

## Равновесие тяжелой рамы

Тяжелая однородная рама расположена в вертикальной плоскости и опирается на неподвижный шарнир  $A$  и наклонный невесомый стержень  $H$ . К раме приложены горизонтальная сила  $P$ , наклонная сила  $Q$  и момент  $M$ . Учитывая погонный вес рамы  $\rho$ , найти реакции опор.

*Кирсанов М.Н. Решебник. Теоретическая механика с. 31.*

**Вариант 1**  
С4.

$\rho = 3 \text{ кН/м}, P = 9 \text{ кН},$   
 $Q = 27 \text{ кН}, M = 25 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 60^\circ, \gamma = 60^\circ,$   
 $HB = 4 \text{ м}, BC = 9 \text{ м},$   
 $CD = 6 \text{ м}, DA = 4 \text{ м},$   
 $BK = 2 \text{ м}, CN = 3 \text{ м}.$

**Вариант 2**  
С4.

$\rho = 2 \text{ кН/м}, P = 7 \text{ кН},$   
 $Q = 32 \text{ кН}, M = 20 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 45^\circ, \gamma = 45^\circ,$   
 $AB = 3 \text{ м}, BC = 4 \text{ м},$   
 $CD = 11 \text{ м}, DH = 4 \text{ м},$   
 $CK = 2 \text{ м}, CN = 2 \text{ м}.$

**Вариант 3**  
С4.

$\rho = 2 \text{ кН/м}, P = 6 \text{ кН},$   
 $Q = 33 \text{ кН}, M = 20 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 30^\circ, \gamma = 45^\circ,$   
 $AB = 5 \text{ м}, BC = 4 \text{ м},$   
 $CD = 14 \text{ м}, DH = 4 \text{ м},$   
 $CK = 2 \text{ м}, CN = 2 \text{ м}.$

**Вариант 4**  
С4.

$\rho = 2 \text{ кН/м}, P = 8 \text{ кН},$   
 $Q = 21 \text{ кН}, M = 50 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 60^\circ, \gamma = 45^\circ,$   
 $AB = 4 \text{ м}, BC = 11 \text{ м},$   
 $CD = 6 \text{ м}, DH = 5 \text{ м},$   
 $BK = 3 \text{ м}, CN = 3 \text{ м}.$

**Вариант 5**  
С4.

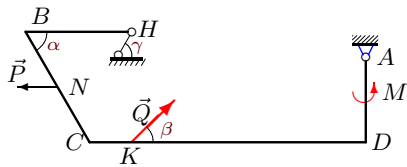
$\rho = 1 \text{ кН/м}, P = 7 \text{ кН},$   
 $Q = 12 \text{ кН}, M = 30 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 60^\circ, \gamma = 30^\circ,$   
 $AB = 6 \text{ м}, BC = 13 \text{ м},$   
 $CD = 4 \text{ м}, DH = 5 \text{ м},$   
 $BK = 3 \text{ м}, CN = 2 \text{ м}.$

**Вариант 6**  
С4.

$\rho = 2 \text{ кН/м}, P = 8 \text{ кН},$   
 $Q = 28 \text{ кН}, M = 20 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 60^\circ, \gamma = 45^\circ,$   
 $AB = 6 \text{ м}, BC = 13 \text{ м},$   
 $CD = 6 \text{ м}, DH = 5 \text{ м},$   
 $BK = 3 \text{ м}, CN = 3 \text{ м}.$

**Вариант 7**

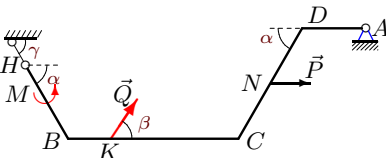
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 11 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 5 \text{ м}$ ,  $BC = 6 \text{ м}$ ,  
 $CD = 13 \text{ м}$ ,  $DA = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 8**

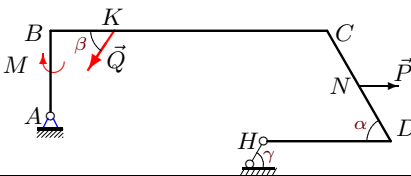
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 9 \text{ кН}$ ,  
 $Q = 19 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 8 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DA = 3 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 9**

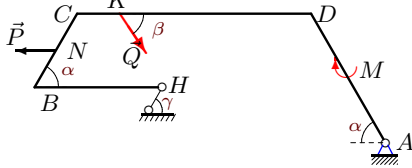
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 27 \text{ кН}$ ,  $M = 20 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 13 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 10**

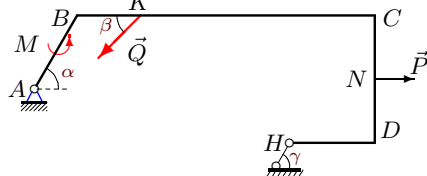
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 9 \text{ кН}$ ,  
 $Q = 25 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 11 \text{ м}$ ,  $DA = 7 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 11**

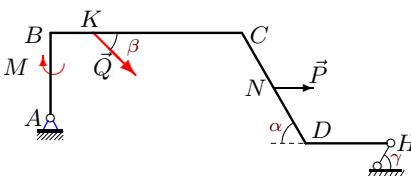
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 15 \text{ кН}$ ,  $M = 30 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 14 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 12**

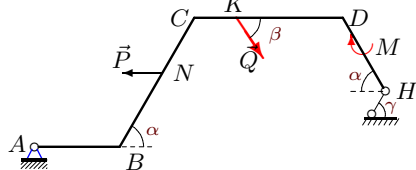
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 29 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 9 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 13**

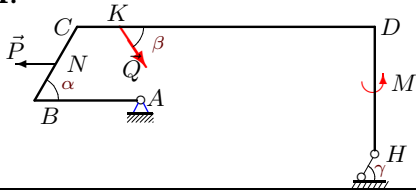
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 22 \text{ кН}$ ,  $M = 20 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 7 \text{ м}$ ,  
 $CD = 7 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 14**

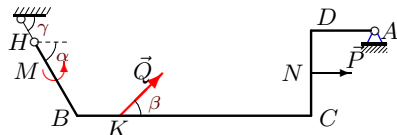
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 15 \text{ кН}$ ,  $M = 30 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 14 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 15**

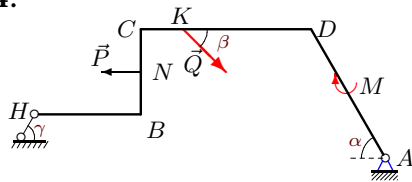
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 14 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 11 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DA = 3 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 16**

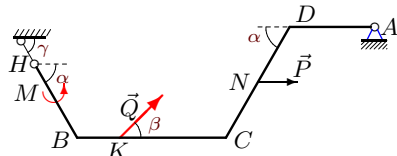
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 34 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 8 \text{ м}$ ,  $DA = 7 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 17**

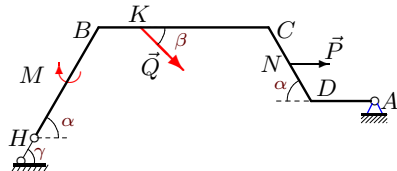
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 18 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 7 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DA = 4 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 18**

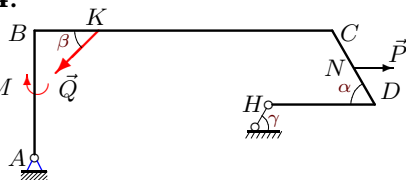
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 26 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 8 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DA = 3 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 19**

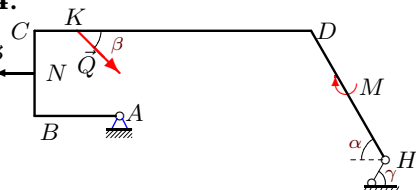
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 35 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 14 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 5 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 20**

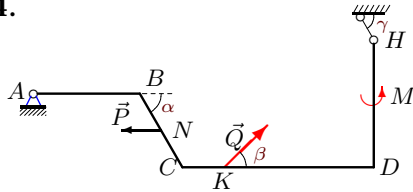
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 27 \text{ кН}$ ,  $M = 20 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 13 \text{ м}$ ,  $DH = 7 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 21**

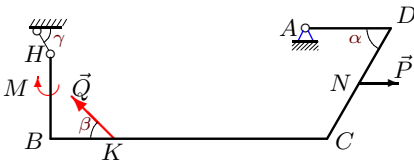
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 15 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 9 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 22**

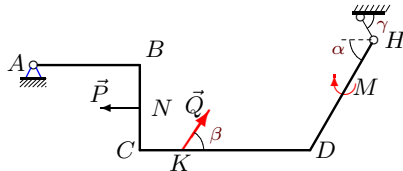
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 27 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 13 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DA = 4 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 23**

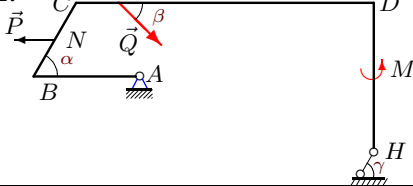
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 31 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 8 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 24**

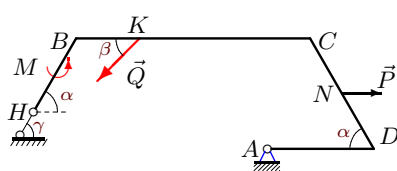
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 15 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 14 \text{ м}$ ,  $DH = 7 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 25**

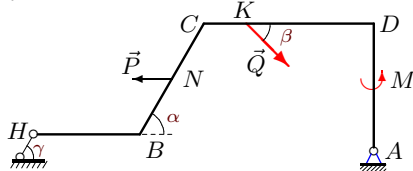
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 19 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 11 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DA = 5 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 26**

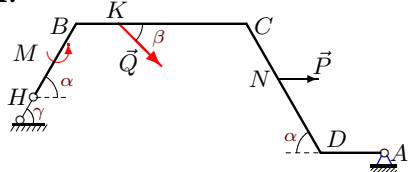
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 13 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 5 \text{ м}$ ,  $BC = 6 \text{ м}$ ,  
 $CD = 8 \text{ м}$ ,  $DA = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 27**

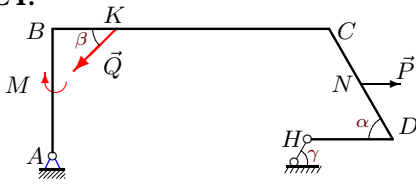
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 17 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 8 \text{ м}$ ,  
 $CD = 7 \text{ м}$ ,  $DA = 3 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 28**

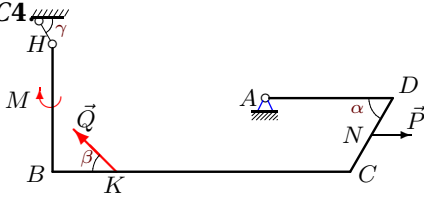
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 28 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 13 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 29**

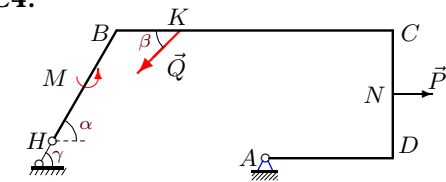
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 31 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 14 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DA = 6 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 30**

C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 15 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 13 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DA = 6 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

Ответы

	$M_A(Q)$	$M_A(P)$	$\Sigma_k M_A(G_k)$	$h$	$X_A$	$Y_A$	$R_H$
1	-257.210	23.383	625.5	-14.454	-9.816	23.648	25.367
2	203.647	-14.000	-340.0	10.935	-4.611	10.357	15.579
3	64.815	-12.000	-71.0	7.399	-18.930	33.851	5.161
4	-54.560	-6.928	-482.0	9.003	-36.259	31.427	54.814
5	31.177	22.373	-264.0	6.536	-24.910	3.803	27.609
6	11.254	-27.215	-478.0	7.210	-44.407	33.841	71.287
7	-54.447	-11.215	717.0	-10.124	-35.402	14.519	71.248
8	-148.090	23.383	514.5	-14.722	-2.885	19.499	31.231
9	-16.148	-11.215	-499.0	7.917	-43.299	32.583	69.013
10	194.856	38.971	762.8	-10.392	-50.245	24.686	93.490
11	7.500	-2.321	-282.0	8.196	-18.089	20.443	30.114
12	-129.459	-7.010	-159.5	9.036	-59.919	20.293	34.415
13	-247.683	27.713	-374.5	9.830	-47.200	18.852	62.509
14	-12.990	12.124	-93.5	7.696	-7.743	37.809	8.363
15	-35.503	14.000	510.0	-14.124	0.646	24.756	39.541
16	-17.000	28.435	564.7	-15.321	-40.433	57.843	35.977
17	-86.599	20.785	523.5	-14.722	-2.807	19.232	35.842
18	138.546	-13.856	538.5	-12.990	-50.949	38.839	49.128
19	74.246	-25.608	-225.5	3.304	-31.543	24.713	58.072
20	-66.531	12.000	-167.5	10.297	-34.003	52.879	23.505
21	132.202	-12.124	-472.0	13.107	12.682	21.105	23.035
22	-271.031	20.785	289.5	-10.990	11.740	60.785	1.297
23	249.928	-14.000	-191.5	9.036	-11.320	-2.218	-3.257
24	-26.136	12.124	-209.0	10.278	-15.509	58.704	16.832
25	142.500	-18.187	135.0	-10.392	-6.390	60.057	31.688
26	0.000	27.215	469.5	-14.258	-21.066	49.771	39.746
27	77.388	-27.713	551.3	-15.588	-41.541	40.747	43.040
28	103.492	-17.010	-227.5	5.304	-6.226	28.292	29.416
29	-201.500	12.124	192.0	-7.392	18.333	77.121	-3.027
30	107.942	-21.000	10.5	-9.062	-3.248	84.498	18.477