Asteroids, Comets and NEOs

Student Worksheet

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Solar System Activities

Q1. Read through the information sheet on asteroids, comets and NEOs then complete the crossword using the clues provided.
Asteroids, Comets and NEOs Crossword

Across
1. Until its status was changed to dwarf planet in 2006, this was the largest known asteroid (5)
3. Part of an asteroid that hits the Earth’s surface (9)
5. A rocky object that orbits the Earth (8)
7. Comets are found in this belt (6)
10. This object is made of ice, gas, and dust (5)
11. This wind heats the particles in a comet to produce the tail (5)
13. These objects approach the Earth very closely (3)
15. One of the ingredients of a comet (3)
16. Another ingredient of a comet (4)
17. Comet’s orbits are ________ (10)
19. These types of comets are usually found in the spherical Oort cloud (4,6)
21. Either the Kuiper or Asteroid ________ (4)
22. An asteroid which is on a collision course with the Earth (9)

Down
1. The bright glowing gases at the central part of a comet (4)
2. Asteroids are not soft, but are described as ________ objects (5)
3. An asteroid which is burning up in the Earth’s atmosphere (6)
4. The part of a comet that glows due to evaporation of the gases and ice, extending as far as 1AU (4)
6. When an asteroid hits the Earth, it is known as an ________ (6)
8. What happens to the gas and ice in a comet when heated by the Sun’s heat (9)
9. These types of comets are generally found in the Kuiper Belt (5, 6)
10. Asteroid orbits are mainly ________ (8)
12. The path of an asteroid or comet around the Sun (5)
14. Popular name for a comet - a dirty ________ (8)
18. An ingredient of a comet (3)
20. The spherical cloud where long period comets are thought to originate (4)
Q2. In the information sheet you have just read, a unit of distance, commonly used by astronomers was introduced - the Astronomical Unit.

One astronomical unit (1AU) is equivalent to 150 million km, or $1.5 \times 10^8$ km. Given the data in the table below, calculate the distances of the bodies in the Solar System to the Sun in either km or AU.

<table>
<thead>
<tr>
<th>Object</th>
<th>Distance (x10^6 km)</th>
<th>Distance (AU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>57.9</td>
<td></td>
</tr>
<tr>
<td>Venus</td>
<td>108.2</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td>150</td>
<td>1</td>
</tr>
<tr>
<td>Mars</td>
<td>227.9</td>
<td></td>
</tr>
<tr>
<td>Asteroid Belt</td>
<td></td>
<td>2.7</td>
</tr>
<tr>
<td>Jupiter</td>
<td>778</td>
<td></td>
</tr>
<tr>
<td>Saturn</td>
<td>1427</td>
<td></td>
</tr>
<tr>
<td>Uranus</td>
<td></td>
<td>19</td>
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<tr>
<td>Neptune</td>
<td>4497</td>
<td></td>
</tr>
<tr>
<td>Pluto</td>
<td>5913</td>
<td></td>
</tr>
<tr>
<td>Kuiper Belt</td>
<td></td>
<td>30-50</td>
</tr>
</tbody>
</table>
Asteroid Activities

Q1. Ceres, a dwarf planet in our Solar System, is 914km in diameter. Given that a double decker bus is approx. 11m in length, to the nearest number, how many double decker buses would fit across the diameter of Ceres?

Q2. Using the instructions given on the worksheet entitled, ‘Using Google to measure impact craters on Earth’, you will be asked to determine the sizes of a variety of impact craters on Earth.

Q3. Below left is a FTN image of asteroid (916) America. Also shown on the right is a zoomed in image of the asteroid.

The field of view of the Faulkes Telescope is 4.6 arcminute, and the CCD is 2048x2048 pixels in size.
a) What is the scale-size of the images with Faulkes in pixels per arcsecond? (Hint: there are 60 arcseconds in 1 arcminute).

In fact, FTN images are **binned** to improve the quality of the images. Essentially, binning means combining pixels on the CCD to create larger pixels.

So, in the case of FTN, a 2x2 square of pixels is taken from which just one pixel is created - this single pixel has twice the width and 4 times the area of the original pixel. This is illustrated in the diagram below.
The top figure shows an unbinned CCD of size 4x4. Once binned in a 2x2 array, the new CCD effectively appears to be of size 2x2 (bottom figure). The charge in each pixel of the unbinned CCD is added together when binned, and the total charge is then assigned to the larger binned pixel.

Thus, after 2x2 binning has been applied, the CCD of FTN has effectively been reduced to 1024x1024 pixels in size.

b) Given the information on binning given above, what is the scale-size of the FTN when binned in a 2x2 array?

c) Count the number of pixels across the centre of asteroid (916) America using ds9. This is done in the following way:

- Open the image of (916) America in ds9.
- Go to Region > Shape > Ruler.
- Zoom in on the asteroid using the zoom button.
- Keeping your finger on the left mouse button, draw a line across the asteroid with the cursor. The length of the line in pixels will now be given.

d) Using your answers to questions b) and c), what is the size of the asteroid in arcseconds?
Q4. In this exercise we are going to estimate the orbital velocities of asteroids in the main asteroid belt. We will assume for simplicity that asteroids in the asteroid belt have circular orbits.

a) Ceres, previously the largest asteroid in the asteroid belt, now a dwarf planet, orbits the Sun every 4.6 years. Calculate how many seconds it takes for Ceres to complete one orbit.

b) Ceres is about 2.77AU from the Sun. 1AU is 150 million km. Calculate the distance of Ceres from the Sun in km.

c) Assume that Ceres is orbiting the Sun in a circle. Sketch a diagram to show the orbit of this asteroid. On your diagram label the Sun, Ceres and the radius of the circle.
d) Given the distance calculated in Q2, how far does Ceres travel in one orbit? 
(Clue: the circumference of a circle is given by \(2\pi r\)).


e) From the formula, speed=distance/time and using your answers from Q1 and 4, determine how quickly Ceres travels around the Sun.


Q5. When will Ceres set?

In this exercise we are going to predict when the dwarf planet Ceres will set (i.e. altitude reaches 0° in the sky) as seen from the Faulkes Telescope North in Hawaii.

The table below are the values of Ceres’ altitude as seen from FTN every day for 20 days from 27/02/06. It is clear from just looking at the altitude values that Ceres is setting, but when will it reach the horizon?

a) Plot day vs. altitude on a graph using the data given in the table below. Draw a line of best fit through the data points.

b) Calculate the gradient of the line and its y-intercept. Thus, assuming that the line of best fit is a straight line, what is the equation for this data?

c) Determine in how many days Ceres will set (Hint: altitude is 0° when object is set)
<table>
<thead>
<tr>
<th>Day</th>
<th>Altitude (°)</th>
<th>Day</th>
<th>Altitude (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>19</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>18</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>17</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>17</td>
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<td>7</td>
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<td>19</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>16</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>21</td>
<td>10</td>
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<tr>
<td>11</td>
<td>15</td>
<td></td>
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</tr>
</tbody>
</table>
Comet Activities

Q1. Draw and label the structure of a comet.

Q2. Does a comet always have a tail? Explain your answer.

Q3. Does a comet’s tail ever point towards the Sun? If not, why not?
Q4. Draw the orbit of a comet around the Sun, including the direction of its tail.

Q5. What are the main differences between comets and asteroids?

NEO Activities

Q1. In this question we look at the amount of kinetic energy that is released when an object that is moving, suddenly stops - for example, when a comet or asteroid hits the Earth. The typical velocities of asteroids hitting the Earth ranges from about 20-70km/s.

To calculate the amount of K.E. released during the impact is given by:

\[ K.E. = \frac{1}{2}mv^2 \]

where \( m \) = mass of the asteroid/comet in kg
\( v \) = velocity of the asteroid/comet in m/s

K.E. = kinetic energy released in the impact, measured in Joules.
a) Imagine a 1kg asteroid hits the Earth at a velocity of 20 km/s. Calculate how much energy would be released in the collision.

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

b) Now imagine that the same asteroid hits the Earth at a velocity of 70 km/s. Calculate how much energy is released in this collision. How does this compare to your answer of a)?

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

____________________________________________________________________________________________________________________

Now let us consider the size of impactor on the energy released.

c) Calculate the energy released when a 2kg asteroid hits the Earth at 20 km/s. Compare your answer to a) above.

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