

Q1.

A student uses a refracting telescope in normal adjustment to make observations of Jupiter.

The telescope has an angular magnification of 75

- (a) The eyepiece has a focal length of 22 mm.

Determine the distance between the eyepiece and the objective lens.

distance = _____ m
(2)

- (b) When viewed through the telescope, the image of Jupiter subtends an angle of 1.7×10^{-2} rad.

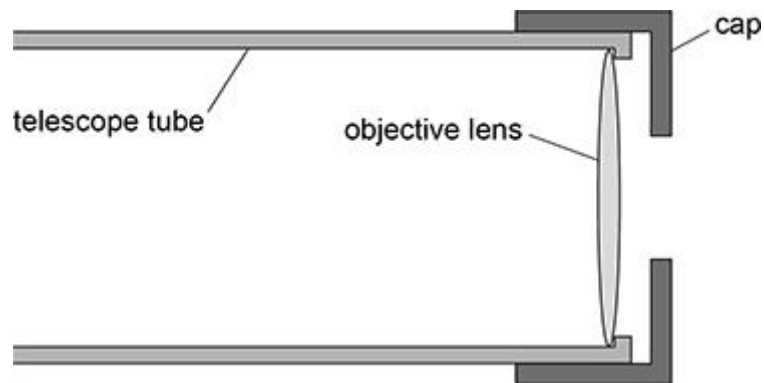
Calculate, in km, the distance between the Earth and Jupiter.

mean radius of Jupiter = 7.0×10^4 km

distance = _____ km
(2)

The student places a cap over one end of the telescope. The cap has a circular hole in its centre.

The figure below shows the end of the telescope, the objective lens and the cap.



- (c) State and explain the effect that the addition of the cap has on the chromatic aberration caused by the lens.

(3)

- (d) Explain **two** other effects that the addition of the cap has on the image of Jupiter.

1

2

(4)

(Total 11 marks)

Q2.

- (a) State what is meant by normal adjustment when applied to an astronomical refracting telescope.

(1)

- (b) Which combination of lenses gives the largest angular magnification when used as an astronomical telescope in normal adjustment?

Tick ✓ **one** box.

Objective lens		Eyepiece lens	
Focal length / cm	Type	Focal length / cm	Type
5	diverging	100	converging
5	converging	100	converging
100	diverging	5	converging
100	converging	5	converging

(1)

V1031 and WASP-82 are two stars in the constellation Orion.
 V1031 appears 40 times brighter than WASP-82 when viewed from Earth.
 The apparent magnitude of V1031 is 6.0

- (c) Calculate the apparent magnitude of WASP-82.

apparent magnitude = _____

(2)

- (d) V1031 is just visible to the naked eye of an astronomer when her pupil diameter is 7 mm.

Suggest whether she can observe WASP-82 using a telescope with an objective diameter of 60 mm.
Support your answer with a calculation.

(2)

- (e) CCDs are often connected to telescopes.

Explain **two** reasons why this improves the ability of astronomers to observe dim stars.

1

2

(3)

(Total 9 marks)

Q3.

- (a) State the defining property of a black hole.

(1)

- (b) In 2019, astronomers linked several radio telescopes to produce a single telescope called the EHT. The resolution of the EHT is the same as the resolution that a telescope with an aperture equal to the diameter of the Earth could achieve.

The table below shows data about the EHT and the Hubble telescope.

	Aperture	Operating wavelength
EHT	$1.3 \times 10^7 \text{ m}$	1.3 mm
Hubble	2.4 m	410 nm

Galaxy M87 is 5.3×10^7 light years from Earth. The supermassive black hole at the centre of M87 has a mass 6.5×10^9 times the mass of the Sun.

The radius of the event horizon is R .

The astronomers propose to use either the EHT or the Hubble telescope to observe stars whose distance from the centre of the black hole is less than $1000R$.

Discuss, with calculations, which telescope is more suitable for this observation.

(4)

- (c) A star is orbiting the black hole in M87. The star is observed in the plane of its orbit. The wavelength of a spectral line observed in the light emitted from the star varies between a maximum and a minimum value.

maximum value observed = 374.96 nm

minimum value observed = 373.53 nm

Calculate the orbital speed of the star.

orbital speed = _____ m s⁻¹

(3)

(Total 8 marks)

Q4.

- (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 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)