GEAR TRANSMISSIONS

OBJECTIVE:

To acquaint the students with various forms of tractor power trains. The student is expected to be able to identify and describe the components of these units and to determine the gear ratio involved.

THEORY:

One method of determining ratios of series or compound gearsets is to establish the ratio of input to output speed. However, this is somewhat difficult unless the unit can be driven by a power source so that a tachometer can be used. A more practical exercise is to count the teeth on mating gears. For example: the gear on an input shaft has 10 teeth and mates with an output gear having 18 teeth. The ratio is 18/10 or 1.8 to 1; that is, the input shaft must turn 1.8 revolutions for each revolution of the output shaft. In the case of compound gearsets, the ratios for individual mating pairs are multiplied together to obtain an overall ratio.

Determining ratios for planetary gears is complicated by the relative motion of gear components that occur under certain conditions.

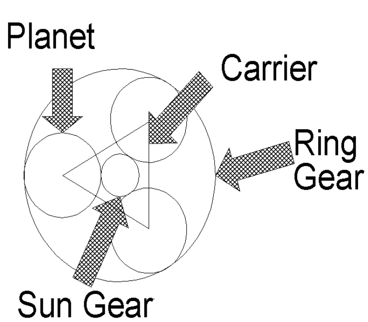
Let N = RPM r = ring gear

T = No. teeth s = sun gear

c = carrier

Then:

1. for ring gear fixed, $N_s/N_c = T_r/T_s + 1$
2. for carrier fixed, $N_s/N_r = -T_r/T_s$
3. for sun fixed, $N_r/N_c = T_s/T_r + 1$
4. for no fixed gears, $(N_r-N_c)/(N_s-N_c) = -T_s/T_r$



LAB QUESTIONS:

For each of the power train units supplied, determine the ratios for all gear selections. Data sheets are supplied for recording the necessary information. Answer all questions and work the accompanying problem. Note that schematic diagrams and tooth numbers are given on the last page of this exercise for transmission units one and four. In addition, remember to enter **all** ratios as input to output ratios.

A. Using the corresponding diagram from page 8 determine the ratios for each gearshift position of the IH transmission.

Unit 1 _ IH Super H Transmission (for Transmission Portion Only)				
Gear Shift	Number of Teeth			Overall
Position	Input Pair	Intermed.	Output Pair	Gear Ratio
1				
2				
3				
4				
5				
Rev				
PTO				

Note: Not all gears will have an Intermediate Pair

B. For Unit 1 also determine:

1. Is the arrangement a parallel-shaft or an in-line shaft arrangement?

2. Is it a sliding-gear or constant-mesh transmission?

3. Type(s) of gear teeth used?

4. Is the transmission synchronized?

5. (a) If synchronized, what type of synchronizers are used?

   (b) Which speeds are synchronized?

6. Determine and record the ratio between the transmission and the differential:

7. Determine and record the ratio between the output of the differential and the rear axle. (Final drive ratio)

8. If one wheel is locked with the brake, does the other wheel turn faster than, slower than, or the same as it would if both wheels were free to turn? If faster or slower, how much so?

C. For Unit 2 (IH torque amplifier) determine:

1. What type gear train is used to obtain reduction?

2. The ratios between input and output? (fill out chart)

GEAR	NO. TEETH	
	HIGH RANGE	LOW RANGE
INPUT GEAR		
1st INTERMED. GEAR		
2nd INTERMED. GEAR		
OUTPUT GEAR		
OVERALL RATIO		

3. Write below a specific explanation of how power is transmitted through the "TA" when it is in:
   a) HIGH RANGE

   b) LOW RANGE

4. If Unit 2 ("TA") were installed in the driveline between the engine and the Unit 1 transmission, what would the gear ratio be between the engine and the output of the transmission with the torque amplifier in low range and the transmission in third gear?

   Ratio -

D. <u>Observe Unit 3 (PTO reduction)</u>

1. What type of gear train is used?

2. Determine the reduction ratio:
3. Briefly describe the operation and power flow through the system (Input end is the blue shaft) when the PTO shaft is:

   a) engaged:

   b) disengaged:

4. For a clockwise input rotation, what direction does output rotate?

5. How many teeth are on the:

   sun gear -

   planet gear -

   ring gear -

   What type of teeth are used?

6. Calculate the input RPM required to obtain a 540 RPM output.

   Input RPM =

E. For Unit 4 use the schematic diagram and color coding scheme at the end of this lab to determine the ratios for each of transmission speeds.

UNIT 4 FORD 4000 8-SPEED							
	NUMBER OF TEETH					OVERALL RATIO	
GEAR SHIFT POSITION	INPUT PAIR	1st INTERMED. GEAR	2nd INTERMED. GEAR	Other INTERMED Gear	OUTPUT PAIR	HIGH RANGE	LOW RANGE
1	/	/	/	/	/	XXXXXXX	
2	/	/	/	/	/	XXXXXXX	
3	/	/	/	/	/	XXXXXXX	
4	/	/	/	/	/	XXXXXXX	
5	/	/	/	/	/		XXXXXXX
6	/	/	/	/	/		XXXXXXX
7	/	/	/	/	/		XXXXXXX
8	/	/	/	/	/		XXXXXXX
REV1	/	/	/	/	/	XXXXXXX	
REV2	/	/	/	/	/		XXXXXXX

F. Also for Unit 4

1. Is the transmission a parallel-shaft or an in-line shaft arrangement?
2. Is it a sliding-gear or constant-mesh transmission?
3. Type(s) of gear teeth used?
4. Is the transmission synchronized?
5. (a) If synchronized, what type of synchronizers are used?

   (b) Which speeds are synchronized?

FORD 4000 DIFFERENTIAL

This unit is the differential gear assembly from a Ford 4000 tractor. It receives its power from the transmission (Unit 4) and transfers it to the final drive assembly (Unit 6) located in the axle housing. Special problems are introduced in this assembly since the power is directed around a 90 degree corner and then divided between the two drive wheels. In addition to transferring power, the differential also allows the rear wheels to turn at different speeds (such as cornering). These functions are accomplished by means of a beveled ring and pinion gear set and a four-geared "spider" assembly.

G. For this unit determine the following:

1. Is the speed changed?
2. If so, is it increased or decreased?
3. What is the gear ratio?
4. What type of gears are used?
5. This unit also features a device to lock both of the axles together. Why would the operator find this desirable?
6. Of what purpose does the small cylinder on the lock serve?
7. Why is the cylinder necessary?
8. Will the lock, once engaged, release automatically? ____________ If so, what operating conditions will cause automatic release?

   What other ways can locks be released?

UNIT 6
FINAL DRIVE UNIT

This unit is the final drive unit from a Ford 4000 tractor. It receives its power from one side of the differential assembly and transmits it to the drive wheels. To do this it uses a planetary gear system.

The planetary gear cluster gets its name from the three components of the system. They are the sun gear (center), the planets (mounted on a single carrier), and the ring gear (outer).

To use the cluster, any one of the three components is held stationary. The remaining two components then become the input and output. By locking two components together, the entire cluster will act as one unit with no change in direction of rotation or speed. This supplies us with a variety of gear ratios in a relatively small package. In this unit, however, only one of these ratios is used.

H. <u>For unit 6 determine:</u>

1. Which component is used as the input?

2. Which is the output?

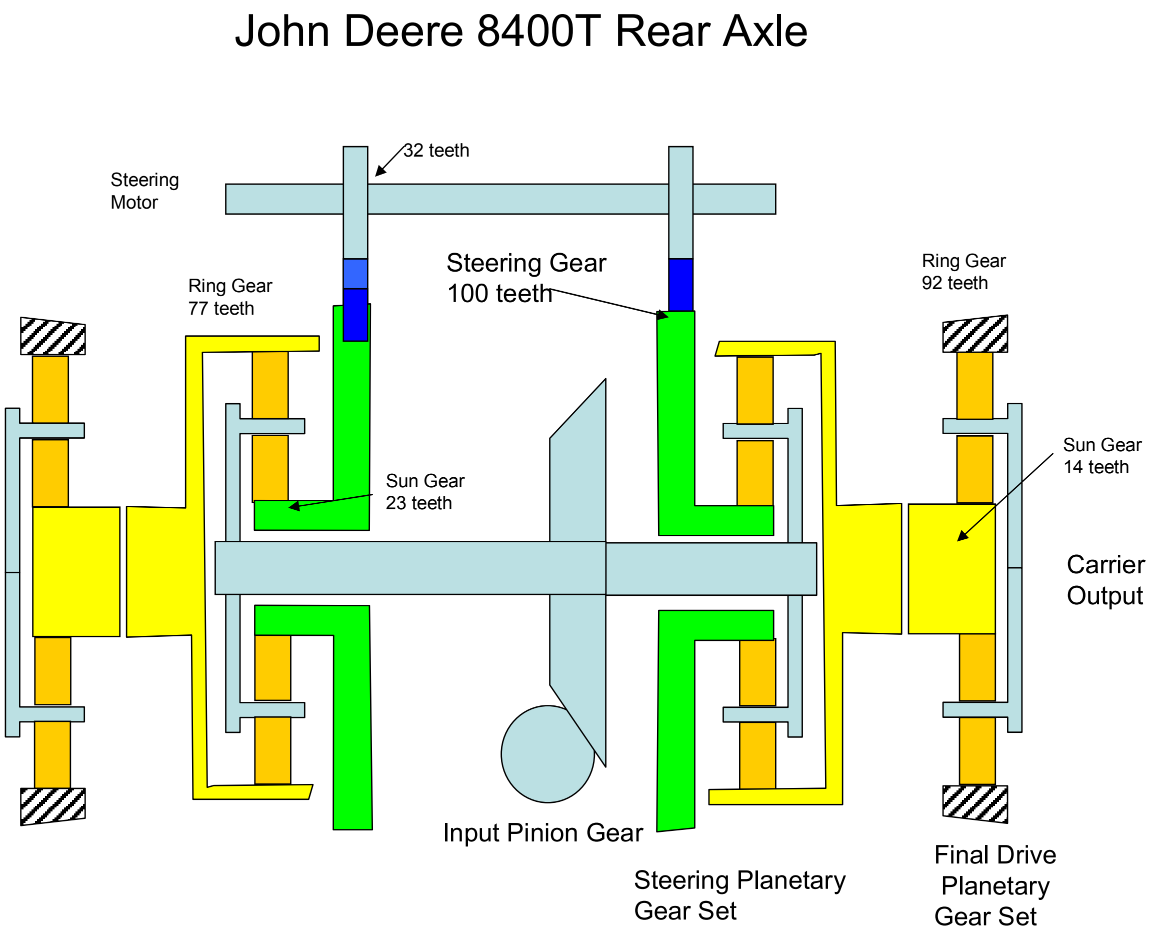
3. Is there a stationary component? ____________ If so, which?
4. Is the speed reduced or increased?

5. What is the ratio?

6. Is there a change in rotation direction between the input and output?

   Explain.

This unit is the final drive unit from a John Deere 8000 series tracked tractor.



Observe the operation of the drive and steering system on cut-away model. Assuming that the crown wheel and pinion set has a gear ratio of 5:1 and that the input to the pinion set at 250 rpm with a torque of 4000 ft.lbs. Determine the following

a). The output torque and speed at the wheel axle assuming that both wheels have equal traction.

b). The steering motor torque required to turn the machine under these conditions, assuming 100% efficiency for all gears etc. Note (Ns-Nc)/(Nr-Nc)=-K, Tr = K* Ts (Torque), and Ts+Tc+Tr = 0.

PROBLEM USING FORD DRIVE COMPONENTS:

Assume an unloaded outside tire with a diameter of 57.1 in. at normal inflation pressure is used. This tire is mounted on the axle of Unit 6 which, in turn, is driven by Units 5 and 4, respectively. When operating under load the tire deflects 5.5 cm below the unloaded radius. The engine is delivering 46.9 hp at 2200 rpm to the transmission input shaft. See diagram below.

Assume efficiencies of 98% each for transmission, differential, and final drive. Wheel slippage may be ignored.

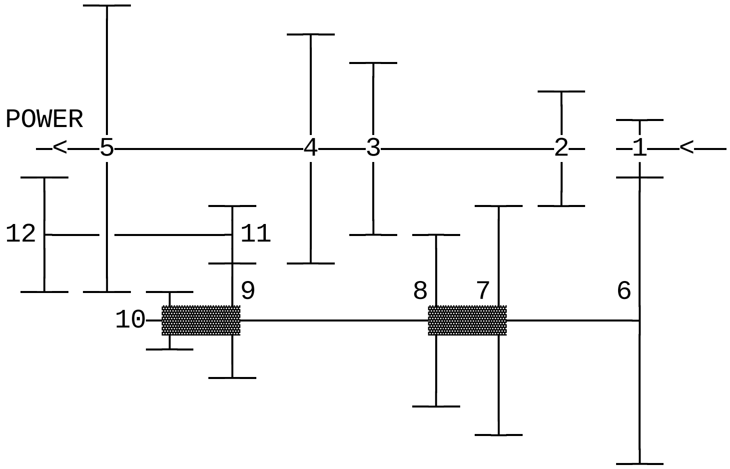
DETERMINE:

1. Ground speed in mph and axle torque in the right axle in ft-lb when transmission is in first gear and moving straight forward.

2. Repeat part 1 for seventh gear.

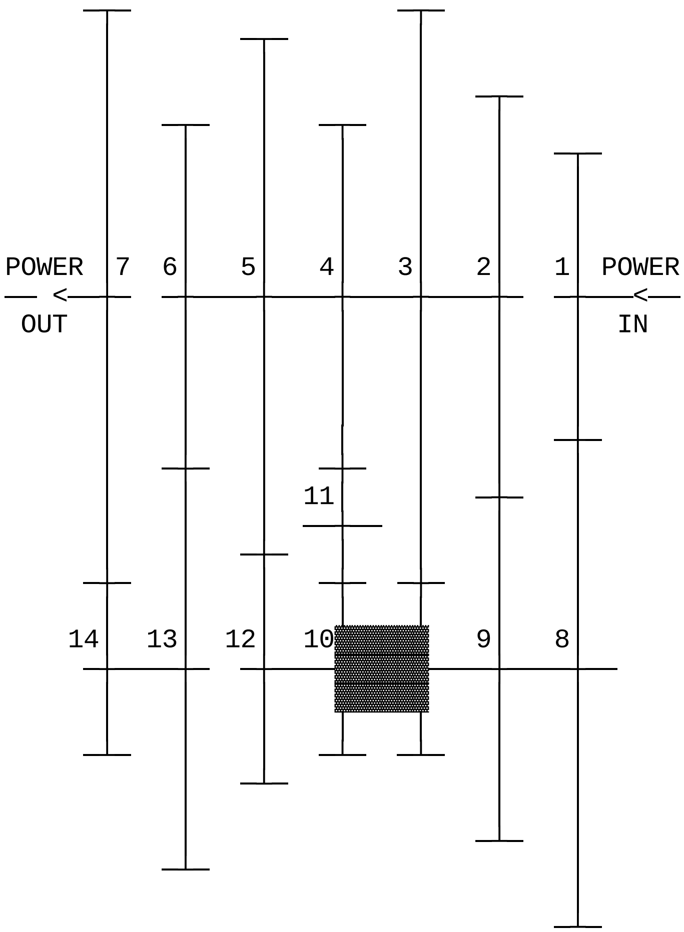
3. Discuss the relations between torque and speed when power is constant between input and output of a gear train. Also discuss the effect of power train efficiency on speed and torque in a gear train.

UNIT 1 - IHC SUPER H TRANSMISSION
(Shown in the neutral Position)



GEAR	TEETH
1	18
2	31
3	36
4	41
5	47
6	55
7	39
8	34
9	29
10	23
11	22
12	22

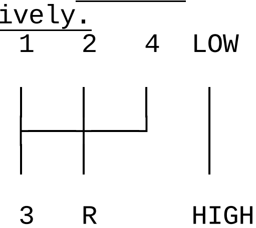
UNIT 4 - FORD 4000 8-SPEED TRANSMISSION



GEAR	TEETH
1	29
2	35
3	46
4	32
5	43
6	30
7	49
8	46
9	30
10	18
11	31
12	21
13	35
14	16

Gears 1 & 8 are used in all speeds
Gears 7 & 14 are used in all low range speeds, exclusively.

1st & 5th.......Red
2nd & 6th......Blue
3rd & 7th....Yellow
4th & 8th..No color
Reverse.......White



= Common Hub

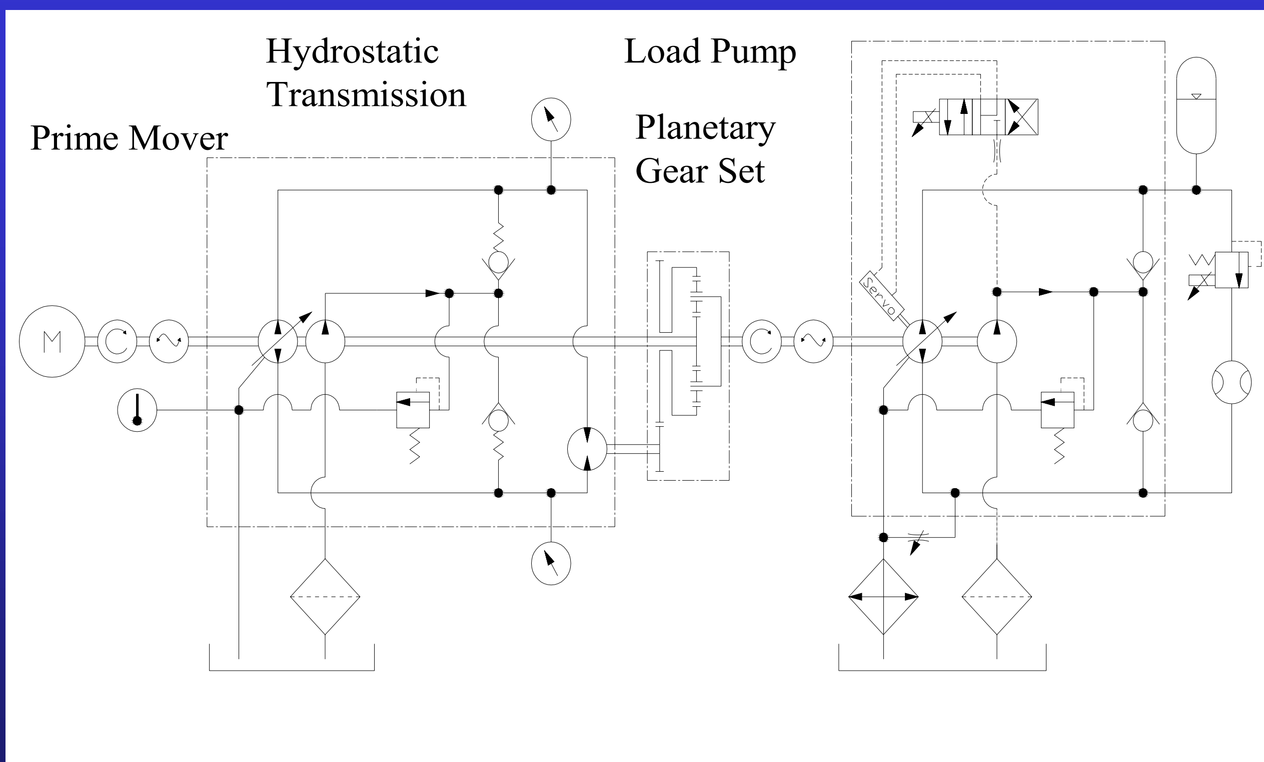
HYDRO-MECHANICAL TRANSMISSIONS

OBJECTIVE:

To acquaint the students with hydro-mechanical transmission. The student is expected to understand the basic operational principles of the transmission, how the gear ratio is adjusted, and the effect of load torque on hydrostat pressures and power transmission.

THEORY:

The hydro-mechanical transmission tested consisted of a hydrostatic transmission connected to a simple planetary gear set. The variable displacement hydrostat pump and sun gear planetary are directly connected to the engine. The fixed displacement hydrostat motor is connected to the ring gear with a gear ratio of 44/36. That is if the hydraulic motor is rotating at 440 RPM, the ring gear rotates at 360 RPM. The output of the hydro-mechanical transmission is the carrier. The planetary gear set has 57 teeth on the ring gear and 27 teeth on the sun gear. Remember that $(N_r-N_c)/(N_s-N_c) = -T_s/T_r$, where N = RPM and T = No. teeth. A schematic of the hydro-mechanical transmission is given below. The pump (at full stroke) and motor displacement is 0.913 in^3/rev (15 cm^3/cm).



Hydraulic Schematic

For the system the following equations hold true:

Nr = Nm * 36 / 44
Nm = Dp / Dm * Np * Volumetric efficiency of the hydrostat.
Theoretical Torque of Pump/Motor (Tp/m) = Δp(psi)*D(in^3)/(2π*12)
Power = 2πTN/33000

The test stand above was used to measure the input speed (Engine/Sun/Pump Speed) and input torque (Engine Torques), the output speed (Carrier/Load Speed) and output/load torque, the ring gear speed and hydraulic gauge pressures in the hydraulic system. The results of tests are provided on the spreadsheet attached. The system was tested under three different conditions:
1) Ramping the pump swash plate angle from -15 to 15 degrees(Full negative to full positive displacement) with zero load torque on the carrier (see Figure 1 on spreadsheet).
2) Ramping the pump swash plate angle from -8 to 8 (restricted by limits of test stand) with different load torques on the carrier resulting from friction. (see Figure 2 & 3 on spreadsheet).
2) Maintaining the pump swash plate angle at a nominal 7.5 degrees while ramping the load from approximately zero to 500 in.lb load torque on the carrier. (see Figure 4 on spreadsheet).

For the three test conditions determine the following information: You will have to take the average of a number of points to do these calculations.

Test Condition 1: No Load, Variable Swash Plate Angle

1) The overall efficiency of hydromechanical transmission at swash plate settings of -15, 0 and +15 degrees.
2) The power lost at swash plate settings of -15, 0 and +15 degrees.

Test Condition 2: Friction Load, Variable Swash Plate Angle

3) The overall efficiency of hydromechanical transmission at swash plate settings of -6, 0 and +6 degrees.
4) The volumetric efficiency of hydrostatic transmission at swash plate settings of -6, and +6 degrees.
5) The power lost at swash plate settings of -6, 0 and +6 degrees.
6) What is the effect of increasing output torque on the hydraulic pressures.

Test Condition 2: Variable Load, Nominal 7.5 deg. Swash Plate Angle

7) The overall efficiency of hydromechanical transmission at output loads 300, 500 and 700 in.lb
8) The volumetric efficiency of hydrostatic transmission at output loads 300, 500 and 700 in.lb
9) The power lost at output loads 300, 500 and 700 in.lb

This is not a formal report but all calculations must be neatly presented and all working shown.