Option F - Astrophysics

- <u>Important Terms:</u>

  Galaxy:
  - A group of stars
  - Three types:
    1. spiral galaxy
    2. elliptical galaxy
    3. irregular galaxy

  Cluster:
  - A group of galaxies

  Supercluster:
  - A cluster of clusters

  Constellation:
  - A recognisable group of stars or galaxies.
    eg. Southern Cross, Big Dipper, Orion.

  Nebula/Nebulae:
  - Glowing clouds of gas or dust.
  - Groups of stars that are so numerous they appear to be a cloud.

  Red Giant:
  - Very large star with low surface temperature
    eg. Betelgeuse

  White Dwarf:
  - Small star (typically about the volume of the Earth) with high surface temperature, eg. Sirius B.

  Neutron Star:
  - Star that has undergone gravitational collapse. The core of this star is made mainly of neutrons.

  Supernova(e):
  - Produced when a neutron star can collapse no further and the outer layers, which are still falling rapidly inwards, are reflected back to cause an enormous shockwave. eg. SK69202 in 1987.

  Pulsar:
  - Rotating neutron star that is left when a star "goes supernova".

  Black Hole:
  - Star that has undergone gravitational collapse and has reached a density and radius such that the gravitational field at the surface of the star prevents the escape of the electromagnetic radiation.

Quasar:

- Quasistellar radio sources. Galaxies that are thousands of times brighter than ordinary galaxies. Very distant. Much smaller than any known galaxy.

- Astronomical Distances:

Astronomical Unit:	The average distance between the Earth & the Sun. (AU)
Light Year:	The distance travelled by light in a year. (ly)
Parsec:	A line of length 1AU subtends an angle of 1 arcsecond at a distance of 1 parsec.

Conversions:

1 AU	1.496×10^{11} m
1 ly	9.46×10^{15} m
1 ly	63 240 AU
1 pc	3.086×10^{16} m
1 pc	3.26 ly
1 pc	206 265 AU

Distance Measurement by Parallax: $P = \frac{1\ \text{AU}}{d}$

- Luminosity (L)— measured in Watts (energy emitted per unit time) (Sun— 3.90×10^{26}) Luminosity of sun also written as $L_\oplus$.

- $b = \frac{L}{4\pi d^2}$ — Apparent Brightness (energy received per unit time per unit area)— measured in W/m^2.

- Apparent Magnitude— use of logarithmic scale (star of brightness 1 is 100 times brighter than star of brightness 6). Related to apparent brightness by equation:

$$m_2 - m_1 = 2.5 \times \log\left(\frac{b_1}{b_2}\right)$$

- Absolute Magnitude— apparent magnitude is "standardised" by placing stars (and galaxies) all at the same distance from Earth (at 10 pc). Apparent magnitude at this distance is called *absolute magnitude*, M. Therefore:

$$M - m = 2.5 \log\left(\frac{100}{d^2}\right) = 5 - 5\log d$$

OR

$$\boxed{M - m = 5\log d - 5}$$

- <u>Black Body Radiation:</u>— Bodies emit different wavelengths of radiation— relationship between this and temperature. Hot bodies emit a whole spectrum of wavelengths. 'Black bodies' are the perfect absorber and perfect emitter of this radiation, eg. hole in tin can at 600K. The radiation wavelengths have a maximum intensity rlationship can be determined by the following equation:

  $\boxed{\lambda_{max} T = \text{constant}}$ or for black bodies, $\boxed{\lambda_{max} = \frac{2.9 \text{ x } 10^{-3}}{T}}$

- <u>Stefan–Boltzmann Law</u>— Relates Luminosity, temperature, and Area of black body:

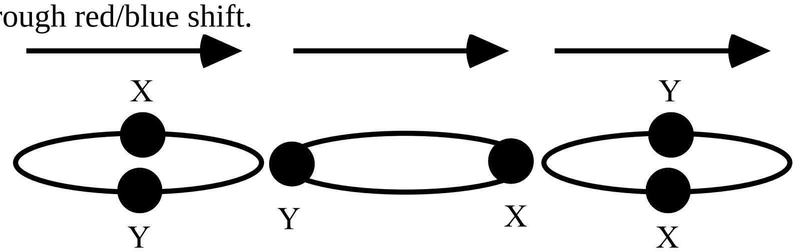
  $\boxed{L = \sigma A T^4}$, where _ = 5.67 x 10^{-8} W m^{-2} K^{-4}. or $\boxed{\frac{\Delta Q}{\Delta t} = \varepsilon \sigma A T^4}$, where _ = emmisivity, a number between 0 & 1 that is characteristic of the material. Very black surfaces have emissivity = 1., and $\frac{\Delta Q}{\Delta t}$ = rate at which energy is absorbed.

  Can also be used for stars— have similar spectra to that of a black body.

- <u>Chemical Composition</u>:— Every element can be identified through *absorbtion spectra.* In this way we can use it to find the chemical composition of the atmosphere of a star. The absorption lines on a star correspond to the emission lines of the elements in the upper atmosphere (*corona*) of a star. In this way we can find elements such as hydrogen, iron, sodium, and calcium. Stars with similar appearing stellar spectra are grouped in similar *spectral classes.* This depends on temperature though. Most stars are approximately the same, ie. 74% H, 25% He, and 1% other elements.

- <u>Hertzsprung-Russell Diagram</u>:— (see page 559, IB Text):
  - *Main Sequence Stars*: Runs from large luminosity/high temperature (top left) to small luminosity/low temperature (bottom right).
  - *Red Giants*: Large luminosity/low temperature (top right). Some stars have very large luminosity— *supergiants.*
  - *White Dwarfs*: Low luminosity/high temperature (bottom left).
  - *Instability Strip*: between main sequence stars and red giants, in it are *variable stars*, *long period variables*, Cepheids, and *RR Variables.* (see p.582 IB Text).

- <u>Binary Stars</u>:
  - Most groups of stars in Galaxy consist of 2 stars, known as Binary stars.
  - Stars move towards and away from Earth in a pattern, can be determined through red/blue shift.



- When star X moves towards earth, and Y away, blue shift is observed.
- When star Y moves towards earth, and X away, red shift is observed.

- The Doppler Effect & Redshift:
  - Hubble's law, shows the universe is moving outwards at a rapid pace. Galaxies move outwards at their *recession speed* (which is different for each galaxy, depending on its distance from earth). This recession speed is proportional to the distance of the galaxy from earth.

  Hubble's Law, which shows this is defined as the following:

$$v = Hd$$

  where d is the distance to the galaxy and v is its recession speed. H is Hubble's constant and has a value 65 km s^{-1} Mpc^{-1}.

- Background Radiation:

  24% of Universe is Helium. Calculation shows that Helium is produced by nuclear fusion within stars cannot account for this. However, the physicists Dicke and Peebles proposed that at some stage the Universe was at a high enough temperature to produce helium by fusion. Many high energy photons would be produced, and these would have a black body spectrum corresponding to the temperature of the Universe. Therefore at the present time the photons should have a maximum wavelength corresponding to a black body spectrum of 3K.
  Penzias & Wilson's experiment with a microwave aerial showed this, which was further evidence for the Big Bang. Modernday measurements show that all space is filled with radiation corresponding to black body spectrum of 2.726 K.

- Methods for Measuring Astronomical Distances:

Distance	Method
up to 100pc	Parallax & Cepheid variables.
up to 60 Mpc	Cepheid variables & spectroscopic parallax
up to 100 Mpc	Spectroscopic parallax and supernovae
up to 250 Mpc	Super redgiants and super blue giants and supernovae
up to 900 Mpc	Globular clusters and Supernovae
beyond 900 Mpc	Supernovae