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| **Lesson Number: 28.9** |
| **Lesson Title: Supernovae and black holes** |
| **Specification Reference** | **3.9.2.6** |
| **Learning Objectives** |
| Defining properties: rapid increase in absolute magnitude of supernovae; composition and density of neutron stars; escape velocity > *c* for black holes.Gamma ray bursts due to the collapse of supergiant stars to form neutron stars or black holes.Comparison of energy output with total energy output of the Sun.Use of type 1a supernovae as standard candles to determine distances. Controversy concerning accelerating Universe and dark energy.Students should be familiar with the light curve of typical type 1a supernovae.Supermassive black holes at the centre of galaxies.Calculation of the radius of the event horizon for a black hole, Schwarzschild radius *R*s ,  |
| **Opportunities for Assessment** |
| Calculations of masses, densities and black hole masses |

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| **Starter:** | Slide #1 recaps the link between the end of a star’s life, supernovae and black holes |
| **Main:** | Slide #2 explains the difference between type II and type Ia supernova – students cal calculate the density of a neutron using the mass of a neutron and the minimum radius using the strong force (0.5fm)Slides #3 - #4 go into more detail on type Ia supernova and roche lobe overflow – A more detailed discussion on standard candles could be done here however this is better left to a lesson on the distance ladderSlides #5 - #6 explain the gamma ray bursts as a theory linked to supernova and the light curve of a type Ia supernova linked to the half-life of Ni-5 and Co-56Slides #7 - #9 explain neutron capture by both the slow and rapid processes and hence the source of the heavy nuclei in the universeSlides #10 - #12 work through the formulae from known basics, through gravitational formulae to the calculation of a Schwarzschild Radius – Be careful **not** to confuse students with the *“mass of photon”*. A discussion about Einstein’s theory of gravity helps here to make students understand how massless photons are effected by bent space-timeSlide #13 enables the assessment of understanding of the mathematicsSlide #14 is a nice picture of an accreting binary system that will create a type Ia supernova |
| **Plenary:** | Slide #15 is a summary |

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| **Homework:** | Research on the mass of the black hole in the centre of the milky way; search for animations and proof, using centripetal forces and gravity, to ascertain its mass |
| **Differentiation / Extension / S&C** |
| Discussion of Einstein’s theory of gravityDiscussion of black-hole theory, Hawking radiation, event horizons, time dilation and sci-fi films |
| **Numeracy / Literacy** | **SMSC / Fundamental British Values** |
| Calculations of Schwarzschild radii | The proof of scientific theories can take longer than the life-time of the scientists that thought them upIs it safe for CERN to make mini-black holes? |
| **RESOURCES:** |
| None |
| **Risk Assessment** e.g. CLEAPSS card reference |
| None |
| **Working Scientifically (HSW)** |
| None |

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