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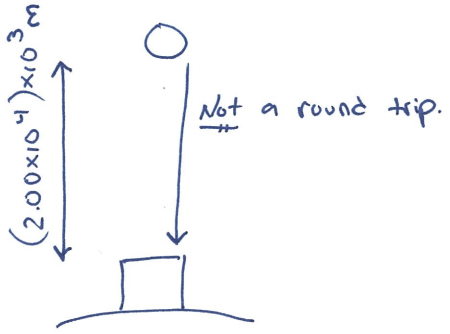
First Name:_____ Last Name:_____

L02 – Worksheet – Speed of Light

Textbook Questions

Pg 652 #5: A communication satellite is in orbit around Earth at an altitude of 2.00×10^4 km. If the satellite is directly above a ground-based station, how long does it take a signal to travel between the satellite and the station?



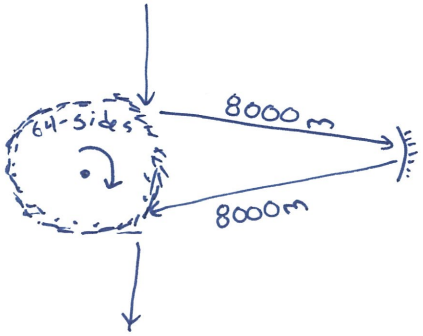
$v = \frac{d}{t}$

$t = \frac{d}{v} = \frac{(2.00\times10^4)\times10^3}{3.0\times10^8}$

$t = 6.\bar{6}\times10^{-2}$ s for a 1-way trip.

(Round trip would be twice as long).

Pg 652 #6: Using a similar approach to Michelson, a student sets up a 64-sided set of rotating mirrors, 8.00 km away from a fixed mirror. What minimum frequency of rotation would be required to successfully measure the speed of light?



Light travels 16,000 m in the time it takes the mirror to do 1/64th of a rotation.

$v = \frac{d}{t}$ or $t = \frac{d}{v} = \frac{16{,}000}{3\times10^8} = 5.\bar{3}\times10^{-5}$ s

So time for 1/64th of a rotation is $5.\bar{3}\times10^{-5}$ s.

Full period is 64x bigger, or $3.41\bar{3}\times10^{-3}$ s.

$f = \frac{1}{T} = \frac{1}{3.41\bar{3}\times10^{-3}} = 292.96875$ Hz

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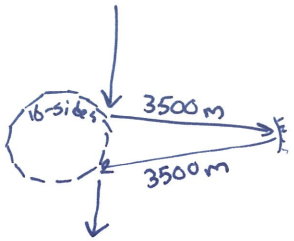
Pg 652 #7: A 16-sided set of rotating mirrors is used to measure the time it takes light to travel a certain distance. At what frequency does the mirror need to rotate such that it makes 1/16th of a rotation in the time it takes light to travel 3.5 km and back again?



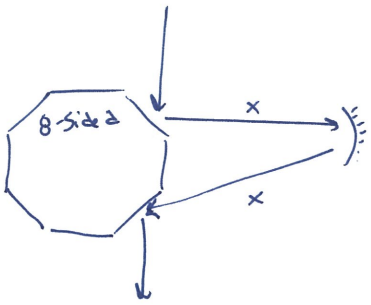
Light travels 7000 m in the time it takes the mirror to do 1/16th of a rotation.

$v = \frac{d}{t}$ or $t = \frac{d}{v} = \frac{7000}{3\times10^8} = 2.\overline{3}\times10^{-5}\,s$

So time for 1/16th of a rotation is $2.\overline{3}\times10^{-5}\,s$.
Period is 16x bigger, or $3.7\overline{3}\times10^{-4}\,s$.

$f = \frac{1}{T} = \frac{1}{3.7\overline{3}\times10^{-4}} = 2678.57\ Hz$

Pg 652 #8: An 8-sided set of rotating mirrors rotates at 545 Hz in an experiment similar to that of Michelson. How far away should the fixed mirror be placed in order to correctly measure the speed of light?



$T = \frac{1}{f} = \frac{1}{545} = 1.83486\ldots\times10^{-3}\,s$

1/8th of a period is $2.2936\times10^{-4}\,s$

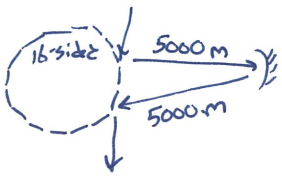
Light travels $2x$ in $2.2936\times10^{-4}\,s$.

$v = \frac{d}{t}$ or $d = vt$

$2x = (3.0\times10^8)(2.2936\times10^{-4}\,s)$

$x = 34{,}403.7\ m$

Pg 652 #9: The speed of light was measured to be 2.97 x 10^8 m/s using a 16-sided set of rotating mirrors and a fixed mirror separated by 5.00 x 10^3 m. At what frequency was the mirror rotating?



$v = \frac{d}{t}$ or $t = \frac{d}{v} = \frac{10{,}000\ m}{2.97\times10^8} = 3.367\times10^{-5}\,s$

This is the time for 1/16th of a rotation. So the period is 16x bigger, or $T = 5.3872\times10^{-4}\,s$

$f = \frac{1}{T} = \frac{1}{5.3872\times10^{-4}} = 1856.25\ Hz$

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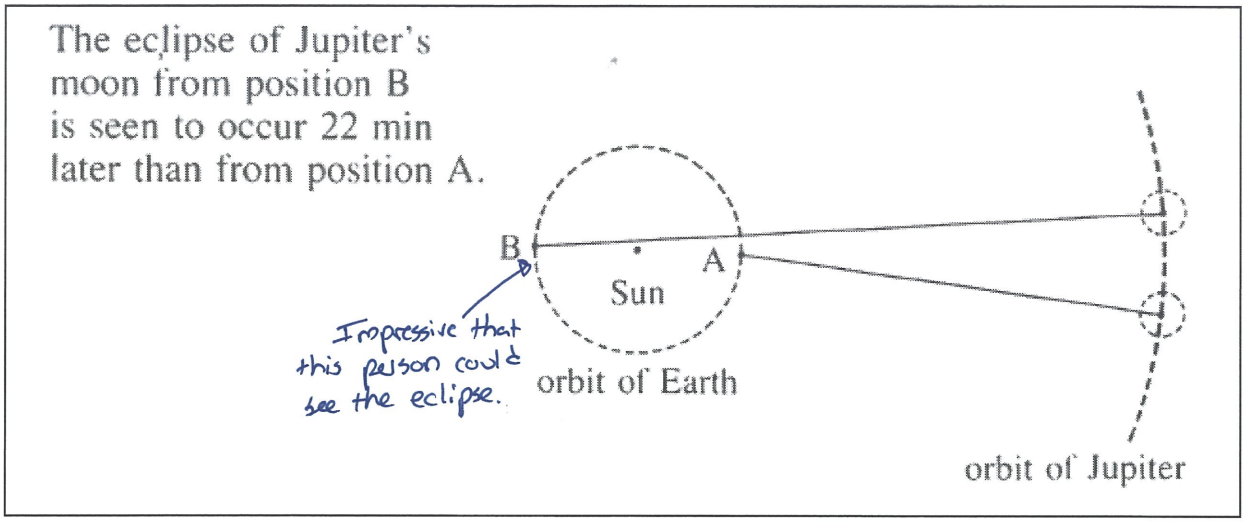
Diploma Worksheet Questions – Speed of Light

Use the following information to answer Q497:



Q497: Given that the diameter of the Earth's orbit is 3.0×10^{11} m, the speed of light as Huygens would have calculated is

$$v = \frac{\Delta d}{\Delta t} = \frac{3.00 \times 10^{11}\ m}{1320\ s} = 2.27 \times 10^{8}\ m/s$$

a. 1.4×10^{8} m/s
b. 1.9×10^{8} m/s
c. 2.3×10^{8} m/s
d. 3.0×10^{8} m/s

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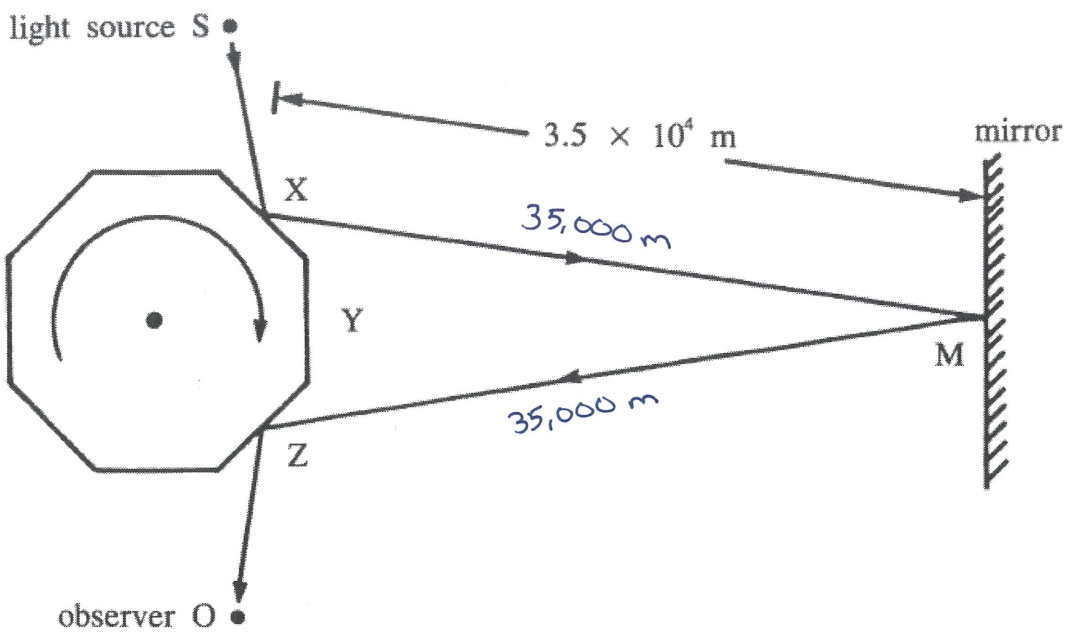
Use the following information to answer Q498:

Measuring the Speed of Light



When the eight-sided mirror is stationary, light travels from S to X to M to Z to O. The distance XM is 3.5×10^4 m. When the eight-sided mirror is rotating, provided that the speed of rotation is correctly adjusted, light travels from S to X to M to Y to O (since Y will have moved to Z).

Q498: The eight-sided mirror rotates at 480 rev/s. The speed of light calculated from this information is

a. 3.0×10^8 m/s
b. 2.7×10^8 m/s
c. 1.7×10^7 m/s
d. 4.2×10^6 m/s

$f = 480\ Hz$

$T = \frac{1}{f} = 2.08\overline{3} \times 10^{-3}\ s$

Time for 1/8th of a rotation is $2.604\overline{16} \times 10^{-4}\ s$

$v = \frac{d}{t} = \frac{70,000\ m}{2.604\overline{16} \times 10^{-4}} = 2.688 \times 10^8\ m/s$