Netid: iabella Name: Abella, Isaac Section: B1X1 Seat #: 271 - 32 ExamID: 118

Module 1 Equation Sheet (you may use front and back of sheet)

Develop this equation sheet as you watch pre-lecture videos, attend lecture, and work homework.

Gravitational Forces

$F_g = G\frac{m_1 m_2}{r^2}$

F_g = attractive Force

m_1 = mass 1, m_2 = mass 2

R = distance between Centers of Mass of two objects

G = gravitational constant: $6.6742\times10^{-11}\ N\text{-}m^2/Kg^2$

Acceleration due to gravity, g

$g = \frac{W}{m} = \frac{F_g}{m}$

$g = \frac{W}{m} = \frac{F_g}{m} = G\frac{M_e}{r_e^2}$ M_e = mass of earth, r_e = radius of earth.

Moments (torque)

Moment = Force x Moment Arm

(Moment Arm is the perpendicular distance between the line of action of the force and point of interest)

- Perpendicular Moment: $|\bar{M}| = |\bar{F}||\bar{r}|$
- Component that is Perpendicular: $|\bar{M}| = |\bar{F}||\bar{r}|\sin\theta$

Materials

Stress: $\frac{F}{A}$ Force (F) divided by cross sectional area (A)

Strain: $\varepsilon = \frac{\Delta L}{L}$ Change in length (ΔL) divided by Original length (L) unitless

Young's Modulus: $\sigma = E\varepsilon$

load and Deformation Relationship (FLEA): $\Delta L = \frac{FL}{EA}$

Factor of Safety: $\frac{\text{Max. Strength}}{\text{Allowable load}} = \frac{\text{Yield Stress}}{\text{Applied Stress}}$

Density Pressure Bouyancy

Mass density: $\rho = \frac{m}{V}$ (rho)

ρ = density in rho

m = mass units: $\frac{Kg}{m^3}$ or g/cm^3

V = volume

Weight density: $\gamma = \frac{W}{V}$ W = weight, V = volume units: $\frac{lb}{ft^3}$ or $\frac{lb}{in^3}$

Specific Gravity:

$SG = \frac{\rho_{object}}{\rho_{water}} = \frac{\gamma_{object}}{\gamma_{water}}$ objects with an SG of less than 1 will float, greater than 1 will sink.

Water: ρ(rho) = 1000 Kg/m^3, $1g/cm^3$, 1.94 $Slug/ft^3$

$\gamma = 9810\ N/m^3 = 62.4\ lb/ft^3$

Pressure p

$p = \frac{F}{A}$ Force divided by area

Units: pascals: 1 Pa = 1 N/m^3; USC = lb/in^2 (PSI) or lb/ft^2 (PSF)

Gauge vs. Absolute vs. Atmospheric Pressure

Atm p = pressure at sea level / surrounding us : Patm = 101,300 Pa or 14.7 psi

Gauge = P_g = relative to atm pressure. $P_{abs} = P_g + P_{atm}$

Absolute = P_{abs} = sum of gauge pressure and atmospheric pressure

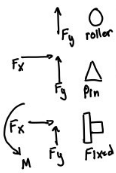
W = mg for SI units, English Units already in Weight.

Convert 1m to 1cm = 1m x 100cm

Convert 1m to 1mm = 1m x 1000

Convert 1m to 1Km = ÷ 1000

Support Structures



prevents movement vertically but allows rotation and translation horizontally

prevents vertical and horizontal movement but will allow rotation.

no translation in any direction and rotation.

Static Equilibrium

$\Sigma\bar{F} = 0$ $\Sigma\bar{F}_x = 0$

$\Sigma\bar{M} = 0$ $\Sigma\bar{F}_y = 0$

$\Sigma\bar{M}_z = 0$

1 Pa = 1 $\frac{N}{m^2}$ and PSI (lb/in^2)

1 P_a = 0.000145 PSI)

use kpa or mpa to solve

: 1 Pa → mPa : divide by 1e+6 or 10^6

1 Pa → kPa : divide by 1000

PSI to PSF = psi x 144

$\frac{pound}{in^2}$ $\frac{pound}{ft^2}$

Fluid Pressure Distribution

$F = \rho g y_c A$

ρ = density

y_c = distance from top of fluid to centroid

A = Cross sectional Area of object.

Bouyancy Force

$F_b = \rho_{fluid} g V$

ρ_{fluid} = mass density

g = gravity

V = volume : of object submerged in the liquid.

Pressure Variation with Depth

$P = \rho g d + P_0$

ρ = density of fluid

d = depth

P_0 = reference pressure at the surface.

hydrostatic Pressure

$P = \rho g h$ ρ = density

h = height g = gravity

density · gravity · height

Viscosity

Units: Pa-s (Poise)

1 poise = 1 g/cm-s

1 cP = 1 mPa-s

Eloss to Bernoulli's:

$E_{loss} = \frac{8 v \eta L}{r^2}$ v = velocity, η = viscosity, L = length of pipe, r = radius

Bernoulli's Flow Rate:

for horizontal pipes

$Q = \frac{\pi r^4 (P_1 - P_2)}{8\eta L}$ η = fluid viscosity, r = radius, $(P_1 - P_2)$ = Pressure drop

Stokes Law and Drag n = fluid viscosity

$F_{drag} = 6\pi n r V$ r = radius V = velocity.

Stability

Tipping: Place Normal force where object will tip.

Calculate Slope θ of tipping. $= \tan^{-1}\left(\frac{x}{y}\right)$

Summary:

- Sum the forces for Sliding. Check direction of friction force.
- Sum moments for tipping. Check the location of the origin point where you sum moments.

Mass Flow Rate:

If we know the volume of fluid and density of fluid we can find the mass.

$\rho = \frac{Mass}{Volume}$

Mass Flow Rate: $\dot{m} = \rho v A$

$\dot{m}$ = mass flow rate

ρ = density of fluid

v = velocity

A = Cross sectional Area

Continuity Equation: $V_1 A_1 = V_2 A_2$

V = Velocity of fluid

A = Cross Sectional Area of fluid flow

Volumetric Flow Rate: Q = vA.

Q = Volumetric flow rate

V = velocity of fluid

A = Cross Sectional Area

Bernoulli's Principle

used for pressure, velocity, and height variations in a system.

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

P = pressure at a defined location

ρ = density of fluid

v = speed of fluid at one location

h = height of fluid at defined location (height is measured from datum)

P_1 and P_2 must be absolute or gauge

Drain time

$V_2 = \sqrt{2gh}$

$V_1 = \sqrt{2gh} \cdot \frac{A_2}{A_1}$

$t_f = \frac{A_1}{A_2}\sqrt{\frac{2h_0}{g}}$

t_f = time final

A_1 = Cross Sectional Area of tank

A_2 = Cross Sectional area of drain

h_0 = height. g = gravity