The Scale of Astrophysics

IB PHYSICS | ASTROPHYSICS

IB Physics Data Booklet

Sub-topic D.1 – Stellar quantities	Sub-topic D.2 – Stellar characteristics and stellar evolution
$d\ (\text{parsec}) = \frac{1}{p\ (\text{arc–second})}$	$\lambda_{\max} T = 2.9 \times 10^{-3}\ \text{m K}$
$L = \sigma A T^4$ $\quad P = e\sigma A T^4$	$L \propto M^{3.5}$ $\quad \lambda_{\max}(\text{metres}) = \frac{2.90\times10^{-3}}{\text{T (kelvin)}}$
$b = \frac{L}{4\pi d^2}$ $\quad I = \frac{P}{A} = \frac{P}{4\pi r^2}$	
Sub-topic D.3 – Cosmology	**Sub-topic D.5 – Further cosmology (HL only)**
$z = \frac{\Delta\lambda}{\lambda_0} \approx \frac{v}{c}$	$v = \sqrt{\frac{4\pi G\rho}{3}}\, r$
$z = \frac{R}{R_0} - 1$	$\rho_c = \frac{3H^2}{8\pi G}$
$v = H_0 d$	
$T \approx \frac{1}{H_0}$	

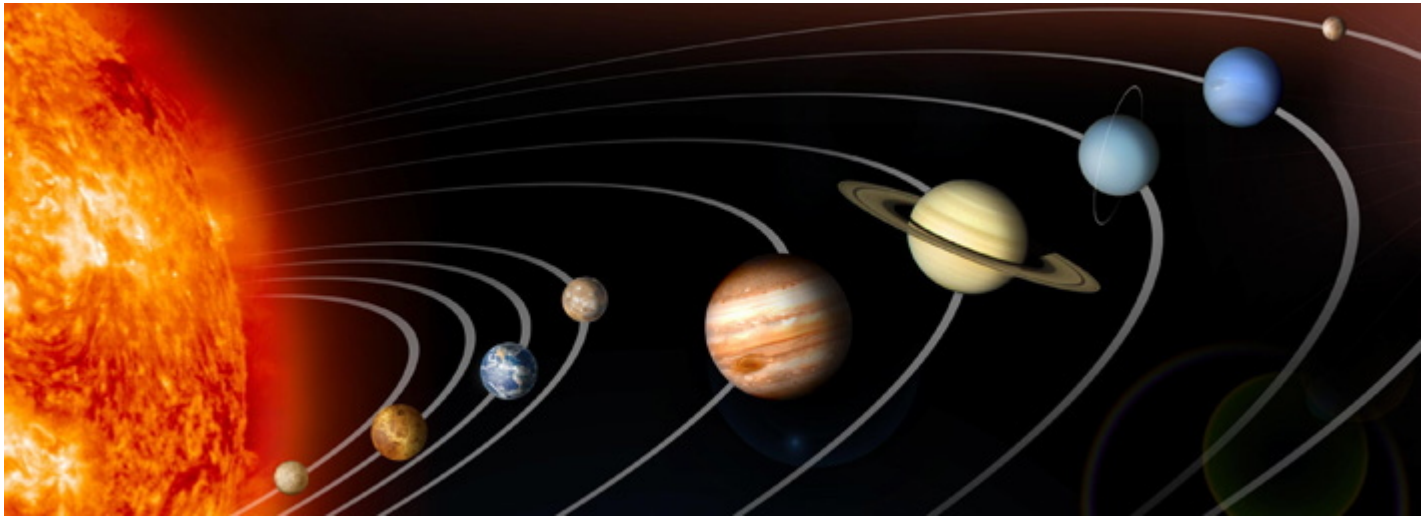
Anything look familiar?

It’s a Great Big Universe…

Animaniacs - Yakko's Universe

The Solar System

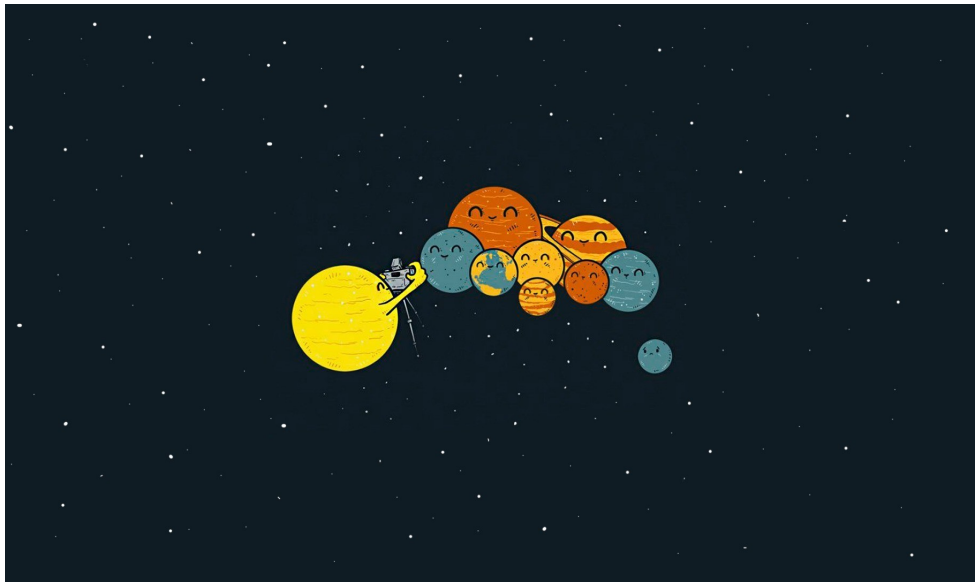
	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Diameter [km]	4,880	12,104	12,756	6,787	142,800	120,000	51,800	49,500
Distance to Sun [$\times 10^8$ m]	58	107.5	149.6	228	778	1,427	2,870	4,497

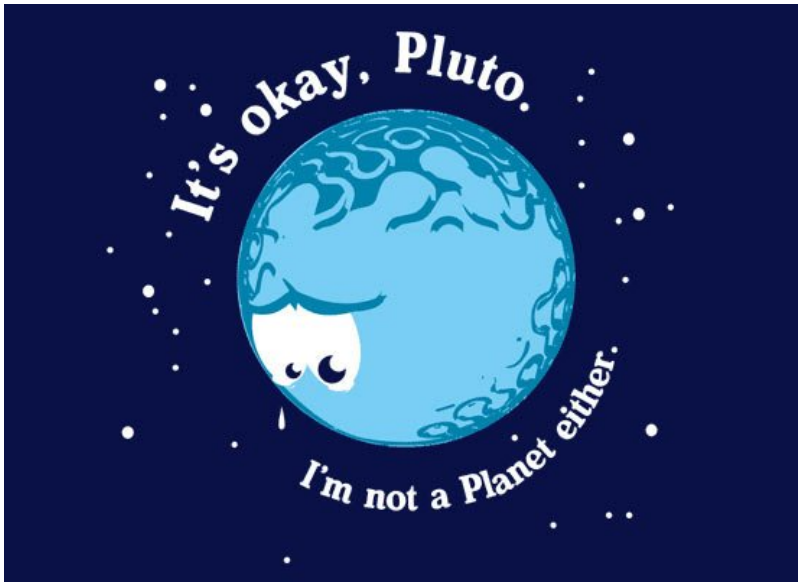


Poor Pluto… :’(

Definition of a Planet (as of 2006)

A celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (c) has cleared the neighbourhood around its orbit.





Measuring Distances

Speed of Light: $c = 3.00 \times 10^8 \text{ m s}^{-1}$

How far is one light year (ly)

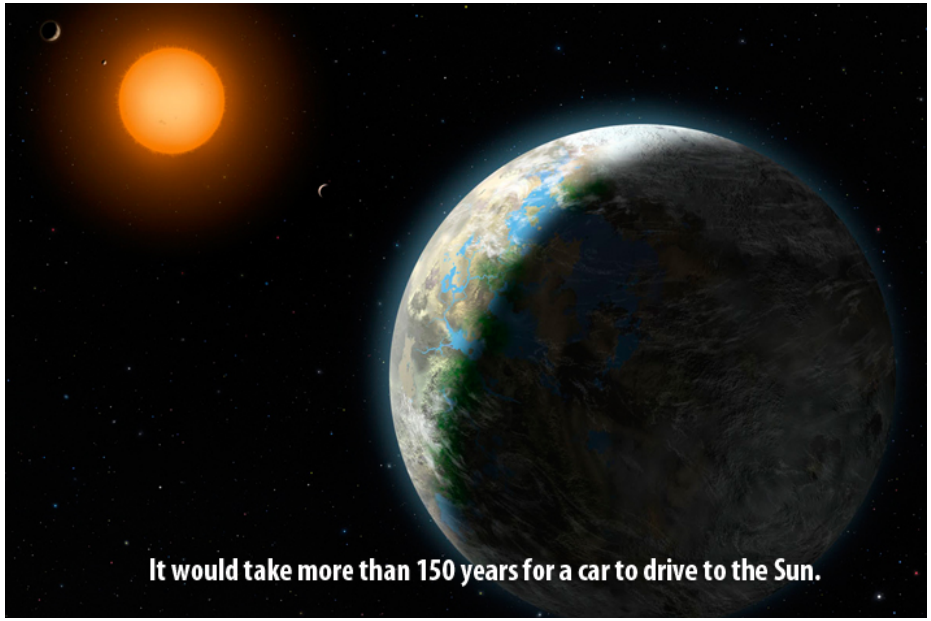
$$\frac{3.00\times10^8\ m}{1\ s} \times \frac{60\ s}{1\ min} \times \frac{60\ min}{1\ hr} \times \frac{24\ hr}{1\ day} \times \frac{365\ days}{1\ yr}$$

$$= 9.46\times10^{15}\ m\ yr^{-1}$$

Measuring Distances

Average Distance between the Earth and the Sun

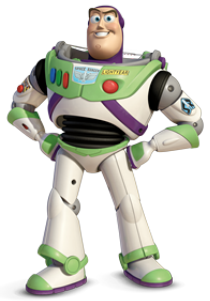
Astronomical Unit [AU] → 1.5×10^{11} m



Measuring Distances

1 light year (ly) = 9.46×10^{15} m

The distance that light travels in an earth year



1 astronomical unit (AU) = 1.50×10^{11} m

The average distance between the earth and the sun

Measuring Angles

60 seconds in 1 minute

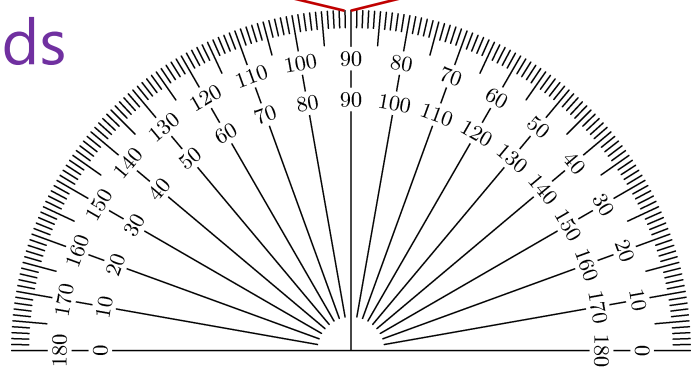
″

60 minutes in 1°

′

1° = 3600 arcseconds

1° = 3600 as

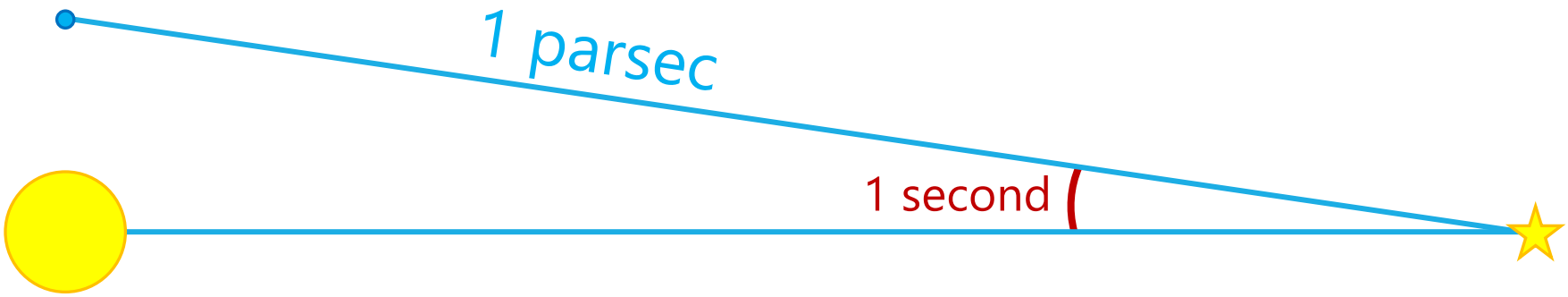


Parsecs

1 parsec (pc) = 3.26 ly

distance at which the mean radius of the earth's orbit subtends an angle of one second of arc.

parsec stands for parallax angle of one second



Parsecs

Why is this claim a little odd?

"It's the ship that made the Kessel run in less than 12 Parsecs."

distance

IB Physics Data Booklet

Unit conversions

1 radian (rad) $\equiv \frac{180°}{\pi}$

Temperature (K) = temperature (°C) + 273

1 light year (ly) = 9.46×10^{15} m

1 parsec (pc) = 3.26 ly

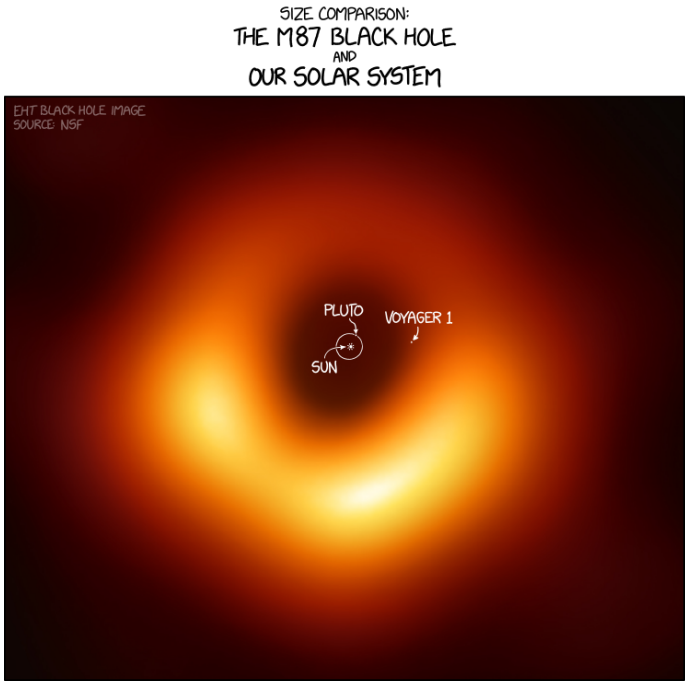
1 astronomical unit (AU) = 1.50×10^{11} m

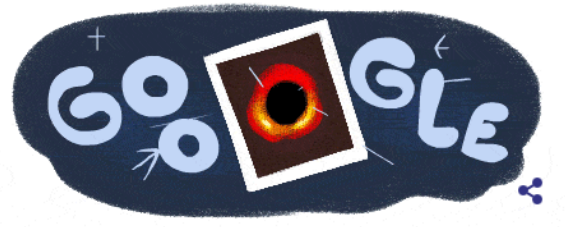
1 kilowatt-hour (kWh) = 3.60×10^{6} J

$hc = 1.99 \times 10^{-25}$ J m = 1.24×10^{-6} eV m

Stefan–Boltzmann constant	σ	5.67×10^{-8} W m^{-2} K^{-4}
Coulomb constant	k	8.99×10^{9} N m^{2} C^{-2}
Permittivity of free space	ε_0	8.85×10^{-12} C^{2} N^{-1} m^{-2}
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ T m A^{-1}
Speed of light in vacuum	c	3.00×10^{8} m s^{-1}
Planck's constant	h	6.63×10^{-34} J s
Elementary charge	e	1.60×10^{-19} C

The Black Hole – by the numbers





Just bigger than our solar system

6.5 billion times the mass of the Sun

55 million light years from Earth

The Science Behind the Picture

Remember: 1° = 3600 arcseconds

1 arcsecond = 1,000,000 μas

**60 μas is about the same as resolving a picture of an orange sitting on the surface of the moon*

The Science Behind the Picture