Name of the Student:_____
Max. Marks : 26 Marks **Time : 26 Minutes**

Q1.

(a) (i) State what is meant by the *Doppler effect*.

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(ii) Explain how observing the spectrum of a star and applying the Doppler equation to the experimental observations enables the speed of recession of the star to be obtained.

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(iii) Give an example from astronomy of a situation where the double Doppler effect would have to be applied, explaining why it is necessary to apply the double effect.

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(6)

(b) One of the brightest galaxies in the Virgo cluster of galaxies is named M87 and is approximately 4.9×10^7 light years away.

(i) Use the value of the Hubble constant given in the Data booklet to show that the speed of M87 relative to Earth is about 8×10^5 m s^{-1}.

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(ii) The wavelength of one particular line in the hydrogen spectrum measured in the laboratory is 6.5647×10^{-7} m. Use the result obtained in part (b)(i) to calculate the wavelength of the equivalent line observed in the spectrum of M87.

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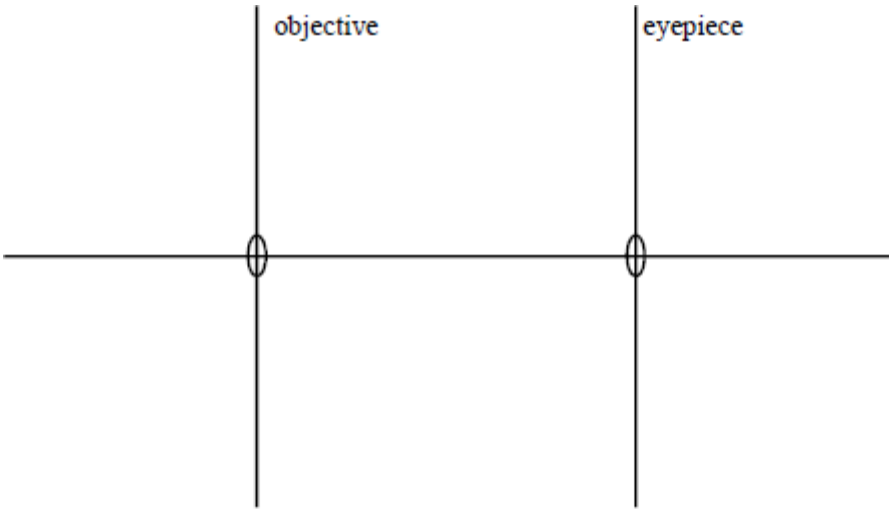
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(4)

(Total 10 marks)

Q2.

(a) An astronomical telescope consists of two thin converging lenses, as shown. The focal lengths of the objective lens and the eyepiece lens are f_o and f_e, respectively. The telescope is used to view the Moon and the separation of the lenses is such that the telescope is in normal adjustment.



(i) Draw rays to show how a magnified image is formed by the telescope. Your ray diagram should show the paths through the telescope of two parallel non-axial rays from a point on the Moon to the observer's eye. Indicate the position of the principal focus for each lens.

(ii) An observer's unaided eye has a resolving power of 120 seconds of arc. If the angular magnification of a telescope is 24, determine the angular separation of two points on the Moon, which the same observer can just resolve with the aid of the telescope.

The angular magnification of the instrument is given by

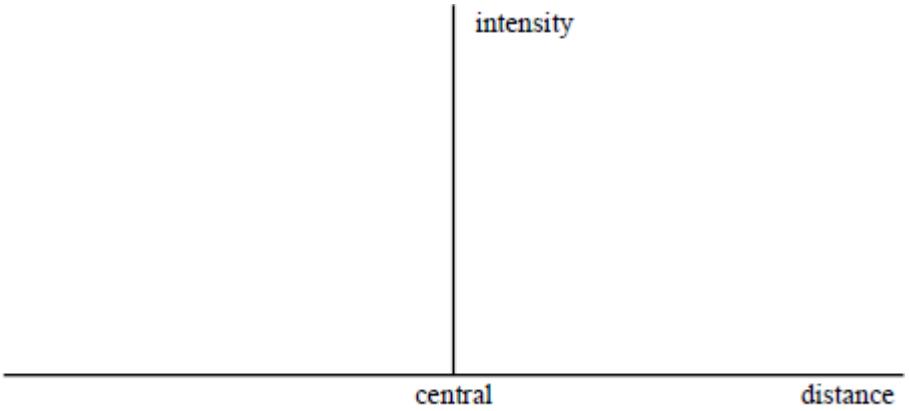
$$M = \frac{\text{angle subtended at the eye by the image}}{\text{angle subtended at the eye by the object}}$$

(7)

(b) A parallel beam of monochromatic light, incident on a converging lens and parallel to the axis, fills the lens aperture completely. After transmission through the lens the beam falls on a plane surface placed parallel to the plane of the aperture and approximately 1 m away from it. The plane surface is in the focal plane of the lens.

(i) Sketch a graph, using the axes, to show how the intensity of the light varies with the radial distance from the central axis of the lens, for small radial distances.

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(ii) With the aid of another diagram, describe *Rayleigh's criterion* for the resolution of two point sources viewed through the lens.

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(5)

(c) (i) The objective lens of the telescope described in part (a) has a diameter of 15 cm. The telescope is used to view the star Mizar, which is a double star with an angular separation of 7.0×10^{-5} rad. Calculate the approximate value of the resolving power of the telescope for light of wavelength 6.0×10^{-7} m. Hence determine whether the two stars could be resolved by the telescope.

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(ii) If a double star, similar to that described in part (c)(i), cannot be resolved by the telescope, discuss whether or not increasing the angular magnification of this telescope would allow resolution.

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(4)
(Total 16 marks)

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