AE 342, Spring 2008 **Test 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:

$\mu_g = F/W = 0.75(1- \exp[-0.3C_nS])$	Slip or TR = $100*(1- V_a / V_o)$
$\rho = TF/W = 1.2/C_n + 0.04$	$TE = P_{db} / P_a$
$C_n = CI*bd/W$	$TE = (F_{db}*V_a)/P_a$
$B_n = [CI\ bd/W]*[(1+5*\delta/h)/(1+3*b/d)]$	$e_i = (TF_i / R_i) *$ Rolling Radius0
$\mu_g = F/W = 0.88*[1- \exp(-0.1B_n)] *[1- \exp(-7.5S)]+0.04$	(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)

Weight Transfer

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

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

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

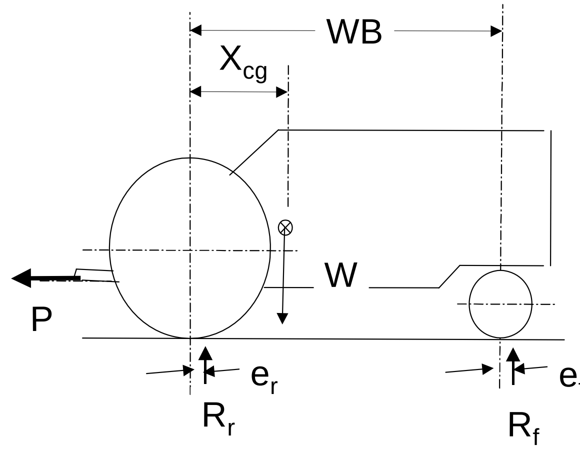
Units Conversions

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 **Test Exam 3** Name____________________

Question 1(25 points)



Given the following information for the tractor shown:

Static Weight on Tires (zero drawbar pull)

	Ballasted Weight	
Rear Axle Weight	15000 lb	(7500 kg)
Front Axle Weight	5000 lb	(2500 kg)
Wheelbase	100"	(2500 mm)
Drawbar Height	20"	(500mm)

Rear Tire Dimensions	Front Tire
b = 19" (480mm)	b = 14" (350mm)
d = 65" (1650 mm)	d = 30" (750 mm)
h = 12" (300mm)	h = 8" (200mm)
δ = 2.4" (60mm)	δ = 1.2" (30mm)

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 7,500 lb. (30,000 N) for a 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 150 psi (100 N/cm^2)

(i) Determine the towed force (TF) for required to move the front tire through the soil. (If you decide to use the radial or bias tire traction equations, assume that slip is 10% to save time, since you do not know actual slip)

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

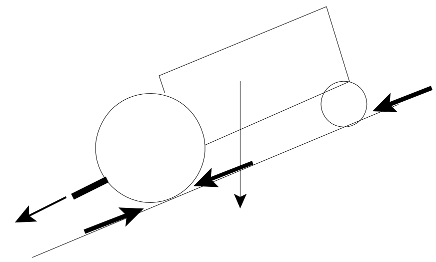
(ii) The Gross Tractive Force (F) required per driving tire.

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

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

Question 2 (25 points)

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



Tractor Mass,	10,000 kg (22,000 lb),	
WheelBase	3000 mm (120")	
Center of gravity		
Xcg	1000 mm (40")	
Zcg	1250 mm (50")	
Drawbar Position		
Height		500mm (20")
Distance from rear axle		1000 mm (40")

Tires	Width	Diameter	Deflection	Section height (h)
Front	300mm (12")	900mm(35")	25mm (1")	200 mm (8")
Rear	450mm (18")	1650mm (65")	50mm (2")	300 mm (12")

Soil Cone Index = 300 N/cm^2 (450 psi), Ground slope = 20 degrees

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

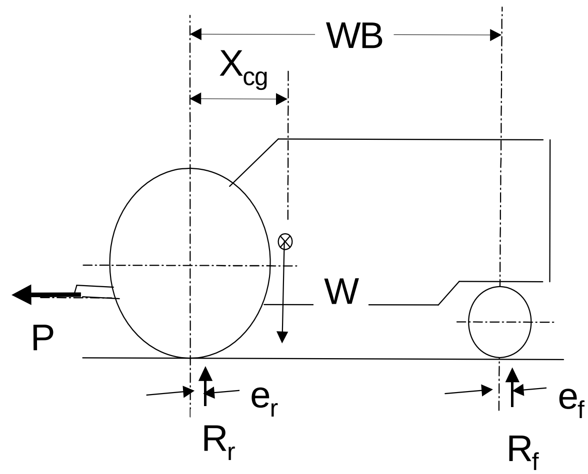
ii). Calculate the stability limited **net drawbar pull** (R_f=0), with the pull line of action being parallel to the ground slope. **Note:** You may assume that the perpendicular (to ground) reaction forces are below the tire axles.

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 calculation)

<u>Question 3 (25 points)</u>

Given the following information for the tractor shown



	Ballasted Weight
Rear Axle Weight	13,500 lb (5,500 kg)
Front Axle Weight	4,500 lb (2,000 kg)
Total Weight	18,000 lb (7,500 kg)

Wheelbase 110" (3000 mm)

Center of Gravity

Height above ground, Zcg 50" (1,250 mm)

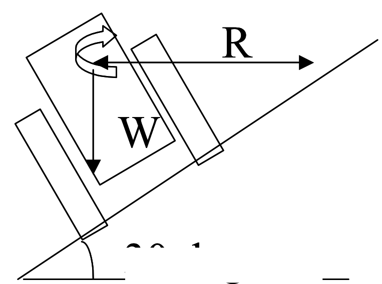
Center of Hitch, Ycg 60" (1,500 mm)

Critical Speed = square root [Y_{cg} * g * r / Z_{cg}] (on level ground)

i). When the tractor is traveling in a circle at 30 mph (50 km/h) it is just on the verge of becoming unstable on a flat level surface. What is the radius of the circle the tractor is travelling on.

ii). Calculate the minimum safe turning radius for this tractor at a forward velocity of 16 km/h (10 mph).

iii) If the tractor is turning on the side of a hill with a 20 degree slope, determine the minimum turning radius that the tractor can safety turn at 16 km/h (10mph). The tractor is at the bottom of the slope turning uphill. Note: The equation for sideways overturn **cannot** be used, moments must be used.



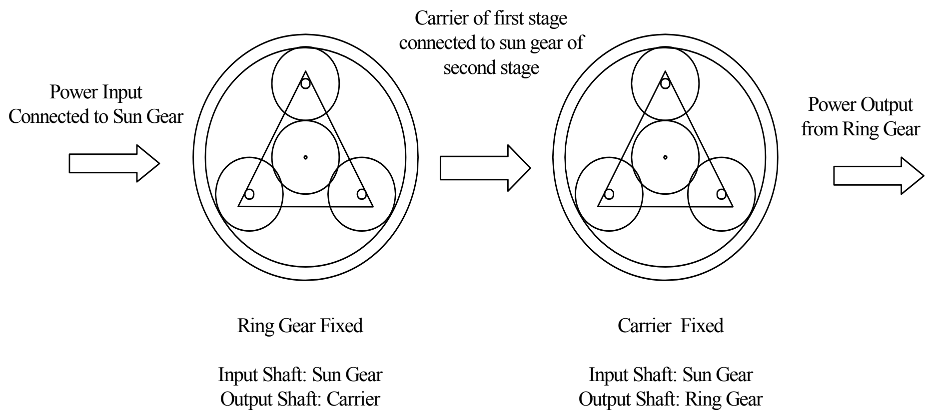
Question 4 Consider the following gearbox which consists of two different planetary gearset connected in series. The ring gear of the first planetary gear is fixed and does not rotate. The power is input via the sun gear of the first planetary gearset. The planetary carrier of the first planetary is 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

Given the following equations:

For Ring Fixed: $Ns/Nc = Tr/Ts + 1$
For Carrier Fixed: $Ns/Nr = -Tr/Ts$
For Sun Fixed: $Nr/Nc = Ts/Tr + 1$

An the following information
First Planetary Set
- Sun Gear 10 Teeth
- Ring Gear 90 Teeth

Second Planetary Set
- Sun Gear ??? Teeth
- Ring Gear 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.

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

b) If the overall gear ratio of the gearbox is 120:1 Determine the number of teeth on the sun gear of the second planetary set.

c) Determine the output speed (rpm) and direction (clockwise/anticlockwise)

d) Calculate the output power and torque from the reduction gearbox

Question 5 (25 points)

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

Pump		**Motor**	
Displacement	55 cm^3/rev (3.3 in^3/rev)	Displacement	80 cm^3/rev (5in^3/rev)
Rated Speed	2500 rpm	Output Speed	1425 rpm
Rate Pressure	20 MPa (3000 psi)	Mechanical Efficiency	0.85
Rated Delivery	125 l/min (33 gal/min) @ rated speed		
Mechanical Efficiency	0.95		

There is 7.0 MPa (1000 psi) pressure losses in the hoses between the pump and motor at the rated delivery.

i). Determine the volumetric efficiency of the pump.

ii) Determine the theoretical input torque to the pump.

iii) Determine the input power to the pump.

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

iv) The volumetric efficiency of the motor.

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

(vi) Calculate the overall efficiency of the system.

Question 6 (25 points)

A certain hydraulic pump and motor combination were tested operating at a maximum system pressure of 20 Mpa (3000 psi). You may assume that there are no pressures losses in the system. During tests the following information is given or recorded.

Hydraulic Motor

Motor Output Speed =	1500 rpm	
System Pressure	20 MPa (3000 psi)	**Motor Mechanical Efficiency** = 0.9
Motor Displacement	130 cm^3/rev (8in^3/rev)	**Motor Volumetric Efficiency** = 0.85

Hydraulic Pump

System Pressure	20 MPa (3000 psi)	Pump Mechanical Efficiency = 0.92
Pump Displacement	90 cm^3/rev (5.5 in^3/rev)	Pump Volumetric Efficiency = 0.80

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 n 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.

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