EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS

NJORO CAMPUS

SECOND SEMESTER 2011/2012

THIRD YEAR EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN AGRICULTURAL ENGINEERING

AGEN 333: TRACTORS AND THEIR POWER UNITS

STREAM: 2009 (Y3) AGEN **TIME:** 2 hours

DAY/TIME: Thursday, 08.30- 11.30 am **DATE:** 03/05/2012

INSTRUCTIONS:

1. The paper consists of **FIVE (5)** questions.
2. Attempt **ANY FOUR** questions.
3. All questions carry equal marks.
4. Marks for each question are shown in parenthesis.
5. You should have a calculator.
6. **EACH QUESTION SHOULD BE STARTED ON A NEW PAGE.**

QUESTION ONE

(a) (i) Sketch a p-v diagram for the Otto cycle and name the processes. **(3 marks)**

(ii) Why is the thermal efficiency of an actual engine considerably less than that indicated by an ideal process? **(3 marks)**

(b) The following information refers to a four-cylinder, four stroke cycle spark ignition engine running at a rated speed of 2800 rpm.

- Engine torque is 56 Nm
- Power developed is 16.4 KW
- Fuel consumption is 0.083kg/minute
- Fuel calorific value $Q_{net,v\ is}$ 44,000 KJ/kg

A Morse test is carried out and the cylinders are cut-out with the corresponding engine torques as shown below:

Cylinder cut-out	Engine Torque
Number 1	40 Nm
Number 2	38 Nm
Number 3	37 Nm
Number 4	40 Nm

Calculate for the given speed

(i) Brake mean effective pressure **(2 marks)**

(ii) Brake thermal efficiency **(2 marks)**

(iii) Mechanical efficiency **(6 marks)**

(iv) Specific fuel consumption **(2 marks)**

(v) Indicated mean effective pressure **(2 marks)**

Also estimate the volumetric efficiency of the engine if an analysis of the exhaust showed no oxygen and negligible carbon monoxide given the following:-

- The engine was tested in a atmosphere at 10^5 N/m^2 and 15 $^{\circ}$C
- Air / fuel ratio 14.5 /1
- PV = MRT where R for air = 0.287×10^3 KJ/kg
- The engine has a bore of 60 mm and a stroke of 90 mm. **(5 marks)**

QUESTION TWO

Describe how the longitudinal and vertical location of the centre of gravity of a tractor can be determined using the weighing method. State any assumptions made in this determination.

(25 marks)

QUESTION THREE

(a) What do you understand by the following terms as applied to engine fuels

(i) Cetane number

(ii) Octane number **(2 marks)**

(b) Thermal efficiency increases with increased compression ratio in internal combustion engines. What limits the use of higher compression ratios in:-

(i) Spark ignition engines

(ii) Compression ignition engines. **(2 marks)**

(c) State one reason as to why heat rejected by a compression ignition engine is at a lower temperature than that rejected by a spark ignition engine. **(2 marks)**

(d) A fuel represented by the hydrocarbon C_7H_{16} is to be used in an engine. Determine the:

(i) Air-fuel ratio for the combustion of this fuel in the engine

(ii) Percent analysis of dry exhaust gases.

Assume that air contains 21% oxygen by volume and 23.3% oxygen by mass. **(11 marks)**

(e) (i) With the aid of sketches, show the combustion chamber designs of direct and indirect injection compression ignition engines. **(4 marks)**

(ii) What are the advantages and disadvantages of the two combustion chamber designs in (e (i) above? **(4 marks)**

QUESTION FOUR

(a) Briefly explain **TWO** ground conditions and **TWO** tractor driver operational characteristics that can cause tractor overturning accidents in the field. **(4 marks)**

(b) Explain how the following are important in the prevention of tractor overturning accidents in the field

(i) Four wheel (4WD) drive tractor

(ii) Ballast

(iii) Wheel track settings and dual wheels

(6 marks)

(c) Show the TWO stages of lateral instability of a conventional four – wheel tractor with pivoting front axle. **(4 marks)**

(d) (i)

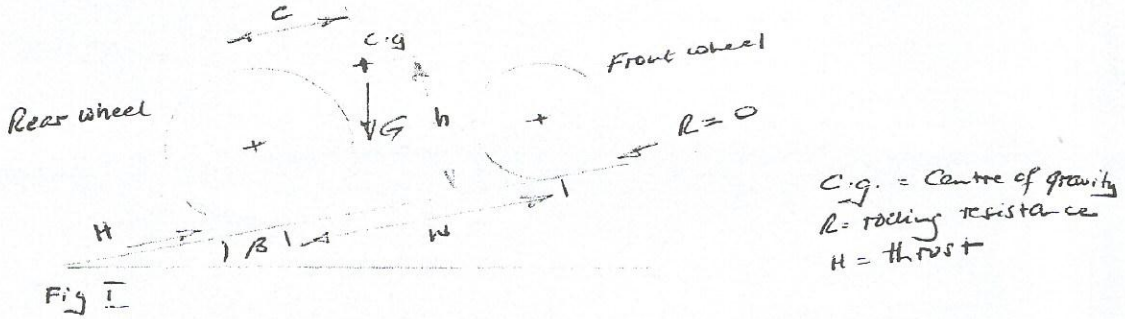

Fig 1

Show that the minimum slope 'β' up which the tractor shown in Figure I can move before wheel slip is given by:

$$\beta = \tan^{-1} \frac{\mu(w - c)}{(w - \mu h)}$$

Where μ is the coefficient of friction. **(7 marks)**

(ii) For the given tractor; c = 0.4 m, h = 0.9 m and w = 1.8 m. If the coefficient of friction between the rear wheels and the ground is 0.4, what would occur first, **Overturn** or **Wheel slip**? **(4 marks)**

QUESTION FIVE

(a) Show that for the tractor shown in Figure II, the effect of the drawbars pull 'P' is to transfer weight from front axle to rear axle and also add a vertical force to rear axle. **(6 marks)**

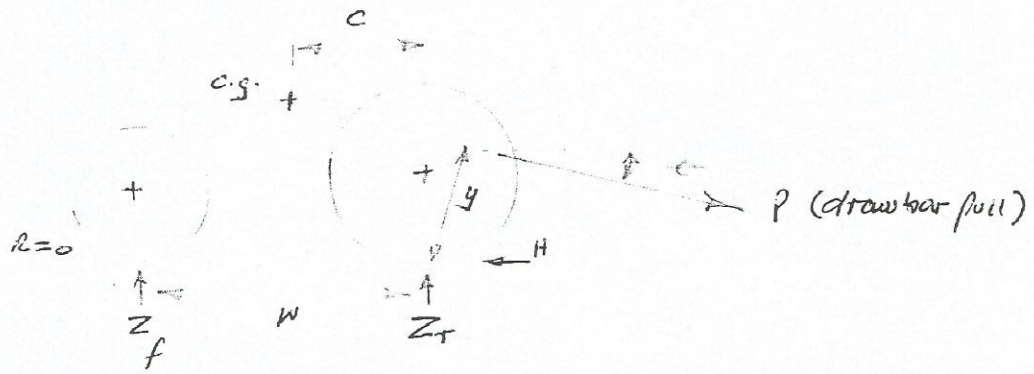

Fig II

(b) A tractor is pulling a 3 – furrow mounted plough in firm soil. Given that:

- Each plough bottom cuts 20 cm deep and 30 cm wide
- Soil resistance is 35 kN/m^2
- Actual forward speed is 6.4 km/hr
- Static rear axle loading is 9.7 kN
- Transmission efficiency 90%

Find:

(i) The drawbar power developed.

(ii) The expected wheel slip.

(iii) Ground efficiency = $\eta_{gd} = \frac{\text{drawbar power}}{\text{axle power}}$

(iv) Engine power.

(v) Possibilities of pulling a 4 – furrow mounted plough.

(vi) Effect of an 8% slope. **(19 marks)**

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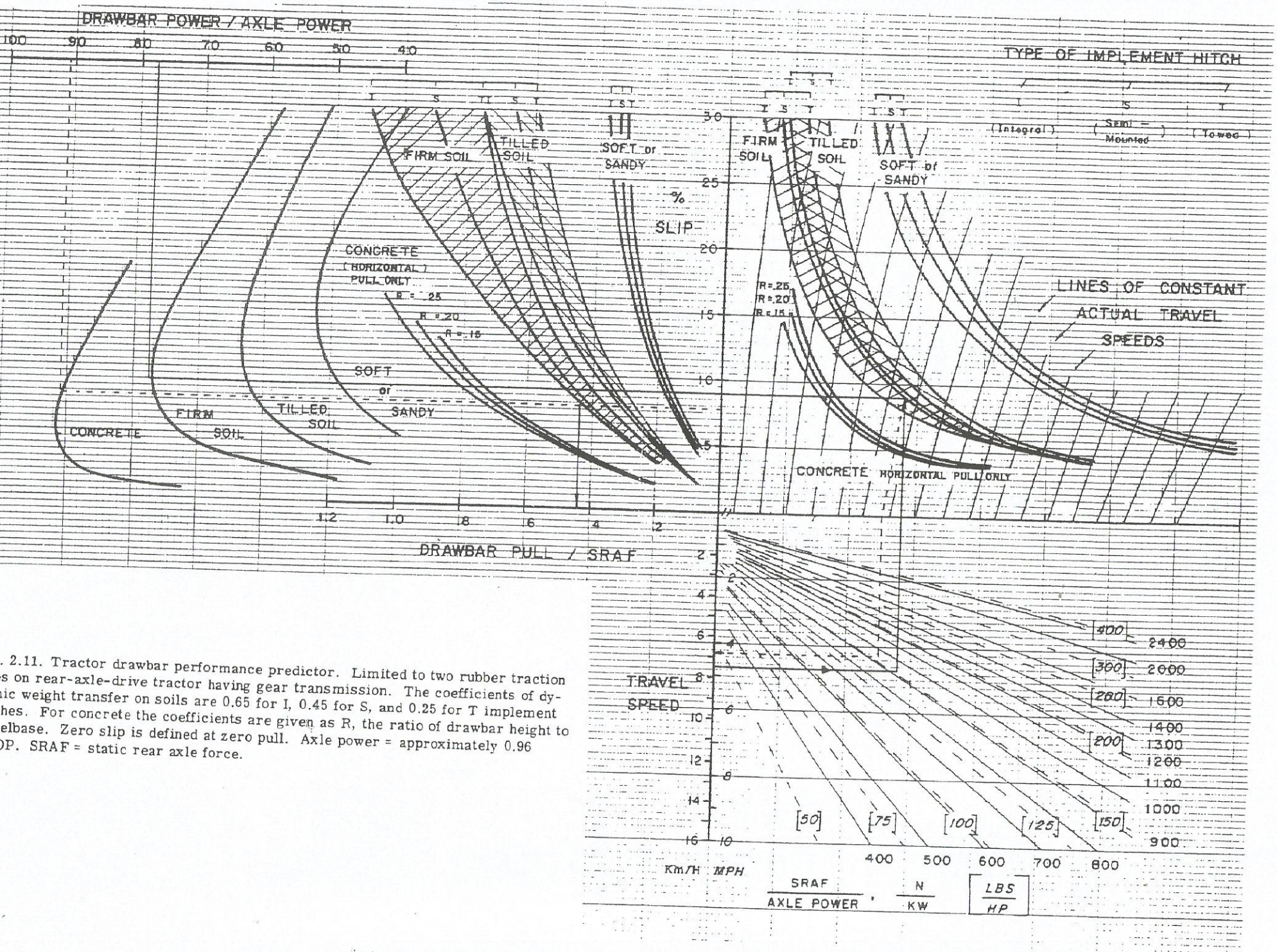

. 2.11. Tractor drawbar performance predictor. Limited to two rubber traction
s on rear-axle-drive tractor having gear transmission. The coefficients of dy-
ic weight transfer on soils are 0.65 for I, 0.45 for S, and 0.25 for T implement
hes. For concrete the coefficients are given as R, the ratio of drawbar height to
elbase. Zero slip is defined at zero pull. Axle power = approximately 0.96
OP. SRAF = static rear axle force.