Practice Quiz 2 <Solution>

D

What's the minimum thickness of a soap film (n=1.33) in which 550nm light will undergo constructive interference?

A) 400nm B) 300nm C) 200nm D) 100nm

Sol.

$n=1$

$n=1.33$

$n=1$

Constructive interference

$\Rightarrow 2t = (m+\frac{1}{2})\lambda_n = (m+\frac{1}{2})\frac{\lambda_{air}}{n}$

$\therefore$ minimum thickness $(m=0) = \frac{1}{2}\times\frac{1}{2}\times\frac{550}{1.33} = 103nm$ //

A

A lense with a circular aperture of 1cm in diameter is just barely capable of seperating two objects that are 1 degree apart. What's the wavelength of the light from the two objects?

a) 0.1mm b) 1mm c) 10mm d) 100mm e)1m

Sol.

$\theta_{min} = 1.22\frac{\lambda}{D}$ $\quad 1^\circ = 0.0175$ rad

$\Rightarrow 0.0175 = 1.22\cdot\frac{\lambda}{0.01} \Rightarrow \lambda = 1.43\times10^{-4}(m) = 0.143$ mm //

A

What limits the angular resolution of earth based radio astronomy?

A) The maximum size radio telescope that can technically be built.
B) The radius of the earth.
C) The manufacturing precision of lenses in the radio frequency range, i.e. spherical aberation.
D) Dispersion, i.e. chromatic aberation.

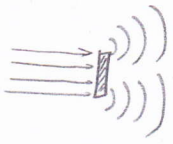
Sol. Resolution is determined by $\theta_{min} = 1.22\cdot\frac{\lambda}{D}$ $\therefore$ the diameter of the lens of the telescope is the main factor.

A

Imagine holding a circular disk in a beam of monochromatic light. If diffraction occurs at the edge of the disk, the center of the shadow is:

A) a bright spot
B) darker than the rest of the shadow
C) bright or dark, depends on the wavelength
D) bright or dark, depends on the distance to the screen

Sol.



A circular disk behaves like a double-slit!

$\therefore$ the center of the shadow should be a bright fringe. //

E

A double slit system is used to measure the wavelength of light. The system has slit spacing d=15 micron and slit-to-screen distance L=2.2m. If the m=1 maximum in the interference pattern occurs 7.1cm from the screen center, what is the wavelength of the light?

A) 375nm B) 400nm C) 425nm D) 450nm E) 475nm

Sol. $y_{1st,max} \approx L \cdot \frac{\lambda}{d} \Rightarrow 7.1\times10^{-2} = 2.2 \times \frac{\lambda}{15\times10^{-6}}$

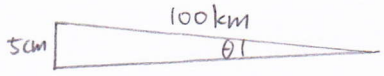
$\Rightarrow \lambda = 4.84\times10^{-7}\ m = 484\ nm$ //

E

The movie "Patriot Games" has a scene in which CIA agents use spy satellites to identify individuals in a terrorist camp. Suppose that a minimum resolution for distinguishing human features is about 5cm. If the spy satellite's optical system is diffraction limited, what diameter mirror or lens is needed to achieve this resolution from an altitude of 100km? Assume a wavelength of 550nm.

A) 1000m B) 0.1m C) 100m D) 10m E) 1m

Sol.



$\theta_{min} \approx \frac{5\,cm}{100\,km} = \frac{5\times10^{-2}}{100\times10^{3}} = 5\times10^{-7}\ rad$

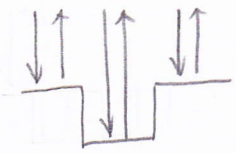
$\theta_{min} = 1.22\frac{\lambda}{D} \Rightarrow 5\times10^{-7} = 1.22 \cdot \frac{550\times10^{-9}}{D} \quad \therefore D = 1.34\ m$ //

C

DVD technology encdes the binary information as depressions in the information layer of the DVD. The zeros and ones are detected via interference of a laser beam with itself after it reflects from the information layer. The depth of the depressions is thus tuned to the wavelength of the laser used. For DVDs laser with wavelength of about 640nm are used. What do you think is the depth of the depressions?

a. 40nm
b. 80nm
c. 160nm
d. 320nm
e. 640nm

Sol.



Assume the depth of the depression is d

$\Rightarrow$ A depression makes the optical path length differ by 2d.

$\because \begin{cases} (\Delta r)_{constructive} = m\cdot\lambda \\ (\Delta r)_{destructive} = (m+\frac{1}{2})\lambda \end{cases} \Rightarrow (\Delta r)_{destructive} - (\Delta r)_{constructive} = \frac{1}{2}\lambda = 2d$

$\Rightarrow \therefore d = \frac{1}{4}\lambda = \frac{1}{4}\times640 = 160\ nm$ //

E

A double slit system is used to measure the wavelength of light. The system has slit spacing d=15 micron and slit-to-screen distance L=2.2m. If the m=1 maximum in the interference pattern occurs 7.1cm from the screen center, what is the wavelength of the light?

A) 375nm B) 400nm C) 425nm D) 450nm E) 475nm

Sol.

Question repeated.