

## How to construct a set of 5 Cubic Calculators.

**Step 1: Select 5 different digits with a sum that ends in zero. We will chose 2 , 3 , 4, 5, and 6. Make each of these numbers the middle number for all the faces one a single die.**

Die 1	Die 2	Die 3	Die 4	Die 5
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E

**DIE 1 :** We have already decided to use a 2 in the 10's place for all number on die 1.

Select a number whose sum can be expressed as several different pairs of single digit numbers.

**Lets chose 12.**

$$3 + 9 = 12 \quad 4 + 8 = 12 \quad 5 + 7 = 12 \quad 6 + 6 = 12 \quad 7 + 5 = 12 \quad 8 + 4 = 12 \quad 9 + 3 = 12$$

Take any sum above and put the single digits in place of F and A on die 1. I used 3 and 9

Do the same thing for the second face on die 1. I used 6 and 6.

Do the same thing for the third face on die 1. I used 7 and 5.

Do the same thing for the forth face on die 1. I used 4 and 8.

Do the same thing for the fifth face on die 1. I used 5 and 7.

Do the same thing for the sixth face on die 1. I used 9 and 3.

Die 1	Die 1
F2A	329
F2A	626
F2A	725
F2A	428
F2A	527
F2A	923

I used 3 and 9 as well as 9 and 3. I also used 5 and 7 as well as 7 and 5. It would be nice to have no pairs repeated but 12 has only 4 different combinations so I had to use 2 pairs with reversed orders

**DIE 2 :** We have already decided to use a 3 in the 10's place for all number on die 2.

Select a number whose sum can be expressed as several different pairs of single digit numbers.

**Lets chose 9.**

$0 + 9 = 9$      $2 + 7 = 9$      $3 + 6 = 9$      $4 + 5 = 9$      $5 + 4 = 9$      $6 + 3 = 9$      $7 + 2 = 9$      $8 + 1 = 9$      $9 + 0 = 9$

Take any 6 of the sums above and put the single digits in place of G and B on die 2.

I used 9 and 0 1 and 8 5 and 4 2 and 7 6 and 3 7 and 2

Die 2	Die 2
G3B	930
G3B	138
G3B	534
G3B	237
G3B	633
G3B	732

You can use 9 and 0 but not 0 and 9. 0 and 9 gives a 039 which is a 2 digit number and should not be used.

I used 2 and 7 as well as 7 and 1. 9 has only 5 different combinations so I had to use 1 pair with reversed orders.

**DIE 3 :** We have already decided to use a 4 in the 10's place for all number on die 3.

Select a number whose sum can be expressed as several different pairs of single digit numbers.

**Lets chose 10.**

$1 + 9$      $2 + 8$      $3 + 7$      $4 + 6$      $5 + 5$      $6 + 4$      $7 + 3$      $8 + 2$      $9 + 1$

Take any 6 of the sums above and put the single digits in place of H and C on die 3.

I used 2 and 8 4 and 6 7 and 3 5 and 5 9 and 1 6 and 4

Die 3	Die 3
H4C	248
H4C	446
H4C	743
H4C	545
H4C	941
H4C	644

I used 3 and 7 as well as 7 and 3. It would be nice to have no pairs repeated but 10 has only 5 different pairs

**DIE 4 :** We have already decided to use a 4 in the 10's place for all number on die 4.

Select a number whose sum can be expressed as several different pairs of single digit numbers.

**Lets chose 8.**

**0 and 8   1 + 7   2 + 6   3 + 5   4 + 4   5 + 3   6 + 2   7 + 1   8 + 0**

Take any 6 of the sums above and put the single digits in place of J and D on die 4.

I used   3 and 5   8 and 0   4 and 4   2 and 6   7 and 1   5 and 3

Die 4	Die 4
J5D	355
J5D	850
J5D	454
J5D	256
J5D	751
J5D	553

I used 3 and 5 as well as 5 and 3. It would be nice to have no pairs repeated but 10 has only 5 different pairs

**DIE 5 :** We have already decided to use a 6 in the 10's place for all number on die 5.

Select a number whose sum can be expressed as several different pairs of single digit numbers.

**Lets chose 11.**

**2 + 9   3 + 8   4 + 7   5 + 6   6 + 5   7 + 4   8 + 3   9 + 2**

Take any 6 of the sums above and put the single digits in place of K and E on die 5.

I used   7 and 4   2 and 9   8 and 3   5 and 6   2 and 9   3 and 8

Die 5	Die 5
K6E	764
K6E	269
K6E	863
K6E	566
K6E	269
K6E	368

I had to repeat 2 pairs because 11 has only 4 different pairs

## How The Magic total is found

The 100's and 1's digits on each separate die total 12 , 9, 10, 8, 11 **and these numbers total 50**  
**This set of dice had 10's digits of 2 , 3, 4 , 5 and 6 and these numbers total 20.**

**The magic total we need is the 50 plus the 2 from the total of the 10's digits.**  
**The magic total is 52.**

Select any one number from Die 1 and then one number from Die 2 and then Die 3 , 4 and 5.

Die 1	Die 2	Die 3	Die 4	Die 5
329	930	248	355	764
626	138	446	850	269
725	534	743	454	863
428	237	545	256	566
527	633	941	751	269
923	732	644	553	368

## How The total of the 5 numbers is found

The sum of the 5 selected numbers will be a 4 digit number

1. The tens and ones digits of the answer will be the sum of the ones digits on the 5 faces of the dice.
2. The thousands and hundreds digits of the answer will be **52** minus the sum of the ones digits

### Example 1

$$\begin{array}{r}
 329 \quad \text{from die 1} \\
 534 \quad \text{from die 2} \\
 743 \quad \text{from die 3} \\
 850 \quad \text{from die 4} \\
 + 269 \quad \text{from die 5} \\
 \hline
 2725 \quad \text{Total of the 5 faces} \\
 \quad \quad \text{of the dice}
 \end{array}$$

the 27 came from the sum  
of the ones digits  
 $9 + 4 + 3 + 0 + 9 = 27$

the 27 came from subtracting  
the ones total from 52  
 $52 - 25 = 27$

### Example 2

$$\begin{array}{r}
 923 \quad \text{from die 1} \\
 930 \quad \text{from die 2} \\
 941 \quad \text{from die 3} \\
 256 \quad \text{from die 4} \\
 + 764 \quad \text{from die 5} \\
 \hline
 3814 \quad \text{Total of the 5 faces} \\
 \quad \quad \text{of the dice}
 \end{array}$$

the 16 came from the sum  
of the ones digits  
 $3 + 0 + 1 + 6 + 4 = 14$

the 38 came from subtracting  
the ones total from 52  
 $52 - 14 = 38$

## Limits on making other die

The first step in creating a set of die is to choose the number of die. We used 5 die in this example. You could also use 3 or 4 die. More than 5 die and students will not be willing to do the addition and 2 die does not allow for much addition practice.

The total of the numbers in the 10's column must end in a zero so the number carried from the ones column becomes the answer in the 10 place.

The die below used 2, 3, 4, 5, and 6 for a total of 20.

Die 1	Die 2	Die 3	Die 4	Die 5
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E

## Limits on the middle numbers

You could choose other combinations that also add to 20. You could choose other single digit numbers that add to 30 or 40. You could repeat digits but that makes the die look more gimmicked. The limiting factor is that **the single digits should be different and add to a multiple of 10.**

If we want the total of the 10's digits on the five die to be 20 with no repeats then we are limited to certain combinations. For example 1, 2, 3, 4 cannot be used because the last number would be a 10. 7, 8, 9 cannot be used as they also total over 20. 1, 8, 8 cannot be used as the other 2 numbers would both need to be 1's which repeat.

A possible straggly would be to start with the 0, 1, 2, 8, 9 set and adjust these numbers, keeping the total 20 and being sure to not have repeated digits.

**5 single digit numbers that total 20 (without repeated numbers could be**

**0, 1, 2, 8, 9 or 1, 2, 3, 7, 9 or 2, 3, 4, 5, 6 or 1, 2, 4, 5, 8 or 1, 2, 3, 5, 7 or 0, 1, 5, 6, 8**

**CAN YOU FIND OTHERS? How many different combinations are there?**

## Placing the digits in the 1's and 100's place

Die 1	Die 2	Die 3	Die 4	Die 5
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E
F2A	G3B	H4C	J5D	K6E

After we select the digits that will go in the 10's location for each die we then select the pairs of digits that will go in the 100's and 1's place on each die. We have to select a number whose sum can be expressed as several different pairs of single digit numbers. For example on die 1 we select a number and find pairs of single digits that add up to that number. We place one of the digits in the 100's place and the other in the 1's place on each face of the die. We then chose other numbers and repeat this process for the other die.

### Example

**DIE 5 :** We have already decided to use a 6 in the 10's place for all number on die 5.

Select a number whose sum can be expressed as several different pairs of single digit numbers.

**Lets chose 11.**

**2 + 9    3 + 8    4 + 7    5 + 6    6 + 5    7 + 4    8 + 3    9 + 2**

Take any 6 of the sums above and put the single digits in place of K and E on die 5.

I used    7 and 4    2 and 9    8 and 3    5 and 6    2 and 9    3 and 8

Die 5	Die 5
K6E	764
K6E	269
K6E	863
K6E	566
K6E	269
K6E	368

## What are the limits on the digits in the 1's and 100's place ?

Select a number whose sum can be expressed as several different pairs of single digit numbers. 0 can be used **but only if it is in the 1's place**. A zero in the 100's place does not produce a three digit number.

**If we chose the total for the 100's and 1's place to be 3, 4 or 5 we do not get enough different pairs to make the die look different. If we choose 6 we get 4 different pairs.** We need to use 2 of the same pairs in reverse order.

Number selected 3 possible pairs	
	3 and 0
1 and 2	2 and 1

Number selected 4 possible pairs	
	4 and 0
1 and 3	3 and 1
2 and 2	

Number selected 5 possible pairs	
	5 and 0
1 and 4	4 and 4
2 and 3	3 and 2

Number selected 6 possible pairs	
	6 and 0
1 and 5	5 and 1
2 and 4	4 and 2
3 and 3	

**If we choose 7 or 9 we get 4 different pairs.** We would need to use 2 of the same pairs in reverse order.  
**If we chose 8 or 10 we get 5 pairs.** We would need to use 1 reversed pair to complete the die.

Number selected 7 possible pairs	
	7 and 0
1 and 6	6 and 1
2 and 5	5 and 2
3 and 4	4 and 3

Number selected 8 possible pairs	
	8 and 0
1 and 7	7 and 1
2 and 6	6 and 2
3 and 5	5 and 3
4 and 4	

Number selected 9 possible pairs	
1 and 8	8 and 1
2 and 7	7 and 2
3 and 6	6 and 3
5 and 4	4 and 5

Number selected 10 possible pairs	
1 and 9	9 and 1
2 and 8	8 and 2
3 and 7	3 and 7
4 and 6	6 and 4
5 and 5	

If we choose 11 , 12 or 13 we get 4 different pairs. We would need to use 2 of the same pairs in reverse order.

If we chose 14 we only get 3 different pairs. We would need to use 2 reversed pair to complete the die and the repeat one of the selections again.

Number selected 11 possible pairs	
2 and 9	9 and 2
3 and 8	8 and 3
4 and 7	7 and 4
5 and 6	6 and 5

Number selected 12 possible pairs	
3 and 9	9 and 3
4 and 8	8 and 4
5 and 7	7 and 5
6 and 6	

Number selected 13 possible pairs	
4 and 9	9 and 4
5 and 8	8 and 5
6 and 7	7 and 6
5 and 6	6 and 5

Number selected 14 possible pairs	
5 and 9	9 and 5
6 and 8	8 and 6
7 and 7	

15 , 16 or 17 or 18 do not work. They require too many repeats

Number selected 15 possible pairs	
6 and 9	9 and 6
7 and 8	8 and 7

Number selected 16 possible pairs	
7 and 9	9 and 7
8 and 8	

Number selected 17 possible pairs	
8 and 9	9 and 8

Number selected 18 possible pairs	
9 and 9	

Numbers above 18 will not work. They do not have any sums made up of 2 single digits.

**Conclusions: The pairs for the 100's and 1's digits are very limited .**

A die has 6 faces so the ideal case would be 6 different pairs of single digit numbers. None of the possible numbers meets this need.

The base case is to use 10 and 8 as they have 5 different pairs and require 1 pair used in reverse order.

We now need 3 other die. The best case is to use 6 , 7, 9, 11, 12 or 13. Each of them have 4 different pairs and only require the use of 2 of the pairs used in reverse order.

The numbers 1 to 5 and the numbers from 14 to 18 are way too limited. There are no numbers above 18 that have any pairs.

**The best way to have the numbers on the die vary is to use 8 and 10 for 2 of the die. Then select from 6 , 7, 9, 11, 12 or 13 for the other die.**



## A General Conclusion

1. Select the number of die you will use. I suggest for 4 to 6.
2. Find a different single digit number for the 10's place on each of the die. The total of the digits must be with a multiple of 10. I suggest 10 for 3 die , 20 for 4 die and 30 for 5 or 6 die. Take one of the numbers selected and write it in all the 10's places on one of the dice. Do the same thing for each of the other numbers on each of the remaining dice.
3. For die 1, **take all 5 pairs of numbers in the left column** of the table for number 8 below. Put one number of the pair in the 100's place and the other number in the 1's place. 8 and 0 must go in that order . **Take 1 pair from the right column** and put one number of the pair in the 100's place and the other number in the 1's place but select the order so as not to repeat previous selections.
4. Use the same procedure for die 2 using number 10. Use the same procedure for the other die using other numbers from the table below. You will now have all your die complete.
5. The magic number for your die will be the sum of the 100's and 10's digits plus the 2 or 3 or 4 from the multiple of 10 you selected in step 2.

**The dice are now ready to use.**

**Select one 3 digit number from each die. Find the total of these numbers**

1. The tens and ones digits of the answer will be the sum of the ones digits on the 5 faces of the dice.
2. The thousands and hundreds digits of the answer will be the magic die number minus the sum of the ones digits

Number selected <b>8</b>	
Use all 5 of these	and 1 of these
<b>8 and 0</b>	
<b>1 and 7</b>	<b>7 and 1</b>
<b>2 and 6</b>	<b>6 and 2</b>
<b>3 and 5</b>	<b>5 and 3</b>
<b>4 and 4</b>	

Number selected <b>10</b>	
Use all 5 of these	and 1 of these
<b>1 and 9</b>	<b>9 and 1</b>
<b>2 and 8</b>	<b>8 and 2</b>
<b>3 and 7</b>	<b>7 and 3</b>
<b>4 and 6</b>	<b>6 and 4</b>
<b>5 and 5</b>	

Number selected <b>6</b>	
Use all 4 of these	and 2 of these
<b>6 and 0</b>	
<b>1 and 5</b>	<b>5 and 1</b>
<b>2 and 4</b>	<b>4 and 2</b>
<b>3 and 3</b>	

Number selected <b>7</b>	
Use all 4 of these	and 2 of these
<b>7 and 0</b>	
<b>1 and 6</b>	<b>6 and 1</b>
<b>2 and 5</b>	<b>5 and 2</b>
<b>3 and 4</b>	<b>4 and 3</b>

Number selected <b>9</b>	
Use all 4 of these	and 2 of these
<b>1 and 8</b>	<b>8 and 1</b>
<b>2 and 7</b>	<b>7 and 2</b>
<b>3 and 6</b>	<b>6 and 3</b>
<b>5 and 4</b>	<b>4 and 5</b>

Number selected <b>11</b>	
Use all 4 of these	and 2 of these
<b>2 and 9</b>	<b>9 and 2</b>
<b>3 and 8</b>	<b>8 and 3</b>
<b>4 and 7</b>	<b>7 and 4</b>
<b>5 and 6</b>	<b>6 and 5</b>

Number selected <b>12</b>	
Use all 4 of these	and 2 of these
<b>3 and 9</b>	<b>9 and 3</b>
<b>4 and 8</b>	<b>8 and 4</b>
<b>5 and 7</b>	<b>7 and 5</b>
<b>6 and 6</b>	

Number selected <b>13</b>	
Use all 4 of these	and 2 of these
<b>4 and 9</b>	<b>9 and 4</b>
<b>5 and 8</b>	<b>8 and 5</b>
<b>6 and 7</b>	<b>7 and 6</b>
<b>5 and 6</b>	<b>6 and 5</b>