AE 340, Fall 2007 **Test Exam 1** Name_____

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

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

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)

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

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

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

(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)

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

Question 1: A soil sample is taken from a field prior to tillage. The dry bulk density of the soil is 1.71875 g/cc, and the degree of saturation is 80%. The particle density is 2.7 g/cc. Determine:

i). The porosity and void ratio of the sample.

ii). The mass of soil and water in 1 cc of bulk sample.

iii). The wet bulk density and water content of the soil.

After tillage the total void volume increases by 40%. After a period of time the moisture content of the tilled soil is 16%. A second soil sample is taken from a field. (The particle density does not change.) Determine:

iv). The total volume of bulk tilled soil occupied by 1.71875 g of dry soil.

v). The mass of water in the total volume of soil found in part (iv).

vi). The porosity and void ratio of the tilled soil sample.

vii). The degree of saturation of the tilled soil sample.

viii). The dry and wet bulk density of the tilled soil sample.

Question 2: The tillage tool operates in the soil at 10.8 km/h. The tine is 25 cm wide and operates at a depth of 50 cm. The tine is inclined at an angle of 25 degrees from horizontal. The effective length of the tine is 50cm. The tine operates in a soil with a bulk density of 1500 kg/m^3. The internal friction angle (Φ) of the soil is 45 degrees and the cohesion (c) of the soil is 200 Pa. The soil/metal friction coefficient is 0.3 and the soil/metal adhesion is 50 Pa.

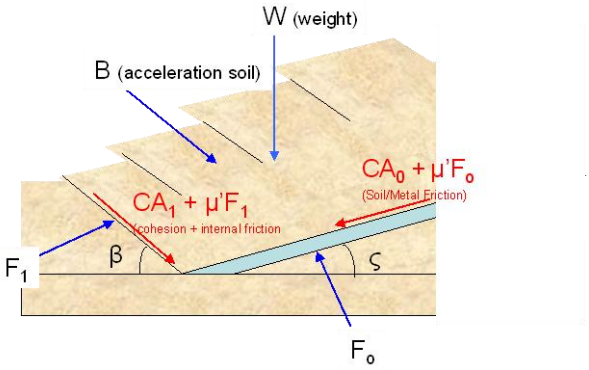
Ignoring any cutting force and any draft effect of the supporting shank, determine the following for a single tine.

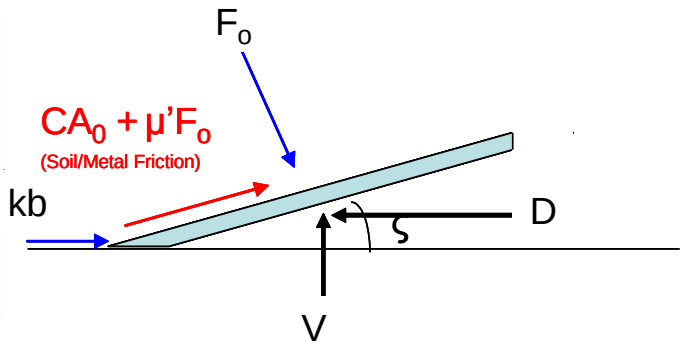
i). The specific draft for a single tine.

ii). The vertical force of the tine.

If a tractor capable of 100 kW drawbar horsepower is used to pull an implement with a number of these tines.

iii). What is the maximum number of tines that can be placed on the implement (Velocity =10.8 km/h)





Question 3: Part i). Consider a 20-foot (6.1 m) wide tandem disk harrow operating 6 inches (15 cm) deep at 6 mph (10 km/hr) in medium soil. Determine the following:

a) Specific draft.
b) Drawbar power required.

Part ii) You are to advise a farmer about the size of a narrow point subsoiler for primary tillage and field cultivator for secondary tillage for a John Deere 7920 tractor, with 175 PTO hp (130 kW). The subsoiler tools are spaced 20" (50 cm) and the field cultivator tines are on a 15" (38 cm). The required depth of operation is 16" (40 cm) for the subsoiler and 4" (10 cm) for the field cultivator. The tractive efficiency for this tractor under primary tillage conditions is estimated to be 85% and under secondary tillage is 75%. Conditions in the field limit the primary tillage speeds to 5 mph (8 km/h) and secondary tillage to 7 mph (12 km/h). The soil is a fine textured for both operations. The disk is to be used for secondary tillage. The farmer's questions in regard to the plow are:

a) What size subsoiler should I purchase for the tractor?
b) Determine the drawbar power for the subsoiler purchased during operation.
c) What size field cultivator (width) should I purchase?
b) Determine the drawbar power for the cultivator purchased during operation.

Table 1 – Draft parameters and an expected range in drafts estimated by the model parameters for tillage and seeding implements

Implement	SI Units				English Units				Soil Parameters			Range
		Machine Parameters				Machine Parameters						
	Width units	*A*	*B*	*C*	Width units	*A*	*B*	*C*	F_1	F_2	F_3	±%
MAJOR TILLAGE TOOLS												
Subsoiler/Manure Injector												
narrow point	tools	226	0.0	1.8	tools	129	0.0	2.7	1.0	0.70	0.45	50
30 cm winged point	tools	294	0.0	2.4	tools	167	0.0	3.5	1.0	0.70	0.45	50
Moldboard Plow	m	652	0.0	5.1	ft	113	0.0	2.3	1.0	0.70	0.45	40
Chisel Plow												
5 cm straight point	tools	91	5.4	0.0	tools	52	4.9	0.0	1.0	0.85	0.65	50
7.5 cm shovel/35 cm sweep	tools	107	6.3	0.0	tools	61	5.8	0.0	1.0	0.85	0.65	50
10 cm twisted shovel	tools	123	7.3	0.0	tools	70	6.7	0.0	1.0	0.85	0.65	50
Sweep Plow												
primary tillage	m	390	19.0	0.0	ft	68	5.2	0.0	1.0	0.85	0.65	45
secondary tillage	m	273	13.3	0.0	ft	48	3.7	0.0	1.0	0.85	0.65	35
Disk Harrow, Tandem												
primary tillage	m	309	16.0	0.0	ft	53	4.6	0.0	1.0	0.88	0.78	50
secondary tillage	m	216	11.2	0.0	ft	37	3.2	0.0	1.0	0.88	0.78	30
Disk Harrow, Offset												
primary tillage	m	364	18.8	0.0	ft	62	5.4	0.0	1.0	0.88	0.78	50
secondary tillage	m	254	13.2	0.0	ft	44	3.8	0.0	1.0	0.88	0.78	30
Disk Gang, Single												
primary tillage	m	124	6.4	0.0	ft	21	1.8	0.0	1.0	0.88	0.78	25
secondary tillage	m	86	4.5	0.0	ft	15	1.3	0.0	1.0	0.88	0.78	20
Coulters												
smooth or ripple	tools	55	2.7	0.0	tools	31	2.5	0.0	1.0	0.88	0.78	25
bubble or flute	tools	66	3.3	0.0	tools	37	3.0	0.0	1.0	0.88	0.78	25
Field Cultivator												
primary tillage	tools	46	2.8	0.0	tools	26	2.5	0.0	1.0	0.85	0.65	30
secondary tillage	tools	32	1.9	0.0	tools	19	1.8	0.0	1.0	0.85	0.65	25
Row Crop Cultivator												
S-tine	rows	140	7.0	0.0	rows	80	6.4	0.0	1.0	0.85	0.65	15
C-shank	rows	260	13.0	0.0	rows	148	11.9	0.0	1.0	0.85	0.65	15
No-till	rows	435	21.8	0.0	rows	248	19.9	0.0	1.0	0.85	0.65	20
Rod Weeder	m	210	10.7	0.0	ft	37	3.0	0.0	1.0	0.85	0.65	25
Disk-Bedder	rows	185	9.5	0.0	rows	106	8.7	0.0	1.0	0.88	0.78	40
MINOR TILLAGE TOOLS												
Rotary Hoe	m	600	0.0	0.0	ft	41	0.0	0.0	1.0	1.0	1.0	30
Coil Tine Harrow	m	250	0.0	0.0	ft	17	0.0	0.0	1.0	1.0	1.0	20
Spike Tooth Harrow	m	600	0.0	0.0	ft	40	0.0	0.0	1.0	1.0	1.0	30
Spring Tooth Harrow	m	2,000	0.0	0.0	ft	135	0.0	0.0	1.0	1.0	1.0	35
Roller Packer	m	600	0.0	0.0	ft	40	0.0	0.0	1.0	1.0	1.0	50
Roller Harrow	m	2,600	0.0	0.0	ft	180	0.0	0.0	1.0	1.0	1.0	50
Land Plane	m	8,000	0.0	0.0	ft	550	0.0	0.0	1.0	1.0	1.0	45
SEEDING IMPLEMENTS												
Row Crop Planter, prepared seedbed												
mounted												
seeding only	rows	500	0.0	0.0	rows	110	0.0	0.0	1.0	1.0	1.0	25
drawn												
seeding only	rows	900	0.0	0.0	rows	200	0.0	0.0	1.0	1.0	1.0	25
seed, fertilizer, herbicides	rows	1,550	0.0	0.0	rows	350	0.0	0.0	1.0	1.0	1.0	25
Row Crop Planter, no-till												
seed, fertilizer, herbicides												
1 fluted coulter/row	rows	1,820	0.0	0.0	rows	410	0.0	0.0	1.0	0.96	0.92	25
Row Crop Planter, zone-till												
seed, fertilizer, herbicides												
3 fluted coulters/row	rows	3,400	0.0	0.0	rows	765	0.0	0.0	1.0	0.94	0.82	35
Grain Drill w/press wheels												
< 2.4 m drill width	rows	400	0.0	0.0	rows	90	0.0	0.0	1.0	1.0	1.0	25
2.4 to 3.7 m drill width	rows	300	0.0	0.0	rows	67	0.0	0.0	1.0	1.0	1.0	25
> 3.7 m drill width	rows	200	0.0	0.0	rows	25	0.0	1.0	1.0	1.0	1.0	25
Grain Drill, no-till												
1 fluted coulter/row	rows	720	0.0	0.0	rows	160	0.0	0.0	1.0	0.92	0.79	35
Hoe Drill												
primary tillage	m	6,100	0.0	0.0	ft	420	0.0	0.0	1.0	1.0	1.0	50
secondary tillage	m	2,900	0.0	0.0	ft	200	0.0	0.0	1.0	1.0	1.0	50
Pneumatic Drill	m	3,700	0.0	0.0	ft	250	0.0	0.0	1.0	1.0	1.0	50

Question 4: In a triaxial test, a soil sample was tested under different consolidation stresses of 250 and 500 kPa. The soil has cohesion of 80 kPa and an internal friction angle of 25 degrees.

i). The maximum shear stress at which the specimen will fail under these two conditions.

ii) A 2WD tractor with single tires on the rear was used to pull a tillage tool through the field. Each rear tire has a soil surface contact area 0.15 m^2 and the total weight of tractor is 5000 kg (50000N), with 60% of the total weight on the rear axle. The tractor is operating such that each rear tire carries the same vertical load, and the tillage tool does not transfer any vertical forces onto the tractor. What is the maximum horizontal draft force the tractor can achieve, assuming the tires generate the maximum shear stress the soil can withstand. (You may ignore any rolling resistance forces on front & rear tires)

iii) The maximum drawbar power the tractor can generate at 7.2 km/h.

Question 5: A seeder is used to broadcast wheat at a travel velocity of 18 km/hr, with a 30 m swath width, through a rectangular orifice opening. The orifice is size is a 25 mm by 50 mm The following information of wheat is provided.

Bulk Density .68 kg/L,	Seed Count 22,500 seeds/L,
Germination rate 90%,	Mean Diameter 4.10 mm,
Seed Density 1120 kg/m^3,	Terminal Velocity 9.81 m/s

Determine:

i). Determine the theoretical flowrate through the orifice.

ii). Calculate the theoretical application rate at this velocity.

iii). Determine the actual population of wheat after germination.

Question 6: A centrifugal seeder is used to broadcast alfalfa seeds. The following information of alfalfa is provided.

Bulk Density .77 kg/L, Seed Count 339,000 seeds/L,
Germination rate 80%, Mean Diameter 1.53 mm,
Seed Density 1184 kg/m^3, Terminal Velocity 5.69 m/s

The following spreader information is provided

Internal radius of the spinner disk 0.15m
Outer radius of the spinner disk 0.30m
Co-efficient of friction 0.33, Rotation speed of spreader = 500 rpm
Blade angle (δ) = 0.0 radians, Disk angle (α) = 0.25 radians

Determine:

i). The angle of disk rotation before the seed leaves the disk. Assume that the seed fall on the disk inner radius along the x-axis, where the x-axis is in the direction of travel.
ii). The velocity of the seeds with respect to the blades at the outer edge of the disk.
iii). The tangential velocity of the disk.
iv). The horizontal (V_{hr}) and vertical component (V_v) of the velocity of the seed.
v). The horizontal velocity of the seed in the direction of travel (Vx) and perpendicular (Vy) to the direction of travel.

Question 7: A centrifugal seeder is used to broadcast orchard grass seeds. The seeds leave the spinning disk at a height of .5m, with a horizontal velocity of 20m/s and a vertical velocity of 2.5 m/s (upwards). The following information of orchard grass is provided.

Bulk Density .18 kg/L, Seed Count 259,000 seeds/L,
Germination rate 55%, Mean Diameter 1.59 mm,
Seed Density 440 kg/m^3, Terminal Velocity 3.37 m/s

Assume the density of the air 1.2 kg/m^3, and the viscosity of the air is $1.835*10^{-5}$ N.s/m^2

Determine:

i). Determine the horizontal and vertical acceleration of the seed at the instant it leaves the disk. Assuming that the horizontal and vertical accelerations of the seed does not change significantly in a short time period, and therefore is constant over the first 0.1 second interval after leaving the disk.

ii). Determine the horizontal and vertical velocity of the seed after 0.1 seconds.

iii). Determine the distance the seed will travel in the horizontal and vertical direction over this 0.1 second interval after leaving the disk.

Question 6: A precision planter is used to plant corn in 76.2 cm rows (30"), traveling at 7.2 km/h (4.5 mph). The rolling radius of the planter wheel is 0.50 m (20") and under the conditions in the field the wheel slip is 5%. The gear ration between the planter seed plate and the planter wheel is such that the seed plate is rotating at 1.5 times the speed of the wheel. The seed plate has 12 cells per revolution (i.e. 12 seeds per revolution).

Determine:

i). The actual rotation speed of the wheel accounting for wheel slip.

ii). The rotation speed of the planter plate.

iii). What is the planting population achieved in this field.

iv). If the germination rate after planting is 90%, what is the final population after germination.