

Question 1 Given the following information for a tractor: (Note: Metric values are approximate conversions of the equivalent English values, therefore answers may be slightly different)

Rear Axle Weight	15500 lb (7000 kg)
Front Axle Weight	4500 lb (2000 kg)
Total Weight	20000 lb (9000 kg)
Wheel Base	110" (2800mm)
Center of Gravity	24.75" (622mm)(Distance from rear axle)
Drawbar Height	24" (600mm)

- Determine the weight transfer to the rear wheels if a horizontal pull of 3000 lb (13.2 kN) is attached to the drawbar.
- Under these conditions, is the weight transfer from the front wheels equal to the weight transfer to the back wheels.
- Determine the horizontal pull required for the front wheels to begin lifting of the ground.

Question 2: Determine the Drawbar Pull, Drawbar Power, Actual Travel Speed and Tractive Efficiency for an Case 2094 Tractor (See Nebraska Tests) at maximum drawbar power operating in 8th Gear , with full tractor ballast under the following conditions

- mounted plough in firm soil.
- towed plough tilled in tilled soil.

Question 3 A double acting hydraulic cylinder has a bore diameter of 4", a rod diameter of 2". The maximum pump pressure is 2200 psi. One cylinder port is connected to the pump, and the return line feeds directly into the reservoir. Assume a pressure drop of 100 psi in both the pressure and return line to the cylinder. Pump delivery rate is 20 gal/min

- What is the maximum load that can be moved when the cylinder is extending.
- What is the maximum load that can be moved when the cylinder is retracting.
- How fast will the cylinder extend.
- How fast will the cylinder retract.
- What is the flowrate of oil from the cylinder when it is retracting.

Question 4 Given the following specifications for a gear pump listed in a catalog.

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

- Calculate theoretical delivery.
- What is the volumetric efficiency?
- What is the actual input Torque?
- What is the theoretical input Torque?
- Calculate the overall efficiency of the pump.
- What is the mechanical efficiency.

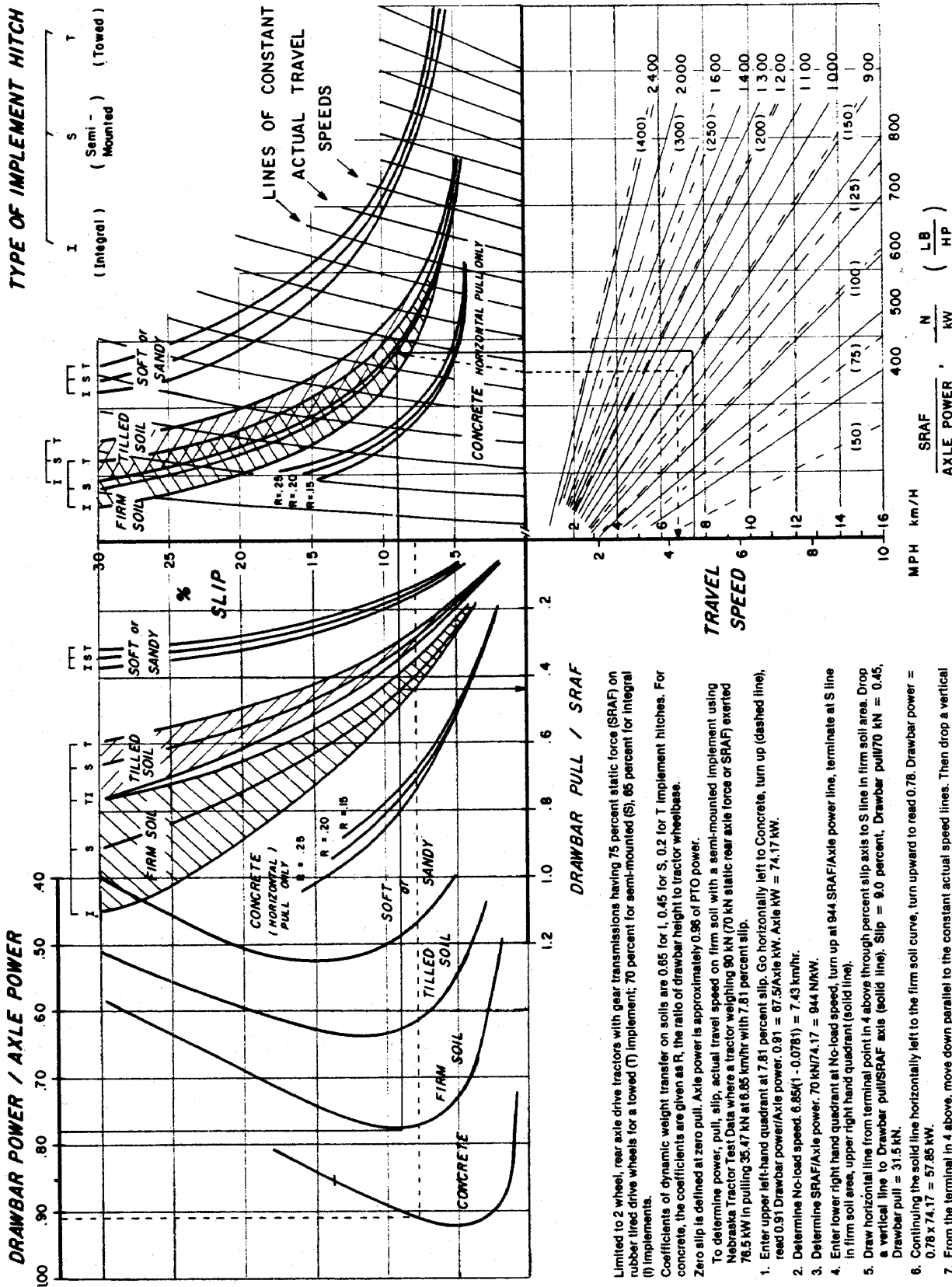
Question 5 Given the following specifications for a motor listed in a catalog.

Displacement = 4 in³/rev (65.5 cm³/rev)
Rate Speed = 1800 rpm
Rated Pressure = 3000 psi (20.7 MPA)
Required Delivery = 35 gal/min (130 l/min)
Power Output = 48 Hp (35.8 kW)

- Calculate theoretical flowrate for the motor at rated speed.
- What is the volumetric efficiency?
- What is the actual output Torque?
- What is the theoretical output Torque .
- Calculate the overall efficiency of the motor.
- Determine the mechanical efficiency of the motor.

Note: $Hp = T N / 5252$
 $Hp = Q P / 1714$

$kW = 2 p T N / 60000$
 $kW = Q P / 60$



Limited to 2 wheel, rear axle drive tractors with gear transmissions having 75 percent static force (SRAF) on rubber lined drive wheels for a towed (T) implement; 70 percent for semi-mounted (S), 65 percent for Integral (I) implements.

Coefficients of dynamic weight transfer on soils are 0.65 for I, 0.45 for S, 0.2 for T implement hitches. For concrete, the coefficients are given as R, the ratio of drawbar height to tractor wheelbase.

Zero slip is defined at zero pull. Axle power is approximately 0.96 of PTO power.

To determine power, pull, slip, actual travel speed on firm soil with a semi-mounted implement using Nebraska Tractor Test Data where a tractor weighing 90 kN (70 kN static rear axle force or SRAF) exerted 76.5 kW in pulling 35.47 kN at 6.85 km/hr with 7.81 percent slip.

1. Enter upper left-hand quadrant at 7.81 percent slip. Go horizontally left to Concrete, turn up (dashed line), read 0.91 Drawbar power/Axle power, 0.91 = 67.5/Axle kW, Axle kW = 74.17 kW.
2. Determine No-load speed, $6.85(1 - 0.0781) = 7.43$ km/hr.
3. Determine SRAF/Axle power, $70 \text{ kN}/74.17 = 944$ N/kW.
4. Enter lower right hand quadrant at No-load speed, turn up at 944 SRAF/Axle power line, terminate at S line in firm soil area, upper right hand quadrant (solid line).
5. Draw horizontal line from terminal point in 4 above through percent slip axis to S line in firm soil area. Drop a vertical line to Drawbar pull/SRAF axis (solid line). Slip = 9.0 percent, Drawbar pull/70 kN = 0.45, Drawbar pull = 31.5 kN.
6. Continuing the solid line horizontally left to the firm soil curve, turn upward to read 0.78. Drawbar power = $0.78 \times 74.17 = 57.85$ kW.
7. From the terminal in 4 above, move down parallel to the constant actual speed lines. Then drop a vertical line to the 944 SRAF/Axle power turning line, go left, and read 6.8 km/hr actual speed (dashed line).

FIGURE 16.9 Traction prediction chart (Reprinted from ASAE Data D230.4, *Agricultural machinery management*, revised December 1983)

NEBRASKA TRACTOR TEST 1525 — CASE 2094 POWERSHIFT DIESEL 12 SPEED

POWER TAKE-OFF PERFORMANCE

Power Hp (kW)	Crank shaft speed rpm	Fuel Consumption		Temperature °F (°C)			Barometer inch Hg (kPa)		
		gal/hr (l/h)	lb/hp-hr (kg/kW-h)	Hp-hr/gal (kW-h/l)	Cooling medium	Air wet bulb		Air dry bulb	
MAXIMUM POWER AND FUEL CONSUMPTION									
Rated Engine Speed—Two Hours (PTO Speed—998 rpm)									
110.50 (82.40)	2100	7.175 (27.157)	0.455 (0.276)	15.40 (3.034)	187 (86.1)	65 (18.3)	75 (23.8)	28.96 (97.80)	
VARYING POWER AND FUEL CONSUMPTION—Two Hours									
97.14 (72.44)	2170	6.561 (24.837)	0.473 (0.288)	14.80 (2.916)	184 (84.2)	65 (18.3)	74 (23.3)	.....
0.00 (0.00)	2302	2.310 (8.744)	.....	.....	174 (78.9)	66 (18.9)	75 (23.9)	.....
49.97 (37.26)	2236	4.341 (16.434)	0.608 (0.370)	11.51 (2.267)	181 (82.8)	66 (18.6)	76 (24.2)	.....
111.42 (83.09)	2100	7.230 (27.368)	0.454 (0.276)	15.41 (3.036)	187 (86.1)	66 (18.6)	75 (23.6)	.....
25.33 (18.99)	2266	3.373 (12.767)	0.992 (0.567)	7.51 (1.480)	175 (79.4)	65 (18.3)	74 (23.1)	.....
73.99 (55.17)	2205	5.366 (20.311)	0.508 (0.309)	13.79 (2.716)	183 (83.6)	66 (18.9)	75 (23.9)	.....
Av Av	59.64 (44.47)	2213	4.864 (18.410)	0.571 (0.347)	12.26 (2.416)	181 (82.5)	66 (18.6)	75 (23.7)	28.94 (97.73)

DRAWBAR PERFORMANCE

Power Hp (kW)	Drawbar pull lbs (kN)	Speed mph (km/h)	Crank- shaft speed rpm	Slip %	Fuel Consumption		Temp. °F (°C)			Barom. inch Hg (kPa)	
					gal/hr (l/h)	lb/hp-hr (kg/kW-h)	Hp-hr/gal (kW-h/l)	Cool- ing med	Air wet bulb		Air dry bulb
Maximum Available Power—Two Hours 8th (3-2) Gear											
98.66 (73.37)	5851 (26.02)	6.32 (10.18)	2099	4.45	7.143 (27.039)	0.507 (0.308)	13.81 (2.721)	192 (88.6)	70 (21.1)	76 (24.2)	29.03 (98.01)
75% of Pull at Maximum Power—Ten Hours 8th (3-2) Gear											
79.36 (59.18)	4443 (19.76)	6.70 (10.78)	2195	3.26	6.136 (23.226)	0.541 (0.329)	12.93 (2.548)	190 (87.6)	70 (20.9)	74 (23.2)	28.86 (97.44)
50% of Pull at Maximum Power—Two Hours 8th (3-2) Gear											
54.15 (40.38)	2962 (13.18)	6.86 (11.03)	2219	2.05	4.807 (18.197)	0.621 (0.378)	11.27 (2.219)	188 (86.4)	73 (22.8)	82 (27.5)	28.87 (97.47)
50% of Pull at Reduced Engine Speed—Two Hours 10th (4-1) Gear											
54.20 (40.41)	2962 (13.18)	6.86 (11.04)	1456	2.09	3.850 (14.574)	0.497 (0.302)	14.08 (2.773)	189 (86.9)	73 (22.5)	83 (28.1)	28.83 (97.34)
MAXIMUM POWER IN SELECTED GEARS											
90.78 (67.69)	11910 (52.98)	2.86 (4.60)	2126	14.83	4th (2-1) Gear		189 (87.2)	68 (20.0)	70 (21.1)	29.00 (97.93)	
98.04 (73.11)	8979 (39.94)	4.09 (6.59)	2101	7.18	5th (2-2) Gear		191 (88.3)	70 (21.1)	74 (23.3)	28.91 (97.62)	
99.08 (73.88)	7975 (35.47)	4.66 (7.50)	2101	6.08	6th (3-1) Gear		192 (88.6)	70 (21.1)	74 (23.3)	28.91 (97.62)	
98.50 (73.45)	7068 (31.44)	5.23 (8.41)	2101	5.33	7th (2-3) Gear		192 (88.9)	70 (21.1)	75 (23.9)	28.91 (97.62)	
100.12 (74.66)	5924 (26.35)	6.34 (10.20)	2100	4.34	8th (3-2) Gear		192 (88.9)	70 (21.1)	75 (23.9)	28.90 (97.59)	
98.64 (73.55)	4619 (20.54)	8.01 (12.89)	2099	3.25	9th (3-3) Gear		193 (89.2)	70 (21.1)	75 (23.9)	28.90 (97.59)	
LUGGING ABILITY IN 8th (3-2) GEAR											
Crankshaft Speed rpm		2100	1892	1683	1472	1255	1053				
Pull—lbs (kN)		5924 (26.35)	6436 (28.85)	6756 (30.28)	6827 (30.60)	6689 (29.98)	6349 (28.46)				
Increase in Pull %		0	9	14	15	13	7				
Power—Hp (kW)		100.12 (74.66)	97.50 (72.71)	90.84 (67.74)	80.18 (59.79)	67.10 (50.03)	53.52 (39.91)				
Speed—Mph (km/h)		6.34 (10.20)	5.68 (9.14)	5.04 (8.12)	4.40 (7.09)	3.76 (6.05)	3.16 (5.09)				
Slip %		4.34	4.80	4.95	5.10	4.95	4.80				

TRACTOR SOUND LEVEL WITH CAB

	dB(A)
Maximum Available Power—Two Hours	77.5
75% of Pull at Maximum Power—Ten Hours	77.0
50% of Pull at Maximum Power—Two Hours	77.5
50% of Pull at Reduced Engine Speed—Two Hours	74.5
Bystander in 12th (4-3) gear	88.0

TIRES, BALLAST AND WEIGHT

	With Ballast		Without Ballast	
	Inner Two 18.4-38; 8; 14 (95)	Outer Two 18.4-38; 6; 14 (95)	Inner Two 18.4-38; 8; 14 (95)	Outer Two 18.4-38; 6; 14 (95)
Rear Tires	—No., size, ply & psi (kPa)			
Ballast	None	78 lb (35 kg)	None	None
Front Tires	—No., size, ply & psi (kPa)			
Ballast	None	125 lb (57 kg)	None	None
Height of Drawbar	19.5 in (495 mm)		19.5 in (495 mm)	
Static Weight with Operator	—Rear		—Rear	
	11230 lb (5094 kg)		10920 lb (4953 kg)	
	—Front		—Front	
	3520 lb (1597 kg)		3270 lb (1483 kg)	
	—Total		—Total	
	14750 lb (6691 kg)		14190 lb (6436 kg)	

Department of Agricultural Engineering

Dates of Test: May 30 to June 16, 1984

Manufacturer: J. I. CASE COMPANY, 700 State Street, Racine, Wisconsin 53404

FUEL, OIL AND TIME: Fuel No. 2 Diesel Cetane No. 46.0 (rating taken from oil company's inspection data) Specific gravity converted to 60°/60° (15°/15°) 0.8408 Fuel weight 7.000 lbs/gal (0.839 kg/l) Oil SAE 30 API service classification SF, CD To motor 4.354 gal (16.481 l) Drained from motor 4.085 gal (15.463 l) Transmission and final drive lubricant Case Powergard PTF transmission fluid Total time engine was operated 40.0 hours.

ENGINE: Make Case Diesel Type six cylinder vertical Serial No. *10356640* Crankshaft lengthwise Rated rpm 2100 Bore and stroke 4.625" x 5.0" (117.5 mm x 127 mm) Compression ratio 16.0 to 1 Displacement 304 cu in (8259 ml) Starting system 12 volt Lubrication pressure Air cleaner two paper elements Oil filter one full flow cartridge Oil cooler radiator for hydraulic and transmission oil Fuel filter two paper cartridges and prestrainer Muffler vertical Cooling medium temperature control two thermostats.

CHASSIS: Type standard with duals Serial No. *9932956* Tread width rear 60" (1524 mm) to 124" (3150 mm) front 60" (1524 mm) to 88" (2235 mm) Wheel base 110" (2794 mm) Center of gravity (without operator or ballast, with minimum tread, with fuel tank filled and tractor serviced for operation) Horizontal distance forward from center-line of rear wheels 25.7" (652 mm) Vertical distance above roadway 40.7" (1034 mm) Horizontal distance from center of rear wheel tread 0" (0 mm) to the right/left Hydraulic control system direct engine drive Transmission selective gear fixed ratio with partial (3) range operator controlled powershift Advertised speeds mph (km/h) first 1.9 (3.1) second 2.5 (4.0) third 3.2 (5.2) fourth 3.2 (5.2) fifth 4.3 (6.9) sixth 4.9 (7.9) seventh 5.4 (8.7) eighth 6.5 (10.5) ninth 8.1 (13.0) tenth 9.9 (15.9) eleventh 13.2 (21.2) twelfth 18.1 (29.1) reverse 3.2 (5.2), 5.4 (8.7), 8.1 (13.0) Clutch wet multiple disc hydraulically power actuated by foot pedal Brakes wet multiple disc hydraulically power actuated by two foot pedals which can be locked together Steering hydrostatic Turning radius (on concrete surface with brake applied) right 161.8" (4.11 m) left 161.8" (4.11 m) (on concrete surface without brake) right 182.2" (4.63 m) left 182.2" (4.63 m) Turning space diameter (on concrete surface with brake applied) right 338" (8.59 m) left 338" (8.59 m) (on concrete surface without brake) right 382.2" (9.71 m) left 382.2" (9.71 m) Power take-off 534 rpm at 2100 engine rpm and 998 rpm at 2100 engine rpm.

REPAIRS AND ADJUSTMENTS: No repairs or adjustments.

REMARKS: All test results were determined from observed data obtained in accordance with SAE and ASAE test codes and the technically equivalent ISO test codes or official Nebraska test procedure. For the maximum power tests, the fuel temperature at the injection pump return was maintained at 180°F (82.2°C). Six gears were chosen between 15% slip and 10 mph (16.1 km/h).

We, the undersigned, certify that this is a true and correct report of official Tractor Test No. 1525, July 19, 1984.

LOUIS I. LEVITICUS
Engineer-in-Charge

K. VON BARGEN
W. E. SPLINTER
T. R. BASTARD