# EGERTON UNIVERSITY

## UNIVERSITY EXAMINATIONS

**NJORO CAMPUS**

**SECOND SEMESTER 2011/2012**

**FOURTH YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN AGRICULTURAL ENGINEERING**

**AGEN 432: FARM MACHINERY II**

**STREAM:** 2008 (Y4) AGEN **TIME:** 2 hours

**DAY/TIME:** Monday, 03.00 – 05.00 pm **DATE:** 07/05/2012

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**INSTRUCTIONS:**

1. The paper consists of **THREE (3)** questions.
2. Attempt **ALL QUESTIONS.**
3. Marks for each question are shown in parenthesis.
4. In case of calculations, show all the working steps as well as the relevant units and indicate any assumptions made.
5. **EACH QUESTION SHOULD BE STARTED ON A NEW PAGE.**

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## QUESTION ONE

**(a)** State the basic processes of a combine harvester. **(2 marks)**

**(b)** With the aid of a sketch, describe the crop flow through a combine harvester. **(10 marks)**

**(c)** Define the following parameters used in the determination of the performance of the threshing mechanism of a combine harvester.

(i) Threshing efficiency

(ii) Separation efficiency

(iii) Grain damage. **(3 marks)**

**(d)** How do the following affect the parameters in (c) above? Give reason (s) for your answer

(i) Cylinder speed

**(c)** How do the following affect the parameters in (c) above? Give reason (s) for your answer

(i) Cylinder speed

(ii) Concave length

(iii) Cylinder / concave gap

(iv) Material feed rate

(v) Crop condition

**(10 marks)**

**(d)** (i) State one parameter used in the evaluation of the straw walkers?

(ii) How is the stated parameter in e(i) above affected by material feed rate?

**(2 marks)**

**(e)** (i) Describe the various losses relating to harvesting of barley using a combine harvester. How are these losses expressed? **(6 marks)**

(ii) How is the header losses of a combine harvester determined in the field? **(7 marks)**

## QUESTION TWO

**(a)** (i) With the aid of a sketch, describe the principle of operation of a precision chop forage harvester. **(11 marks)**

(ii) How is the length of chop varied on a precision chop forage harvester? **(2 marks)**

(iii) Explain why actual chop lengths of some particles from a forage harvester are longer than calculated lengths. **(2 marks)**

**(b)** What is the function of the following hay making equipments?

(i) Tedder

(ii) Turner

(iii) Crimper

**(6 marks)**

**(c)** (i) With the aid of a sketch, describe the crop flow through a rectangular pick-up baler.

(ii) What determines the density of rectangular bales? **(13 marks)**

**(d)** The following information refers to a baler forming rectangular bales of mass 20 kg and 200 kg/m$^3$ density.

- Depth of bale chamber 0.36 m
- Width of bale chamber 0.46 m
- Thickness of each compressed hay slice 0.2 m
- Baler crank speed 90 rpm

**Determine:**

(i) Material feed rate to the baler

(ii) Baling rate (bales / hour)

(iii) Length of each bale **(6 marks)**

## QUESTION THREE

**(a)** Describe the construction and operation of hammer mills **(6 marks)**

**(b)** (i) What are the advantages and disadvantages of the mills in (a) above? **(4 marks)**

(ii) What happens to the milling rate as the moisture content of grains decrease? **(1 mark)**

(iii) What determines the fineness of grinding in a hammer mill? **(1 mark)**

**(c)** With the aid of a sketch, describe the principle of operation of a cyclone separator.

**(5 marks)**

**(d)** Show that for a bucket elevator the speed of the head pulley is given by the relationship

$$n = \frac{1}{2\pi}\sqrt{\frac{g}{r}}$$

Where: n = speed of head pulley

r = radius to centre of rotation of material in bucket

g = acceleration due to gravity **(5 marks)**

**(e)** A pneumatic conveyor is to convey barley to a vertical height of 8 m and through a horizontal distance of 20 m at a rate of 20,000 kg/hr. The transport line has two 90° bends and its diameter is 12.7 cm. Calculate

(i) The total pressure drop

(ii) The blower power requirement

**(20 marks)**

Refer to Appendix I for the necessary data and formulae.

# APPENDIX I

$\rho$ = density of air = 1.2 kg/m$^3$
V = Velocity of air m/s = 2.5 m/s
L = Length of conveying duct (m)
D = diameter of duct (m)
$R_e$ = Reynolds number
$\Delta_z$ = lift height (m)

$$\Phi = \frac{\text{mass flow of solids}}{\text{mass flow of air}} = 15$$

$\mu$ = viscosity of air = $10^{-5}$ Ns/m$^2$

**Line pressure loss**

$$\Delta P_L = \lambda_L \frac{\rho}{2} v^2 \frac{L}{D}$$

and $$\frac{\lambda_L}{4} = 0.0014 + 0.125 Re^{-0.32}$$

$$R_e = \frac{\rho VD}{\mu}$$

**Acceleration pressure drop**

~~$\Delta P_a = \Phi_m V P C$~~ $$\Delta P_a = \Phi m V \rho c$$

$$\frac{C}{V} = 1 - 0.68 d^{0.92} \rho_p^{0.5} \rho^{-0.2} D^{0.54}$$

C = Velocity of solid particles
$\rho_p$ = density of solid particles
= 1330 kg/m$^3$
d = equivalent particle diameter = 4.05 x $10^{-3}$ m

Pressure drop due to solids

$$\Delta P_s = \Phi_m \lambda_s \frac{\rho}{2} v^2 \frac{L}{D}$$

$$\lambda_s = \frac{0.0285 \sqrt{gD}}{c}$$

**Pressure drop due to lift height**

$$\Delta P_g = \rho^* g \Delta_z$$

$$p^* = \frac{\Phi_m v p}{c}$$

$\rho^*$ = apparent bulk density
$\Delta_z$ = lift height

**Pressure drop to bends**

Equivalent length $L_e = \frac{KD}{\lambda_L}$

K = 0.9
K = fitting less coefficient

**Pressure drop due to solids**

$$\Delta P_{b,\ solids} = 0.245 \left[\frac{M}{\rho V D^2}\right]^{1.267} \left[\frac{R}{D}\right]^{-0.260}$$

Take $\frac{R}{D} = 5$

Power $\frac{\Delta P Q}{\eta_b}$

and $\eta_b = 60\%$