**Stacked Deck:**  This great demonstration was introduced to us at the 2013 OAPT conference by Dr. David Harrison of U of Toronto. For more details go to <http://www.upscale.utoronto.ca/Practicals/Modules/SciMethod/SciMethod_Student.pdf>

**Case Study: Neptune (page 31 -33)** **Read page 31-32**

**Understanding Content Question 1:**

* These MC questions can be used as assessment for and assessment of understanding. More importantly, they can be used to stimulate student discussions that will increase their understanding and develop their communication skills.
* Three of the objects in the table – the Asteroid belt, Uranus and Neptune were discovered after Bode published his model. How does this support your answer to question 1?

Theories should explain the existing observations and predict for future observations.

* Use the formula to predict what the orbital radii of the next two objects - Pluto (n = 8) and Eris (n = 9) will be. The predicted values are 77 and 154.
* The observed radii are 39 and 68. How does this affect your answer to question 1?

The model breaks down after Neptune. Another reason to stop considering Pluto as a planet?

**Understanding Content Question 4**:

* This is a simple factual recall question.
* What would your answer to question 4 be if the planet were Neptune? Why is this question more difficult with Neptune?

**Adams** and **Verrier** predicted it – Verrier`s calculations were more accurate.

British saw it but didn`t recognize it as a planet. **Galle** was the first to recognize it.

**Exploring Context Questions 2 and 3**.

* These questions work well together. In each case, the planet’s orbit had a wobble that could either be explained by another planet or by a fundamental change in the physics. Searching for another planet is the simpler, more conservative solution and worked for Neptune and Pluto. It didn’t work for Mercury.
* Question 3 is hard to answer without a little more experience. Take a cardboard ellipse and trace around it several times on a flat surface. It traces out the same ellipse again and again. Do the same thing on a balloon. After going around once, you will not be back at the starting point and after going around many times you will have a pattern that looks like a daisy or something drawn with a Spyrograph. This is the pattern that Mercury’s orbit makes and it suggests that space is curved. Correctly modelling Mercury’s orbit was the first success of Einstein’s General Relativity. This wobble or precession has also been demonstrated for Venus and the Earth. It is easiest to observe the precession for the planets that are closest to the sun because that is where the curvature of gravity is greatest.
* **Case Study CMB (p. 23-24)**: Include elastic band and paper clips model and

Minute Physics: Picture of the Big Bang <http://www.youtube.com/watch?v=_mZQ-5-KYHw>

* **Case Study Dark Matter (p. 25-27)**: Include Mystery of Dark Matter resource and

Minute Physics: What is Dark Matter? <http://www.youtube.com/watch?v=Af0_vWDfJwQ>