Q1.(a) Draw a ray diagram for an astronomical refracting telescope in normal adjustment. Your diagram should show the paths of **three** non-axial rays passing through both lenses. Label the principal foci of the two lenses.

(3)

(b) The Treptow Giant Telescope in Berlin is the longest moveable refracting telescope on Earth. Some of its properties are summarised below:

distance between the objective lens and eyepiece lens = 21 m

angular magnification = 210

objective lens diameter = 0.68 m

(i) Calculate the focal lengths of the eyepiece lens and objective lens of the Treptow Giant Telescope.

eyepiece lens focal length .... m

objective lens focal length .... m

(2)

(ii) Early telescopes had very small diameter objective lenses. State **two** advantages of using an astronomical telescope that has a large diameter objective lens when making observations.

Advantage 1...

....

....

Advantage 2...

....

....

(2)

(c) The images formed by refracting telescopes can suffer from chromatic aberration.

Draw a labelled diagram to show how a converging lens causes chromatic aberration.

(1)
(Total 8 marks)

Q2.(a) Draw a ray diagram to show how a converging lens can be used to form a diminished image of a real object. Label the object, image and principal foci of the lens on your diagram.

(3)

(b) A student experimented with a converging lens whose focal length was known to be approximately 50 cm. She placed an object and screen a fixed distance of 200 cm apart. With the lens 128 cm from the object, she observed a sharp image on the screen.

Calculate the focal length of the lens.

focal length .... cm

(2)

(c) The lens was used as one of the components of a simple refracting astronomical telescope. State whether the lens formed the eyepiece or objective, giving reasons for your answer.

....

....

....

....

....

....

....

(2)
(Total 7 marks)

Q3. (a) Draw a ray diagram for an astronomical refracting telescope in normal adjustment.
Your diagram should show the paths of **three** non-axial rays through both lenses.
Label the principal foci of the two lenses.

(3)

(b) An early form of this telescope was built by Johannes Hevelius. It was 3.7 m long and had an angular magnification of 50. Hevelius used it to help produce one of the earliest maps of the Moon's surface.

(i) Calculate the focal lengths of the objective lens and eyepiece lens in an astronomical telescope of length 3.7 m and angular magnification 50.

focal length of objective lens = ... m

focal length of eyepiece lens = ... m

(2)

(ii) The Triesnecker Crater on the Moon has a diameter of 23 km. Calculate the angle subtended by the image of this crater when viewed through a telescope of angular magnification 50 on the Earth.

distance from Earth to Moon = 3.8×10^5 km

angle = ... rad

(2)

(c) Early refracting telescopes suffered significantly from chromatic aberration. Draw a diagram to show how a single converging lens produces chromatic aberration.

(2)
(Total 9 marks)

Q4. The last refracting telescope that could be called 'the largest optical telescope in the world' was one with an objective lens of diameter 0.90 m. It was superseded in 1889 by a reflecting telescope with an objective mirror of diameter 1.52 m.

(a) Calculate

(i) the ratio $\frac{\text{resolving power of the reflector}}{\text{resolving power of the refractor}}$,

....

....

....

....

(ii) the ratio $\frac{\text{the amount of light energy that can be collected per second by the reflector}}{\text{the amount of light energy that can be collected per second by the refractor}}$.

....

....

....

....

(3)

(b) Spherical aberration can be a problem with reflecting telescopes.

(i) Draw a ray diagram to show how spherical aberration arises in a reflecting telescope.

(ii) State how this problem can be prevented.

....

(2)

(c) The image produced by a refracting telescope can be clearer than that of a similar diameter reflector because of the position of the secondary mirror.

(i) Sketch a diagram to show the position of the mirrors in a Cassegrain telescope.

(ii) Give **two** reasons why the secondary mirror in the Cassegrain telescope affects the clarity of the image.

....

....

....

....

(3)
(Total 8 marks)

Q5. (a) Draw a ray diagram for an astronomical refracting telescope in normal adjustment. Your diagram should show the paths of three non-axial rays through both lenses.
Label the principal foci of the two lenses.

(3)

(b) **Figure 1** shows an astronomical telescope made from two cardboard tubes of slightly different diameter, two convex lenses of focal lengths 0.10 m and 0.50 m respectively and some modelling clay.

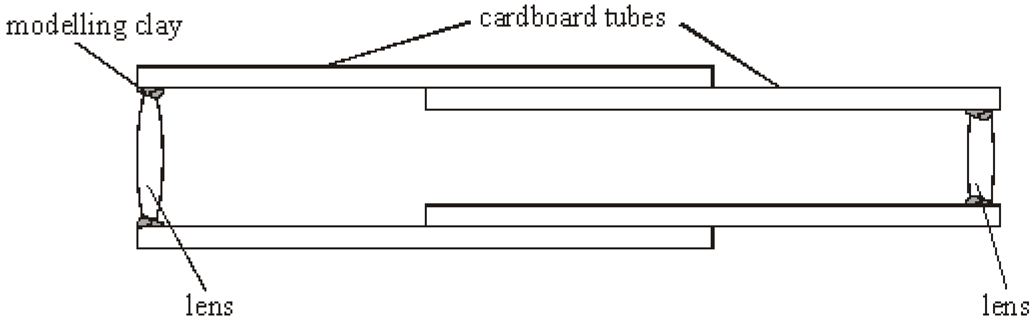

Figure 1

(i) Calculate the distance between the two lenses when the telescope is in normal adjustment.

....

(ii) The Moon is 380 000 km from the Earth and has a diameter of 3 500 km.

Calculate the angle subtended by the image of the full Moon when viewed through the telescope.

....

....

....

....

(iii) The telescope suffers from chromatic aberration. Describe how this affects the appearance of the image.

....

....

(4)
(Total 7 marks)

Q6. (a) Draw a ray diagram to show the path of two rays, parallel to the axis, through a Cassegrain telescope, as far as the eyepiece.

(2)

(b) The UKIRT is a Cassegrain telescope capable of detecting both infrared and visible radiation. It has an objective diameter of 3.8 m.

(i) Calculate the resolving power of this telescope for infrared light of wavelength 2.0 μm.

....

....

....

(ii) Explain why the resolving power of this telescope is better in the visible region than in the infrared region.

....

....

....

....

(4)

(c) To reduce atmospheric absorption problems, the telescope was built at the top of Mount Mauna Kea in Hawaii.

(i) What, in the atmosphere, is responsible for absorbing infrared radiation?

....

(ii) The spectrum of light from a star can be used to determine its temperature. Explain why this absorption can lead to errors in the value.

....

....

....

(3)
(Total 9 marks)