UNIVERSITY OF SWAZILAND
FINAL EXAMINATION PAPER

PROGRAMME: BSC AGRIC. 4 (LWM)

COURSE CODE: LUM 412

TITLE OF PAPER: SOIL AND WATER CONSERVATION

TIME ALLOWED: TWO (2) HOURS

SPECIAL MATERIAL REQUIRED: NONE

INSTRUCTIONS: ANSWER QUESTION ONE AND ANY TWO OTHER QUESTIONS.

DO NOT OPEN THIS PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE CHIEF INVIGILATOR

SECTION I: COMPULSORY QUESTION

QUESTION 1

(a) It has been established that soil detachment and transport are influenced by rainfall intensity. Explain why.

(20 Marks)

(b) Responses of soils to forces responsible for soil erosion are dependent on their mechanical makeup and chemical composition. Discuss mechanical, chemical and mineralogical properties of soils as they affect soil erosion.

(20 Marks)

SECTION II: ANSWER TWO QUESTIONS FROM THIS SECTION

QUESTION 2

(a) The Universal Soil Loss Equation (USLE) has many applications and is widely used because of its simplicity. However, it is also widely abused. Discuss.

(15 Marks)

(b) Estimate the mean annual soil loss, using the SLEMSA, on a 100m long slope of 8° on a sandy clay soil under soya beans at Luyengo with a mean annual precipitation of 953 mm. The crop was in the second year of zero tillage.

(15 Marks)

QUESTION 3

When one drives through Swaziland one sees different types of ecological zones with different soil and water problems. Outline the measures you would recommend to combat them. (30 Marks)

QUESTION 4

(a) Mulching is recognised as a very effective means of controlling erosion. Briefly discuss the mechanics of mulch in controlling erosion.

(15 Marks)

(b) It has been established that different soils require different rates of mulch application. Estimate the required application rates of maize-stalk mulch on a sandy loam soil with a 4° slope and a flow depth of 100mm.

(15 Marks)

APPENDIX

$n_m = 0.105M^{0.84}$ (for maize stalk mulch)

where M = mulch rate (kg/m^2)
n_m = value of Manning's n due to the mulch

$$v = \frac{r^{2/3} s^{1/2}}{n}$$

where r = hydraulic radius, for simplicity assume it is approximated by the depth of flow
s = slope, can be represented by the tangent of the slope angle
n = Manning's roughness coefficient,

$$n_m = \left(n^{3/2} - n_s^{3/2}\right)^{2/3}$$

where n_s = Manning's n due to the soil

Maximum safe velocities in channels (maximum velocity on cover expected after two seasons

Material	Bare m/s	Medium grass cover m/s	Very good grass cover m/s
Very light silty sand	0.3	0.75	1.5
Light loose sand	0.5	0.9	1.5
Coarse sand	0.75	1.25	1.7
Sandy soil	0.75	1.5	2.0
Firm clay loam	1.0	1.7	2.3
Stiff clay or stiff gravelly soil	1.5	1.8	2.5
Coarse gravels	1.5	1.8	unlikely to form
Shale, hardpan, soft rock, etc.	1.8	2.1	very good grass cover
Hard cemented conglomerates	2.5	–	–
Intermediate values may be selected			

The Soil Loss Estimator for Southern Africa (SLEMSA):

$$Z = K.X.C$$

Where Z is mean annual soil loss (t/ha)
K is mean annual soil loss (t/ha) from a standard field plot, 30m long, 10m wide, at 2.5° slope for a known soil of known erodibility (F) under weed free bare fallow
X is a combined slope length and steepness factor
C is a crop management factor

The value of K is determined by relating mean annual soil loss to mean annual rainfall (P in mm) energy (E) using the exponential relationship:

$$\ln K = b\ln E + a$$
$$E = 18.846R_a \text{ (Elwell, 1979 – Zimbabwe)}$$

where E is in J/m^2, R_a is the mean annual rainfall and the values of a and b are functions of the soil erodibility factor (F):

$$a = 2.884 - 8.2109F$$
$$b = 0.4681 + 0/7663F$$
$$X = L^{1/2}(0.76 + 0.53s + 0.076s^2)/25.65$$

Where L is the slope length (m)
s is the percentage slope

Input values for soil erodibility and crop cover for use in SLEMSA

Soil erodibility (F factor)		
Soil texture	Soil Type	F Value
Light	Sands Loamy sands Sandy loams	4
Medium	Sandy clay loam Clay loam Sandy clay	5
Heavy	Clay Heavy clay	6

Subtract the following from the F value:

1 for light-textured soils consisting mainly of sands and silts

1 for restricted vertical permeability within one metre of the surface or for severe soil crusting.

1 for ridging up-and-down the slope.

1 for deterioration in soil structure due to excessive soil loss in the previous year (>20t/ha) or for poor management.

0.5 for slight to moderate surface crusting or for soil losses of 10 – 20t/ha in the previous year.

Add the following to the F value:

2 for deep (>2m) well-drained, light-textured soils.

1 for tillage techniques which encourage maximum retention of water on the surface, e.g. ridging on the contour.

1 for tillage techniques which encourage high surface infiltration and maximum water storage in the profile, e.g. ripping, wheel-track planting.

1 for first season of no tillage.

2 for subsequent seasons of no tillage.

Crop cover ratings (C)	
Crop	Average percentage cover
Cotton	40 – 65
Cowpeas	40 – 55
Tobacco	11 – 54
Sorghum	50 – 70
Sunflower	20 – 59
Groundnuts	55 – 65
Velvet beans	46 – 70
Coffee	60 – 80
Maize	42 – 80
Rotational grass	80 – 98
Soya beans	40 – 65
Rice	70 – 78
Weed fallow	100

After Elwell and Wendelaar (1977); Elwell (1978)

The crop management factor (C) adjusts the value of soil loss for the standard bare soil condition to that from a cropped field. The value is dependent upon the percentage of the rainfall energy intercepted by the crop (i). For crops and natural grassland with $i < 50$ per cent and for dense pastures and mulches when $i \geq 50$ per cent, the following relationship is used:

$$C = e^{(-0.06i)}$$

For crops and natural grasslands when $i > 50$ per cent, the relationship is:

$$C = (2.3 - 0.01i)/30$$

Manning's roughness coefficient

Channels free from vegetation	n
Uniform cross-section, regular alignment free from pebbles and vegetation, in fine sedimentary soils	0.016
Uniform cross-section, regular alignment free from pebbles and vegetation, in stiff clay soils or hardpan	0.018
Uniform cross-section, regular alignment free from pebbles and vegetation, in clay loam	0.020
Small variations in cross-section, fairly regular alignment, few stones, thin grass at edges, in sandy and clay soils, also newly cleaned, ploughed and harrowed channels	0.0225
Irregular alignment, ripples on bottom, in gravelly soil or shale, with jagged banks or vegetation	0.025
Irregular section and alignment, scattered rocks and loose gravel on bottom, or considerable weeds on sloping banks, or in gravelly material up to 150mm diameter	0.030
Eroded irregular channels, channels blasted in rock	0.030