Jet Propulsion Laboratory
California Institute of Technology

Answer Key

π IN THE SKY ²

Guess what. You just calculated some of the same math problems that NASA scientists and engineers use to explore space. So ... you're basically an honorary rocket scientist. Just sayin'. Check below to see how the experts solved these stellar problems. Do your answers match up?

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Mars Marathon

1. Calculate the Opportunity rover's wheel circumference using the pi formula for circumference

$2\pi r = \text{diameter} \cdot \pi$

$25\ \text{cm} \cdot \pi$

2. Convert the wheel circumference (in cm) to kilometers

$(25\ \text{cm} \cdot \pi)\ /\ 100{,}000$

3. Divide the marathon distance by the wheel circumference

$42.195\ \text{km}\ /\ [(25\ \text{cm} \cdot \pi)\ /\ 100{,}000]\ \text{km} \approx 53{,}724.3$

53,724.3 ROTATIONS

Pixel Puzzler

1. Calculate the surface area of Ceres using the pi formula for the surface area of a sphere

$4\pi r^2 = 4\pi(475\ \text{km})^2 \approx 2{,}835{,}287\ \text{km}^2$

2. Find the surface area of a single image taken by the Dawn spacecraft

$s^2 = 26\ \text{km} \cdot 26\ \text{km} = 676\ \text{km}^2$

3. Divide the surface area of Ceres by the surface area of the image

$2{,}835{,}287\ \text{km}^2\ /\ 676\ \text{km}^2 \approx 4{,}194.2$

4,195 IMAGES

Frozen Formula

1. Find the minimum and maximum radius of Europa minus its ice shell

Min: $1{,}561\ \text{km} - 30\ \text{km} = 1{,}531\ \text{km}$

Max: $1{,}561\ \text{km} - 2\ \text{km} = 1{,}559\ \text{km}$

2. Find the minimum and maximum radius of Europa's rocky interior by subtracting the ice thickness and ocean depth from the radius

Min: $1{,}561\ \text{km} - (2\ \text{km} + 100\ \text{km}) = 1459\ \text{km}$

Max: $1{,}561\ \text{km} - (30\ \text{km} + 3.5\ \text{km}) = 1{,}527.5\ \text{km}$

3. Use the pi formula for the volume of a sphere ($\frac{4}{3}\pi r^3$) to find the minimum and maximum volume for Europa's ocean layer

Min: $\frac{4}{3}\pi(1{,}531^3 - 1{,}527.5^3) \approx 102{,}857{,}290\ \text{km}^3$

Max: $\frac{4}{3}\pi(1{,}559^3 - 1{,}459^3) \approx 2{,}862{,}511{,}574\ \text{km}^3$

102,857,290 km³ TO 2,862,511,574 km³

Hear Here

1. Find the radius of Voyager's signal at Earth using tangent and the distance between Earth and Voyager

$\tan 0.25^\circ = \dfrac{X}{131\ \text{AU}}$

$\tan 0.25^\circ = \dfrac{X}{131 \cdot (1.5 \cdot 10^8\ \text{km})}$

$X = (1.965 \cdot 10^{10}\ \text{km}) \cdot \tan 0.25^\circ \approx 8.574 \cdot 10^7\ \text{km}$

2. Convert kilometers to meters. Then use the pi formula for area of a cirle (πr^2) to find the ratio of the area of the DSN antenna to the area of Voyager's signal at Earth

$(8.574 \cdot 10^7\ \text{km}) \cdot 1{,}000 = 8.574 \cdot 10^{10}\ \text{m}$

$\dfrac{\pi(35\ \text{m})^2}{\pi(8.574 \cdot 10^{10}\ \text{m})^2} = 1.7 \cdot 10^{-19}$

3. Multiply the fraction of the signal received at Earth by the original signal wattage sent from Voyager

$(1.7 \cdot 10^{-19}) \cdot 12.5\ \text{watts} = 2.1 \cdot 10^{-18}\ \text{watts}$

$1.7 \cdot 10^{-19}$ **$2.1 \cdot 10^{-18}$ WATTS**