A-Level Physics

Telescopes

Question Paper

Time available: 83 minutes
Marks available: 45 marks

1. (a) Draw a ray diagram to show how a converging lens can cause spherical aberration.

principal axis

(1)

(b) Draw a labelled ray diagram for an astronomical refracting telescope in normal adjustment.

Show **three** non-axial rays passing through both lenses. Label the principal foci of the lenses.

principal axis

(3)

(c) The James Lick telescope is an astronomical refracting telescope.

When in normal adjustment, the distance between the lenses of the telescope is $17.4\ \mathrm{m}$ and the angular magnification is 750

Calculate the focal length of the eyepiece lens.

focal length = _______________ m

(2)

(d) The James Lick telescope can be used to identify binary stars.

Two techniques are available using this telescope:

- using a processed image from a CCD, and
- direct observation using the naked eye.

Compare the use of a CCD with the use of the naked eye to observe binary stars with this telescope.

(3)

(Total 9 marks)

2. (a) Explain what is meant by the Rayleigh criterion.

(2)

(b) A telescope uses wavelengths in the range 90 nm to 120 nm.

Explain why this telescope must be located in space.

Go on to discuss **one** advantage that this telescope has compared to a telescope with the same aperture that uses visible light.

(3)

(c) The table below shows information about two telescopes.

Telescope	Diameter / m	Dish shape
Arecibo	305	spherical
Lovell	76	parabolic

Each telescope detects radio waves with a wavelength of 21 cm.

Compare the performances of the telescopes in the table above when both are used to observe the same faint radio objects.

(3)
(Total 8 marks)

3. (a) Draw a ray diagram for a Cassegrain telescope.
Your diagram should show the paths of **two** rays up to the eyepiece lens.
The rays should initially be parallel to the principal axis.

____ principal axis

(2)

(b) A spacecraft passes Pluto at a distance of 12 500 km. The telescope on board has an aperture of diameter 0.21 m and operates at a wavelength of 450 nm.

Discuss whether this telescope is suitable for studying a crater with a diameter of approximately 1 km on Pluto.

____

____

____

____

____

____

(3)

(c) The Hubble telescope has an aperture of diameter 2.4 m.

Compare the collecting power of the Hubble telescope with the telescope on the spacecraft in part (b).

(2)

(d) An astrophysicist had to decide whether to use a reflecting telescope or a refracting telescope on the spacecraft in part (b).

Discuss which type of telescope to use.

(3)

(Total 10 marks)

4. The Griffith Observatory in Los Angeles includes an astronomical refracting telescope (Griffith telescope) with an objective lens of diameter 305 mm and focal length 5.03 m

(a) Calculate the wavelength of light for which the Griffith telescope has a minimum angular resolution of 1.8×10^{-6} rad

wavelength = ____________________ m

(2)

(b) The Griffith telescope is used to observe two point objects which subtend an angle of 1.8×10^{-6} rad at the unaided eye.

The typical human eye has a minimum angular resolution of approximately 3.2×10^{-4} rad

Calculate the focal length of the eyepiece lens so that an observer can just resolve the two objects when observing them through the Griffith telescope.

focal length = ____________________ m

(3)

(c) The asteroid Apophis has a diameter of 325 m

It has been calculated that, in 2029, its distance of closest approach to the Earth's surface will be 3.0×10^4 km

The Griffith telescope may be used to view Apophis using the eyepiece calculated in question (b)

Deduce whether this telescope is suitable to obtain a detailed view of Apophis. Support your answer with a calculation.

(3)

(Total 8 marks)

5. The concave mirrors used in some reflecting telescopes can suffer from spherical aberration.

(a) Draw a diagram to show what is meant by spherical aberration when produced by a concave mirror.

(2)

(b) The International Ultraviolet Explorer (IUE) and the Gran Telescopio Canarias (GTC) are two examples of reflecting telescopes.

The table below summarises some of the properties of the two telescopes.

Name	**IUE**	**GTC**
Objective Diameter	0.45 m	10.4 m
Location	Geosynchronous Earth orbit	Earth's surface, 2300 m above sea level
Spectrum detected	Ultraviolet	Visible and Infrared
Typical wavelength detected	2.0×10^{-7} m	1.0×10^{-6} m

Compare the two telescopes in terms of their location, collecting power and minimum angular resolution.

Include calculations to support your comparisons.

(6)

(c) The Charge Coupled Device (CCD) is an important part of the detection system of many modern telescopes due to its high quantum efficiency.

Explain what is meant by quantum efficiency and compare the quantum efficiency of a CCD with that of the eye.

____

____

____

(2)
(Total 10 marks)