Worksheet: Circular Aperture Diffraction and Resolution

Question Video

Q1: The headlights of a car are 1.3 m apart. What is the maximum distance at which an eye with a pupil diameter of 0.40 cm can resolve these two headlights? Assume that the wavelength of light from the headlights is 555 nm.

A 4.0 km

B 6.2 km

C 2.8 km

D 5.9 km

E 7.7 km

Q2: The primary mirror of the orbiting Hubble Space Telescope has an angular resolution of 2.80×10^{-7} rad. What is the smallest detail that it can observe at a distance of 384.4×10^{3} km?

A 160 m

B 610 m

C 107 m

D 16.7 m

E 70.1 m

Q3: The 8.1-m-diameter Gemini North telescope at Mauna Kea, Hawaii, observes two objects on the Moon. What is the minimum distance on the lunar surface that the objects must be separated by for them to be resolvable? Assume that only the diffraction effects of the telescope aperture limit the resolution and that 550 nm wavelength light is used to observe the objects. Use 4.0×10^6 m as the distance to the Moon.

A 12 m

B 17 m

C 20 m

D 25 m

E 33 m

Q4: Quasars, or quasi-stellar radio sources, are astronomical objects discovered in 1960. They are distant but strong emitters of radio waves at very small angular sizes. The quasar 3C405 is actually two discrete radio sources that subtend an angle of 82 arcsec. If this object is studied using radio emissions at a frequency of 410 MHz, what is the minimum diameter of a radio telescope that can resolve the two sources?

A 1.4 km

B 2.6 km

C 2.9 km

D 2.0 km

E 2.2 km

Q5: Light of wavelength 461.9 nm emerges from the 2.0-mm-diameter circular aperture of a krypton ion laser. Due to diffraction, the beam widens as it moves away from the laser.

- What is the diameter of the central bright spot produced by this beam 1.0 m away from the laser?

A 0.35 mm

B 0.41 mm

C 0.25 mm

D 0.17 mm

E 0.28 mm

- What is the diameter of the central bright spot produced by this beam 1.0 km away from the laser?

A 0.36 m

B 0.44 m

C 0.33 m

D 0.25 m

E 0.28 m

What is the diameter of the central bright spot produced by this beam 1,000 km away from the laser?

A 440 m

B 500 m

C 380 m

D 330 m

E 280 m

What is the diameter of the central bright spot produced by this beam 400 000 km away from the laser?

A 200 km

B 250 km

C 170 km

D 130 km

E 110 km

Q6: The limit to the eye's acuity is actually related to diffraction by the pupil. Assume that the pupil of an eye is 3.00 mm in diameter and that light has an average wavelength of 550 nm.

What is the angle between two points of light that are just-resolvable by the eye?

A 2.10×10^{-4} rad

B 2.24×10^{-4} rad

C 2.37×10^{-4} rad

D 2.17×10^{-4} rad

E 2.30×10^{-4} rad

Taking the angle between two points just-resolvable by the eye, what is the greatest possible distance a car can be from an eye if the eye can resolve the car's two headlights, given that the headlights are 1.30 m apart?

A 1.35 km

B 5.81 km

C 3.84 km

D 2.59 km

E 3.06 km

What is the distance between two just-resolvable points held at a distance of 0.800 m from an eye?

A 0.165 mm

B 0.179 mm

C 0.211 mm

D 0.189 mm

E 0.197 mm

Q7: The characters of a stadium scoreboard are formed with closely spaced lightbulbs that radiate primarily yellow light of wavelength 6.0×10^{-7} m. Determine how closely the bulbs must be spaced so that an observer 80.0 m away sees a display of continuous lines rather than the individual bulbs. Use a value of 5.0 mm for the pupil diameter of the observer's eye.

A 1.2 cm

B 2.1 cm

C 1.0 cm

D 1.5 cm

E 1.8 cm

Q8: A Helium-Neon laser beam has a wavelength of 633 nm.

What is the minimum angular spread of the beam?

A 8.71×10^{-4} rad

B 1.65×10^{-3} rad

C 1.22×10^{-3} rad

D 6.28×10^{-4} rad

E 7.72×10^{-4} rad

What is the diameter of an illuminated spot that this beam would create on a surface 15.0 km away from its source?

A 22.3 m

B 24.1 m

C 22.8 m

D 21.7 m

E 23.2 m

What is the diameter of an illuminated spot that this beam would create on a surface at a distance of 384.4×10^3 km from the source?

A 88.3 km

B 313 km

C 138 km

D 13.9 km

E 590 km

Q9: You are looking down at a highway from inside an airplane flying at an altitude of 6.0 km, and you can just distinguish between two individual cars that are very close together on the ground. How far apart must the two cars be? Assume that the light from the cars has a wavelength of 550 nm and that the diameter of your pupils is 4.0 mm.

A 1.0 m

B 1.2 m

C 1.6 m

D 1.4 m

E 0.83 m

Q10: A spy satellite orbits Earth at a height of 1.8×10^5 m. What is the minimum diameter of the objective lens in a telescope that must be used to resolve columns of troops marching 2.0 m apart? Assume that the light received by the satellite has a wavelength of 550 nm.

A 5.4 cm

B 5.0 cm

C 6.0 cm

D 4.4 cm

E 3.8 cm

Q11: A 295 m diameter radio telescope detects radio waves with a 5.00 cm average wavelength. The telescope just resolves two very distant objects.

- What is the angle between the two very distant objects?

A 2.07×10^{-4} rad

B 1.36×10^{-4} rad

C 3.85×10^{-4} rad

D 2.00×10^{-4} rad

E 1.54×10^{-4} rad

What is the minimum separation of these two very distant objects if they are 1.80*million* light years distant from the telescope? Consider the objects to be point sources.

A 372 ly

B 300 ly

C 473 ly

D 256 ly

E 268 ly

Q12: Find the minimum angular spreading of a 630 nm average wavelength flashlight beam that is originally 4.63 cm in diameter.

A 2.21×10^{-5} rad

B 0.689×10^{-5} rad

C 1.66×10^{-5} rad

D 2.35×10^{-5} rad

E 1.76×10^{-5} rad

Q13: Find the minimum diameter mirror on a telescope that would allow you to see details as small as 500 m on the Moon. Use a value of 384 000 km for the distance to the Moon. Assume an average wavelength of 550 nm for the light received.

A 51.5 cm

B 79.5 cm

C 48.6 cm

D 33.9 cm

E 50.6 cm

Q14: What is the minimum angular separation of two stars that are just resolvable by a 9.30 m diameter telescope, if atmospheric effects do not limit resolution? Use 570 nm for the wavelength of the light from the stars.

A 5.98×10^{-8} rad

B 7.55×10^{-8} rad

C 7.48×10^{-8} rad

D 6.85×10^{-8} rad

E 8.36×10^{-8} rad

Q15: When dots are placed on a page from a laser printer, they must be close enough so that you do not see the individual dots of ink. To do this, the separation of the dots must be less than Raleigh's criterion. Take the pupil diameter of the eye to be 2.5 mm and the distance from the paper to the eye to be 50 cm. Find the minimum separation of two dots such that they cannot be resolved. Take the wavelength of light to be 570 nm.

A 0.28 mm

B 0.10 mm

C 0.75 mm

D 0.14 mm

E 0.33 mm

Q16: Two lamps producing light of wavelength 590 nm are fixed 2.00 m apart on a wooden plank. What is the maximum distance an observer can be from the lamps and still resolve them as two separate sources of light if the resolution is affected solely by the diffraction of light entering the eye? Assume light enters the eye through a pupil of diameter 3.60 mm.

A 10.5 km

B 10.0 km

C 9.00 km

D 13.0 km

E 11.5 km

Q17: Findhow far apart two objects on the Moon must be to be distinguishable by eye ifonly the diffraction effects of the eye's pupil limit the resolution. Use avalue of 500 nm for the wavelength of light, a value of 4.6 mm for the pupil diameter, and a value of 400 000 km for the distance to the Moon.

A 53 km

B 38 km

C 63 km

D 50 km

E 49 km

Q18: Radiotelescopes are telescopes used for the detection of radio emission from space.Because radio waves have much longer wavelengths than visible light, thediameter of a radiotelescope must be very large to provide good resolution. A radio telescope hasa diameter of 32 m and can be operated at frequencies as high as 6.7 GHz.

Whatis the wavelength corresponding to the telescope's highest operating frequency?

A 0.045 m

B 0.036 m

C 0.049 m

D 0.052 m

E 0.064 m

Whatis the angular separation of two radio sources that can be resolved by thistelescope?

A 1.7×10^{-3} rad

B 1.4×10^{-3} rad

C 2.8×10^{-3} rad

D 5.3×10^{-3} rad

E 3.4×10^{-3} rad

Q19: A spy satellite can resolve objects 13.0 cm apart while operating 200 km above the surface of Earth.What is the diameter of the aperture of the telescope if theresolution is only limited by the diffraction effects? Use 540 nm for the wavelengthof light from the objects.

A 1.24 m

B 1.10 m

C 1.05 m

D 1.50 m

E 1.01 m

Q20: Suppose a certain person's visual acuity is such that he can clearly see objects that form an image 5.00 mm high on his retina. What is the maximum distance at which he can read the 86.0 cm high letters on the side of an airplane? Assume the lens to retina distance is 2.50 cm.

A 4.30 m

B 2.25 m

C 8.35 m

D 5.23 m

E 3.40 m