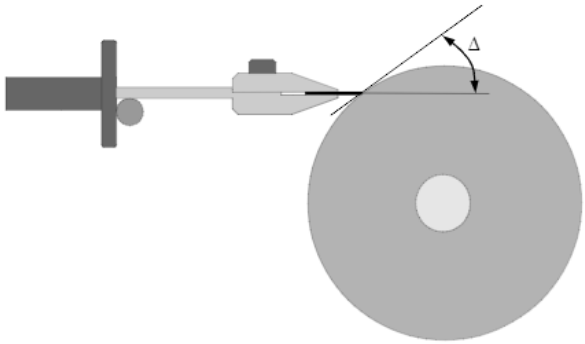
simple and accurate

Grinding Angle Adjustment



with the adjustable knife-jig

on the

Tormek-T7 grinder

by Ton Nillesen © 2013

simple and accurate

Grinding Angle Adjustment

with the adjustable knife-jig on the Tormek-T7 grinder

Contents

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1. Introduction

After years of grinding my tools on a bench grinder, I decided to buy a Tormek-T7 grinder in order to get better control on the sharpening and eliminate the risk of loosing hardening by overheating
After some experimenting and grinding of the available knives, blades, scissors etc. it became clear to me that the reproducibility of the grinding angles was rather poor if the adjustment was done according to the procedure described in the handbook. Good reproduction can be obtained if the bevel is coloured with a marker pen and the support is adjusted until the stone clears the bevel.
That method however is not fast and easy. I wanted a simple method which could be realised by measuring and adjusting the position of the universal support and the length of the adjustable jig.
This document describes the method which I use since then, it derives the mathematical background and gives tables which can be used instead of the mathematical formulas.

Denominations

In the handbook you can read:
“In the literature on this subject, there are various denominations for the edge angle. It is called bevel angle, cutting angle or sharpening angle. The edge angle on a tool with bevels on both sides is called the included bevel angle, the effective bevel angle, profile angle, total cutting angle or the combined bevel angle.”
That was rather confusing, therefore I decided to use “grinding angle” which in my opinion is unambiguous. Dutch however is the native language of the author rather than English, so it might turn out to be “double-dutch” for the reader. The author asks for comprehension if that might happen occasionally.

2. The cosine rule

The proposed adjustment procedure is based on the cosine rule.
In trigonometry, the cosine rule (also known as the cosine formula or law of cosines) relates the lengths of the sides of a triangle to the cosine of the opposite angle.
Using notation as in Fig. 2.1, the cosine rule states:

$$c^2 = a^2 + b^2 - 2ab * \cos(\gamma)$$

where γ denotes the angle con-

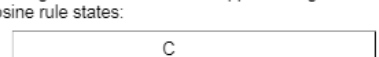

Table 9. Personal choices

Knife	grinding angle

where γ denotes the angle contained between sides of lengths a and b and opposite the side of length c.
The law of cosines is useful for computing the third side of a triangle when two sides and their enclosed angle are known, and in computing the angles of a triangle if all three sides are known.
Identical formulas can be given for the other sides::

$$a^2 = b^2 + c^2 - 2bc * \cos(\alpha)$$

and $$b^2 = a^2 + c^2 - 2ac * \cos(\beta)$$

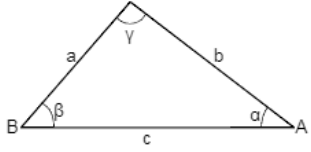

Fig. 2.1: A triangle. The angles α (or A), β (or B), and γ (or C) are respectively opposite the sides a, b, and c.

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 8. Stone diameter=180 mm

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	118	124	130	135	141	147	153	158	164	170	175	181	186
11	116	122	128	134	140	146	151	157	163	168	174	179	185
12	115	121	127	133	139	144	150	156	161	167	172	178	183
13	114	120	126	131	137	143	149	154	160	166	171	177	182
14	112	118	124	130	136	142	147	153	159	164	170	175	181
15	111	117	123	129	135	140	146	152	157	163	168	174	179
16	110	116	122	128	133	139	145	150	156	162	167	173	178
17	109	115	120	126	132	138	143	149	155	160	166	171	177
18	107	113	119	125	131	137	142	148	153	159	164	170	175
19	106	112	118	124	130	135	141	147	152	158	163	169	174
20	105	111	117	123	128	134	140	145	151	156	162	167	173
21	104	110	116	122	127	133	139	144	150	155	161	166	172
22	103	109	115	120	126	132	137	143	149	154	160	165	170
23	102	108	114	119	125	131	136	142	147	153	158	164	169
24	101	107	112	118	124	130	135	141	146	152	157	163	168
25	100	106	111	117	123	128	134	140	145	151	156	161	167
26	99	105	110	116	122	127	133	138	144	149	155	160	166
27	98	104	109	115	121	126	132	137	143	148	154	159	165
28	97	103	108	114	120	125	131	136	142	147	153	158	164
29	96	102	107	113	119	124	130	135	141	146	152	157	162
30	95	101	106	112	118	123	129	134	140	145	151	156	161

3. The knife jigs

This document refers to the knife grinding jig "Knife Jig SVM-45" (see Fig. 3.1) and the jig for longer knfes "long Knife Jig SVM-140" (see Fig. 3.2).
The jigs rest on the "Universal Support" of which the position with respect to the grinding stone can be adjusted. See also Fig. 4.1.

Fig. 3.1: Knife Jig SVM-45

Fig. 3.2: long Knife Jig SVM-140

Apart from the adjustable clamp ('1' in Fig. 3.3) for holding knives of any thickness, the jigs comprise an adjustable stop (2) by which the distance from the knife edge to the universal support can be adjusted to the desired length. Thus we have the following parameters for adjusting the grinding angle:

- the distance from the universal support to the stone
- the distance from the knife edge (in the clamp) to the adjustable stop

Fig. 3.3 Knife jig design

4. Adjustment of the grinding angle

The adjustment procedure will be explained with reference to Fig. 4.1, which gives the notation of the available parameters.
Δ = grinding angle.
A = **A**djustable length between the adjustable stop and the knife edge
K = length of jig between support-top and **K**nife edge
S = distance from support-top to the **S**tone
R_1, R_2 = **R**adius of the stone=R
D = **D**istance from support to the centre of the stone ($D=S+R_2=S+R$)
Notes:

- The reference point on the jig for the distances K and S (also D) is above the centre of the universal support.
- The maximum value of D is 215 mm
- Length between stop and clamp edge is adjustable from 108 to 125 mm
- Diameter of support bar is 12 mm
- The stone diameter varies from 250 mm to a recommended minimum of 180 mm.

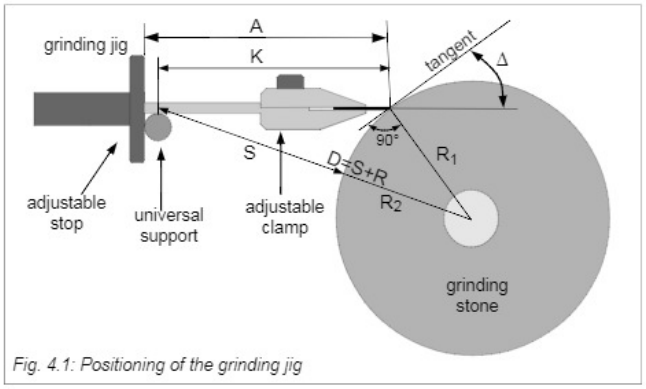

Fig. 4.1: Positioning of the grinding jig

Consider the triangle determined by the knife jig, via R_1 to the centre of the stone and via the long side D (=R_2+S) back to the jig on the universal support.
The angle opposite side D (=S+R) is equal to 90°+Δ because the grinding angle Δ is equal to the angle between the knife blade and the tangent to the stone while the radius R_1 is perpendicular to the tangent.

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 7. Stone diameter=190 mm

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	119	125	131	137	143	149	155	161	166	172	178	183	189
11	118	124	130	136	142	148	153	159	165	170	176	182	187
12	116	123	129	135	140	146	152	158	163	169	175	180	186
13	115	121	127	133	139	145	151	156	162	168	173	179	184
14	114	120	126	132	138	143	149	155	161	166	172	177	183
15	112	119	125	130	136	142	148	153	159	165	170	176	181
16	111	117	123	129	135	141	146	152	158	163	169	174	180
17	110	116	122	128	134	139	145	151	156	162	168	173	179
18	109	115	121	127	132	138	144	149	155	161	166	172	177
19	107	113	119	125	131	137	142	148	154	159	165	170	176

With the cosine-law we get $D^2=K^2+R_1^2-2*K*R_1*\cos(90°+\Delta)$

which can be simplified to: $D^2=K^2+R^2+2*K*R*\sin(\Delta)$ [F0]

So the grinding angle Δ is determined by: $\Delta=\arcsin\left(\frac{D^2-K^2-R^2}{2*K*R}\right)$ [F1]

and D should be adjusted to $D=\sqrt{(K^2+R^2+2*K*R*\sin(\Delta))}$ [F2]

If D is fixed, then the grinding angle can be adjusted by changing the distance K with the adjustable stop.

The required length K can be determined by solving K from the following equation derived from [F0]: $K^2+2*R*\sin(\Delta)*K+R^2-D^2=0$

That gives: $K=-R*\sin(\Delta)+\sqrt{R^2*\sin^2(\Delta)+D^2-R^2}$ [F3]

We can also express the formulas as a function of the distance S between support and stone. Then D in formula F1 and F2 should be replaced by S+R:

Formula F2 can then be rewritten as: $S=-R+\sqrt{R^2+K^2+2*K*R*\sin(\Delta)}$ [F4]

Distance S will normally be adjusted in coarse steps of e.g 5-10mm whereas fine adjustment of the grinding angle will be done via the adjustable stop (A).

By substitution of S+R for D in formula F3 we get:

$K=-R*\sin(\Delta)+\sqrt{R^2*\sin^2(\Delta)+S^2+2*S*R}$ [F5]

As the diameter of the support bar is 12 mm, it follows that A=K+6

Hence $\boxed{A=6-R*\sin(\Delta)+\sqrt{R^2*\sin^2(\Delta)+S^2+2*S*R}}$ [F6]

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 6. Stone diameter=200 mm

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	121	127	133	139	145	151	157	163	168	174	180	185	191
11	120	126	132	138	144	150	155	161	167	173	178	184	189
12	118	124	130	136	142	148	154	160	165	171	177	182	188
13	117	123	129	135	141	147	152	158	164	170	175	181	186
14	115	121	127	133	139	145	151	157	162	168	174	179	185
15	114	120	126	132	138	144	150	155	161	167	172	178	183
16	113	119	125	131	137	142	148	154	160	165	171	176	182
17	111	117	123	129	135	141	147	152	158	164	169	175	180
18	110	116	122	128	134	140	145	151	157	162	168	173	179
19	109	115	121	127	132	138	144	150	155	161	167	172	178
20	107	113	119	125	131	137	143	148	154	160	165	171	176
21	106	112	118	124	130	136	141	147	153	158	164	169	175
22	105	111	117	123	129	134	140	146	151	157	163	168	174
23	104	110	116	122	127	133	139	144	150	156	161	167	172
24	103	109	115	120	126	132	138	143	149	154	160	165	171
25	102	108	113	119	125	131	136	142	148	153	159	164	170
26	101	106	112	118	124	130	135	141	146	152	157	163	168
27	99	105	111	117	123	128	134	140	145	151	156	162	167
28	98	104	110	116	122	127	133	139	144	150	155	161	166
29	97	103	109	115	121	126	132	137	143	148	154	159	165
30	96	102	108	114	119	125	131	136	142	147	153	158	164

5. Range of grinding angles

The handbook of the Tormek grinder gives recommended edge angles in the figure copied in Fig. 5.1.

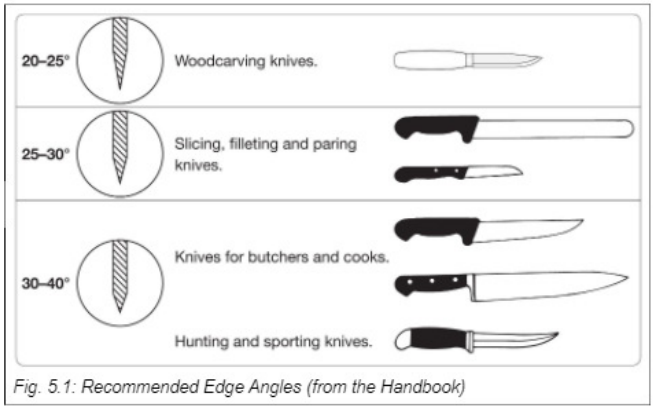

Fig. 5.1: Recommended Edge Angles (from the Handbook)

So the grinding angle adjustment should cover a range from 10°-20° if grinding is done at both sides.

With respect to the recommended angle for kitchen knives, I found the following text on a forum of "the Society for Culinary Arts & Letters":

The Myth of Thick Edges

The theory is that thick edges (larger angles) last longer than thin edges, and the majority of the knife buying public wants the edge to last as long as possible. But it doesn't work out that way in practice. Thinner edges actually outlast thicker edges almost all the time.

The thinner edge starts out performing better than the thicker edge. So even if it does degrade it has a lot of ground to lose before it falls to the performance level of the thick edge.

Thinner edges cut more easily, putting less stress on the edge. If a thin edge takes three slices to get through a big slab of raw meat, a thicker edge might take six or seven. Or three with a lot more force. The thicker edge is doing twice as much work, degrading twice as quickly.

Thinner edges are easier to control. Lateral stresses are a significant source of edge degradation. The more smoothly, accurately and easily you are able to cut, the less lateral stress you put on the edge.

Thin is good.

Furthermore the following recommendation was given:

The best compromise in the kitchen has proven to be a 15/20 double bevel. That is a 15 degree back bevel with a 20 degree primary edge face.

The "double bevel" refers to a second, more acute, angle behind the edge bevel. This secondary bevel is sometimes called a back bevel or relief angle. The back bevel solves one of the great problems with V-edges, the fact that the metal behind the edge gets progressively thicker as the knife is sharpened over time. The knife doesn't cut as well and becomes harder and harder to sharpen. The answer is to grind the shoulders off the edge at an acute angle, i.e. add a back bevel, then reestablish the primary bevel.

It's purpose is to thin the metal behind the edge. The thinner

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 5. Stone diameter=210 mm

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	123	129	135	141	147	153	159	165	171	176	182	188	193
11	121	127	134	140	146	151	157	163	169	175	180	186	192
12	120	126	132	138	144	150	156	162	167	173	179	184	190
13	118	124	130	137	142	148	154	160	166	171	177	183	188

the edge, the greater the cutting ability. However, an edge that is too thin is susceptible to damage. So you add a smaller, more obtuse primary bevel to the very edge to give it the strength to avoid damage from impaction, chipping or rolling.

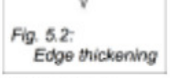

Fig. 5.2:
Edge thickening

Following the quoted text, I decided to adjust the grinding angle of my knives to 10°, resulting in a cutting edge of 20°.

6. Adjustment tables

Formula [F6]: $A=6-R*\sin(\Delta)+\sqrt{R^2*\sin^2(\Delta)+S^2+2*S*R}$ is not a simple calculation. Therefore the required adjustments associated with several parameters have been combined in tables on the following pages.

- Each table is made for a certain stone diameter, ranging from 250mm to the recommended minimum stone diameter of 180mm. The stone diameters in the tables are reduced in steps of 10mm.
- The top row of each table gives the parameter S for which the underlying column has been calculated.
- The left column of the table gives the grinding angle Δ for which the associated row has been calculated.
- The table cell in the column of a given S, in the row of the desired Δ gives the value at which the adjustable stop of the knife-jig should be adjusted.

Example:
Consider a cooks knife with a width of 45mm. The jig can grip the knife to a depth of 14mm. As a consequence the knife edge extends 31mm from the clamp.
Thus the distance A between the knife edge and the adjustable stop can be varied between 108+31 and 125+31 mm, that is from 139mm to 156mm.
In Table 1. on the following page two column sections have been indicated in fat lines. The included table cells cover the whole range of grinding angles from 10° to 30° within the adjustable range of 139-156mm. The distance S should then be set to 85mm or 100mm or values in between.

In Table 9. on page 15 personal notes can be made on grinding angles chosen for certain knifes

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 4. Stone diameter=220 mm and for the honing wheel

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	124	131	137	143	149	155	161	167	173	178	184	190	195
11	123	129	135	141	147	153	159	165	171	177	182	188	194
12	121	127	134	140	146	152	158	163	169	175	181	186	192
13	120	126	132	138	144	150	156	162	168	173	179	185	190
14	118	124	130	137	143	149	154	160	166	172	177	183	189
15	117	123	129	135	141	147	153	159	164	170	176	182	187
16	115	121	127	134	140	145	151	157	163	169	174	180	186
17	114	120	126	132	138	144	150	156	161	167	173	178	184
18	112	118	125	131	137	142	148	154	160	166	171	177	182
19	111	117	123	129	135	141	147	153	158	164	170	175	181
20	110	116	122	128	134	140	145	151	157	163	168	174	179
21	108	114	120	126	132	138	144	150	155	161	167	172	178
22	107	113	119	125	131	137	143	148	154	160	165	171	177
23	106	112	118	124	130	135	141	147	153	158	164	170	175
24	105	111	117	123	128	134	140	146	151	157	163	168	174
25	103	109	115	121	127	133	139	144	150	156	161	167	172
26	102	108	114	120	126	132	137	143	149	154	160	165	171
27	101	107	113	119	125	130	136	142	147	153	159	164	170
28	100	106	112	118	123	129	135	141	146	152	157	163	168
29	99	105	111	117	122	128	134	139	145	151	156	162	167
30	98	104	110	115	121	127	133	138	144	149	155	160	166

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 1. Stone diameter=250 mm

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	129	136	142	148	154	161	167	173	179	184	190	196	202
11	127	134	140	146	153	159	165	171	177	183	188	194	200
12	125	132	138	145	151	157	163	169	175	181	187	192	198
13	124	130	137	143	149	155	161	167	173	179	185	190	196
14	122	128	135	141	147	153	159	165	171	177	183	189	194
15	120	127	133	139	145	152	158	164	169	175	181	187	193
16	119	125	131	138	144	150	156	162	168	174	179	185	191
17	117	124	130	136	142	148	154	160	166	172	178	183	189
18	116	122	128	134	140	147	152	158	164	170	176	182	187
19	114	120	127	133	139	145	151	157	163	168	174	180	186
20	113	119	125	131	137	143	149	155	161	167	173	178	184
21	111	117	124	130	136	142	148	154	159	165	171	177	182
22	110	116	122	128	134	140	146	152	158	164	169	175	181
23	108	115	121	127	133	139	145	151	156	162	168	173	179
24	107	113	119	125	131	137	143	149	155	161	166	172	178
25	106	112	118	124	130	136	142	148	153	159	165	170	176
26	104	111	117	123	129	135	140	146	152	158	163	169	175
27	103	109	115	121	127	133	139	145	150	156	162	167	173
28	102	108	114	120	126	132	138	143	149	155	160	166	172
29	101	107	113	119	125	131	136	142	148	153	159	165	170
30	100	106	112	118	123	129	135	141	146	152	158	163	169

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 2. Stone diameter=240 mm

Adjustment of the length A between adjustable stop and knife-edge
for a grinding edge Δ
at a preset of the distance S between support-top and stone

Table 3. Stone diameter=230 mm

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	126	133	139	145	151	158	164	170	176	181	187	193	199
11	125	131	137	143	150	156	162	168	174	180	185	191	197
12	123	129	136	142	148	154	160	166	172	178	184	189	195
13	121	128	134	140	146	152	158	164	170	176	182	187	193
14	120	126	132	138	144	150	156	162	168	173	179	185	190
15	118	124	130	137	143	149	154	160	166	172	177	183	189
16	117	123	129	135	141	147	153	159	164	170	176	182	187
17	115	121	127	134	140	145	151	157	163	169	174	180	186
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27	101	108	114	120	125	131	137	142	148	153	159	164	170
28	100	106	112	118	124	130	135	141	146	152	157	163	168
29	99	105	111	117	123	128	134	140	145	151	156	162	167
30	97	103	109	115	120	126	132	137	143	148	154	159	165

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	127	134	140	147	153	159	165	171	177	182	188	194	200
11	126	132	139	145	151	157	163	169	175	181	186	192	198
12	124	130	137	143	149	155	161	167	173	179	185	190	196
13	122	129	135	141	147	153	159	165	171	177	183	189	194
14	121	127	133	140	146	152	158	164	169	175	181	187	193
15	119	125	132	138	144	150	156	162	168	174	179	185	191
16	118	124	130	136	142	148	154	160	166	172	178	183	189
17	116	122	129	135	141	147	153	159	164	170	176	182	187
18	115	121	127	133	139	145	151	157	163	169	174	180	186
19	113	119	126	132	138	144	150	155	161	167	173	178	184
20	112	118	124	130	136	142	148	154	160	165	171	177	182
21	110	116	123	129	135	141	147	152	158	164	170	175	181
22	109	115	121	127	133	139	145	151	157	162	168	174	179
23	108	114	120	126	132	138	144	149	155	161	167	172	178
24	106	112	118	124	130	136	142	148	154	159	165	171	176
25	105	111	117	123	129	135	141	147	152	158	164	169	175
26	104	110	116	122	128	134	139	145	151	157	162	168	173
27	102	109	115	121	126	132	138	144	149	155	161	166	172
28	101	107	113	119	125	131	137	142	148	154	159	165	171
29	100	106	112	118	124	130	135	141	147	152	158	164	169
30	99	105	111	117	123	128	134	140	146	151	157	162	168

S=	65	70	75	80	85	90	95	100	105	110	115	120	125
Δ(°)	Adjustable length A (mm)												
10	126	132	139	145	151	157	163	169	175	180	186	192	198
11	124	131	137	143	149	155	161	167	173	179	184	190	196
12	123	129	135	141	147	153	159	165	171	177	183	188	194
13	121	127	134	140	146	152	158	164	169	175	181	187	192
14	119	126	132	138	144	150	156	162	168	174	179	185	191
15	118	124	130	137	143	149	154	160	166	172	178	183	189
16	116	123	129	135	141	147	153	159	165	170	176	182	187
17	115	121	127	133	139	145	151	157	163	169	174	180	186
18	113	120	126	132	138	144	150	156	161	167	173	178	184
19	112	118	124	130	136	142	148	154	160	166	171	177	183
20	111	117	123	129	135	141	147	153	158	164	170	175	181
21	109	115	122	128	134	139	145	151	157	163	168	174	179
22	108	114	120	126	132	138	144	150	155	161	167	172	178
23	107	113	119	125	131	137	142	148	154	160	165	171	176
24	105	112	118	124	129	135	141	147	153	158	164	169	175
25	104	110	116	122	128	134	140	145	151	157	162	168	174
26	103	109	115	121	127	133	138	144	150	155	161	167	172
27	102	108	114	120	126	131	137	143	148	154	160	165	171
28	101	107	113	118	124	130	136	142	147	153	158	164	169
29	100	106	111	117	123	129	135	140	146	152	157	163	168
30	98	104	110	116	122	128	133	139	145	150	156	161	167