

# IT for Astronomy

## AA1055

Available as a *University Certificate*  
and a module for *CertHE*, *DipHE* and *BSc in Astronomy*.

### Sample Notes

This module consists of 10 sections of notes with embedded practical exercises, and three appendices providing further guidance and experience for the students. Topics include using widely-available office software for scientific tasks such as data analysis, accessing sources of information and astronomical data via the World Wide Web, and using the Internet as a resource for astronomical software. It is assessed via reports on a set of computer-based activities, presented as different forms of electronic documents.

The sample learning materials consists of pages selected from each of the 10 sections of notes.

- All the module materials for AA1055 are supplied on-line on WebCT. Internet access is essential for this module. There is no CDROM for this course.

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# Introduction

*Astronomy has made extensive use of computers since they were invented. Today they permeate every aspect of the subject, and allow us to study our Universe in unprecedented ways. IT for Astronomy addresses some of the basic aspects of those uses, and touches on some of the cutting edge applications in both theoretical and observational areas.*

## Section

# 1

**I**n this first section we introduce the main aspects of the module, and provide basic information to get you going with your own study. This section only is provided in both paper and electronic form, in order to help you over any initial problems. Subsequent sections are available solely in electronic form. Please read this entire section before proceeding. We make no apologies if much of this information seems elementary to you; other students may not have your breadth of experience. Many of the terms used here are included in the Glossary. In the on-line version, follow the link from the word you wish to check in the Glossary.

Information Technology is a rapidly changing area. The diversity of available computer applications and information develops continuously. Thus it may be that elements of these notes are slightly out of date by the time you are using them 6 months after they undergo their final revision. Consequently we have tried to stick with general concepts and approaches, with specific examples where we feel this would help. For your own work and development in this area, you will find it very useful to make use of the built-in help that many computer systems now provide. This will both enable you to continue developing your own skills and to deal with any differences between the examples we provide and the actual process required by the computer system you are using. This is a particularly useful skill if you are using computers in the work place or when learning elsewhere - the computer systems will often be different from those you might use at home, and being able to sort out minor problems on your own will be invaluable.

## Materials outline

### Notes

1. Introduction - this section
2. Scientific reports - writing reports and using word processors
3. Data manipulation - using spreadsheets to manipulate numerical data
4. Data analysis - using spreadsheets to analyse data for astronomical information
5. Information resources on the WWW - using the web as a resource for information
6. Documents on the WWW - writing for the web and webpages
7. Astronomical applications - computer programmes available on the WWW
8. Astronomical uses of databases - applications of database software
9. Electronic presentation - creating presentations to support talks
10. Further astronomical resources - more resources for in depth study

## The World Wide Web

The World Wide Web (WWW) is often seen as synonymous with the Internet (see below). In this module, we use the two distinctly:

- The Internet is the hardware which allows us to transfer information rapidly;
- the WWW is the information itself.

The WWW is made up of numerous "web-pages" that are generally constructed of text and images conveying information. Many more advanced web-pages can do other things, but these other functions are somewhat beyond the scope of this module. A "web-site" is simply a collection of web-pages, usually but not always with some coherent connection between them. You use the Internet to "download" these web-pages to your computer, and your web "browser" displays them according to how the content is laid out. A browser is simply a piece of software which can interpret the web-pages as they are down-loaded.

### How it works

#### Break down of the URL <http://www.uclan.ac.uk/pasm>

protocol	local domain	global domain	local web-site
<a href="http://">http://</a>	<a href="http://www.uclan">www.uclan.</a>	<a href="http://www.uclan.ac.uk">ac.uk</a>	<a href="http://www.uclan.ac.uk/pasm">/pasm</a>

So how do the Internet and the WWW work together to provide you with information? The heart of the system is the **Uniform Resource Locator**, or **URL** (usually pronounced as three separate letters). This is also commonly called an Internet address (although this is prone to confusion with an email address or even a postal address). It consists of four elements:

#### Protocol

The means by which the computers talk to each other. The commonest is **http** or "hypertext transport protocol". Others include ftp (file transport protocol) and https (an encrypted version of http).

#### Local domain

Domains define the virtual "areas" of the Internet. The first part of a URL identifies the local domain, used only by web-sites originating with that organization. For example at the University of Central Lancashire (UCLan) this is **www.uclan**.

#### Global domain

The larger area domain, grouping local domains together into more or less logical areas. For example UK Universities are grouped under the Academic domain of **ac.uk**.

#### Local web-site

Under a given top-level URL, other web-sites can be defined, generally appending words after a forward slash. For example UCLan's Department of Physics, Astronomy & Mathematics uses **pasm** to direct users to the departmental web-site. Where such a local web-site is missing, users are directed to the organization's top-level web-site.

## Greek characters and their names

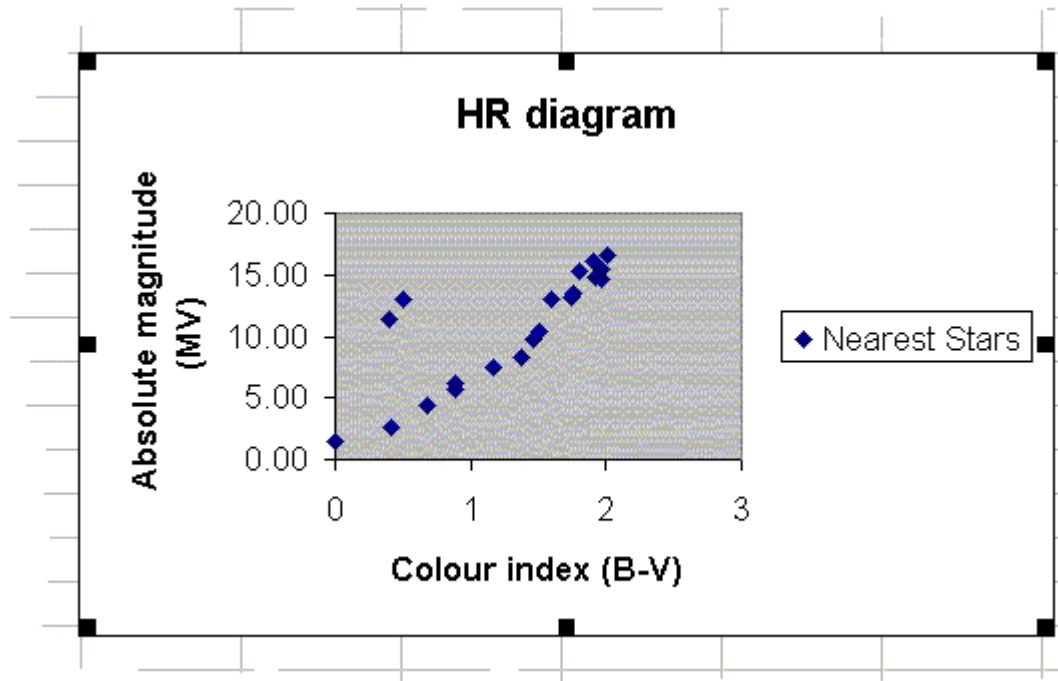
Here we show Greek characters widely used in **astronomy** to represent mathematical concepts and physical quantities. The wide use of Greek characters stems from the classical training of many of the "fathers" of modern astronomy, from the seventeenth to twentieth centuries.

Table 2-6.  
Greek  
characters  
and their  
usage

Greek characters in (Greek) alphabetical order			
Name	upper case	upper case	Notes & usage
Alpha	A	$\alpha$	Often denotes angles, including Right Ascension.
Beta	B	$\beta$	
Gamma	$\Gamma$	$\gamma$	
Delta	$\Delta$	$\delta$	Often denotes uncertainties (uppercase) or small changes (lowercase). Declination often denoted with lowercase form.
Epsilon	E	$\epsilon, \epsilon$	The two lowercase forms often represent different mathematical or physical quantities.
Zeta	Z	$\zeta$	
Eta	H	$\eta$	
Theta	$\Theta$	$\theta$	Often denotes angles.
Iota	I	$\iota$	
Kappa	K	$\kappa$	
Lambda	$\Lambda$	$\lambda$	Lowercase form is standard symbol for wavelength.
Mu	M	$\mu$	
Nu	N	$\nu$	Lowercase form is standard symbol for frequency.
Xi	$\Xi$	$\xi$	The X is pronounced as a Z - in other words, you say this letter "zye".
Omicron	O	$o$	
Pi	$\Pi$	$\pi$	Lowercase form denotes the ratio of a circle's circumference to its diameter. This irrational number is a crucial mathematical constant.
Rho	P	$\rho$	Lowercase form often denotes mass density.
Sigma	$\Sigma$	$\sigma, \varsigma$	The second lowercase form is rarely used in scientific reports.
Tau	T	$\tau$	
Upsilon	Y	$\upsilon$	
Phi	$\Phi$	$\phi, \phi$	The two lowercase forms often represent different mathematical or physical quantities. Often denotes angles.
Chi	X	$\chi$	Pronounced like the name Kai.
Psi	$\Psi$	$\psi$	Pronounced with a silent p.
Omega	$\Omega$	$\omega, \omega$	The two lowercase forms often represent different mathematical or physical quantities.

A basic HR diagram should appear on the spreadsheet. It may be obscuring some of the data. With the chart selected (it will appear with a black outline and have little black squares around the edge), click with the left mouse button in a blank part of the chart, and you should be able to move it to an empty part of the sheet. In the following exercises we will add the data for the Brightest Stars and the Sun, and modify the appearance of the chart appropriately for a scientific report. The basic chart should look something like Figure 3-13.

Figure 3-13.  
The initial HR  
diagram  
selected in  
Excel.



### More data

We now want to take our HR diagram and add the **rest** of the data. When you add the Brightest stars and the Sun data, your spreadsheet should **automatically** change the range of the x and y axes to display all the data. If it does not then you will need to determine the range from your data and manually adjust the x and y scales. You may be able to find the minimum and maximum in your data using a sort facility, but take care that you don't destroy the meaning of the formulas used to determine the absolute magnitudes for the Nearest Stars. It is probably safer to use a spreadsheet **function** to determine the minimum and maximum of each set of data.

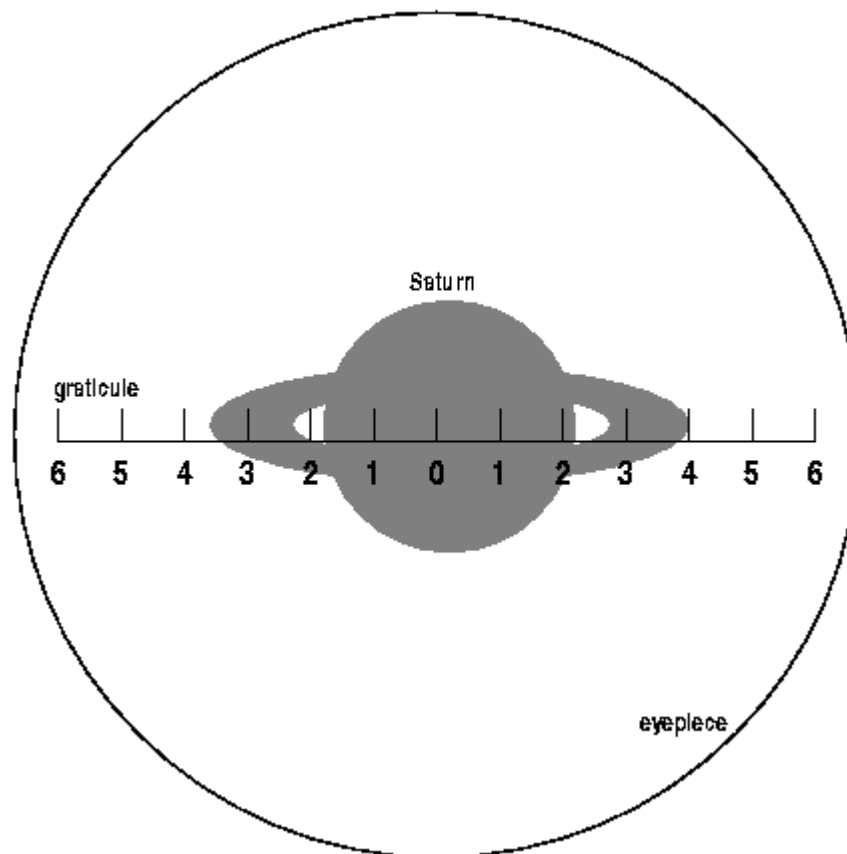
## Reading uncertainties

The precision of any measurements will also be fundamentally restricted by reading uncertainties when taking measurements. With **analogue instruments**, where the scale is continuous and directly related to the (usually continuous) measured quantity, concepts such as the experience of the observer come into play. This is illustrated in the example below. However, increasingly we use **digital instruments**, where measurements are always taken in exact intervals. For example, if a photometer has a four-digit display then measurements can only be made to the *fourth* significant figure. The true value could actually vary by up to 0.5 units in the *fifth* significant figure above or below the fourth significant figure. This is an absolute reading uncertainty, which cannot be improved upon by the observer's experience. In general the random noise in any set of measurements will exceed the read uncertainties; if this isn't the case, then reading uncertainties become the dominant error, and it may be useful to improve the instrument.

### Example: The rings of Saturn

When using a graticule (an *analogue instrument*) to measure the major axis of Saturn's rings, it is difficult to correctly judge the value to better than half the distance between adjacent tick marks on the scale. This is illustrated in Figure 4-5.

Figure 4-5.  
Illustration of  
a graticule  
used to  
measure the  
size of  
Saturn's  
rings.



The graticule is marked at every **unit**. The observer has carefully aligned the right hand extreme of the ring with a tick mark. Counting right to left we can measure the size of the rings to be around 7.5 units. The **reading precision** on this would formally be taken as  $\pm 0.5$  units, as the tick marks are spaced at 1 unit intervals. In fact with a device like a graticule, it is possible with experience to estimate the size to better than this. For example, you might feel that you can judge to the nearest half-division, which would not be unreasonable. This would give the

measurement as  $7.5 \pm 0.25$  units. In fact when this diagram was drawn, the rings were created to be slightly bigger than 7.5 units, and it might be sensible to acquire a graticule with **finer divisions**. This would only be the case however if the read uncertainty introduced by this graticule was judged to be the **dominant** source of uncertainty.

### Example: Digital uncertainties

Suppose you had a **photometer** (a device for counting photons) with a *four*-digit display. On one night observing conditions are middling, and the observational uncertainties are dominated by those conditions. On another night the conditions are exceptional and the uncertainties are dominated by the limitations of the display. Table 4-1 below illustrates both possibilities, showing 11 measurements of a single star from each night. Here we imagine we have a second, more precise, photometer which allows us to see a *fifth* digit; then we can see how variations in that digit are not precisely recorded by the four-digit photometer.

Table 4-1.  
Digital  
photometer

<b>Digital read uncertainties</b>			
<b>middling conditions</b>		<b>excellent conditions</b>	
<b>four digit reading</b>	<b>five digit reading</b>	<b>four digit reading</b>	<b>five digit reading</b>
4347	4346.5	4338	4338.4
4306	4305.7	4338	4338.3
4378	4377.7	4338	4338.4
4289	4288.9	4338	4338.2
4280	4280.4	4338	4338.1
4371	4370.6	4338	4337.6
4356	4356.2	4338	4338.4
4372	4371.9	4338	4337.6
4329	4329.0	4338	4337.8
4360	4360.3	4338	4337.8
4346	4345.6	4338	4338.3
<b>means of readings</b>			
4340	4339.4	4338	4338.1

There are a number of things to note in Table 4-1. Look at all the numbers in the **first** column. They vary considerably in the last three digits, and this is a **random** variation due to the observing conditions. We will return to this later.

Now compare the **first and second** columns. Note that each number in the second column can be rounded in the usual fashion to the corresponding number in the first column. The "usual" fashion here means that if the number in the first decimal place is 5 or more, round up, otherwise round down. However, the variation **across** the measurements in the first column are far wider than the difference **between** corresponding numbers in the first and second columns - in other words the conditions **dominate** over the limitations of the device.

In the third column, the effects of the excellent observing conditions are clear in the fact that all the numbers are **identical** (4338). This means that the conditions were so good that the four-digit photometer cannot detect any variations. These numbers relate to those in the fourth column in the same way that the numbers in the first two columns are related. However, in the "excellent conditions" case all the variation is in the *fifth* digit.

## Your location



To determine a star's rise and set times, you need to know your **longitude** and **latitude**. Any decent atlas can supply this. Alternatively, visit the **Getty Thesaurus of Geographic Names** [[www.getty.edu/research/tools/vocabulary/tgn/index.html](http://www.getty.edu/research/tools/vocabulary/tgn/index.html)]. Supply your town's name, and scan down the results page until you see the one that matches. Follow the link, and right near the top of the page is your longitude and latitude. Note this down or save the page to your **section 5 area** for later reference. This web-site goes to pretty small towns, and also includes geographic features, but if it doesn't include your location pick the nearest larger town. This should be close enough. If you really can't find you longitude and latitude, use Preston's location at longitude 53 46 N, latitude 002 42 W (degrees and minutes) for the rest of this exercise.

## Rise and set times



Given the RA and Dec of an object, it is pretty straight forward to determine the **rise and set times** for a given location on Earth on a given date. The mathematics involved is beyond the scope of this course. Instead, let us use a programme on the WWW which calculates times for us. Let's try the one at the ING [[STARALT v2.0](#)]. This web-site is a little quirky, but the following should work. Ignore the pop-up menu with various observatories in it. Instead, in the box alongside **Observatory** type you latitude, longitude and altitude above sea level. The longitude needs to be to the *east*. If you have a value to the *west*, you need to subtract that number from 360 and use the result instead. Choose the **Output format** to be Gif-HTML. Finally, type **ZAnd** and the RA and DEC into the big box. Do not put a *space* in the star's name. The completed page should look something like this:

<b>Mode</b>	Staralt
<b>Date</b>	28 August 2002 (Staralt,Startrack)
<b>Observatory</b>	Roque de los muchachos (La Palma-Spain) or specify own site: E.Long. Lat. [Alt.] 357 14 0 53 46 0 10
<b>Coordinates</b>	Coord. format: [object] hh mm ss ±dd mm ss ZAnd 23 39 39.95 +48 49 05.95 and/or specify a file containing the coordinates Browse...
<b>Options</b>	Moon Distance Include on plot (Staralt only) 10 Min. Elevation (Starobs,Starmult only) Gif-HTML Output Format

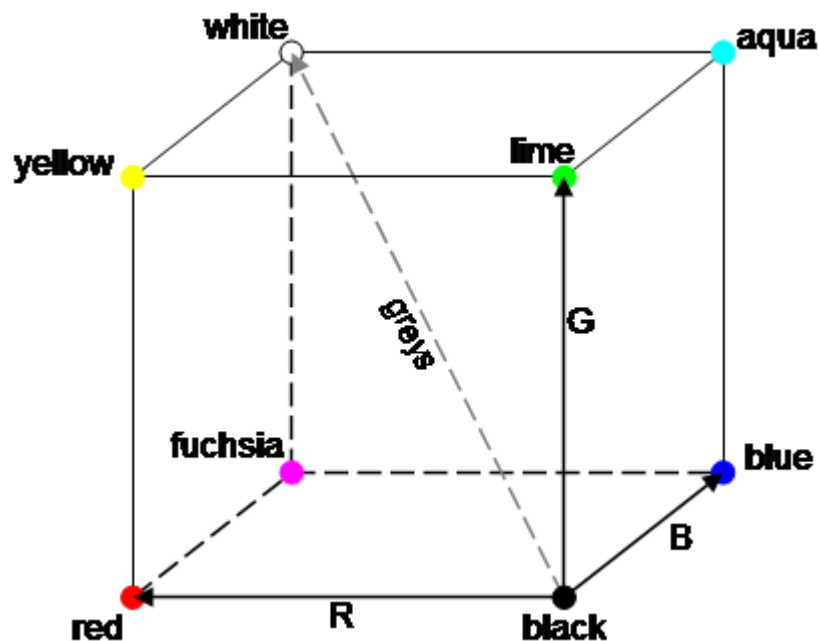
where we have used the location of Preston as an example. You can also use decimal degrees, in which case the information in the box for specifying your own



## The RGB model of colour

The standard television-style computer monitor (also known as a cathode-ray tube or CRT monitor) is able to create only three colours - **red**, **green** and **blue**. Consequently CSS defines every other colour by assigning different values to each of the three basic colours. The **mixture** of these three in principle can create any colour between white (a pure mix of all three colours) and black (an complete absence of all three colours). In practice CSS restricts itself to only 256 values of each of the base colours. This still gives  $256^3 = 16,777,216$  colours (including black and white). There are a number of ways to represent this in a CSS statement, but the easiest is to simply replace the colour name (e.g. orange or purple in the example above) with the text **rgb(R,G,B)** where R, G and B are numbers between 0 and 255 that tell the web-browser how much of each colour to include. The R,G,B values for the standard colours are given in Table 6-2. Clearly with some experimentation it is possible to come up with much subtler and attractive colours. For example the headings in these notes range from **rgb(80,0,0)** for the level 1 headings to **rgb(255,0,0)** for the level 6 ones. You may find it useful to think of these numbers in terms of the colour cube presented in Figure 6-1.

Figure 6-1.  
The RGB  
colour cube  
showing  
combinations  
of the three  
basic colours  
- red, green  
and blue.



### Hands-on exercise



In your exercises webpage file, change the word-based colour values to the **rgb( )** equivalents. Now experiment with different R,G,B combinations to manipulate the colours of the headings, table headings and border.

## Professional astronomy software

### Flexible Image Transport System



The Flexible Image Transport System (universally referred to as FITS) is a standard computer file format for storing astronomical data along with any observational or analysis information. The standard is maintained by the NASA/Science Office of Standards and Technology (NOST) and made available on their web-site [[fits.gsfc.nasa.gov](http://fits.gsfc.nasa.gov)]. Like the HTML standard provided by the W3C (see Section 6), the FITS standard is a technical document. The important points are summarised here.

#### FITS headers

The FITS standard defines the format of the header information. This is information like the telescope used, the sky-position observed, the observation date, and so on. The header is presented in ASCII, which means that it can be viewed by any normal text editor. However, this can be difficult to do, as FITS files appear all on one line in such an editor, and the data portion is not ASCII.

#### The data

In a FITS file, the data is stored as binary code, which is another way of saying computer-readable code. This is in many ways similar to the contents of an executable programme, in that it is not understandable to a person reading it. The reasons for using binary code are primarily that it takes up far less space than ASCII, and it is far more difficult to change the content of the file in a meaningless way. By providing software tools to manipulate the FITS data areas, any changes can be sure to make sense to a computer reading the file. This is not the same as the changes making any *physical* sense. For example, you could multiply every point in the data by a different random number; the result would be understandable by a computer, but the result would be a random mess. Because the data is binary code representing digital information, the FITS file can hold any sort of data, not just "images" in the usual sense of the word. A one-dimensional FITS file can hold a spectrum, a two-dimensional FITS file can hold a picture, an three-dimensional FITS file a data-cube of spectra taken over many positions on the sky.

#### Extension tables

The third part of a FITS file are the extension tables. These are also in binary format. They contain additional information about the data, particularly changes that have been made. Common extension tables include a history table, which records all the software tools that have acted on the FITS file, and a plot table which holds any printable versions of the data. Calibration information (e.g. information on how bright each point is in physical units) is also often held in extension tables.

#### Why FITS?

In Section 6, we discussed lossy file formats, and their usefulness in web-publishing. In this section, we briefly mentioned that the packages available from educational or commercial sources use various file formats. However, the most

## Adding animation



There is an enormous range of animation options, but in Powerpoint they are all accessed in the same way.

1. **Select** the object in question with the mouse.
2. Choose the **Custom Animation** option from the Slide Show menu.
3. Use the various text boxes, menus and selection boxes at the bottom of the Custom Animation window to **set up** the animation.
4. Use the **Preview** button to test it, then press OK.
5. Run the **slide show** to check how things happen in practice.

In a diagram, each part is a separate object, but you can select them and **group** them to allow you to animate (or otherwise edit) several objects together. One important thing to note is the impact of animation on any **printed** form of the presentation. This is mentioned in the relevant following subsections, but if you think you might need to print out your presentation in any form, it is worth keeping this in mind when adding animation.

## Hands-on exercise

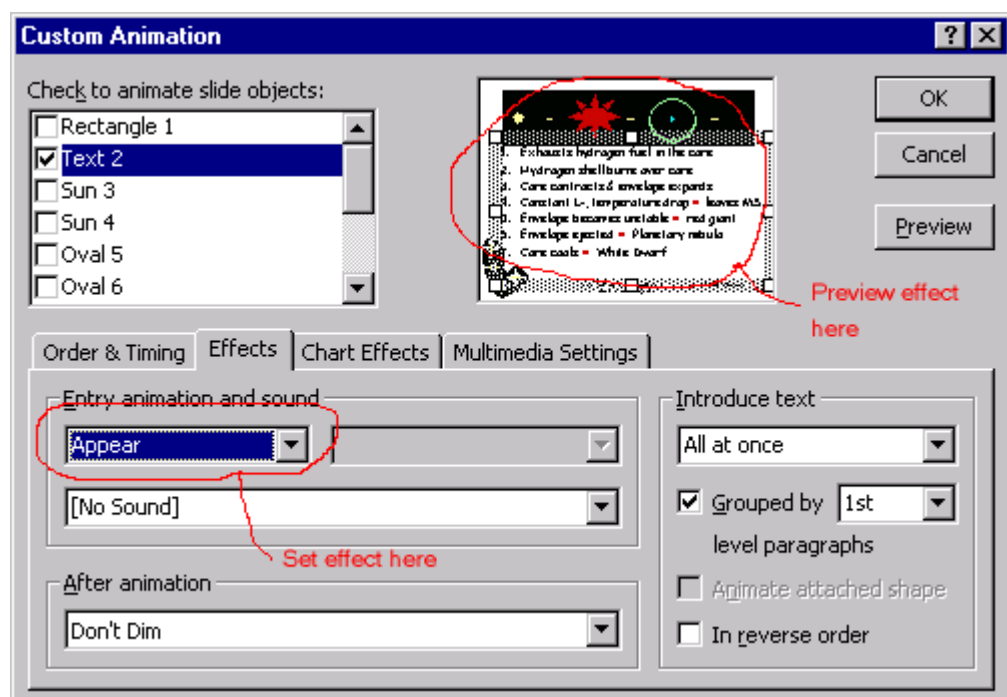


Open your **Exercises presentation** and move to a slide with a text list on it. Select the text list with the mouse and

1. Choose **Custom Animation** from the Slide Show menu.
2. In the Custom Animation window (Figure 7-6), change the Effect from **No Effect** to **Appear**.
3. Press the Preview button to see what happens.
4. Try some other effects.
5. Now do the same for the chart you inserted.

Depending upon what you are trying to present, different animation may be appropriate. Save your **Exercises presentation**.

Figure 7-6.  
Powerpoint  
Custom  
Animation  
window main  
features



## Find x-ray sources and binary stars in the Globular Cluster NGC 104

The part of CDS best suited to this aim is the VizieR service (yes, the last letter is also a capital). Go back to the main CDS web-site and choose the *VizieR* link near the top. Follow that link, and scroll down until you come to the area that looks like Figure 10-2.

Figure 10-2.  
Part of the  
CDS VizieR  
interface

This part of the interface allows you to choose to look for observation results for a given object. The first box allows you to choose by the broad wavelength range, with the options:

- Radio - usually above about 1 mm wavelength.
- IR - infrared, which is beyond the visible range but short of the radio.
- optical - the range we can see with the human eye.
- UV - ultraviolet, shorter wavelength than optical.
- EUV - extreme UV, spanning the range up to X-rays.
- X-ray - between about 10 and 0.01 nm.
- Gamma-ray - extremely high-energy photons.

These criteria are not arbitrary. Rather, they reflect the ranges over which particular sets of observational techniques can be applied. For example, EUV observatories use a blend of techniques suitable for longer-wavelength UV and shorter-wavelength X-ray. The energy range of the photons determines directly how they interact with the detectors.



Choose the X-ray option, skip over the other options for now, and type **NGC 104** in the Target name box. The **Find Data** button will look for X-ray results within the globular cluster NGC 104. The other button **Find Catalogues** would find catalogues that might have relevant data in them. For now the **Find Data** button is probably more useful. Press **Find Data**. The first table of results is a set of papers specifically about NGC 104; these are not always related to the sort of object you are looking for. The following tables are pulled from specific catalogues, based on them having a position within 10 arcmin of the centre of the cluster.