national accelerator laboratory

TM-117
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RELKIN: A RELATIVISTIC KINEMATICS PROGRAM

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A brief description of RELKIN follows. It is operational on the computer at Boulder, Colorado: to run the program call Ward Schultz 303-443-2211, etc. 7264 and use the telephone credit number J654-3460-234.

The program will do two types of problems: (1) 2 bodies in, 2 out and (2) decays.

$$A + B \rightarrow C + D, \tag{1}$$

and

$$A \rightarrow C + D.$$

The control cards are set up so that it is easy to specify a problem like $\pi^- + p \rightarrow A_2^\circ + n$ where $p_{\pi^-}^{inc}$ goes from 25 GeV/c to 400 GeV/c in steps of 25 GeV/c (this would be 16 problems at 1.5 sec each = 24 seconds of computer central processer time). A "standard" output is θ^{CM} going from 0° to 180° in 5° steps; this can be modified via control cards. Ward can punch up the control cards for you and hence the description of control cards that follows is unnecessary.

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission

Card 1 Format (8F10.5)

M1, M2, M3, M4, PMIN1, PMAX1, P2

Card 2 Format (8F10.5)

TMIN1, TMAX1, DELTA (P or T), THETMN, THETMX, DTHET

M1 = mass of A - particle in (1) or (2)

M2 = mass of B - particle in (1) [Blank or zero in (2)]

M3 = mass of C - particle in (1) or (2)

M4 = mass of D - particle in (1) or (2)

PMIN1 = the starting lab momentum of A

PMAX1 = the end lap momentum of A

DELTA = increment in going from PMIN1 to PMAX1

TMIN1, TMAX1 are not used (zero or blank) if you are working with incident momenta instead of incident kinetic energy.

P2 is zero or blank if particle B in (2) is at rest; you can give it + or - momenta along the direction of A to simulate a small class of Fermi momenta.

THETMN, THETMX, DTHET are center-of-mass variables; if zero or blank the program assumes a "standard problem" of 0° to 180° in steps of 5°.

As many sets of 2 cards can be used at one time as you want; one blank card at the very end will terminate the program in a natural way.

Sample output for (1) and (2) are appended. Directions for reading output:

MOM = P = momentum, T = kinetic energy, V = velocity, M = mass. Units are C = 1.0, THETA and THECM in degrees. Suffix CM means center-of-mass system, no suffix means lab system. Particle 1 is the incident particle, 2 is the target particle. P2 is zero unless specified otherwise; 3, 4 are final state particles. Direction of +P1 defines zero degree angles for all particles. Input data must be in consistent units. Output quantities will be in the same units as the input data; CM/LABT is the center-of-mass-to-lab transformation factor: $d\Omega(CM)/d\Omega(lab)$.

$\Lambda^0 \to p + \pi^-$ @ $p^{lab}(\Lambda^0) = 25$ GeV/c (2)

II. PROBLEM SOLVED BELOW FOR P1= 25.00000 P2= -0.00000

CENTER OF MASS RELATIVE TO LAB GAMMA = 22.43498, V= .99901, ETA = 22.41268, TOTAL ENERGY CM = 1.115440

M1= 1.115440, P1= 25.00000, T1= 23.90943, V1= .99901, P1CM= 0.00000, T1CM= 0.00000, V1CM= 0.00000
M3= .938260, FOR LAB QUANTITIES OF PRTCL 3 SEE TABLE BELOW, P3CM= .10023, T3CM= .00534, V3CM= .10623
M4= .139580, FOR LAB QUANTITIES OF PRTCL 4 SEE TABLE BELOW, P4CM= .10023, T4CM= .03226, V4CM= .58329

THET3CM	THET3	MOM3	T3	V3	CM/LABT	COSTHET3	THET4	MOM4	T4	V4	CM/LABT	COSTHET4
-0.000	0.000	23.3973	22.4779	.99920	54406.3	1.00000	0.000	1.60268	1.46916	.99623	255.660	1.00000
5.000	.021	23.3888	22.4693	.99920	54616.4	1.00000	.311	1.61126	1.47771	.99627	262.186	.99999
10.000	.043	23.3632	22.4437	.99919	55005.4	1.00000	.609	1.63693	1.50329	.99638	282.729	.99994
15.000	.064	23.3207	22.4013	.99919	55669.4	1.00000	.885	1.67950	1.54571	.99656	320.456	.99988
20.000	.084	23.2617	22.3424	.99919	56633.7	1.00000	1.130	1.73863	1.60465	.99679	381.719	.99981
25.000	.105	23.1867	22.2674	.99918	57936.3	1.00000	1.338	1.81386	1.67964	.99705	478.324	.99973
30.000	.124	23.0961	22.1769	.99918	59632.2	1.00000	1.508	1.90461	1.77014	.99733	632.830	.99965
35.000	.143	22.9907	22.0716	.99917	61798.6	1.00000	1.639	2.01018	1.87544	.99760	892.223	.99959
40.000	.161	22.8713	21.9523	.99916	64544.5	1.00000	1.734	2.12976	1.99475	.99786	1370.45	.99954
45.000	.179	22.7388	21.8199	.99915	68024.9	1.00000	1.795	2.26243	2.12715	.99810	2428.56	.99951
50.000	.195	22.5942	21.6754	.99914	72465.1	.99999	1.828	2.40718	2.27165	.99832	6118.71	.99949
55.000	.210	22.4386	21.5199	.99913	78203.3	.99999	1.836	2.56291	2.42713	.99852	42249.7	.99949
60.000	.223	22.2731	21.3546	.99911	85767.6	.99999	1.823	2.72843	2.59242	.99869	6258.39	.99949
65.000	.236	22.0991	21.1808	.99910	96028.7	.99999	1.794	2.90248	2.76626	.99885	3918.72	.99951
70.000	.246	21.9179	20.9997	.99908	110527	.99999	1.750	3.08375	2.94732	.99898	3133.52	.99953
75.000	.255	21.7308	20.8128	.99907	132265	.99999	1.696	3.27084	3.13423	.99909	2782.08	.99956
80.000	.263	21.5393	20.6215	.99905	167980	.99999	1.634	3.46234	3.32557	.99919	2614.78	.99959
85.000	.268	21.3448	20.4272	.99904	236546	.99999	1.565	3.65679	3.51988	.99927	2544.14	.99963
90.000	.272	21.1488	20.2314	.99902	418687	.99999	1.491	3.85273	3.71567	.99934	2531.25	.99966
95.000	.273	20.9528	20.0356	.99900	2257779	.99999	1.413	4.04864	3.91147	.99941	2555.86	.99970
100.000	.272	20.7583	19.8413	.99898	625373	.99999	1.333	4.24306	4.10578	.99946	2606.11	.99973
105.000	.270	20.5668	19.6499	.99896	268505	.99999	1.251	4.43450	4.29711	.99951	2674.32	.99976
110.000	.265	20.3797	19.4630	.99894	169021	.99999	1.168	4.62150	4.48403	.99954	2755.10	.99979
115.000	.258	20.1984	19.2819	.99892	122620	.99999	1.084	4.80264	4.66509	.99958	2844.33	.99982
120.000	.248	20.0244	19.1081	.99890	95992.3	.99999	.999	4.97655	4.83893	.99961	2938.71	.99985
125.000	.237	19.8589	18.9428	.99889	78888.1	.99999	.915	5.14190	5.00422	.99963	3035.43	.99987
130.000	.223	19.7033	18.7873	.99887	67107.3	.99999	.831	5.29744	5.15970	.99965	3132.02	.99989
135.000	.208	19.5586	18.6428	.99885	58612.6	.99999	.746	5.44199	5.30420	.99967	3226.28	.99992
140.000	.190	19.4260	18.5104	.99884	52298.3	.99999	.662	5.57443	5.43660	.99969	3316.23	.99993
145.000	.171	19.3066	18.3911	.99882	47514.5	1.00000	.579	5.69378	5.55591	.99970	3400.05	.99995
150.000	.150	19.2012	18.2858	.99881	43856.5	1.00000	.495	5.79911	5.66121	.99971	3476.13	.99996
155.000	.127	19.1106	18.1953	.99880	41061.4	1.00000	.412	5.88963	5.75170	.99972	3543.03	.99997
160.000	.103	19.0355	18.1203	.99879	38953.6	1.00000	.329	5.96465	5.82670	.99973	3599.51	.99998
165.000	.078	18.9765	18.0614	.99878	37414.7	1.00000	.247	6.02360	5.88564	.99973	3644.54	.99999
170.000	.053	18.9340	18.0190	.99877	36365.3	1.00000	.164	6.06603	5.92805	.99974	3677.29	1.00000
175.000	.026	18.9084	17.9934	.99877	35754.4	1.00000	.082	6.09162	5.95364	.99974	3697.19	1.00000
180.000	0.000	18.8998	17.9848	.99877	35553.9	1.00000	0.000	6.10017	5.96218	.99974	3703.86	1.00000

II. PROBLEM SOLVED BELOW FOR P1= 300.00000 P2= -0.00000

CENTER OF MASS RELATIVE TO LAB GAMMA = 12.66377, V= .99688, ETA = 12.6423, TOTAL ENERGY CM = 23.763826

M1= .938260, P1= 300.00000, T1= 299.06321, V1= 1.00000, P1CM= 11.8481, T1CM= 10.94365, V1CM= .99688
M2= .938260, P2= -0.00000, T2= 0.00000, V2= 0.00000, P2CM= 11.8481, T2CM= 10.94365, V2CM= .99688
M3= .938260, FOR LAB QUANTITIES OF PRTCL 3 SEE TABLE BELOW, P3CM= 11.8481, T3CM= 10.94365, V3CM= .99688
M4= .938260, FOR LAB QUANTITIES OF PRTCL 4 SEE TABLE BELOW, P4CM= 11.8481, T4CM= 10.94365, V4CM= .99688

THET3CM	THET3	MOM3	T3	V3	CM/LABT	COSTHET3	THET4	MOM4	T4	V4	CM/LABT	COSTHET4
-0.000	0.000	300.000	299.063	1.00000	641.485	1.00000	90.000	.000000	*000000	.00000	*000000	-.00000
5.000	.198	299.431	298.494	1.00000	639.057	.99999	61.061	1.17964	.569013	.78263	.020498	.48387
10.000	.396	297.728	296.791	1.00000	631.821	.99998	42.069	3.06980	2.27172	.95633	.090481	.74234
15.000	.596	294.905	293.968	.99999	619.913	.99995	30.955	5.96002	5.09517	.98783	.295237	.85757
20.000	.798	290.982	290.045	.99999	603.557	.99990	24.125	9.91181	9.01786	.99555	.767257	.91266
25.000	1.003	285.990	285.053	.99999	583.058	.99985	19.605	14.9187	14.0099	.99803	1.68401	.94203
30.000	1.212	279.966	279.030	.99999	558.796	.99978	16.420	20.9507	20.0334	.99900	3.26156	.95921
35.000	1.426	272.957	272.021	.99999	531.212	.99969	14.060	27.9650	27.0425	.99944	5.74624	.97004
40.000	1.646	265.016	264.079	.99999	500.804	.99959	12.241	35.9098	34.9837	.99966	9.40495	.97726
45.000	1.873	256.203	255.266	.99999	468.106	.99947	10.793	44.7252	43.7968	.99978	14.5144	.98231
50.000	2.109	246.585	245.649	.99999	433.682	.99932	9.611	54.3447	53.4145	.99985	21.3500	.98596
55.000	2.354	236.236	235.299	.99999	398.109	.99916	8.626	64.6953	63.7638	.99989	30.1737	.98869
60.000	2.610	225.234	224.297	.99999	361.961	.99896	7.788	75.6982	74.7658	.99992	41.2230	.99078
65.000	2.880	213.663	212.726	.99999	325.799	.99874	7.066	87.2700	86.3368	.99994	54.6997	.99241
70.000	3.165	201.611	200.674	.99999	290.157	.99847	6.434	99.3226	98.3888	.99996	70.7594	.99370
75.000	3.467	189.169	188.233	.99999	255.529	.99817	5.876	111.764	110.830	.99996	89.5030	.99475
80.000	3.791	176.433	175.497	.99999	222.360	.99781	5.376	124.500	123.566	.99997	110.969	.99560
85.000	4.139	163.500	162.564	.99998	191.034	.99739	4.925	137.434	136.499	.99998	135.126	.99631
90.000	4.515	150.467	149.532	.99998	161.874	.99690	4.515	150.467	149.532	.99998	161.874	.99690
95.000	4.925	137.434	136.499	.99998	135.126	.99631	4.139	163.500	162.564	.99998	191.034	.99739
100.000	5.376	124.500	123.566	.99997	110.969	.99560	3.791	176.433	175.497	.99999	222.360	.99781
105.000	5.876	111.764	110.830	.99996	89.5030	.99475	3.467	189.169	188.233	.99999	255.529	.99817
110.000	6.434	99.3226	98.3888	.99996	70.7594	.99370	3.165	201.611	200.674	.99999	290.157	.99847
115.000	7.066	87.2700	86.3368	.99994	54.6997	.99241	2.880	213.663	212.726	.99999	325.799	.99874
120.000	7.788	75.6982	74.7658	.99992	41.2230	.99078	2.610	225.234	224.297	.99999	361.961	.99896
125.000	8.626	64.6953	63.7638	.99989	30.1737	.98869	2.354	236.236	235.299	.99999	398.109	.99916
130.000	9.611	54.3447	53.4145	.99985	21.3500	.98596	2.109	246.585	245.649	.99999	433.682	.99932
135.000	10.793	44.7252	43.7968	.99978	14.5144	.98231	1.873	256.203	255.266	.99999	468.106	.99947
140.000	12.241	35.9098	34.9837	.99966	9.40495	.97726	1.646	265.016	264.079	.99999	500.804	.99959
145.000	14.060	27.9650	27.0425	.99944	5.74624	.97004	1.426	272.957	272.021	.99999	531.212	.99969
150.000	16.420	20.9507	20.0334	.99900	3.26156	.95921	1.212	279.966	279.030	.99999	558.796	.99978
155.000	19.605	14.9187	14.0099	.99803	1.68401	.94203	1.003	285.990	285.053	.99999	583.058	.99985
160.000	24.125	9.91181	9.01786	.99555	.767257	.91266	.798	290.982	290.045	.99999	603.557	.99990
165.000	30.955	5.96002	5.09517	.98783	.295237	.85757	.596	294.905	293.968	.99999	619.913	.99995
170.000	42.069	3.06980	2.27172	.95633	.090481	.74234	.396	297.728	296.791	1.00000	631.821	.99998
175.000	61.061	1.17964	.569013	.78263	.020498	.48387	.198	299.431	298.494	1.00000	639.057	.99999
180.000	90.000	.000000	*000000	.00000	*000000	-.00000	0.000	300.000	299.063	1.00000	641.485	1.00000