Question 1 Consider the following gearbox which consists of two different planetary gearset connected in series. The ring gear of the first planetary gear is fixed and does not rotate. The power is input via the sun gear of the first planetary gearset. The planetary carrier of the first planetary is directly connected to the sun gear of the second planetary gearset. The carrier of the second planetary gearset is fixed and does not rotate The gearbox output is connected to the ring gear of the second planetary gearset

First Planetary Set					
Sun Gear		10	Teeth	10	Teeth
Ring Gear		90	Teeth	90	Teeth
Second Planetary Set					
Sun Gear	???		Teeth	???	Teeth
Ring Gear		180	Teeth	180	Teeth

A clockwise input of 2500 rpm at a torque of 200 ft-lb (270Nm) is applied to the sun gear and the efficiency of each planetary gearset is 0.98.

N	2500		2500	
Tin	200	ft.lb	270	Nm
Eff	0.98		0.98	
Tout	19208	ft.lb	25930.8	ft.lb

a) Determine the gear ratio for the first set of planetary gears

Ns/Nc	10		10	

b) If the output torque required from this transmission is 19208 ft-lb (25930.8 Nm). Determine the minimum overall gear ratio (to nearest integer value) that is required to achieve this output torque.

Go	100		100	

c) Determine the output speed under these conditions, and determine the number of teeth required on the sun gear of the second planetary set.

Nout	25		25	
Teeth sun	18		18	

d) Calculate torque transmitted from the carrier shaft of the first planetary set, to the sun gear of the second planetary set.

K	9		9	
Ts	200	ft.lb	270	Nm
Tc	-2000	ft.lb	-2700	Nm

e) Determine the resisting torque (Tr) required to hold the ring gear of the first planetary set stationary, under these conditions. (Reminder: Ts+Tr+Tc=0, and Tr=K*Ts , where T is the torque)

Ts	200	ft.lb	270	Nm
Tc	-2000	ft.lb	-2700	Nm
Tr	1800	ft.lb	2430	Nm

Question 2(25 points)

Given the following information for the tractor shown (JD8230):

Static Weight on Tires (zero drawbar pull)

	Unballasted Weight			
Total Weight	23200	lb	10500	kg
Xcg	50	"	1270	mm
Wheelbase	120	"	3050	mm
Drawbar Height	22	"	560	mm
Gravity			9.81	

Rear Tire Dimensions

4 x 480/80R46

#	4		4	
b	18.7	"	475	mm
d	77.1	"	1958	mm
h	15.5	"	394	mm
Rolling Radius	36.8	"	935	mm

Front Tire Dimensions

2 x 420/90R30

#	2		2	
b	17.3	"	439	mm
d	58.5	"	1486	mm
h	14.25	"	362	mm
Rolling Radius	27.3	"	693	mm

You must use the Bias tire traction equations for this question .

Horizontal Pull	7300	lb	32000	N
CI	350	lb/in2	250	N/cm2
delta_r	1.75		44	
delta_f	1.95		50	

Given the horizontal pull P, on the drawbar is 7,300 lb. (32kN) for an unballasted tractor, with the **MFWD disengaged** and duals on the rear tires.

Static Forces Per axle				
Rr	13533.333	lb	6127.868852	kg
Rf	9666.6667	lb	4372.131148	kg
Dynamic Forces Per axle				
DF	-1338.333	lb	-5875.40984	N
DR	1338.3333	lb	5875.409836	N
Rf	8328.3333	lb	37015.19672	N
Rr	14871.667	lb	65989.80328	N

i). Determine Dynamic Weight on each of the front and rear tires. You may assume that reaction forces are directly below the axle of the respective wheels.

Rf (per tire)	4164.17	lb	18507.60	N
Rr (per tire)	3717.92	lb	16497.45	N

b) If the tractor is operating in soil with a cone index of 350 psi (250 N/cm ^{2})

Cnf	85.06	88.12
Cnr	135.73	140.94
Bnf	270.37	281.01
Bnr	366.85	379.48

(i) Determine the towed force (TF) for required to move a single front tire through the soil. (Assume that slip is 10% to save time)

Assumed slip	0.10		0.10	
pf	0.05		0.05	
TFf	194.63	lb	861.37	N

(ii) Determine the towed force (TF) for required to move a single rear tire through the soil. (Assume that slip is 10% to save time)

pr	0.05		0.05	
TFr	168.56	lb	745.72	N

(ii) The Gross Tractive Force (F) required per driving tire.

Gross Tractive Force	2090.87	lb	9176.40	N

(iii) Calculate the Actual Travel Reduction (or wheel slip) required to generate the Gross Tractive force required to develop the drawbar pull.

Using Brixius Equation

Ug (required)	0.5623774	0.55623136	
Ug (calc)	0.562378	0.556231615	Used for solver
Diff	-5.13E-07	-2.5505E-07	Used for solver
Slip	0.1218611	0.119558345	

Wismer Luth Equation

Ug (required)	0.5623774	0.55623136
Slip	0.0340302	0.032009444
Check Ug	0.56	0.56

Question 3 (25 points)

For a 2 WD tractor, without duals, operating on a down hill slope

Assume gravity	10 m/s2	
Tractor Mass	10000 kg	22000 lb
WheelBase	3050 mm	120 "
Center of gravity		
Horizontal distance, Xc	1270 mm	50 "
Vertical distance, Zcg	1000 mm	40 "
Drawbar Position		
Height	750 mm	30 "
Front Tires		
Width	300 mm	12 "
Diameter	900 mm	36 "
Deflection	25 mm	1 "
Section height (h)	200 mm	8 "
Rear Tires		
Width	450 mm	18 "
Diameter	1650 mm	65 "
Deflection	50 mm	2 "
Section height (h)	300 mm	12 "
Ground Slope	-15 deg	-15 deg
	-0.2617994 rad	-0.2618 rad
Soil Cone Index =	600 N/cm2	900 psi

i). Determine the static reaction forces (Drawbar Pull=0) on the front and rear tires

	Wcos	96592.583 N	21250.4 lb
	Wsin	-25881.905 N	-5694 lb
(i)	Rf (axle)	48706.388 N	10752.3 lb
	Rr (axle)	47886.194 N	10498 lb
	Rf (tire)	24353.194 N	5376.16 lb
	Rr (tire)	23943.097 N	5249.02 lb

ii). If the draft force is 15000 lb (67.5 kN). Determine the dynamic reaction forces on each of the rear tires.

Draft	67500 N	15000 lb
Delta R	16598.361 N	3750 lb
Rf (tire)	16054.014 N	3501.16 lb
Rr(tire)	32242.277 N	7124.02 lb

iii) At a draft of 15000 lb (67.5 kN). Determine the gross tractive force per tire required to generate this drawbar pull and the total axle torque required. (You may ignore the towed forces for all tires for this calculation)

F (tire)	20809.048 N	4652.99 lb
Torque (per tire)	16127.012 N.m	11826.4 ft.lb
Torque (Axle Total)	32254.024 N.m	23652.7 ft.lb

iv). Determine the travel reduction (or slip) required to generate the tractive force determined in part (iii) if this is possible. (Show all calculations)

Ug	0.6453963	0.65314
Cnr	138.17262	147.81
Bnr	139.32406	148.017
Using the Wismer Luth Equation (solve for Slip)		
Slip	0.0475226	0.04616
Using the Brixius (bias) Equation (solve for Slip)		
Ug (required)	0.645396336	0.653141
Ug (calc)	0.645396992	0.653142 Used for solver
Diff	-6.55493E-07	-9.4E-07 Used for solver
Slip	0.157630925	0.161514

Question 4 (25 points)

Given the following information for the 2WD tractor shown, for **bias tires** without duals. (Assume gravity = 10 m/s2)

Static Weight on Tires (zero drawbar pull)

		Unballasted Weight		
Total Weight		15000	lb	7000 kg
Wheelbase		120	"	3000 mm
Zf		120	"	3000 mm
Zr		40	"	1000 mm
Gravity				10 m/s2
Rear Tires	#	2		2
Front Tires	#	2		2

a) i) If a wieght transfer of 5000 lbs (22500N) from the front wheel results in the front tire just lifting off the ground (Rf=0). What was the static reaction force on the front axle with zero pull.

Required Weigth Transfer from Front	5000	lb	22500 N
Static Forces			
Rf (axle)	5000	lb	2250 kg
Rf (tire)	2500	lb	1125 kg

ii) What was the static reaction force on the rear axle (zero pull).

Static Forces			
Rr (axle)	10000	lb	4750 kg
Rr (tire)	5000	lb	2375 kg

iii) Determine the horizontal distance from the center of the rear axle to the center of gravity of the tractor (Xcg).

Xcg	40	"	964.29 mm

b) For a drawbar force of Fdb = 4000 lb. (18,000N)

Drawbar Pull	4000	lb	18000 N

i) Determine the dynamic weight on the front axle

Dynamic Forces Per axle			
DF	-1333.33	lb	-6000 N
Rf	3666.67	lb	16500 N

ii). Determine the dynamic weight on the rear axle

DR	4000	lb	18000 N
Rr	14000	lb	65500 N

iii). Given that the mobility number under these conditions are Bn(front tire)=250 and Bn(rear tire)=500.

Bnf	250.00	250.00
Bnr	500.00	500.00

1) Determine the towed forces for the front and rear tires (to save time you may assume 10% slip)

Assumed slip	0.10		0.10	
Rf (per tire)	1833.33	lb	8250.00	N
pf	0.05		0.05	
TFf	86.46	lb	389.09	N
Rr (per tire)	7000.00	lb	32750.00	N
pr	0.04		0.04	
TFr	309.65	lb	1448.73	N

2) Determine the Gross tractive force required for each rear tire..

Gross Tractive Force	2396.12	lb	10837.82 N

3) Determine the travel reduction (or slip) required to generate the tractive force determined in part (2) if this is possible. (Show all calculations)

Using Brixius Equation			
Ug (required)	0.3423	0.3309258	
Ug (calc)	0.3423	0.3309256	Used for solver
Diff	1.6E-07	1.85E-07	Used for solver
Slip	0.05723	0.0546068	

Question 5 (25 points)

The following specifications for a certain pump and motor combination were given:

Pump

Displacement	29.5	cm3/rev	1.8	in3/rev
Input Speed	2500	rpm	2500	rpm
Rate Pressure	20.7	MPa	3000	psi
Rated Delivery	68.13	l/min	18	gal/min
Power Input	28.35	kW	38	Hp

Motor

Displacement	65.5	cm3/rev	4	in3/rev
Mechanical Efficiency	0.85		0.85	
N	1250	rpm	1250	rpm
Qactual	90	l/min	24	gal/min

To operate at 1250 rpm the required flowrate (Qin) to the motor would need to be 90

You may assume that there is no pressure losses between the pump and motor. (1 gal = 231 in^3) (1 L = 1000 cm^3)

i). Determine the volumetric efficiency of the pump.

Qth	73.75	l/min	19.481	gal/min
evp	0.923797		0.924	

ii) Determine the mechanical efficiency of the pump.

Tin	108.289	N.m	79.832	ft.lb
Tth	97.18797	N.m	71.62	ft.lb
emp	0.897487		0.8971	

iii). Determine the volumetric efficiency of the hydraulic motor

Qa (@1250)	90	l/min	24	gal/min
Qth (@1250)	81.875	l/min	21.645	gal/min
evm	0.909722		0.9019	

iv) Calculate the actual speed of rotation of the motor if it is connected to the pump output.

Qa	68.13	l/min	18	gal/min
Nth	1040.153	rpm	1039.5	rpm
Nactual	946.25	rpm	937.5	rpm

(v) Determine the actual power output from the motor.

Tout	183.4217	N.m	135.28	ft.lb
Pout	18.17545	kW	24.148	Hp
eo	0.641109		0.6355	
eo(check)	0.641109		0.6355	