The Expanding Universe

IB PHYSICS | ASTROPHYSICS

IB Physics Data Booklet

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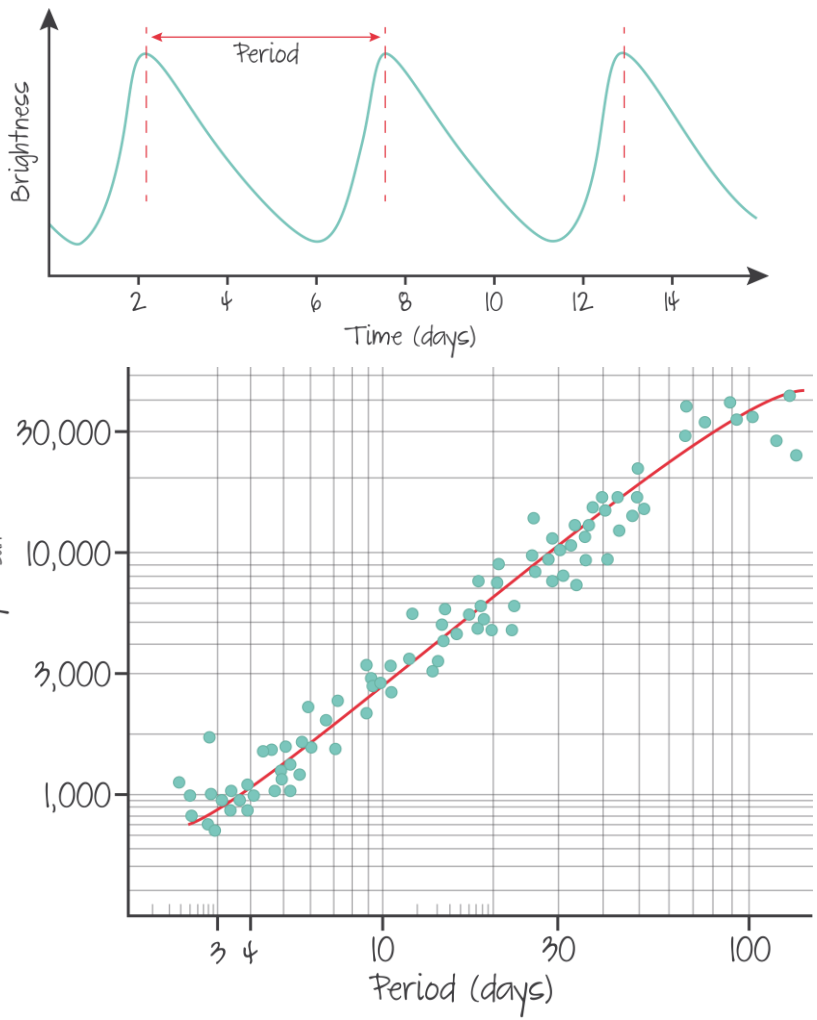
Henrietta Swan Leavitt

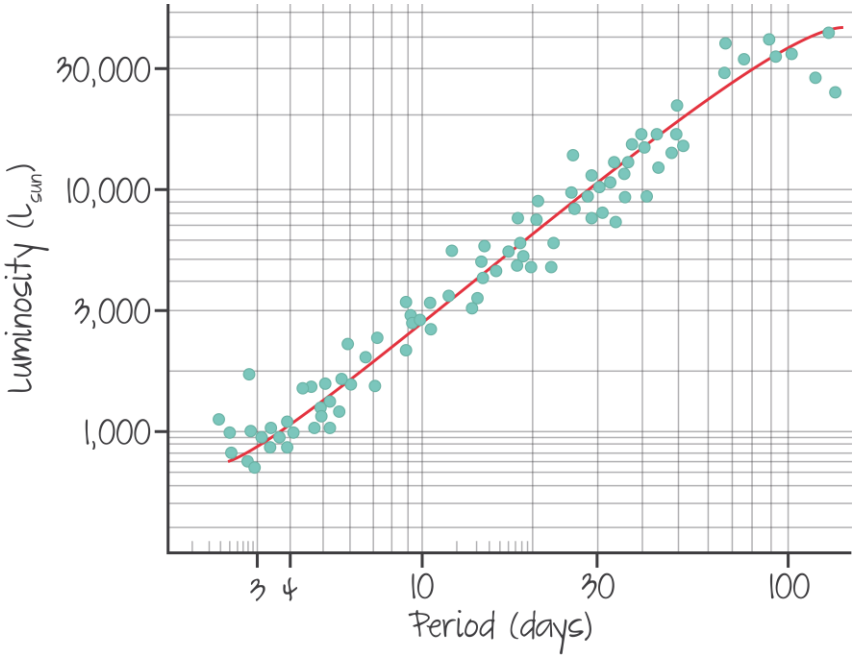
Cephid Variables

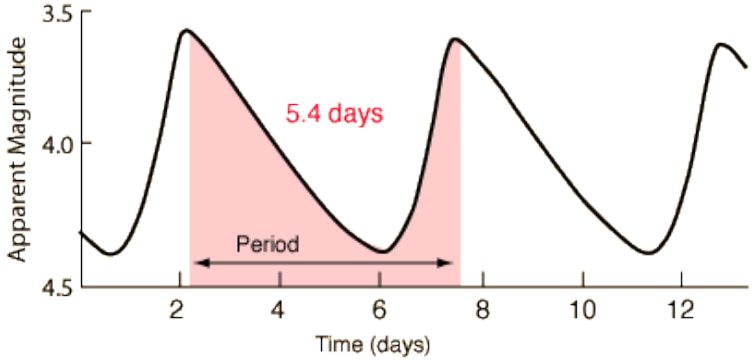
“Standard Candle”



Cephid Variables

$1\ L_{sun} = 3.84 \times 10^{24}\ W$



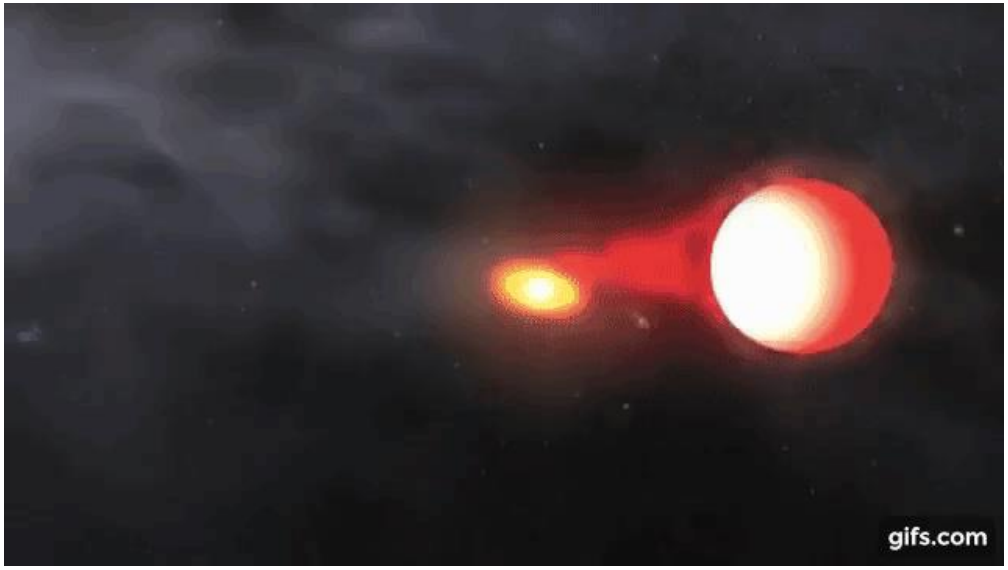


What is the distance of the Cephid Variable with the period shown in the graph above? The brightness of this star is $8 \times 10^{-10}\ W\ m^{-2}$.

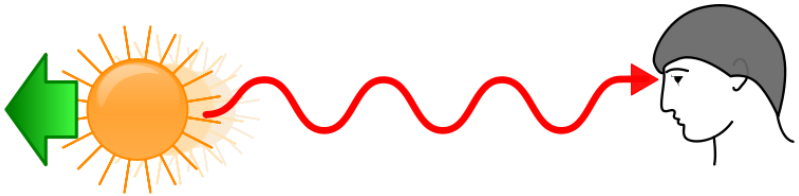
Type Ia Supernova

A type Ia Supernova forms when a white dwarf accretes matter from a companion star until it exceeds the Chandrasekhar limit and explodes

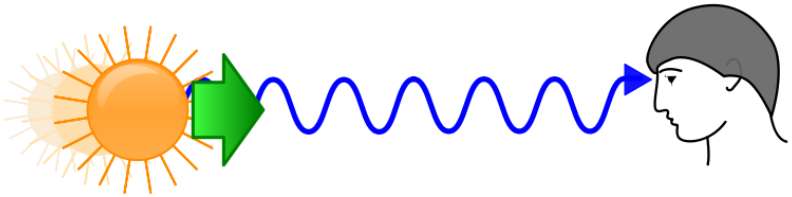
These supernovae have a constant luminosity so their brightness can be analyzed as a standard candle much like the Cephid Variables

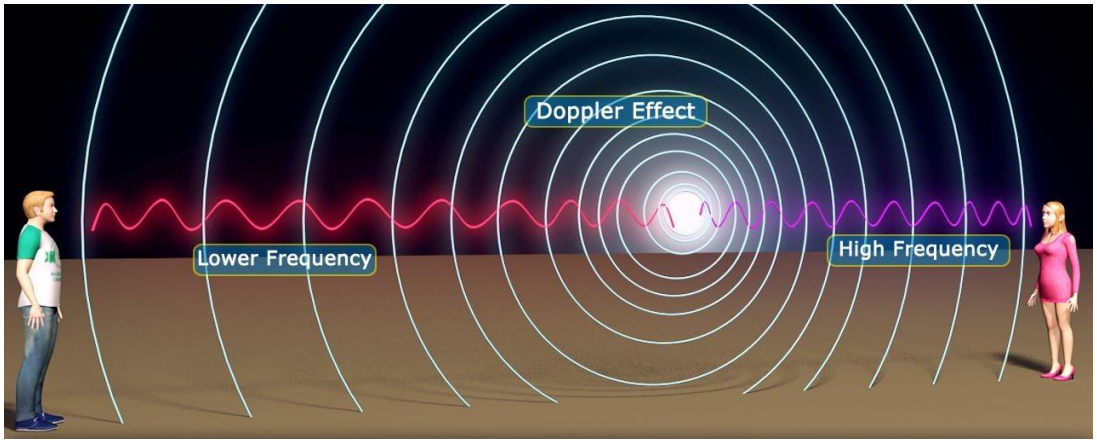


Doppler Effect



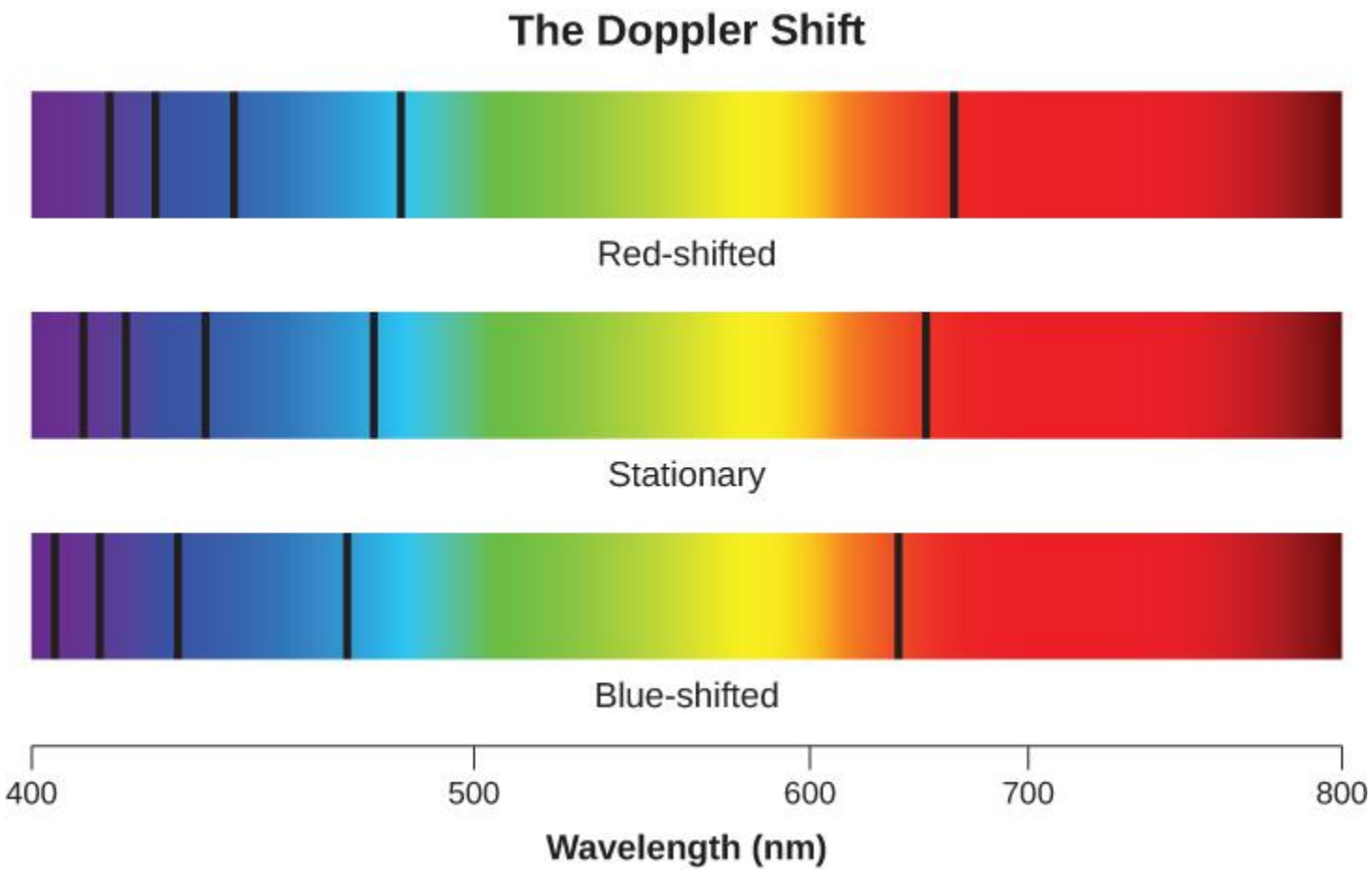
Red-shifted





Fun Science: Light

Red Shift, Blue Shift



Calculating Redshift

$$z = \frac{\Delta\lambda}{\lambda_o} \approx \frac{v}{c}$$

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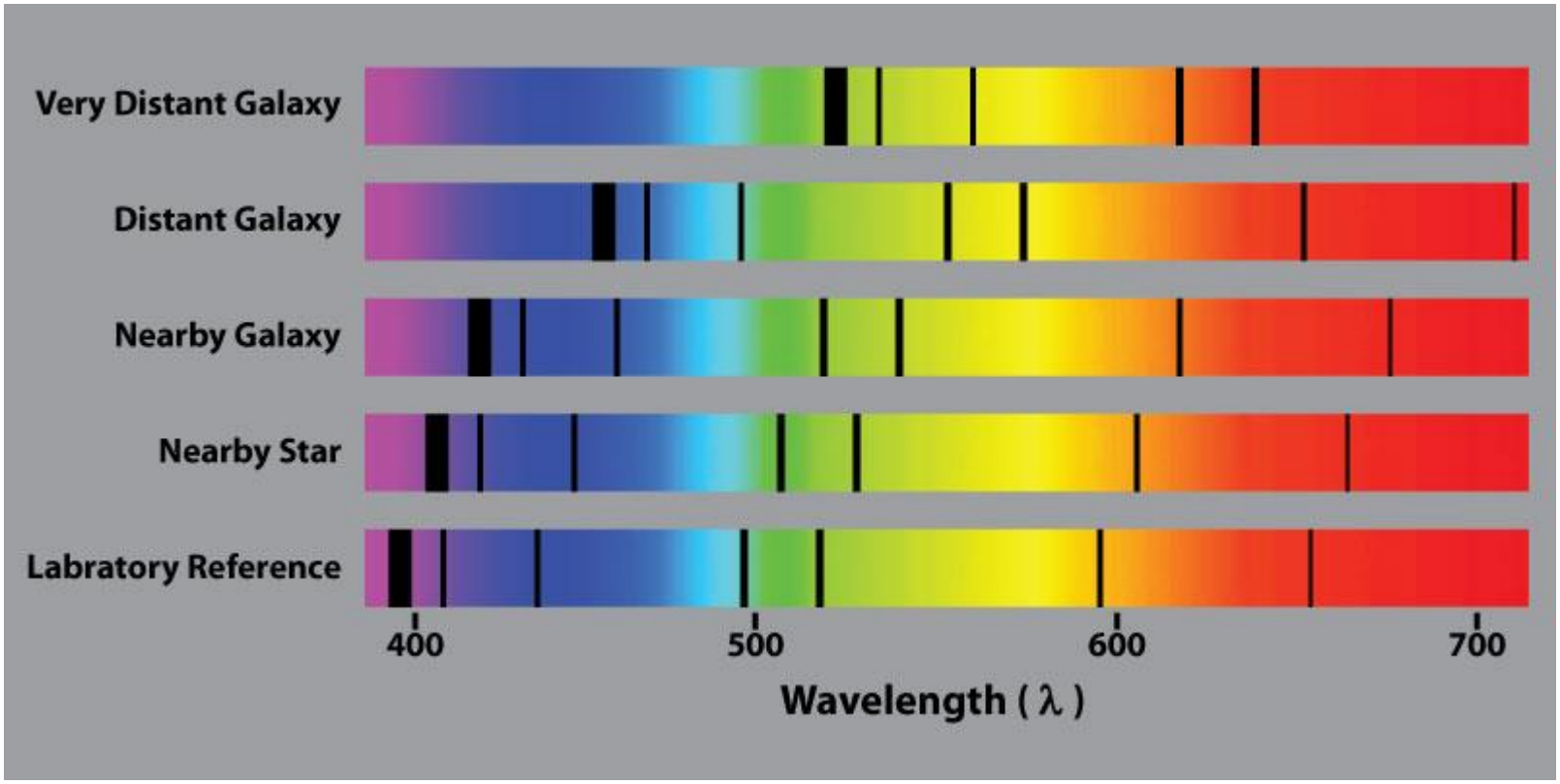
Calculating Redshift

A characteristic absorption line often seen in stars is due to ionized helium. It occurs at 468.6 nm. If the spectrum of a star has this line at a measured wavelength of 499.3 nm what is the recession speed of the star?

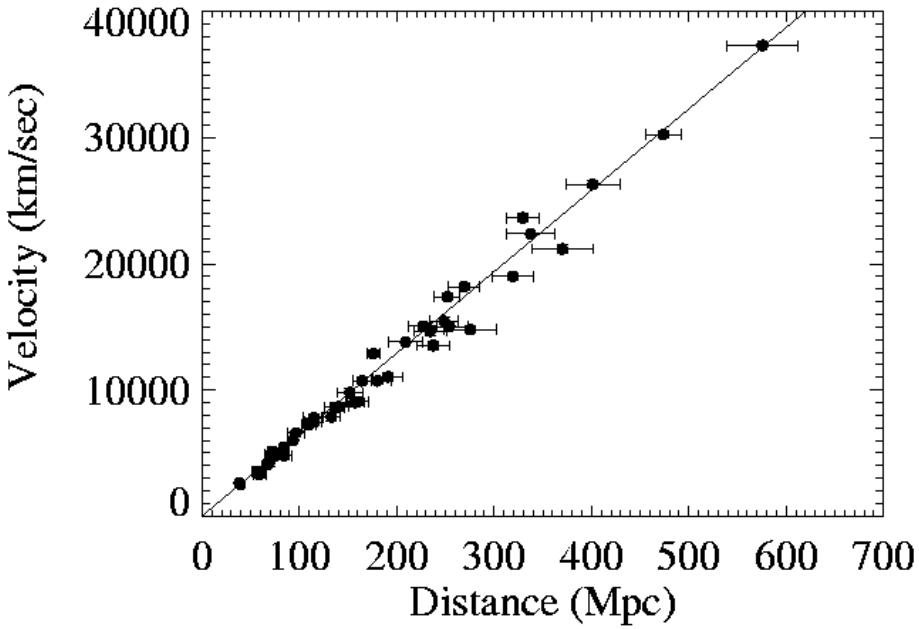
$$\frac{\Delta\lambda}{\lambda_o} \approx \frac{v}{c}$$

Hubble's Big Discovery

Edwin Hubble discovered that the amount of redshift changed by the distance



The Universe is Expanding



$$v = H_0 d$$

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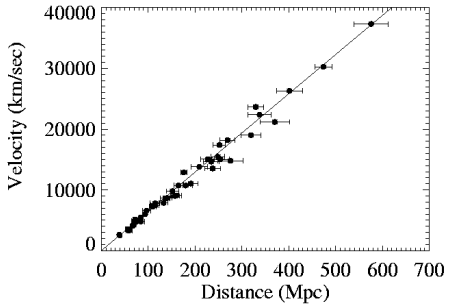
Using the Hubble “Constant”

Estimate the distance from the Earth to a galaxy with a recessional velocity of 150 km s^{-1}

If a galaxy is 20 Mpc from Earth, how fast will it be receding?

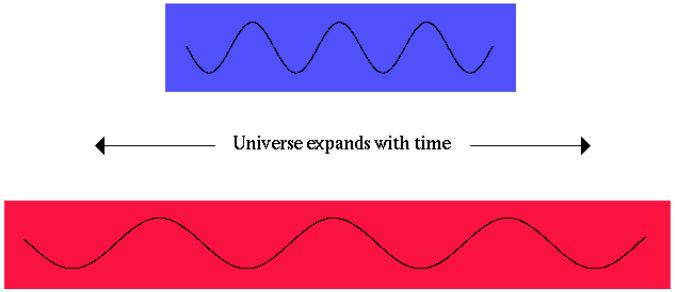
Calculating Redshift

Nothing can go faster than the speed of light so the Doppler effect can't really hold up…



Calculating Redshift

Think of the wavelength change due to the stretching of space-time



$$z = \frac{R}{R_o} - 1$$

Calculating Redshift

If the redshift z = 3, what was the scale factor at the time that the light was emitted?

$$z = \frac{R}{R_o} - 1$$

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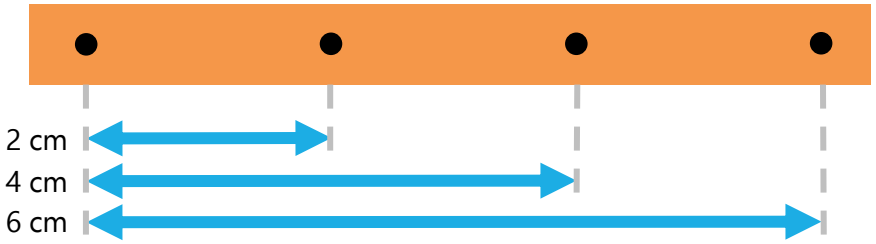

Think of a rubber band with marks when it is stretched out… Relative to the first dot, which dot moves the fastest?

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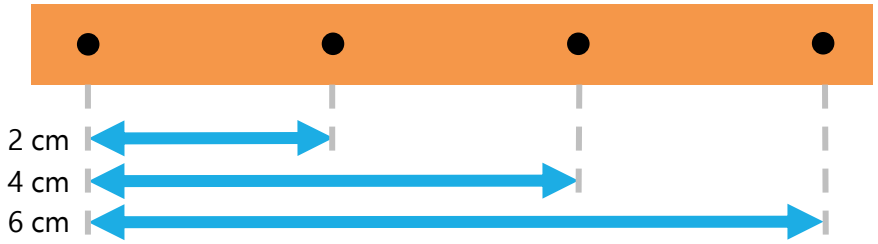

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