SAMPLE LESSON PLAN FOR OCTAGON AR

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Subject	Science – Life on Mars		
Year Group	9 (age 13-14)	***Timing***	1 hour
Number of Pupils:	25, divided into 5 groups, assume mixture of abilities		

Context:
The class will already have studied the solar system in general – size, contents, how the planets are arranged. Now we are going to look more quantitatively at planetary data and in more detail at the features of a particular planet.

Curriculum (Key Stage 3):

- Comparing gravity on different planets
- Comparing surface temperature and distance from Sun (radiation and absorption)
- Using AR to become familiar with the features of a planet
- Extension: Practising calculation skills and understanding powers of ten

Skills developed:
Data extraction and analysis; graph drawing and interpolation; comparing forces

Equipment needed:

- Whiteboard or similar to write on
- Set of 15 iPads loaded with Space 4D+, sound muted
- 5 sets of Space 4D+ trigger cards (planets only, having removed Mars)
- 1 complete set of cards for teacher, with iPad connected to projector for viewing by whole class
- Gravity box (large cardboard box with hidden weights inside, each representing the weight of 1kg on different planets: 1kg (Earth), 2.6kg (Jupiter), 0.9kg (Venus), 0.4kg (Mars), 1.2kg (Neptune), 0.15kg (Moon). Each has a string labelled A → F emerging from lid of box.

Follow Up:
Homework will be set: Describe what you would see and feel if you visited Mars in a spacecraft for a day.
The following lesson could explore Kepler's 1st Law: T^2 vs R^3, or move on to study stellar evolution and nuclear fusion.

Lesson Activities – ***teacher instructions/questions/comments in italics***	
Timing	**Details**
8 mins starter revision activity	Teacher has solar system 4D+ on screen to explore as students enter as stimulus. *Perhaps one of you will be the first person to set foot on Mars! I wonder what that would* ***feel*** *like?* Possible questions by way of revision whilst exploring solar system: • *Order of planets from Sun? Rocky dwarves vs gas giants? Which one is Mars?* • *What is this?* (points at asteroid belt) • *What is special about Pluto's orbit, now classified as a minor planet?* (highly eccentric or elliptical) • *Which planets are likely to be the hottest?* • *What determines how strong gravity is on each planet?* (Students may have seen footage of astronauts on Moon, or film The Martian, for context and have idea that size/mass of planet is relevant). • EXTENSION: *By discussion with partner, identify 3 unrealistic aspects of the animation* (orbital speeds, lack of Moons, planetary rotation, relative distances)
20 mins card sort and data extraction & graphical analysis	In 5 groups of 5, the students sort the planets cards into order, from Mercury to Neptune. *Which one is missing?* (Mars) *Write down the names of the planets in order and, turning the cards over, write down the surface temperature of each one. Remember to leave a space for Mars. What sort of pattern can you see? Can you predict what the temperature on Mars might be?* Using the iPad the students access the Space 4D+ app (**info side bar**) to write down the distance from the Sun of each planet in millions of km. The students draw a graph with distance on the horizontal axis and surface temperature on the vertical axis and plot a point for each planet. (for less able pupils a pre-prepared set of axes could be provided as scaffolding) *Add Mars, which is at a distance of 228 million km. Can you predict its temperature now?*
5 mins interpreting graph	*What does the graph show?* The further a planet is from the Sun, the colder it is – since the Sun's radiation spreads out and more distance planets receive less. However, there are some exceptions – e.g. Venus is very hot because it has a thick atmosphere which absorbs radiation (c.f. Earth's greenhouse effect). From

	the graph we would predict/ interpolate Mars's temperature to be between -20 and -100, perhaps. The groups are now given the missing card and add Mars's temperature to their graph (-55 deg C). *This is called **interpolation**. So, it's pretty cold, on average. How might we deal with that if we visited Mars?*
5 mins discussion on gravity	*Now let's think about how the gravitational pull might feel.* Teacher reminds students that on earth, every kg is pulled with a force of about 10 N (its weight). If gravitational fields strength on Mars is less, you would feel lighter. Using the iPads, the students choose **size comparison** within the app and make a prediction in their groups about how strong the gravity might be on Mars, based on its size. *Will strength of gravity only depends on size? Also depends on mass*. [In fact it depends on the mass AND the radius, according to this equation: $g = GM/R^2$, where g = gravitational field strength, i.e. how much 1kg weighs on that planet), M = mass of planet and R = radius of planet. G is a constant (6.67×10^{-11} $m^3kg^{-1}s^{-2}$). Teacher might provide this extra info to more able students.]
10 mins gravity box activity/AR exploration	Teacher tells students that inside Gravity Box is a weight on a string representing how 1 kg would feel on various planets which the teacher writes on the board (Earth, Jupiter, Venue, Mars, Neptune, Moon – not a planet!. They work out which one matches which planet. In groups, the students try the activity and write their group's guess next to each planet on the board. In the meantime, the other groups can begin to explore Mars using iPads with the 4D+ app.
7 mins plenary	Discussion – *what have we discovered about Mars?* **Temperature** - cold, **gravity** – weaker than Earth, in fact about 4N/kg – 40% of Earth's. Teacher shows AR rendition of Mars from 4D+ on screen – note surface features such as 'canals' and mountains, rotate image around to see frozen poles and note two Moons, Phobos and Deimos, atmosphere (causes air resistance, erosion), absence of any liquid. The teacher could show a clip from The Martian showing a few seconds of the astronaut walking around on Mars, or this analysis (from 9'20" – 10'54"): https://www.youtube.com/watch?v=KCxQ3hYHrZk
5 mins wrap-up	Set homework task - **Describe what you would see and feel if you visited Mars in a spacecraft for a day**. Write about 1 side of A4. Use the Space 4D+ app at home to get more data and look at the 3D image of Mars.