AE 340, Fall 2006 **Test Exam 2** 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. I strongly suggest that you use metric units due to the text book. Open text, open notes.

Question 1: An alfalfa plant with stem diameter 2.00 mm is to be impact cut 20 mm above the soil. The modulus of elasticity is 1500 N/mm^2 and the ultimate tensile strength is 35 N/mm^2

a) Determine the horizontal force required that would cause the plant to fail in bending assuming the plant acts as a cantilever beam.

b) Determine the horizontal deflection of the plant at failure.

The mass of the plant above the cut is 0.015 kg and cutting occurs when the knife pressure is 30 N/mm^2. The knife bevel angle is 15 degrees and the clearance angle is 5 degrees, with an edge radius of 0.25 mm. The bulk modulus of the material 10 N/mm^2 and co-efficient of friction 0.4. Assume the exponent =1.5.

c) Calculated the knife force to achieve cutting, at the point at which the knife is 1 mm into the stalk..

d) The minimum knife speed required for impact cutting.

Question 2: A forage harvester is to harvest silage, with a yield of 10 Mg/ha, at a harvest speed of 10.8 kph, cutting a 3 m swath. The harvester has 4 knives and the rotational speed of the cutter is 1000 rpm. The nominal required cut length is 12 mm. The diameter of the cutter head is 400mm and is 500 mm wide. The compressed corn silage density is 360 kg/m3, and the specific cutting energy is 15 J.m/kg. The coefficient of friction between the forage and housing is 0.5 and the material travels in a 120 arc before exiting the housing.

a) Calculate the peripheral speed required for the feed rolls into the cutter head.

b) The thickness of the material mat flowing into the cutter head.

c) Determine the total power requirements for this forage harvester under these conditions, accounting for all the different power consuming processes.

d) If the height of the inlet opening to the cutter head is 250mm, determine the maximum feedrate capacity of the cutter.

e) What is the maximum forward travel velocity that can be achieved at this feedrate.

Question 3. A combine with a 9000 kg (360 bu) grain tank and a sixteen-row corn head, is capable of harvesting corn at 7.2 km/h (4.5 mph). The corn is yielding 12.5 Mg/ha (200 bushels/ac) and is in 800m (1/2 mile) rows, and in 0.762 m (30 inch) row spacing. The average travel distance to the trucks for offloading is 400m (1/4 mile). The average turn time at the end of field rows for the combine is 30 seconds. A single 25000kg (1000 bu) grain wagon is available, capable of traveling 10.8 km/h (6.75 mph) in the field. In addition it takes 30 seconds to position the wagon at the truck before unloading and 20 seconds for the wagon to match the combine speed before unloading the grain tank may begin. The unloading rate of the wagon is 12500 kg/min (500 bu/min).

a) Determine the theoretical Field Capacity, Effective Field Capacity and Field Efficiency in terms of ha/hr (ac/hr) and Mg/hr (bu/hr) for the combine accounting for all inefficiencies for both operations (combine & wagon)

Question 4.

a) Assume a farmer starts has to plant 600 acres (250 ha) of corn Maximum corn yield in the location occurs when corn is planted from May 1 to May 10. For corn planted after May 10 the expected yield decrease is 1 bushel per acre (62.5 kg/ha) per day. If the weather allows an average planting rate of only 40 acres per day (15 ha/day).

(i) If you start planting on May 1, what is the timeliness penalty in bushels (kg) of corn?

(ii) If the price of corn is $2.50 per bu ($100 per Mg) what is the average timeliness in $/ac ($/ha)

b) A chisel plow overall implement width is 26 ft (7.8 m), and operates with a 1 foot (30 cm) overlap during operation. The tractor is capable of pulling the tool at 5.5 mph (9 km/h) and the field is 1/4 mile (440m) in length. Turns at headlands take 15 seconds and on average 2 minutes per hour is wasted in unproductive time.

i) Determine the theoretical Field Capacity, Effective Field Capacity and Field Efficiency in terms of ha/hr (ac/hr).

ii) If the probability of a working day is 0.75 and the chisel plow is operated on average for 10 hours a day, how many days will be taken to complete tillage of 2500 acres (1000 ha)

Question 5.

b) A 135 kW (180 Hp) tractor is purchased for $150,000. The tractor total annual use is 500 hours. The tractor is partly used to plant 400 ha (1000 acres) of soybeans, with an average planting rate of 15 ha (40 acres) in a ten hour day. The interest rate is 8% per annum and inflation is 1% per annum. Assume the annual charge for housing, taxes, and insurance is 5% of the remaining farm value at the beginning of the year. The labor costs are $10/hr and diesel fuel cost $0.50/l ($2.00/gallon). The engine operates at 60% of rated power and you may assume that the cost of oil and lubrication costs may be ignored. Assume that for repairs and maintenance RF1 = 0.007 and RF2 is 2.0. Assume that the remaining farm value, RFV (i.e Salvage value) of the machine can be found from the following:

$$RFV = LP * 0.68 * (0.92)^{y}$$

Where: RFV = remaining farm value, $,
LP = purchase price, $,
y = machine age, years

i) Estimate the total ownership costs per annum for the tractor, for the first year after purchase

ii) Estimate the total ownership costs per ha for planting the soybeans, , for the first year after purchase

iii) Estimate the tractor operating costs per ha for planting the soybean.

iv) Estimate the total tractor planting costs per ha

Question 6. A self-propelled combine rates at a maximum power of 300kW (400Hp) with a sixteen-row corn head, is capable of harvesting corn at 7.2 km/h (4.5 mph). The corn is yielding 10 Mg/ha (160 bushels/ac) and in 0.762 m (30 inch) row spacing. The field efficiency of the combine is 65%.

a) Determine the theoretical and actual field capacity of the combine (ha/hr, ac/hr).

The combine purchase price is $450,000 and has an expected life of 8 years. The interest rate is 8% and inflation is at 2%. The salvage value of the machine after 8 years is 10% of the purchase price. Cost of taxes, insurance and housing is 2% of the purchase price per annum. The labour costs are $10/hr and diesel fuel cost $0.50/l ($2.00/gallon). The engine operates at over 80% of rated power and you may assume that the cost of oil and lubrication costs may be ignored. Assume that for repairs and maintenance RF1 = 0.08 and RF2 is 2.1. The combine operates on average 250 hours a year, with 10 hours harvest days. Assume that the timeliness coefficient is 0.002 and that harvest operations are evenly balanced about the optimum harvest date. The price of corn is $100/Mg ($2.50/bu). The probability of a working day is 0.65 during harvest.

b) Determine the annual ownership costs per annum (per ha, per ac)

c) Determine the operating costs excluding timeliness costs (per ha, per ac)

d) Determine the timeliness costs (per ha, per ac)

If the unit price function for combines is $30,000 h/ha

e) Determine the optimum effective field capacity.