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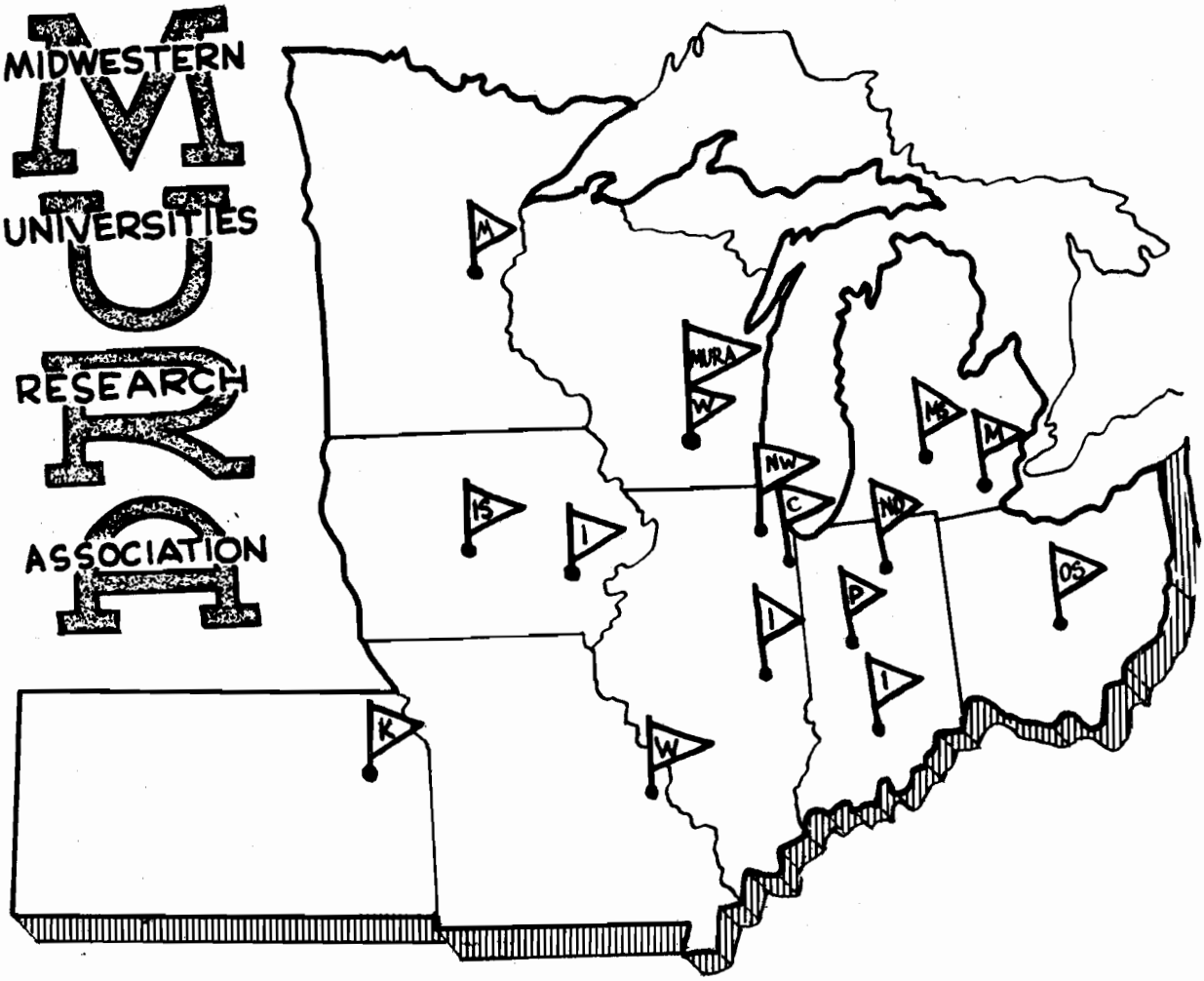

REPORT DUCK ANSWER
(Program 75)
February-March, 1957

NUMBER 237
Internal
(IBM Program)

DUCK ANSWER
(Programme 75)

J. N. Snyder

This program was finally inspired by MURA NOTES of 5 November 1956 which referred to MURA NOTES of 25 August 1956 both authored by L. Jackson Laslett.

The program integrates the equations:

$$\frac{d\rho}{d\tau} = \frac{p_\rho}{1+e_0 R_{21}}$$

$$\frac{d\psi}{d\tau} = \frac{p_\psi}{1+e_1 R_{22}}$$

$$\begin{aligned}\frac{dp_\rho}{d\tau} = {} & 10R_1\rho + \lambda_2\left[R_3\rho^2 + R_4\psi^2\right] + \lambda_4\left[R_5\rho^3 + R_6\rho\psi^2\right] \\ & + \lambda_6\left[R_8\rho^4 + 3R_9\rho^2\psi^2 + R_{10}\psi^4\right] \\ & + \epsilon_0 R_{11} + \mu_0 R_{13}\psi + \mu_2\left[2R_{14}\rho\psi\right] + \mu_4\left[3R_{16}\rho^2\psi + R_{17}\psi^3\right] \\ & + \mu_6\left[4R_{18}\rho^3\psi + 2R_{19}\rho\psi^3\right]\end{aligned}$$

$$\begin{aligned}\frac{dp_\psi}{d\tau} = {} & 10R_2\psi + \lambda_3\left[2R_4\rho\psi\right] + \lambda_5\left[R_6\rho^2\psi + R_7\psi^3\right] \\ & + \lambda_7\left[2R_9\rho^3\psi + 4R_{10}\rho\psi^3\right] \\ & + \epsilon_1 R_{12} + \mu_1 R_{13}\rho + \mu_3\left[R_{14}\rho^2 + R_{15}\psi^2\right] + \mu_5\left[R_{16}\rho^3 + 3R_{17}\rho\psi^2\right] \\ & + \mu_7\left[R_{18}\rho^4 + 3R_{19}\rho^2\psi^2 + R_{20}\psi^4\right]\end{aligned}$$

where

$$\begin{aligned}R_i = {} & S_i + A_i\cos(2\tau + \alpha_i\pi) + B_i\cos\left(\frac{4\tau}{N_1} + \beta_i\pi\right) \\ & + C_i\cos\left(\frac{6\tau}{N_2} + \gamma_i\pi\right) + \Gamma_i\,\frac{\sin(2\tau + \delta\pi)}{\sin\left(\frac{2\tau + \delta\pi}{N_3}\right)}\end{aligned}$$

with N_1, N_2, N_3 integers. $|N_3| < 64$ but $|N_1|, |N_2| < 2^{35}$. The variable τ is carried in units of π and can be represented as:

$$\left(\frac{\tau}{\pi}\right) = k + \tau'$$

where k is an integer and $0 \leq \tau' < 1$. Initial values k_0 and τ_0 may be given to this variable. N_{RK} integration steps are used in an interval $\Delta(\tau/\pi) = 1$. Results are printed every N_p steps and the entire run lasts for N_e steps.

In order to save computation time, the "switches" $e_0, e_1, \epsilon_0, \epsilon_1, \lambda_i$ and μ_i are provided. If any such switch be given the value zero the corresponding term

will be omitted from the equations and not even computed. Setting a switch equal to 1 inserts the term in the equations. The counters which count to N_e and N_p may be given initial values $(C_e)_0$ and $(C_\rho)_0$.

A sample agendum sheet is attached. All parameters will be regarded as zero unless specifically set, except $N_1 = N_2 = N_3 = 1$ and $(p_\rho)_{max} = (p_\psi)_{max} = (\rho)_{max} = (\psi)_{max} = 40$ are automatically used unless otherwise set. These latter are overflow constants on the respective variables, and are scaled by 2^{-6} for entry on the agendum. Note that the addresses associated with these quantities are in error. Instead of 91, 92, 93, 94 read 2139, 2140, 2141, 2142. Such corrections should be made if these quantities be changed on an agendum. Only those quantities which differ from the above discussed automatic values should be entered on the agendum sheet. The program accepts an 11 digit ID number so the recipe

$$10^8 A + i$$

with A = Human ID, i = Run ID should be used.

All parameters are retained from run-to-run in a series. The agenda for a series should be carefully stapled together. Only those quantities which change should be entered on subsequent sheets. The standard Search Feature is provided for a series and a box for requesting this feature is provided. If requested, the first run of a series which reaches N_e steps will terminate the series. Note that the dependent variables are scaled by 10^{-2} both on entry and on printing.

The print format is as follows:

PRINT FORMAT

00075	ID				
00075	N_e	N_p	N_{RK}		
00075	e_0	e_1			
00075	λ_2	λ_4	λ_6		
00075	λ_3	λ_5	λ_7		
00075	ϵ_0	ϵ_1			
00075	μ_0	μ_2	μ_4	μ_6	
00075	μ_1	μ_3	μ_5	μ_7	
00075	N_1	N_2	N_3		
00075	δ				
			(Space)		
00001	S_1	A_1	B_1	C_1	Γ_1
00001	α_1	β_1	γ_1		
00002	S_2	A_2	B_2	C_2	Γ_2
00002	α_2	β_2	γ_2		
.					
.					
.					
.					
00022	S_{22}	A_{22}	B_{22}	C_{22}	Γ_{22}
00022	α_{22}	β_{22}	γ_{22}		
			(New page)		
k_0	τ'_0	$10^{-2}(p\rho)_0$	$10^{-2}(p\psi)_0$	$10^{-2}\rho_0$	$10^{-2}\psi_0$
k_1	τ'_1	$10^{-2}(p\rho)_1$	$10^{-2}(p\psi)_1$	$10^{-2}\rho_1$	$10^{-2}\psi_1$
k_2	τ'_2	$10^{-2}(p\rho)_2$	$10^{-2}(p\psi)_2$	$10^{-2}\rho_2$	$10^{-2}\psi_2$
.					
.					
.					
k_m	τ'_m	$10^{-2}(p\rho)_m$	$10^{-2}(p\psi)_m$	$10^{-2}\rho_m$	$10^{-2}\psi_m$

END

(Five digit failure mark, if run terminated by overflow) ← Both not present → (If run ran to N_e integration steps)

Note that only those R_i which are pertinent in a given run as determined by the switch settings will be printed.

Restrictions placed upon the variables and parameters are as follows along with the failure mark which will result on their respective violation: (Magnitudes of the quantities are to be understood throughout)

Restriction	Failure Mark
$R_1 < 4$	1
$R_2 < 4$	2
$\vdots$	$\vdots$
$R_{22} < 4$	22
$\dfrac{\sin(2\Gamma + \pi\delta)}{\sin\left(\dfrac{2\Gamma + \pi\delta}{N_3}\right)} < 64$	30
$2^m h \, p_\rho / 1+e_0 \; R_{21} < 64$	31
$2^m h \, p_\psi / 1+e_1 \; R_{22} < 64$	32

(where $h = \pi / N_{RK}$ and m is the greatest integer such that $2^m h < 1$)

$10 R_1 \rho < 64$	33
$10 R_2 \psi < 64$	34
Terms in λ_2 or $\lambda_3 < 64$	35
Terms in λ_4 or $\lambda_5 < 64$	36
Terms in λ_6 or $\lambda_7 < 64$	37
Terms in μ_2 or $\mu_3 < 64$	38
Terms in μ_4 or $\mu_5 < 64$	39
Terms in μ_6 or $\mu_7 < 64$	40
$p'_\rho < 64$	41
$p'_\psi < 64$	42
$p_\rho < (p_\rho)_{max} \; (< 64)$	51
$p_\psi < (p_\psi)_{max} \; (< 64)$	52
$\rho < (\rho)_{max} \; (< 64)$	53
$\psi < (\psi)_{max} \; (< 64)$	54

Of course,

$$S_i, A_i, B_i, C_i, \Gamma_i, \alpha_i, \beta_i, \gamma_i, \delta < 1$$

MEMORANDUM

TO: Computer Users

FROM: J. F. McNall - November 23, 1959

SUBJECT: Addition to DUCK ANSWER

DUCK ANSWER, INVARIANT DUCK BUMPS, and DUCNALA (programs 75, 77, 219) have been modified so that the user may cause a new R_i to be calculated if he so desires.

$$R_i = S_i + A_i \cos(m_1 2\tau + \alpha_i \pi) + B_i \cos(m_2 4\tau + \beta_i \pi)$$

$$+ C_i \cos(m_3 6\tau + \gamma_i \pi) + D_i \cos(m_4 \; 8\tau + \delta_i \pi)$$

where $D_i \equiv \Gamma_i$

If all of the above m's are equal to zero, then the normal DUCK ANSWER is run. If any of these parameters is non-zero, then R_i is computed as above. If some of the m's are equal to zero, they will be set equal to one by the program.

This addition in no way changes the normal operation of DUCK ANSWER.

An agenda sheet is available for this addition and should be used in conjunction with the normal DUCK ANSWER agendum.

m_1, m_2, m_3, m_4 are printed as a separate line of fractions following the line which prints only δ. The δ_i are printed on the same line as α_i, β_i, and γ_i.

DUCK ANSWER AGENDUM (PROGRAMME 75)

1. All parameters will be zero unless set otherwise (except $N_1 = N_2 = N_3 = 1$, $(p_\rho)_{max} = (p_\psi)_{max} = (\rho)_{max} = (\psi)_{max} = 40$). Do not enter such zero values.
2. All values are held from run to run. In a series, enter only those parameters which change on subsequent sheets.
3. The e's, λ's, ϵ's and μ's have only the values 0 (need not enter) or 1 (enter).
4. In forward integration ($N_{RK} > 0$), $\kappa \geq 0$, $\tau' \geq 0$ is necessary. In backward integration ($N_{RK} < 0$), $\kappa_0 \leq -0$, $\tau' \leq -0$ is necessary. The -0 must be consciously entered.
5. For application of the Search Feature (SS6 UP), check vividly. ☐

Parameter	Address	Value	Parameter	Address	Value
ID#	30		μ_0	44	
N_E	31		μ_2	45	
N_p	32		μ_4	46	
N_{RK}	33		μ_6	47	
e_0	34		μ_1	48	
e_1	35		μ_3	49	
λ_2	36		μ_5	50	
λ_4	37		μ_7	51	
λ_6	38		N_1	52	
λ_3	39		N_2	53	
λ_5	40		N_3	54	
λ_7	41		k_0	55	
ϵ_0	42		$(C_e)_0$	56	
ϵ_1	43		$(C_p)_0$	57	
					END INTEGERS
$(p_\rho)_0$ 10^{-2}	95		δ	100	
$(p_\psi)_0$ 10	96		$2^{-6}(p_\rho)_{max}$	2139	
$(\rho)_0$ 10^{-2}	97		$2^{-6}(p_\psi)_{max}$	2140	
$(\psi)_0$ 10^{-2}	98		$2^{-6}(\rho)_{max}$	2141	
τ'	99		$2^{-6}(\psi)_{max}$	2142	
S_1	101		A_1	131	
S_2	102		A_2	132	
S_3	103		A_3	133	
S_4	104		A_4	134	
S_5	105		A_5	135	
S_6	106		A_6	136	
S_7	107		A_7	137	
S_8	108		A_8	138	
S_9	109		A_9	139	
S_{10}	110		A_{10}	140	
S_{11}	111		A_{11}	141	
S_{12}	112		A_{12}	142	
S_{13}	113		A_{13}	143	
S_{14}	114		A_{14}	144	
S_{15}	115		A_{15}	145	
S_{16}	116		A_{16}	146	
S_{17}	117		A_{17}	147	
S_{18}	118		A_{18}	148	
S_{19}	119		A_{19}	149	
S_{20}	120		A_{20}	150	
S_{21}	121		A_{21}	151	
S_{22}	122		A_{22}	152	

B_1	161		Γ_1	221		β_1	281	
B_2	162		Γ_2	222		β_2	282	
B_3	163		Γ_3	223		β_3	283	
B_4	164		Γ_4	224		β_4	284	
B_5	165		Γ_5	225		β_5	285	
B_6	166		Γ_6	226		β_6	286	
B_7	167		Γ_7	227		β_7	287	
B_8	168		Γ_8	228		β_8	288	
B_9	169		Γ_9	229		β_9	289	
B_{10}	170		Γ_{10}	230		β_{10}	290	
B_{11}	171		Γ_{11}	231		β_{11}	291	
B_{12}	172		Γ_{12}	232		β_{12}	292	
B_{13}	173		Γ_{13}	233		β_{13}	293	
B_{14}	174		Γ_{14}	234		β_{14}	294	
B_{15}	175		Γ_{15}	235		β_{15}	295	
B_{16}	176		Γ_{16}	236		β_{16}	296	
B_{17}	177		Γ_{17}	237		β_{17}	297	
B_{18}	178		Γ_{18}	238		β_{18}	298	
B_{19}	179		Γ_{19}	239		β_{19}	299	
B_{20}	180		Γ_{20}	240		β_{20}	300	
B_{21}	181		Γ_{21}	241		β_{21}	301	
B_{22}	182		Γ_{22}	242		β_{22}	302	
C_1	191		α_1	251		γ_1	311	
C_2	192		α_2	252		γ_2	312	
C_3	193		α_3	253		γ_3	313	
C_4	194		α_4	254		γ_4	314	
C_5	195		α_5	255		γ_5	315	
C_6	196		α_6	256		γ_6	316	
C_7	197		α_7	257		γ_7	317	
C_8	198		α_8	258		γ_8	318	
C_9	199		α_9	259		γ_9	319	
C_{10}	200		α_{10}	260		γ_{10}	320	
C_{11}	201		α_{11}	261		γ_{11}	321	
C_{12}	202		α_{12}	262		γ_{12}	322	
C_{13}	203		α_{13}	263		γ_{13}	323	
C_{14}	204		α_{14}	264		γ_{14}	324	
C_{15}	205		α_{15}	265		γ_{15}	325	
C_{16}	206		α_{16}	266		γ_{16}	326	
C_{17}	207		α_{17}	267		γ_{17}	327	
C_{18}	208		α_{18}	268		γ_{18}	328	
C_{19}	209		α_{19}	269		γ_{19}	329	
C_{20}	210		α_{20}	270		γ_{20}	330	
C_{21}	211		α_{21}	271		γ_{21}	331	
C_{22}	212		α_{22}	272		γ_{22}	332	

END FRACTIONS