Contents

The Magic Manual

Section 11

Estimation

A guide for fabricators and users to stations from the Magic Mathworks Travelling Circus

11. ESTIMATION

Each station springs a surprise designed to spark an enquiry into the mathematics responsible.

In **11.1** to **11.3** the volume is invariant.

11.1 THE MAGIC BOX

c What the caption asserts is of course false: the gap does not disappear but, because the volume of the air space = area x height, and height and area therefore stand in inverse proportion, the small area and big height in the first case correspond to a big area and small height in the second.

11.2 THE MAGIC BOTTLE

c The cross-sectional area this time is that of a circle.

Looking from the side, one compares diameters whereas, to make a good estimate, one needs to view the bottle in plan and thus compare their squares.

11.3 THE MAGIC CONE

c On inverting the cone, the mark barely changes. This is because the powder volume P

$= (5^3 - 4^3)k = 61k$

and the air volume A

$= 4^3k = 64k \approx P.$

11.4

c Here one substitutes mass for volume but the investigator is to assume the density constant and the 2 quantities therefore proportional.

The source of the deception is again viewing the wrong dimensions.

Any view presents an area, $\propto$ (the scale factor)^2, whereas one should compare volumes, $\propto$ (the scale factor)^3.

Though only roughly true in **11.4.2**, the objects in both cases are taken to be geometrically similar.

11.4.1 THE TWO BEARS

p Here a quantitative prediction is tested by making an actual measurement.

11.4.2 WEIGHT-LIFTING

p Here, via an aesthetico-dynamic mental act, the experimenter performs a virtual weighing which s/he follows with an experiment which is still qualitative but now physical.

SECTION		AGE RANGE					
		Appropriate point of entry - not necessarily to the task set by the caption - and levels on which extension activities generated (some to be pursued off-site)					
STATION							
NUMBER	NAME	4	7	10	13	16	19+
11.1	THE MAGIC BOX			*	*	*	
11.2	THE MAGIC BOTTLE		*	*	*	*	
11.3	THE MAGIC CONE		*	*	*	*	*
11.4.1	THE 2 BEARS			*	*	*	
11.4.2	WEIGHT-LIFTING			*	*	*	

	INSTRUCTION NEEDED				SUPERVISION NEEDED			SERVICING NEEDED		
→	Needs no explanation or caption	Caption enough for most people	Needs aural prompt	Visitors must be talked through stages	None	Benefits from a helper's input	Session must be directed	None	A little	Much
11.1		*			*			*		
11.2		*			*			*		
11.3		*			*			*		
11.4.1		*			*			*		
11.4.2		*			*			*		

	NUMBER	TITLE
GROUP	11	ESTIMATION
STATION	11.1	THE MAGIC BOX
TOPIC		Cuboid volume = area x height

THE MAGIC BOX

- ▶ You've been cheated!
  This cereal packet is not full.
- ● Look at the gap at the top:

- ▶ But don't worry: it's a MAGIC box.
- ● Lay it flat. Give it a good shake and, ABRACADABRA,

... it's full again!

PICTURE KEY	DESCRIPTION	TRADE NAME	U.K. SOURCE
	as caption: 'cereal packet': box in 3 mm perspex, i.e. cast acrylic sheet size and shape that of typical cereal box, depth small in proportion to height 'cereal': millet seed - supplied as bird feed by pet shops - filling 90% of box		local local

	NUMBER	TITLE
GROUP	11	ESTIMATION
STATION	11.2	THE MAGIC BOTTLE
TOPIC		Area factor = scale factor^2

THE MAGIC BOTTLE

▶ This sherry bottle is almost empty.
The sherry only comes to the '1' mark.

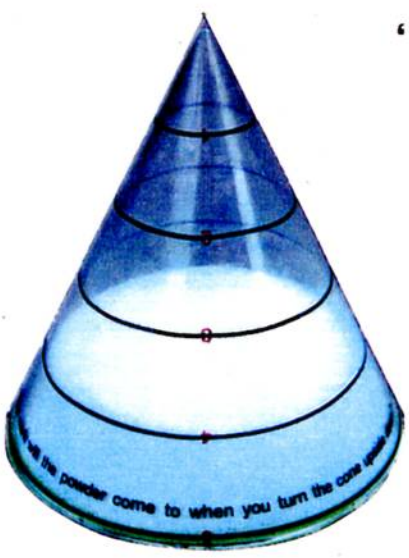
■ Which mark will the sherry come to when you turn the bottle upside down?

PICTURE KEY	DESCRIPTION	TRADE NAME	U.K. SOURCE
	as caption:		
	'sherry bottle':		
	any bottle with a long, thin neck		local
	Mark neck at 10 mm intervals with rings of 1 mm-wide rubber tape of the sort used by road surveyors to mark routes on maps - try a supplier of drawing office equipment and stationery, numbering the rings from the neck.		local
	When the bottle is inverted, the 'sherry' should reach the final ring.		
	'sherry':		
	any dark liquid which does not smear the glass surface as it drains, e.g. fountain pen ink		local
	Fill bottle base to depth of 10 mm and mark with single ring as above.		

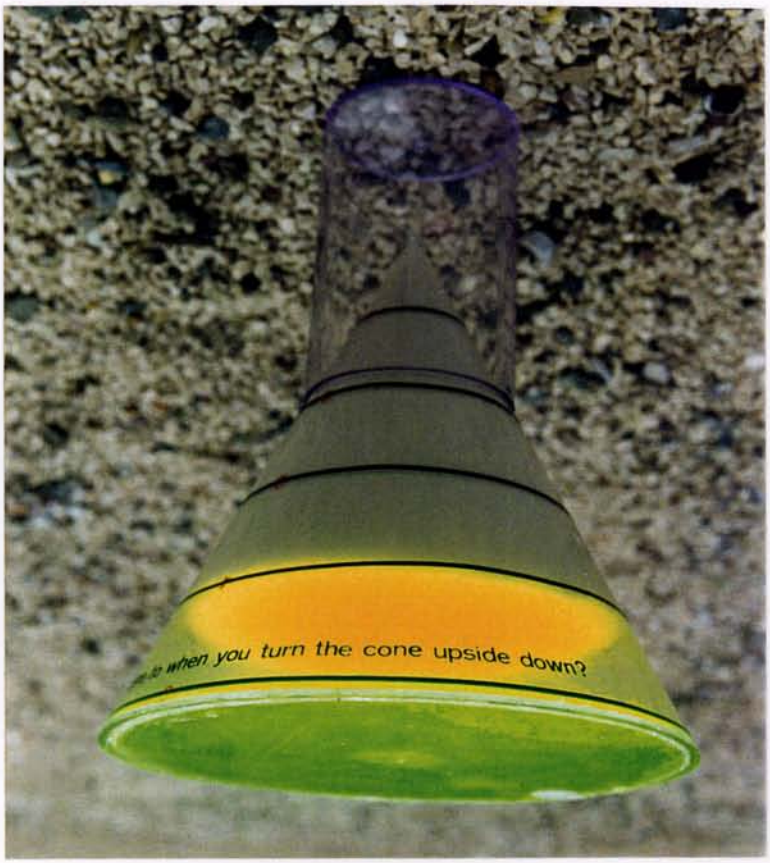
	NUMBER	TITLE
GROUP	11	ESTIMATION
STATION	11.3	THE MAGIC CONE
TOPIC		Volume factor = scale factor^3

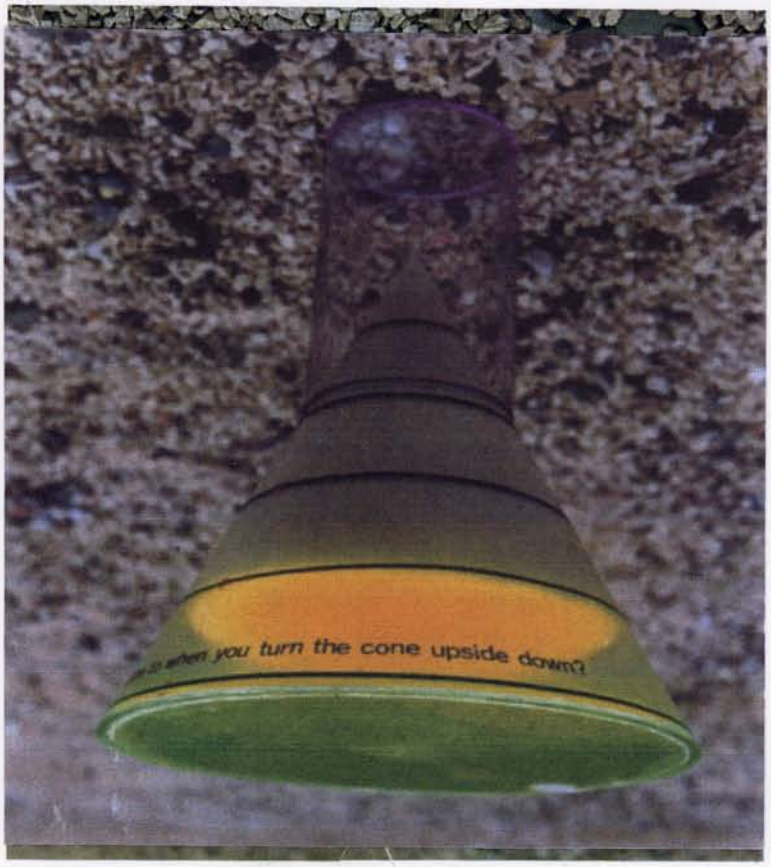
THE MAGIC CONE

■ If you turn this cone



which mark will the powder come to?


when you turn the cone upside down?


when you turn the cone upside down?

PICTURE KEY	DESCRIPTION	TRADE NAME	U.K. SOURCE
	as caption:		
	perspex cone, height: 205 mm, diameter: 205 mm	Hope catalogue: PL 580/096	Hope Education Ltd (address above)
	This has 2 holes in the base, which must be blocked with perspex disks after the cone is filled.		
	The cone is graduated with 5 equally-spaced circles, one of which is the base circumference, numbered from the apex.		
	polystyrene beads:		
	no longer available:	**XGB-560-P**	**Griffin Education** (address above)
	A new supply is being sought.		
	In the meantime, these beads, though rather large, are satisfactory:	Styrocell	Philip Harris Education Lynn Lane Shenstone Lichfield Staffordshire WS14 0EE T +44 1543 480077 F +44 1543 483056
	3 packs x 500 g (code given) **are needed.**	Harris catalogue: P 235009	

	NUMBER	TITLE
GROUP	11	ESTIMATION
STATION	11.4.1	THE TWO BEARS
TOPIC		Mass factor $\propto$ scale factor^3

THE TWO BEARS

▶ **Here are 2 bears, a big and a small.**
The big one is

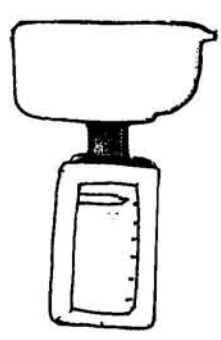
2 x as long,
2 x as wide,
2 x as tall

as the small one.

● **Place the small bear on the balance.**
Look where the needle comes to.

■ **Which mark will it come to**
when you weigh the big bear?

● **Test your guess.**



PICTURE KEY	DESCRIPTION	TRADE NAME	U.K. SOURCE
	as caption: 2 'bears': model animals in a homogeneous material, similar, scaled as stated		
	Those shown are made from: - 12 and 96 respectively. (See last note to **7.9.**)	Centicube: 08200	Economatics Ltd (address above)
	spring balance, graduated 0 - 250 g x 2 g or more finely		local
	The type shown is sold as 'diet scales' by dispensing chemists and 'health' shops,		

	NUMBER	TITLE
GROUP	11	ESTIMATION
STATION	11.4.2	WEIGHT-LIFTING
TOPIC		As 11.4.1

WEIGHT-LIFTING

- **Lift the smallest bar-bell:**

Lower it again.

- **Now shut your eyes.**
  In your imagination
  lift the middle-sized, then the biggest bar-bell.

- **Keep in mind how heavy each feels.**

- **Open your eyes.**
  Try the real bar-bells:

PICTURE KEY	DESCRIPTION	TRADE NAME	U.K. SOURCE
	as caption: 3 bar-bells, approximately similar If the masses are stated, they should be painted over.		local