Suggested answers (1)

Centre No.						Paper Reference							Surname	Initial(s)
Candidate No.						1	6	2	7	/	0	1	Signature	

Paper Reference(s)

1627/01

Edexcel GCSE

Astronomy

Paper 01

Tuesday 13 June 2006 – Morning

Time: 2 hours

In particular, please note the detailed and extensive answer in connexion with number (17) (c), about comets.

Materials required for examination	Items included with question papers
Nil	Nil

I have extended some of these answers well beyond the syllabus requirements. It is my hope that these amplifications prove interesting. You should regard the JF² material as essential background reading — I know that you like to be stretched.

Instructions to Candidates

In the boxes above, write your centre number, candidate number, your surname and initial(s) and your signature.
Answer ALL questions in the spaces provided in this book.
Show all stages in any calculations and state the units. Calculators may be used.
Include diagrams in your answers where these are helpful.

Information for Candidates

The marks for the various parts of questions are shown in round brackets: e.g. (2).
This paper has 20 questions. There are two blank pages.

DF
2011, Jan. 28

Advice to Candidates

Amended 2017, November 11

This symbol shows where the quality of your written answer will also be assessed.

Additional answer sheets may also be used.

1
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Total

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edexcel

(2)

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1. (a) Four planets are listed below:

Mars   Neptune   Saturn   Venus

Which of these planets

(i) is the largest,

Saturn ✓

(ii) has the highest surface temperature,

Venus ✓

(iii) is furthest from the Sun?

Neptune ✓

(3)

(b) State two reasons why the Earth is the most suitable planet on which life can exist in our solar system.

(i) Correct temperature range
(ii) Oxygen-rich atmosphere
(iii) Liquid water ✓✓

} Related to the distance of the Earth from the Sun.

(2)

(Total 5 marks)

Q1

N 2 2 6 1 9 B 0 2 2 8

(3)

Leave blank

2. The photograph shows the garden of the William Herschel Museum in Bath. The planet Uranus was discovered from this garden in 1781.

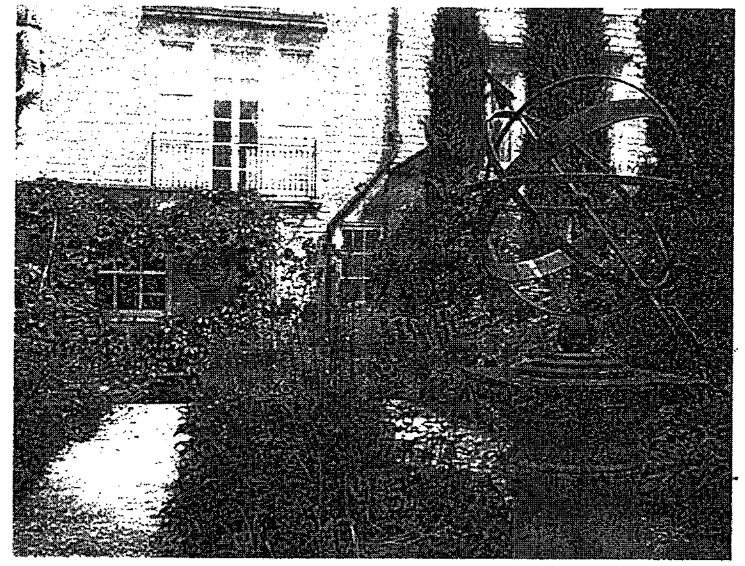


Image courtesy of Ann Picot

(a) Outline the discovery of the planet Uranus.

(Home-made) observations with his own telescope.
✓ Discovery of a star-like object that moved
✓ slightly against the stellar background.
Details of the orbit determined, leading to the conclusion that another planet had been discovered

(2)

(b) When seeing conditions are favourable, Uranus is **just** visible with the naked eye in the night sky. Circle the apparent magnitude of Uranus when it is just visible.

1   3   (6)   10 ✓

(1)

(c) When Uranus is at opposition, it is 18 AU from the Earth. How far from the Earth is Uranus when it is at conjunction? Circle the correct answer.

9 AU   16 AU   (20 AU)   36 AU ✓

(1)

(d) One of Uranus' large moons is called Miranda. Briefly describe its surface.

(i) High cliffs ✓
(ii) Deep ridges ✓
(iii) Suggestions of "splitting and reforming"

(2)

Q2

(Total 6 marks)

N 2 2 6 1 9 B 0 3 2 8

Turn over

Leave blank

3. Five distances are listed below:

3500 km   13 000 km   380 000 km   1 400 000 km   150 000 000 km

Which of these is

(i) the diameter of the Earth,

13,000 km ✓

(ii) the diameter of the Moon,

3500 km ✓

(iii) the diameter of the Sun,

1, 400, 000 km ✓

(iv) the distance between the Earth and the Moon?

380, 000 km. ✓

Q3

Leave blank

4. (a) State two properties of sunspots.

1 4000K (2000 degrees cooler than the photosphere – the blackness is only relative)

2. Regions of localised magnetic fields. ✓

3. The sunspots occur in pairs. ✓

4. Umbral and penumbral regions ✓ ✓

Any two

(2)

(b) At the start of the 11-year solar cycle, most sunspots have a latitude of about 40°. During one solar cycle

(i) state how the position of sunspots changes, ✓

Move closer to the solar equator / to lower latitudes

(ii) state how the number of sunspots change.

Increases, then decreases. ✓

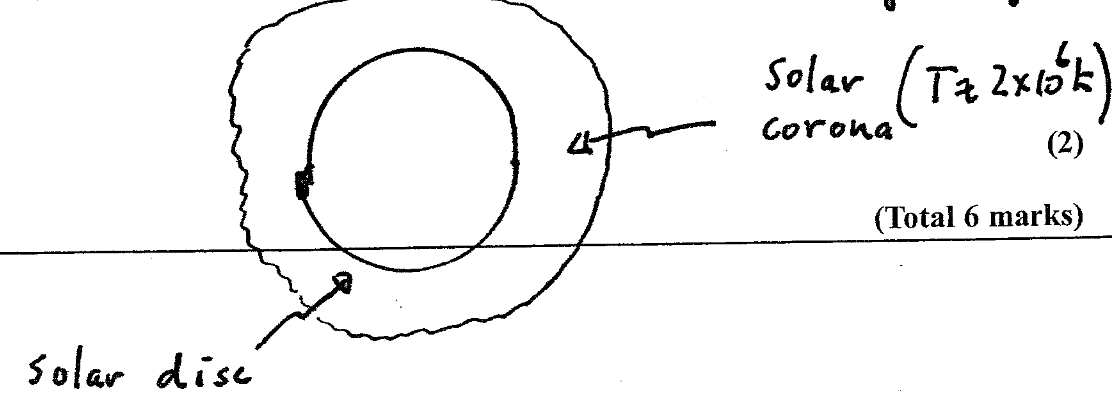
(2)

(c) The Sun's magnetic activity reaches a maximum about half-way through the solar cycle. Draw a labelled diagram to show the shape of the Sun's corona at this time.

The extent, shape and density of the solar corona are affected by the magnetic activity of the sun.

At the solar maximum, one principal feature of the corona is its symmetry.

For radio waves, $\lambda = 1$ m, the refractive index of the outer corona can become very large.



(2)

Q4

(Total 6 marks)

5. Four important dates in the year are listed below.

March 21st   June 21st   September 21st   December 21st

On which date does

(i) the Summer Solstice occur,

June 21

(ii) the Sun have a declination of $-23\frac{1}{2}$ degrees,

December 21

(iii) the Sun cross the Celestial Equator moving from south to north,

March 21

(iv) the longest night occur in the northern hemisphere?

December 21

Q5

(Total 4 marks)

Leave blank

6. The photograph shows a rille on the surface of the Moon.

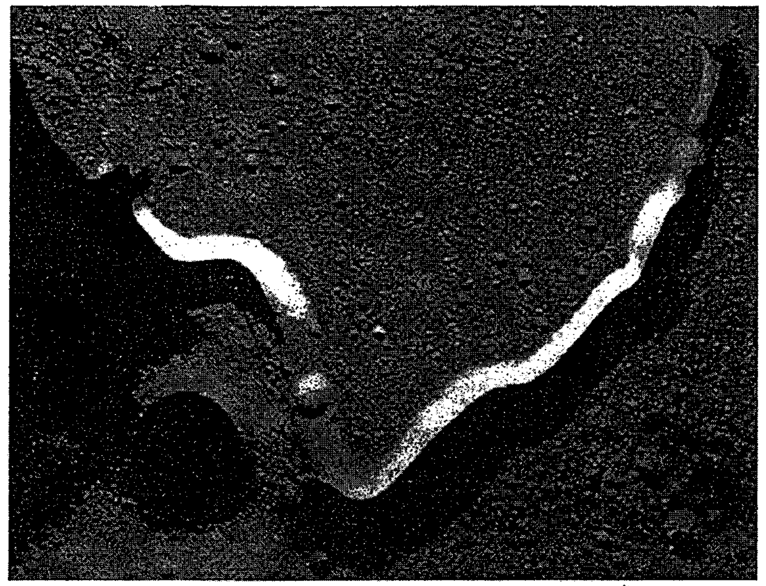


Image courtesy of NASA

(a) (i) What are rilles?

Grooves / channels in the lunar surface

(ii) How are rilles likely to have formed?

Either collapsed lava tubes, or faults in the crust

(2)

(b) State one other feature of the lunar surface and briefly describe its likely origin.

The relatively bright "highland" regions, peppered with impact craters.

(2)

Q6

(Total 4 marks)

(8)

Leave blank

7. (a) At 11:56 GMT, a student at Greenwich observes that the Sun is due south.

Calculate the value for the equation of time. Use the equation

mean solar time = apparent solar time – equation of time

E.O.T. = + 4 minutes ✓

✓

(2)

(b) On the same day, a second student is located at a longitude of 1.5° W. At what time (GMT) would this student observe that the Sun was due south?

6 minute difference ✓

12:02 ✓

(2)

(c) The Earth is divided into a number of time zones. Explain briefly the need for these.

✓ As a result of the rotation of the Earth, different parts of its surface are illuminated at different times. ✓

(2)

Q7

(Total 6 marks)

✓ (9)

Leave blank

8. Explain briefly why

(i) the sky is blue,

Scattering of light by the dust particles $\propto \frac{1}{\lambda^4}$

$\lambda_{blue} \approx 0.5\,\lambda_{red}$ ∴ $\text{Scattering}_{blue} = \frac{1}{(0.5)^4}\,\text{Scattering}_{red}$

$= 16$ ✓

(ii) the Moon appears a reddish/copper colour during a total lunar eclipse,

The refraction of sunlight by the atmosphere of the Earth ✓ ✓

* the photosphere

(iii) the surface of the Sun, a G type star, appears yellow.

$T_{photosphere} \approx$ 5700k means that the "colour" of the radiation emitted (over the full spectrum range) is yellow-dominant ✓ ✓

(Total 7 marks)

Note:

I am not entirely happy with my answer to number eight. However, jejune it might appear, it is the best that I can do at this level.

We shall need to discuss this in class.

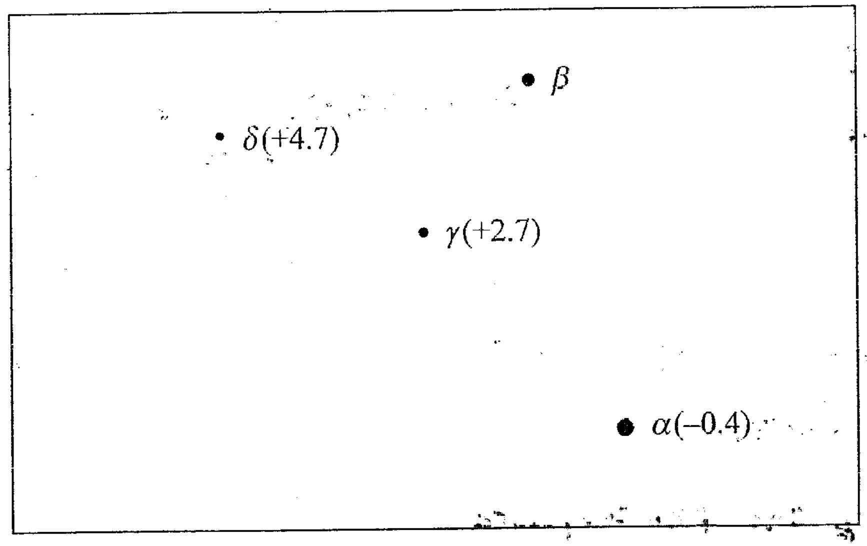
DF

2007, September 6

(10)

Leave blank

9. The sketch shows four stars in a constellation. The apparent magnitudes of three of the stars are given in brackets.



(a) (i) How many times brighter than star δ is star γ?

6·25 ✓

(ii) Star β is 2.5 times fainter than star α. What is the magnitude of β?

0·6 ✓

(2)

(b) The distance to star δ is 10 000 pc. Calculate the absolute magnitude of δ.
Use the relationship $M = m + 5 - 5 \lg d$.

Correct substitution gives

M = −10·3 ✓✓

(2)

Q9

(Total 4 marks)

Leave blank

(11)

10. Our galaxy is believed to contain millions of black holes.

(a) What are black holes?

Dense, "dead" stars with strong gravitational field strengths close to their surfaces.

(2)

(b) How do astronomers know that black holes exist?

X-rays emitted as matter is absorbed

Accretion discs ✓✓

Binary companions around "invisible" stars

The quality of the written answers should be considered. ✓

(3)

Q10

(Total 5 marks)

N 2 2 6 1 9 B 0 1 1 2 8

Turn over

Leave blank

11. The image shows a time-lapse photograph taken in the UK showing the Moon and Venus at 2-minute intervals.

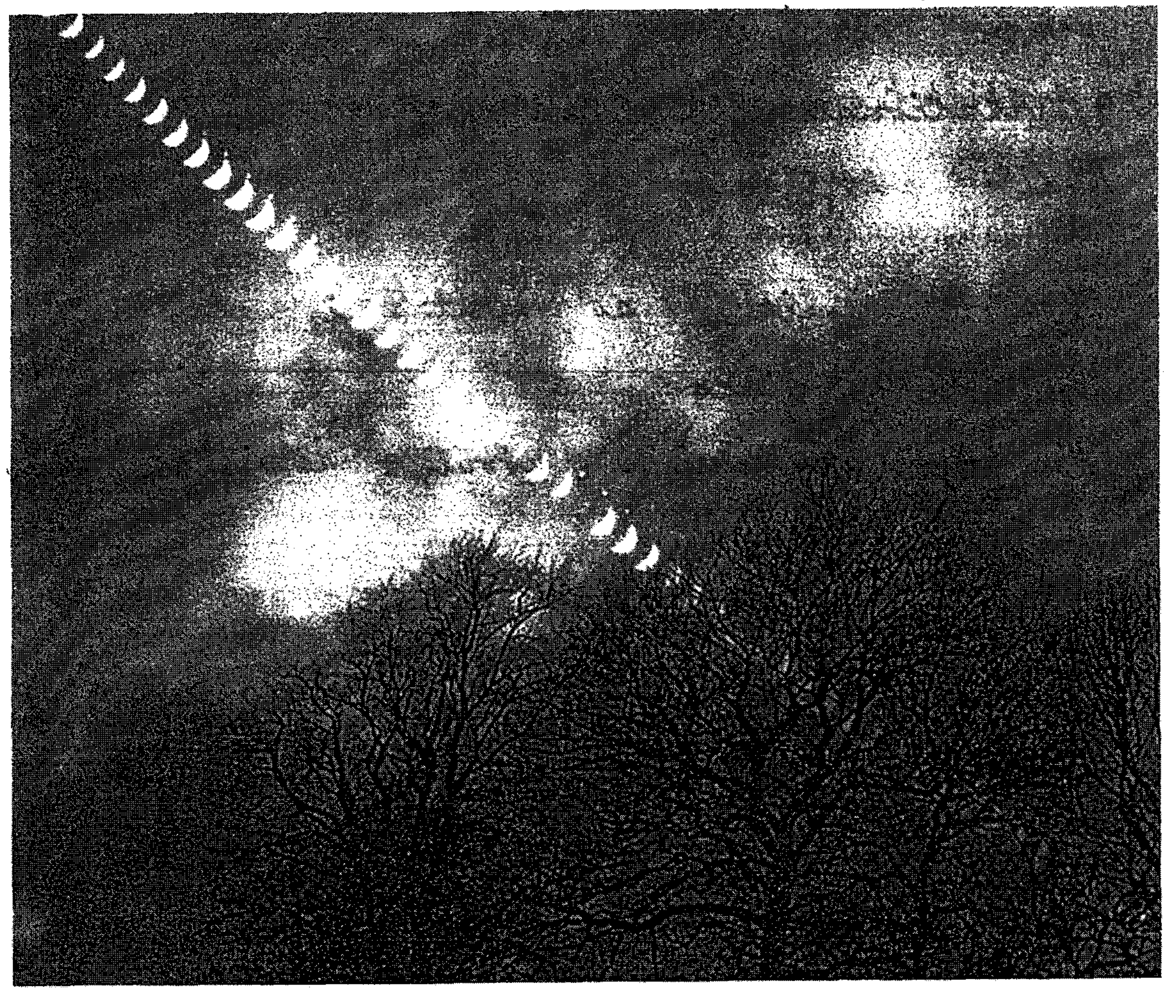


Image courtesy of Andrew Greenwood

(a) (i) What phase of the Moon is shown?

crescent ✓

(ii) Deduce the phase of Venus.

crescent ✓

(2)

(b) (i) State whether the Moon is rising or setting.

Setting ✓

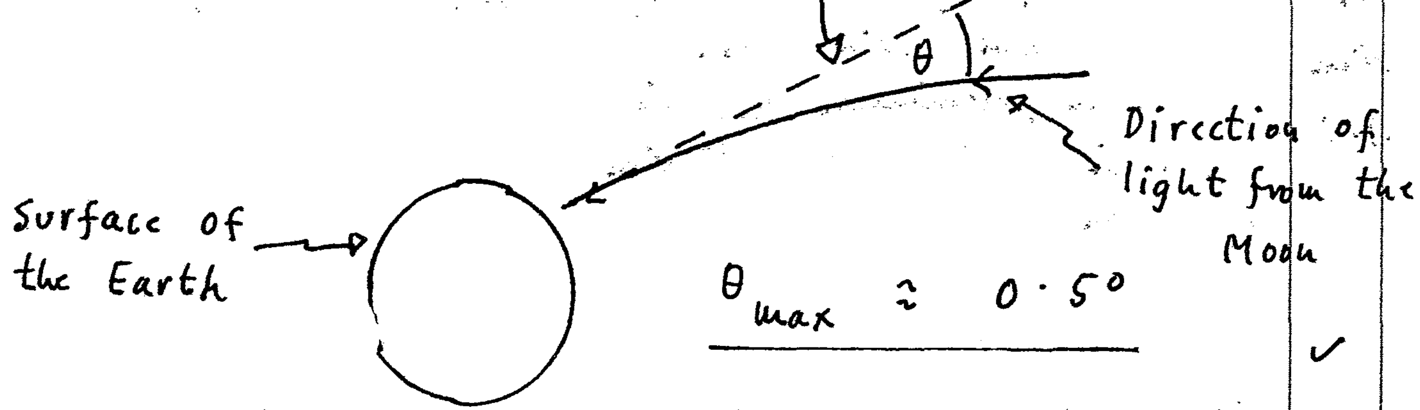
(ii) Give a reason for your answer.

The Sun is on the "right" of the Moon, in the Western sky ✓

(2)

Leave blank

(c) When the Moon is close to the horizon, its apparent position is higher than expected. With the aid of a labelled diagram, explain why this is so.



The terrestrial atmosphere increases in optical density (the refractive index increases) towards the surface of the Earth. This means that light is bent towards the normal as it travels through the atmosphere. ✓ ✓ ✓

(3)

Q11

(Total 7 marks)

Note: (JF²)

For refraction through the atmosphere of the Earth,

$$\frac{n-1}{d} = \text{constant}$$

where d is the density of the atmosphere, and n is its refractive index

Also, like a lens, the terrestrial atmosphere disperses a beam of white light into a small spectrum.

N 2 2 6 1 9 B 0 1 3 2 8

Turn over

(14)

Leave blank

12. (a) State three key facts about the cosmic background radiation. (C. M. B.)

First detected in 1965

1 Consists of γ-radiation, X-rays, infra-red, micro and radio waves.

2 The prominence of microwave radiation.

3 This background radiation does not come from any identified source.

(3)

(b) The discovery of the cosmic background radiation in 1965 presented new evidence for the 'Big Bang' theory of the origin of the Universe. Describe the other main observational evidence to support this theory.

The spectral flux density peaks at a wavelength of around 1 mm. To one significant figure the temperature of the C.M.B. is 3 K.*. Similar distributions would be seen from anywhere in the Universe at the present time.

(3) Q12

(Total 6 marks)

* $T = 2.725 \pm 0.002$ K

JF²

The C.M.B. that is observed at the present time, is radiation that was last scattered at a redshift of about 1100 ($t \sim 3$ to 4×10^5 years)

Thus, light from distant galaxies is particularly important in C.M.B. studies

(15)

Leave blank

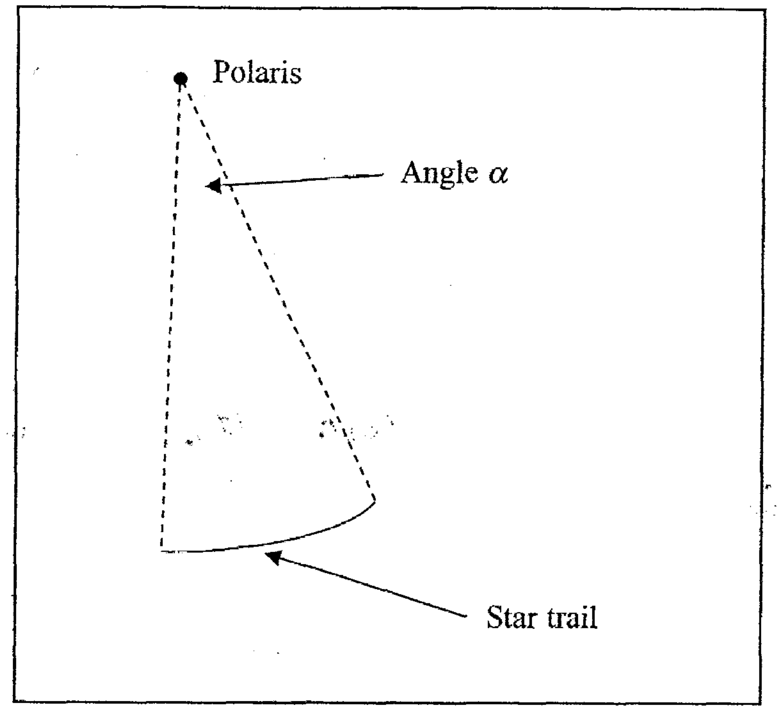
13. (a) Long-exposure photographs of star trails allow the value of the Earth's sidereal day to be determined.

By how many minutes does a sidereal day differ from a solar day?

Four minutes

(1)

(b) The sketch shows the star Polaris and the trail made by a star during a 2.0 hour exposure. **The sketch is not to scale.**



(i) Calculate the value of angle α to the nearest degree.

The Earth rotates 360° in 24 hours.

∴ would rotate 30° in 2 hours ($\frac{1}{12}$ of 360°)

(ii) The observations were made from a latitude of 55 °N. At its lowest point in the sky, the star is 18° above the northern horizon. What is the declination of the star?

At a latitude of 55° N, Polaris is 55° above the observer's horizon.

∴ the star is (55° − 18°) = 37° from Polaris

∴ the Declination of the star is (90° − 37°) = 53°

(5) Q13

(Total 6 marks)

(16)

14. The image shows the Lovell Radio Telescope at the Jodrell Bank Observatory in Cheshire. The diameter of the dish is 76 metres.

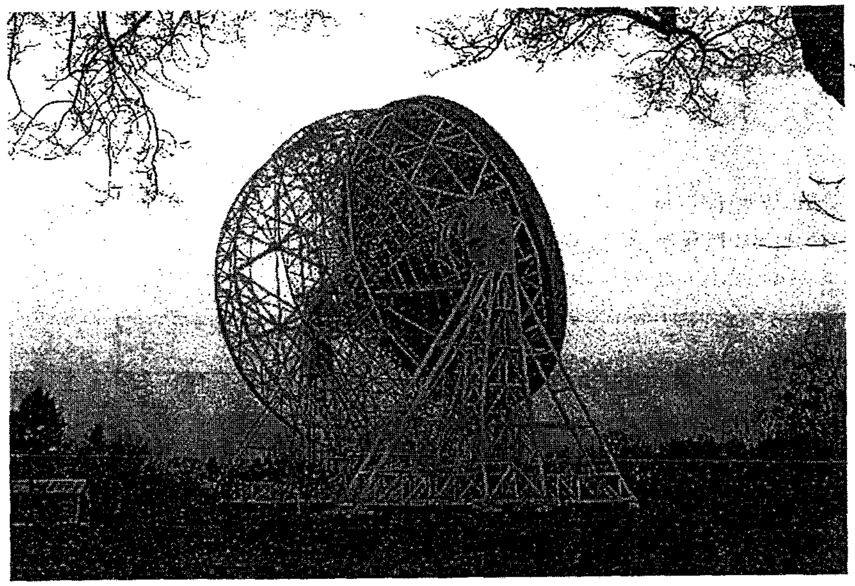


Image courtesy of Chris Cartwright

(a) Describe the function of this giant dish.

To collect and then reflect the radiation to the receiver

(2)

(b) Explain why radio telescopes are generally much larger than optical telescopes.

Because the wavelengths of radio-waves are much greater than the wavelength of "visible" radiation, the aperture of the radio telescope has to be large, in order to resolve detail.

(2)

(c) A second radio telescope has a dish of diameter 38 metres. How many times more powerful is the Lovell Telescope compared with this second telescope?

The Lovell telescope has four times the radiation-gathering power ($A \propto d^2$) but only twice the resolving power

θ (angle of resolution) $\propto \frac{\lambda}{\text{diameter}}$

(1)

(17)

(d) Describe two major discoveries made by radio astronomers.

1 Large-scale structure of the Milky Way Galaxy (That is, its shape, particularly that of the spiral arms.

2 Details of the angular momenta of black holes

3. Emissions of the sun in radio frequencies

(2)

Q14

(Total 7 marks)

JF²

The distribution of radio brightness across the sun at various wavelengths.

4. The sharp increase in cosmic rays observed at the time of a solar flare.

5. The "radio sky" at different wavelengths.

6. Recorded profiles of 21-cm line radiation from Hydrogen in the Galactic plane.

7. The rotation of the Galaxy.

8. Positions of supernovae.

9. The origin of meteor showers.

10. The measured velocities of meteors.

11. The radio temperatures of the Moon through one lunar month.

12. Large-scale distribution of galaxies.

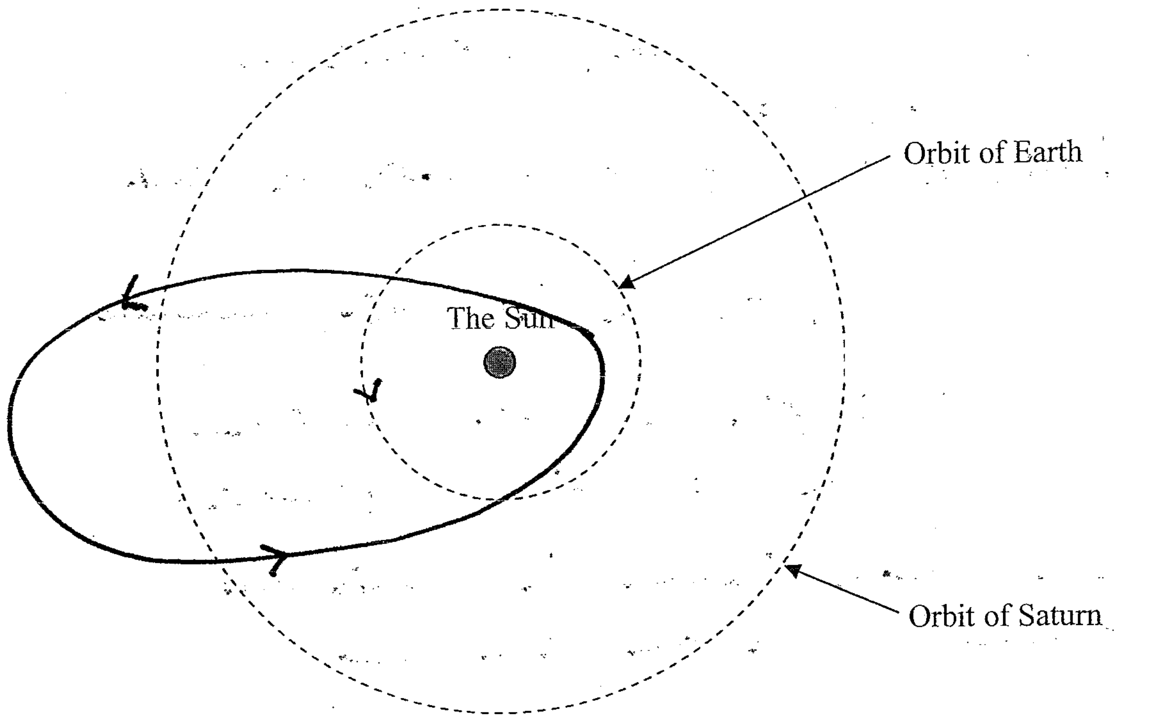
13. The reflexion of radar pulses by the Moon.

14. Radio waves from Jupiter.

etc.

Leave blank

15. The sketch shows the Sun, the orbit of the Earth and the orbit of Saturn.



(a) On the sketch, draw the orbit of a typical short-period comet. **(2)**

(b) State three ways in which the orbit of a comet may differ from the orbit of a typical planet.

1 Extremely elliptical, more so than any planet.

2 Can be seriously perturbed by the major planets.

3 Large inclinations to the Ecliptic are possible. **(3)**

4. Retrograde or prograde orbits.

(c) A short-period comet is 2.5 AU from the Sun when at perihelion. When it is at aphelion, the comet is 12.5 AU from the Sun.

How many times greater is the pull of the Sun's gravity on the comet when it is at perihelion compared with when it is at aphelion?

At perihelion, it is five times closer than when at aphelion. **(2)**

∴ the gravitational field is 5^2 times greater.

That is, 25 times greater.

Leave blank

(d) Many comets are believed to originate from the Oort Cloud. Describe the nature of the Oort Cloud.

A huge cloud of comets surrounding the Solar System, stretching up to tens of thousands of A.U. First postulated by Jan Oort; likely to contain over 10^{11} comets, thrown from the inner Solar System by the influence from the giant planets. **(2)**

Q15

(Total 9 marks)

Supplements to the answers to no. 15 (JF²)

Short-period comets tend to have orbits which are confined to the planetary system, with periods less than two hundred years and orbits mostly prograde. These orbits can have quite large eccentricities (a value of $e = 0.6$ might be typical).

Most of the short-period comets are thought to come from not the Oort Cloud, but from the Kuiper Belt. The few comets that are retrograde are likely to have been long-period comets that were gravitationally captured into short-period comets by a close approach to Jupiter.

The ices in comets are mainly water (H_2O). However, other ices are present, such as frozen ammonia (NH_3), carbon dioxide (CO_2) and carbon monoxide (CO). These ices are mixed with dust particles, forming what has been referred to as "dirty snow."

16. The photograph shows the globular cluster M13.

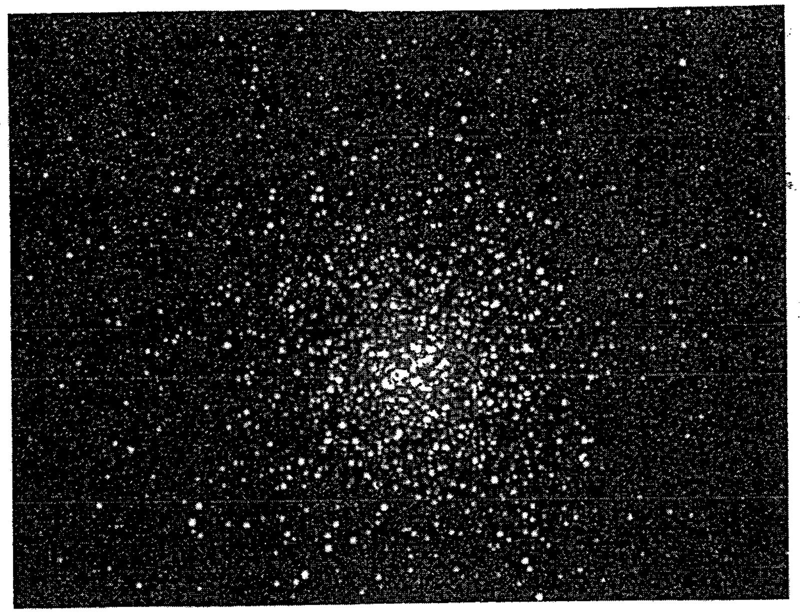
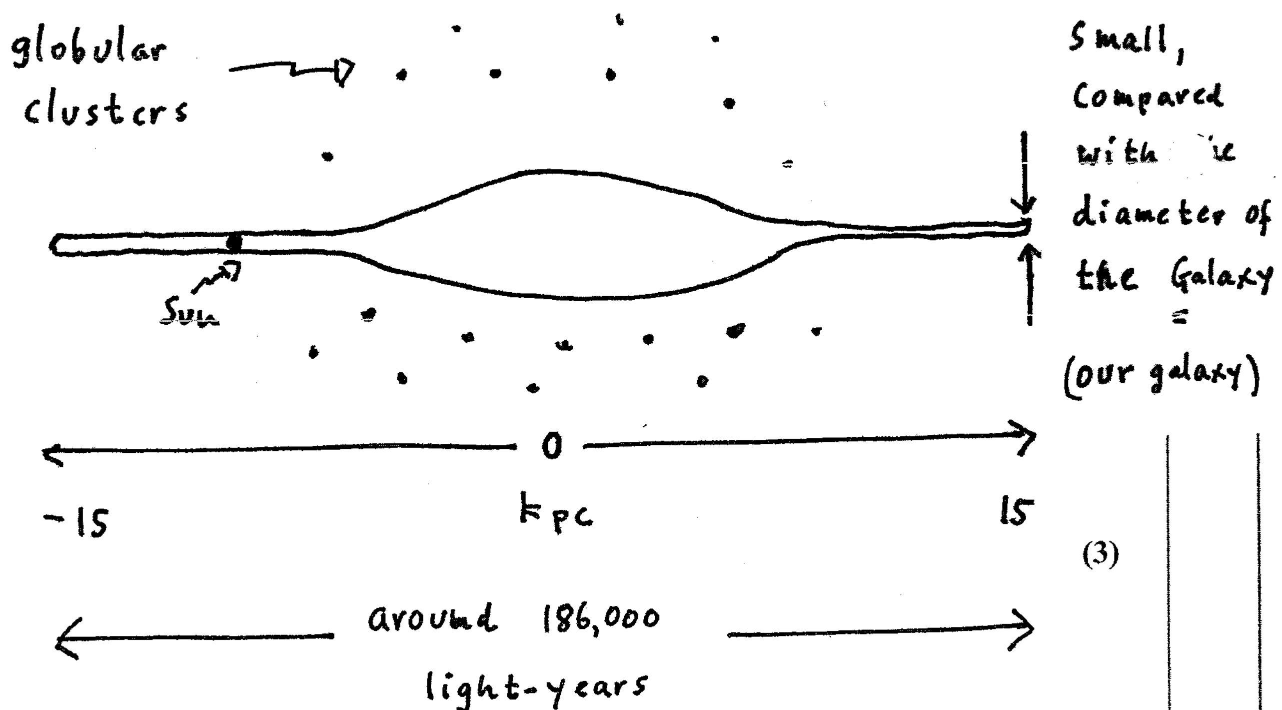


Image courtesy of NASA

(a) With the aid of a labelled diagram, show where globular clusters are located in our galaxy.

They are distributed approximately spherically about the centre of the Galaxy, in contrast to the highly flattened shape of the disc.



(3)

(b) Describe the physical nature of globular clusters.

Compact, dense clusters of very old stars, containing, typically, 10^4 to 10^6 members, each one less than 50pc in diameter. About two-thirds of the clusters belong to the stellar halo and about one-third to the disc.

(2)

(c) Open clusters, such as the Pleiades, are often observed in a band across the sky which we call the Milky Way. Explain why open clusters are seen here.

Most stars of the Milky Way reside in the Galactic disc. Usually stars do not form alone, but instead evolve in clusters or associations. This is a consequence of stars forming from dense molecular clouds.

(2)

Q16

(Total 7 marks)

Open clusters occupy regions of space, typically 2 → 3 pc across, where the density of stars is enhanced locally by a group of a few tens to a few hundred stars that formed at the same time.

The cluster members are bound together by their mutual gravitational attraction. There are thousands of open clusters in the Galactic disc. Some are sufficiently prominent to be visible to the naked eye, most notably the Pleiades. A typical age (young stars) ~ 80 Myr (80×10^6 yr), with star formation in the spiral arms.

(22)

Leave blank

17. (a) The *Magellan* space probe was launched in 1989. The instruments on board used a radar technique to map the surface of a planet.

(i) Which planet was mapped by Magellan?

Venus

(ii) Why was it not possible to map the surface of this planet using normal photography?

The dense atmosphere of Venus is opaque to light.

(2)

(b) Outline the radar technique used by astronomers to determine distances.

The Radio pulse is transmitted and received. Combined with the speed of the pulse and the time interval between transmission and reception yields the distance.

(3)

(c) The *Giotto* space probe was launched in 1986.

(i) Which astronomical object did *Giotto* study?

*Edmond Halley's Comet

(ii) What new discoveries about the object were made by *Giotto*?

(a) The comet, an active one, loses about 10^{11} kg of its mass during each perihelion passage.

(b) That it appeared to be outgassing from only 10% of its surface

(c) Further information about the ion tail (gaseous ions from the comet emitting light).

(c) Research on the dust tail: light reflected and scattered from small dust particles that were ejected from the comet and are →

Q17

(23)

Leave blank

now orbiting the sun. Incidentally, the ion tail develops while the comet is travelling away from the sun, under the influence of the solar wind.

The loss in mass of a typical comet leads to a reduction of about one metre of material from the surface. After a few thousand perihelion passages, the comet will have decayed considerably. Indeed, comets can decay much more rapidly than this, as they are occasionally seen to split and fragment.

This means that, once a comet enters the inner solar system, its lifetime is relatively short compared with the age of the solar system — a few thousand, or tens of thousand, years.

Comets eject gases (due to sublimation* of the ices) and small, rocky dust particles that give rise to meteoroid streams. They are leftovers from the planetary accretion processes. Thus, they have very old, relatively unprocessed, material within them.

* solid state → gaseous state. (no liquid) [Think of Iodine crystals]

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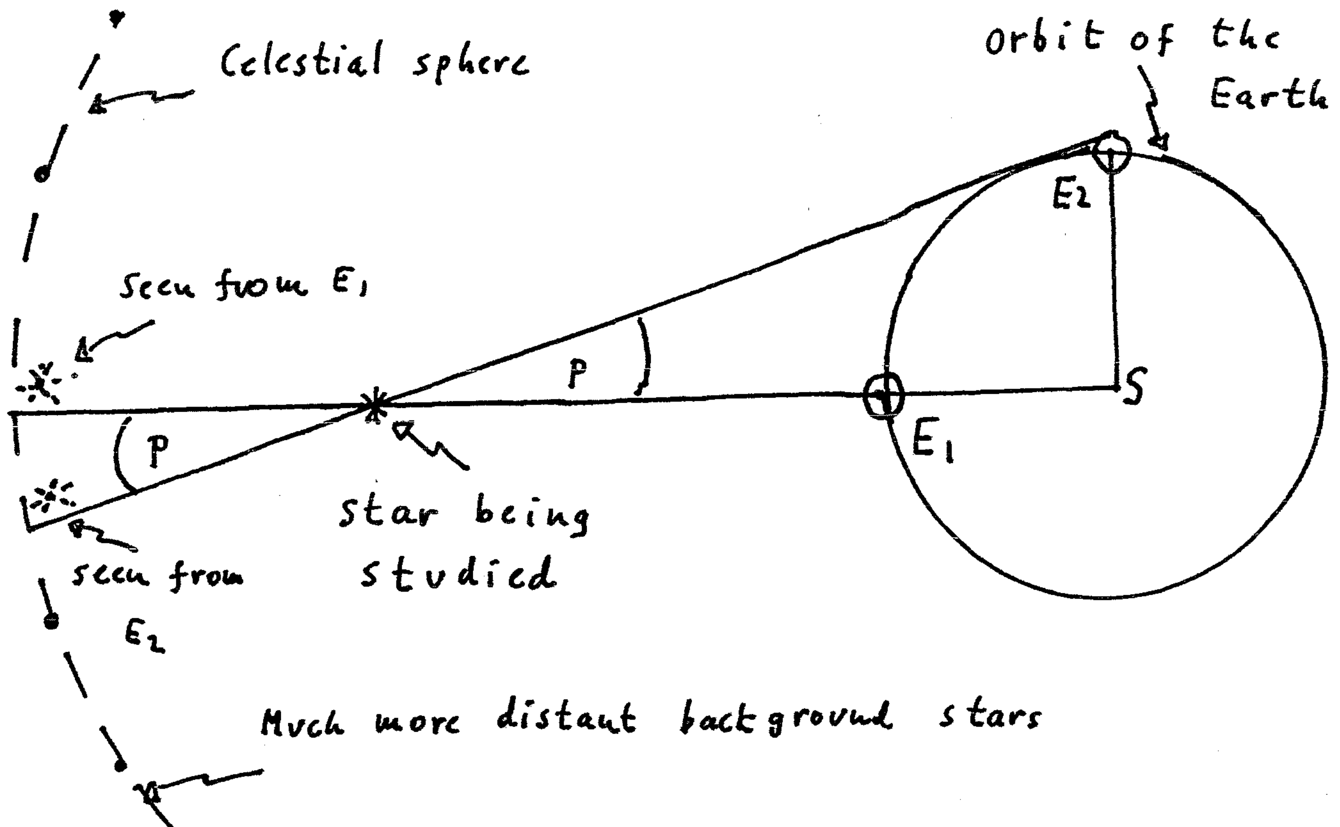
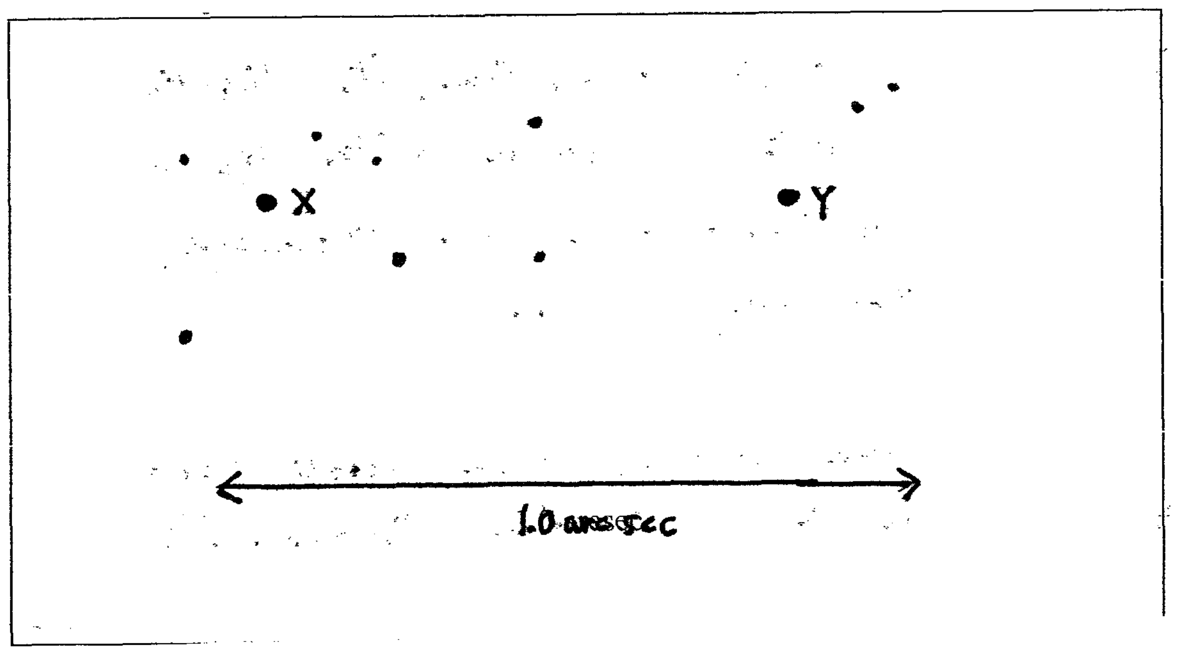
18. (a) With the aid of a labelled diagram, describe how the technique of heliocentric parallax can be used to determine the distance to a nearby star.



(b) The diagram shows the positions X and Y of a nearby star on two dates, exactly six months apart. An angular distance of 1.0 arcsec and some distant fixed stars are also shown.



The angle p subtended by the radius of the orbit of the Earth at the star is the heliocentric parallax. It is determined by measuring the parallactic shift of the against the celestial sphere from two positions of the Earth in its orbit.

Leave blank

(i) Take measurements from the diagram and calculate the parallax angle of the nearby star.

From the diagram, XY = 69 mm and 1 arcsec ≡ 92 mm

So, $XY = \frac{69}{92}$ arc sec (") ∴ The parallax angle

= 0.75 arc sec (") = 0.375 arc sec (")

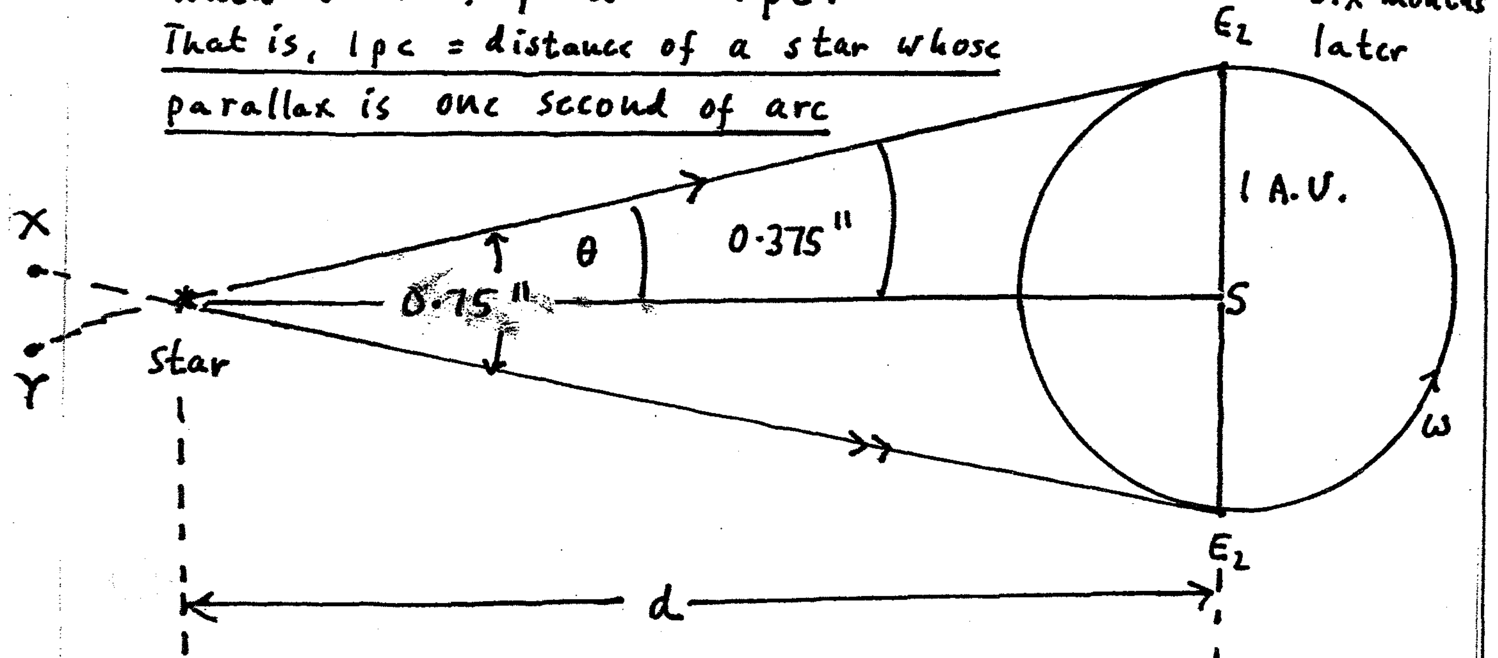
(ii) Calculate the distance to the star in parsecs.

See below

(5) Q18

(Total 9 marks)

When θ = 1", d = 1 pc.
That is, 1 pc = distance of a star whose parallax is one second of arc



From the trigonometry of the above, (remembering that d is being calculated in terms of Astronomical Units = 1.5×10^{11} m)

$\tan 0.375'' = \frac{1}{d}$

Rearranging,

$d = \frac{1}{\tan 0.375''}$

I hope that this diagram clarifies the one on the question paper.

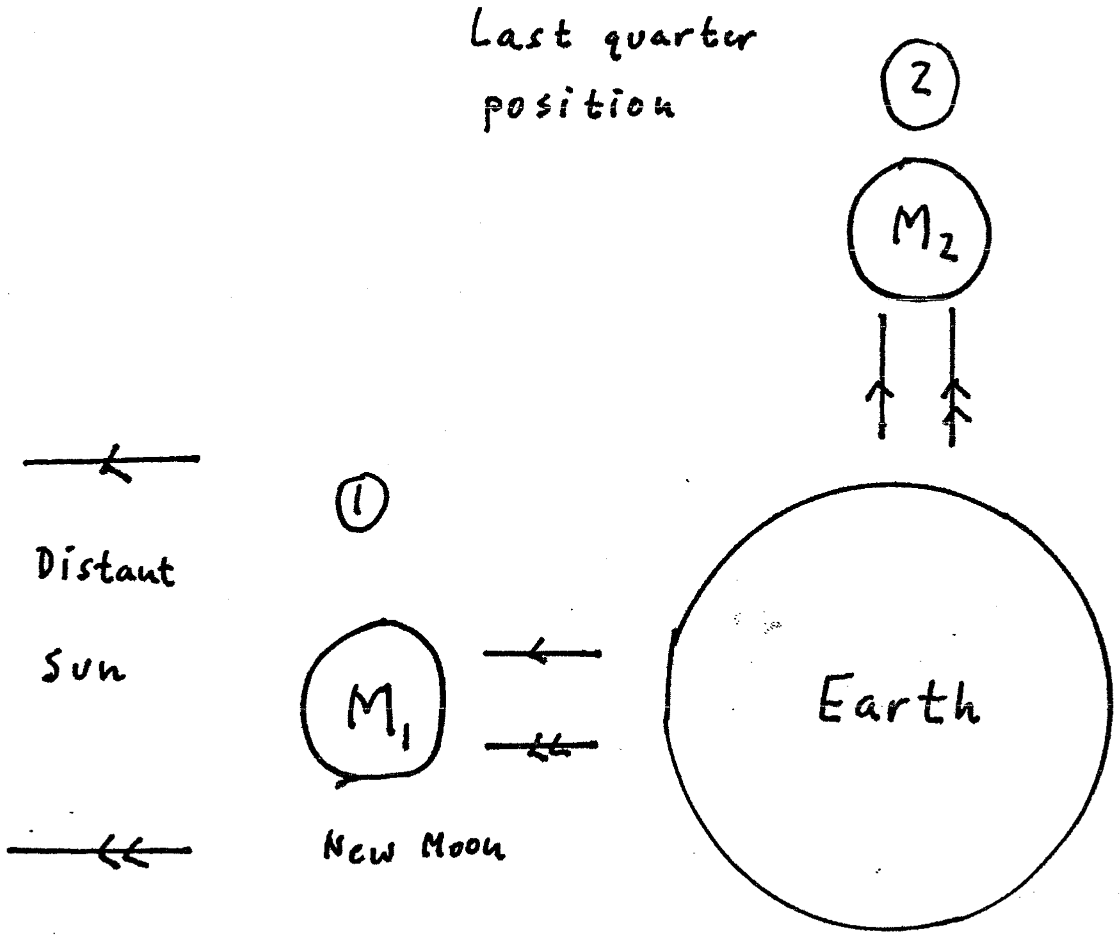
DF
2007, Sept. 8

Conversion factors:

(a) 1 pc 3.1×10^{16} m (= 2.06×10^{5} A.U.)

Leave blank

19. The water surface of the Earth is influenced by the Sun and Moon. With the aid of a labelled diagram explain how our tides differ when the phase of the Moon is new compared with when it is half-full.



In position ①, the gravitational pulls of the Sun and the Moon reinforce each other. (Maximum effect) Spring tide
In position ②, the pulls are at right-angles to each other. Smaller effect. Neap tide

Q19

Note: In essence, the tide-raising force is the difference between the attraction of the Moon upon the water on the surface of the Earth and its attraction upon the almost rigid Earth.

Leave blank

20. (a) State Kepler's second law of planetary motion.

The radius vector sweeps out equal areas of space during equal time intervals.
That is, $\frac{dA}{dt} = \text{constant}$

(2)

(b) The orbital period of an artificial satellite around the Earth is 3.5 h. Booster rockets are fired to increase its orbit radius four times. Calculate the new orbital period.

Use the equation $\left(\frac{T_1}{T_2}\right)^2 = \left(\frac{r_1}{r_2}\right)^3$.

Derived from K III: The square of the period of revolution of a secondary around a primary is proportional to the cube of the mean of the separation between the two. $[T^2 \propto r^3]$

That is, $\frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3} = \frac{T_3^2}{r_3^3}$ or $\frac{T^2}{r^3} = \text{constant}$

(3)

Q20

(Total 5 marks)

TOTAL FOR PAPER: 120 MARKS

END

Let the initial radius of the artificial satellite orbit be r. ∴ the new orbital radius will be 4r. Let the new period be T.
Using the above equation and substituting:

$$\frac{(3 \cdot 5\,h)^2}{r^3} = \frac{T^2}{(4r)^3}$$

Rearranging:

$$T^2 = \frac{(3 \cdot 5h)^2 \times 64r^3}{r^3}$$ [Divide throughout by r^3]

Simplifying:

$T^2 = 12 \cdot 2 h^2 \times 64$

$\therefore T = \sqrt{12 \cdot 2 h^2 \times 64}$

$= \sqrt{780 h^2}$

$= 28\,h$

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