

## 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.

$\rho = 3 \text{ кН/м}, P = 8 \text{ кН},$   
 $Q = 21 \text{ кН}, M = 70 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 45^\circ, \gamma = 60^\circ,$   
 $HB = 3 \text{ м}, BC = 6 \text{ м},$   
 $CD = 8 \text{ м}, DA = 4 \text{ м},$   
 $CK = 2 \text{ м}, CN = 3 \text{ м}.$

**Вариант 2**  
С4.

$\rho = 3 \text{ кН/м}, P = 7 \text{ кН},$   
 $Q = 25 \text{ кН}, M = 25 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 30^\circ, \gamma = 60^\circ,$   
 $HB = 4 \text{ м}, BC = 8 \text{ м},$   
 $CD = 6 \text{ м}, DA = 3 \text{ м},$   
 $BK = 2 \text{ м}, CN = 3 \text{ м}.$

**Вариант 3**  
С4.

$\rho = 2 \text{ кН/м}, P = 6 \text{ кН},$   
 $Q = 34 \text{ кН}, M = 20 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 30^\circ, \gamma = 45^\circ,$   
 $AB = 6 \text{ м}, BC = 13 \text{ м},$   
 $CD = 6 \text{ м}, DH = 6 \text{ м},$   
 $BK = 3 \text{ м}, CN = 3 \text{ м}.$

**Вариант 4**  
С4.

$\rho = 3 \text{ кН/м}, P = 8 \text{ кН},$   
 $Q = 22 \text{ кН}, M = 25 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 45^\circ, \gamma = 60^\circ,$   
 $HB = 6 \text{ м}, BC = 6 \text{ м},$   
 $CD = 10 \text{ м}, DA = 6 \text{ м},$   
 $CK = 2 \text{ м}, CN = 3 \text{ м}.$

**Вариант 5**  
С4.

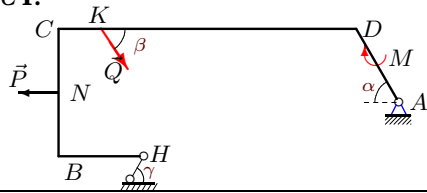
$\rho = 3 \text{ кН/м}, P = 8 \text{ кН},$   
 $Q = 27 \text{ кН}, M = 25 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 45^\circ, \gamma = 60^\circ,$   
 $HB = 4 \text{ м}, BC = 4 \text{ м},$   
 $CD = 14 \text{ м}, DA = 4 \text{ м},$   
 $CK = 2 \text{ м}, CN = 2 \text{ м}.$

**Вариант 6**  
С4.

$\rho = 3 \text{ кН/м}, P = 7 \text{ кН},$   
 $Q = 25 \text{ кН}, M = 25 \text{ кНм},$   
 $\alpha = 60^\circ, \beta = 30^\circ, \gamma = 60^\circ,$   
 $HB = 6 \text{ м}, BC = 10 \text{ м},$   
 $CD = 6 \text{ м}, DA = 6 \text{ м},$   
 $BK = 3 \text{ м}, CN = 3 \text{ м}.$

**Вариант 7**

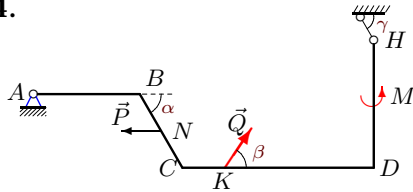
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 9 \text{ кН}$ ,  
 $Q = 31 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 6 \text{ м}$ ,  
 $CD = 14 \text{ м}$ ,  $DA = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 8**

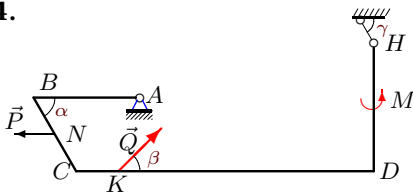
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 8 \text{ кН}$ ,  
 $Q = 14 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 9 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 9**

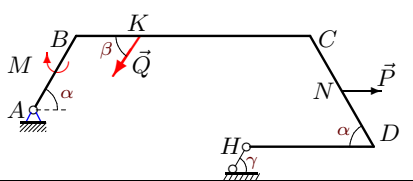
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 12 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 14 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 10**

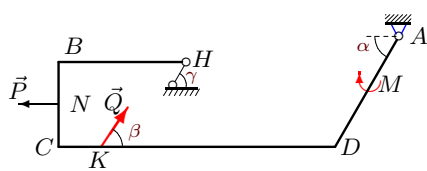
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 22 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 11 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 11**

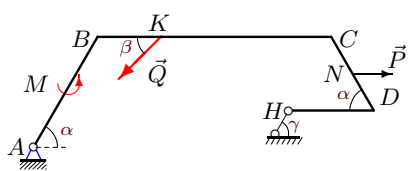
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 9 \text{ кН}$ ,  
 $Q = 34 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 13 \text{ м}$ ,  $DA = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 12**

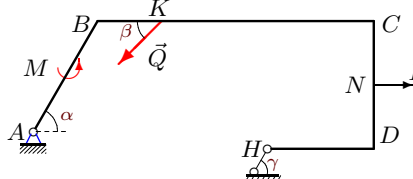
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 21 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 11 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 13**

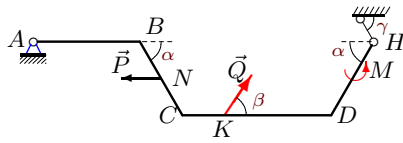
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 13 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 13 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 5 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 14**

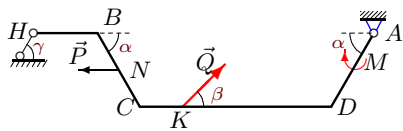
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 20 \text{ кН}$ ,  $M = 30 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 7 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 15**

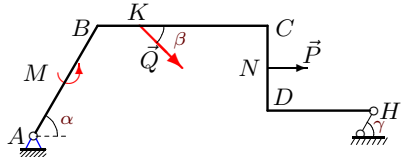
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 25 \text{ кН}$ ,  $M = 25 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 3 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 9 \text{ м}$ ,  $DA = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 16**

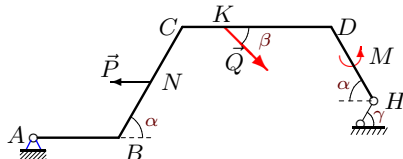
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 11 \text{ кН}$ ,  $M = 30 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 8 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 5 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 17**

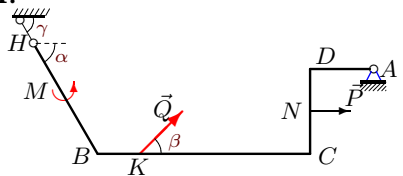
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 16 \text{ кН}$ ,  $M = 30 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 6 \text{ м}$ ,  
 $CD = 7 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 18**

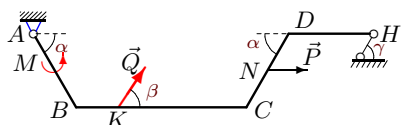
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 11 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 10 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DA = 3 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 19**

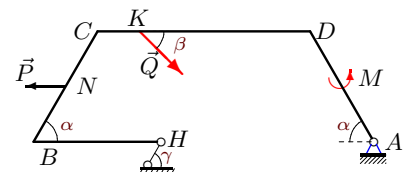
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 18 \text{ кН}$ ,  $M = 30 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 8 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 20**

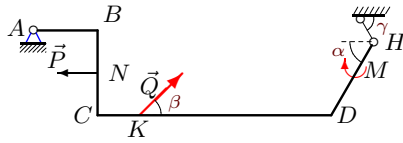
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 18 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 6 \text{ м}$ ,  $BC = 6 \text{ м}$ ,  
 $CD = 10 \text{ м}$ ,  $DA = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 21**

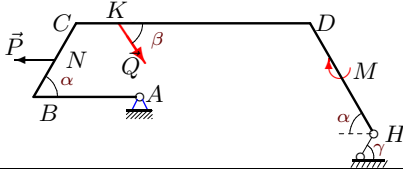
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 31 \text{ кН}$ ,  $M = 20 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 3 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 11 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 22**

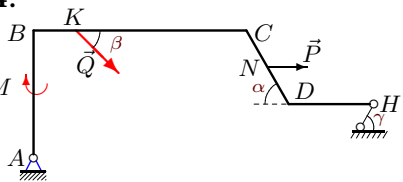
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 25 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 60^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 11 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 23**

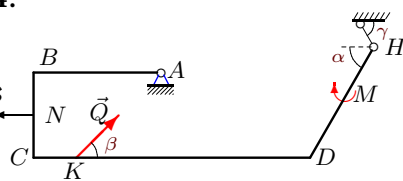
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 31 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 10 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 4 \text{ м}$ ,  
 $BK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 24**

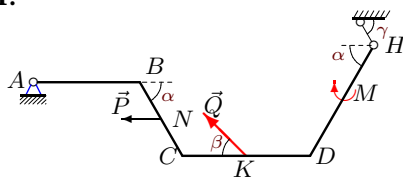
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 35 \text{ кН}$ ,  $M = 20 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 13 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 25**

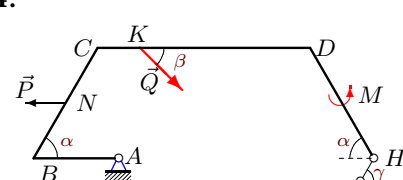
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 26 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 45^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 5 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 6 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 26**

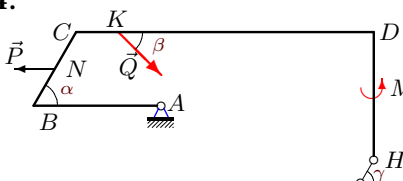
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 20 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 6 \text{ м}$ ,  
 $CD = 10 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 3 \text{ м}$ .

**Вариант 27**

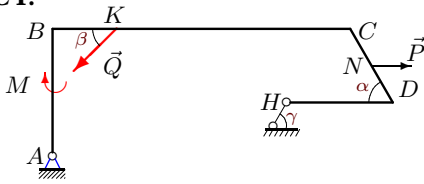
C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 13 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 4 \text{ м}$ ,  
 $CD = 14 \text{ м}$ ,  $DH = 6 \text{ м}$ ,  
 $CK = 2 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 28**

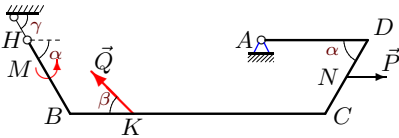
C4.



$\rho = 1 \text{ кН/м}$ ,  $P = 5 \text{ кН}$ ,  
 $Q = 29 \text{ кН}$ ,  $M = 15 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 30^\circ$ ,  
 $AB = 6 \text{ м}$ ,  $BC = 14 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 5 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 29**

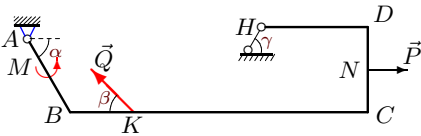
C4.



$\rho = 3 \text{ кН/м}$ ,  $P = 7 \text{ кН}$ ,  
 $Q = 17 \text{ кН}$ ,  $M = 70 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 60^\circ$ ,  
 $HB = 4 \text{ м}$ ,  $BC = 12 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DA = 5 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

**Вариант 30**

C4.



$\rho = 2 \text{ кН/м}$ ,  $P = 6 \text{ кН}$ ,  
 $Q = 15 \text{ кН}$ ,  $M = 50 \text{ кНм}$ ,  
 $\alpha = 60^\circ$ ,  $\beta = 30^\circ$ ,  $\gamma = 45^\circ$ ,  
 $AB = 4 \text{ м}$ ,  $BC = 14 \text{ м}$ ,  
 $CD = 4 \text{ м}$ ,  $DH = 5 \text{ м}$ ,  
 $BK = 3 \text{ м}$ ,  $CN = 2 \text{ м}$ .

Ответы

	$M_A(Q)$	$M_A(P)$	$\Sigma_k M_A(G_k)$	$h$	$X_A$	$Y_A$	$R_H$
1	-67.355	-6.928	493.5	-14.722	-23.464	19.373	33.229
2	37.500	-18.187	514.5	-14.722	-45.931	45.570	34.560
3	125.669	-20.412	-499.0	6.503	-21.546	34.009	63.627
4	90.287	20.785	762.0	-8.660	-56.520	14.749	97.927
5	-201.150	-11.713	750.0	-10.660	-35.113	17.303	48.042
6	162.500	-18.187	78.0	-8.660	3.259	76.769	22.784
7	322.161	4.177	846.0	-9.124	-69.372	1.949	125.745
8	133.368	-13.856	-472.0	13.107	17.319	19.557	23.079
9	20.909	-12.124	-187.0	9.571	7.987	40.042	13.396
10	-57.158	-6.062	-251.5	6.500	-39.930	20.689	50.726
11	-323.894	-28.765	823.5	-8.062	-35.650	9.664	55.300
12	31.500	-20.785	-437.0	7.261	-24.460	23.853	51.826
13	19.500	-13.177	-592.0	8.347	-40.123	21.118	64.179
14	190.526	-12.124	-170.0	8.000	-7.157	5.080	-4.800
15	-37.500	-12.124	462.0	-13.856	-28.629	23.289	27.956
16	-77.000	-15.981	-176.5	6.964	-44.307	11.306	34.388
17	-144.000	12.990	-174.5	6.500	-45.564	7.807	42.386
18	-22.395	14.000	550.5	-13.258	6.558	23.518	46.168
19	93.531	12.124	-152.0	8.000	-17.769	3.390	2.043
20	18.000	18.187	762.0	-8.660	-58.713	6.181	100.250
21	197.283	-14.000	-340.0	10.935	-3.493	10.652	16.161
22	-21.651	12.124	-56.0	7.000	-15.463	41.899	11.504
23	-192.081	-21.340	-150.0	5.804	-88.313	6.899	65.202
24	51.244	-12.000	-31.0	7.917	-23.261	39.450	1.485
25	120.161	-10.392	-183.5	9.500	32.474	-2.055	9.340
26	-100.000	15.588	-160.0	8.485	-27.521	45.799	22.912
27	-26.000	10.392	-128.0	8.864	-12.726	59.033	10.560
28	107.188	-21.340	-225.5	3.304	-20.423	20.095	46.809
29	-102.000	12.124	142.5	-9.526	14.159	55.352	12.872
30	-7.500	8.785	-523.0	7.399	-38.089	1.421	63.752