



“Investing in Africa’s future”

COLLEGE OF HEALTH AGRICULTURE AND NATURAL SCIENCES

NAAE 211: FARM POWER AND MACHINERY

END OF SECOND SEMESTER FINAL EXAMINATIONS

MAY 2021

LECTURER: MR. W. ZENDERA

DURATION: 7 HOURS

INSTRUCTIONS

- 1) Answer ANY ONE question.
- 2) ALL questions carry 100 marks
- 3) Clearly show all your calculations.

Question 1

- a) Briefly explain how an energy hybrid system can be used to solve power shortages for a group of dairy farmers who frequently have electricity power cuts from the national grid in a remote farming area. [10 marks]
- b) Mrs Njoroge intends to start a tillage business. She has acquired a 75 Hp MF375 Tractor together with a 2 disc plough. Custom charges for tillage are pegged at \$80 USD per hectare dry rate. On average her tractor consumes 30 litres of diesel to plough one hectare. She would like to know if it is profitable to run the tillage business at the current rate.

The following information is provided in Table 1 for the machinery and implement, additional information is in Appendices 1 & 2.

Table 1

Information	Tractor	Disc plough
Current list price	\$20 000.00	\$2 000.00
Purchase price of current used machine	15 000.00	\$ 1800.00
Accumulated hours to date	0 hours	800 hours
Economic life	10 years	5 years
Interest rate	5 %	5 %
Annual usage	600 hrs	400 hrs
Engine power	75 Hp	(55 Hp required)
Fuel price	\$1.20	
Labour rate	\$0.60	

Required

Ownership costs for the tractor

- a) Calculate the
- i. Salvage value , [3 marks]
 - ii. Total depreciation, [3 marks]

- iii. Capital recovery , [3 marks]
- iv. Taxes, insurance, and housing, [3 marks]
- v. Total ownership costs per year [3 marks]
- vi. Total ownership costs per hour [3 marks]

Estimate the operation costs of the tractor

- b)
 - i. Total accumulated hours at disposal [3 marks]
 - ii. Total accumulated repair cost [3 marks]
 - iii. Average repair costs [3 marks]
 - iv. Calculate the fuel costs/hr [3 marks]
 - v. Lubrication costs/hr [3 marks]
 - vi. Labour costs [3 marks]
 - vii. Total operating costs [3 marks]
 - viii. Total costs of running the tractor per hour. [3 marks]

Ownership costs for the disc plough

- c) Calculate the
 - i. Salvage value , [3 marks]
 - ii. Total depreciation, [3 marks]
 - iii. Capital recovery , [3 marks]
 - iv. Taxes, insurance, and housing, [3 marks]
 - v. Total ownership costs per year [3 marks]

Estimate the operation costs of the disc plough

- d)
 - i. Total accumulated hours at disposal, [3 marks]
 - ii. Total accumulated repair cost, [3 marks]
 - iii. Average repair costs/hr, [3 marks]
 - iv. Calculate the fuel costs/hr, [3 marks]
 - v. Lubrication costs/hr, [3 marks]
 - vi. Labour costs/hr, [3 marks]
 - vii. Total operating costs , [3 marks]
 - viii. Total costs of running the disc plough. [3 marks]
- e) Calculate the total costs of running the tillage business [4 marks]
- f) Comment on the profitability of the tillage business at the current prescribed rate [5 marks]

Question 2

- a) Mr Mwamba recently acquired a Massey Ferguson tractor with the following specifications in Appendix 3. He is planning to use the tractor on his farm and he wants to buy a disc plough to match the tractor power available. Most of the soils at his 200 ha farm are loam soils and the employees usually work for 8 hours per day for 5 days in a week. Ploughing is considered critical operations and is usually done within the first 10 working days at the onset of the rain season.

Table 1

Implement		unit	Speed km/hr	Draft force for soil type (N/unit/cm depth)		
				Clay	Loamy	Sandy
Major tillage tools						
Moldboard plough		Meter	7	1.281	896	580
Disc plough		Meter	8	890	645	510
Disc harrow tandem		Meter	9	672	592	529

Required

- i. Calculate the work rate in ha/hr. [5 marks]
 - ii. Estimate the width of the plough assuming 20 % field efficiency losses. [5 marks]
 - iii. Determine the soil resistance assuming a ploughing depth of 10 cm. [10 marks]
 - iv. Calculate the drawbar power required by the disc plough. [10 marks]
 - v. Using the 86 % rule estimate the PTO required. [10 marks]
 - vi. Estimate the engine power from the PTO power. Does the power required match the tractor specifications of the MF375 in Appendix 3? [10 marks]
- b) Derive the equation for estimating the theoretical power/indicated power of a 4 cylinder combustion engine. Explain how the equation is different in a four stroke and two stroke engines. [20 marks]

- c) Using the equation derived in (b) above calculate the maximum pressure generated inside the combustion chamber. [10 marks]
- d) Show that the engine capacity of the tractor in Appendix 3 is 4.07 litres. [10 marks]
- e) Calculate the clearance volume of the engine. [10 marks]

Question 3

- a) Discuss the challenges faced by small scale farmers in using harvesting machines like the combine harvester. [30 marks]
- b) Discuss the emerging innovative technology that has potential in the advancement of farm machinery. [30 marks]
- c) A sugar bean farmer intends to apply Dual Magnum a pre-emergence herbicide to his sugar bean crop. The label of on the herbicide states that Dual Magnum has to be applied at a rate of 1.1 litres per ha. The farmer carried out a test on his boom sprayer and got an average nozzle discharge rate of 2 litres per minute. The recommended operating speed for the boom is 8 km/hr. The tank capacity is 400 litres
- i. Calculate the boom application rate in litres per ha. [10 marks]
 - ii. Calculate the amount of pesticide required per tank. [10 marks]
 - iii. If the spraying is to be done on a 50 ha field how many tanks of water needs to be field. [5 marks]
 - iv. Calculate the quantity of Dual Magnum required to finish the 50 ha. [5 marks]
 - v. Calculate the theoretical field capacity of carrying out this operation if the boom has 12 nozzles spaced at 0.5 m. [10 marks]

Appendix 1


Capital recovery factors

Interest Rate	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
Years														
1	1.020	1.030	1.040	1.050	1.060	1.070	1.080	1.090	1.100	1.110	1.120	1.130	1.140	1.150
2	0.515	0.523	0.530	0.538	0.545	0.553	0.561	0.568	0.576	0.584	0.592	0.599	0.607	0.615
3	0.347	0.354	0.360	0.367	0.374	0.381	0.388	0.395	0.402	0.409	0.416	0.424	0.431	0.438
4	0.263	0.269	0.275	0.282	0.289	0.295	0.302	0.309	0.315	0.322	0.329	0.336	0.343	0.350
5	0.212	0.218	0.225	0.231	0.237	0.244	0.250	0.257	0.264	0.271	0.277	0.284	0.291	0.298
6	0.179	0.185	0.191	0.197	0.203	0.210	0.216	0.223	0.230	0.236	0.243	0.250	0.257	0.264
7	0.155	0.161	0.167	0.173	0.179	0.186	0.192	0.199	0.205	0.212	0.219	0.226	0.233	0.240
8	0.137	0.142	0.149	0.155	0.161	0.167	0.174	0.181	0.187	0.194	0.201	0.208	0.216	0.223
9	0.123	0.128	0.134	0.141	0.147	0.153	0.160	0.167	0.174	0.181	0.188	0.195	0.202	0.210
10	0.111	0.117	0.123	0.130	0.136	0.142	0.149	0.156	0.163	0.170	0.177	0.184	0.192	0.199
11	0.102	0.108	0.114	0.120	0.120	0.133	0.140	0.147	0.154	0.161	0.168	0.176	0.183	0.191
12	0.095	0.100	0.107	0.113	0.119	0.126	0.133	0.140	0.147	0.154	0.161	0.169	0.177	0.184
13	0.088	0.094	0.100	0.106	0.113	0.120	0.127	0.134	0.141	0.148	0.156	0.163	0.171	0.179
14	0.083	0.089	0.095	0.101	0.108	0.114	0.121	0.128	0.136	0.143	0.151	0.159	0.167	0.175
15	0.078	0.084	0.090	0.096	0.103	0.110	0.117	0.124	0.131	0.139	0.147	0.155	0.163	0.171
16	0.074	0.080	0.086	0.092	0.099	0.106	0.113	0.120	0.128	0.136	0.143	0.151	0.160	0.168
17	0.070	0.076	0.082	0.089	0.095	0.102	0.110	0.117	0.125	0.132	0.140	0.149	0.157	0.165
18	0.067	0.073	0.079	0.086	0.092	0.099	0.107	0.114	0.122	0.130	0.138	0.146	0.155	0.163
19	0.064	0.070	0.076	0.083	0.090	0.097	0.104	0.112	0.120	0.128	0.136	0.144	0.153	0.161
20	0.061	0.067	0.074	0.080	0.087	0.094	0.102	0.110	0.117	0.126	0.134	0.142	0.151	0.160

Appendix 2: Accumulated repair costs as a percentage of new list price.

Type of Machine	Accumulated Hours	1,000	2,000	3,000	4,000	5,000	6,000	7,000	8,000	9,000	10,000
Two-wheel drive tractor		1%	3%	6%	11%	18%	25%	34%	45%	57%	70%
Four-wheel drive tractor		0%	1%	3%	5%	8%	11%	15%	19%	24%	30%
Type of Machine	Accumulated Hours	200	400	600	800	1,000	1,200	1,400	1,600	1,800	2,000
Mouldboard Plough		2%	6%	12%	19%	29%	40%	53%	68%	84%	101%
Disc plough		1%	4%	8%	12%	18%	25%	32%	40%	49%	58%
Tandem disk		1%	4%	8%	12%	18%	25%	32%	40%	49%	58%
Chisel plow		3%	8%	14%	20%	28%	36%	45%	54%	64%	74%
Field cultivator		3%	7%	13%	20%	27%	35%	43%	52%	61%	71%
Harrow		3%	7%	13%	20%	27%	35%	43%	52%	61%	71%
Roller-packer, mulcher		2%	5%	8%	12%	16%	20%	25%	29%	34%	39%
Rotary hoe		2%	6%	11%	17%	23%	30%	37%	44%	52%	61%
Row crop cultivator		0%	2%	6%	10%	17%	25%	36%	48%	62%	78%

Appendix 3



MASSEY FERGUSON

MF375

75 HP

PERFORMANCE

Maximum engine power at 2,200 rpm	75 (B.S) hp
Maximum torque at 1,400 rpm	290 Nm
Maximum PTO power at rated engine speed	69.5 hp**
PTO power at 540 rpm	63.0 hp
*Certified to BU AU 141a : (1971)	
** Manufacturer's estimate	

ENGINE

Type	Diesel / 4.248
No. Of Cylinders	4
Injection	Direct
Bore	101 mm
Stroke	127 mm
Capacity	4.07 l
Compression ratio	16 : 1
Aspiration	Natural
Starting Aid	Thermostat
Throttle control	Hand and foot
Cooling	Water
Air Cleaner Type	Oil bath
Air Pre-Cleaner	Over Bonnet
Fuel filter	Dual, high capacity
Exhaust	Vertical muffler under bonnet

ELECTRICS

Voltage	12 V, Negative Earth
Battery	110 Ah
Starter	2.8 kW
Alternator	45 Amp

CLUTCH

Type	Dual clutch
Diameter	305 x 254 mm
Lining Material	Cerametallic

TRANSMISSION

Type	Sliding Spur
Number of gears	8 forward, 2 reverse
Road speed at 2,200 engine rpm with 16.9 / 14 - 30 rear tyres	
Gear	Speed (kph)
Forward 1 (first low)	2.3
Forward 2	3.4
Forward 3	4.7
Forward 4	6.3
Forward 5 (first high)	9.3
Forward 6	13.6
Forward 7	18.6
Forward 8	25.0
Reverse 1 (low)	3.2
Reverse 2 (high)	12.7

POWER TAKE OFF

Type	Live
Engine speed at 540 PTO rpm	1,789 rpm
Shaft diameter	35 mm
no. Of splines	6

HYDRAULICS

Functions	Draft control, Position control, Response control, Constant pumping
Pump Type	Reciprocating Ferguson Pump
Maximum Oil Flow	16.7 l / min
Maximum Pressure	21.2 Mpa at normal operating temperature
Max. Lift capacity with lower links horizontal	2,145 kg
Lower Links	With cat. I & II interchangeable balls

FRONT AXLE

Type	Heavy duty Box Section, Adjustable
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STEERING

Type	Hydrostatic
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REAR AXLE AND BRAKES

Rear Axle	Straddle with epicyclic reduction unit
Brake Type	oil immersed, multi-disc
Brake pedal	Pendant
Braking Area	1,774 sq. cm.
Brakes Actuation	Hydraulic
Parking Brake	Hand Lever operated

INSTRUMENTATION

Gauges	Technometer, Hourmeter, Fuel level, Battery condition & Water temperature
Warning lights	Direction indicators, Battery charge, Headlight main beam, Low engine oil pressure & Brake lights Auxiliary socket

TYRES

Front	7.50 - 16 (6PR)
Rear	16.9 / 14 - 30 (6PR)

TRACK ADJUSTMENT

Front	1,271 - 1,881 mm
Rear	1,423 - 2,134 mm

WEIGHTS AND DIMENSIONS

Weight

Gross Weight	2,355 kg
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Dimensions

Wheel base	2,170 mm
Overall Length	3,760 mm
Overall width (min)	1,970 mm

Height

Over exhaust	2,485 mm
Over steering wheel	1,730 mm

Turning circle

with brakes	7,260 mm
Without brakes	8,095 mm

Ground clearance

Under gear box	465 mm
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CAPACITIES

Fuel tank	108.0 l
Engine pump	7.5 l
Cooling system	15.2 l
Hydraulic system	36.0 l
Hydrostatic steering reservoir	2.0 l
Oil bath air-cleaner	0.7 l
Brake oil	0.25 l

STANDARD EQUIPMENT

Weight frame without weights, standard tool box with set of tools, Top link, Top link end cat-I, Cat-I & II balls, Check chains, Stabiliser chains, Spring suspension seat, Flat top fenders & operator's Manual

OPTIONAL EQUIPMENT

Front end weights, swinging drawbar, sun Canopy, pintle hook and 9 hole drawbar