AE 340, Fall 2006 **Example Exam 2** Name____________________

Please find below examples of the topics and types of question that will be in exam 2. I strongly suggest you work through the problems. Unfortunately, I will not have any time to provide solutions.

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

This will also be an Open Book Exam. (Please do not consider open book to mean "I do not have to study." You will find that this assumption will tend to cause you to run out of time)

Rotary Spreader

$$\{ (C_1+f)\exp[C_2*(C_1-f)*\theta] + (C_1-f)\exp[-C_2*(C_1+f)*\theta] \}/\{2*C_1\} = \{ r_o - (C_3*g)/(C_4*\omega*\omega) \} / \{ C_5\, r_i - (C_3*g)/(C_4*\omega*\omega) \}$$

$$V_r = \omega/(2*C_1) * \{ C_5\, r_i - (f*g)/(\omega*\omega) \} * \{\exp[C_2*(C_1-f)*\theta] - \exp[-C_2*(C_1+f)*\theta] \}$$

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

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

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

Where :

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

$C_4 = \cos(\alpha) - f*\sin(\alpha)$ $C_5 = \cos(\varsigma) - f*\sin(\varsigma)$ $\gamma = \mathrm{atan}\ [r_i *\tan(\varsigma)/(r_o - r_i)]$

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 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) = 0.1 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 2: A centrifugal seeder is used to broadcast orchard grass seeds. The seeds leave the spinning disk at a height of 1m, with a horizontal velocity of 10 m/s at 45 degree angle to the line of travel (towards the rear), and a vertical velocity of 0.5 m/s. The following information of orchard grass is provided.

Bulk Density	0.18 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). The magnitude of the vertical and horizontal drag forces at the time the particle leaves the spinning disk.
ii). The magnitude of the vertical and horizontal acceleration of the particle when it leaves the disk.
iii). Assuming that the mean vertical acceleration is 50% of that found in part (ii) (and to simplify calculations is assumed to be constant), determine the time it takes to seed to reach the ground.
ii). If the mean horizontal acceleration is 50% of that found in part (ii) determine the horizontal location (x,y), (x direction of travel, y perpendicular to direction of travel) at which the seed hits the ground.

Question 3: The boom on a sprayer is equipped with 12 nozzles spaced 50 cm (20 inches) apart. The sprayer mixture contains 0.01 kg of active ingredient per liter of water (0.08 lb/gal). The product must be applied such that 3 kg/ha (2.5 lb/acre) of active ingredient is applied. The desired ground speed is 14.4 km/hr (9 mph). The available nozzle orifice diameter is 1.0 mm (0.04 in) and is this capable of providing 0.15 l/min (0.40 gal/min) at 350 kPa (50 psi). (Note 128 fluid oz = 1 gal)

a) What is the required flow rate from each nozzle in liters per minute (gal/min)?

b) What pressure is required at the nozzle to obtain the correct flowrate.

c) What is the total pump flowrate required for this application rate.

d) The sprayer tank is 2 m (80in) long and 1.5 m (60in) in diameter. A mechanical agitation system is used that is 30 cm (12in) above the bottom of the tank, and the combined width of the paddles is 10% of the tank length. The paddles lengths are 25 cm (8 in).Determine the minimum peripheral speed of the paddles and the power required to drive the paddles assuming a 1 % emulsion.

e) Assume that the pump operates at a pressure of 400 kPa (60 psi) before the pressure regulation to control nozzle flowrate. The volumetric efficiency of the pump is 0.70 and the mechanical efficiency is 0.85. What is the power required to drive the pump?

Question 4: A sprayer is required to provide a total application rate of 200 liters per hectare (20 gal/a), at a ground speed of 21.6 km/hr (13.5 mph), with 50 cm (20 in) nozzle spacing, and a 27m (90ft) swath width. The available nozzle orifice diameter is 1.0 mm (0.04 in) and is this capable of providing 3.0 l/min (0.8 gal/min) at 300 kPa (40 psi). At this pressure the volume median diameters of the spray droplets are 300 µm (0.010 in).

a) What is the required flow rate from each nozzle in liters per minute (gal/min)?

b) What pressure is required at the nozzle to obtain the correct flowrate.

c) Assuming that the full sprayer tank holds 2000 L gallons (500), determine the minimum re circulation flowrate required for hydraulic agitation of the tank for oil-water emulsions (10% oil).

d) Assume that the pump operates at a pressure of 50 kPa (80 psi) before the pressure regulation to control nozzle flowrate. The volumetric efficiency of the pump is 0.70 and the mechanical efficiency is 0.85. What is the total power required to drive the pump?

After a period of operation the orifice diameter increases by 15%.

e) What is the new flow rate from each worn nozzle in liters per minute (gal/min)?

f) What is the new volume median diameter of the spray droplets.

g) What is the application rate for the worn nozzles.

Question 5: A sprayer is required to provide a total application rate of 300 liters per hectare (30 gal/a), at a ground speed of 20 km/hr (12 mph), with 40 cm (16 in) nozzle spacing. An extended range XR8004 Flat Fan Nozzle provides 1.44 l/min (51 oz/min) at a pressure of 250 kPa(40 psi). At this pressure the volume median diameters of the spray droplets are 300 µm (0.010 in).

a) What is the required flow rate from each nozzle in liters per minute (gal/min)?

b) What pressure is required at the nozzle to obtain the correct flowrate.

After a period of operation the pressure gauge becomes faulty and the operating pressure increases by 25%.

c) What is the new flow rate from each nozzle in liters per minute (gal/min)?

d) What is the new volume median diameter of the spray droplets.

e) What is the application rate for the worn nozzles.

f) On a spray table, the following "normalized" distribution data was collected for one of these nozzles, in 5cm length increments: Determine the coefficient of variation for the "whole" sprayer assuming all nozzles are identical, and on a 40 cm (16 in) spacing.

f) The operator notices that the spray pattern is incorrect and changes nozzle spacing to 60 cm (24 in). Determine the coefficient of variation for the "whole" sprayer assuming all nozzles are identical, and on a 60 cm (24in) spacing.

	Distance from Center of Nozzle														
cm	35	30	25	20	15	10	5	0	5	10	15	20	25	30	35
(in)	14	12	10	8	6	4	2	0	2	4	6	8	10	12	14
Application Vol. (Single)	0	0.2	0.4	0.6	0.8	1.0	1.0	1.0	1.0	1.0	0.8	0.6	0.4	0.2	0

<u>Question 6:</u> The following data was collected from a field test for corn with a 12 row rotary self-propelled combine, (0.762m or 30 in rows). The gross yield on the field was 10 Mg/ha (160 bu/acre) and the MOG/Grain ratio during harvest was 0.40. The combine traveled at 7.2 km/h (4.5 mph). The measured losses were as follows:

Preharvest Loss 0.75%, Header Loss 0.1%, Threshing Losses 1.25%, Cleaning Losses 2%

Determine the following information

(a) The total mass of grain per hectare (acre) on the ground prior to harvest.
(b) The total mass of grain per hectare (acre) on the ground after header passes over the ground
(c) The total mass of grain per hectare (acre) on the ground after the combine passes over the ground
(d) The mass flowrate of unthreshed corn leaving the rear of the combine
(e) The mass flowrate of threshed corn leaving the rear of the combine
(f) The mass flowrate of corn measured by a grain yield monitor entering the grain bin.

<u>Question 7:</u> A combine is harvesting corn, with a 8-row head in 0.762 (30 in) rows at 7.2 km/h (4.25 mph). The yield in the field is 10 000 kg/ha, (160 bu/acre) and the MOG/Grain ratio is 0.30. Under these conditions, 75% of the grain is separated at the cylinder concave and the total separator losses are 5%.

a) Determine the grain separation losses in the walker
b) Estimate the length of walkers that will achieve these losses.
c) If the walker length was increases by 25%, what will be the estimated percent separation losses from the machine assuming the cylinder concave operations does not change.

<u>Question 8:</u> A combine fitted with a 12 row corn head (0.762m or 30 inch rows) is used to harvest corn at 7.2 kph (4.5 mph). The MOG feedrate is 350 kg/min (160 lb/min) and the MOG/grain ratio is 0.25. Assume that 50% of the grain is separated by the cylinder.

(i) Determine the grain flowrate into the combine, and corn yield.
(ii). Calculate the length of the length of the straw walker required to achieve grain separation losses less than 1% (Total grain basis)
(iii). If the combine is fitted with a 2.5 m long straw walker determine the expected separator loss as a percentage of total grain flow.
(iv). If the corn price is \$100/tonne (\$2.50 bu), calculate the cost of the lost grain in terms of dollars per hectare (acre).
(v) If the MOG/grain ratio is increased to 0.40, without changes in field yield (MOG feed rate changes), what would be the expected separator loss as a percentage of total grain flow with a 2.5 m long straw walker.