

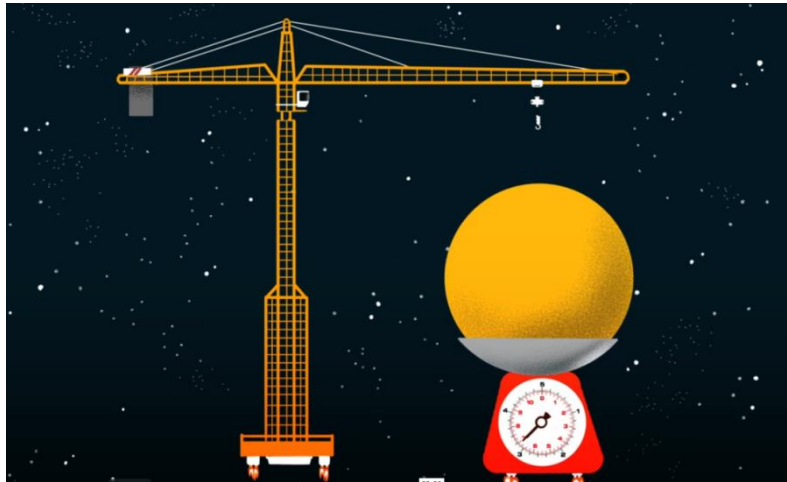
## Calculating the mass of the Sun

Key Stage 4

**Topics covered:** Newton's law of gravitation, Kepler's third law

Watch the video "How do we know how old the Sun is?"

<https://vimeo.com/88978362>



Kepler's third law states that the orbital period of a planet,  $T$ , squared is proportional to its distance from the Sun,  $R$ , cubed:

$$T^2 \propto R^3 \quad (1)$$

Newton's law of gravity states that the mutual gravitational force that the Sun and an orbiting planet feel is proportional to the mass of the Sun,  $M$ ; the mass of the planet,  $m$  and is inversely proportional to the distance between the two squared,  $R^2$ :

$$F = \frac{GMm}{R^2} \quad (2)$$

Kepler's third law can be derived from Newton's law of gravity, the result is this:

$$\frac{T^2}{R^3} M = \frac{4\pi^2}{G} \quad (3)$$

$T$  is in seconds,  $R$  is in kilometres,  $M$  is in kilograms and  $G$  is the gravitational constant =  $6.67 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-1}$ .

If  $T$  is in years and  $R$  is in astronomical units (AU) then  $T^2 = R^3$ .

1. The orbital period of Saturn is 29.5 years. Calculate the orbital distance of Saturn in AU. Convert this into kilometres.
2. Convert the orbital period of Saturn into seconds.
3. Rearrange equation 3 and calculate the mass of the Sun.

## Calculating the mass of the Sun: **ANSWERS**

### Key Stage 4

1. 9.54 AU;  $1.43 \times 10^9$  km
2. 930949200 seconds
3. The mass of the Sun is  $2 \times 10^{30}$  kg