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Section B

Answer **one** question from this Section in the spaces provided.

6 **(a)** Fig. 6.1 shows a six-string electric guitar. The sounds are amplified by electronic pickups (microphones), and an amplifier to convert the vibration of its strings into electrical signals and ultimately reproduced by loudspeakers as sound.

Fig. 6.1

(i) State the conditions required for the formation of stationary waves.

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(ii) A guitar string produces a note of fundamental frequency 622 Hz. The velocity of wave travelling along the guitar string is 405 m s^{-1}.

1. Determine the effective length of the string.

length = ……………………… m [2]

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2. The amplitude of the vibrating guitar string is 3.3 mm.

Determine the maximum velocity of the vibrating string when the whole string is momentarily at the equilibrium position.

maximum velocity = ……………………… m s^{-1} [2]

(iii) The output of the electric guitar is fed into a loudspeaker. The loudspeaker emits hemispherical sound waves of mean power 200 W. A small microphone is placed at a distance 10.0 m from the loudspeaker.

1. Determine the mean intensity I of the sound wave detected by the microphone.

I = ……………………… W m^{-2} [2]

2. Two identical loudspeakers are connected to an electric guitar playing a note of a single frequency. The loudspeakers are then placed a distance apart and facing each other.

State two reasons why a stationary wave may not be formed between the two loudspeakers.

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2. ……………………………………………………………………………………

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(b) Fig. 6.2 shows a human eye. To see an object, light from the object enters the eye through a small aperture known as the pupil and forms an image at the retina. The average diameter of the pupil is 3.00 mm and the distance between the pupil and the position of image at the retina is 17.0 mm.

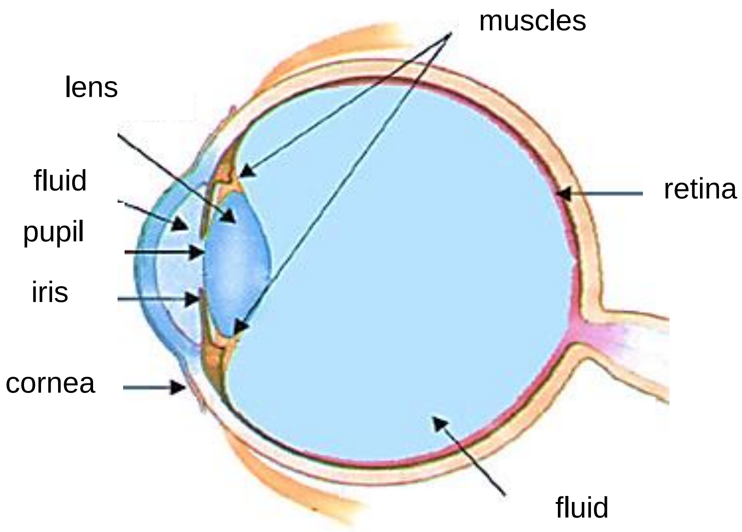

Fig. 6.2

(i) A beam of blue light passes through the pupil. The distance between the positions of zero intensity on both sides of the central bright fringe of the image is 4.80 μm on the retina.

Determine the wavelength of the blue light.

wavelength = ……………………… nm [3]

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(ii) The Dutch artist Vincent van Gogh painted the *Irises* in 1889.

Fig. 6.3(a) shows an image of the actual painting.

Fig. 6.3(b) shows a pixelated poster of the *Irises*. The pixels have varying colours, shades or light intensities.

The wavelength of blue light ranges from 380 nm to 500 nm.

Fig. 6.3(a)

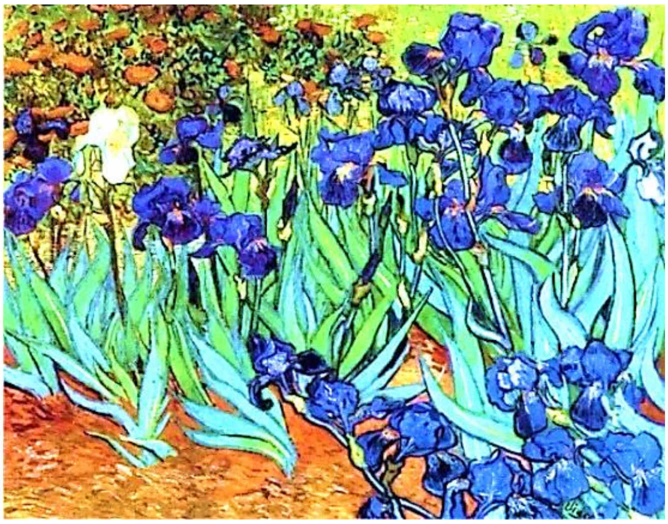
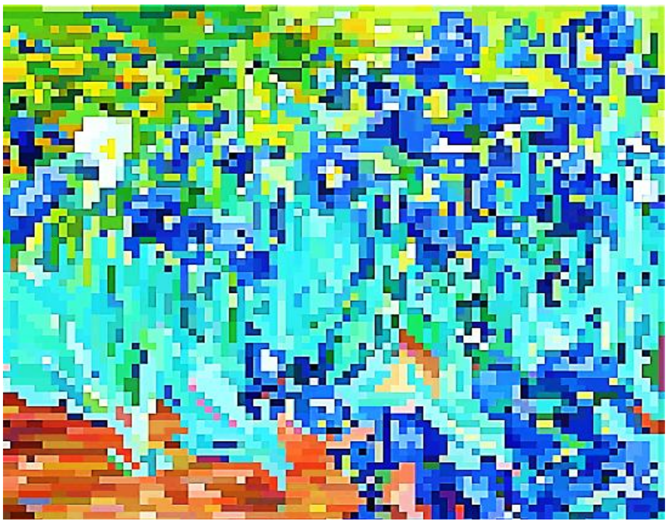


Fig. 6.3(b)



1. Explain the *Rayleigh criterion* for the optical resolution of two images.

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2. Determine the minimum angular resolution for the human eye to distinguish two adjacent pixels of blue light according to the *Rayleigh criterion*.

minimum angular resolution = ……………………… rad [1]

3. In the pixelated poster of *Iris*es, there are 710 pixels within 72 cm vertically, and 820 pixels within 93 cm horizontally. The pixels of the flowers and majority of the leaves are in blue.

In practice, the angular resolution of a human eye is about 2.91×10^{-4} rad.

Determine if an observer can distinguish two adjacent blue pixels of the same wavelength in all directions if the distance between his eye and the poster is 1.5 m.

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…………………………………………………………………………………… [3]

4. In dimmer lighting, the pupil diameter will increase to allow more light to enter the eye. For the observer in **(b)(ii)3.**, state and explain the change, if any, to the minimum distance between his eye and the poster to distinguish two adjacent blue pixels.

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[Total: 20]