Instructions:

Answer 3 out of the 6 questions.

No extra credit will be given for more than three answers. If more than three questions are attempted, CLEARLY indicate which questions are to be graded, otherwise only the first three answers will be graded, and the rest ignored.

Show all calculation steps to ensure that partial credit is earned, even if the final answer is incorrect. In cases where the answer is obviously wrong, some credit will be given if you identify this as an improbable answer.

If you make any assumptions, clearly state these assumptions. If you run out of time briefly describe how you would answer the remaining questions, to receive partial credit

You may use a single page of notes for reference during the test. The equations below will be given

Statistics

Mean = $1/N * \sum X_i$, Std Dev = $\{1/(N-1) * [\sum(X_i^2)-1/N*(\sum X_i)^2]\}^{0.5}$

Draft Forces

$$D = F_i[A+B(S)+C(S)^2]WT$$

Tillage Forces:

$D = F_o*[\sin(\varsigma)+\mu'\cos(\varsigma)] + C_\alpha A_0 \cos(\varsigma) + kb$ Where: $\mu = \tan(\Phi)$, and $\beta = (90-\Phi)/2$

$D^* = W/Z + [CA_1+B]/\{Z*[\sin(\beta)+ \mu\cos(\beta)]\}+ [C_\alpha A_0]/\{Z*[\sin(\varsigma)+\mu'\cos(\varsigma)]\}$

$Z = [\cos(\varsigma)-\mu'\sin(\varsigma)]/[\sin(\varsigma)+\mu'\cos(\varsigma)] + [\cos(\beta) - \mu\sin(\beta)]/[\sin(\beta)+ \mu\cos(\beta)]$

$F_o = [D^* - C_\alpha A_0 \cos(\varsigma)] /[\sin(\varsigma)+\mu'\cos(\varsigma)]$ γ = Bulk density (kg/m^3)

$A_1 = d*b/\{\sin(\beta)\}$ b = tool width (m)

$A_0 = b*L_o$ d = depth (m)

$\mathbf{W = g*\gamma*b*d^\ddagger * [L_o+(L_1+L_2)/2]}$ $d^\ddagger = d*[\sin(\varsigma+\beta)]/ \{\sin(\beta)\}$

$\mathbf{B = \gamma*d*b*(V_0)^2*[\sin(\varsigma)]/[\sin(\varsigma + \beta)]}$ $L_1 = d*[\cos(\varsigma+\beta)]/ \{\sin(\beta)\}$

g = gravity $L_2 = d^\ddagger *\tan(\varsigma)$

(Note: Equations for **W** and **B** in the textbook are incorrect for metric units. In the text the formula for W omits g, and then in formula for B divides by g. Check units and you will see that the above equations are correct if you want to find W, and B in terms of forces (Newton).)

Orifice Flow:

$Q = -.0342 + 770 A_n* (g*D_e)^{(0.5)}$ Where: $D_e=D-k*d$ (circular)

$a'=a-k*d$, $b'=b-k*d$, $D_e = 0.5*a'*b' /(a'+b')$ (rectangular)

Rotary Spreader

$\{ (C_1+f)\exp[C_2*(C_1-f)*\theta] + (C_1-f)\exp[-C_2*(C_1+f)*\theta] \}/\{2*C_1\}$

$= \{ r_o - (C_3*g)/(C_4*\omega*\omega) \} / \{ C_5 r_i - (C_3*g)/(C_4*\omega*\omega) \}$

$V_r = \{C_4*\omega/C_2\}* \{[r_i - (C_3*g)/(C_4*\omega*\omega)]/[(2*C_1)]\}* \{\exp[C_2*(C_1-f)*\theta] - \exp[-C_2*(C_1+f)*\theta] \}$

$V_{hr} = \{ [V_r*\cos(\alpha)*\cos(\gamma)]^2 + [r_o*\omega + V_r*\cos(\alpha)*\sin(\gamma)]^2 \}^{0.5}$

$\beta = \text{atan} \{ [V_r*\cos(\alpha)*\cos(\gamma)]/[r_o*\omega + V_r*\cos(\alpha)*\sin(\gamma)]\}$

$V_v = V_r * \sin(\alpha)$

Where :

$C_1 = (f*f + C_4/C_2)^{0.5}$ $C_2 = \cos(\alpha)$ $C_3 = \sin(\alpha) + f*\cos(\alpha)$

$C_4 = \cos(\alpha) - f*\sin(\alpha)$ $\gamma = \text{atan} [r_i *\tan(\varsigma)/(r_o - r_i)]$

Drag Forces

$D_f = [C_d*\rho_a*A*V*V]/ 2$

$C_d = 24/N_{re}$ (N_{re}=<1) $C_d = 26.38*N_{re}^{(-.845)} + .49$ (N_{re}>1)

$N_{re} = \rho_a*V*D_p / \mu_a$

$\mu_a = 4.79*10^{-6} \exp (0.678 + 0.00227*T)$ (Note T= Temperature in degrees Kelvin)

$\rho_a = P / [(8.314/29) * T]$