg \cdot m^2}{s^2}$ or $\frac{slug\ ft^2}{s^2}$

(f) Moment of a force: Force x Distance $F.L$ $\frac{kg \cdot m^2}{s^2}$ or $\frac{slug\ ft^2}{s^2}$

(g) Momentum = mass · velocity = $\frac{\text{Force}}{\text{acceleration}}$ · velocity = $[\text{Momentum}] = FL^2L^{-1}Lt^{-1} = F \cdot t$ $L\ \frac{kg\,m}{s}$ or $\frac{slug\ ft}{s}$

(h) Shear stress (pressure) $= FL^{-2}$

(i) Strain dimensionless distance/distance $[\text{Strain}] = 1$.

Problem 1.28

(a) $\frac{1\ lbf}{ft^2} = 47.88\ Pa$. (from table 1.2)

$\frac{1\ lbf}{ft^2} \cdot \left(\frac{1\ ft}{12\ in}\right)^2 = 47.88\ Pa \rightarrow \boxed{1\ N/m^2 = 1.45 \cdot 10^{-4} \cdot \frac{lbf}{in^2}}$

(b) $\boxed{1\ hp = 745.7\ W}$

(c) mass conversion $1\ kg = 2.204\ lbm$

heat conversion $1\ N \cdot m = 9.4782 \cdot 10^{-4}\ BTU$

$\frac{1\ Nm}{kg} = \frac{9.4782 \cdot 10^{-4}}{2.204}\ \frac{BTU}{lbm} \rightarrow \boxed{1\ \frac{Nm}{kg} = 4.299 \cdot \frac{BTU}{lbm}}$

Problem 2.5

$$\vec{V} = (Ax+B)\vec{i} - Ay\vec{j}$$

Streamline:

$$\frac{dx}{u} = \frac{dy}{v} \Rightarrow \frac{dx}{(Ax+B)} = \frac{dy}{-Ay} \xrightarrow{\text{integrate}} \frac{1}{A}\ln(Ax+B) = -\frac{1}{A}\ln y + C$$

$$\ln(Ax+B)^{1/A} = \ln[y^{-1/A}\cdot C_1] \xrightarrow[\exp(*)]{(*)} (Ax+B)^{1/A} = y^{-1/A}\cdot C_1 \Rightarrow (A+B)^{1/A} = 2^{-1/A}\cdot C_1$$

Streamline that passes through $(x,y) = (1,2)$

Find $C_1 = \dfrac{1}{2^{-A}(A+B)}$

Streamline function $y = \dfrac{2(A+B)}{(Ax+B)}$

Substitute A and B: $A = 10\,ft/s\,/\,ft$, $B = 3\,ft/s$

$$y = \frac{26}{10x+3}$$ (Streamline that passes through $[x,y] = [1,2]$ for different C_1.

$$y = \frac{C_1^{\,A}}{Ax+B}$$

Problem 2.1.

(1) $\vec{V} = \vec{V}(x) \rightarrow 1D$; $\vec{V} \neq \vec{V}(t) \rightarrow$ Steady

(2) $\vec{V} = \vec{V}(x) \rightarrow 1D$; $\vec{V} \neq \vec{V}(t)$ Steady

(3) $\vec{V} = \vec{V}(x) \rightarrow 1D$; $\vec{V} = \vec{V}(t) \rightarrow$ Unsteady

(4) $\vec{V} = \vec{V}(x,y) \rightarrow 2D$; $\vec{V} \neq \vec{V}(t)$ Steady

(5) $\vec{V} = \vec{V}(x,y) \rightarrow 2D$; $\vec{V} = \vec{V}(t) \rightarrow$ unsteady

(6) $\vec{V} = \vec{V}(x,z) \rightarrow 2D$; $\vec{V} \neq \vec{V}(t)$ Steady

(7) $\vec{V} = \vec{V}(x,y,z) \rightarrow 3D$; $\vec{V} \neq \vec{V}(t) \rightarrow$ Steady

(8) $\vec{V} = \vec{V}(x,y,z) \rightarrow 3D$; $\vec{V} = \vec{V}(t)$ unsteady.

Problem 2.14

$\vec{v} = ax(1+bt)\vec{i} + cy\vec{j}$

pathline for a particle:

$u = dx/dt = ax(1+bt) \rightarrow \frac{dx}{x} = a(1+bt)dt \rightarrow \ln x = a\left(t + \frac{bt^2}{2}\right) + C_1$

$v = dy/dt = cy \rightarrow dy/y = c\,dt \rightarrow \ln y = ct + C_2$

particle that passes through $(x,y) = (1,1)$ at $t = 0s$.

$x = C_1^* e^{a(t+bt^2/2)}$ | $1 = C_1^* e^{a(0+0)}$ $\quad C_1^* = 1$

$y = C_2^* e^{ct}$ | $1 = C_2^* e^{c0}$ $\quad C_2^* = 1$

$$\begin{bmatrix} x = e^{a(t+bt^2/2)} \\ y = e^{ct} \end{bmatrix} \quad a = c = 1\ s^{-1},\ b = 0.2\ s^{-1} \quad \begin{bmatrix} x = e^{t+0.1t^2} \\ y = et \end{bmatrix}$$

Streamlines:

$\frac{dx}{u} = \frac{dy}{v} \rightarrow \frac{dx}{ax(1+bt)} = \frac{dy}{cy} \rightarrow \frac{1}{a(1+bt)} \ln x = \frac{1}{c} \ln y + C_1$

$\ln x^{\frac{1}{a(1+bt)}} = \ln\left[y^{1/c} \cdot C_*\right] \rightarrow x^{\frac{1}{a(1+bt)}} = y^{1/c} \cdot C_*$

Streamline that passes through $(x,y) = (1,1)$: $C_* = 1$.

$$\left| y = x^{\frac{c}{a(1+bt)}} \right| \text{ for } t = 0s \quad y = x$$

$a = c = 1\ s^{-1}$, $b = 0.2\ s^{-1}$ $\rightarrow$ $t = 1s \quad y = x^{1/1.2}$

$t = 2s \quad y = x^{1/1.4}$