### Banbury handout 1

### Sketching bottle-filling graphs

You have four variables: height (h), cross-sectional area (a), flow rate (r) and time (t)

Filling with constant flow rate:

**Plot h and a as functions of each other**

**Plot both as functions of time**

Emptying through a small hole. Flow rate varies with height remaining in bottle so

**Plot h and r as functions of each other**

**Plot h and a as functions of each other**

**Plot all against time**

### Banbury handout 2

Typical difficulties with graphing:

labelling axes as number track instead of numberline

problems with where zero is

thinking the axis has to be like a ruler, so intervals have to be units, tens or hundreds

thinking the axes have to be scaled the same way

not predicting suitable range of values for y

drawing in ink so no chance of correcting it

joining points with straight lines, whether appropriate or not

making all graphs go through the origin

other ....

### Banbury handout 3

### Problems distinguishing between graphs derived from experiments (all positive values, approximate measures, graph-fitting) and algebraic relations

### Problems with understanding algebraic graphs which derive from plotting points

not going beyond or between the plotted points

data points are ‘join the dots’ for the graph, rather than particular instances

trouble calculating points for negative values of x

not going beyond whole numbers

not coordinating algebraic, graphical and numerical data

not seeing *all* points on a curve as instances

### Problems with understanding graphs which derive from using plotting software

not going beyond the limit of screen, page, diagram

not seeing all features because of choice of scale or domain/range

### Problems with linear graphs

equal aspect assumed for y=x

the roles of y, x, m and c in y=mx+c are very different from each other

want the x-intercept to appear in a similar way to the y-intercept. For linear functions there is the implicit form: ax + by = c

expectations that all functions have smooth recognisable graphical representations

## Quadratics

* the y-intercept is visible clearly as c in this form: y = ax2 +bx+c but the roles of a and b are obscure
* the x-intercepts are visible as roots a and b in the factorised form y = k(x-a)(x-b) but the y-intercept is not obvious; changing the value of k is interesting, particularly with software
* the turning point (probably the most obvious visual feature of quadratics) is most visible as (a,b) in the completed square form: y = k (x-a)2 + b. The displacement of +a in the x-direction appears in (x-a) which many students find a counter-intuitive representation

### Banbury handout 4

## What students have to understand about graphs of functions:

* the relation between coordinates for individual points
* the same relation applies to sets of points
* the equation and line represent this relationship and all the points that have it.
* procedure for generating the y-values, given the x-value
* understand the pattern between points
* work with the invariant properties of the whole relationship.

### What might students know about functions?

x 7

+ 5

x

y = 4x + 7

|  |  |
| --- | --- |
| x | y |
| 0 | 2 |
| 1 | 3 |
| 2 | 6 |
| 3 | 11 |
| 4 | 18 |

Whole objects which have particular characteristics

Whole objects which can be transformed by scaling, translating and so on

Structures of variables defined by parameters and relations

e.g. the parameters a, b & c define the function f(x) =ax2 + bx + c

Relations between variables, represented in different ways