

# Woolly Thoughts

IN PURSUIT OF CRAFTY MATHEMATICS



## *Grime Dice Juggling Balls*

*A set of Grime Dice which can also be used as juggling balls  
designed by*

*Pat Ashforth & Steve Plummer*

## *Grime Dice Juggling Balls*

### **The Concept**

Grime Dice are a set of five dice with the numbers arranged so that you can always choose a dice that will, over time, beat the dice chosen by your opponent. They are known as non-transitive dice. Using dice A, B and C, A will beat B, B will beat C and, amazingly, C will beat A. Several sets of non-transitive dice have been documented. Grime Dice are slightly different because you can use a set of 3 or a set of 5 and you can change the order in which they work by choosing to use two sets of dice. There are several different tricks that can be employed to beat the opposition. If the opponent works out the trick you are using you can use different rules to ensure that you will still win. You can even play against two opponents at the same time - and beat both of them.

The chances of winning rely on the probability of the score of each dice. The names of the colours are very important to learning the tricks to enable you to win.

Grime Dice were discovered by a young mathematician named Dr James Grime. James is The Enigma Project Officer at the University of Cambridge. He is also well-known to many people as one of the presenters of Numberphile videos and an organiser of MathsJam. He occasionally pops up on TV and radio talking on various aspects of Maths. In his spare time he likes juggling, unicycling and other circus skills.

It seemed fitting to combine the love of juggling with the maths of the dice to create *Grime Dice Juggling Balls*.

### **The Pattern**

The main instructions are for knitted juggling balls. You can also make dice in plastic canvas, or use the nets to make paper dice.

The pattern does not include information about the reason for the choice of colours or about how to use the dice to ensure that you will win. This information has been covered, at length, by James, and other people, in various videos and teaching resources.

### **Internet Links**

There are many internet references to Grime Dice and other types of non-transitive dice. Some of the most useful are listed here.

Be aware that there are some older web pages where you might find dice with different colour/number combinations from those shown here. The colours used in this pattern are the same as those used for the 'official' Grime Dice that you can buy from Maths Gear <http://www.mathsgear.co.uk/non-transitive-dice-set-of-5/>

<http://grime.s3-website-eu-west-1.amazonaws.com/>

<http://www.think-maths.co.uk/downloads/grime-dice-lesson-resources>

<http://www.teachmaths-inthinking.co.uk/activities/grime-dice.htm>

[http://en.wikipedia.org/wiki/Nontransitive\\_dice](http://en.wikipedia.org/wiki/Nontransitive_dice)

### Die or Dice?

Historically, the name for one was die. This word is rarely used these days and people use the word dice whether they are talking about one or more.

## *Knitted Grime Dice*

### **Yarn**

Approximately 20 metres (22 yards) DK each of red, blue, olive, yellow and magenta. (The colours are important and should not be changed.)

Approximately 60 metres (66 yards) black for the set of five dice.

Other thicknesses of yarn could be used but will give bigger, or smaller, dice.

### **Needles**

Use needles slightly smaller than you would normally use for your chosen yarn. The knitting should be as firm as you can comfortably make it. Two double-pointed needles are needed for finishing the dice. You could use these throughout as you will only be working with a small number of stitches.

### **Filling**

If you want your dice to stay square you could put wooden blocks inside, or cut up car sponges to fit. If they are to double as juggling balls the filling should be heavy and more fluid. This means that the dice will always tend towards being spheres.

There are many possible fillings such as rice, lentils, millet, etc. This type of filling should be in a secure bag inside the knitting. Bags can be made from any very fine and soft fabric. They should be bigger than the knitted cubes so that the filling has room to move about and fill all the corners.

Pieces cut from the legs of tights work well. You can also use pop socks so that one end is already finished. Cut off the foot of the sock so that it is about 12 cm (5") long, insert the filling and stitch across the open end very securely so that the filling can't escape. I used 100 grams of rice in each bag. If you are making balls for a particular juggler you might want to check what weight they prefer.

### **Construction**

The faces of the cubes could be joined in many different ways. The method given was chosen because it is quick, easy and very secure. It does not give matching joins on all edges. This would not be noticeable to most people but you might want to change the method to make them match more closely. (The only method that would ensure all joins are exactly alike would be to make six separate squares, edge them in the contrast colour, then stitch them together.)



## Method

Work in garter stitch throughout.

Using black and the long-tail method, cast on 9 stitches.  
Change to main colour and knit 9 garter ridges (18 rows).

Knit 2 ridges black, 9 ridges main, 2 ridges black, 9 ridges main, 2 ridges black, 9 ridges main.

Knit one row black. Cast off on the wrong side.

*Carry the black yarn up the side, to avoid having many ends to darn in. Do not twist the yarns at the end of each ridge as this will make it difficult to pick up stitches later. Catching it in two places is sufficient. On the 5th ridge, knit the first stitch, trap the black behind the main yarn and keep knitting. Repeat this on the 9th ridge.*

Using black pick up one stitch from the end of each garter ridge along the edge marked **A** (9 stitches).

Knit 3 more rows (2 garter ridges in total) black then 9 ridges main, one row black. Cast off on the wrong side.

Make a matching square on the other side, as shown.

## Adding the spots

Embroider the spots, as shown on page 4.

## Edging and joining

Using black, pick up stitches along the edges marked **B**, as follows:

1 from the black ridge, 9 from main, 4 from black, 9 from main, 2 from black, 9 from main, 1 from black.

Cast off 11, knit to end.

Slip the first 12 stitches onto a double-pointed needle, and the other 2 stitches onto another double pointed needle. Fold the knitting with right sides together and cast off through both sets of stitches at the same time. Fasten off and use the end to darn any gap there might be in the corner of the join.

Using black, pick up 11 stitches along the edge marked **C**, as follows:

1 from the black ridge, 9 from main, 1 from black. Cast off.

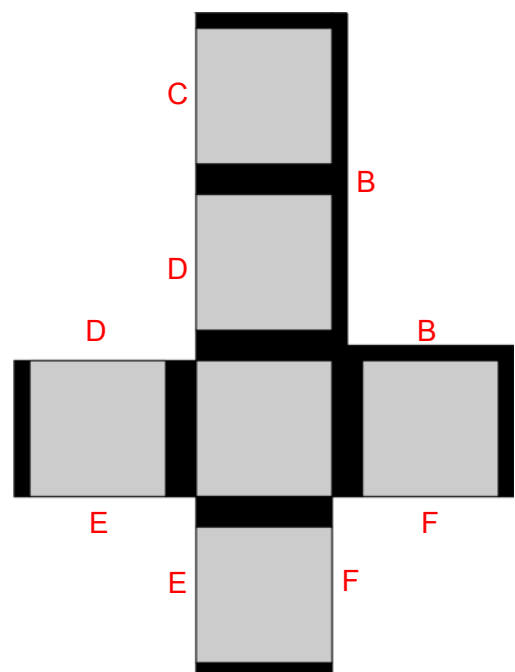
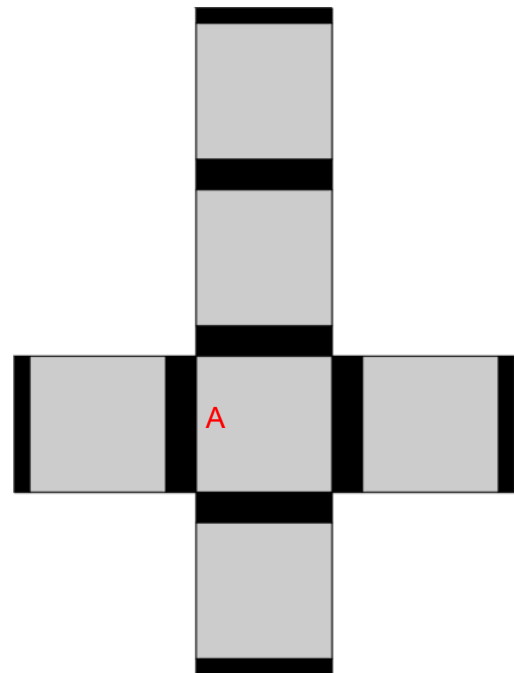
Using black, pick up stitches along the edges marked **D**, as follows:

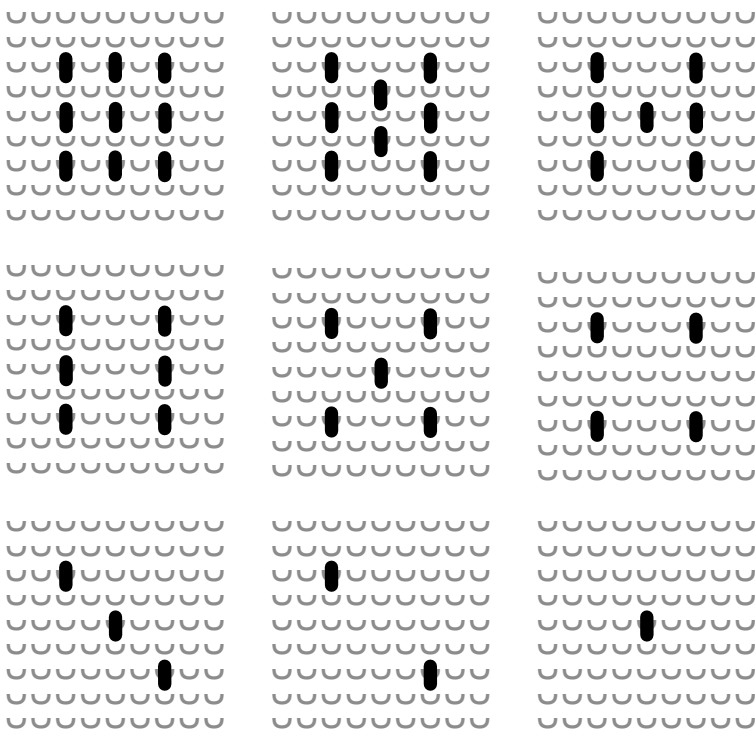
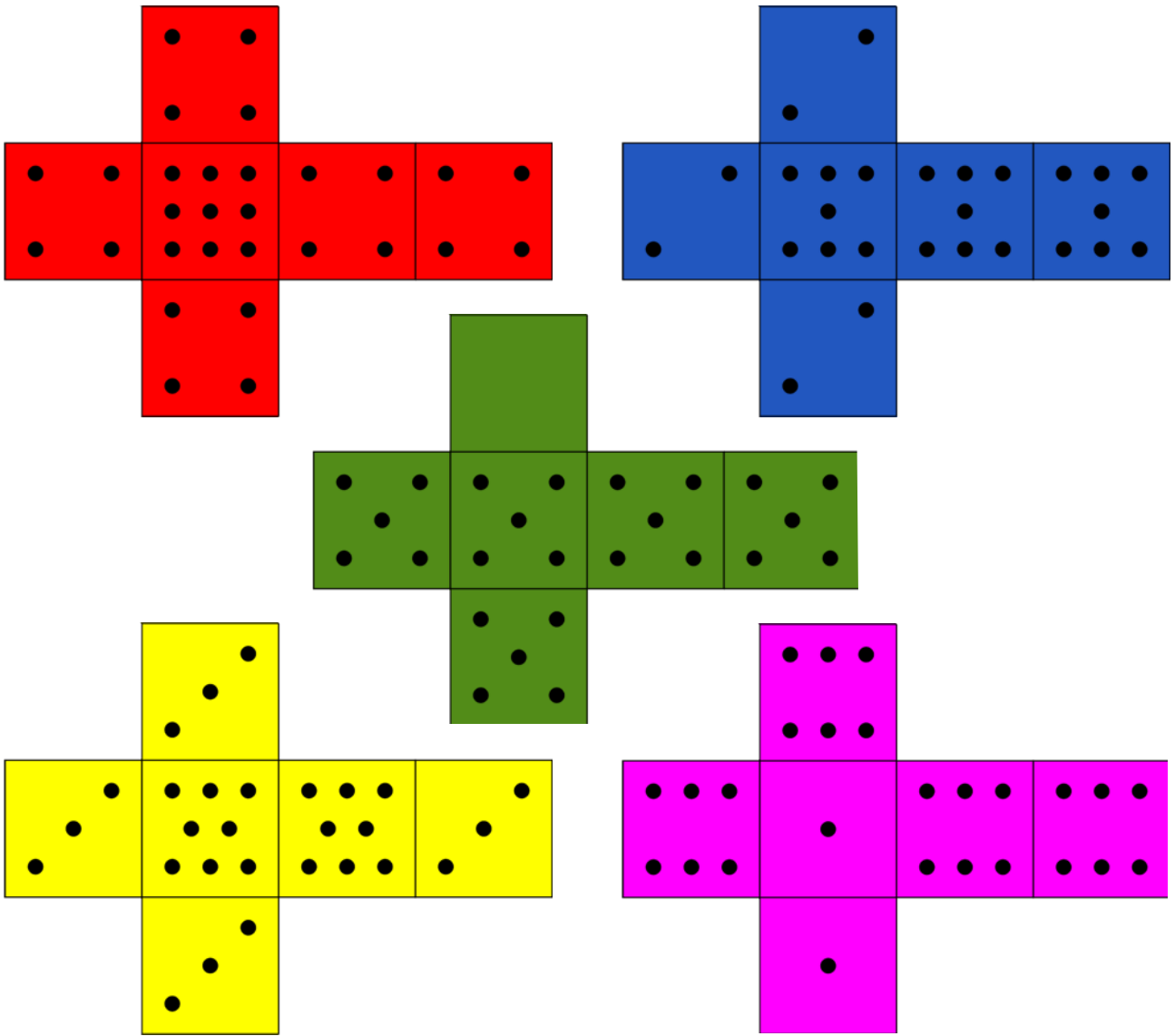
1 from the black ridge, 9 from main, 4 from black, 9 from main, 1 from black.

Slip onto double-pointed needles and complete as for side **A**.

For edges **E** and **F** work as for edge **C**.

The cube should now be closed except for the 'lid'. On the outside oversew (whip-stitch) two of the sides in place. Insert the filling and stitch the remaining side.





Use the garter stitch bumps as a grid to place the spots.

Using black make three or four stitches over the appropriate bump. Make sure you do not pull the yarn too tight when you move from one bump to the next as the balls will not be able to stretch sufficiently.

## Plastic Canvas Grime Dice

### Yarn

Small amounts of any smooth yarn that will fit through the holes in the plastic canvas. The colours are red, blue, olive, yellow and magenta. (The colours are important and should not be changed.)

Black yarn for edgings and spots.

### Plastic canvas

Plastic canvas comes in different sizes, which have different numbers of holes to the inch. You can use any type you like.

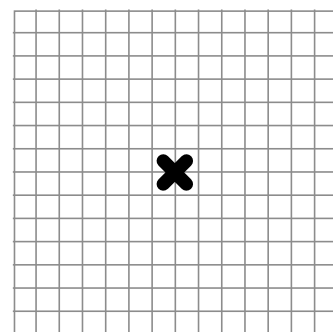
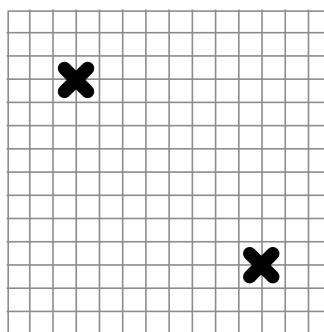
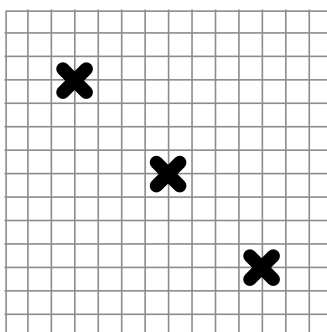
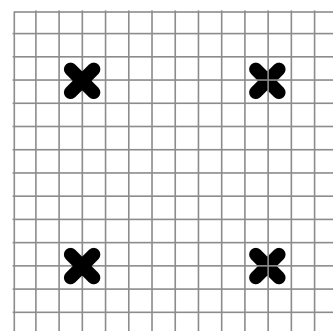
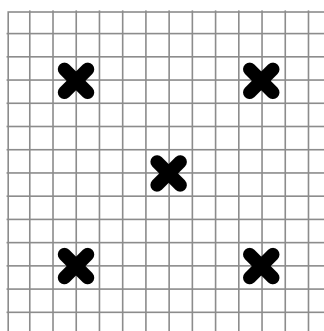
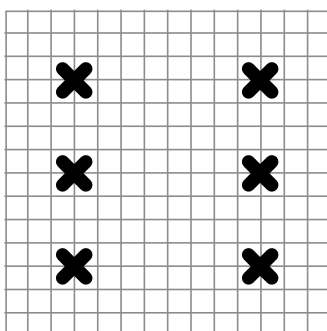
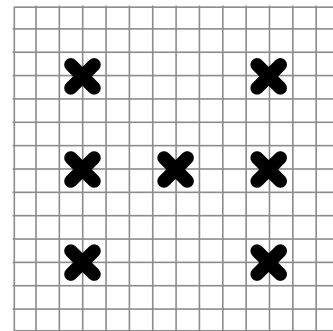
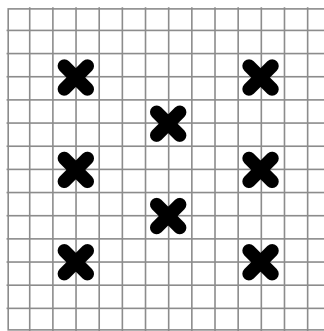
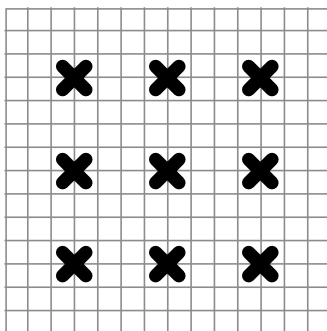
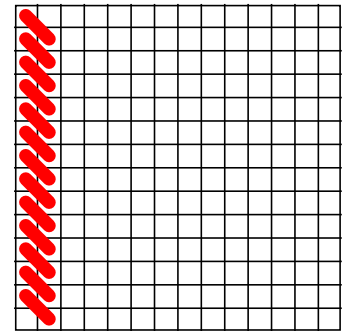
You will need 6 squares for each cube (30 in total) with 14 holes in each direction. (If you decide to change the size of the pieces of canvas you use, make sure the spots can be spaced evenly on the canvas.)

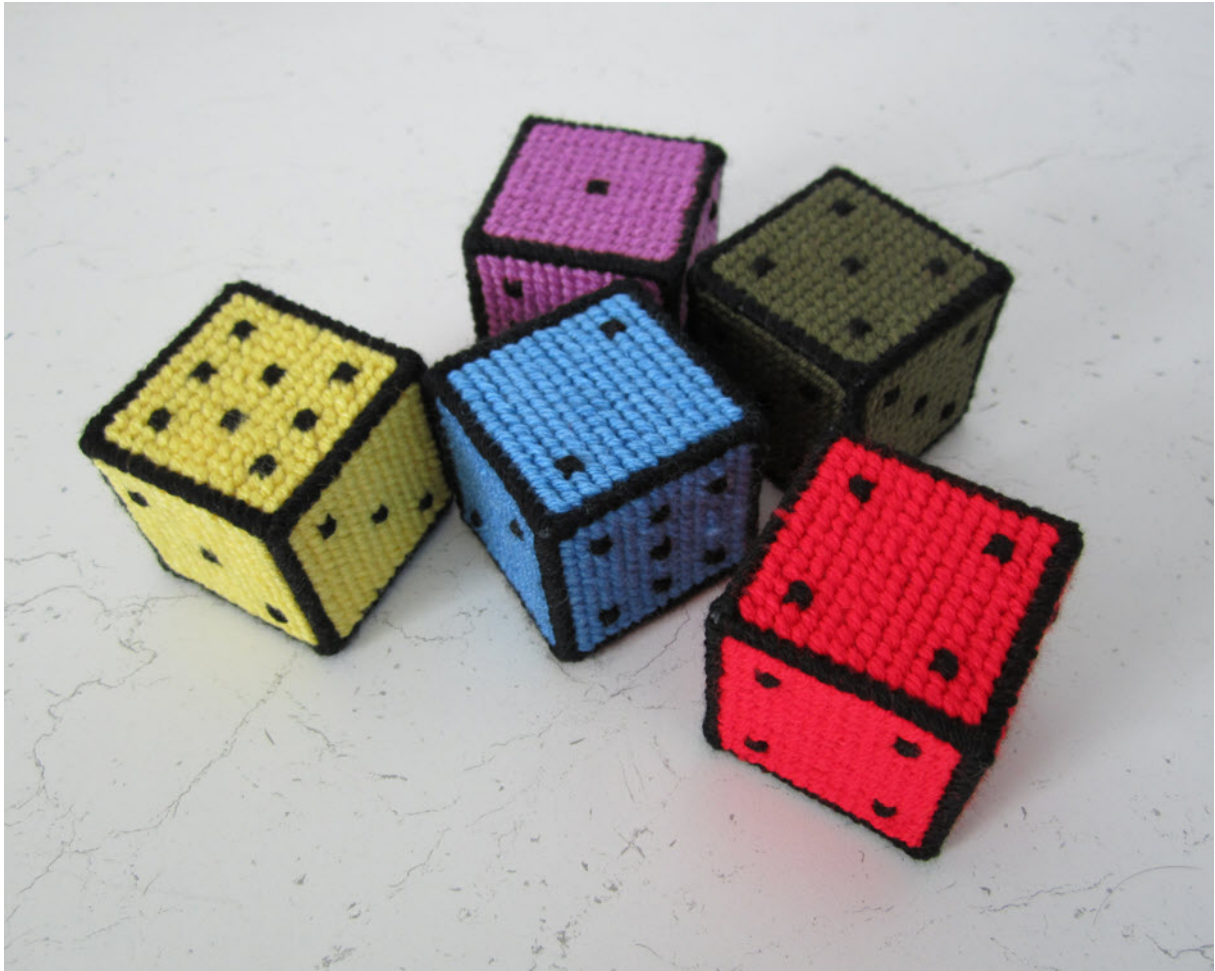
### Method

Stitch over each bar with diagonal stitches until the whole surface is covered (except the outer edges). Make six in each colour.

Add black crosses for the spots, as shown below, using the nets on page 4 for the placement of the spots.

Stitch the pieces together using the black yarn,





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