

**BAE 517**  
**Off-Road Vehicle Design**

**Exam No. 2**  
**(Take Home, Open-Book, Open-Note)**

**Name:** \_\_\_\_\_

**Instructions:** Solve five of the following six problems completely. You must solve problem No. 6. Each problem is worth 20 points for an exam total of 100 points. If you would like receive up to 10 points extra credit, simply solve the remaining problem. List all assumptions used in arriving at you final answer. You are to provide supporting work for each solution. Work neatly as partial credit will be awarded. This is to be an individual effort. Students should not confer with their contemporaries. Any questions regarding the problem statements should be directed to the instructor of the course.

1. You are to evaluate the possible rated speed for a six-cylinder, four-cycle engine with a displacement of 6.8 L. Assume the brake mean effective pressure is 830 kPa. Calculate the brake output power for 2400 and 2000 rpm. What is the inertial requirement of the flywheel-clutch combination if the cyclic speed variation is to be less than 0.4%?

2. A 4.0 L, naturally aspirate CI engine is running on No. 2 diesel fuel with a stoichiometric A/F ratio of 17:1. The air temperature is 25 F and the barometric pressure is 100 kPa. The brake mean effective pressure is 750 kPa, and the BSFC is 0.27 kg/kWh at rated engine speed and power. The rated engine speed is 2400 rpm, and the high idle speed is 2450 rpm. Assume the fuel consumption falls to 3.8 kg/h at high idle. Calculate the new equivalent ratio at this condition.

3. The following data were collected from a 4-cylinder CI engine running on methyl ester:  $N_e=2,250$  rpm,  $m_f=12.1$  kg/hr,  $H_g=39,000$  kJ/kg,  $D_e=2.4$ L,  $r=15$ ,  $p_{ime}=1,050$  kPa, and  $p_1=100$ kPa. Determine the fuel equivalent power (kW), indicated power (kW), and indicated thermal efficiency.

4. Determine the equivalent molecule for a volume blend of 80% petroleum diesel ( $C_{16}H_{34}$ ) and 20% methyl ester ( $C_{19}H_{36}O_2$ ). Assume  $\phi=1$  and determine the ideal air/fuel ratio for this blended fuel.

5. The following data were collected from a 4-cylinder CI engine running on diesel fuel:  $N_e=2,250$  rpm,  $m_f=10.1$  kg/hr,  $H_g=45,600$  kJ/kg,  $D_e=2.2$ L,  $r=16$ ,  $p_{ime}=1,050$  kPa, and  $p_1=100$ kPa. What is the dual-cycle efficiency of this engine? Use a  $\beta_{dc}$  of 1 and a  $T_3/T_1$  ratio of 9.

6. Using the data from the attached Tractor Test Report, determine the fuel equivalent power during the PTO test at rated engine speed.

# NEBRASKA TRACTOR TEST 1770

## JOHN DEERE 5105 DIESEL

### 8 SPEED

#### POWERTAKE-OFF PERFORMANCE

Power HP (kW)	Crank shaft speed rpm	Gall/hr (L)	lb/gal (kg/L)	Hp/gal (kW/L)	Mean Atmospheric Conditions
---------------------	--------------------------------	----------------	------------------	------------------	--------------------------------

#### MAXIMUM POWER AND FUEL CONSUMPTION

		Rated Engine Speed (PTO speed 2640 rpm)		
40.56 (30.26)	2300	9.39 (9.04)	0.416 (0.255)	16.99 (12.55)
		Standard Power Take-off Speed - (2400 rpm)		
40.59 (30.35)	2200	9.35 (8.92)	0.409 (0.249)	17.33 (12.90)

#### VARYING POWER AND FUEL CONSUMPTION

40.56 (30.26)	2300	9.39 (9.04)	0.416 (0.255)	16.99 (12.55)	Air temperature
35.34 (26.35)	2254	9.16 (8.20)	0.433 (0.265)	16.32 (12.22)	79°F (26°C)
28.91 (20.97)	2402	1.78 (6.73)	0.468 (0.293)	15.10 (11.27)	Relative humidity
18.19 (13.56)	2423	1.49 (5.62)	0.577 (0.352)	10.24 (7.41)	34%
9.17 (6.84)	2455	1.19 (4.50)	0.916 (0.557)	7.71 (5.72)	Barometer
0.58 (0.43)	2482	0.88 (3.22)	10.349 (6.295)	0.68 (0.15)	29.99 Hg (99.17 kPa)

Maximum Torque 114 lb.-ft. (154 Nm) at 1402 rpm

Maximum Torque Rise - 22.7%

Torque rise at 1801 rpm - 1.7%

#### TRACTOR SOUND LEVEL WITHOUT CAB

	Front Wheel Drive	
	Engaged dB(A)	Disengaged dB(A)
At no load in 3rd(A3) gear	87.5	87.3
Transport speed-no load-8th(B4) gear	--	91.7
Hylander in 8th(B4) gear	--	81.3

#### TIRES AND WEIGHT

Rear Tires No., size, ply & psi (kPa)  
Front Tires No., size, ply & psi (kPa)  
Height of Drawbar  
Basic Weight with operator Rear  
Front  
Total

#### Tested Without Ballast

Two 16.9-28; 8:12 (55)  
Two 9.5-24; 6:12 (55)  
17.3 in (443 mm)  
2773 lb (1259 kg)  
1890 lb (857 kg)  
4663 lb (2114 kg)

Location of Test: Nebraska Tractor Test Laboratory, University of Nebraska, Lincoln Nebraska 68583-0832

Dates of Test: May 2 - 17, 2000

Manufacturer: John Deere Commercial Products Inc., 700 Horizon South Parkway, Grovetown Ga. USA, 30815

**FUEL, OIL and TIME:** Fuel No. 2 Diesel Specific gravity converted to 60°/60°F (15°/15°C) 0.8487 Fuel weight 7.067 lb/gal (0.347 kg/l) Oil SAE 15W40 API service classification CC-4 Transmission and hydraulic lubricant John Deere Hy-Card Fluid Front axle lubricant SAE SOW90 API GL-5 Total time engine was operated 11.5 hours

**ENGINE:** Make John Deere Diesel Type three cylinder vertical Serial No. \*PE5029D072454\* Crankshaft lengthwise Rated engine speed 2300 Bore and stroke 4.19" x 4.33" (106.4 mm x 110.0 mm) Compression ratio 17.4 to 1 Displacement 179 cu in (2934 ml) Starting system 12 volt Lubrication pressure Air cleaner one paper element and one polyester felt element Oil filter one full flow cartridge Fuel filter one paper element Muffler underhood Exhaust vertical Cooling medium temperature control one thermostat

**ENGINE OPERATING PARAMETERS:** Fuel rate: 15.8 - 17.8 lb/h (7.2 - 8.1 kg/h) High idle: 2475 - 2525 rpm

**CHASSIS:** Type front wheel assist Serial No. \*LV5105B110157\* Tread width rear 55.8" (1417 mm) to 71.7" (1820 mm) front 52.8" (1340 mm) to 75.0" (1904 mm) Wheelbase 76.8" (1950 mm) Hydraulic control system direct engine drive Transmission selective gear fixed ratio Nominal travel speeds mph (km/h) first 1.94 (3.13) second 2.78 (4.48) third 3.95 (6.33) fourth 5.51 (8.87) 6th 6.44 (10.36) sixth 9.72 (15.64) seventh 15.74 (22.11) eighth 19.26 (31.00) reverse 2.32 (3.74), 3.32 (5.34), 4.70 (7.56), 6.58 (10.59) Clutch single dry disc operated by foot pedal Brakes single wet disc mechanically operated by two foot pedals which can be locked together Steering hydrostatic Power take-off 540 rpm at 2199 engine rpm Unladen tractor mass 4500 lb (2041 kg)

### THREE POINT HITCH PERFORMANCE (OECD Static Test)

CATEGORY: II

Quick Attach: None

Maximum Force Exerted Through Whole Range: 3173 lbs (14.1 kN)

i) Opening pressure of relief valve:	NA
Sustained pressure of the open relief valve:	2820 psi (194 bar)
ii) Pump delivery rate at minimum pressure and rated engine speed:	11.8 GPM (43.9 l/min)
iii) Pump delivery rate at maximum hydraulic power:	9.5 GPM (36.0 l/min)
Delivery pressure:	2500 psi (172 bar)
Power:	13.9 HP (10.4 kW)

### THREE POINT HITCH PERFORMANCE

Observed Maximum Pressure psi.(bar)	2760(190)
Location:	hydraulic service port
Hydraulic oil temperature: °F.(°C)	158(70)
Location:	hydraulic sump
Category:	II
Quick attach:	none

#### SAE Static Test System pressure 2485 psi (171 Bar)

Hitch point distance to ground level in. (mm)	8.0(203)	15.0(381)	22.0(559)	29.0(737)	36.0(914)
Lift force on frame lb	2612	4190	4358	4275	4124
" " " " " (kN)	(11.7)	(18.6)	(19.4)	(19.0)	(18.3)

#### ASAE Static Test System pressure 2755 psi (190 Bar)

Hitch point distance to ground level in. (mm)	8.0(203)	15.0(381)	22.0(559)	29.0(737)	36.0(914)
Lift force on frame lb	4227	4890	4894	4776	4388
" " " " " (kN)	(18.8)	(21.8)	(21.7)	(21.2)	(19.7)

	SAE/ASAE Test		OECD Test	
	inch	mm	inch	mm
A	24.3	617	25.2	641
B	11.4	290	11.4	290
C	13.2	334	13.2	334
D	12.1	308	12.1	308
E	12.0	305	12.0	305
F	4.9	124	4.9	124
G	28.4	670	28.4	670
H	1.8	46	1.8	46
I	12.0	305	12.0	305
J	21.5	546	21.5	546
K	15.8	402	15.8	402
L	36.2	918	36.2	918
M	21.9	555	21.9	555
N	29.9	760	29.9	760
O	8.0	203	8.0	203
P	40.5	1029	45.5	1156
Q	36.1	916	36.1	916
R	22.5	572	22.5	572

HITCH DIMENSIONS AS TESTED - NO LOAD



REPAIRS AND ADJUSTMENTS: The hydraulic relief valve was replaced.

REMARKS: All test results were determined from observed data obtained in accordance with official OECD, SAE and Nebraska test procedures. For the maximum power tests, the fuel temperature at the injection pump inlet was maintained at 122°F (50°C).

We, the undersigned, certify that this is a true and correct report of official Tractor Test No. 1770, July 7, 2000.

Leonard L. Bashford  
Director

C. J. Hoffman  
M. F. Kocher  
R. D. Crisso Jr.  
Board of Tractor Test Engineers



John Deere 5105 Diesel