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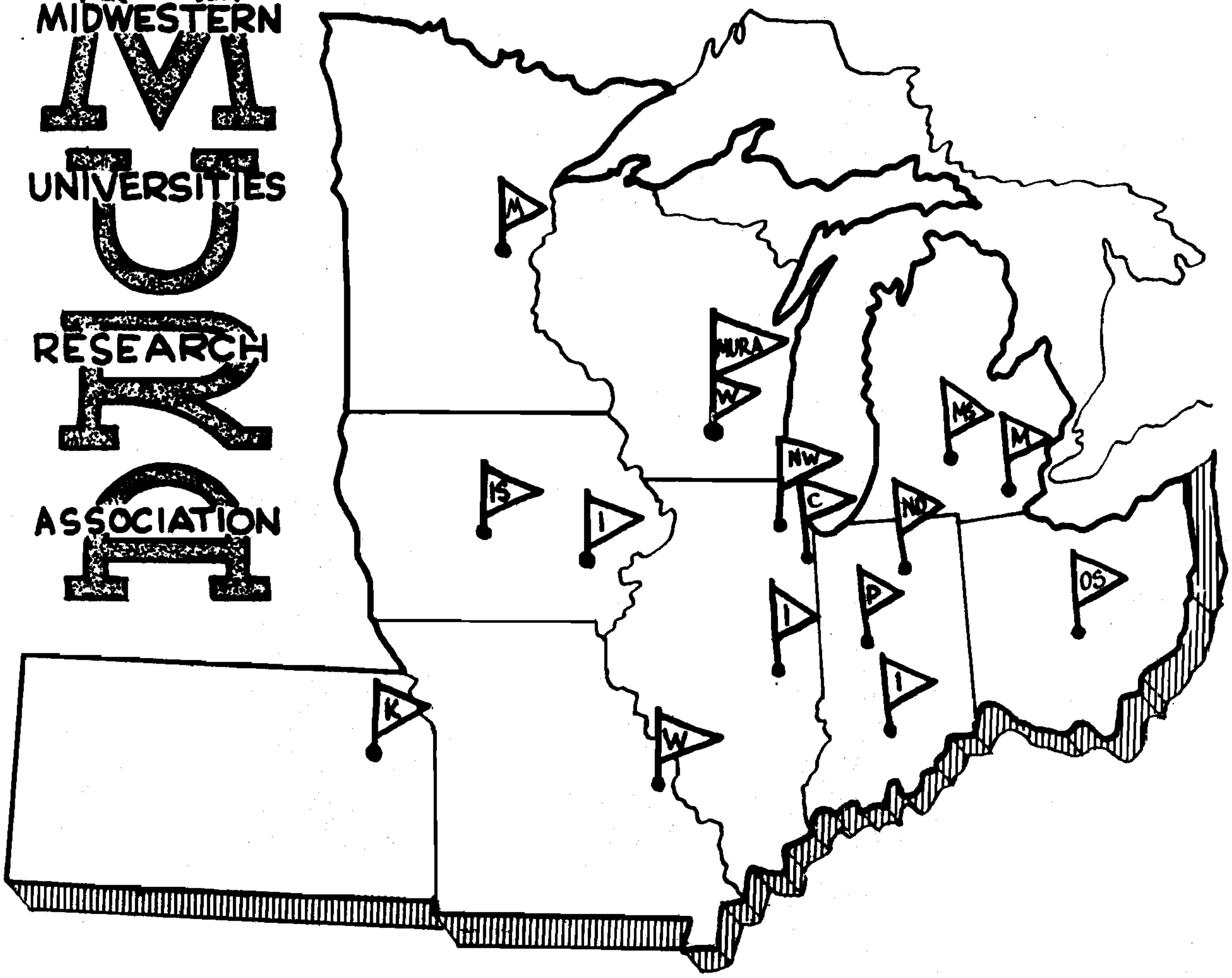

REPORT INVARIANT DUCK BUMPS
(Program 77)
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INVARIANT DUCK BUMPS
(Programme 77)

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This program arose from memoranda of 5 Nov. 1956 L. Jackson Laslett to J. N. Snyder and of 28 Dec. 1956. It gives the DUCK ANSWER (Program 75) all the facilities which have become standard in the MURA armamentarium of routines.

The program provides either invariants, or fumble-type bumps, or both, or neither (in which case use Program 75, DUCK ANSWER). The details of these facilities are given below. To use the invariants facility staple an INVARIANT DUCK BUMPS (INVARIANTS) AGENDUM to the front of the pertinent series of DUCK ANSWER runs. To use the bumps facility staple an INVARIANT DUCK BUMPS . (BUMPS) AGENDUM to the front of the pertinent series of DUCK ANSWER runs. Both sheets can be so appended. If SS3 be moved up no invariants will be computed; if SS4 be moved up no bumps will be applied. However in the latter case the phase in the bump cycle will not be lost so that the bump can be caused to reappear by moving SS4 down again.

Sample agendum sheets are attached. In all cases, a parameter not entered will be treated as zero. It is not necessary to enter such parameters. All parameters are held from run to run in a series. Changes may be made later in a series by entering only those parameters which change.

The printing format is the same as DUCK ANSWER (Program 75) except all program numbers are changed from 75 to 77. Also the two invariants will be printed just after the line of variables to which it applies.

INVARIANTS

Each time the variables are printed the quantities

$$K_\rho = \left[\xi_\rho(\rho-\rho_f)^2 + \eta_\rho(\rho-\rho_f)(p_\rho - p_{\rho f}) + \zeta_\rho(p_\rho - p_{\rho f})^2\right]^{1/2}$$

$$K_\psi = \left[\xi_\psi(\psi-\psi_f)^2 + \eta_\psi(\psi-\psi_f)(p_\psi - p_{\psi f}) + \zeta_\psi(p_\psi - p_{\psi f})^2\right]^{1/2}$$

are computed. The above are computed if C_e / N_{RK} is an integer where C_e is the total number of integration steps taken to date and N_{RK} is the number of integration steps in a "period" i. e. an interval $\Delta\Upsilon = \pi$. If C_e/N_{RK} is not an integer a similar pair of quantities using a different set of parameters (indicated by primes) is computed. $10^{-3}K_x$ and $10^{-3}K_y$ are printed just after the variables are printed. The unprimed invariants are printed with a 5 digit marker of 00000; the primed invariants with a marker of 10000. The input parameters to the invariants portion of the program are all scaled by 10^{-2} as indicated on the AGENDUM SHEET.

BUMPS

The machine is regarded as having a larger periodicity consisting of N_B integration steps. A counter C_B (to which an initial value $(C_B)_0$ can be given) counts up to N_B, is reset to zero, etc. After the integration step on which

$$C_B = n$$

a transformation B is applied to the variables.

$$\rho_1 = (\Delta\rho) + \alpha_\rho \rho + \beta_\rho p_\rho + E(P,Q)$$
$$p_{\rho_1} = (\Delta p_\rho) + \gamma_\rho \rho + \delta_\rho p_\rho + F(P,Q)$$
$$\psi_1 = (\Delta\psi) + \alpha_\psi \psi + \beta_\psi p_\psi + G(P,Q)$$
$$p_{\psi_1} = (\Delta p_\psi) + \gamma_\psi \psi + \delta_\psi p_\psi + H(P,Q)$$

where

$$P = r_\rho \rho + s_\rho p_\rho$$
$$Q = r_\psi \psi + s_\psi p_\psi$$

and

$$E(P,Q) = e_1 P^2 + e_2 Q^2 + e_3 PQ + e_4 P^3 + e_5 Q^3 + e_6 P^2 Q + e_7 PQ^2$$
$$F(P,Q) = f_1 P^2 + f_2 Q^2 + f_3 PQ + f_4 P^3 + f_5 Q^3 + f_6 P^2 Q + f_7 PQ^2$$
$$G(P,Q) = g_1 P^2 + g_2 Q^2 + g_3 PQ + g_4 P^3 + g_5 Q^3 + g_6 P^2 Q + g_7 PQ^2$$
$$H(P,Q) = h_1 P^2 + h_2 Q^2 + h_3 PQ + h_4 P^3 + h_5 Q^3 + h_6 P^2 Q + h_7 PQ^2$$

After the step on which

$$C_B = n'$$

a transformation B' of the same form is applied with all parameters designated by primes. It is necessary that all of these parameters given on an AGENDUM SHEET be scaled by 2^{-5}.

If printing is called for on a step on which a bump is applied, printing will occur after the bump.

$$1 \le n < N_B$$
$$1 \le n' < N_B$$

is necessary.

If E, F. G, or H exceed 64 during the computation, an overflow signal of 25 will be printed and the problem will be terminated. Overflow in forming ρ_1, ψ_1, p_{ρ_1}, p_{ψ_1} will be detected by the nonsensical results.

INVARIANT DUCK BUMPS (INVARIANTS) AGENDUM (Programme 77)

(To be attached by staples to the front of a series of DUCK ANSWER runs which are to employ the invariants feature of the INVARIANT DUCK BUMPS Programme.)

(Sense Switch 3 must be down; otherwise invariants not computed even if invariants overwrite be present.)

All quantities are fractions and go among FRACTION DATA

Parameter	Address	Value	Remarks
$10^{-2}\xi_\rho$	3000		Let C_e = number of RK steps done so far and C_p = number of RK steps of a print cycle done so far. N_{RK} = number of RK steps per sector. (C_e and C_p are the "end" and "print" counters.) If $C_p = 0$ and if $\text{Remainder}\left(\frac{N_e}{N_{RK}}\right) = 0$ these values of the parameters will be used.
$10^{-2}\xi_\psi$	3001		
$10^{-2}\eta_\rho$	3002		
$10^{-2}\eta_\psi$	3003		
$10^{-2}\zeta_\rho$	3004		
$10^{-2}\zeta_\psi$	3005		
$10^{-2}\rho_f$	3006		
$10^{-2}\psi_f$	3007		
$10^{-2}p_{\rho_f}$	3008		
$10^{-2}p_{\psi_f}$	3009		
$10^{-2}\xi'_\rho$	3012		If $C_p = 0$ and if $\text{Remainder}\left(\frac{N_e}{N_{RK}}\right) \neq 0$ these values of the parameters will be used. Invariants can be computed only at a step on which printing is called for, i.e., when $C_p = 0$.
$10^{-2}\xi'_\psi$	3013		
$10^{-2}\eta'_\rho$	3014		
$10^{-2}\eta'_\psi$	3015		
$10^{-2}\zeta'_\rho$	3016		
$10^{-2}\zeta'_\psi$	3017		
$10^{-2}\rho'_f$	3018		
$10^{-2}\psi'_f$	3019		
$10^{-2}p'_{\rho_f}$	3020		
$10^{-2}p'_{\psi_f}$	3021		

INVARIANT DUCK BUMPS (BUMPS) AGENDUM (Programme 77)

(To be attached by staples to the front of a series of DUCK ANSWER runs)
Sense Switch 4 must be down, otherwise bumps are omitted.
Quantities not entered will be assumed to be zero.
All quantities are held from run to run.

Parameter	Address	Value	Parameter	Address	Value	
N_B	4045		$(C_B)_0$	4046		INTEGERS
n	4047		n'	4048		INTEGERS
$2^{-5}e_1$	4001		$2^{-5}e'_1$	4049		FRACTIONS
$2^{-5}f_1$	4002		$2^{-5}f'_1$	4050		FRACTIONS
$2^{-5}g_1$	4003		$2^{-5}g'_1$	4051		FRACTIONS
$2^{-5}h_1$	4004		$2^{-5}h'_1$	4052		FRACTIONS
$2^{-5}e_2$	4005		$2^{-5}e'_2$	4053		FRACTIONS
$2^{-5}f_2$	4006		$2^{-5}f'_2$	4054		FRACTIONS
$2^{-5}g_2$	4007		$2^{-5}g'_2$	4055		FRACTIONS
$2^{-5}h_2$	4008		$2^{-5}h'_2$	4056		FRACTIONS
$2^{-5}e_3$	4009		$2^{-5}e'_3$	4057		FRACTIONS
$2^{-5}f_3$	4010		$2^{-5}f'_3$	4058		FRACTIONS
$2^{-5}g_3$	4011		$2^{-5}g'_3$	4059		FRACTIONS
$2^{-5}h_3$	4012		$2^{-5}h'_3$	4060		FRACTIONS
$2^{-5}e_4$	4013		$2^{-5}e'_4$	4061		FRACTIONS
$2^{-5}f_4$	4014		$2^{-5}f'_4$	4062		FRACTIONS
$2^{-5}g_4$	4015		$2^{-5}g'_4$	4063		FRACTIONS
$2^{-5}h_4$	4016		$2^{-5}h'_4$	4064		FRACTIONS
$2^{-5}e_5$	4017		$2^{-5}e'_5$	4065		FRACTIONS
$2^{-5}f_5$	4018		$2^{-5}f'_5$	4066		FRACTIONS
$2^{-5}g_5$	4019		$2^{-5}g'_5$	4067		FRACTIONS
$2^{-5}h_5$	4020		$2^{-5}h'_5$	4068		FRACTIONS
$2^{-5}e_6$	4021		$2^{-5}e'_6$	4069		FRACTIONS
$2^{-5}f_6$	4022		$2^{-5}f'_6$	4070		FRACTIONS
$2^{-5}g_6$	4023		$2^{-5}g'_6$	4071		FRACTIONS
$2^{-5}h_6$	4024		$2^{-5}h'_6$	4072		FRACTIONS
$2^{-5}e_7$	4025		$2^{-5}e'_7$	4073		FRACTIONS
$2^{-5}f_7$	4026		$2^{-5}f'_7$	4074		FRACTIONS
$2^{-5}g_7$	4027		$2^{-5}g'_7$	4075		FRACTIONS
$2^{-5}h_7$	4028		$2^{-5}h'_7$	4076		FRACTIONS
$2^{-5}\alpha_\rho$	4029		$2^{-5}\alpha'_\rho$	4077		FRACTIONS
$2^{-5}\alpha_\psi$	4030		$2^{-5}\alpha'_\psi$	4078		FRACTIONS
$2^{-5}\beta_\rho$	4031		$2^{-5}\beta'_\rho$	4079		FRACTIONS
$2^{-5}\beta_\psi$	4032		$2^{-5}\beta'_\psi$	4080		FRACTIONS
$2^{-5}\gamma_\rho$	4033		$2^{-5}\gamma'_\rho$	4081		FRACTIONS
$2^{-5}\gamma_\psi$	4034		$2^{-5}\gamma'_\psi$	4082		FRACTIONS
$2^{-5}\delta_\rho$	4035		$2^{-5}\delta'_\rho$	4083		FRACTIONS
$2^{-5}\delta_\psi$	4036		$2^{-5}\delta'_\psi$	4084		FRACTIONS
$2^{-5}\Delta\rho$	4037		$2^{-5}\Delta\rho'$	4085		FRACTIONS
$2^{-5}\Delta\psi$	4038		$2^{-5}\Delta\psi'$	4086		FRACTIONS
$2^{-5}\Delta p_\rho$	4039		$2^{-5}\Delta p'_\rho$	4087		FRACTIONS
$2^{-5}\Delta p_\psi$	4040		$2^{-5}\Delta p'_\psi$	4088		FRACTIONS
$2^{-5}r_\rho$	4041		$2^{-5}r'_\rho$	4089		FRACTIONS
$2^{-5}r_\psi$	4042		$2^{-5}r'_\psi$	4090		FRACTIONS
$2^{-5}s_\rho$	4043		$2^{-5}s'_\rho$	4091		FRACTIONS
$2^{-5}s_\psi$	4044		$2^{-5}s'_\psi$	4092		FRACTIONS

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.