

PI IN THE SKY⁴

Pi is a handy tool for exploring the solar system and beyond. Did you make any stellar discoveries using pi? Check your answers below and find out!

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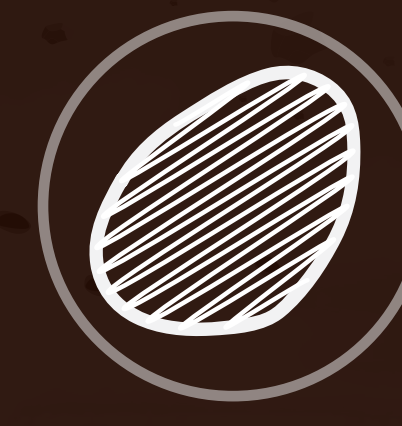
Crater Curiosity

Using the circularity ratio formula, determine which of the Mars craters would have the butterfly ejecta pattern.



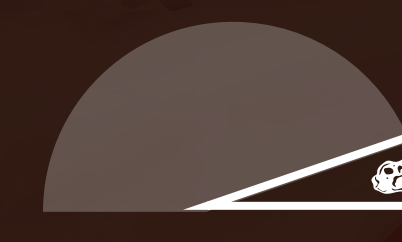
- 1 Use the formula to find the circularity ratio of Aveiro crater.

$$\frac{4\pi A}{p^2} = \frac{4\pi(67 \text{ km}^2)}{(30 \text{ km})^2} \approx 0.94$$



- 2 Use the formula to find the circularity ratio of the unnamed crater.

$$\frac{4\pi A}{p^2} = \frac{4\pi(32 \text{ km}^2)}{(21 \text{ km})^2} \approx 0.97$$



- 3 Determine which of the circularity ratios is below 0.925 (which suggests that the object that formed the crater struck at an angle below 20 degrees and created a butterfly ejecta pattern).

Unnamed Crater

AVEIRO CRATER  A (area) = 67 km²
 p (perimeter) = 30 km

CRATER CURIOSITY

Craters form when an object hits the surface of a planet or other body. The impact creates a round impression surrounded by material, called ejecta, that gets blasted out of the crater. Scientists study ejecta because it contains clues about what's below a planet's surface. When an object hits Mars at an angle under 20 degrees, the crater is less circular and the ejecta settles in a butterfly shape. Some areas around the crater contain no blast material. Finding craters that formed this way can help scientists understand how meteor impacts change the surface of a planet. Craters that are more circular than 0.925, it suggests that an object impacted at an angle under 20 degrees and created a butterfly ejecta pattern.

Using the circularity ratio formula, $\frac{4\pi A}{p^2}$, determine which of the craters shown here would have the butterfly ejecta pattern.

LEARN MORE ABOUT MARS CRATERS
bit.ly/marscraters

Epic Eclipse

What is the approximate surface area of Earth that will be covered by the disk of the moon's shadow at any one time during the eclipse?

- 1 Find the length of the portion of the moon's shadow that is blocked by Earth.

$$377,700 \text{ km} - 372,027 \text{ km} = 5,673 \text{ km}$$

$$5,673 \text{ km} + 6,378 \text{ km} = 12,051 \text{ km}$$

- 2 Use properties of similar triangles to find the radius of the shadow on Earth.

$$\frac{1,738 \text{ km}}{377,700 \text{ km}} = \frac{r}{12,051 \text{ km}}$$

$$(r \cdot 377,700 \text{ km}) = (1,738 \text{ km} \cdot 12,051 \text{ km})$$

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$$\frac{377,700 \text{ km}}{377,700 \text{ km}} = \frac{1,738 \text{ km} \cdot 12,051 \text{ km}}{377,700 \text{ km}}$$

$$r \approx 55.45 \text{ km}$$

- 3 Use the shadow's radius to find its area.

$$A = \pi r^2$$

$$A = \pi(55.45 \text{ km})^2 \approx 9,659 \text{ km}^2$$

Finale Fanfare

Approximately how many days will each of Cassini's 22 grand finale orbits take?

- 1 Convert the periapsis and apoapsis to meters and find the semi-major axis of Cassini's orbit.

$$a_{sc} = \frac{(63,022,000 \text{ m} + 1,274,828,000 \text{ m})}{2} = 668,925,000 \text{ m}$$

- 2 Use Kepler's third law to find the orbital period for Cassini's grand finale orbits.

$$a_{sc}^3 = \mu_{cb} \left(\frac{T_{sc}}{2\pi} \right)^2$$

$$(668,925,000 \text{ m})^3 = 3.7931187 \times 10^{16} \frac{\text{m}^3}{\text{s}^2} \cdot \left(\frac{T_{sc}}{2\pi} \right)^2$$

$$T_{sc}^2 = \frac{(668,925,000 \text{ m})^3 \cdot (2\pi)^2}{3.7931187 \times 10^{16} \frac{\text{m}^3}{\text{s}^2}}$$

$$T_{sc} \approx 558,146 \text{ seconds} \approx 6.46 \text{ days}$$

Approximately what day will Cassini dive into Saturn's atmosphere?

- 1 Multiply the orbital period by the number of orbits until Cassini's dive into Saturn.

$$6.46 \text{ days} \cdot 22.5 \text{ orbits} = 145.35 \text{ days}$$

$$145.35 \text{ days from April 23, 2017} = \text{Sept. 15, 2017}$$

Habitable Hunt

What are the inner and outer radii (r), in AU, of TRAPPIST-1's habitable zone?

- 1 Use the formula and the high end of the temperature range (295 K) to find the inner radius of TRAPPIST-1's habitable zone.

$$r_{inner} = \sqrt{\frac{(1-A)L_*}{16\pi\sigma T^4}} = \sqrt{\frac{(1-0.3) \cdot (2.0097 \times 10^{23} \text{ W})}{16\pi(5.67 \times 10^{-8} \text{ Wm}^{-2}\text{K}^{-4}) \cdot (295 \text{ K})^4}}$$

$$r_{inner} \approx 2,552,960,826 \text{ m} \approx 2,552,960.826 \text{ km} \approx 0.017 \text{ AU}$$

- 2 Repeat Step 1 using the low end of the temperature range (192 K) for the TRAPPIST-1 system to find the outer radius of the habitable zone ...

$$r_{outer} \approx 6,026,785,371 \text{ m} \approx 6,026,785.371 \text{ km} \approx 0.040 \text{ AU}$$

Which of TRAPPIST-1's planets are in the habitable zone?

- 1 Convert the orbital periods (T_p) to seconds and use Kepler's third law to find the semi-major axis (a_p) of each planet's orbit to determine which are in the star's habitable zone.

$$a_{TRAPPIST-1b}^3 = \mu_{cb} \left(\frac{T_{TRAPPIST-1b}}{2\pi} \right)^2$$

$$a_{TRAPPIST-1b}^3 = (1.06198 \times 10^{19} \frac{\text{m}^3}{\text{s}^2}) \left(\frac{130,539.237984 \text{ sec}}{2\pi} \right)^2 \approx 4.58394 \times 10^{27} \text{ m}^3$$

$$a_{TRAPPIST-1b} \approx 1,661,165,569 \text{ m} \approx 0.011104 \text{ AU}$$

$$a_{TRAPPIST-1c} \approx 0.015209 \text{ AU}$$

$$a_{TRAPPIST-1d} \approx 0.021426 \text{ AU}$$

$$a_{TRAPPIST-1e} \approx 0.028153 \text{ AU}$$

$$a_{TRAPPIST-1f} \approx 0.037045 \text{ AU}$$

$$a_{TRAPPIST-1g} \approx 0.045065 \text{ AU}$$

$$a_{TRAPPIST-1h} \approx 0.06 \text{ AU}$$