AE 342, Spring 2008 **Exam 3** Name____________________

Instructions:

Answer 3 out of the 6 questions. No extra credit will be given for more than 3 answers. If more than three questions are attempted, CLEARLY indicate which questions are to be graded, otherwise only the first three answers will be graded, and the rest ignored.

Note: All information is given in metric and English units. You may select the units of your choice for each of the questions. **However do NOT use different unit systems within a single question.**

Show all calculation steps to ensure that partial credit is earned, even if the final answer is incorrect. In cases where the answer is obviously wrong, some credit will be given if you identify this as an improbable answer.

Power Equations

$P=2\pi TN/60{,}000$ or $P=2\pi TN/33{,}000$

Traction Equations:

$\mu_g = F/W = 0.75(1- \exp[-0.3C_nS])$ $\rho = TF/W = 1.2/C_n + 0.04$ (Wismer-Luth)

Slip or TR $= 100*(1- V_a / V_o)$

$C_n = CI*bd/W$

$B_n = [CI\ bd/W]*[(1+5*\delta/h)/(1+3*b/d)]$

$\mu_g = F/W = 0.88*[1- \exp(-0.1B_n)]*[1- \exp(-7.5S)]+0.04$ (Bias Ply)

$\rho = TF/W = 1.0/B_n + 0.04 + 0.5s/(B_n)^{1/2}$ (Bias Ply)

$\mu_g = F/W = 0.88*[1- \exp(-0.1B_n)]*[1- \exp(-9.5S)]+0.0325$ (Radial Ply)

$\rho = TF/W = 0.9/B_n + 0.0325 + 0.5s/(B_n)^{1/2}$ (Radial Ply)

$TE = P_{db} / P_a$

$TE = (F_{db}*V_a)/P_a$

$e_i = (TF_i / R_i) *$ Rolling Radius0

Weight Transfer

$W*X_{cg} = R_f*WB + F_{db}*Z_r$

$R_r*WB = W*(WB-X_{cg}) + F_{db}*Z_f$

Planetary Gears

$(Ns-Nc)/(Nr-Nc) = -K$

Sideways Overturns

$V_c = [(g * r *Y_{cg})/Z_{cg}]^{1/2}$ (On flat surface only)

Hydraulics. The equations below are given without units, and may require unit conversions

Force	$F = p*A$		
Flowrate	$Q = V*A$		
Flowrate,	$Q_{Theoretical} = D*N$		
Torque,	$T_{Theoretical} = p*D/2\pi$	$T = p*D/2\pi$	$T = p*D/2\pi *1/12$
Power,	$P = p*Q$	$P = p*Q/60$	$P = p*Q*231*1/12*1/33000$

Note: F= force, P=Power, Q=Flowrate, p=pressure, T=Torque, N=rpm, V=velocity

Units Conversions

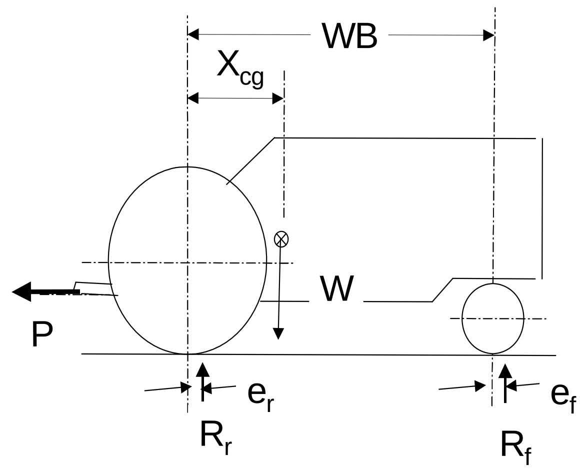
1 BTU = 778 ft.lb of work	1 kN.m = 1 kJ	1 Hp = 0.7457 kW
33000 ft.lb/min = 1 Hp	1 kJ/sec = 1 kW	1 ft.lb = 1.356 N.m
550 ft.lb/sec = 1 Hp	1000 liters = 1 m3	1 pound force = 4.45 Newton
1 gal = 231 cubic inches	1000 cm3 = 1 liter	1 gal = 3.785 liters
1 mile = 5280 ft		1 psi = 6.8948 kPa
		1 inch = 0.0254 meters
		1 ft = 0.3048 meters
		1 BTU = 1.0551 kJ

Force (N)=mass(kg)*gravity(m/s2) 1 (N)= 1 (kg) * 9.8 (m/s2)

AE 342, Spring 2008 **Exam 3** Name____________________

<u>Question 1(25 points)</u>

Given the following information for the tractor shown:



Static Weight on Tires (zero drawbar pull)

	Ballasted Weight
Rear Axle Weight	25000 lb (11000 kg)
Front Axle Weight	6000 lb (3000 kg)
Total Weight	31000 lb (14000 kg)

Rear Tire Dimensions	Front Tire Dimensions
b = 19.2" (488mm)	b = 14" (355mm)
d = 64.8" (1645 mm)	d = 30" (785 mm)
h = 12" (300mm)	h = 8" (200mm)
Rolling Radius = 30" (785)	Rolling Radius = 13.8" (350)

Wheelbase	112"	(2845 mm)
Drawbar Height	20"	(500mm)

You may use either the Wismer-Luth, Radial or Bias tire traction equations for this question. However only use one set of equations.

Given the horizontal pull P, on the drawbar is 12,500 lb. (55000N) for an ballasted tractor, 2 wheel drive tractor.
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.

b) If the tractor is operating in soil with a cone index of 350 psi (250 N/cm^2)
(i) Determine the towed force (TF) for required to move the front tire through the soil. (If you use radial or bias traction equations, assume that slip is 10% to save time)

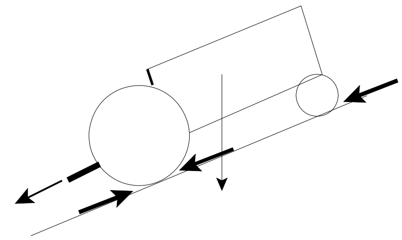
(ii) Determine the towed force (TF) for required to move the rear tire through the soil. (If you use radial or bias traction equations, assume that slip is 10% to save time)

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

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

AE 342, Spring 2008 **Exam 3** Name____________________

Question 2 (25 points)



Given the following information: Assume gravity = 10 m/s^2 (32 ft/s^2)

Tractor Mass,	15,000 kg (22,000 lb),			
WheelBase	3050 mm (120")			
Center of gravity				
Horizontal distance from rear axle, Xcg		1270 mm (50")		
Vertical distance from ground (horizontal plane), Zcg		1000 mm (40")		
Drawbar Position				
Height	750mm (30")			
Tires	Width	Diameter	Deflection	Section height (h)
Front	300mm (12")	900mm(36")	20mm (1")	200 mm (8")
Rear	450mm (18")	1650mm (65")	50mm (2")	300 mm (12")
Ground Slope =	15 degrees	Soil Cone Index =	300 N/cm^2 (450 psi)	

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

ii). Calculate the stability limited **net drawbar pull** (R_f=0), with the pull line of action being parallel to the ground slope. **Note:** You may assume that the perpendicular (to ground) reaction forces are directly below the tire axles.

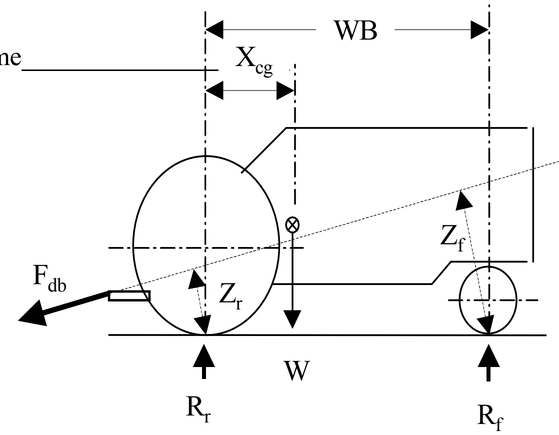
iii). Determine the gross tractive force per tire required to generate this drawbar pull and the total axle torque required. (You may ignore the towed forces for this calculation)

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

AE 342, Spring 2008 **Exam 3** Name________________

Question 3 (25 points)

Given the following information for the tractor shown



Static Weight (zero drawbar Pull)

Total Weight	25000 lb (11250 kg)
Wheelbase	120" (3000 mm)
Thread Width	60" (1500mm)

Given

Z_r= 40" (1000mm) and Z_f=120" (3000mm)

a) i) If a drawbar force of 21000lb (94.5kN) results in the front tire just lifting off the ground (Rf=0). Determine the horizontal distance from the center of the rear axle to the center of gravity of the tractor (Xcg).

ii) What was the static reaction force on the front axle with zero pull.

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

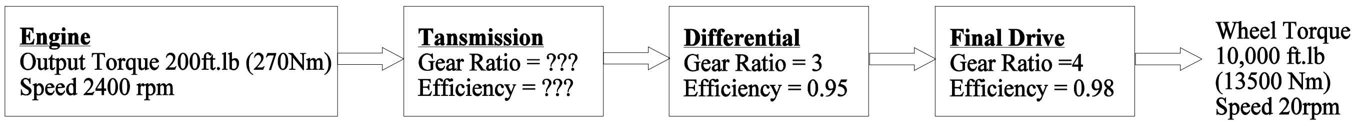
b) For a drawbar force of Fdb = 15000 lb. (67.5kN)

i) Determine the dynamic weight on the front axle

ii). Determine the dynamic weight on the rear axle

Question 4

The power train of a tractor is given below: The engine provides 220 ft.lb (300 Nm) of torque at 2400 rpm.



a) A transmission of unknown gear ratio and efficiency is to be installed. If the required speed of the wheels is 20 rpm. Calculate the transmission gear ratio to required to achieve this wheel speed. Give the gear ratio to the nearest whole integer.

b) If the torque required at each wheel is 10000 ft.lb (13500Nm). What is the lowest possible efficiency of the transmission that can be tolerated.

c). Calculate the output power for each wheel.

d). What speed would the right wheel turn if the left wheel is stationary, assuming engine rpm and transmission gear ratio do not change.

e) A tractor is used to drive an irrigation pump via the Power Take Off (pto). The pto operates at 1000 rpm at an engine speed of 2400 rpm. The PTO torque was found to be 500 N.m (370 lb.f). Assume 95 percent of engine brake horsepower is available at the pto.

(i). Determine the engine brake power and engine brake torque required for this operation.

(ii). If the speed of the PTO is reduced to 750 rpm while maintaining the same PTO power as in part e(i). What is the additional torque reserve required for the Engine. You may assume that all the efficiencies remain the same.

Question 5 (25 points)

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

Pump

Displacement	90 cm^3/rev (5.5 in^3/rev)
Rated Speed	2400 rpm
Rate Pressure	20.7 MPa (3000 psi)
Rated Delivery	210 l/min (55 gal/min) @ rated speed
Power Input	80.0 kW (110 Hp) @ rated delivery and speed

Motor

Displacement	130 cm^3/rev (8in^3/rev)

Volumetric Efficiency = 0.9

Mechanical Efficiency = 0.95

i). Determine the volumetric efficiency of the pump.

ii) Determine the mechanical efficiency of the pump.

iii). Determine the output torque from the motor shaft.

iv) Calculate the actual speed of rotation of the motor.

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

(vi) Calculate the overall efficiency of the system.

AE 342, Spring 2008 **Exam 3** Name____________________

Question 6 (25 points)

A certain hydraulic pump and motor combination is tested operating at a maximum pump pressure of 20.7 Mpa (3000 psi). There is a 1.7 MPa (250 psi) total line pressure loss between the hydraulic pump and motor units. During tests the following information is given or recorded.

Hydraulic Motor

Motor Output Speed	1500 rpm	
Motor Inlet Pressure	19 MPa (2750 psi)	Motor Mechanical Efficiency = 0.93
Motor Displacement	130 cm^3/rev (8in^3/rev)	Motor Volumetric Efficiency = 0.85

Hydraulic Pump

Pump Outlet Pressure	20.7 MPa (3000 psi)	Pump Mechanical Efficiency = 0.92
Pump Displacement	90 cm^3/rev (5.5 in^3/rev)	Pump Volumetric Efficiency = 0.84

i). Determine the theoretical output torque from the motor shaft.

ii). Determine the actual output torque from the motor shaft.

iii). Determine the actual power output from the motor.

iv) Calculate the actual flowrate required into the motor to achieve an output speed of 1500 rpm.

(v) Calculate the actual speed the pump must operate to achieve this flowrate.

(vi) Determine the theoretical input torque into the pump shaft.

(vii) Determine the actual input torque required into the pump shaft.

(viii) Calculate the input power required to drive the pump

(ix) Calculate the overall efficiency of the hydraulic system.