Homework

1.1 $F = C_D \cdot \rho \cdot V^2 \frac{A}{2} \rightarrow C_D = \frac{F \cdot 2}{\rho \cdot V^2 \cdot A} = \frac{ML T^{-2}}{(ML^{-3})(LT^{-1})^2(L^2)}$

$\rightarrow C_D = \frac{ML T^{-2}}{ML T^{-2}} = (M^{1-1})(L^{1-1})(T^{-2+2}) = M^0 L^0 T^0$

$\rightarrow C_D$ is dimensionless

1.2 $Ma = \frac{V}{\sqrt{kR'T}}$

$V = LT^{-1}$

k: dimensionless const

$T: \Theta$

$R' = \frac{R}{M} = \frac{P.V}{n.T.M} = \frac{\frac{F}{A}.V}{T.M} = \frac{FL}{TM} = \frac{(ML T^{-2})L}{\Theta . M} = \frac{L^2 . T^{-2}}{\Theta}$

$\rightarrow Ma = \frac{L.T^{-1}}{\sqrt{\frac{L^2.T^{-2}}{\Theta}.\Theta}} = \frac{L.T^{-1}}{\sqrt{\frac{L^2}{T^2}}} = L^0 . T^0 \rightarrow$ Ma is dimensionless

1.3 a) volume $= V = L \times L \times L = L^3$

in FLT system, $V = L^3$

in MLT system, $V = L^3$

b) acceleration $= a = \frac{v}{t} = \frac{\frac{s}{t}}{t} = \frac{s}{t^2} = \frac{L}{T^2}$

in FLT system, $a = L.T^{-2}$

in MLT system, $a = L.T^{-2}$

c) mass $= m = \frac{F}{a} = \frac{F}{L.T^{-2}} = F.L^{-1}.T^2$

in FLT system, $m = FL^{-1}T^2$

in MLT system, $m = M$

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d) moment of inertia = area × area = $L^2 \times L^2 = L^4$

in FLT system, moment of inertia = L^4

in MLT system, moment of inertia = L^4

e) work = $F.d = F.L = ma.L = M.LT^{-2}.L$

in FLT system, $w = FL$

in MLT system, $w = ML^2T^{-2}$

1.6 Given: u: velocity → $u = L.T^{-1}$

x: distance → $x = L$

t: time → $t = T$

a) $\frac{\partial u}{\partial t} = \frac{LT^{-1}}{T} = LT^{-2}$

b) $\frac{\partial^2 u}{\partial x \partial t} = \frac{LT^{-1}}{LT} = T^{-2}$

c) $\int \frac{\partial u}{\partial t} dx = \frac{LT^{-1}}{T} . L = L^2T^{-2}$

1.20 a) 10,2 in/min = 4,32 mm/s

b) 4,81 slugs = 70,2 kg

c) 3,02 lb = 13,4 N

d) 73,1 ft/s^2 = 22,3 m/s^2

e) 0,0234 $lb.s/ft^2$ = 1,12 $N.s/m^2$

1.28 Given:

$m = 500 kg$

$SG = 2$

$V = ?$

$\rho = SG . 1000 = 2000 (kg/m^3)$

$V = \frac{m}{\rho} = \frac{500}{2000} = 0,25 m^3$

1.44 Given: $P = 24 lb/in^2 = 3456 lb/ft^2$; $r = 4,67 in = 0,389 ft$

$T = 70°F = 529,67°R$

$V = \frac{4}{3}\pi . r^3 = \frac{4}{3}\pi (0,389)^3 = 0,247 ft^3$

$M = 28,96 g/mol = 1,9.10^{-3} slugs/mol$

$R = 8,314 \frac{J}{mol.K} = 3,404 \frac{ft.lb}{mol.°R}$

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ideal gas law: $P = \rho . R' . T$

$\rightarrow P = \frac{m}{V} . \frac{R}{M} . T \rightarrow m = \frac{P . V . M}{R . T}$

$\rightarrow m = \frac{(3456\ lb/ft^2)(0,247\ ft^3)(1,9.10^{-3}\ slugs/mol)}{(3,404\ ft.lb/mol.^\circ R)(529,67^\circ R)}$

$\rightarrow m = 8,99 \times 10^{-4}\ slugs$

1.93

$\rho = SG . 1000 = 1,5 . 1000 = 1500\ (kg/m^3)$

$c = \sqrt{\frac{E_v}{\rho}} \Rightarrow E_v = c^2 . \rho = 1500^2 . 1500 = 33,75.10^6\ N/m^2$