UNIVERSITY OF GLASGOW

Department of Physics and Astronomy **Thursday 4th Nov 2004**
EXCOS 1X 2004-2005 **1pm – 2pm**

Exploring the Sky: Class Test

Students should attempt **all 20** Multiple Choice questions by indicating, on the grid provided, the letter corresponding to the correct answer for each question.

1. The eighth planet, in order of distance from the Sun, is

A. Jupiter
B. Saturn
C. Uranus
D. Neptune

Exploring the Sky

Lecture 1: Basic Observations – What's in the Sky?

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mnemonic to remember the order of the planets from the Sun is:

My Very Efficient Memory Just Stored Up Nine Planets

2. The constellation of Crux Australis points towards

A. The North Celestial Pole
B. The South Celestial Pole
C. The horizon
D. The zenith

Exploring the Sky

Course Website: ***http://www.astro.gla.ac.uk/users/martin/teaching/ets/index.html***

(username: aone; password: aone)

Lecture 2: The Stars and Their Positions in the Sky

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The Stars from Different Locations

If we move our observing location on the surface of the Earth, the shapes and sizes of the constellations are unchanged, but their apparent position in the sky is altered. Suppose we move due North; eventually we will reach the North Pole, where the Pole Star will be directly overhead – i.e. all the stars would seem to rotate around us, neither rising nor setting. Suppose we travel next to the Equator; the NCP would now lie on the horizon, with the **South Celestial Pole** (SCP) also on the horizon in the opposite direction. (There isn't a bright star close to the SCP in the sky, so it's harder to find, but the constellation **Crux Australis**, or Southern Cross, points to the SCP). At the

3. As seen from Glasgow, stars reach their highest altitude when they are due

A. North
B. South
C. East
D. West

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Lecture 2: The Stars and Their Positions in the Sky

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Diurnal Motion

During the period of one day (24 hours) how does the sky behave? We are conscious of a slow 'drift' of the Sun, Moon, planets and stars across the sky; using the reference points of NSEW provided by a magnetic compass we see that this motion is from East to West. Watching the sky carefully throughout the night quickly reveals a general pattern (see also fig. 3):

- Stars rise in the East, reach their maximum height above the horizon in the South – along the North-South line, known as the **Meridian** – and then set in the West

4. The angular width of the Plough is about

A. 10 degrees
B. 20 degrees
C. 30 degrees
D. 40 degrees

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Lecture 2: The Stars and Their Positions in the Sky

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Estimating Angles on the Sky: A Matter of Degrees

In order to describe the positions of objects relative to each other in the sky, or to local landmarks, it is important to have a feel for angular measurements. First we need to know the basic definition that there are 360° around a circle. Some simple 'rules of thumb' can then help us (see fig. 5):

- The thickness of your thumb or index finger, held at arm's length, covers (*subtends*) about 1° on the sky. This is twice the angle subtended by the Full Moon
- The thickness of your fist, held at arm's length, subtends about 10° on the sky (roughly the width of the Plough)

5. **When observing from a large city a naked-eye observer can typically see stars brighter than apparent magnitude**

A. -3
B. -6
C. $+3$
D. $+6$

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(username: aone; password: aone)

Lecture 3: Stellar Brightness

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The Magnitude Scale

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Since the time of Hipparchus the magnitude scale has been greatly extended and refined, although the basic idea remains the same: fainter stars have larger magnitudes.

- The naked eye can see stars down to about sixth magnitude, although only in the absence of light pollution; in a large city only stars brighter than about third magnitude are visible.
- A small amateur telescope might see stars down to about magnitude +10

6. In Johann Bayer's catalogue *'Uranometria'* the brightest star in the constellation of Orion was known as

A. Rigel
B. Betelgeuse
C. Polaris
D. α *Orionis*

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Lecture 2: The Stars and Their Positions in the Sky

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The stars are too numerous for all to be given individual names, and in any case the name gives no indication of which constellation a star belongs to. In 1603, Johann Bayer introduced a major change in the naming of stars with his star map **Uranometria**. In this map the constellation figures were beautifully drawn, but the stars were labelled by their constellation and by a Greek letter (α, β, γ, δ etc) denoting their apparent brightness: α = brightest star in the constellation, β = 2nd brightest star, and so on. Thus: Vega = α *Lyrae*; Rigel = *β Orionis*. (Nowadays, the constellation part of the name is usually abbreviated to three letters – e.g. *Ori[on]*, *Tau[rus]*

7. The star Sirius has apparent magnitude –1.47 and the star σ Canis Majoris has apparent magnitude +3.46. This means that

A. Sirius is about 100 times brighter than σ Canis Majoris
B. Sirius is about 100 times fainter than σ Canis Majoris
C. Sirius is about 5 times brighter than σ Canis Majoris
D. Sirius is about 5 times fainter than σ Canis Majoris

Exploring the Sky

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Lecture 3: Stellar Brightness

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The Magnitude Scale

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intermediate brightness were assigned to the second, third, fourth and fifth classes. The smaller the number, the brighter is the star (think of golf handicaps as an analogy: the smaller the handicap the better the golfer!).

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Pogson set the magnitude scale so that a change in brightness by a factor of 100 corresponded to a difference of exactly 5 in apparent magnitude. This means that a magnitude difference of 1

8. The three stars of Orion's Belt lie very close to

A. The North Celestial Pole
B. The South Celestial Pole
C. The Ecliptic
D. The Celestial Equator

Exploring the Sky

Lecture 4: The Apparent Motion of the Sun and Planets

The Celestial Equator

In addition to the NCP and SCP, another important reference marker in the sky is the **Celestial Equator** (CE). This is a **great circle** on the Celestial Sphere (CS) whose circumference is 90° from the NCP and SCP. (A great circle is 'great' because its centre is the centre of the CS; any other circle on the CS is called a **small circle**). The CE is the projection of the Earth's equator onto the CS (fig. 1). Its position in the sky depends on the observer's location: for an observer at the North or South poles the CE passes through the local horizon. For an observer situated at the Equator, on the other hand, the CE passes through the E/W points on the horizon and through the **zenith** (the point directly overhead). The three stars of Orion's belt lie very close to the CE.

9. In Chicago (latitude 42° N, longitude 88° W)

A. the Sun crosses the Local Meridian about 6 hours after it does so in Greenwich
B. the Sun crosses the Local Meridian about 3 hours after it does so in Greenwich
C. the Sun crosses the Local Meridian about 6 hours before it does so in Greenwich
D. the Sun crosses the Local Meridian about 3 hours before it does so in Greenwich

Exploring the Sky

Lecture 5: Celestial Coordinate Systems

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We can work out the effect on the night (and day!) sky of the difference in longitude between Glasgow and Greenwich Meridian. Moving Westwards of the Greenwich Meridian on the surface of the Earth makes the stars appear to move *Eastwards*. Since the CS appears to rotate from East to West, this means that stars would appear to cross the Meridian in Greenwich *before* they cross the Meridian in Glasgow – where a observer would have to wait for the CS to 'rotate' to catch up with the view seen from Greenwich. We can work out the 'time lag' in Glasgow from its longitude.

Test example: Chicago, longitude 88 W ~ 90 W = (90/15) h = 6 hrs

10. The Sun crosses the Celestial Equator moving Northwards on

A. the Summer Solstice
B. the Winter Solstice
C. the Vernal Equinox
D. the Autumnal Equinox

Exploring the Sky

Lecture 4: The Apparent Motion of the Sun and Planets

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The point when the Sun crosses the CE, moving from the S. Hemisphere to the N. Hemisphere, is known as the **Vernal** (Spring) **Equinox**, around Mar 21^{st}. On this date day and night are of equal length ('Equinox' = 'Equal night'). Six months later (around Sep 21^{st}) the Sun crosses the CE heading south, at the **Autumnal Equinox**; again on this date day and night are of equal length.

11. Each day the Sun travels along the Ecliptic an angular distance of

A. about 1 degree
B. about 2 degrees
C. about 3 degrees
D. about 4 degrees

Exploring the Sky

Lecture 4: The Apparent Motion of the Sun and Planets

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The Sun's daily motion on the CS is quite significant. During the Earth's orbital period of 365.25 days, the Sun works its way around 360° of the Ecliptic. This corresponds to about 1°, or two solar diameters, per day.

12. On a particular date the Sun is at Right Ascension 16h. Which planet would be at opposition on this date?

A. Mercury, at Right Ascension 15h
B. Venus, at Right Ascension 18h
C. Mars, at Right Ascension 4h
D. Jupiter, at Right Ascension 6h

Exploring the Sky

Lecture 4: The Apparent Motion of the Sun and Planets

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Because Mercury and Venus have orbits inside that of the Earth, their angle from the Sun is never too large (this is why e.g. Venus is also known as the 'Morning' or 'Evening Star'). On the other hand Mars, Jupiter and Saturn (and Uranus, Neptune and Pluto) have orbits outside that of the Earth, and may be seen at any angle from the Sun – from 0° (behind the Sun) to 180° (opposite the Sun – when the planet is at **opposition**). The planets are especially bright during winter oppositions, since they are high in the South at midnight (when the Sun is low *below* the horizon in the North, and the sky is very dark). We return to the motion of the planets in Lectures 8 and 9.

13. The Earth's seasons are principally due to

A. the precession of the equinoxes
B. the eccentricity of its orbit
C. the obliquity of the Ecliptic
D. the variability of the Sun's luminosity

Exploring the Sky

Lecture 4: The Apparent Motion of the Sun and Planets

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Because the orbit of the Earth is not exactly circular, there are small (2%) changes in the Earth-Sun distance through the year – with the closest approach (known as *perihelion)* in January. This only has a very small effect, however; by far the main cause of the seasons is the tilt of the Earth's axis.

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The path followed by the Sun during the year is a great circle on the CS known as the **Ecliptic**. It is tilted with respect to the CE because the Earth's rotation axis (and hence its equator) is tilted with respect to the plane of its orbit around the Sun (see figs. 3 and 4). The Ecliptic is inclined to the CE at angle of about 23.5°; this angle is known as the **obliquity of the ecliptic**. The Ecliptic passes through a series of constellations that are referred to as the **Zodiac**, and comprise

14. The bright star Deneb has Right Ascension $20^h 41^m$. The star will be due south at midnight

A. in late January
B. in late April
C. in late July
D. in late October

Need to know when the SUN has RA 8h 41m.

Exploring the Sky

Lecture 6: Celestial Calendars and Clocks

The Sky at Night as a Calendar

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Date	RA of Sun	RA of 'midnight constellations'	Examples
Mar 21st	0 hrs	12 hrs	Leo, Ursa Major
Jun 21st	6 hrs	18 hrs	Hercules, Lyra
Sep 21st	12 hrs	0 hrs	Andromeda, Cassiopeia
Dec 21st	18 hrs	6 hrs	Auriga, Orion

The Sun moves Eastwards along the Ecliptic at about 2 hours (= 24 hrs / 12 months) per month, or about 0.5 hours per week. We can use this to work out the most favourable time to view particular

Jul 21st: RA(Sun) = 8 hrs; 1.5 weeks later RA(Sun) = 8h 45m

15. In the Gregorian Calendar, a year ending in '00' is a leap year only when

A. it is divisible by 100
B. it is divisible by 200
C. it is divisible by 300
D. it is divisible by 400

Exploring the Sky

Lecture 6: Celestial Calendars and Clocks

The Sky at Night as a Calendar

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accurately – given by 365.2422 days). In our modern system the turn of the century is only a leap year if divisible by 400 (e.g. 2000 was a leap year, but not 1900 or 2100). This calendar scheme is

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The Julian Calendar was used throughout Europe until 1582, but by this time the cumulative error caused by assuming an orbital period of 365.25 days had increased to 10 days. In 1582 Pope Gregory XIII decreed that October 4th should be followed by October 15th – thus correcting the error – and thereafter the 'divisible by 400' leap year rule should be adopted. This is known as the **Gregorian Calendar** and is the scheme which we still use today. Protestant areas of Europe did

16. The Moon is known to be much nearer to us than the Sun because of its

A. craters and mountains
B. phases
C. apparent size
D. parallax shift

Exploring the Sky

Lecture 7: The Moon

Our nearest celestial neighbour has had a significant influence on all cultures throughout recorded history. The Islamic Calendar is regulated by the appearance and behaviour of the Moon, Mayan and Aztec astronomers in pre-Columbian America based much of their mythology around the Moon and even in Scotland many megalithic stone circles – dating from up to 5000 years ago – were believed to be lunar observatories. The term *lunatic* had its origins in the belief (no longer held!) that the Full Moon could induce madness.

The nearness of the Moon to the Earth is indicated by its **parallax shift** – about two degrees (four Full Moon diameters) from one side of the Earth to the other. We can now measure the Moon's distance very precisely, by bouncing laser light off 'corner-cube' reflectors left on its surface by the Apollo astronauts and timing how long it takes for the laser beam to return. Since we know the speed of light, we can determine the distance using the relation **distance** = **speed** × **time**. The average distance of the Moon is about 384,400 km, or about 30 times the diameter of the Earth. 'Laser ranging' of the Moon has allowed its orbit to be determined very precisely

17. The synodic period of the Moon is the time

A. for the Moon to complete one orbit of the Sun
B. from one New Moon to the next
C. from one lunar eclipse to the next
D. for the Moon to return to the same point on the sky

Exploring the Sky

Lecture 7: The Moon

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The Orbit of the Moon

Our calendar months are not all of the same length, so we must be more precise when we say that the orbital period of the Moon is one month. The **Synodic Period** of the Moon is the time from one New Moon to the next, and is approximately **29.53 days**. During this time, however, the Earth will have moved some way in its orbit around the Sun, so the next New Moon will not line up with the same background stars. The **Sidereal Period** of the Moon is the time taken for the Moon to

18. In a solar eclipse, the inner part of the Moon's shadow is known as

A. the Umbra
B. the Penumbra
C. the Saros
D. the Annulus

Exploring the Sky

Lecture 7: The Moon

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Figure 4 (not to scale!) shows the shadow cast by the Moon . The central part of the shadow is known as the **umbra**; any part of the Earth that lies in the umbra at the time of the eclipse will experience a **total eclipse** – i.e. the New Moon will completely cover the Sun's disk. The outer

19. Neap Tides are the lowest tides because

A. they occur when the tidal pull of the Sun and the Moon act together
B. they occur when the tidal pull of the Sun and the Moon act against each other
C. they occur when the Earth is closest to the Sun
D. they occur in springtime

Exploring the Sky

Lecture 7: The Moon

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Although the Moon's gravity is the stronger effect, the Earth's tides are also due in part to the gravitational pull of the Sun. This means that the height of the tides varies depending on the position of the Sun and Moon. At Full Moon or New Moon, the Earth, Sun and Moon are aligned. The tidal pull of the Sun and Moon then act together and the tides are at their highest – these are known as **Spring tides**. At First Quarter or Third Quarter, on the other hand, the Earth, Sun and Moon are at right angles. The tidal pull of the Sun and Moon then act against each other and the tides are at their lowest – these are known as **Neap tides**.

20. Lunar eclipses are seen from Glasgow more often than solar eclipses because

A. The Moon's shadow on the Earth is much larger than the Earth's shadow on the Moon
B. The Earth's shadow on the Moon is much larger than the Moon's shadow on the Earth
C. The Earth's shadow on the Sun is much larger than the Moon's shadow on the Sun
D. The Sun's shadow on the Earth is much larger than the Sun's shadow on the Moon

Exploring the Sky

Lecture 7: The Moon

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Because the Earth's shadow is much larger than the Moon's shadow, a Lunar eclipse will typically be visible over a much larger portion of the Earth's surface. Hence Lunar eclipses are visible from, e.g., the UK much more frequently than Solar eclipses.